BONNEVILLE POWER ADMINISTRATION

Impact Evaluation of FY2015 UES Residential Lighting Projects

Contributors

Developed by:

Jes Rivas, Divya Iyer, Rebecca Legett, and Rosanna Ren, Navigant Consulting, Inc.

Santiago Rodriguez-Anderson and Mike Baker, SBW Consulting

Developed for the Bonneville Power Administration

Please refer questions to:
Lauren Gage, lsmgage@bpa.gov, 503.319.7195

Table of Contents

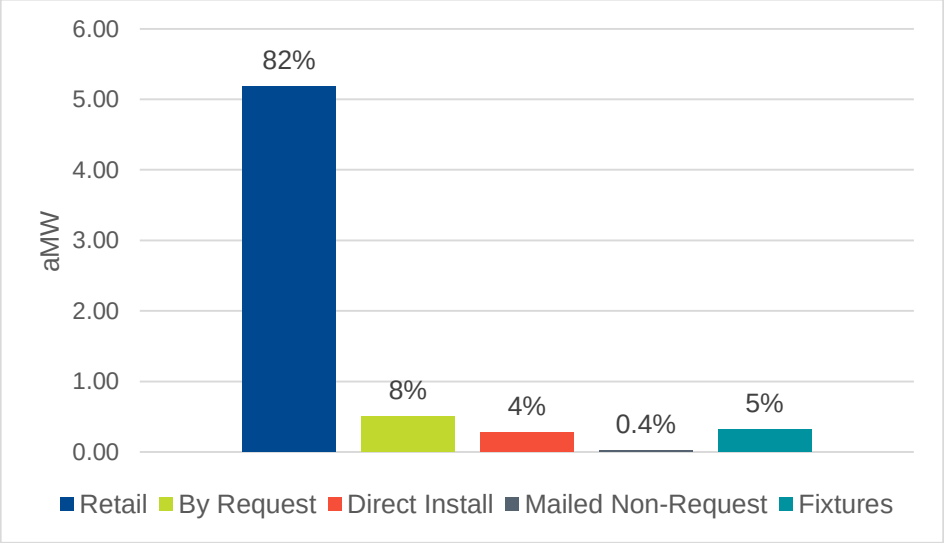
Executive Summary

This report describes the impact evaluation of Bonneville Power Administration's (BPA) Retail and By-Request residential lighting measures that contributed to savings within BPA's FY2015 Unit Energy Savings (UES)[1] portfolio. It also provides insight into the smaller Direct Install and Fixture measures.

Background

BPA's UES portfolio contains measures that span all sectors which together account for roughly 60 percent of BPA's total reported savings. Residential lighting measures are the largest contributor to UES savings, providing 49 percent of the total FY2015 UES residential portfolio, with 8.4 aMW. As shown in Figure ES-1, Retail and By-Request measures account for 90 percent of total residential lighting UES savings.

Figure ES-1 Residential Lighting UES – FY2015 Savings by Delivery Mechanism*



** Excludes non-participant savings.*
Source: Navigant analysis of 3/18/2016 IS2.0 extract.

UES lighting measures are included in BPA's Simple Steps program[2] as well as in utility run efficiency programs. For Retail measures, BPA's Retail Sales Allocation Tool[3] (RSAT)

[1] UES Measures utilize a constant savings value of reach measure application.
[2] Simple Steps is BPA's regional promotion designed to increase adoption of energy efficient residential products, including compact fluorescent lamps (CFLs), light emitting diode bulbs (LEDs), light fixtures, energy-saving showerheads, advanced power strips, and efficient appliances such as clothes washers, refrigerators, and freezers.
[3] https://www.bpa.gov/EE/Sectors/Residential/Pages/Retail%20Sales%20Allocation%20Tool%20(RSAT).aspx

allocates sales of energy efficiency products at a given retail store to utilities with territories adjacent to the store[4].

Objectives

There are three evaluation objectives for the impact evaluation of UES residential lighting Retail and By-Request measures:

- Evaluate the energy savings achieved for consistency with the savings claimed.
- Assess the cost-effectiveness of the evaluated savings using ProCost[5] and the updated 7th Plan inputs.
- As needed, provide feedback to improve program operation and measures. This may include recommendations on data collection, oversight and program procedures.

Methodology

The evaluation team determined that the required project documentation, as specified in BPA's Implementation Manual[6], should satisfy the delivery verification requirements for Retail and By-Request measures, summarized in Table ES-1 . As such, the evaluation team requested and reviewed project documentation, primarily invoices, for a representative sample of reported projects as a means to verify the impacts achieved by these lighting measures. The details of this sample are provided in Section 2.2.

The evaluation team conducted a thorough review of the required project documentation and delivery verification requirements. If the evaluation team did not identify any discrepancies between the project documentation and the claimed savings, the team attributed full credit for a sampled project. If the team identified discrepancies (e.g., different wattage) the team assigned evaluated savings using the appropriate UES value. Finally, if data were missing, the team assigned zero savings[7].

The evaluation team also reviewed project documentation for a small sample of Direct Install and Fixture measures to inform future year's evaluation activities and to provide programmatic insight.

[4] RSAT allocations are available to utilities whether they are participating in the Simple Steps program or not.
[5] ProCost is a model developed by the Northwest Power and Conservation Council and is used by the RTF to estimate the cost effectiveness of efficiency measures.
[6] Bonneville Power Administration, Energy Efficiency Implementation Manual, October 1, 2014. Page 73 and 75. http://www.bpa.gov/EE/Policy/IManual/Documents/FINAL_October_2014_Implementation_Manual.pdf
[7] Evaluated savings are presented in this report and included as the numerator in all realization rates calculated and shown herein. These evaluated savings were not used to replace or update the savings reported in IS2.0 or the BPA BOOM report.

Results

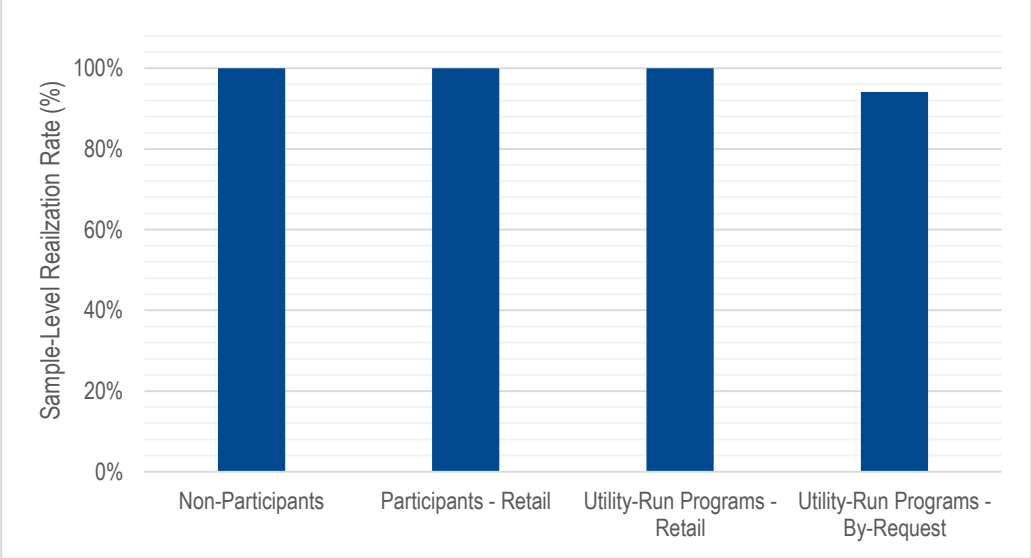
Overall, the impact evaluation was able to verify the savings reported. The high realization rates shown in Table ES-1 and Figure ES-1 reflect that the data included in project documentation aligns very closely with the measure data reported to BPA for Retail and By-Request measures.

Table ES-1: Savings for FY2015 Retail and By-Request Residential Lighting UES Measures

Savings Channel	Reported Savings (aMW)	Evaluated Savings (aMW)	Population-Level Realization Rate (%)
Non-Participant	**2.10**	**2.10**	**1.00**
Utility Reported*	**5.58**	**5.55**	**0.995**
Retail	*5.08*	*5.09*	1.00
By-Request	*0.49*	*0.46*	0.929
Total	**7.68**	**7.65**	**N/A****

**Utility reported savings come from Simple Steps and utility-run programs, which are not distinguished in BPA's reporting system. Utility-run programs include residential lighting savings outside of the Simple Steps program.*
***Participant and utility-reported realization rates cannot by aggregated because of different sampling mechanisms.*
Source: Navigant analysis

Figure ES-2: Realization Rate by Savings Stream[8]



Source: Navigant analysis

Using ProCost and the evaluated savings values, the evaluation team found both the By-Request and the Retail measure groups to be cost-effective, with a benefit/cost ratio well above 1.

[8] Realization rate is calculated as evaluated savings over reported savings.

