Impact Evaluation of the FY2012-13 Site-Specific Savings Portfolio

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IMPACT EVALUATION OF THE FY2012-13 SITE-SPECIFIC SAVINGS PORTFOLIO

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Acknowledgements

We want to acknowledge the tremendous efforts made by BPA staff and its program contractors, utility staff, end users, and the staff of the Regional Technical Forum to support this study. Many hours were spent reviewing plans and draft work products along with time spent gathering documentation, answering questions from the evaluation team and escorting the evaluation team during its inspections and metering equipment installations at 150 locations throughout the BPA service territory. This study could not have been completed without these contributions to our efforts.

EXECUTIVE SUMMARY

BPA, in partnership with its public power utility partners, acquires savings from many types of energy efficiency programs and offerings, some of which require site-specific savings estimates. This report documents the first comprehensive impact evaluation of the Site-Specific Savings portfolio.

Background

The Site-Specific Savings portfolio typically accounts for almost half of BPA's total energy efficiency achievements. However, there have been no previous evaluations of this portfolio. BPA and its customer utilities apply significant resources to estimation of site-specific savings. BPA has undertaken this evaluation to determine what portion of these savings can be verified through the independent data collection and analysis of an appropriately trained team of engineers and technicians.

The evaluation plan established the following objectives:

1. Estimate first-year kWh savings for the portfolio and for separate domains as needed to understand the savings performance of important portions of the portfolio.
2. Estimate the lifecycle cost-effectiveness of the portfolio and its domains.
3. Identify opportunities for improving M&V practices (including data collection and savings estimation) and evaluation methods.

Methodology

This impact evaluation addressed the capital measures delivered as part of the Site-Specific Savings portfolio during fiscal year (FY) 2012 and 2013 (October 1, 2011 thru September 30, 2013). The BPA reporting system provided data on the projects and measures that comprise this portfolio.

BPA decided to divide this portfolio into nine domains defined by Option (utilities are Option 1 or 2 for M&V purposes), measure type (Lighting, Non-Lighting, and Energy Smart Reserve Projects), and sector (Industrial and Commercial). These domains are treated as equivalent to a typical "program." We evaluated a stratified random sample of measures that represented each domain. Overall, this study evaluated less than 3% of measures in the population, but 28% of the savings. Three of the Option 2 utilities chose to increase the sample size so that it would be possible to estimate savings for their service area. There was a low non-response rate; we succeeded in evaluating 90% of the sampled measures.

We adhered to the following principles in estimating savings for each sampled measure: (a) Treat all measures consistently; (b) Reuse available data; (c) Focus on the key determinants of Savings; (d) Prioritize items with greatest savings within each measure. Lighting savings were evaluated with a consistent calculation methodology across all sites. Lighting hours of operation were based on data collected from interviews and metering. Non-Lighting and Energy Smart Reserve Power (ESRP) measures were evaluated with best practical algorithms and input data, including, where needed, data from site inspection and efficient-case metering.

Portfolio Savings

The evaluation verified that the savings for the portfolio were nearly the same as the reported savings. As shown in Figure 1, the realization rate (RR)[1] for the entire portfolio is close to one. The reported savings for the entire portfolio falls within the sampling error around the evaluation estimate of savings (RR=0.98 with a relative precision of 3% at a confidence level of 90%[2]). Realization rates vary across the domains, but in total, the highs and lows balance out and yield a portfolio realization rate near one.

The evaluation also verified costs and benefits associated with the portfolio. Based on the Total Resource Cost Test the evaluation found that these savings have a Benefit to Cost ratio of 2.65 (lifetime benefits are more than two and a half times the lifetime costs).

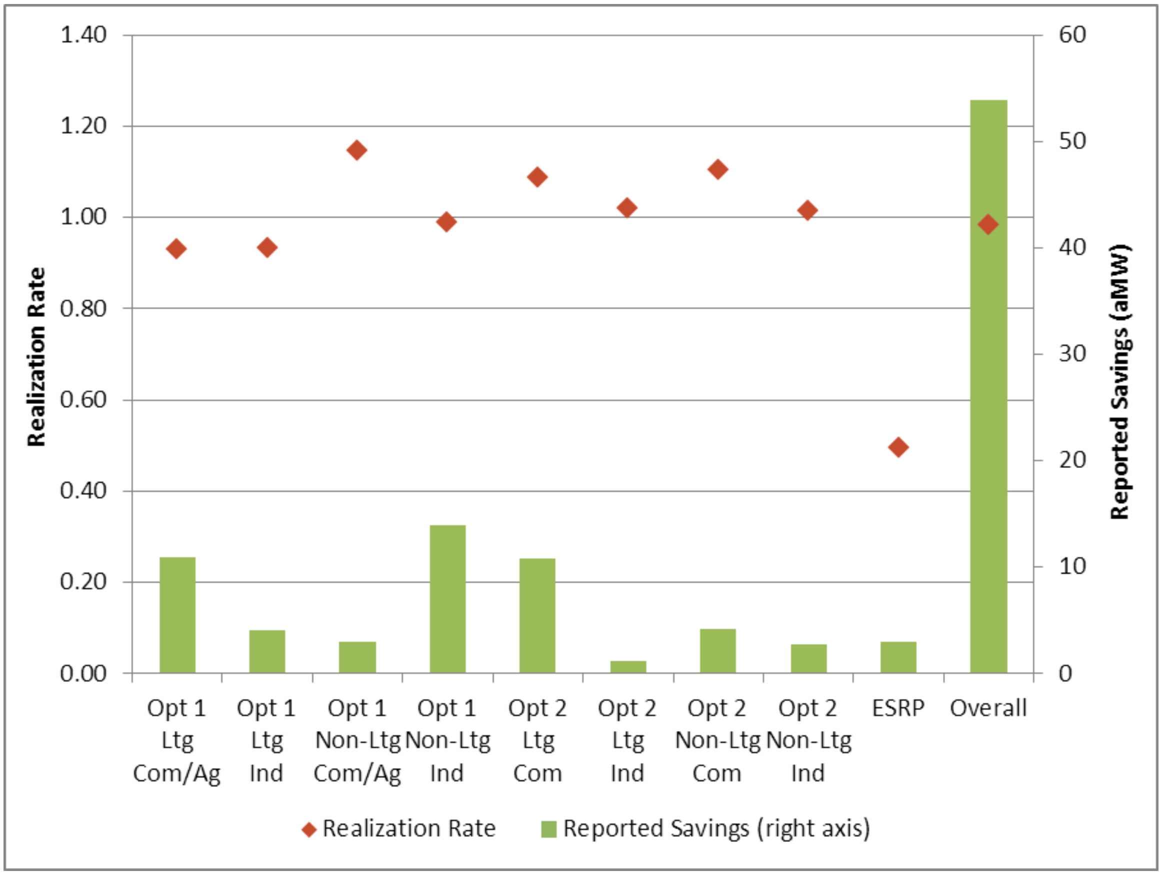

Figure 1: Realization Rates and Reported Savings by Domain and Overall

Even though the overall realization rate was close to one, there is considerable variation in the realization rates among the sampled measures. Figure 2 plots the realization rates for each of the 205 measures that we evaluated, with colors and shapes separating the nine domains of

[1] Realization rate is the ratio of evaluation savings to reported savings. Realization rates greater than one mean that we found more savings than was reported.

[2] The relative precision and its associated confidence level will be referred to as the sampling error.

the evaluation. A substantial number of measures (approximately 40%) are above and below the dashed lines indicating that their evaluated savings is more than 20% different than the reported savings. However, for the entire portfolio these differences offset each other and result in the portfolio realization rate of 0.98.

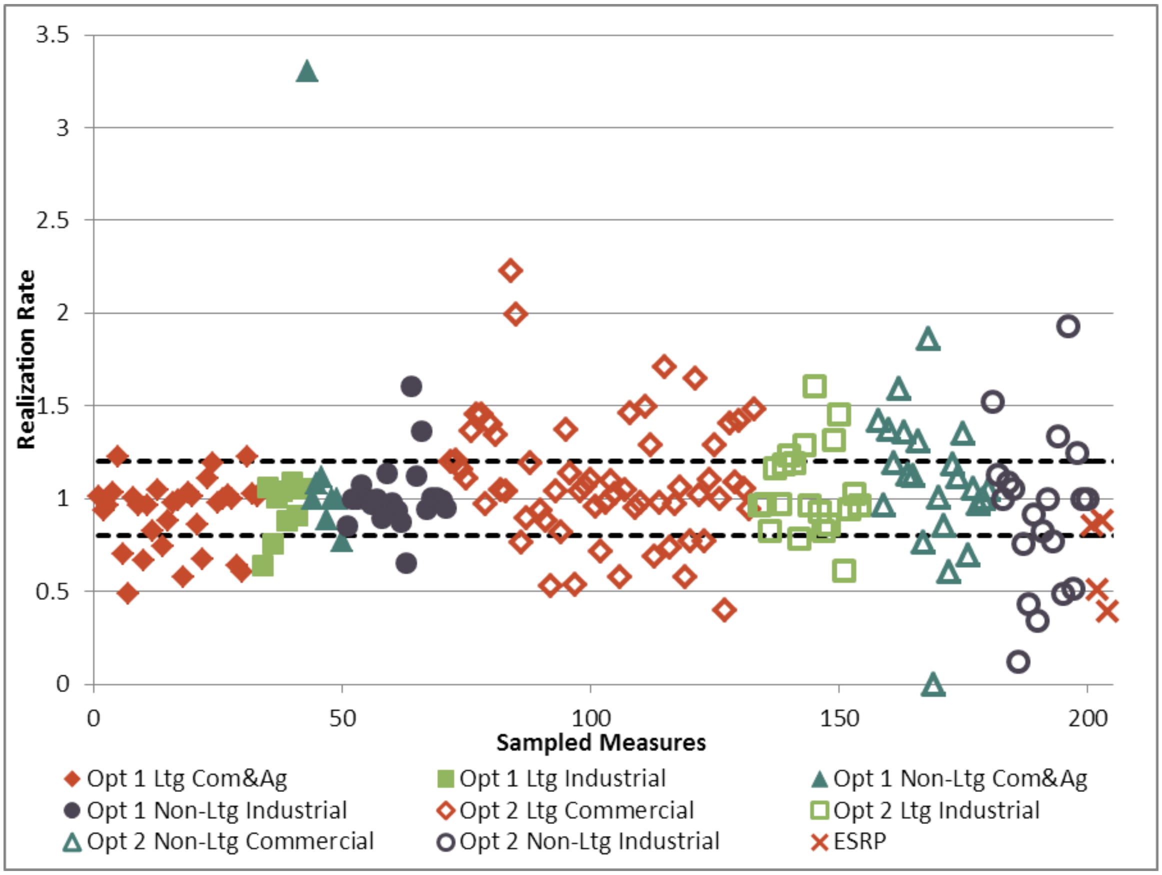

Figure 2: Distribution of Realization Rates within Each Domain

Lighting Savings

Lighting measures had an overall realization rate of 1. However, we found significant offsetting effects between Option 1 (RR=0.93) and Option 2 (RR=1.08) utilities. As shown in Figure 3, sector made little difference for Option 1, where the evaluation found about 7% less savings for both Commercial and Industrial measures. However, for Option 2, the evaluation found 8.6% more savings for Commercial measures, and 1.9% more for Industrial measures. One Option 2 utility applied realization rates (from a prior evaluation) before reporting savings to BPA. However, this was done almost exclusively for Commercial measures.

Based on the Total Resource Cost Test, the evaluation found that the savings for Lighting measures have a Benefit to Cost ratio of 2.47. This ratio for Option 1-Lighting (2.74) is higher than for Option 2-Lighting (2.23).

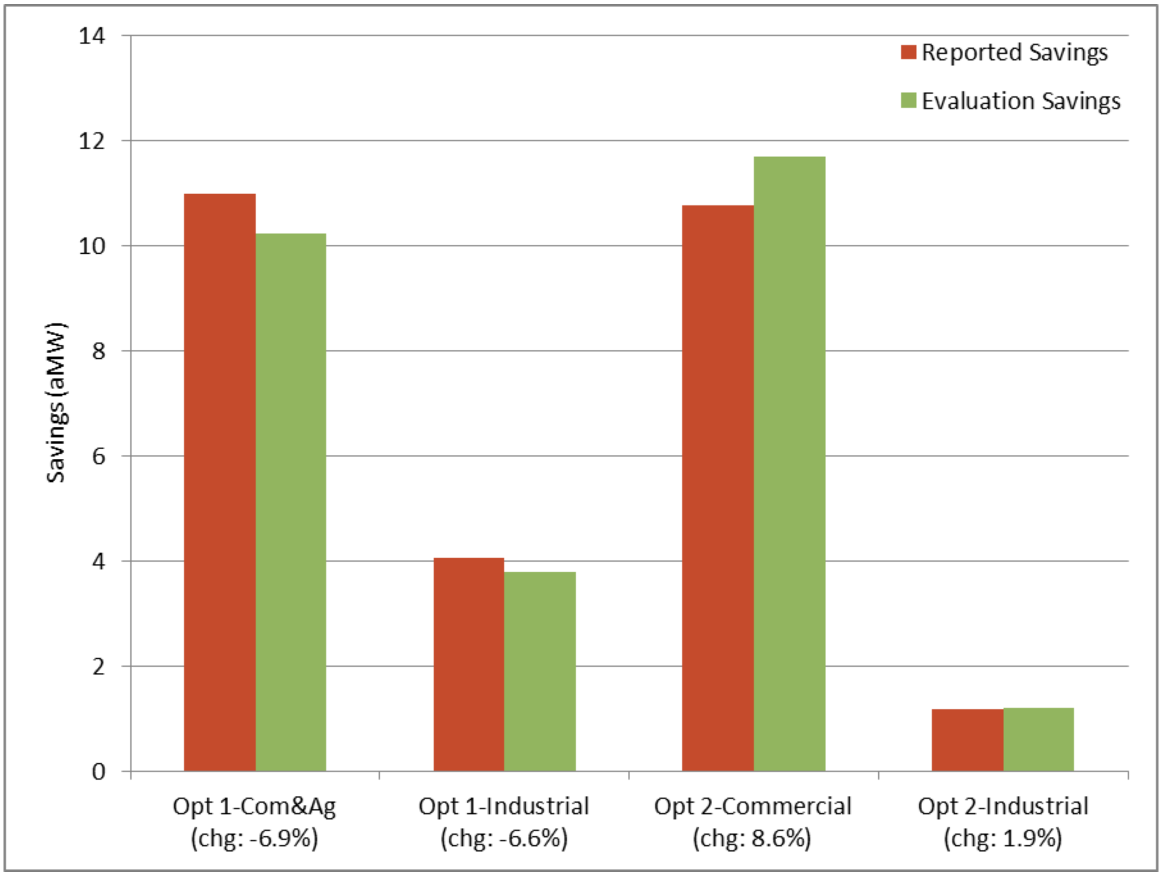

Figure 3: Lighting Savings (aMW) by Domain

Non-Lighting Savings

For Non-Lighting measures, the overall realization rate is 1.03. Both Option 1 and 2 have realization rates greater than 1, but the Option 2 realization rate of 1.07 is higher than Option 1 RR of 1.02. As shown in Figure 4, sector makes a difference, with reported and evaluated savings much closer for Industrial measure than for commercial. Evaluation found at least 10% more savings for Commercial savings for both Option 1 and 2.

Based on the Total Resource Cost Test the evaluation found that the savings for Non-Lighting measures have a Benefit to Cost ratio of 2.85, somewhat higher than for Lighting measures. This ratio for Option 1 (3.17) is higher than for Option 2 (2.25).

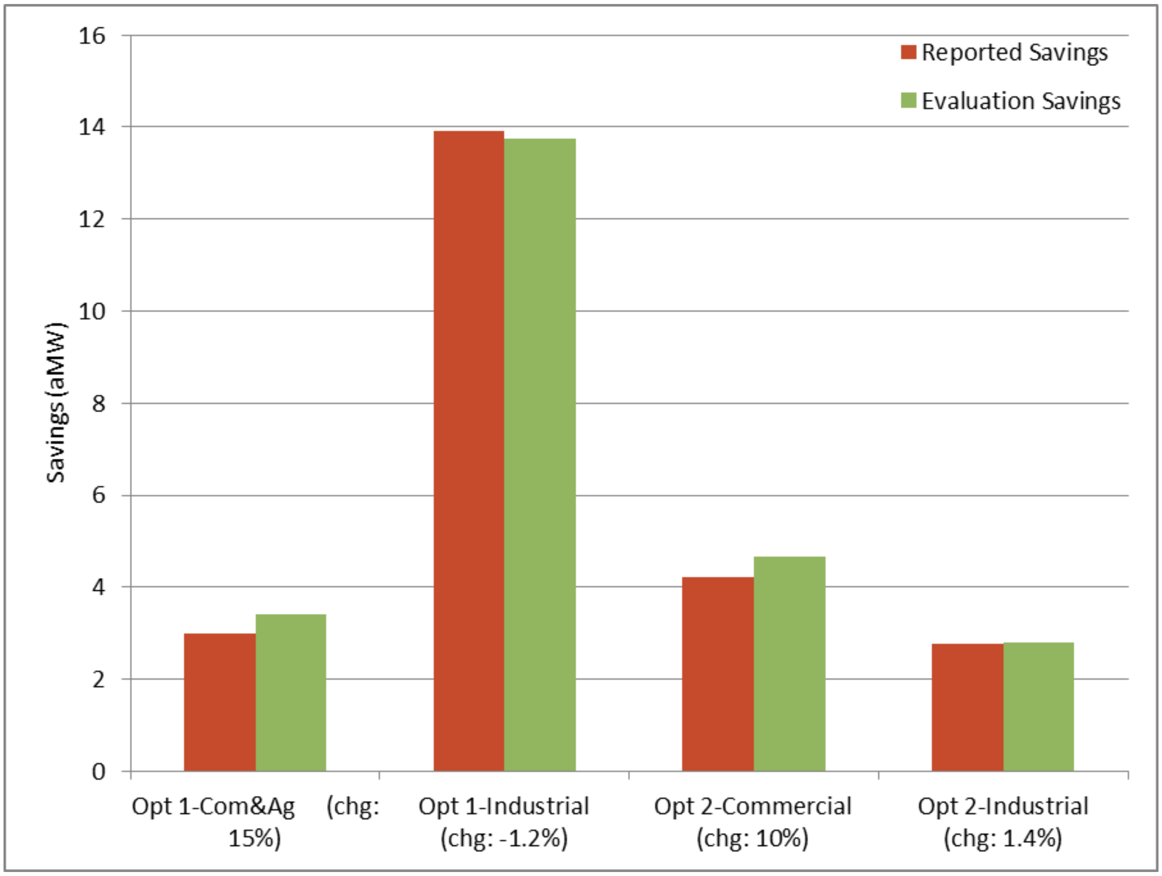

Figure 4: Non-Lighting Savings (aMW) by Domain

ESRP Savings

Evaluated savings for this program are substantially lower than reported, yet due to its small size, the impact on the portfolio is not substantial. The ESRP realization rate of 0.49 is the lowest among all the domains. The factors leading to this low realization rate include incomplete implementation of measure and downstream reuse of a large portion of the "saved" water. Even with this low realization rate, these savings still have a benefit to cost ratio of 2.76.

Adherence to Protocols

The evaluation also had several findings related to compliance with BPA M&V Protocols and other “Guidelines” that are relevant to this portfolio. Compliance with the BPA M&V protocol selection guide was highest with Option 1 measures and was lowest with Option 2-Commercial measures. Most measures complied with IM documentation requirements, except for Option 1 Lighting, Option 1 Non-lighting, and ESRP invoices. Working savings models are very useful for evaluation and were available for most measures, except for Option 2-Industrial and ESRP measures. Regarding TAP assignment, Option 1 lighting measures did not have TAP codes and Option 2 measures were misclassified more than 40% of the time.