Table ES-2: Retail and By-Request Lighting Measure Cost-Effectiveness

Measure Group	Present Value of Benefits	Present Value of Costs	Total Resource Benefit/Cost Ratio
Retail	$6,773,640	$1,494,617	4.5
By-Request	$3,480,865	$336,918	10.3
Total	**$10,254,505**	**$1,831,535**	**5.6**

**Non-participant savings are not included in the cost-effectiveness analysis.*
Source: ProCost Analysis using 7th Power plan inputs

Findings & Recommendations

The evaluation team presents the following findings:

Documentation Supports Savings Claimed. Nearly all sampled reported savings for residential lighting Retail and By-Request measures was accounted for in the required project documentation. The high overall realization rate was driven by the Retail measure group, which represents over 82 percent of the lighting savings, and which itself had a realization rate of 1.00.

Incorrect Reference Numbers were sometimes reported for By-Request measures. Project documentation revealed that some utilities incorrectly assigned reference numbers (RefNos), leading to a few of the sampled By-Request line items reporting incorrect UES values. While half of the sampled utilities with By-Request measures required RefNo corrections, these corrections only represented 3.5 percent of the total By-Request sampled savings (aMW).

Documentation Review May Satisfy DV for Simple Step Fixture Measures. The evaluation team determined that delivery verification through documentation review could be a viable option for Fixture measures being reported through the Simple Steps program. However, it is important to note that these are BPA Qualified measures, so delivery verification would not qualify as impact evaluation.

The evaluation team provides the following recommendations on how to improve program operations and future evaluations:

Create unique Reference Numbers to distinguish between Simple Steps and Non-Simple Steps measures. The IS2.0 database uses the same measure reference numbers regardless of program. This makes it impossible to clearly identify which measures saved energy under which program. BPA should enhance their measure tracking processes to allow BPA to clearly identify the amount of savings reported to the Simple Steps program versus utility-run programs.[9]

Opportunities exist to streamline utility-run program data collection and reporting. Very few utilities were able to easily provide project documentation for their sampled projects, and the mapping process used (linking a specific reported measure to its required project documentation) was often inconsistent, labor intensive and/or

[9] The evaluation team has learned that BPA is planning to create separate and unique retail lighting measures for Simple Steps and utility run programs.

complex. In fact, one utility was unable to provide this information within a seven-month data collection period. The evaluation team recommends customer utilities use distribution logs similar to those used by the Simple Steps third-party implementer. This would increase the efficiency and accuracy of future evaluation efforts. It may also allow utilities to more efficiently and accurately assign UES values and report savings, especially for By-Request measures.

Alter Measure Distribution Log to include installed location for Direct Install lamps. The delivery verification requirements for Direct Install (DI) lamps include installation location.[10] BPA's required project documentation requirement, namely the Measure Distribution Log[11], does not currently require this information. The evaluation team recommends that BPA alter the Measure Distribution Log to require location information for Direct Install lamps to allow for evaluation via document review in the future.

[10] Deemed savings for DI lamps are allocated by location.
[11] https://www.bpa.gov/EE/Policy/IManual/Documents/Residential_Measure_Distribution_Log.xls

1. Introduction

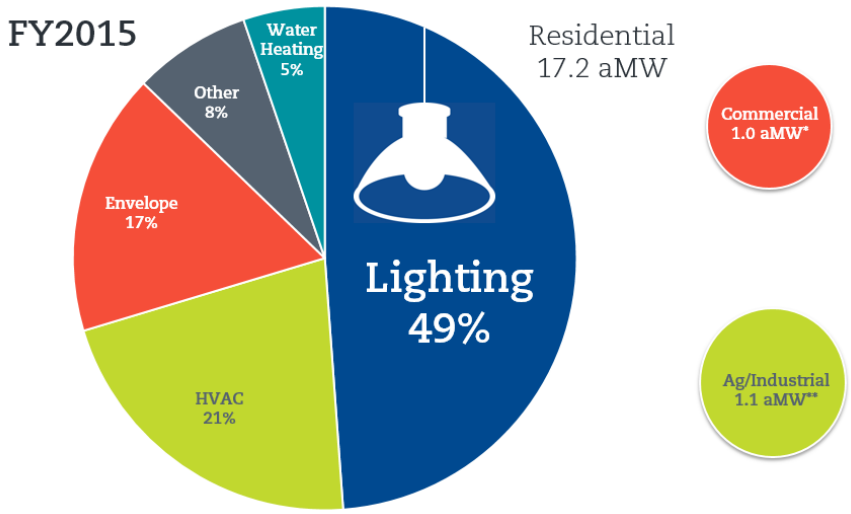
This document presents the results of the impact evaluation of select residential lighting measures included in the BPA UES portfolio. Navigant, together with SBW Consulting, conducted this impact evaluation of fiscal year (FY) 2015 Retail and By-Request lighting projects as a part of a larger evaluation of BPA's UES portfolio, as outlined in the BPA UES Portfolio Evaluation Plan for CY2016 Activities.[12] This report outlines the evaluation team's methodology, sample design, data collection effort and results. It also provides key findings and recommendations focused on increasing accuracy and efficiency in program reporting and future evaluation.

1.1. FY2015 UES Portfolio Summary

BPA, with its public power utility partners, acquires savings from a portfolio of energy efficiency programs and measures. About 60 percent of BPA's total savings comes from UES measures, which utilize a constant deemed savings value for each measure application.

UES measures fall into several categories of residential, commercial, and industrial equipment. As seen in Figure 1, residential lighting measures are the largest contributor to the UES savings, providing 49 percent of the total FY2015 UES residential portfolio, with 8.4 aMW.

Figure 1: FY2015 UES Portfolio Summary



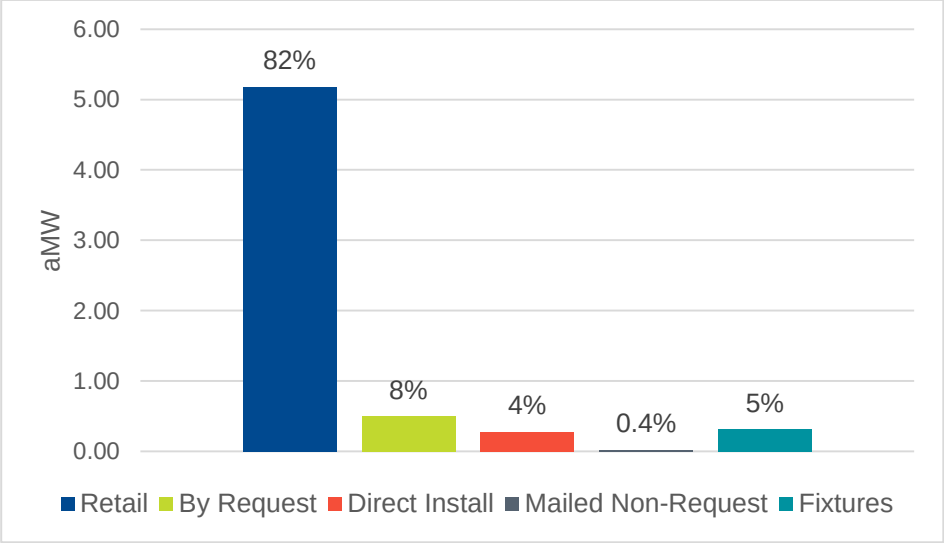
** Savings from Energy Smart Grocers deemed measures are not included in this summary.*
*** Ag/Industrial value does not include savings achieved through the Scientific Irrigation Scheduling measure.*
Source: Summarized from BPA's IS2.0 database, accessed 3/18/2016

[12] Navigant Consulting, Inc. April 2016. Bonneville Power Administration UES Portfolio Evaluation Plan CY2016 Activities. https://www.bpa.gov/EE/Utility/research-archive/Documents/Evaluation/BPA_UES_Evaluation_Plan_FINAL_04012016_V3.pdf

1.2. Overview of Residential Lighting Measures

As shown in Figure 2, Retail and By-Request are the largest delivery mechanisms, accounting for 90 percent of total residential lighting UES savings.

Figure 2 : Residential Lighting UES Savings by Delivery Mechanism (FY2015)



** This figure does not include the 2.1 aMW of non-participant savings that is not reported into BPA's IS2.0 system. Since these savings are not allocated to utilities, they are not included in IS2.0.*
Source: Navigant analysis of 3/18/2016 IS2.0 extract.

There are three mechanisms for reporting savings for residential lighting UES measures:

- Program savings: BPA offers utilities a selection of residential lighting UES measures that can be rebated as part of the Simple Steps program.[13] In this pathway, BPA contracted a third-party implementer to manage and promote the installation of RTF-proven lighting measures across a utility's service territory. Participating utilities are responsible for reporting savings achieved through Simple Steps into BPA's data tracking system IS 2.0, and these are referred to as program savings.
- Non-participant savings: In addition to the Simple Steps program savings, savings are achieved through lamps the program implementer delivers through Simple Steps that are not tied to a reporting BPA utility. These are referred to as non-participant savings. The program implementer tracks the savings and assigns them to a utility service territory based on location, but they are not part of that utility's savings reported to BPA. While not reported through any utility,

[13] Simple Steps is BPA's regional promotion designed to increase adoption of energy efficient residential products, including lighting and other home appliances. BPA designed Simple Steps to provide ease and support to utilities promoting energy efficiency in the residential market.

they represent 2.1 aMW of ex-ante savings, a significant share of the overall residential lighting domain.

- Utility-run program savings: A third group of savings are reported to BPA by the utilities themselves that do not involve the Simple Steps program. These are referred to as outside program savings and also appear in IS 2.0.

The combined populations of program savings and utility-run program savings are referred to as 'utility reported' savings in the tables included throughout this report.

1.3. Evaluation Objectives

There are three evaluation objectives for the impact evaluation of UES residential lighting Retail and By-Request measures:

- Evaluate the energy savings achieved for consistency with the savings claimed.
- Assess the cost-effectiveness of the evaluated savings using ProCost[14] and the updated 7th Plan inputs.
- Provide feedback to improve program operation and measures.
    - Where appropriate, assess savings to inform RTF or BPA Qualified estimates.
    - Develop recommendations on data collection, oversight and program procedures, including but not limited to documentation and data handling, to improve reliability and reduce cost for future evaluation years.

2. Methodology

This section describes the data, sampling design and approach used to evaluate the impact of the selected residential lighting UES measures. This methodology builds on the guidelines set forth in the Quality System Strategy & Implementation (QSSI) document, Regional Technical Forum (RTF) Guidelines and the BPA Implementation Manual (IM).

2.1. Data Sources

The evaluation team used the BPA tracking database (Interim Solution 2.0 or IS2.0), the Simple Steps third party implementer's database and project documentation (the documentation required per the IM) as the primary data sources used to evaluate the impacts of the residential lighting UES measures.

[14] ProCost is a model developed by the Northwest Power and Conservation Council and is used by the RTF to estimate the cost effectiveness of efficiency measures.

Appendix F describes the project documentation required for these measures.

2.2. Sample Design

BPA's QSSI policies establish a target for impact evaluation, striving for measure group-level evaluations to attain relative error of 10% at the 90% confidence level, with a minimum acceptable level of 80/20. While BPA together with the evaluation team believes that uncertainty within the savings estimates for residential lighting measures is low, the sheer volume of these measures and their contribution to the BPA portfolio is significant. Therefore, the team structured the sample design to target a 90/10 confidence/precision for Retail measures and 90/15 for By-Request measures. The sampling unit used in this design is a line item within the IS2.0 database.

The following sections describe the team's sample design for each stream of savings.

2.2.1. Utility Reported Savings

The evaluation team used the IS2.0 database as the sample frame for utility-reported savings, those savings achieved via Simple Steps and utility-run programs. In order to minimize the burden on utilities and evaluation cost, the evaluation team used a two stage cluster sampling design, first sampling utilities, then sampling projects within each utility's participant population. The first stage sample of utilities was stratified by size, according to a common set of criteria:

- We sampled all large contributors, those making up greater than 5% of the Retail and By-Request lighting measures (i.e., certainty sample).
- We sampled medium contributors (making up 2 to 5% of a measure group) and small contributors (making up between 0.05 and 2% of a measure group) randomly in order to meet confidence and precision objectives.
- We excluded tiny contributors, including the smallest contributors with savings that sum to 5% of the savings or less, from the sample.[15]

The team took two additional steps at the first-stage sample, in order to ensure representativeness and minimize burden.

1. To the extent possible, any utility drawn as a small contributor which received FY2014 oversight was dropped from the sample and replaced.[16]
2. After the sample was drawn, representativeness quotas were checked to ensure that the random sample of utilities faithfully represented the overall population.

[15] In some cases, if a utility selected for another evaluation activity in CY2016 had lighting projects, the evaluation team selected a sample here as well, even if the savings would otherwise cause the utility to fall in the "tiny contributors" category.
[16] FY2014 oversight was conducted on medium-sized utilities. The evaluation team does not currently believe this represents a bias to the sample.

After stratifying and drawing the utility sample, the evaluation team randomly drew project-level samples. The second stage of cluster sampling was performed differently for the large contributor stratum versus the small contributors, in order to optimize the sample efficiency. For the large contributors, the team pulled a stratified random sample of projects across all of the large contributors combined. For the small contributors, the team requested a random sample of project files weighted by the utility's savings contribution.

Using FY2015 data, the evaluation team identified the target sample sizes presented in Table 1, using the estimated coefficients of variation provided therein.

Table 1: Target and Achieved Sample Design

Measure Group	Utilities (FY2015)	Reported Projects* (FY2015)	FY2015 Reported Savings (aMW)	Sampled Utilities**	Sampled Projects*	Sampled Savings (aMW)	% of Total FY2015 Savings Sampled
Retail	55	3,194	5.09	7	70	0.55	11%
By-Request	43	337	0.49	6	40	0.34	68%

**Line items in IS2.0*
***Some utilities were sample for both Retail and By-Request projects. 9 total utilities are included in this sample.*
Note: The evaluation team also collected data for a small sample of Direct Install and Fixtures projects to inform future evaluation planning.
Source: Navigant

The evaluation team also reviewed project documentation for a small sample of Direct Install and Fixture measures to inform future year's evaluation activities and to provide programmatic insight.

2.2.2. Non-Participants

Through the Simple Steps program, all BPA utility customers and neighboring IOUs are allocated savings through the program's Retail Sales Allocation Tool (RSAT).[17] However, BPA public utility customers who do not participate in the program do not receive savings and are termed as non-participants.

While the savings allocated to non-participants is included in the UES portfolio, the IS2.0 database does not contain project information for non-participant projects. Instead, the evaluation team used the third party implementer's database of non-participant projects to design the sample.

The team first stratified the utilities by size of total savings contribution--large, medium and small--each comprising approximately one-third of the total energy savings. Then the team randomly selected three large, three medium, and three small utilities from which to sample. For each sampled utility, the team sampled a census of projects within a randomly-selected reporting period (~1 month) during FY2015.

[17] The RSAT and allocation process were not directly evaluated as a part of this work.

2.3. Data Collection

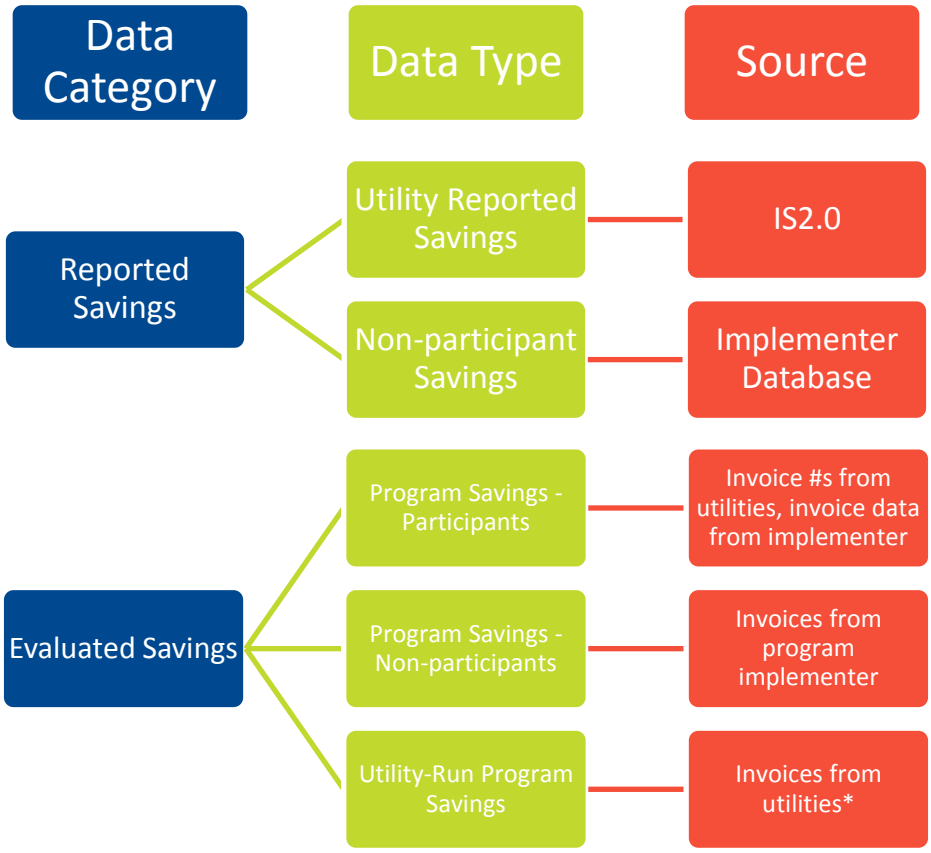
For Simple Steps projects, the evaluation team asked utilities to provide the invoice numbers corresponding to the sampled projects.[18] The third party implementer then provided project documentation for these invoices directly to the evaluation team. In addition, the third party implementer provided the team Excel workbooks that recorded all relevant measure sales for a given utility and reporting period. These proved invaluable in allowing the evaluation team to efficiently and accurately map reported measures to their invoices, as invoices often spanned sampled projects, making it difficult to determine which items on large invoices corresponded to the line items the evaluation team was attempting to verify.