Recommendations

Our most important recommendations are:

1. **Avoid Embedded Realization Rates**. Best practice is to apply realization rates to the total savings for a domain or portfolio rather than in the individual measure savings data maintained the reporting system. Do not allow utilities to apply realization rates to their savings estimates prior to reporting savings to BPA.
2. **Enhance the M&V Protocols**
   a. **Avoid or Improve Simplified Saving Calculators**: Some Option 2 projects use "deemed" values or simplified calculators for Non-Lighting measures. These do not provide reliable site-specific estimates of savings. Require that site-specific savings estimates be in accordance with BPA M&V protocols or that simplified calculators are upgraded to conform to the RTF guidelines for Standard Protocols.
   b. **Clarify BPA M&V Protocols.** The BPA M&V Protocols do not provide clear direction on when and how to compute first-year vs. lifetime savings. They are also not aligned with RTF Guidelines on the definition of current practice baseline. Both issues should be clarified.
3. **Improve Quality Control for ESRP projects**. The savings for this domain are being overestimated, although this domain accounts for only 3% of the portfolio. Provide additional quality control review of M&V data collection and modelling for these projects.
4. **Improve Lighting Calculators**: The BPA and Option 2 lighting calculators are not consistent and they both lack key features. Improve the BPA Lighting Calculator and require that Option 2 calculators include the same improvements.
5. **Improve and Simplify Program Documentation**: Ensure that project documentation includes working M&V models, the M&V protocol used, project invoices, and improved TAP coding. Also, investigate opportunities for reducing redundancy or unnecessary reporting and for developing tools that reduce the reporting effort and facilitate quality control.
6. **Improve Future Evaluations**: Align future evaluations with updated M&V protocols, consider faster or real-time evaluation approaches and simplify end-user contact.

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1. INTRODUCTION

BPA, in partnership with its public power utility partners, acquires savings from many types of energy efficiency programs and offerings, some of which require site-specific savings estimates. The programs and offerings requiring site-specific savings estimates are known for the purposes of this report as the BPA **Site-Specific Savings** portfolio**.** In this portfolio, the majority of the savings are from two major areas: custom projects and lighting calculators.

Within the Site-Specific Savings portfolio, Option 1 and 2 utilities[3] develop capital[4] projects for the industrial, commercial, agricultural, irrigation and federal end users. Site-specific savings estimates are developed using lighting calculators (both BPA and some utility-specific calculators) and by following BPA's custom project M&V protocols[5]. The portfolio also includes the Energy Management Pilot operated by BPA Industrial Energy Smart Services program, which acquires savings from operations, maintenance and behavioral (O&MB) measures.

The subject of this report is the savings reported for the capital measure portion of the Site-Specific Savings portfolio. The evaluation of the Energy Management Pilot is described in a separate report.

1.1. Key Terms

See Appendix A for definitions of key terms such as reported savings, measure, and realization rate, which are used throughout this report.

1.2. Background

The Site-Specific Savings portfolio typically accounts for almost half of BPA's total energy efficiency achievements. However, there have been no previous evaluations of the entire portfolio. The lighting portion was evaluated in 2007[6] and Energy Management Pilot was evaluated in 2012[7]. BPA and its customer utilities apply significant resources to estimation of site-specific savings. BPA has undertaken this evaluation to determine what portion of these

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3 For Option 1 utilities, BPA is often involved throughout the project lifecycle by providing technical support for project development, implementation, approval and M&V. Option 2 utilities provide their own technical support including M&V and custom project quality control, e.g., project proposal and completion report review.

4 Capital projects involve the installation, setup and commissioning of new equipment. They are distinct from projects undertaken by the Energy Management Pilot, which may only involve changing how existing equipment is operated.

5 BPA M&V Protocols are described in the following reports. *2011. Existing Building Commissioning an M&V Protocol Application Guide. Engineering Calculations with Verification Protocol. Verification by Energy Modeling Protocol. Verification by Equipment or End-Use Metering Protocol. Verification by Energy Use Indexing Protocol*. Copies may be obtained from: www.conduitnw.org and BPA Implementation Manual Document Library (https://www.bpa.gov/EE/Policy/IManual/Pages/IM-Document-Library.aspx)

6 http://www.bpa.gov/EE/Utility/research-archive/Documents/Evaluation_of_BPA_Commercial_Lighting_Program.pdf

7 http://www.bpa.gov/EE/Utility/research-archive/Documents/BPA_Energy_Management_Impact_Evaluation_Final_Report_with_Cover.pdf

savings can be verified through the independent data collection and analysis of an appropriately trained team of engineers and technicians.

In recent years, BPA and the RTF (Regional Technical Forum) have developed a series of documents that provide guidance on how to reliably estimate savings from efficiency measures. These documents play an important role in the programs and offerings of this portfolio and in defining the methods used in conducting this evaluation.

- RTF Guidelines[8] – are the guidelines the RTF follows to judge the quality and reliability of measure assessments (savings, costs, benefits, and lifetime) for all types of efficiency measures.
- BPA M&V Guidelines and Protocols (May 2012) – are a series of volumes designed to assist the M&V practitioner charged with estimating site-specific energy savings for custom projects.
- BPA Implementation Manual (IM)[9] – The IM, together with the customer's Energy Conservation Agreement (ECA) and specifications in BPA's energy efficiency reporting system, provides the implementation requirements for projects whose savings are reported to BPA.

The plan for this evaluation was developed in close cooperation with BPA staff and the staff from BPA member utilities. We began the planning process by examining data from the BPA reporting system and samples of site-specific documentation from a number of utilities. The next step was to review the guidelines described above and to develop an evaluation methodology that would meet BPA's evaluation objectives. Procedures for data collection and analysis were developed, which relied as much as possible on data already collected by the programs in order to minimize the impact on end users and the participating utilities. We also met with BPA and utility staff to determine how to divide the portfolio into important domains[10], e.g., Option 1 Industrial Lighting. We then developed a sample design that would provide sufficient sampling precision for each of these domains. All of these components were combined in an evaluation plan that was reviewed by BPA and utility staff prior to being approved at the end of 2013[11].

8 Complete Operative Guidelines (Released 06-17-14).

9 The requirements defined in the Energy Efficiency Implementation Manual, April, 1 2013, updated June 13, 2013 were used for this evaluation.

10 The RTF Guidelines call for the impact evaluation of "programs." Regional programs account for only a portion of BPA's portfolio. Therefore BPA decided to divide its portfolio into domains defined by Option, sector and measure type, which are treated as equivalent to the RTF concept of a "program."

11 http://www.bpa.gov/EE/Utility/research-archive/Documents/SiteSpecificSavingsEvaluationPlan12-23-13.pdf

1.3. Objectives

The evaluation plan established the following objectives:

1. Estimate first-year kWh savings for the Site-Specific Savings portfolio and for separate domains[12] as needed to understand the savings performance of important portions of the portfolio.
2. Estimate the lifecycle cost-effectiveness of the Site-Specific Savings portfolio and its domains.
3. Identify opportunities for improving M&V practices (including data collection and savings estimation) and evaluation methods for the portfolio and its domains.

[12] This evaluation covers ten domains. Nine of them are defined by the utility option (1 or 2), measure type (Energy Smart Reserve Program, Lighting and Non-lighting), and sector (industrial and commercial or the combination of commercial and agricultural for Option 1 utilities). A tenth domain is devoted to the industrial energy management initiative, addressed in a separate report.

2. METHODOLOGY

This section describes how we developed a sampling frame, sampled measures, estimated savings for the sample of measures, and used the evaluation savings estimates to determine what portion of the BPA reported savings were realized for the portfolio and its domains. At the conclusion of this section, we also describe the review of evaluation results conducted by BPA and utility staff.

2.1. Developing the Sampling Frame

This impact evaluation addressed the capital measures delivered as part of the Site-Specific Savings portfolio during fiscal year (FY) 2012 and 2013 (October 1, 2011 thru September 30, 2013)[13]. The BPA reporting system provided data on the projects and measures that comprise this portfolio. We reorganized the data from the reporting system to create a list of all measures containing the information needed for sample design and selection. This list constituted the sampling frame for this evaluation and we randomly selected our sample from this list.

As defined in Appendix A, a project is a phase of work at an end user location that improves energy efficiency. Project data available from the reporting system included the date when the project was complete, along with the name of the end user, the location where the work was carried out, and other data critical to this evaluation. The reporting system also provided data on measures that comprise projects. A measure is a collection of energy efficiency items, within a project, that have the same Technology/Activity/Practice (TAP) description. The BPA reporting system uses a standardized taxonomy (Technology/Activity/Practice) for classifying measures. For custom projects[14], the reporting system provided data on the individual measures that comprise custom projects; BPA or utility staff assigned the TAPs to these measures at the time of project reporting. For Option 1 lighting projects[15], the BPA reporting system does not contain measure-level information. Therefore, BPA provided the associated lighting calculators that list the items[16] that comprise each lighting project. Then, the evaluation team assigned a TAP based on the data in the calculators. For example, lighting projects may have many items describing specific lamp and ballast combinations, but all of them would be assigned the TAP code indicating "Lamps/Ballasts."

[13] Energy Smart Grocer custom projects and Scientific Irrigation Scheduling (SIS) were not included in this study. Two problems led to them being excluded. First, Grocer Smart is in a separate database system. Second, SIS and other calculator or protocol measures were coded as Deemed measures in the BPA tracking system. Both Grocer Smart and SIS should be included in any future evaluations of the Site-Specific Savings portfolio.

[14] In the BPA reporting system, custom projects include all projects from Option 2 utilities plus Option 1 Non-Lighting projects. Some large Option 1 Lighting projects are also classified as custom in the reporting system. During this time frame, all Option 2 utilities used their own lighting calculators.

[15] Option 2 Lighting projects are classified as custom in the reporting system and the Option 2 utilities store the associated lighting calculators.

[16] Each item is a group of fixtures which are modified by changes in fixtures, lamps, ballasts or controls.

Measure-level data was assembled from the sources described above to create the sampling frame for this evaluation. In total, the sampling frame comprised 7,501 measures.

2.2. Sampling Measures

Typically, portfolio-level evaluations are broken down into separate studies of individual programs for sampling and reporting purposes. This practice is consistent with the RTF Guidelines that call for impact evaluation of "programs." Regional programs account for only a portion of BPA's portfolio. Therefore, BPA decided to divide its portfolio into nine domains defined by Option (utilities are Option 1 or 2 for M&V purposes), measure type (Lighting, Non-Lighting, and Energy Smart Reserve Projects[17]), and sector (Industrial and Commercial[18]). These domains are treated as equivalent to the RTF concept of a "program." Once the sampling frame was created, each measure in the frame was associated with one of these nine domains. Figure 5 illustrates how the nine domains were defined for this evaluation.

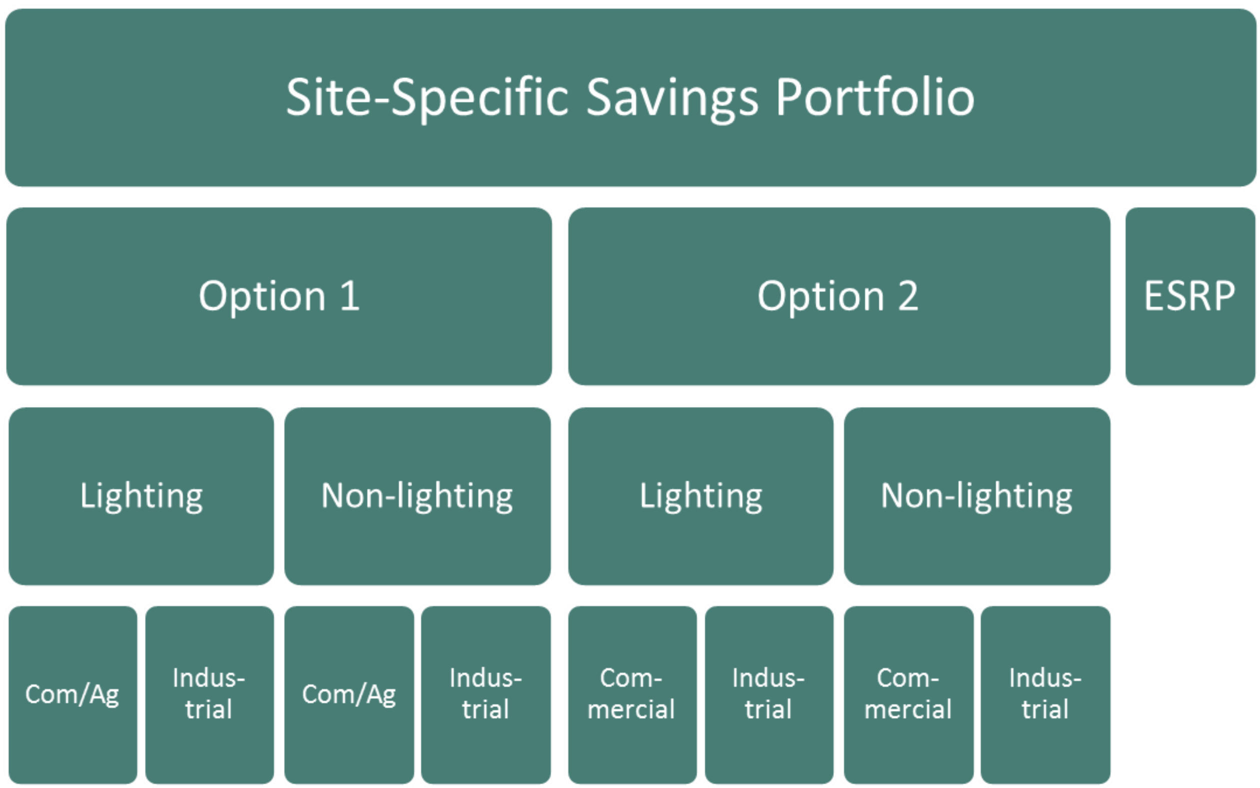

Figure 5: Impact Evaluation Domains

[17] Energy Smart Reserve Projects (ESRP) was defined as a separate domain because of its unique delivery mechanism. Public utilities are not involved in the development of ESRP measures. Instead BPA engineers work directly with direct-served BPA customers, which typically are irrigation districts.

[18] For Option 1 utilities, the Commercial sector was expanded to include Agricultural measures and the sector is abbreviated as Com/Ag.

We created a stratified random sample design for each domain. Each domain was divided into strata defined by the size of the measure savings, as found in the reporting system. The number of strata and their upper and lower bounds of savings were optimized for each domain in order to achieve the target sampling precision (set by BPA) with the smallest possible sample. Appendix E.2 describes how the relative precision was computed for the stratified random sample. The strata defined for each domain, including their upper and lower bounds of reported savings, are listed in Appendix F. As will be described in section 2.4.1, these samples are used to derive an evaluated savings and savings realization rate for each domain and for various combinations of these domains.

Table 1 shows the total number of measures completed in FY2012-13 and the reported savings associated with each domain. The table also shows the target sample size and sampling precision[19] for each domain and for the portfolio in total. BPA adjusted sampling precision targets to reflect the size of the savings in each domain and the fact that certain Option 2 utilities chose to oversample in order to obtain results for their service areas. For example, the Option 1-Lighting-Com/Ag[20] stratum has a 90/10 target as it accounts for 20 percent of reported savings for the portfolio. An 80/20 target was set for Option 1-Lighting-Industrial stratum as it only accounted for eight percent of the total savings.

The target sample size shown in Table 1 includes sample funded by certain Option 2 utilities as described in section 2.2.1. The reader should note that all savings values shown in this report are busbar savings, i.e., they include line losses of 9.056% above the site energy savings. Counting the contribution from the oversample utilities, we were able to evaluate approximately 3% of the measures delivered during the evaluation period. Because the sample was stratified, increasing the chances of picking measures with large savings, the sample accounted for approximately 28% of reporting savings during that period.

[19] Sampling precision is expressed as a relative error at a confidence level, e.g., we are 90 percent confident that our estimate for a domain's savings or realization rate is within +/- 10 percent of the true value. It is important to note that this statement of precision only captures the errors associated with random sampling. It does not address measurement error, which in general cannot be quantified for the engineering models used to estimate many of the site-specific savings values.

[20] This term is abbreviated for Option 1 measures as Com/Ag. Option 2 does not have agricultural measures so this sector is referred to as Commercial. When the sector refers to both Option 1 and 2, we use the term Com/Ag, reflecting the presences of agricultural measures.

Table 1: Sample Design – Reported Savings and Target Precision by Domain

Domain			Measures		Reported Savings		Target	
Option	Measure Type	Sector	Target Sample	Population	kWh	Percent	Confidence Level	Relative Precision
1	Lighting	Com/Ag	38	3,845	96,102,952	20%	90%	10%
		Industrial	9	303	35,454,862	8%	80%	20%
	Non-Lighting	Com/Ag	8	200	26,093,810	6%	80%	20%
		Industrial	21	226	121,830,074	26%	90%	10%
2	Lighting	Commercial	62	2,369	94,299,631	20%	90%	10%
		Industrial	24	119	10,244,042	2%	90%	10%
	Non-Lighting	Commercial	23	347	36,903,752	8%	90%	10%
		Industrial	20	77	24,142,514	5%	90%	10%
ESRP			5	15	26,433,063	6%	80%	20%
Site-Specific Portfolio			**210**	**7,501**	**471,504,700**	**100%**	**90%**	**5%**

2.2.1. Utility Oversample

Three of the Option 2 utilities chose to increase the sample size for their service area. This allowed us to separately estimate savings for each of these utilities. These oversamples were designed to meet the sampling precision objectives of each of these three utilities and the results were provided in separate reports to each utility. The additional sample size enhanced the sample precision for the BPA portfolio evaluation reported in this report.

Table 2 shows the contribution of the oversample utilities; in total they provided funding for 66 of the 129 sampled measures in the Option 2 domains.

Table 2: Option 2 Oversample – Contribution to Sample by Domain

Measure Type	Sector	Sample Size		Utility-Funded	
		Total	Utility-Funded	% Measures	% Savings
Lighting	Commercial	62	29	47%	78%
	Industrial	24	13	54%	69%
Non-Lighting	Commercial	23	13	57%	76%
	Industrial	20	11	55%	68%
Total of Option 2		**129**	**66**	**51%**	**73%**

Figure 6 graphically depicts the evaluation sample sizes relative to the reported savings, as well as the contribution from the oversample utilities.