Project documentation for utility-run program and By-Request measures was provided directly by the utility, except in those instances where their program was implemented by the same third-party provider as the Simple Steps program. For some of the sample, invoices were sufficient to allow the evaluation team to identify and verify sampled line items in IS2.0. For the rest, the matching process ranged from complex to impossible. The evaluation team found that utilities often purchased lamps in bulk orders and then distributed the lamps at different points in time (sometimes combining lamps from different bulk orders into a single distribution), reporting each distribution event as a different project in IS2.0. As such, many of the bulk invoices provided to the evaluation team required additional data from the utility that could be used to map lamps to reported line items. This need for additional data led to delays in data collection, and revealed that the sampled utilities had different methods and formats of keeping these records.

For non-participants, the third party implementer provided invoices and sales records.

[18] This step was necessary because while the implementer maintains invoices, utilities are responsible for reporting savings to BPA. This process allows only the reporting utility (and not the implementer) to know which invoice numbers correspond to which specific IS2.0 entries.

Figure 3: How the Evaluation Team Used Data



** Some utility programs were run by the same third party implementer as the Simple Steps program. For those utilities, the third party implementer provided invoices directly to the evaluation team.*
Source: Navigant

The evaluation team worked with BPA Energy Efficiency Representatives (EERs) as much as possible to communicate with sampled utilities. Nevertheless, several utilities did not submit invoice data until well after the data collection deadline. This problem was particularly acute for utility-run program sampled measures.

2.4. Delivery Verification

BPA together with the evaluation team aims to select the best approach available to conduct evaluation while balancing strategic considerations including a measure's status, contribution to savings, uncertainty in claimed savings and programmatic importance.

The evaluation team determined that the required project documentation, as specified in BPA's Implementation Manual[19], should satisfy the delivery verification

[19] Bonneville Power Administration, Energy Efficiency Implementation Manual, October 1, 2014. Page 73 and 75.
http://www.bpa.gov/EE/Policy/IManual/Documents/FINAL_October_2014_Implementation_Manual.pdf

requirements for Retail and By-Request measures, summarized in Table ES-1 . With 95 percent of savings contributed by Proven measures, the team decided to use delivery verification to evaluate the impacts of residential lighting UES measures.[20]

This approach verifies measure delivery via the verification of a pre-defined set of key measure parameters. Table 2 lists these parameters as well as the data source the team used to verify each. The detailed delivery requirements are provided in Appendix E.

Table 2: Delivery Verification Checklist

Measure Parameter Requiring Delivery Verification	Data Source
Delivery mechanism	Utility response
Lamp type Appropriate efficient technology, lumen category	Invoice – lookup via make, model, SKU
Quantity	Invoice
Evaluation range	Invoice date
Included on Energy Star qualified list	Invoice – lookup via model

Source: UES Portfolio Evaluation Plan, CY2016

As discussed in the previous section, the evaluation team received invoices and other information, either from utilities or from the program implementer, to verify the sampled line items. Most invoices provided a bulb's product number (SKU) which the team used to look up lamp type and lumen category, when that information was not provided directly on the invoice. Product information included on the invoice was also used to verify that products were included on the Energy Star qualified product list.

For determining the per-unit energy savings to be assigned to each sampled project, the evaluation team referred to BPA's UES Measure List, which contains the deemed per-unit savings and specifications for all UES measures.[21] This list is updated regularly to reflect the region and BPA's most current savings estimates and assumptions, but for purposes of this evaluation, we verified savings using the UES measure list that was in place at the time of delivery.[22] Each specific measure in the UES measure list is identified with a unique reference number (RefNo), and each line item in IS2.0 lists the RefNo associated with that project. In that way, the evaluation team was able to use the RefNo of the IS2.0 line item to assign a UES value to each sampled measure.

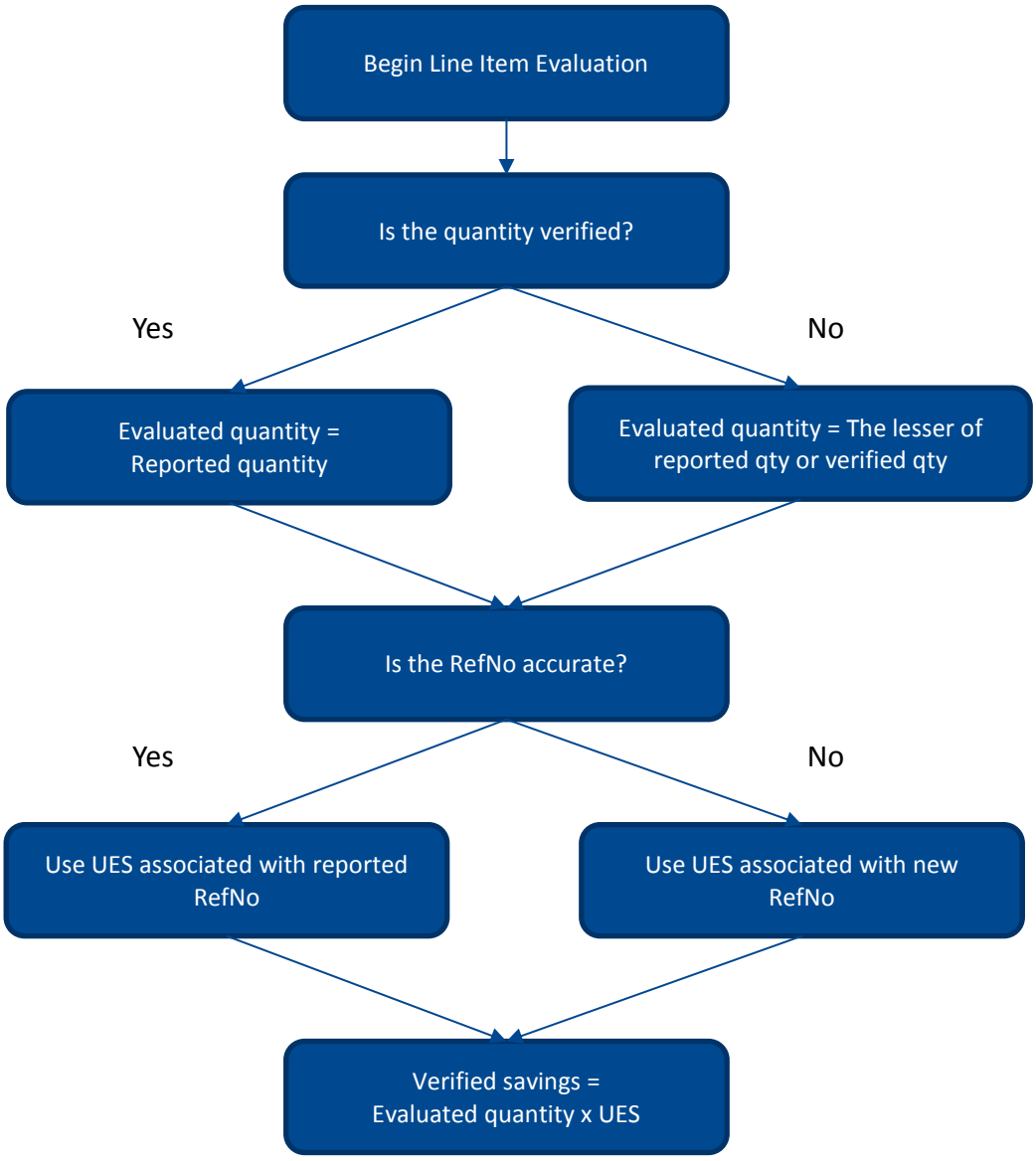
The evaluation team reviewed the required project documentation, defined delivery verification requirements and detailed UES specifications to assign one of the following three types of savings for each sampled project in the evaluation:

[20] RTF Guidelines stipulate that Impact Evaluation may be accomplished using delivery verification to estimate savings for Proven measures, i.e., savings equal the verified delivery quantity multiplied by the proven UES savings value.
[21] BPA updates the UES measure list regularly. It is downloadable off of the Interim Solutions 2.0 Files website. https://www.bpa.gov/EE/Policy/Solutions/Pages/default.aspx
[22] UES Measure List Version 3.0 was used for FY2015 UES measures.

1. Verified Savings: If the evaluation team does not identify any discrepancies between the provided project documentation and the claimed utility savings, the team will attribute full credit to each sampled project in the evaluation.
2. Revised Savings: If the evaluation team identifies that the appropriate data are collected, but there are minor discrepancies (e.g., different wattage, lumen range) indicating that the utility had assigned the incorrect RefNo to the project, the team will assign evaluated savings using the appropriate UES value for each sampled project.[23]
3. No Savings: If the evaluation team identifies that any required data is missing in the project documentation (i.e. invoices), zero credit will be attributed to that particular sampled project in the evaluation.

[23] Evaluated savings are presented in this report and included as the numerator in all realization rates calculated and shown herein. These evaluated savings were not used to replace or update the savings reported in IS2.0 or the BPA BOOM report.

Figure 4: Flowchart of Delivery Verification Logic



Source: Navigant

After estimating the verified savings using the above method, the evaluation team calculated the realization rate, defined as the evaluated savings divided by the reported savings. The team calculated a realization rate for each line item, each utility and the sample. Finally, the team calculated a realization rate for the overall population, extrapolated from the sample.

2.5. Life-cycle Cost Effectiveness

For each sampled measure, the team used the RTF model ProCost[24] to estimate the lifetime sum of costs and benefits. This model implements the Total Resource Cost (TRC) methodology which accounts for "all the costs of a measure with all of its benefits, regardless of who pays those costs or who receives the benefits"[25]. ProCost[26] outputs the discounted sum of costs and benefits over a measure's life.[27]

The team obtained data on measure quantities from documentation provided by the program. The team verified applied program level realization rates to the expected savings for each measure electric savings. Data not provided by the program was taken from corresponding measures in RTF measure workbooks. This includes annual Non-Electric Benefits (NEBs) such as O&M costs, and gas benefits from implementing measures.

To calculate the Total Resource Cost test (benefit divided by costs) for each domain and for the portfolio, the team used the sample case weights to calculate an appropriately weighted sum of costs and benefits. The team also calculated the Total Resource Cost test for each sampled measure excluding any non-electric benefits.

3. Results

This section provides the detailed results of our impact evaluation, including the evaluated savings by delivery mechanism, cost-effectiveness and our key findings and recommendations for the future.

3.1. Savings

Overall, the impact evaluation was able to verify the savings reported to BPA for Retail and By-Request residential lighting UES measures. The realization rates, (calculated as evaluated savings divided by reported savings) near to or at 1.0 reflect that the data included in project documentation aligns very closely with the measure data reported. Additionally, the evaluation team calculated a realization rate of 1.0 for the sampled non-participant savings using project documentation provided by the third party implementer data.

[24] ProCost is a model developed by the Northwest Power and Conservation Council and is used by the RTF to estimate the cost-effectiveness of efficiency measures.
[25] From the 6th Power Plan.
[26] ProCost uses a slightly different busbar factor than the one used by BPA, which is also the one we have used throughout this report to showing reported and evaluation savings. The ProCost busbar factor is 1.09066 and the BPA busbar factor is 1.09056.
[27] The average busbar factor used in this ProCost model is 1.075. For FY2015. the busbar factor used for BPA's residential lighting Retail and By-Request measures varied between 0.917 and 1.167.

Table 3: Summary of Overall Results

Savings Channel	Reported Savings (aMW)	Evaluated Savings (aMW)	Population-Level Realization Rate (%)
Non-Participant	**2.10**	**2.10**	**1.00**
Utility Reported*	**5.58**	**5.55**	**0.995**
Retail	*5.08*	*5.09*	1.00
By-Request	*0.49*	*0.46*	0.929
Total	**7.68**	**7.65**	**N/A****

**Utility reported savings come from Simple Steps and utility-run programs, which are not distinguished in BPA's reporting system. Utility-run programs include residential lighting savings outside of the Simple Steps program.*
***Participant and utility-reported realization rates cannot by aggregated because of different sampling mechanisms.*
Source: Navigant analysis

Table 4 provides a detailed breakdown of the evaluated savings, broken apart by sample strata. Using the verified savings of the sample, the evaluation team extrapolated the realization rate to the overall population to determine program-level savings. The team first estimated project-level realization rates for each project within the sample using the method described above. These realization rates were then weighted by project size within each stratum to develop a stratum-level realization rate. Finally, stratum-level realization rates were rolled up to the entire participant population to estimate verified impacts at the population level.

Table 4: Detailed Portfolio-level Savings for Residential Lighting UES Measures

Domain			Real-ization Rate	Relative Precision	Reported Savings (aMW)	Evaluation Savings		RR of Meas. Group	Relative Precision of Meas. Group
Measure Group	Utility Size	Project Size				aMW	% of Portfolio		
By-Request	Large	Large	0.94	N/A*	0.23	0.22	4%	0.929	5.5%
	Small	Large	0.99	N/A*	0.08	0.07	1%		
		Medium	0.84	18.0%	0.15	0.16	2%		
		Small	1.05	27.0%	0.05	0.04	1%		
Retail	Large	Large	1.00	0.0%	2.60	2.60	47%	1.002	0.2%
		Medium	1.00	0.3%	0.94	0.94	17%		
		Small	0.99	1.1%	0.06	0.06	1%		
	Small	Large	1.00	0**	0.30	0.30	5%		
		Medium	1.00	0**	0.85	0.85	15%		
		Small	1.03	3.5%	0.33	0.35	6%		
Overall					**5.58**	**5.55**	**100%**	**0.995**	**0.5%**

** All of the projects in these strata were sampled; therefore, a relative precision could not be calculated.*
*** Too few projects in these strata were sampled for a relative precision to be calculated.*
Source: Navigant

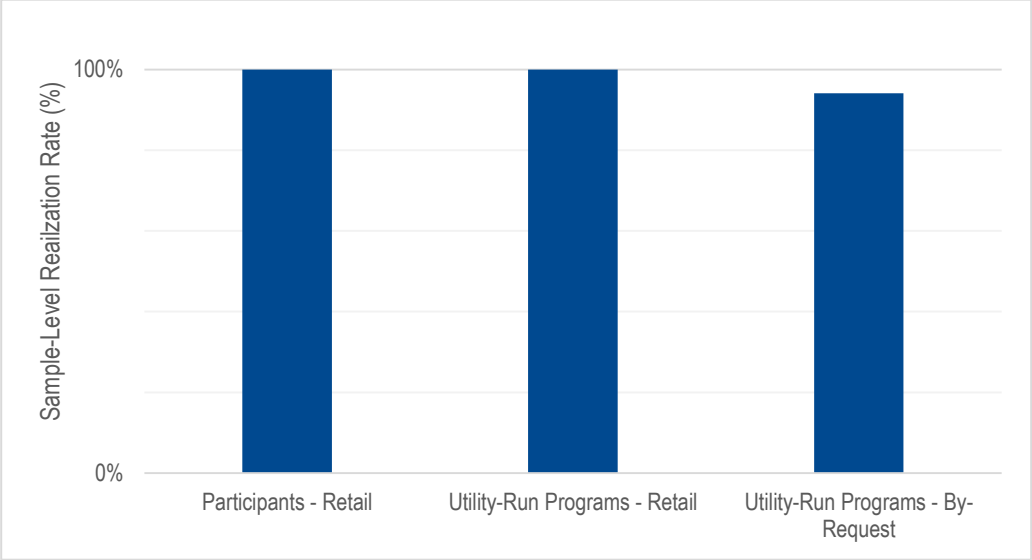
3.1.1. Key Drivers

The evaluation team presents the following information to better understand the drivers behind the results presented above.

As a first step, the evaluation team compared the realization rate for Simple Steps versus utility-run program projects at the sample level. The evaluation team was not

able to calculate the population-level realization rate for Simple Steps projects separate from those delivered via utility-run programs due to the fact that identical RefNos are used to report savings into IS2.0. The team relied on data from utilities to make this distinction at the sample-level.

Figure 5: Participant and Utility-Run Program Retail Projects had Similar Realization Rates at the Sample-Level