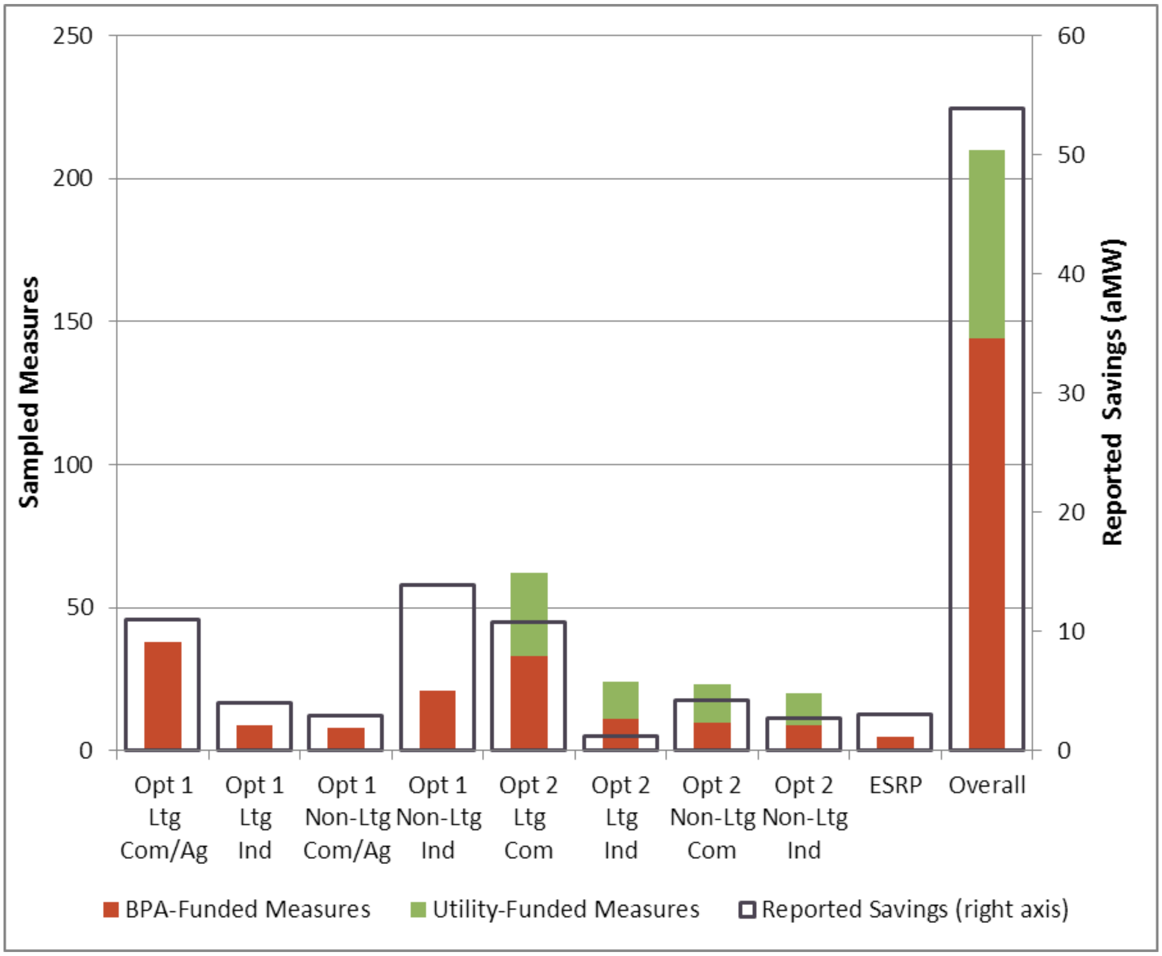

Figure 6: Sampled Measures Funded by BPA and Oversample Utilities

Figure 7 presents the same information as above but in terms of percentages. For example, in the Option 2 Non-Lighting Industrial domain, we sampled 26% (12% BPA-funded, 14% Utility-funded) of the population of measures whose reported savings comprised 58% of that domain's reported savings. Overall, we sampled 3% (2% BPA-funded, 1% Utility-funded) of the population of measures whose reported savings comprised 28% of the reported savings for the portfolio.

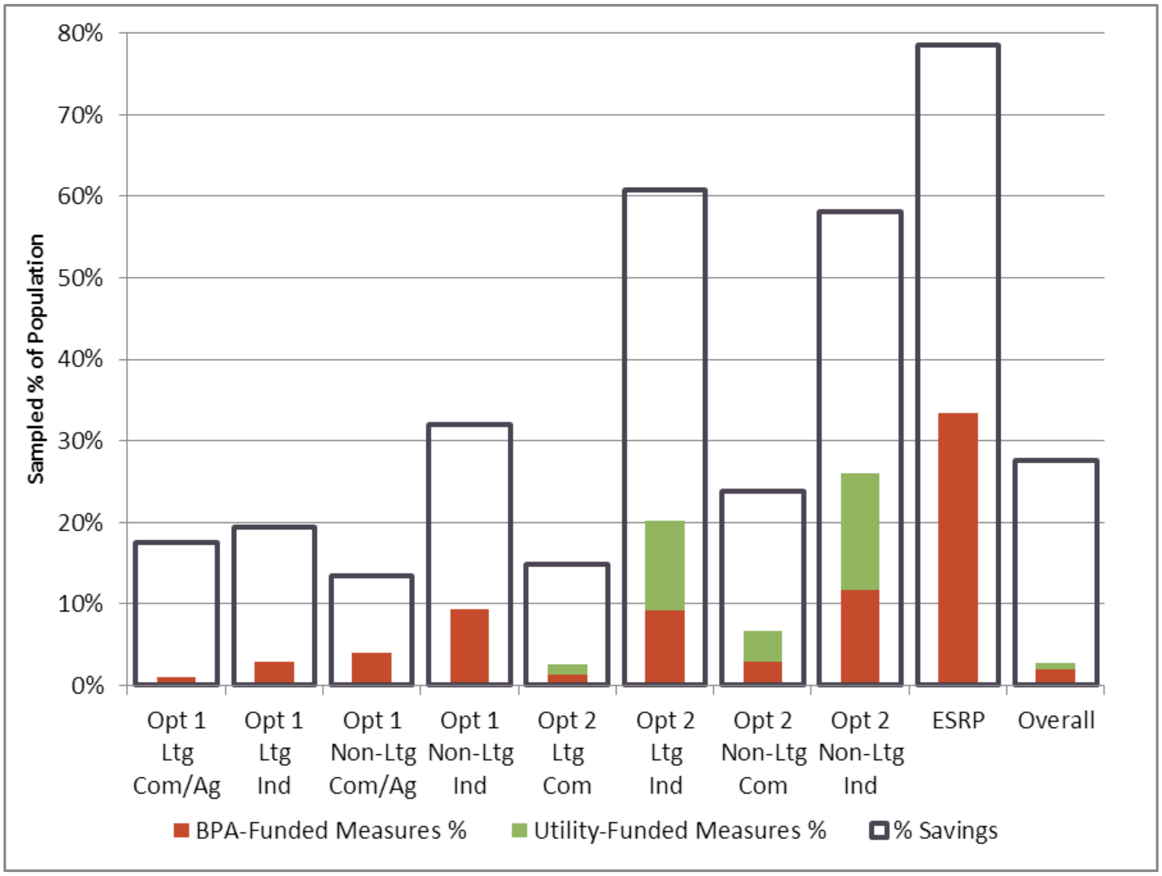

Figure 7: Sampled Measures Percent of Domain Population and Savings

2.2.2. Additional Sample Details

This evaluation was designed to achieve sample precision for the nine domains and for combinations of these domains. However, some readers may be interested in using the data to understand other important groups of measures. In particular, those concerned with lighting may want to know how many measures were sampled for each building type, as shown in Table 3. In addition, the sampled lighting measures, along with their building type, are listed individually in Appendix C.1.

Table 3: Lighting Distribution by Building Type

	Measures	
Building Type	Population	Sample
Agricultural	2	0
Grocery	187	4
Hospital	26	2
Hotel/Motel	106	2
Manufacturing	422	33
Office	798	13
Restaurant	224	0
Retail	1,251	22
School	468	8
University	85	4
Warehouse	730	6
Other	2,337	39
Total	**6,636**	**133**

Likewise, readers may be interested in the end uses for non-lighting measures, e.g., HVAC or process. Table 4 shows the breakdown of the non-lighting population and sample by sector and end use. Both of these classifications are included in the non-lighting sample listing found in Appendix C.2.

Table 4: Non-Lighting Distribution by Sector and End-Use

Sector	End Use	Measures Population	Measures Sample
Com/Ag	Compressed Air	7	0
	Electronics	1	0
	Food Preparation	21	0
	HVAC	376	21
	Irrigation	21	1
Com/Ag	Motors/Drives	50	7
	Multiple	0	0
	Process Loads	34	2
	Refrigeration	19	0
	Utility Distribution System	3	0
	Utility Transmission System	1	0
	Water Heating	5	0
	Whole Bldg/Meter Level	9	0
Total Com/Ag		**547**	**31**
Industrial	Compressed Air	92	8
	Facility Distribution System	5	0
	HVAC	18	2
	Motors/Drives	86	12
	Process Loads	70	11
	Refrigeration	31	8
	Whole Bldg./Meter Level	1	0
Total Industrial		**303**	**41**
Total		**850**	**72**

2.2.3. Selection and Replacement Procedure

The sample was selected by assigning a random number to all measures, sorting by the random number in each stratum, and then recruiting measures until the target sample size was achieved. If the evaluation could not be completed for a measure, it was replaced by the next measure in random order within its stratum.

2.2.4. Strategies for Avoiding Bias

To minimize the risk of introducing substantial bias in the results, we employed four primary strategies.

1. Replacement, if needed, by random selection within each sample stratum.
2. Enforcing consistent data collection and modeling, including selection of proper baselines.
3. Minimizing sample replacement to avoid non-response bias.
4. Ensuring consistent treatment during BPA and utility reviews of our savings estimates, as explained in Section 2.5.

2.2.5. Sample Disposition

We established through file review which sampled measures required site visits. We then notified the relevant utilities, as described in Appendix G. Typically, the utilities assisted by making an initial contact with the end users, followed by email or phone contacts from our team. Some measures were dropped because we could not convince the end user to participate. Other recruited measures were dropped if we were unable to collect the data necessary to reliably estimate savings, e.g., an end user refusing to provide access for installation of logging equipment. In one instance, a utility indicated that we should replace one of the sampled measures because the affected end user already had two other measures sampled, and we agreed this was an undue burden on the end user.

Table 5 presents the sample disposition for this evaluation by study. Overall, the response rate was 90%. Only one domain had fewer completions than their target sample size, which was caused by the evaluation not collecting sufficient hours of operation data for five Option 1-Com/Ag-Lighting measures.

Table 5: Sample Disposition

Domain							
Option	Measure Type	Sector	Target	Attempted	Dropped	Completed	Response Rate
1	Lighting	Com/Ag	38	39	6	33	85%
		Industrial	9	12	3	9	75%
	Non-Lighting	Com/Ag	8	10	2	8	80%
		Industrial	21	22	1	21	95%
2	Lighting	Commercial	62	69	7	62	90%
		Industrial	24	24	0	24	100%
	Non-Lighting	Commercial	23	26	3	23	88%
		Industrial	20	22	2	20	91%
ESRP			5	5	0	5	100%
			210	**229**	**24**	**205**	**90%**

2.3. Estimating Site-Specific Savings

This section summarizes how we estimated first-year savings for each of the sampled measures. Further description of our methods can be found in Appendix B. We adhered to the following principles in estimating savings:

- **Treat all measures consistently**. The sample was stratified by the size of reported savings. In a stratified sample design, measures with small savings represent many measures in the population; therefore, they are just as important as measures with large savings. The program often uses less expensive protocols in estimating savings for measures with small savings. However, for the evaluation, we did not consider the size of the savings in determining how to reliably estimate savings for a measure.
- **Reuse available data**. The program collects substantial data on baseline and efficient conditions, often arising from multiple interactions with the end user. BPA wanted us to minimize the burden on end users, so we re-used as much of the program-collected data as we determined to be reliable.
- **Focus on the key determinants**. Only a limited number of parameters are key determinants for any measure. For example, operating hours are critical to reliable estimation of lighting savings. As another example, part load efficiency of the equipment installed is critical to many HVAC measures along with set points and the schedule of occupancy. We narrowed our search for data to only parameters related to key determinants of savings for each measure.
- **Prioritize items with greatest savings within each measure**. A measure may comprise many separate items. For example, lighting measure with a TAP code “Lamps/Ballasts”

could include many T-8 lamp replacements in offices, along with a small number of CFL replacements in a lobby. In this case, our data collection, including the installation of loggers to record operating hours, would focus on the office areas if the CFL replacements accounted for only a few percent of savings.

Figure 8 illustrates the steps in our general approach, which is described in more depth in subsequent sections and Appendix B.

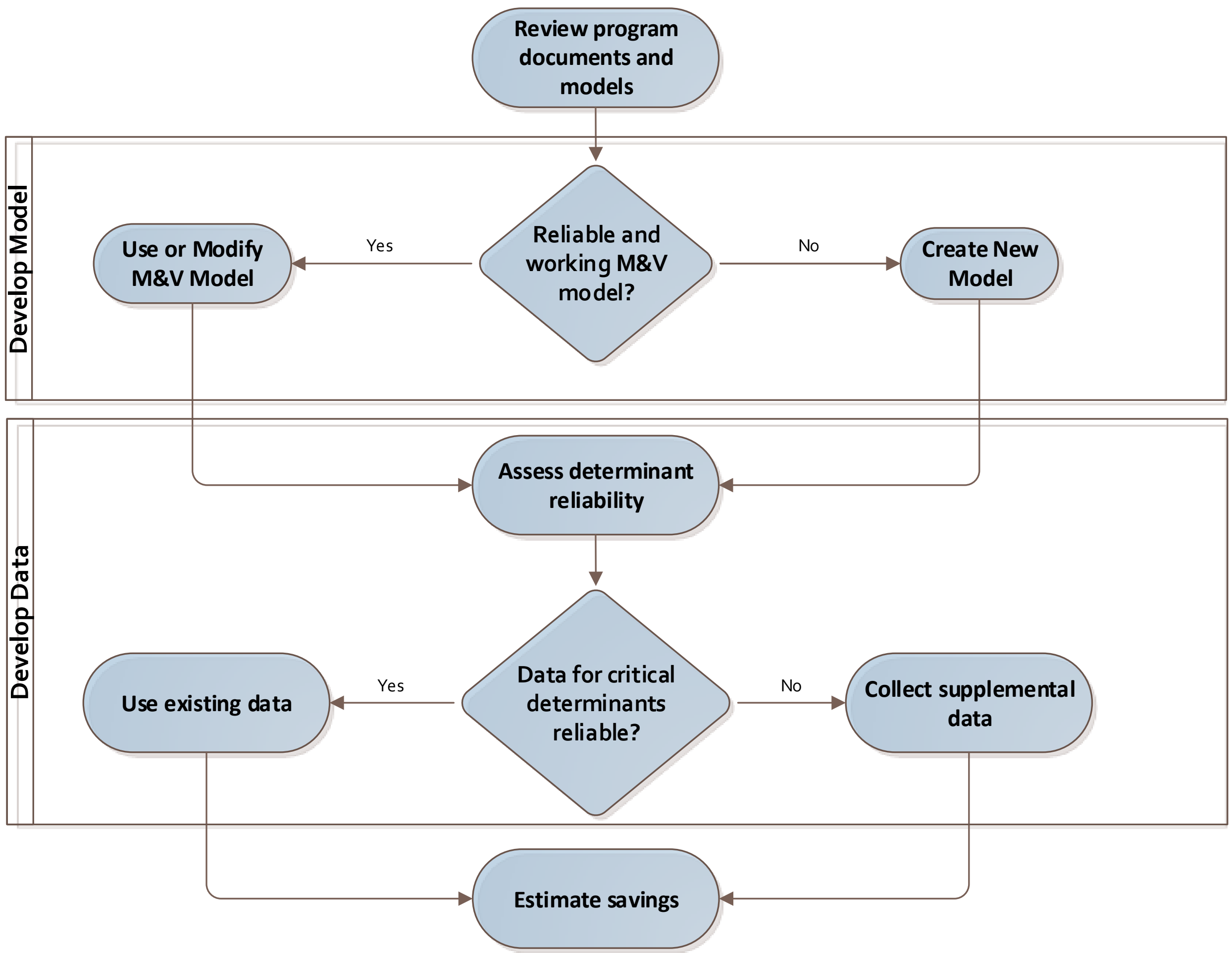

Figure 8: Process for Estimating Measure Savings

2.3.1. Review Program Documents and M&V Model

We obtained and reviewed available documentation for each sampled measure. As part of this review we extracted:

- Measure descriptions detailing how the measure saved energy, affected systems and equipment, determinants of savings, and the baseline (Current Practice or Pre-Conditions; see Appendix A for definitions of these baselines)
- Data used as baseline or efficient condition inputs to the M&V savings estimation model, including data from visual inspections, operator/occupant interviews, trend metering or

secondary sources. Secondary source data included design documents, manufacturer specifications, equipment databases (e.g., MotorMaster+), and weather data.

- M&V savings was obtained from the lighting calculator or custom project completion reports. This may or may not have included busbar[21] savings. In some cases, it was a different quantity than the savings entered in the BPA reporting system due to busbar savings or other adjustments. All M&V and evaluation savings were corrected to include busbar savings prior to being used in computing realization rates.
- Files used to estimate savings, including, if available, a working final version of the M&V model.
- Invoices, receipts, and other data useful for estimating incremental measure costs.
- Data useful in identifying non-electric benefits or costs, such measure impacts on water and wastewater use, or operations and maintenance labor and materials.
- Data that informed estimates of measure life.

The project engineer (staff of BPA, utilities or contractors) associated with each measure, was another possible source of data. Prior to any end-user contact, we communicated with the project engineers by telephone or email to obtain information not found in the program documentation. In some cases, we determined that even with the help of the project engineer we still needed information that could only be obtained by contacting the end user. For these cases we had further discussions with the project engineer to:

1. Confirm that the only practical strategy for obtaining the data required contacting the end user.
2. Obtain a better understanding of the history and circumstances at the end user site, such as other measures and projects that are under way or completed in the same time frame as the sampled measure that might affect our ability to collect the necessary data.
3. Identify the least intrusive strategy for obtaining the data, including identifying specific members of the end user staff or vendors who could best assist the data collection.

2.3.2. Develop a Model

After reviewing program documents, we developed a savings estimation model to be used in the evaluation. In some cases, this was same model used by the program. In other cases, we determined that a new model was required.

For lighting, we needed a consistent M&V model for all measures in the sample. Therefore, we used the BPA Lighting Calculator v3[22], which was modified to adjust for certain baseline

[21] Busbar savings is equal to 1.09056 times site savings. It accounts for avoided losses in transmission and distributions systems.

[22] We used v3.1 and v3.3 of this calculator as needed to correctly model retrofit and new construction projects. For some projects, which involved a large number of line items, we developed custom calculators that produced the same estimates as v3.1/v3.3.

conditions (see Appendix B.1 for further details). All projects using prior versions of the BPA lighting calculator or other calculators used by Option 2 utilities were transferred to v3. All of the Option 2 utilities used their own calculators during the period covered by this evaluation.

For non-lighting measures, a number of factors determined whether we developed a new model or used the program's M&V model. The first consideration was whether we had obtained a working M&V model. "Working" meant that we had the spreadsheet or other files used by the program to estimate savings. For example, a PDF image of sheets in an Excel workbook would not be a working model. The second consideration was whether the model was reliable. Typically, for a measure with small savings, the program used the BPA M&V protocol called *Engineering Calculations with Verification* (ECwV). This was fully justified from a program operation perspective. However, ECwV does not require baseline or efficient-case metering. After examining the ECwV calculations we may have determined that the resulting savings estimate was not reliable. In this case, if practical, we would collect efficient-case metering data and use this data in creating a new model. When other M&V protocols were applied by the program, the collection of additional data might lead to the creation of a new model or simply to improved estimates for parameters in the M&V model.

2.3.3. Assess Determinant Reliability

The next step was to examine the data used in the M&V model to see if it was sufficiently reliable. If a new model was created in the previous step, it often required new data. Even if the M&V model was found to be reliable, in some cases, we determined that certain input data that characterized determinants of savings, e.g., operating hours for lighting, were not reliable. Some determinants are more important than others or are more or less practical to measure, e.g. HVAC interaction factors are relatively important but very difficult to measure. We considered importance, reliability and difficulty of measuring each of the model inputs before deciding what additional data needed to be obtained.