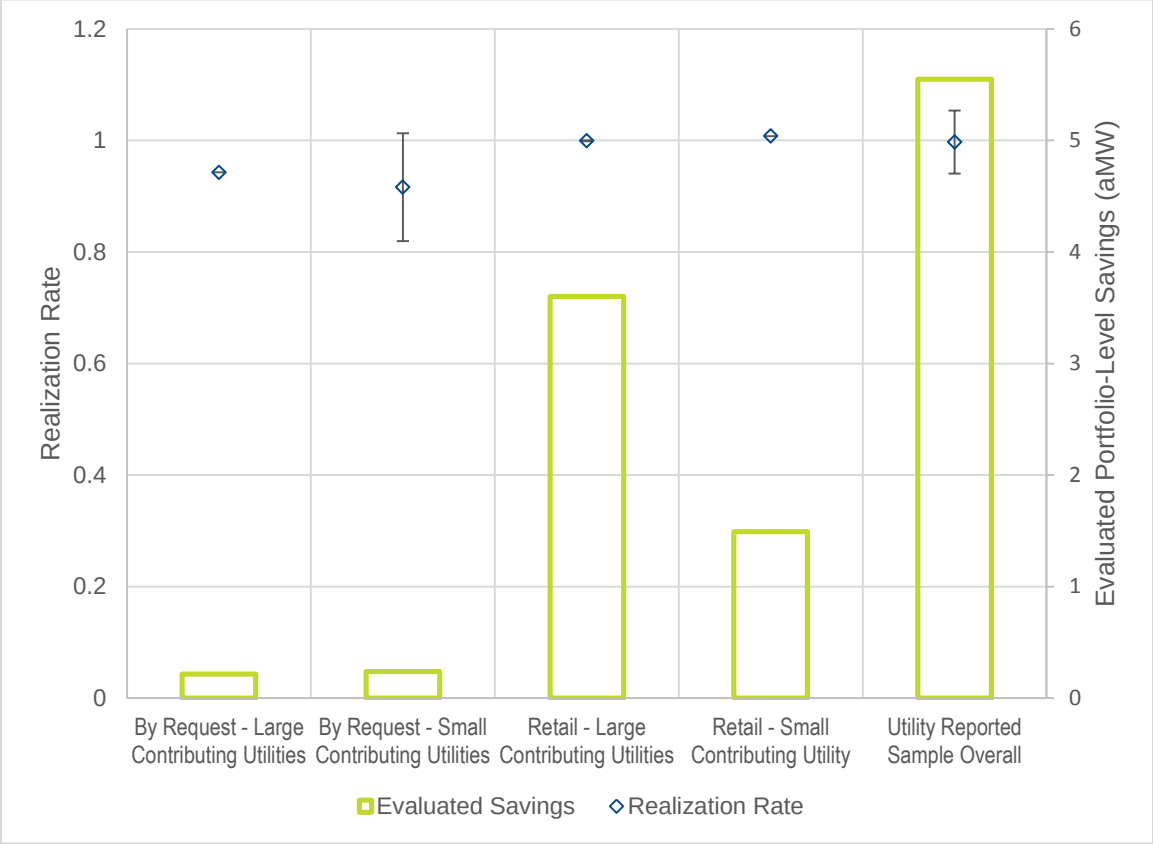


Source: Navigant

As shown in Figure 5, sampled Simple Steps and utility-run program Retail measures both had high realization rates. The evaluation team was unable, however, to verify 100 percent of the reported savings for the sampled By-Request measures, leading to a slightly lower realization rate for this measure group. This was driven by three issues; 1) The evaluation team received project documentation which required a quantity adjustment for a few sampled projects, 2) The evaluation team received project documentation which required a reassignment of reference numbers and UES values for a few sampled projects, and 3) One utility was unable to provide all necessary documentation, resulting in zero savings assigned for a few sampled measures.[28] Figure 6 shows this impact these issues have on the realization rate for the By-Request sample. The lines around the realization rates shown in this figure indicate the variation in realization rates calculated for the sampled projects.

[28] Missing documentation accounted for 0.25% of the total By-Request sampled savings.

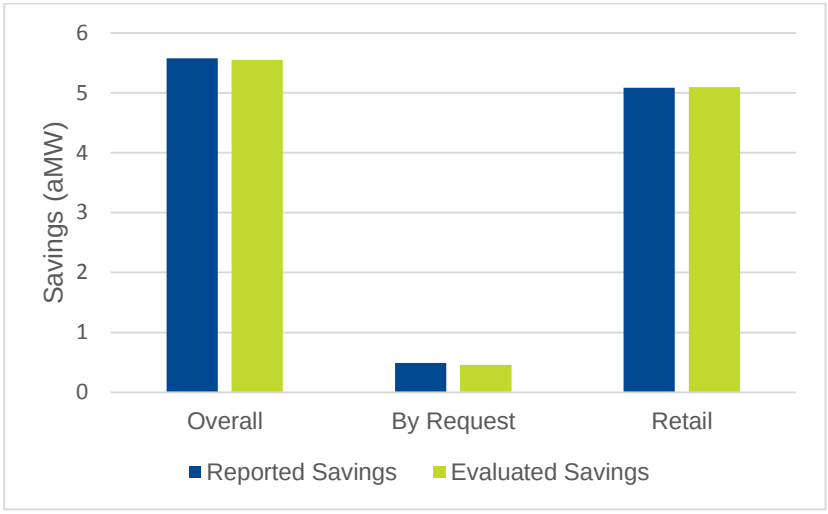
Figure 6: By-Request Measures Show the Largest Variation in Realization Rate



Source: Navigant

As seen in both Figure 6 and Figure 7, the Retail measures' contribution to savings is large enough to almost completely obscure the impact of the By-Request sample in the overall realization rate.

Figure 7: Comparison of Population Savings across Measure Groups



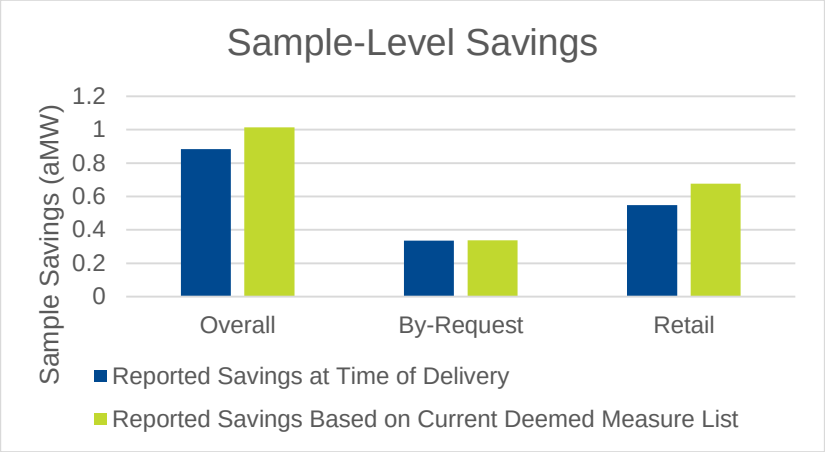
Source: Navigant

3.1.2. Measure Changes

As described above, the deemed savings BPA assigns to its UES measures change over time and are stored in the UES Measure List BPA maintains. In FY2015, residential lighting UES measures referenced version 3.0 of the UES Measure List.

In order to understand the impact of changes made to the deemed savings values for these sampled lighting measures, the evaluation team recalculated evaluated savings using the most current UES Measure List, version 5.0. Figure 8 shows the impact of the variations in UES savings for residential lighting measures. Deemed savings for Retail measures appear to have increased, causing the savings for residential lighting to increase overall.

Figure 8: Effect of RTF Changes in Measure List



Source: Navigant

3.2. Cost-Effectiveness

Using ProCost and the adjusted savings values, where necessary, the evaluation team found both the By-Request and the Retail measure groups to be cost-effective, with a benefit/cost ratio well above 1.

Table 5: Cost-Effectiveness of Evaluated Measure Groups

Measure Group	Present Value of Benefits	Present Value of Costs	Total Resource Benefit/Cost Ratio
By-Request	$3,480,865	$336,918	10.3
Retail	$6,773,640	$1,494,617	4.5
Total	**$10,254,505**	**$1,831,535**	**5.6**

Note: Non-participant savings not included in cost-effectiveness analysis.
Source: ProCost Analysis

3.3. Findings & Recommendations

The evaluation team presents the following findings:

Documentation Supports Savings Claimed. Nearly all sampled reported savings for residential lighting Retail and By-Request measures was accounted for in the required project documentation. The high overall realization rate was driven by the Retail measure group, which represents over 82 percent of the lighting savings, and which itself had a realization rate of 1.00.

Incorrect Reference Numbers were sometimes reported for By-Request measures. Project documentation revealed that some utilities incorrectly assigned reference numbers (RefNos), leading to a few of the sampled By-Request line items reporting incorrect UES values. While half of the sampled utilities with By-Request measures required RefNo corrections, these corrections only represented 3.5% of the total By-Request sampled savings (aMW).

Documentation Review May Satisfy DV for Simple Step Fixture Measures. The evaluation team determined that delivery verification through documentation review could be a viable option for Fixture measures being reported through the Simple Steps program.[29] However, it is important to note that these are BPA Qualified measures, so delivery verification would not qualify as impact evaluation.

The evaluation team provides the following recommendations on how to improve program operations and future evaluations:

Create unique Reference Numbers to distinguish between Simple Steps and Non-Simple Steps measures. The IS2.0 database uses the same measure reference numbers regardless of program. This makes it impossible to clearly identify which measures saved energy under which program. BPA should enhance their measure tracking processes to allow BPA to clearly identify the amount of savings reported to the Simple Steps program versus utility-run programs.[30]

Opportunities exist to streamline utility-run program data collection and reporting. Very few utilities were able to easily provide project documentation for their sampled projects, and the mapping process used (linking a specific reported measure to its required project documentation) was often inconsistent, labor intensive and/or complex. In one example, the information needed to fully verify lighting projects was spread across multiple sets of documents: sales reports with the quantity sold that matched to a particular IS2.0 line item; store receipts with specifications including lamp type, lumen bucket, wattage, etc.; and bulk invoices that recorded the total number of units purchased. The evaluation team had to make sure the quantities and specifications in the invoices matched the claimed quantity for each RefNo recorded in the sales reports. In fact, one utility was unable to provide this information within a seven-month data collection period. The evaluation team recommends customer utilities use distribution logs similar to those used by the Simple Steps third-party implementer. This would increase the efficiency and accuracy of future evaluation

[29] Since the completion of the data collection and analysis phase, the evaluation team has learned that the CFL fixtures included in the sample are no longer offered as a BPA UES measure.
[30] The evaluation team has learned that BPA is planning to create separate and unique retail lighting measures for Simple Steps and utility run programs.

efforts. It may also allow utilities to more efficiently and accurately assign UES values and report savings, especially for By-Request measures.

Alter Measure Distribution Log to include installed location for Direct Install lamps. The delivery verification requirements for Direct Install (DI) lamps include installation location.[31] BPA's required project documentation requirement, namely the Measure Distribution Log[32], does not currently require this information. The evaluation team recommends that BPA alter the Measure Distribution Log to require location information for Direct Install lamps to allow for evaluation via document review in the future.

[31] Deemed savings for DI lamps are allocated by location.
[32] https://www.bpa.gov/EE/Policy/IManual/Documents/Residential_Measure_Distribution_Log.xls

Appendix A. Glossary

Coefficient of Variation (CV)

A normalized measure of dispersion of a probability distribution and defined as the ratio of the standard deviation, σ, to the mean, μ:

$$c_v = \frac{\sigma}{\mu}$$

Delivery Verification - RTF Guidelines stipulate that Impact Evaluation may be accomplished using delivery verification to estimate savings for Proven UES (Unit Energy Savings) measures, i.e., savings equal the verified delivery quantity multiplied by the proven UES savings value. Delivery verification may also be useful in measure development and providing feedback to programs. The RTF Guidelines provide the following additional definition:

> *"Delivery verification involves physical inspection of measures or documentation of measures at the location where the program operator delivers them. For measures delivered to an end use, this involves collecting data from the end user facility to confirm that equipment conforms to the measure specifications. For measures delivered upstream of the end use, for example efficient bulbs sold through retailers, this might involve inspection of retailer or end user records of bulb sales or purchases."*[33]

Evaluation Measure Group - In order to design an efficient evaluation, the evaluation team defined subsets within sectors as a group of measures that have similar end-uses, measure statuses and/or that use similar program delivery method.

Impact Evaluation

Impact evaluation is used to estimate savings from energy efficiency measures. According to the RTF Guidelines, "program impact evaluations estimate savings from a period of program operation. Program impact evaluations involve the analysis of a reliable sample of program participants (and possibly non-participants) to determine the savings." The RTF Guidelines generally refer to evaluation of a portfolio or program, but are flexible in how evaluators define "program."

Measure Status - In the RTF Guidelines, a measure's category defines the savings estimation that should be used to evaluate savings. The RTF approves four measure categories within the UES portfolio; Proven, Small Saver, Provisional and Other.

Other UES

This includes measures that fall into the RTF-Small Saver and Planning categories, as well as UES measures that have been created by program operators but are not recognized by the RTF, such as BPA-qualified measures. Savings estimation methods

[33] Details of the delivery verification strategies included in the 2016 UES evaluation approaches are discussed in detail for each domain in the Appendices.

for these measures require conducting one or more studies that may require site-specific data collection and analyses.

Realization Rate

The term is used in several contexts in the development of reported program savings. The primary applications include the ratio of project tracking system savings data (e.g., initial estimates of project savings) to savings that (1) are adjusted for data errors and (2) incorporate evaluated or verified results of the tracked savings. In the Updated Guidelines, the realization rate does not include program attribution.

Relative Precision

Measures the expected error bound of an estimate on a normalized basis. It must be expressed for a specified confidence level. The relative precision (*rp*) of an estimate at 90% confidence is:

$$rp = 1.645 \frac{cv}{\sqrt{n}} \sqrt{1 - \frac{n}{N}}$$

where *n* is the sample size, *N* is the population size, and the coefficient of variance is *cv* = standard deviation / estimate mean value. The square root expression at the end of the equation is the finite population correction factor, which becomes inconsequential and unnecessary for large populations.

RTF Proven

These are measures for which the RTF has determined that savings estimation methods are proven and reliable.

Savings Realization Rate (RR)

The ratio of the field of evaluation energy savings to the program's claimed savings. The RR represents the percentage of program-estimated savings that the impact evaluation team estimates as being actually achieved based on the results of the evaluation M&V analysis.

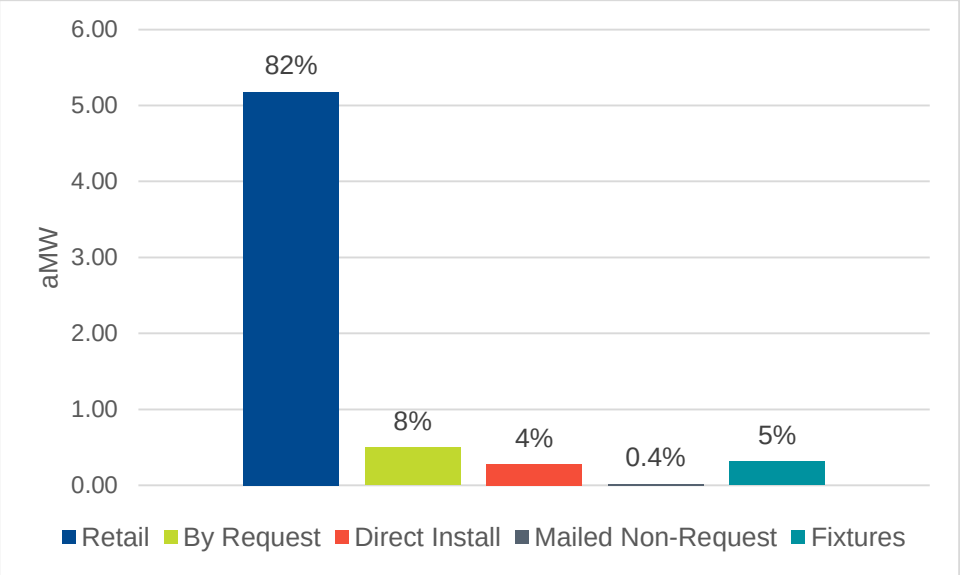
Savings Validation

Savings validation uses impact evaluation to provide a comparison of savings for a measure or group of measures to the deemed UES values. For the purposes of this document, existing measure savings validation is considered a measure development activity, in that it informs savings estimates associated with a measure. If the savings validation shows a significant deviation from the deemed savings estimates, additional measure development may be needed.

Appendix B. Measure Details

The following figures show the breakdown of energy savings for residential lighting UES measures by measure group. Figure B-1 shows the savings breakdown by delivery mechanism and Figure B-2 shows the savings breakdown by lamp type and delivery mechanism. Figure B-3 shows the breakdown of the savings by Simple Steps and utility-run program savings for Retail and By-Request delivery mechanism.

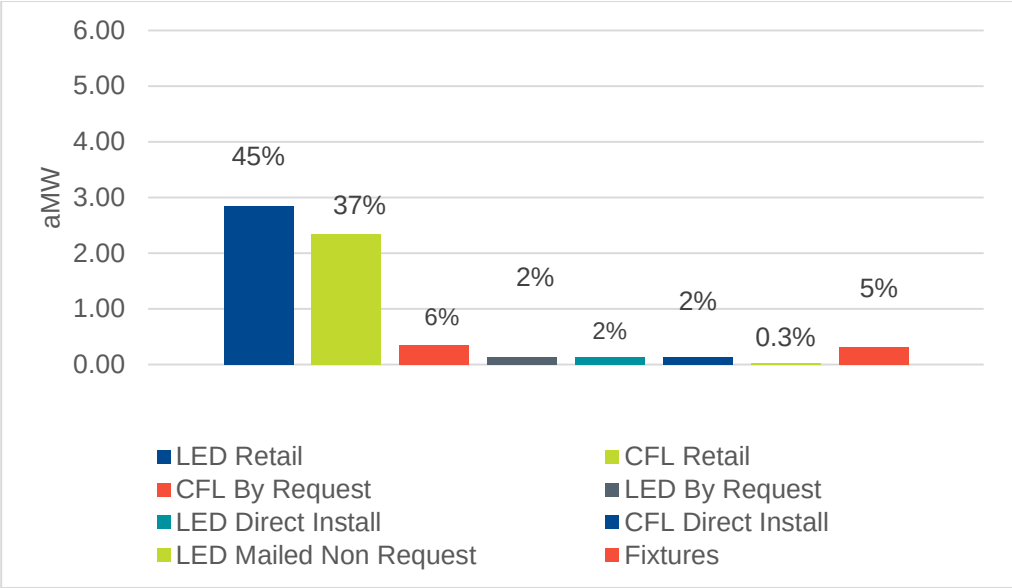
Figure B-1: Residential Lighting Domain Savings – Breakdown by Delivery Mechanism (FY2015[34])



Source: Navigant analysis of 3/18/216 IS2.0 extract.