2.3.4. Develop Data

Based on the assessment of determinant reliability, we developed a supplemental data request for each measure that required more data than could be obtained from program documentation or discussion with project engineers. Utilities were notified about the data needed and assisted in making contact with the end user to start the process of obtaining this data. To the extent possible, we worked by telephone and email with the operations staff, occupants or vendors associated with a measure to obtain the needed data. In many cases, a site visit was necessary to inspect affected systems (equipment and controls), conduct in-person interviews with operation staff, review electrical and mechanical plans, and take one-time measurements. Metering equipment was installed for a few weeks for many lighting measures and in some cases for non-lighting measures. Table 6 shows the number of measures for which various types of supplemental data were collected.

Table 6: Number of Measures with Supplemental Data Collection

Domain				Supplemental Data Collection		
Option	Measure Type	Sector	Evaluated Measures	Phone Surveys	Site Surveys	Metering
1	Lighting	Com/Ag	33	33	33	24
		Industrial	9	9	9	5
	Non-Lighting	Com/Ag	8	7	5	0
		Industrial	21	17	15	6
2	Lighting	Commercial	62	61	60	49
		Industrial	24	22	22	21
	Non-Lighting	Commercial	23	20	16	15
		Industrial	20	17	12	7
ESRP			5	5	5	1
			205	**191**	**177**	**128**

2.3.5. Estimate Savings

All of the data described above was used in estimating savings for the first year of each measure's operation. We had to identify and ignore any changes that happened since the end of the first year to avoid confusing our estimates with persistence effects. In addition, we focused on first-year savings to avoid the errors associated with forecasting typical conditions and associated savings over the lifetime of each measure. Savings were normalized to the conditions found or inferred for this first year of operation. For example, if a grocery store increased its store hours six months after the measure was implemented, we accounted for those increased hours in estimating savings for the first year.

Another important, but infrequently occurring issue, was measure interaction. A small number of measures were part of larger projects. For those measures, we reviewed the program estimate for the whole project. If the project savings were reliable, we did not modify the savings for the sampled measure, even if the wrong amount of savings had been allocated to that measure. This avoided biasing the estimate of savings for the portfolio. There was one type of measure interaction that we did not attempt to model — the impact of HVAC measures on lighting savings. BPA's Lighting Calculator accounts for HVAC interactions. However, the interaction coefficients in the model do not distinguish between more or less efficient HVAC systems. This would be a relatively small effect and estimating it would require individual building simulation modelling, which was beyond the scope of this evaluation.

2.4. Estimating Portfolio Savings

This section describes how we used the results from the sample to estimate savings and cost-effectiveness for each domain and for the portfolio as a whole.

2.4.1. Evaluated Energy Savings and Realization Rates

We evaluated energy savings for each sampled measure by applying the data collection and modeling methods described in Section 2.3. Reported savings for each sampled measure was obtained from the BPA reporting system as described in Section 2.1. A realization rate for each measure was computed as the ratio of evaluation savings to reported savings. Realization rates greater than 1 mean that we found more savings than was reported. Realization rates less than 1 mean less savings were found. The realization rates for each measure are shown in Appendix C.

Our next step was to compute a realization rate for each domain, accounting for each domain's stratified sample design. These stratified designs cause the probability of selecting a measure to vary from one stratum to the next. We account for the stratified design by assigning a case weight to each measure equal to the number of measures in the stratum population divided by the number of measures evaluated in that stratum. These case weights are listed for each measure in Appendix C.

Once the case weights were assigned, we could sum the case-weighted savings across the sampled measures to estimate the domain savings. This was done for both reported savings and evaluated savings. The realization rate for the domain is then the sum of case-weighted evaluation savings divided by the sum of case-weighted reported savings. Due to sampling error, the case-weighted sum of reported savings does not exactly match the total reported savings for each domain. Therefore, to estimate evaluated savings for the domain we multiply the realization rate by the total reported savings.

The portfolio savings were computed by summing the estimates across domains. Appendix E presents the formulas for the calculation of the realization rate and the sampling precision of that realization rate. The same equations are applied to calculate results for other levels of aggregation, such as across options and for the portfolio.

2.4.2. Life-Cycle Cost-Effectiveness

For each sampled measure, we used ProCost[23] to estimate the lifetime sum of costs and benefits. We verified, or re-estimated as necessary, key inputs to ProCost including incremental measure cost, measure life, O&M costs and other non-electric benefits. Relatively few evaluation resources were applied to estimating these inputs, as they were assigned a low priority by BPA.

[23] 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.

Data on measure incremental costs were obtained from documentation provided by the program, which in some cases include invoices. Measure lifetime values were initially obtained from the reporting system. These were reviewed for each sample measure to determine whether reasonable. We modified lifetime for approximately 5% of the measures. Some measures comprised multiple items with different lifetimes. For these we estimated a savings weighted average lifetime.

Our estimate of Non-Electric Benefits (NEBs) focused on the costs associated with changes in gas use, water and wastewater volumes, and operation and maintenance (O&M) activities. For some measures the program had estimated NEBs and those were reviewed and modified if appropriate. We also estimated some NEBs not reported by the program. The most important instance of this is for lighting measures where decreased lighting caused increase in gas use for space heating. This was computed using the HVAC interaction factors built into the BPA lighting calculator. This was the most frequently occurring additional NEB in our evaluation.

All versions of the BPA lighting calculators calculate the lifecycle costs and benefits, including the NEB associated with the cost of the natural gas. Three out of four Option 2 calculators include cost and benefit analysis. However, none of them consider the cost of increased gas use due to HVAC interactions. How they treat other NEBs varies, e.g., some include maintenance costs and others do not.

Using the information described above, the RTF model called ProCost was used to compute life cycle costs, benefits and benefit to cost ratio. 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”[24]. ProCost[25] outputs the discounted sum of costs and benefits over a measure’s life.

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

2.5. Review by BPA and Utilities

BPA and utility staff collaborated in a review of our savings estimation models and results for many of the sampled measures. We carefully structured this collaboration to avoid introducing bias. The guiding principle of this collaboration was that the evaluation team was ultimately responsible for developing a reliable and unbiased estimate of savings. We carefully considered input from BPA and the utilities, but only implemented suggested changes if we believed that it improved the reliability of the savings estimate. Both BPA and the utilities were urged to apply equal review resources to all measures, avoiding a review that would just focus on those

[24] From the 6th Power Plan.

[25] 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.

measures that had low realization rates. The steps in this collaboration depended on which organization funded the evaluation of each measure.

2.5.1. BPA-Funded Measure Review

The review of the BPA-funded measures was conducted in three steps:

1. Once we completed the review of documents and files, we developed a preliminary list of non-lighting measures where we intended to create new models for estimating savings. Both the old and new models were summarized and presented to BPA. One-on-one discussions followed between a BPA engineer and the lead engineer from our evaluation team to determine the final evaluation model.
2. After savings were estimated for all measures, we provided complete documentation for BPA review. This included all documents obtained or created during the evaluation of each measure. BPA engineers reviewed all of the non-lighting measures and a random sample of the lighting measures. One-on-one discussions followed between BPA engineers and the lead engineers from our evaluation team. A final discussion of some cases occurred as a group and various issues were resolved by the evaluation team.
3. Following BPA review, the documentation for these measures was provided to the utilities. Each utility only received the measures for end users which were their customers. One-on-one discussions followed between the utility staff and the lead engineers from our evaluation team.

2.5.2. Oversample Utility Review

Complete documentation was provided to the oversample utilities for all measures in their service area, both BPA- and utility-funded measures. This included all documents obtained or created during the evaluation of each measure. Utility staff reviewed this documentation. One-on-one discussions followed between a utility staff and the lead engineer from our evaluation team. BPA did not review measures funded by the oversample utilities.

3. Findings

This section describes what we found after applying the methodology described above to a random sample of measures drawn from the Site-Specific Savings Portfolio. This section is divided into the following parts:

- Savings
- Life-Cycle Cost-Effectiveness
- Factors that Changed Measure Savings
- Adherence to BPA M&V Protocols and Guidelines

3.1. Savings

In this section, we present our findings regarding the savings of the entire portfolio, as well as for specific portions of the portfolio defined by Measure Type (lighting and non-lighting), Sector (commercial/agricultural[26], industrial, and ERSP), and Option (Option 1 and Option 2 utilities). Our most important findings are as follows:

1. **Portfolio**. The evaluation verified that the savings for the portfolio were nearly the same as the savings reported by the program. The realization rate[27] for the entire portfolio is 0.98 with a relative precision of 3% at a confidence level (CL) of 90%[28]. The reported savings for the portfolio falls within the sampling error around the evaluation estimate of savings. Realization rates vary across the domains, but in total, the highs and lows balance out and yield a portfolio realization rate near one.
2. **Domains**. In six domains, the evaluation savings were verified to be close to the reported savings (i.e., realization rate near one and within the sampling error). Reported savings is different than evaluation savings by more than the sampling error for three domains (shown with their respective realization rates):
    - Option1-Lighting-Com/Ag (0.93)
    - Option2-Non-Lighting-Commercial (1.10)
    - ESRP (0.49)
3. **Lighting**. Overall the saving for Lighting measures had a realization rate of 1. However, we found significant offsetting effects between the measures completed by Option 1 and Option 2 utilities. The higher realization rate for Lighting-Option 2 is in part due to one

[26] This term is abbreviated for Option 1 measures as Com/Ag. Option 2 does not have agricultural measures so this sector is referred to as Commercial. When the sector refers to both Option 1 and 2, we use the term Com/Ag, reflecting the presences of agricultural measures.

[27] Realization rate is the ratio of evaluation savings to reported savings. Realization rates greater than one mean that we found more savings than was reported.

[28] The relative precision and its associated confidence level will be referred to as the sampling error.

utility's practice of applying realization rates (from a previous evaluation) to its savings estimates prior to reporting savings to BPA. These are referred to in this report as the "embedded realization rates."

4. **Non-Lighting**. For Non-Lighting measures, the overall realization rate is 1.03. Both Option 1 and 2 have realization rates greater than 1, but the Option 2 realization rate is higher, again consistent with the embedded realization rates.
5. **ESRP**. Evaluated savings for this program are substantially lower than reported, yet due to its small size, the impact on the portfolio is not substantial. The ESRP realization rate of 0.49 is the lowest among all the domains. The factors leading to this low realization rate include incomplete implementation of measure and downstream reuse of a large portion of the "saved" water.
6. **Sector**. In total, the realization rates for both sectors (Com/Ag and Industrial) are nearly 1 as higher and lower realization rates for the underlying domains largely cancel each other out. For both sectors the reported savings are within the sampling error.
7. **Option**. Option 2 utilities have a higher realization rate than Option 1. For Option 2 measures, the realization rate is greater than 1, consistent with the effect of embedded realization rates. Within each option, realization rates vary by Measure Type and Sector. Option 1-Lighting (RR = 0.93) and Option 2-Non-Lighting (RR = 1.07) are different from the evaluation savings by more than the sampling error. All combinations of Option and Sector have realization rates close to 1 except for Option 2-Commercial, which has a realization rate of 1.09. The reported savings for that group is different from the evaluation result by more than the sampling error.

3.1.1. Portfolio

Our estimates of savings for each domain and the entire portfolio are shown in Table 7, along with the achieved and target sampling error[29]. We find that the realization rate for the entire portfolio is 0.98 and the reported savings for the entire portfolio are within the sampling error around our evaluation's estimate of savings. Realization rates vary across the domains, but in total the high and low realization rates balance out and yield a portfolio realization rate near one.

The highest realization rate (1.15) was found for Option1-Non-Lighting-Com/Ag. However, with a relative precision of 19% at 80% CL, the reported savings are within the sampling error. ESRP has the lowest realization rate (0.49). With a relative precision for this domain of 18% at 80% CL, the reported savings are well outside the sampling error.

The reported savings is outside the sampling error for the following domains:

- Option1-Lighting-Com/Ag (RR = 0.93, RP= +/- 5% at 90% CL)

[29] Sampling error is expressed as a relative precision of the realization rate, e.g., +/- X% at Y% confidence level (CL). This means that considering only the sampling error we are Y% confident that the true realization rate lies within that +/- range.

- Option2-Non-Lighting-Commercial (RR = 1.10, RP = +/- 8% at 90% CL)
- ESRP (RR = 0.49, RP = +/- 18% at 80% CL)

Table 7: Savings Results by Domain and for the Portfolio

Domain			Realization Rate	Confi-dence Level	Relative Precision		Reported Savings (MWh)	Evaluation Savings	
Option	Measure Type	Sector			Achieved	Target		MWh	% of Portfolio
1	Lighting	Com/Ag	0.93	90%	5%	10%	96,103	89,471	19%
		Industrial	0.93	80%	8%	20%	35,455	33,117	7%
	Non-Lighting	Com/Ag	1.15	80%	19%	20%	26,094	29,886	6%
		Industrial	0.99	90%	5%	10%	121,830	120,332	26%
2	Lighting	Commercial	1.09	90%	8%	10%	94,300	102,407	22%
		Industrial	1.02	90%	3%	10%	10,244	10,443	2%
	Non-Lighting	Commercial	1.10	90%	8%	10%	36,904	40,776	9%
		Industrial	1.01	90%	7%	10%	24,143	24,484	5%
ESRP			0.49	80%	18%	20%	26,433	13,078	3%
Site-Specific Portfolio			**0.98**	**90%**	**3%**		**471,505**	**463,994**	**100%**

Figure 9 shows the realization rates and reported savings for each domain and overall. The "whiskers" around each realization rates depict the confidence interval as defined in Appendix E.2.

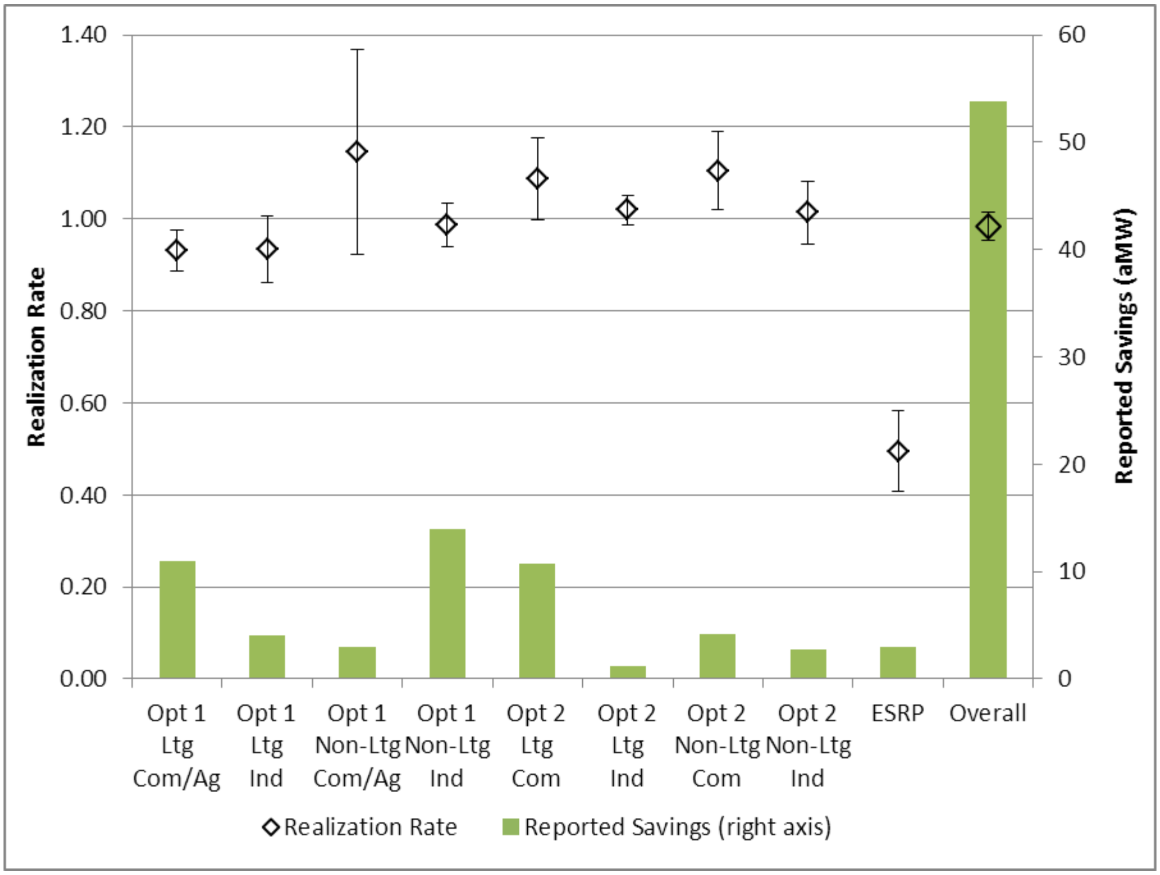

Figure 9: Realization Rates with Confidence Interval by Domain and Overall

The sample can also be used to estimate savings for combinations of the domains. This helps to compare realization rates between measure types, sectors and options. The following tables show our findings for various combinations of domains. Due to the unique delivery of ESRP, it was considered its own Option, Measure Type and Sector and therefore is shown in all tables below.

In Table 8, we have grouped the sample by Measure Type (Lighting, Non-Lighting and ESRP). Lighting and Non-Lighting measures each account for approximately half of the total portfolio savings. Their realization rates are both close to 1 and the reported savings falls within our sampling error. ESRP is a small portion of the portfolio savings and as noted earlier has a low realization rate.

Table 8: Savings by Measure Type

Measure Type	Realization Rate	Confidence Level	Relative Precision	Reported Savings (kWh)	Evaluation Savings kWh	Evaluation Savings Percent of Portfolio
Lighting	1.00	90%	4%	236,101,487	235,926,861	51%
Non-Lighting	1.03	90%	5%	208,970,150	215,249,204	46%
ESRP	0.49	80%	18%	26,433,063	13,078,253	3%
Site-Specific Portfolio	**0.98**	**90%**	**3%**	**471,504,700**	**463,142,726**	**100%**

In Table 9, measures are grouped by sector (Com/Ag, Industrial and ESRP)[30]. The realization rates for Com/Ag and Industrial are nearly one; as higher and lower realization rates for the underlying domains largely cancel each other out. For all sectors except ESRP, the reported savings are within the sampling error.

Table 9: Savings by Sector

Sector	Realization Rate	Confidence Level	Relative Precision	Reported Savings (kWh)	Evaluation Savings kWh	Evaluation Savings Percent of Portfolio
Com/Ag	0.98	90%	7%	253,400,144	247,884,386	55%
Industrial	0.98	90%	4%	191,671,493	188,535,164	42%
ESRP	0.49	80%	18%	26,433,063	13,078,253	3%
Site-Specific Portfolio	**0.98**	**90%**	**3%**	**471,504,700**	**463,142,726**	**100%**

Table 10 groups measures by Option[31]. As noted before, the Option 1 and 2 differ in terms of who is responsible for overseeing the development of measures and preparing the M&V savings estimate. BPA engineers (or their contractors) perform this work for measures delivered to Option 1 utility customers and ESRP. Option 2 utility staff performs this work for their own customers. Although there are only five Option 2 utilities, compared to more than one hundred Option 1 utilities, the Option 2 utilities account for 38% of total reported savings.

The table shows a realization rate that is greater than 1 for Option 2 utilities and reported savings that are different than evaluation savings by more than the sampling error. The realization rate is greater than 1 in part due to one utility's practice of applying realization rates (from a previous evaluation) to its savings estimates prior to reporting savings to BPA (i.e., an embedded realization rate).

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[30] ESRP is included in this table to account for the entire portfolio. It is shown as a separate line because it does not fall under either of the sectors.

[31] ESRP is included in this table to account for the entire portfolio. It is shown as a separate line because it does not fall under either of the options.