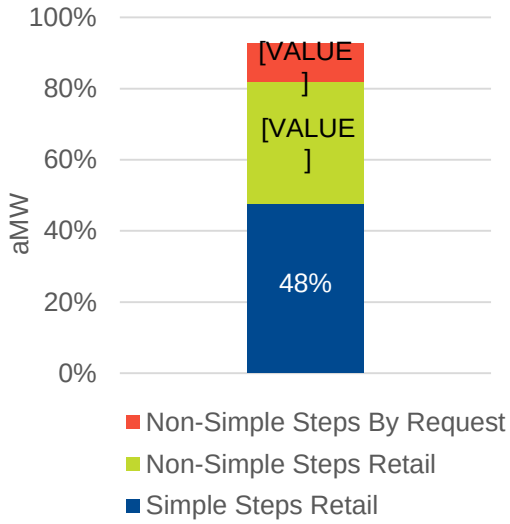
[34] FY 2015 is from October 1st 2014 to September 30th 2015.

Figure B-2: Residential Lighting Domain Savings –Breakdown by Lamp Type & Delivery Mechanism (FY2015[35])



Source: Navigant analysis measures reported into the of BPA Is2.0 based on the 3/18/2016 data pull

Figure B-3: Residential Lighting Domain Savings –Breakdown by Program Type & Delivery Mechanism (FY2014*)



**Please note that this breakdown is for FY2014.*
Source: Navigant analysis of measures reported into the BPA IS2.0

[35] FY 2015 is from October 1st 2014 to September 30th 2015.

Appendix C. Sample Details

The overall confidence and precision target for the residential lighting domain is 90/10. In addition, the Retail lighting measure group has a target confidence and precision of 90/10, and the By-Request lighting measure group has a target confidence and precision of 90/15.

Reviewing preliminary FY2015 data, the evaluation team identified measure group populations between 300 and roughly 3000 projects. Table C-1 provides the assumed coefficient of variation and target sample sizes.

Table C-1: Draft 2016 Sample Size for the Residential Lighting Domain

Measure Group	Strata	Assumed CV	Number of Utilities	Target Number of Projects
Retail	Large Contributors	0.4	4	40
	Medium and Small Contributors	0.4	3	30
	Subtotal		**7**	**70**
By-Request	Large Contributors	0.4	4	28
	Medium and Small Contributors	0.4	2	12
	Subtotal		**6**	**40**
Total			**9**	**110**

Source: Navigant Analysis

Appendix D. Comparison to RTF UES Values

The evaluation team developed mapping protocols to tie each UES measure within the Residential Lighting domain to its RTF workbook. A link was considered correct when the annual savings at the site (kWh per year) and roughly 15 additional parameters were identical between the UES Measure List[36] and the RTF workbook for a given measure. Following this procedure, we were able to map every measure in the Lamps TAP to one of four RTF workbooks.[37]

- ResSpecialtyLigthing_v1.2
- ResLightingLED_v3_0
- ResLightingLED_v2
- ResLightingCFLandLEDLamps_v3_3_LED2

In a few cases, the delivery mechanism referenced for a deemed value within the UES Measure List did not align with the delivery mechanism for the same savings value listed in the RTF workbook.[38] Table D-1 provides a summary of these discrepancies by lamp type. This is because the RTF values for some measures changed between the time of delivery and the time of the evaluation. Thus, the evaluation team reported the evaluated savings and realization rates compared to two sets of values: 1) current BPA UES deemed measure values and 2) BPA deemed measure values at time of delivery[39]. In addition, the team provided an overview of the timing and lags of BPA reporting system values to current RTF values.

Table D-1: Summary of Identified Discrepancies within the Residential Lighting Domain

Measure Group	BPA Delivery Mechanism	RTF Delivery Mechanism	RTF workbook version
LEDs	By-Request (Over-the-counter)	Documented requested in-person give-away. Unit must comply with Energy Star specifications.	ResLightingLED_v3_0
CFLs	By-Request (Over-the-counter)	Give-away/Mail by Request	ResCFLLighting_v2_2
Specialty CFLs	By-Request (Other distribution method)	Retail	ResSpecialtyLigthing_v1.2

Source: Navigant Analysis

[36] Version 3.0 (Valid through Sept. 30, 2015) https://www.bpa.gov/EE/Policy/Solutions/Pages/default.aspx
[37] Navigant could not map measures within the Fixtures TAP to a RTF workbook due to lack of lamp information.
[38] RTF UES values reference different removal and storage rates for the different delivery mechanisms, resulting in different savings value.
[39] http://rtf.nwcouncil.org//measures/

Appendix E. Delivery Verification Requirements

The RTF Guidelines stipulate that for Proven measures, which make up the majority of residential lighting UES measures, savings assessment can be completed via delivery verification, i.e., savings equals the verified delivery quantity multiplied by the proven UES savings value.

In May of 2015, the RTF defined the delivery verification requirements for the Residential Lighting domain. As summarized in Table E-1, the requirements vary by delivery mechanism and not lamp or program type.

Table E-1: Delivery Verification Requirements

Measure Parameter	Delivery Mechanism Retail	Delivery Mechanism Direct Install & NEEA Socket Count	Delivery Mechanism Mail by Request, Unsolicited Mailing, Give Away
Measure Identifiers	✓Check savings are from retail ✓Check savings match appropriate efficient technology ✓Check savings match appropriate lamp type ✓Check savings match appropriate lumen category	✓Check savings are from direct install or NEEA socket count ✓Check savings match appropriate efficient technology ✓Check savings match appropriate lamp type ✓Check savings match appropriate lumen category ✓Check savings match appropriate room type	✓Check savings are from mail by request, unsolicited mailing or give away ✓Check savings match appropriate efficient technology ✓Check savings match appropriate lamp type ✓Check savings match appropriate lumen category
Savings Baseline	n/a		
Implementation & Product Standards	✓ Check that CFL or LED is on the Energy Star Qualified list		
Sunset Date	n/a		

Source: RTF, First Batch May 2015

Appendix F. Documentation Requirements

The following table provides the detailed documentation requirements for the residential lighting measure groups included in impact evaluation of FY2015 projects.

Table F-1: Documentation Requirements by Delivery Mechanism

Distribution Type	Requirements and Specifications	Documentation Description (Retain in Customer File)
Direct Install	Customers must (1) physically install measures, (2) witness installation or (3) visually inspect a representative sample after installation by another party.	Completed Measure Distribution Documentation form (available in the Document Library) or equivalent form with required information.
Retail Markdown	• Customers may use in-store markdown or end-user coupons. • For in-store markdown, customers must submit a store sales report for each participating store with date, manufacturer, model number. Measure type and any other identifying elements of each sale generated by the promotion. Reports must document the allocation methodology when a store serves multiple utility customers.	Store sales reports or, for coupons, other documentation that product meets BPA's requirements.
Direct Mail/Mail by Request	The requirements and payment levels in place on the date the product enters the mail stream apply (i.e., for drop shipments, the "round stamp" date on United States Postal Service (USPS) form 8125 and for straight mailings, the "statement certification date" of USPS form 3607R).	Completed Measure Distribution Documentation form (available in the Document Library) or equivalent form with required information.
Over-the-Counter (e.g., distribution at customer events or customer's office or left a customer's house upon request)	Customer representatives must distribute measure to verified end users.	Completed Measure Distribution Documentation form (available in the Document Library) or equivalent form with required information.
Other	See your COTR for requirements and specifications.	See your COTS for requirements. At a minimum, required documentation includes date of distribution, distribution recipients and quantity.

Source: BPA Implementation Manual, Oct 2014

Appendix G. Changes to Measure

Effective April 1, 2015, the following changes were made to measures included within the existing residential lighting delivery mechanisms.

Table G-1: Updated Delivery Mechanism Definitions

Distribution Type	Requirements and Specifications	Documentation Description (Retain in Customer File)
Retail	• Customers may use in-store markdown or end user coupons. • For in-store markdown, customers must submit a store sales report for each participating store with the date, manufacturer, model number, measure type and any other identifying elements of each sale generated by the promotion. Reports must document the allocation methodology when a store serves multiple utility customers. • Coupons must contain the (utility) customer name and end-user address and require the customer to (1) document that the product meets BPA's requirements or (2) create store sales reports.	Store sales reports or, for coupons, other documentation that product meets BPA's requirements.
Mailed, Non-Request (CFL and LED bulbs only)	The requirements and payment levels in place on the date the product enters the mail stream apply (i.e., for drop shipments, the "round stamp" date on United States Postal Service (USPS form 8125 and 3607R).	Completed Measure Distribution Documentation form (available in the Document Library) or equivalent form with required information.
By-Request	Mail by Request-see requirements for Mailed, Non-Request above	
	Other delivery mechanisms that include distributing produces "over the counter", at events, or otherwise directly to the customer upon their request.	
Direct Install	Customers must (1) physically install measures, (2) witness installation or (3) visually inspect a representative sample after installation by another party.	

Source: BPA Implementation Manual, Oct 2014