Table 10: Savings by Option

Option	Realization Rate	Confidence Level	Relative Precision	Reported Savings (kWh)	Evaluation Savings kWh	Evaluation Savings Percent of Portfolio
1	0.98	90%	4%	279,481,698	273,208,253	59%
2	1.08	90%	5%	165,589,939	178,187,384	38%
ESRP	0.49	80%	18%	26,433,063	13,078,253	3%
Site-Specific Portfolio	**0.98**	**90%**	**3%**	**471,504,700**	**463,142,726**	**100%**

In Table 11, measures are grouped by Measure Type and Option. For Option 1, Lighting has a lower realization rate (0.93) than Non-Lighting (1.02), while for Option 2 both have realization rates greater than one, due in part to the embedded realization rate found in some Option 2 measures. The reported savings for Option 1-Lighting (RR=0.93), Option 2-Lighting (RR=1.08), and Option 2-Non-Lighting (RR=1.07) are different from the evaluation savings by more than the sampling error.

Table 11: Savings by Option and Measure Type

Option	Measure Type	Realization Rate	Confidence Level	Relative Precision	Reported Savings (kWh)	Evaluation Savings kWh	Evaluation Savings Percent of Portfolio
1	Lighting	0.93	90%	4%	131,557,815	122,578,738	26%
	Non-Lighting	1.02	90%	6%	147,923,884	150,241,850	32%
2	Lighting	1.08	90%	7%	104,543,673	112,801,854	24%
	Non-Lighting	1.07	90%	5%	61,046,266	65,339,041	14%
ESRP		0.49	80%	18%	26,433,063	13,078,253	3%
Site-Specific Portfolio		**0.98**	**90%**	**3%**	**471,504,700**	**463,142,726**	**100%**

In Table 12, measures are grouped by Sector and Option. The impact of embedded realization rates is most clearly seen here as the embedded realization rates are almost exclusively in Option 2-Commercial. All combinations of Option and Sector have realization rates close to one except for Option 2-Commercial, which has a realization rate of 1.09. The reported savings for that group is different from the evaluation result by more than the sampling error.

Table 12: Savings by Option and Sector

Option	Sector	Realization Rate	Confidence Level	Relative Precision	Reported Savings (kWh)	Evaluation Savings kWh	Evaluation Savings Percent of Portfolio
1	Com/Ag	0.98	90%	7%	122,196,762	119,536,906	26%
	Industrial	0.98	90%	4%	157,284,936	153,670,606	33%
2	Commercial	1.09	90%	6%	131,203,383	143,128,679	31%
	Industrial	1.02	90%	5%	34,386,556	34,936,610	8%
ESRP		0.49	80%	18%	26,433,063	13,078,253	3%
Site-Specific Portfolio		**0.98**	**90%**	**3%**	**471,504,700**	**463,142,726**	**100%**

3.1.2. Lighting

In this section, we graphically depict the reported and evaluation savings for Lighting measures. We also show the distribution of the realization rates[32] that was found among the sampled Lighting measures.

Figure 10 shows overall lighting savings and the totals for Option 1 and 2. In addition, the percent change in savings from reported to evaluated savings is shown at the bottom of each set of bars. The overall savings change little (-0.3%). However, this is due to the offsetting effects of a reduction in Option 1 savings (-6.8%) and an increase in Option 2 savings (7.9%). Option 2 savings are higher in part due to the embedded realization rates.

[32] These realizations rates and their associated sample case-weights are listed for each sampled measure in Appendix C.1.

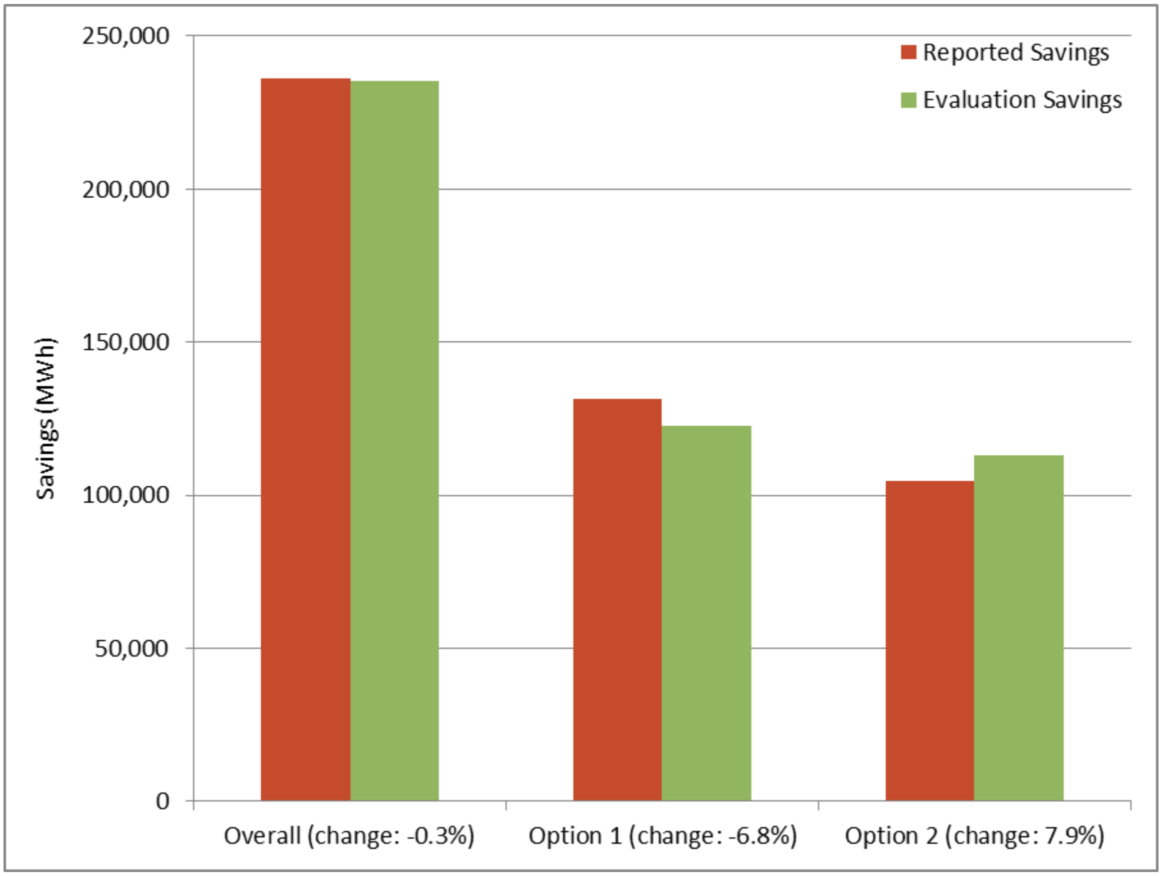

Figure 10: Lighting Savings in Total and by Option

Figure 11 further decomposes lighting savings by Option and Sector. Here we see similar reductions in savings for both Option 1 sectors. For Option 2, there is a larger increase in savings for commercial measures (8.6%) than for industrial measures (1.9%). This is consistent with our finding that all but one of the embedded realization rates occurs in this sector for Option 2.

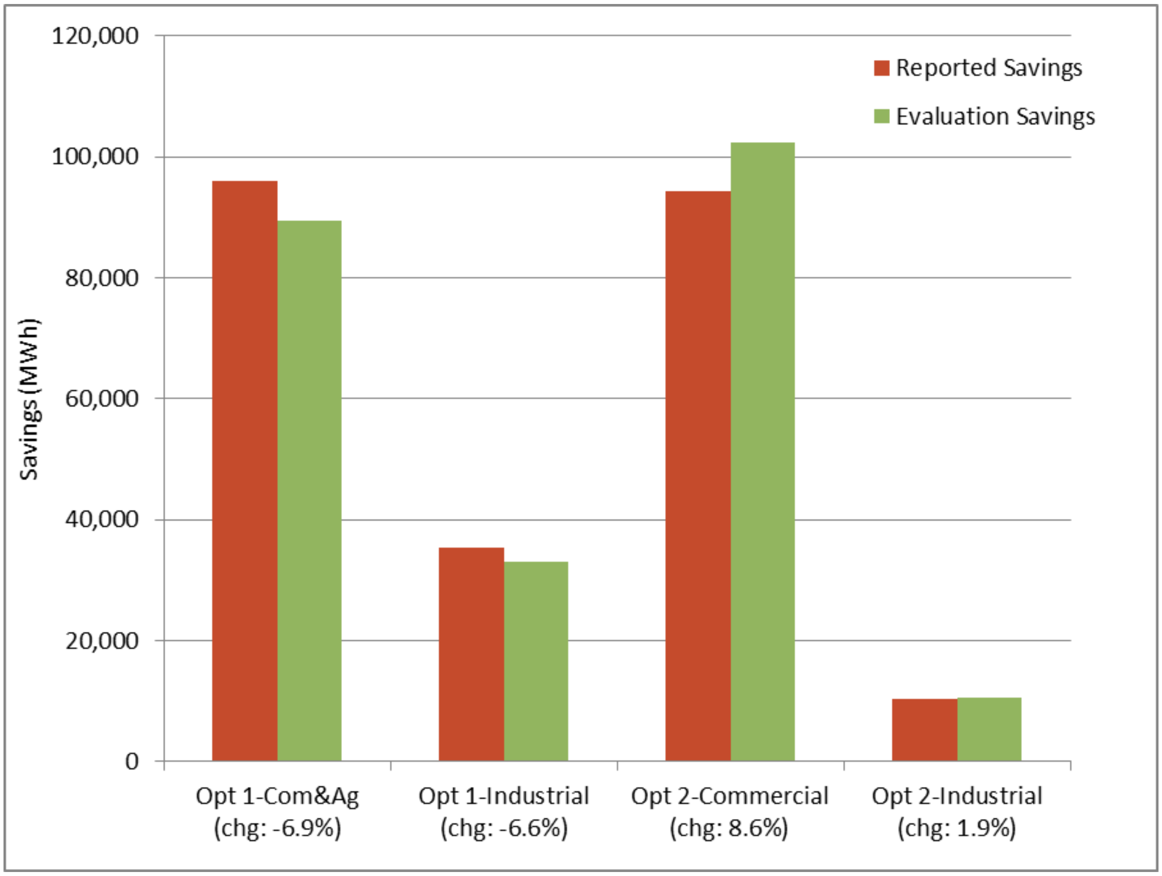

Figure 11: Lighting Savings by Domain

Figure 12 is a bubble chart that shows the distribution of realization rates within the lighting domains; each bubble is a sampled measure. The bubble colors distinguish the samples for each of the four domains. The size of the bubbles represents the weighted evaluation savings for each measure and thus its influence on the realization rate for the domain.

Many lighting measures in all domains have reported savings within 20% of the evaluation savings[33]. However, one-third of the measures are outside this range and the number outside this range varies among the lighting domains. We will refer to realization rates less than 0.8 and those greater than 1.2, respectively, as Low and High. How many are Low and High, for each domain, is shown at the bottom of Figure 12. The Option 1 Lighting measures (both sectors) have the highest incidence of Low realization rates and few are High. This is consistent with realization rates, of 0.93 in both of these domains. For Option 2, both sectors have more High than Low, especially in the commercial sector, which is in part due to embedded realization rates applied to commercial retrofit measures by one utility.

[33] The criteria of 20% reflects our judgement of what is a reasonable expectation concerning the accuracy of the savings estimate for an individual measure.

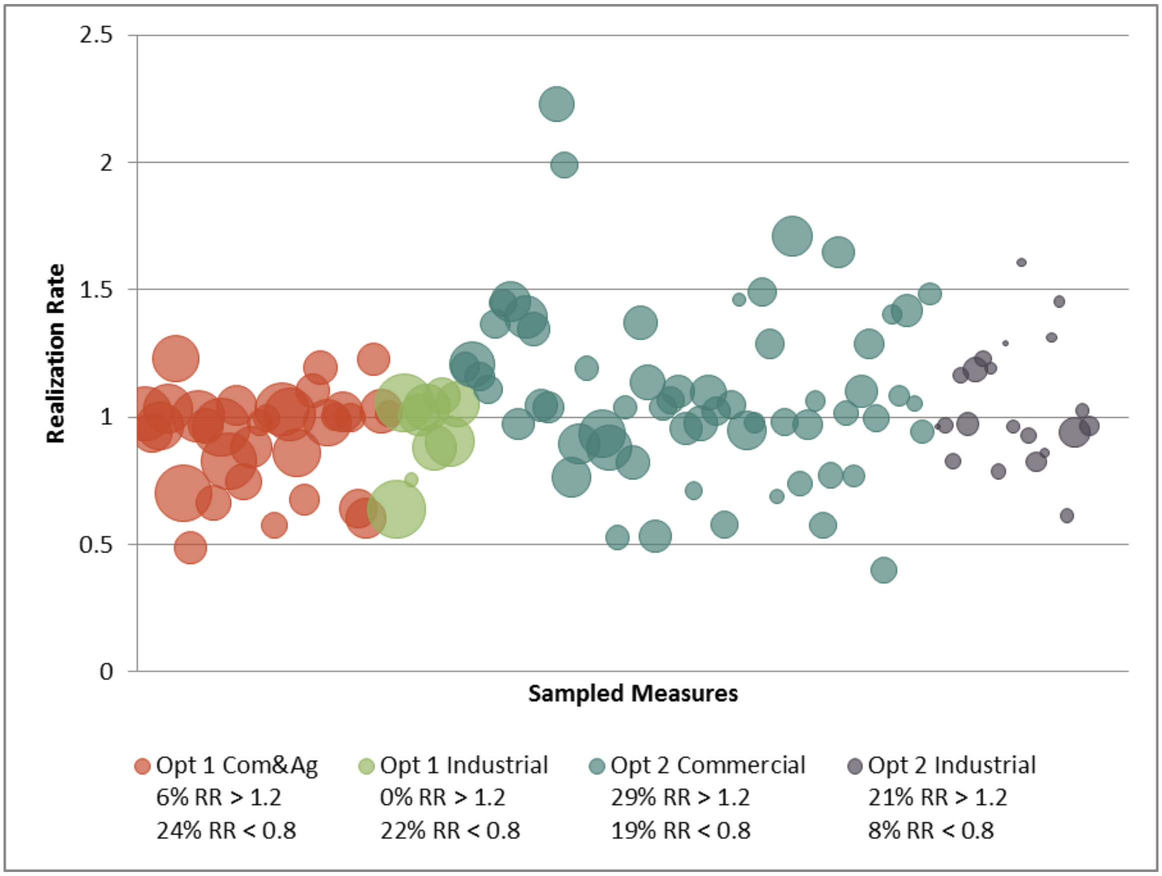

Figure 12: Distribution of Realization Rates Within Lighting Domains

3.1.3. Non-Lighting

The change between reported and evaluation savings for Non-Lighting measures, overall and for Option 1 and 2, is shown in Figure 13. The overall savings increase by 3.1% compared to reported savings. Both Option 1 and 2 savings increase, but the increase is larger for Option 2 (6.9% vs. 1.6%), again consistent with the embedded realization rates.

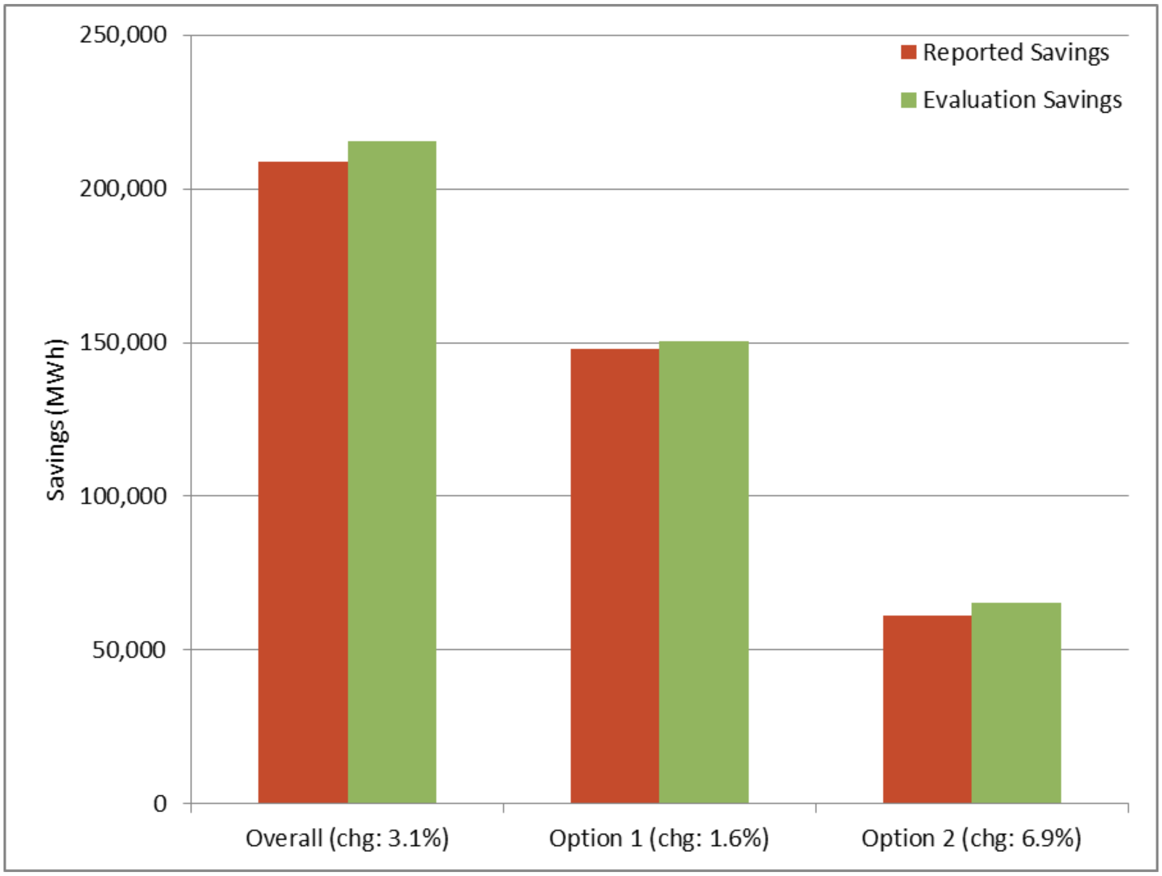

Figure 13: Non-Lighting Savings in Total and by Option

Figure 14 further decomposes Non-lighting by Option and Sector. Here the largest change is for Option 1-Com/Ag. This change is caused by factors related to how savings are modeled and the quality of inputs to these models, and will be further discussed in Section 3.3.2. Savings for Option 2-Commercial measures also increase but not as much (10% vs 15%) as for Option 1. This change is in part caused by the embedded realization rates, but other measure-specific factors are present. There is little change among industrial measures for either Option 1 or 2.

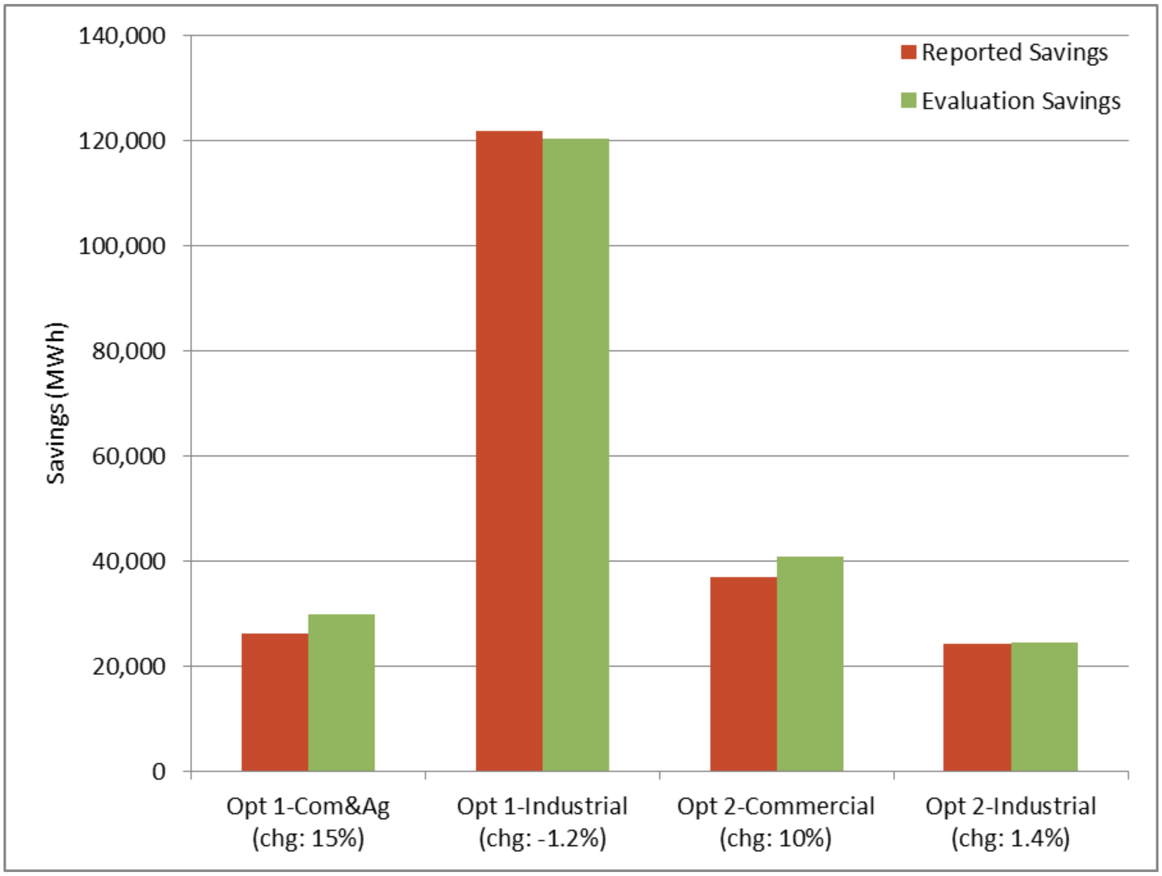

Figure 14: Non-Lighting Savings by Domain

The Figure 15 bubble chart shows the distribution of realization rates[34] within the Non-Lighting domains. Option 1 Non-lighting measures exhibit less scatter than Option 2 measures. Approximately half of the measures in both Option 2 sectors have either High (RR > 1.2) or Low (RR < .8) realization rates. Thirty percent of the Option 2 commercial measures have High realization rates, which is consistent with the impact of the embedded realization rates. However, there also 17% with Low realization rates, so other measure-specific factors are present and causing changes in the savings estimates. The scatter is less within Option 1 for both sectors, but more realizations rates are High than are Low for Industrial measures.

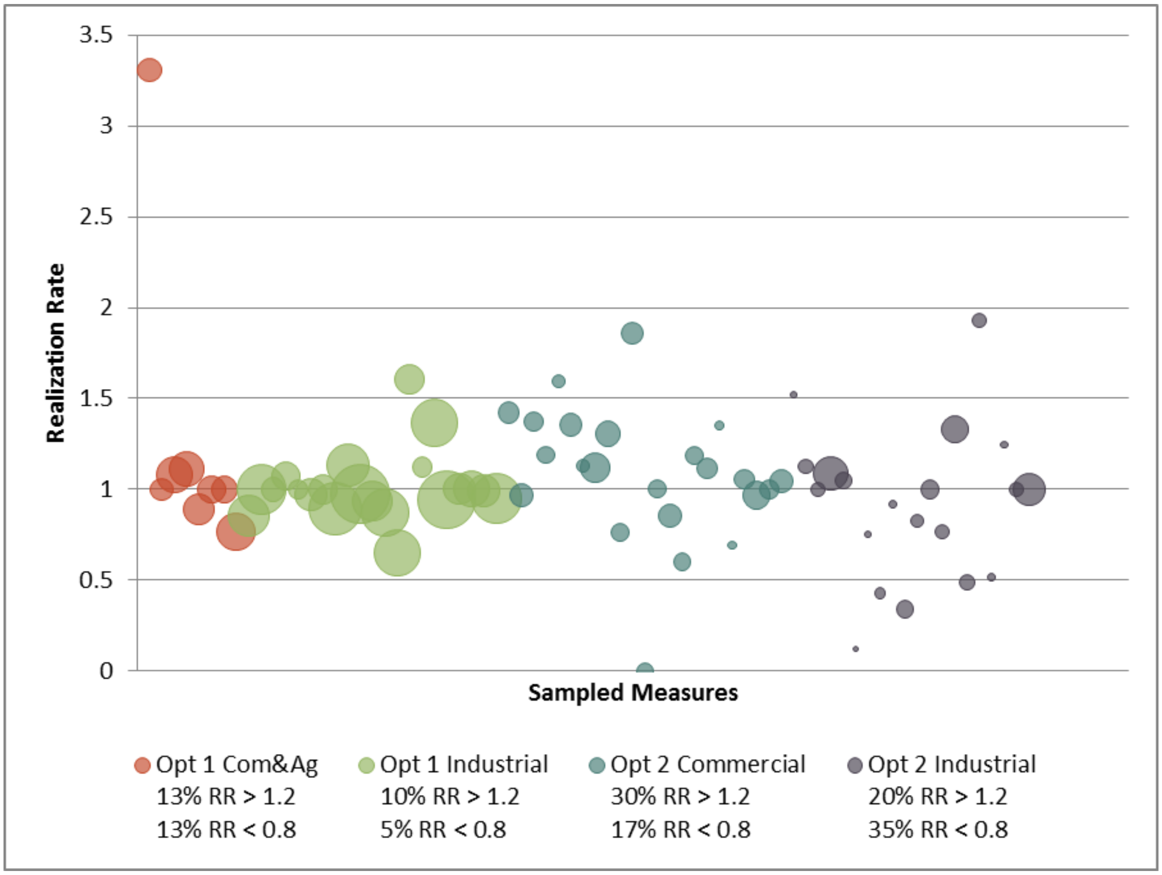

Figure 15: Distribution of Realization Rates Within Non-Lighting Domains

3.1.4. ESRP

This section focuses on the distribution of the realization rates[35] that we found among the sampled ESRP measures. In total, the ESRP realization rate is 0.49. As shown in Figure 16, 60% of the measures have Low realization rates (RR < 0.8). Two of these three measures have realization rates below 0.5 and one of these three has a negative realization rate, i.e., the

[34] These realizations rates and their associated sample case-weights are listed for each sampled measure in Appendix C.2.

[35] These realizations rates and their associated sample case-weights are listed for each sampled measure in Appendix C.3.

measure increased electrical use. The sample and the domain population are small, but there appear to be some common factors causing the change in savings. The largest sampled measure realized only 51% of its reported savings, primarily due to incomplete implementation. A significant portion of this project's savings relied upon adjustments to operating procedures which did not occur. Two of the other four projects had significant changes because the savings estimate did not properly account for downstream reuse of a large portion of the "saved" water (per the irrigated region's standard water accounting protocol).

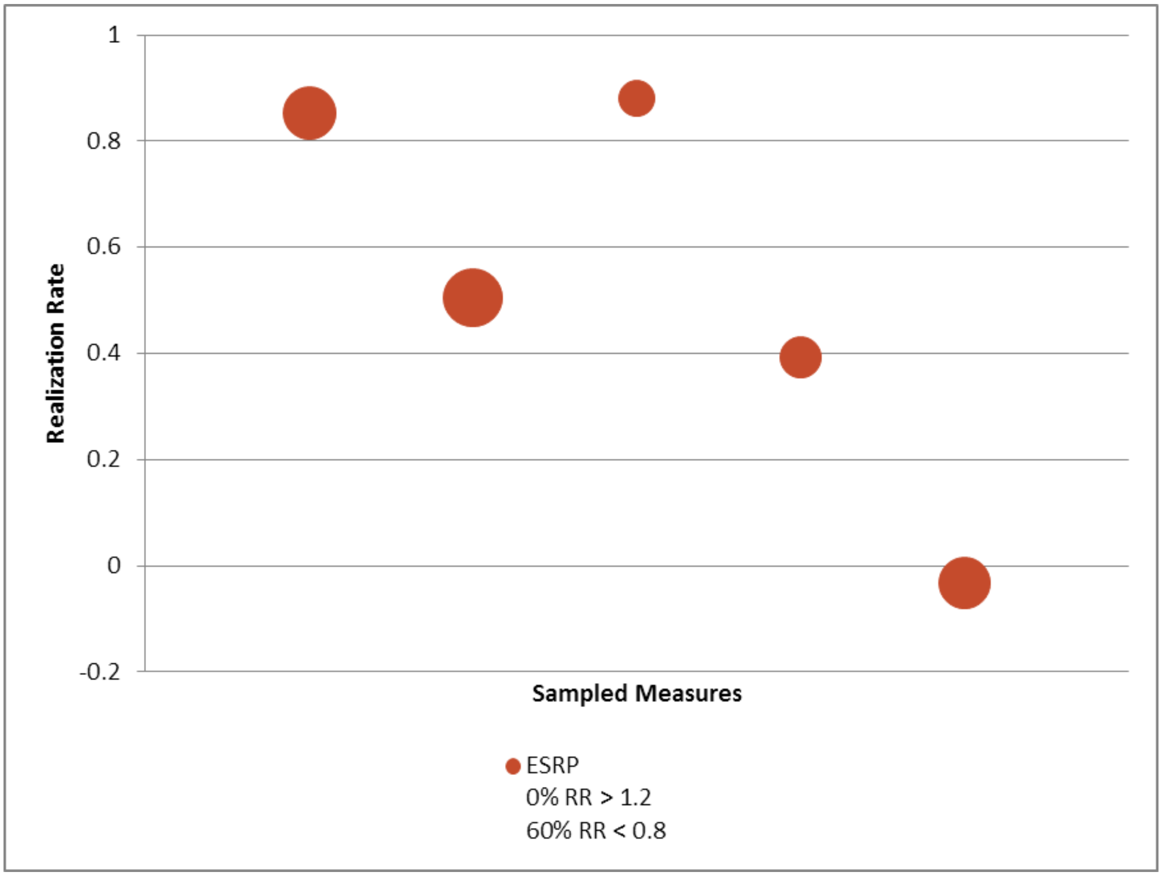

Figure 16: Distribution of Realization Rates for ESRP

3.2. Life-Cycle Cost-Effectiveness

Most of our evaluation resources were devoted to estimating first-year savings for the sampled measures. However, the evaluation plan called for some examination of the life cycle cost-effectiveness. Three parameters were considered: incremental cost of each measure, measure lifetime, and quantifiable non-electric benefits (NEBs[36]).

[36] Non-Electric Benefits (NEB) can be positive or negative. A negative NEB could also be called a cost. See *Complete Operative Guidelines (Released 06-17-14)*, volume *Guidelines for the Estimation of Incremental Measure Costs and Benefits*.

In this section, we present our findings regarding the cost-effectiveness of the entire portfolio, as well as specific domains, defined by Measure Type (Lighting, Non-Lighting and ESRP) and Sector (commercial/agricultural and industrial). Our most important findings are as follows:

1. **Cost-Effectiveness**. Based on this analysis, we conclude that each of the domains and the portfolio in total is cost-effective. The portfolio Total Resource Cost (TRC) ratio is 2.65, indicating that lifetime benefits were more than two and half times the value of lifetime costs. Option 2-Lighting-Industrial measures have the highest TRC (3.82) but even the lowest TRC, which is for Option 2-Non-Lighting-Commercial, is cost-effective with a TRC of 1.88.
2. **Impact of Non-Electric Benefits**. For the portfolio, the inclusion of NEBs increases the TRC ratio by 6%. The inclusion of NEBs causes a decrease in the TRC ratio for half of the lighting domains, where the negative NEBs associated with increased gas use has the greatest impact. However, for Option 2-Non-Lighting NEBs increase the TRC ratio and on balance cause the effect of NEBs to be positive for the entire portfolio.

Table 13 shows the life cycle benefits and costs for each domain. Also shown is the benefit to cost ratio, which are all greater than one, i.e., benefits exceed costs over the lifetime of the measures.

Table 13: Total Resource Cost Test by Domain

Domain			Total Resource Cost Test		
Option	Measure Type	Sector	Benefits	Costs	Benefit/Cost Ratio
1	Lighting	Com/Ag	114,479,203	45,635,453	2.51
		Industrial	38,424,121	10,123,019	3.80
	Non-Lighting	Com/Ag	42,772,492	14,711,262	2.91
		Industrial	167,715,850	51,602,622	3.25
2	Lighting	Commercial	133,380,600	62,399,748	2.14
		Industrial	14,109,709	3,695,057	3.82
	Non-Lighting	Commercial	52,780,644	28,088,751	1.88
		Industrial	27,654,060	7,615,320	3.63
ESRP			19,850,216	7,187,354	2.76
Site-Specific Portfolio			**611,166,896**	**231,058,588**	**2.65**

Table 14 shows the TRC ratios with and without NEBs. For the portfolio, the inclusion of NEBs increases TRC by 6%. The inclusion of NEBs changes the TRC ratio by less than 10% in all domains except for Option 2 Non-Lighting Commercial where they increased the ratio by 33%. NEBs cause a decrease in half of the lighting domains, where the negative NEBs associated with increased gas use has the greatest impact. However, for Option 2-Non-Lighting NEBs increase TRC and on balance cause the effect of NEBs to be positive for the entire portfolio.

Table 14: Impact of NEBs on Total Resource Cost Test

Domain			Total Resource Cost Test		
Option	Measure Type	Sector	without NEBS	with NEBs	% Change
1	Lighting	Com/Ag	2.60	2.51	-4%
		Industrial	3.80	3.80	0%
	Non-Lighting	Com/Ag	2.87	2.91	1%
		Industrial	3.37	3.25	-3%
2	Lighting	Commercial	2.10	2.14	2%
		Industrial	4.08	3.82	-6%
	Non-Lighting	Commercial	1.41	1.88	33%
		Industrial	3.41	3.63	7%
ESRP			2.68	2.76	3%
Site-Specific Portfolio			**2.49**	**2.65**	**6%**

Figure 17 shows the distribution of the B/C ratios within each of the domains. Two measures had positive benefits but negative costs which resulted in an infinite value for the B/C ratio. We limited the upper bound on the vertical axis to 15 to zoom in on the points with B/C ratio closer to 1 which excluded 9 measures with B/C ratios greater than 15. There are 22 measures with B/C ratios less than 1. The dotted line across the plot is at a B/C ratio of 1. All measures above the line are cost-effective and all below are not.

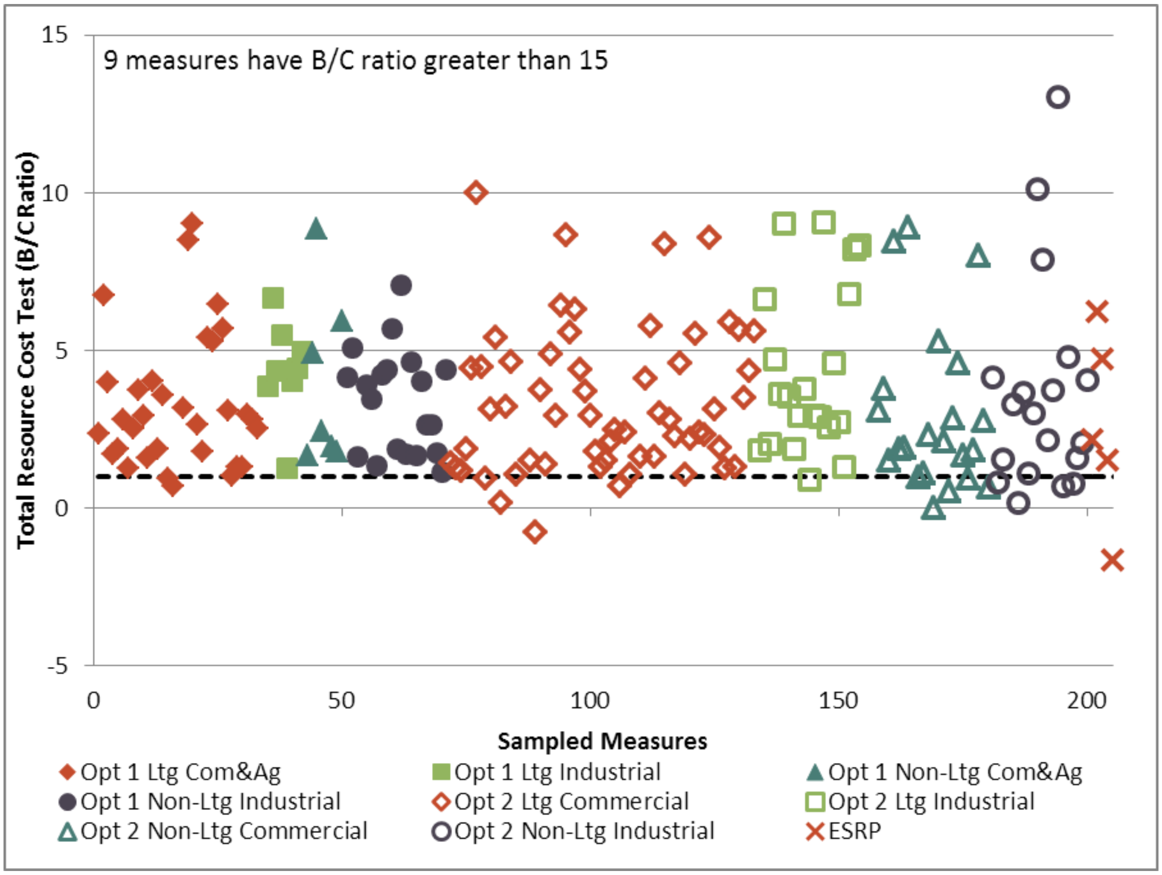

Figure 17: Distribution of Total Resource Cost Test within Each Domain

3.3. Factors that Changed Measure Savings

In this section, we present our findings regarding the factors that resulted in evaluated savings differing from reported savings. These findings varied, particularly based on whether measures were lighting or non-lighting; Option 1 or Option 2 utilities; or ESRP. Our most important findings are as follows:

1. **Lighting**.
    a. **Option 1**. Using the BPA Lighting Calculator v3 to estimate savings reduced savings by 0.4%. Modifying lighting hours of operation based on our metering results caused a further 4.4% reduction in savings. Other changes (including changes in fixture wattage and quantity), further reduced savings by 2.0%.
    b. **Option 2**. Removing the embedded realization rates increased savings by 5.0%. Using the BPA Lighting Calculator v3 to estimate savings increased savings by an additional 2.2%. Modifying lighting hours of operation based on our metering results caused a 3.2% reduction in savings. All other changes (including changes to fixture wattage and quantity) increased savings by 3.9%.

2. **Non-Lighting**.
    a. **Option 1**. The most frequently changed key determinant was Load Profile (Commercial building occupancy rates, and all other changes not captured by the other categories of key determinants), affecting 34% of the sample. However, about the same number of changes increased or decreased savings. Hours of Operation changes affected 16% of the measures. No changes were made to the Production determinant (Number of production units per unit of time).
    b. **Option 2**. Embedded realization rates caused a 7% increase in Commercial sector savings and a 5% increase for the Industrial sector. Load Profile changes affected more than half of the sample, 33% decreasing savings and 21% increasing savings. Efficiency Profile had 21% increases and 9% decreases.
3. **ESRP**. The evaluation made substantial changes to key parameters for all sampled ESRP measures, which significantly affected savings. Many of the changes can be attributed to incomplete implementation of a measure and downstream reuse of a large portion of the "saved" water.

3.3.1. Lighting

The impact for some of the factors that changed lighting savings can be quantified. For other factors, it was only possible to qualitatively determine whether they caused savings to increase or decrease. The quantifiable factors include the following:

- **Embedded Realization Rate**. This change was caused by one utility applying realization rates prior to reporting savings to BPA. This factor only affects Option 2 savings.
- **BPA Lighting Calculator v3**[37]. This is the change in savings caused by the differences between the program and evaluation lighting calculators.
- **Metering Hours of Operation**. This is the change in savings caused by modifying the number of baseline or efficient-case hours of operation for lighting. We modified hours based on data collected from metering lighting fixtures/circuits and other data gathered during site visits.

The magnitude and reasons for these changes will be discussed in the following section as they apply to measures representing Option 1 and 2 utilities.

3.3.1.1. Option 1 Utilities

Two of the three quantifiable factors changed savings for Option 1-Lighting measures. The incremental impact of these factors is shown in Figure 18. Using the BPA Lighting Calculator v3

[37] As discussed in Appendix B.1, we modified the calculator to allow for full savings credit for baseline fixtures potentially affected by the federal Energy Policy Act (EPAct), such as T-12s that are being phased out under EPAct, or fixtures affected by the Energy Independence and Security Act (EISA), such as incandescent lamps. This modification was needed as neither EPAct nor EISA were fully in effect for all of the period covered by this evaluation (FY2012-13)

to estimate savings reduced savings by 0.4%, as it caused some fixtures to be given new wattages and HVAC interaction factors were adjusted or used for the first time. Modifying lighting hours of operation based on our metering results caused a further 4.4% reduction in savings. All other changes (including changes in fixture wattage and quantity that were based on our review of program documentation or observations during site visits) further reduced savings by 2.0%.

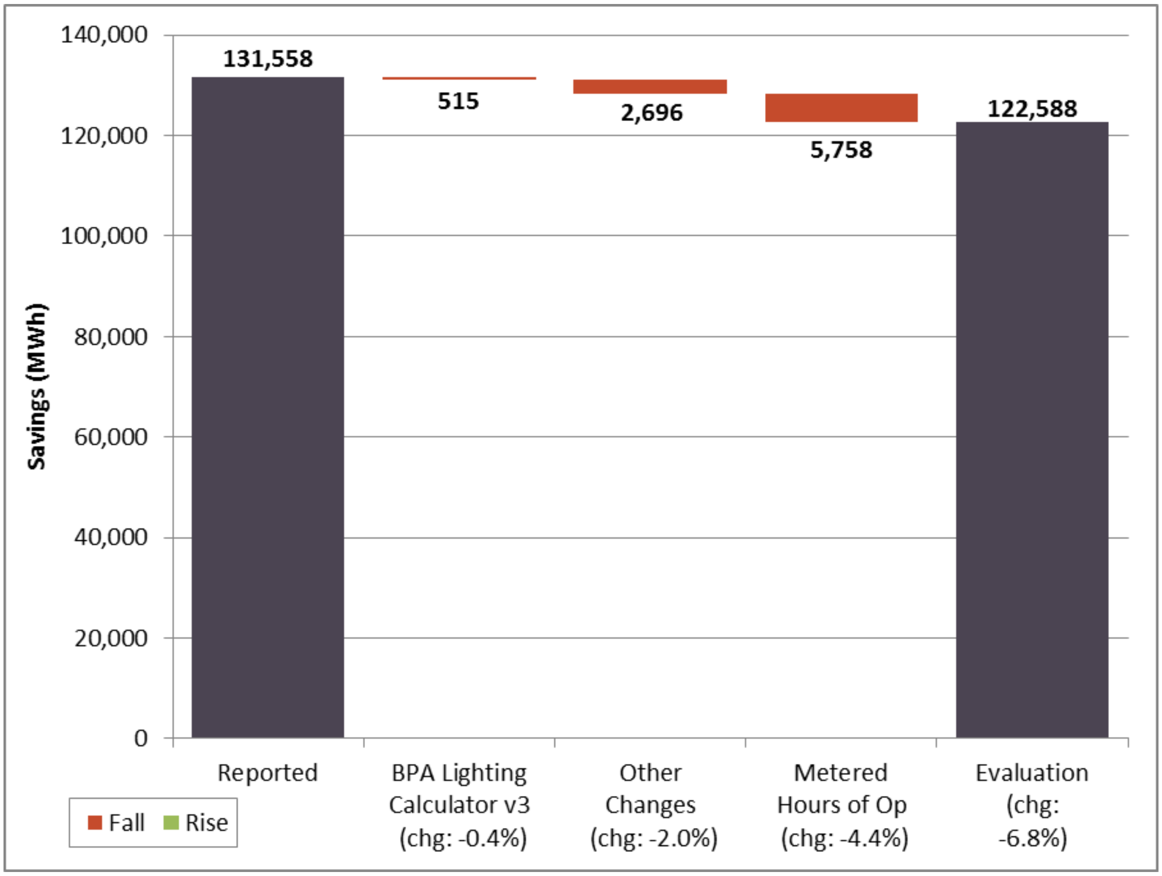

Figure 18: Option 1: Quantifiable Changes in Lighting Savings

BPA Lighting Calculator v3

Using the BPA Lighting Calculator v3 to estimate savings caused a very small change in savings overall. Some fixtures were given new wattages and HVAC interaction factors were adjusted or used for the first time. For Option 1 utilities, the change in calculators was from BPA Lighting Calculator v2.2/2.3 to v3. The change had different effects for each of the Lighting TAPs. Table 15 shows the impact of this change by TAP for the sample (not weighted to the population). Savings were increased for TAPs that involved installation of lighting controls. For non-control TAPs the savings were decreased. None of the changes are greater than 10%.

Table 15: Option 1: Impact of Lighting Calculator Change by TAP

		Savings (kWh)		
Technology/Activity/Practice	**Measures**	**Program Calculator**	**BPA v3 Calculator**	**% Change**
Lamps/Ballasts/Fixtures	33	17,042,181	16,230,925	-5%
Lamps/Ballasts/Fixtures w/Delamping	1	218,073	199,138	-9%
Lamps/Ballasts/Fixtures w/Controls	6	2,443,675	2,547,698	4%
Lamps/Ballasts/Fixtures w/Delamping and Controls	1	3,424,196	3,557,130	4%
Lost Opportunity (New Construction)	1	557,168	557,168	0%

Changes in Key Determinants

To understand why lighting savings differed from reported savings for individual measures, we tracked the frequency with which changes in key determinants of savings occurred, what caused the change (input or algorithm), and the direction of the change[38] (i.e., whether the change caused an increase or decrease in savings). Four key determinants were tracked:

- **Connected load**. Did baseline[39] or efficient-case fixture kW or quantity change?
- **Efficiency profile**. Was there a change in HVAC interaction factors?
- **Hours of operation**. Did baseline or efficient-case hours of operation change?
- **Load Profile**. Did we the change the level and frequency of dimming?

Figure 19 shows the frequency and direction of changes to key determinants for the Option 1 Lighting sample. The most frequent change occurred for Hours of Operation, where input changes occurred for 40% of the sample. Changes included those made to baseline and efficient-case hours. The majority of these were decreases in inputs (31% of the sample). The next most frequent changes were to Connected Load, where 19% of the sample had changes; most of these were input changes.

[38] It was possible to quantify certain factors, such as the change to the BPA Lighting Calculator v3. This was accomplished by imposing the program's input data on the new calculator. However, it was not practical to model each step in the process of estimating savings, particularly for Non-Lighting measures that have non-standard and complex models.

[39] As noted earlier, we modified the BPA Lighting Calculator v3 so that it could model the observed baseline conditions, not the market average baseline. This is the same baseline that v2.2/2.3 calculators modelled. We could then make adjustments to this baseline based on our review of program documentation and site visit observations and interviews.]

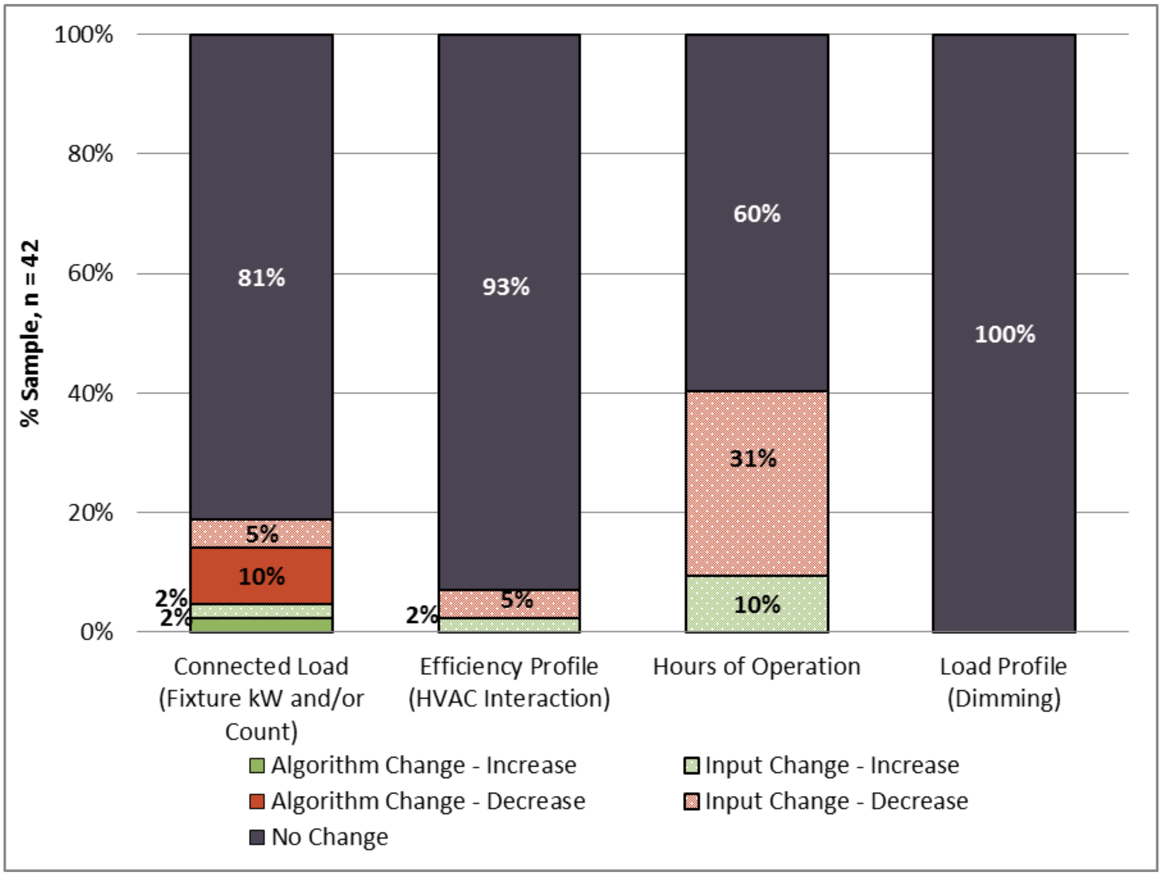

Figure 19: Option 1: Frequency of Lighting Key Determinant Changes

3.3.1.2. Option 2 Utilities

All three quantifiable factors changed savings for Option 2-Lighting measures. The incremental impact of these factors is shown in Figure 20. The removal of embedded realization rates increased savings by 5.0%. Using the BPA Lighting Calculator v3 to estimate savings increased savings by an additional 2.2%. Modifying lighting hours of operation based on our metering results caused a 3.2% reduction in savings. All other changes (including changes to fixture wattage and quantity) increased savings by 3.9%.

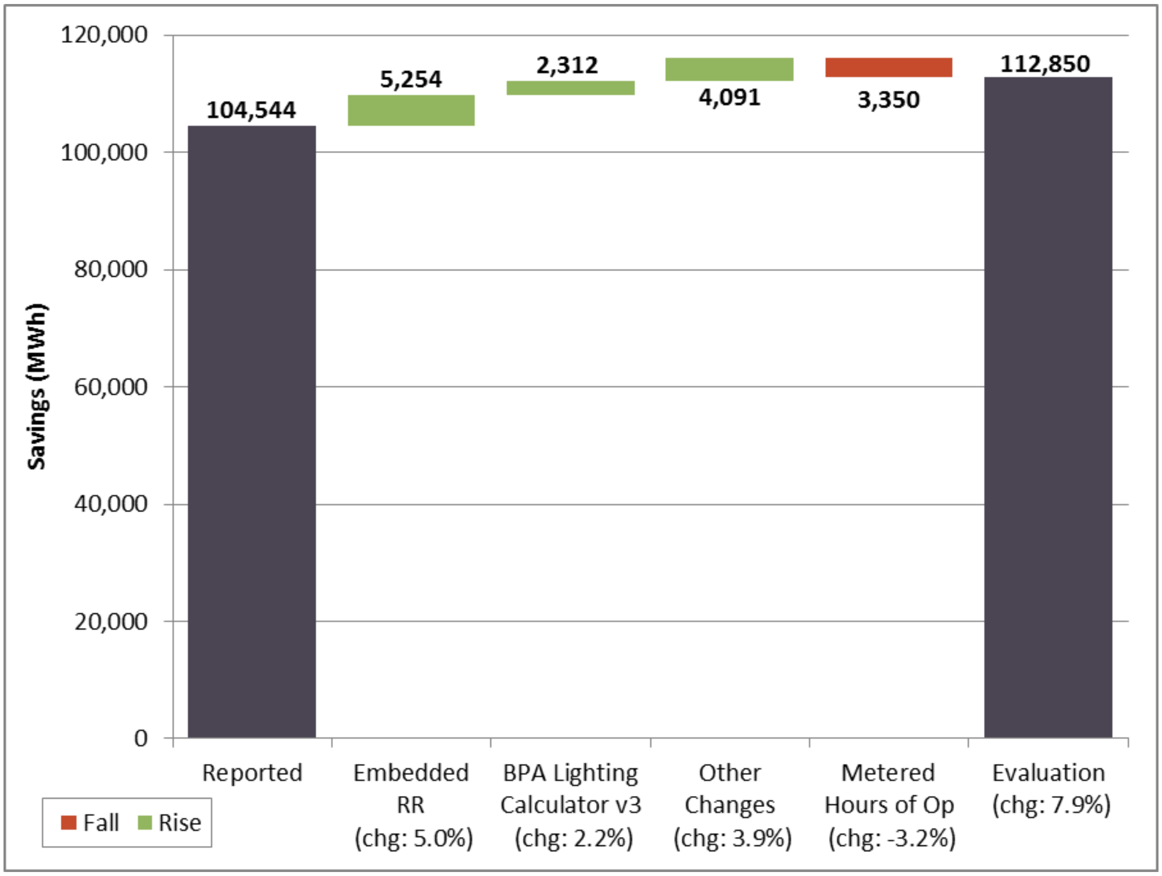

Figure 20: Option 2: Quantifiable Changes in Lighting Savings

Embedded Realization Rates

For the Option 2-Lighting domain, the embedded realization rates lead to a 5.0% increase in savings. As noted earlier, one of the Option 2 utilities applies a realization rate which is less than one (from a previous evaluation) to its savings estimates prior to reporting savings to BPA. All of these adjustments were applied to commercial retrofit projects except one which was applied to an industrial retrofit project. These adjustments were detected when we compared program documents provided by the Option 2 utilities to the savings obtained from BPA's reporting system.

BPA Lighting Calculator v3

For Option 2 utilities the change in calculators was from calculators created by the utilities to BPA v3 calculator. The change had different effects for each of the Lighting TAPs. Table 16 shows the impact of this change by TAP for the sample (not weighted to the population). Savings for the lost opportunity (new construction) measures changed negligibly. Unlike Option 1, there were both increases and decrease in savings for control measures. Savings increased for all non-control TAPs.

Table 16: Option 2: Impact of Lighting Calculator Change by TAP

Technology/Activity/Practice	Measures	Savings (kWh) Program Calculator	Savings (kWh) BPA v3 Calculator	% Change
Lamps/Ballasts	9	1,308,495	1,364,405	4%
Lamps/Ballasts/Fixtures	36	10,930,323	11,082,717	1%
Lamps/Ballasts/Fixtures w/De-lamping	3	224,167	229,039	2%
Control Panels	1	116,908	93,344	-20%
Occupancy Sensors	1	27,857	28,188	1%
Lamps/Ballasts w/Controls	1	89,316	92,980	4%
Lamps/Ballasts/Fixtures w/Controls	18	3,699,242	3,782,195	2%
Lamps/Ballasts w/De-lamping and Controls	2	203,152	191,873	-6%
Lamps/Ballasts/Fixtures w/De-lamping and Controls	8	2,913,166	3,093,068	6%
Lost Opportunity (New Construction)	5	2,019,137	2,015,850	0%

Changes in Key Determinants

Figure 21 shows how the frequency and direction of changes to key determinants for the Option 2 Lighting sample. The most frequent change occurred for Hours of Operation, where 44% of the sample had input changes (increased savings for 21%; decreased savings for 23%). The next most frequent changes were to Connected Load, where 29% of the sample had algorithm and input changes. Efficiency Profile (HVAC Interaction) changes also impacted 21% of the sample.

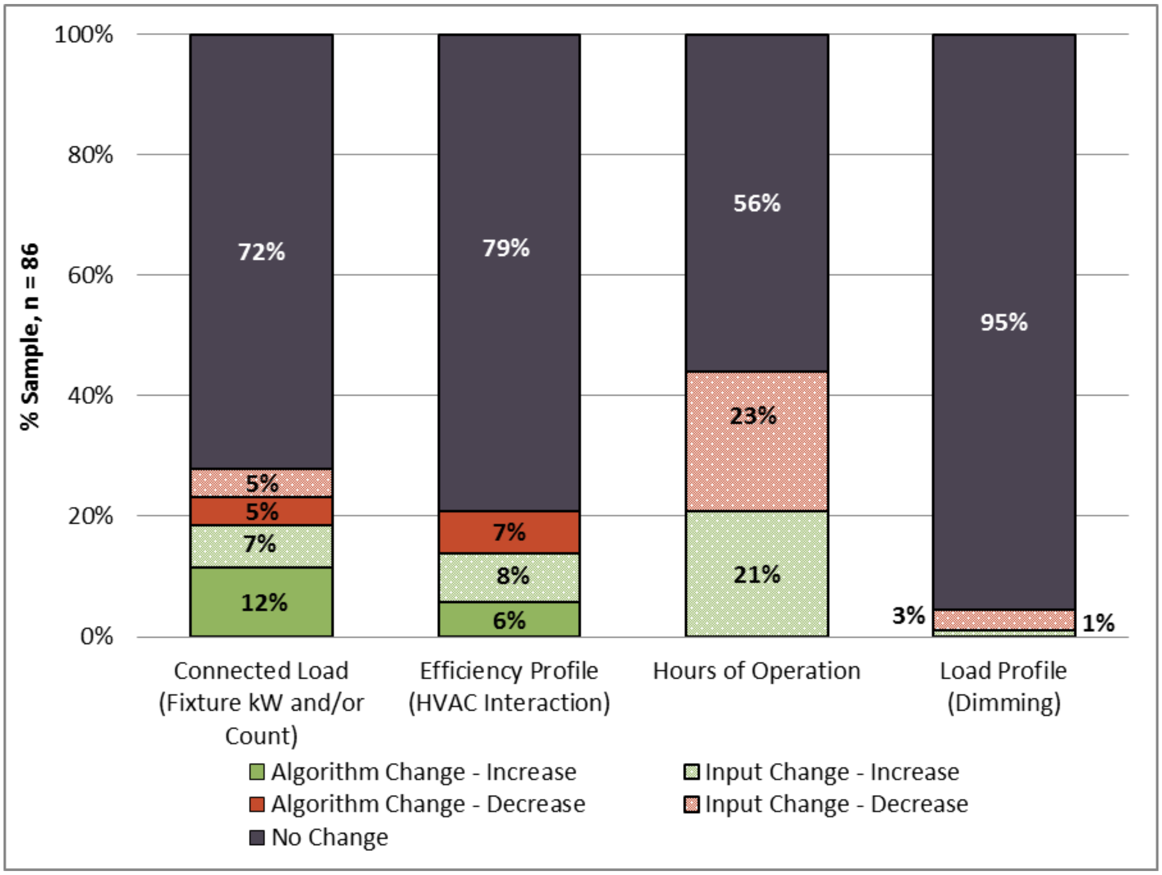

Figure 21: Option 2: Frequency of Lighting Key Determinant Changes

3.3.2. Non-Lighting

This section discusses the factors that caused changes in the savings estimated for Non-Lighting measures. Only one of these factors was quantifiable, which was the impact of embedded realization rate on Option 2 measures. In addition, the frequency and direction of changes in key determinants was tracked as we completed the evaluation of each sampled measure. Further breakdown of these changes by end-use is presented in Appendix D.

Unlike lighting, the models used to estimate non-lighting savings are highly varied in their structure. Even within an end use, e.g., HVAC, some models may be based on analysis of billing records, while others will be based on engineering principles and direct measurement of baseline and efficient case energy use for an affected piece of equipment. It would be a difficult task to quantify all the factors that might be different between the M&V model used by the program and the evaluation model. Therefore, this evaluation focused on the frequency and direction of six key determinants.

3.3.2.1. Option 1 Utilities

There were no quantifiable factors for Option 1-Non-Lighting measures. However, we did track the frequency and direction of changes in key determinants of savings and what caused the change (input or algorithm). Six key determinants were tracked:

- **Connected load.** Were there changes to baseline or efficient-case kW demand and/or the quantity of the equipment?
- **Efficiency profile.** Was there a change in part-load impacts on demand profile?
- **Hours of operation.** Did baseline or efficient-case schedule of operation change?
- **Load Profile.** Were there changes in building occupancy or determinants not captured by the other categories of key determinants?
- **Production.** Did the production units or type change?
- **Weather**. Did weather-based data change for weather-sensitive measures?

Changes in Key Determinants

Figure 22 shows the frequency and direction of changes to key determinants for the Option 1-Non-Lighting sample. The most frequently changed key determinant was Load Profile, affecting 34% of the sample; the majority of these were due to changes in which key determinants were modeled in estimating savings. About the same number of Load Profile changes increased or decreased savings. Hours of operation changed for 16% of the sample, with algorithm increases occurring for 10% of the sample. Changes to Connected Load decreased savings for 10% of the sample and there we no counterbalancing increases to savings.

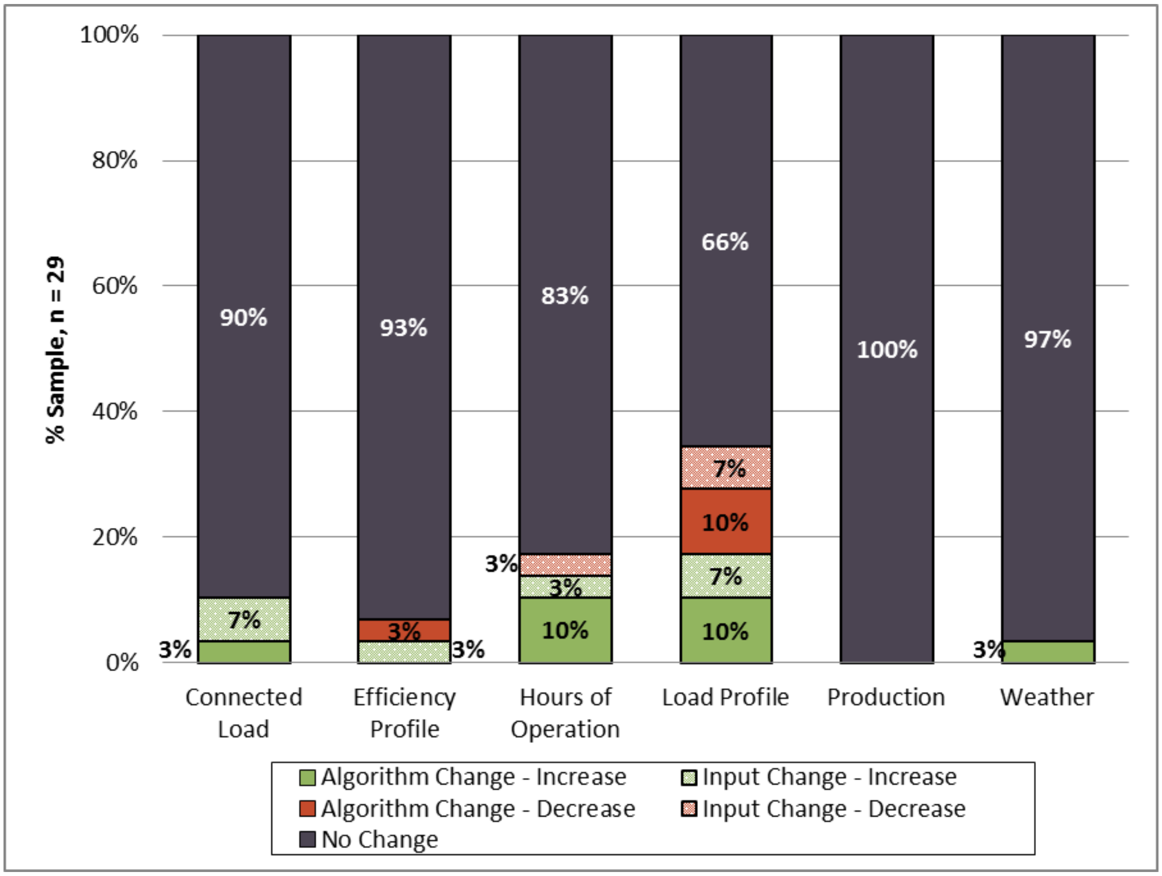

Figure 22: Option 1: Factors Changing Non-Lighting Savings

3.3.2.2. Option 2 Utilities

For Option 2-Non-Lighting measures we quantified the impact of the embedded realization rates. Figure 23 shows that the removal of the embedded realization rates results in savings that are 7% higher for the commercial sector. All other factors combined increased commercial savings by an additional 3%. The impact on industrial savings was smaller, with removal of the embedded realization rates increasing savings by 5% and all other factors reducing that savings by 4%.

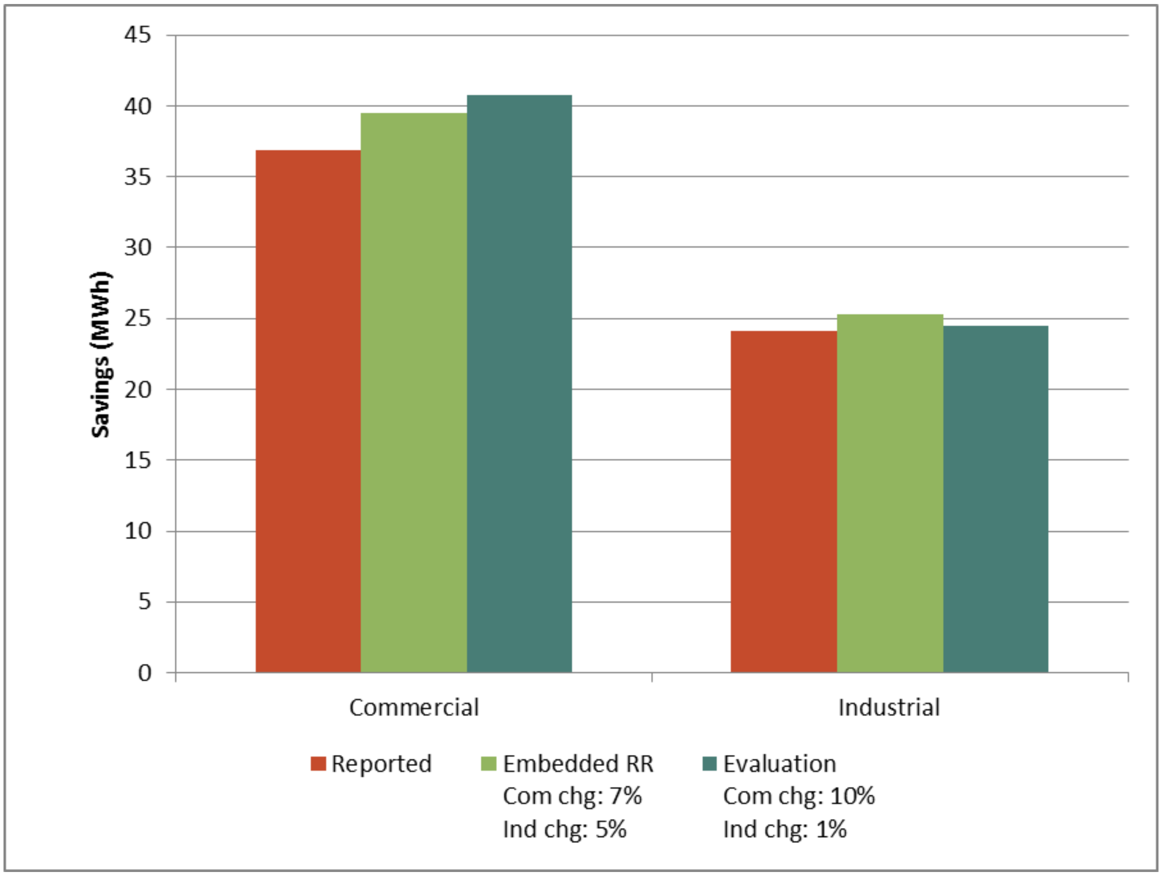

Figure 23: Option 2: Non-Lighting Savings Change Caused by Embedded Realization Rate

Changes in Key Determinants

We also tracked the frequency and direction of changes in key determinants for Option 2-Non-Lighting measures, using the same set of determinants as defined above for Option 1.

Figure 24 shows how frequently changes to key determinants occurred for the Option 2-Non-Lighting sample. As in the case of Option 1, the most frequently changed key determinant was Load Profile. However for Option 2, this affected more than half of the sample, and decreases in savings were more frequent than increases in savings (33% and 21% of the sample, respectively). The next most frequent changes occurred for Efficiency Profile, where 30% of the sample had changes. Changes to Hours of Operation were balanced with 9% increasing and 9% decreasing savings.

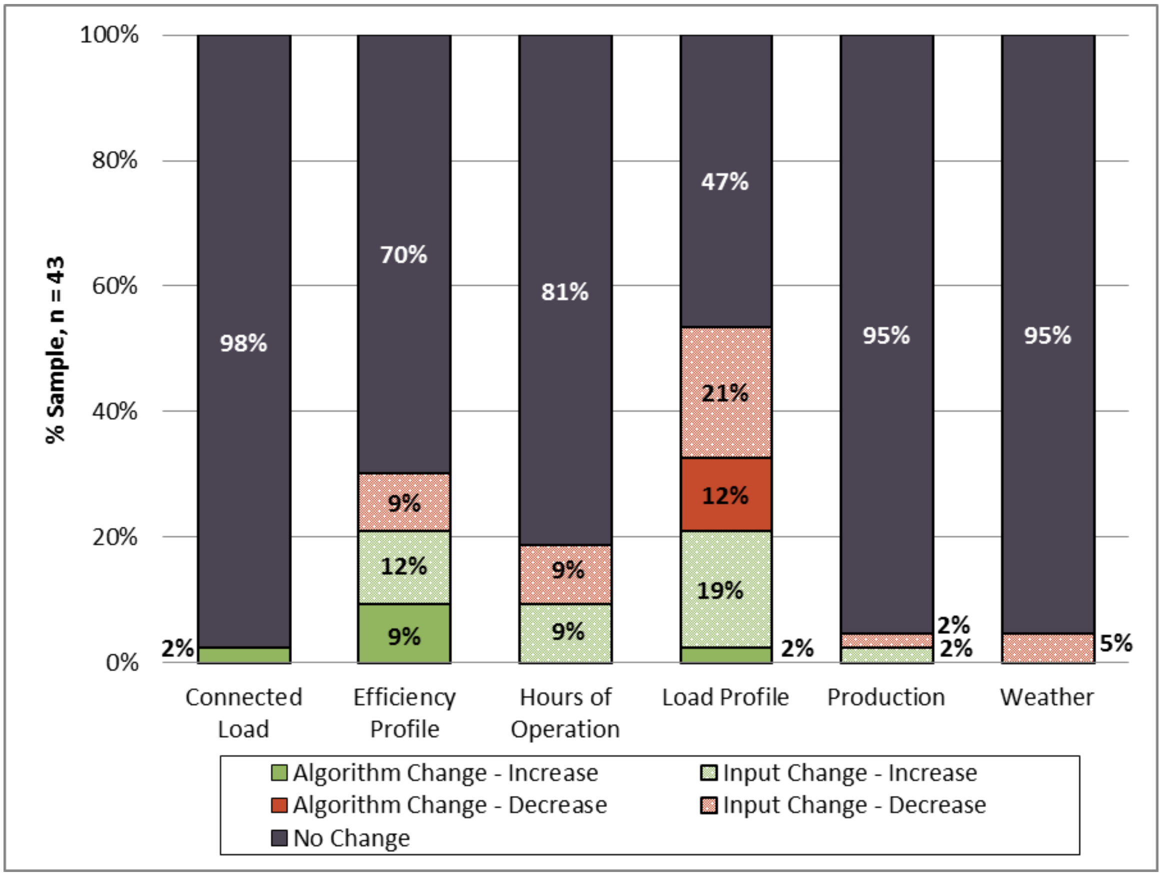

Figure 24: Option 2: Factors Changing Non-Lighting Savings

Additionally, there were a few cases in which significant baseline changes caused substantial savings adjustments on lost opportunity measures. These baseline changes fell under various key determinants. In particular, for a couple of cases, the original M&V assumed current state energy code as the current practice baseline. Upon interviewing knowledgeable staff at the sites, we determined that what the end user would have done in the absence of the program was more efficient than current codes. These interview data were used to determine the current practice baseline. This is consistent with RTF Guidelines, but is not specifically called for in the BPA's Implementation Manual (IM). For one of these cases, the baseline change resulted in zero savings.

Further, we observed that Option 2 utilities occasionally used in-house "deemed" savings and "standardized" calculators. These use typical input values and simple models to estimate savings. We found that these models were not reliably estimating savings and we replaced them with more reliable models for this evaluation. In the sample, we encountered two such calculators:

- Replacement of On-Off Reciprocating Compressors with VFD Screw Compressors. Measure savings based on an average of 9 previous projects with similar types of compressors.

- Installation of inverter-type welders in place of rectifier-type welders. Constant kW savings per welder upgrade were based on an "in-house" study and were generalized to other projects that involved different welding applications with different load profiles

3.3.3. ESRP

There were five ESRP measures included in the sample. The largest sampled measure realized only 51% of its reported savings, primarily due to incomplete implementation. A significant portion of this project's savings relied upon adjustments to operating procedures (load profile) which did not occur. Two of the other four projects had significant changes because the savings estimate did not properly account (load profile) for downstream reuse of a large portion of the "saved" water (per the irrigated region's standard water accounting protocol).

3.4. Adherence to Protocols and Guidelines

In this section we explore a number of findings related to BPA M&V Protocols and other "Guidelines" that are relevant to this portfolio. First we examine whether the program staff selected the correct M&V protocol for each measure. This is followed by a discussion of problems observed in the application of the protocols. Next, we look at whether the documentation available for the sampled measures satisfies the IM (Implementation Manual) requirements. Further, we explore whether the documentation that was needed by the evaluation, in excess of the IM requirements, was available. Finally we examine the information provided on measure classification, i.e., the assignment of TAP codes, to see whether this was sufficient.

Our most important findings are:

1. **Compliance with M&V Protocol Selection Guideline**. The compliance rate varied substantially across Option and Sector. Option 2 utilities were less likely to select the correct protocol, especially for commercial measures, where they selected the correct protocol for only 48% of the measures.
2. **Errors in Implementing Correctly Selected Protocols**. For all domains, the highest error rate was found for the Load Profile determinant. ESRP had the highest incidence of errors for the Load Profile and Efficiency Profile determinants. Other than ESRP, the highest incidence of Load Profile errors (92%) was found for Option 2 Commercial measures. Even though some of these error rates are high, it is important to note that these errors do not necessarily imply substantial over or under estimation of savings.
3. **IM Documentation Requirements**. We tried to obtain all the documentation required by the IM either from BPA or the utilities. We were unable to obtain invoices for 50% of the Option 1-Lighting sample. Invoices were not available for 100% of ESRP measures. Other than ESRP, we found the highest incidence of missing invoices for Option 1-Non-Lighting measures (Com/Ag 20% and Industrial 30%). In addition, the completion version of the Custom Project Calculator was missing for 13% of Option 1-Com/Ag measures.

4. **Documentation Useful to Evaluation**. We also tried to obtain documentation that was useful to our evaluation but was not required by the IM. Working savings models and logger data were the two most important types of documentation. Working models were received for only 55% of Option 2-Industrial measures and 60% of ESRP measures. Logger data was received from all sites (where it was requested) except for Option 2, where it was received for 94% of measures.

5. **TAP Assignment**. The reporting system does not have TAP codes for Option 1 Lighting measures, and the evaluation had to manually code measures. Additionally, there seems to be little consistency in how Option 2 utilities define measures and apply TAP codes. There were a substantial number of misclassified TAP codes, especially for Option 2 measures. TAPs were misclassified for more than 40% of Option 2 measures.

3.4.1. Compliance with Protocol Selection Guideline

Part of the BPA M&V Protocols[40] is a guide to protocol selection, which is basically the set of rules the program should use in determining which protocol applies to a project and its constituent measures. Following these rules, the program staff (including staff of BPA, BPA contractors, utility and utility contractors) is expected to select one of the following protocols when evaluating a measure's savings:

- Existing Building Commissioning an M&V Protocol Application Guide
- Engineering Calculations with Verification Protocol
- Verification by Energy Modeling Protocol
- Verification by Equipment or End-Use Metering Protocol
- Verification by Energy Use Indexing Protocol

The selection guide allows savings for lighting measures to be estimated with a calculator. All lighting measures used either a BPA calculator[41] or one created by an Option 2 utility, so all lighting measures adhered to the protocol selection guideline.

For Non-Lighting measures, we applied the criteria in the selection guide to determine whether the program selected the correct protocol and thus complied with the guideline. Table 17 shows that the compliance rate varied substantially across Option and Sector. Option 1 measures were nearly all compliant with the M&V protocols. Option 2 utilities were substantially less likely to select the correct protocol, especially for commercial measures, where they selected the correct protocol for only 48% of the measures.

[40] BPA M&V Protocols are described in the following reports. *2011. Existing Building Commissioning an M&V Protocol Application Guide. Engineering Calculations with Verification Protocol. Verification by Energy Modeling Protocol. Verification by Equipment or End-Use Metering Protocol. Verification by Energy Use Indexing Protocol*. Copies may be obtained from: www.conduitnw.org

[41] There were some Option 1 "custom" lighting projects in the sample. Even though they were classified as custom, they program still used the BPA lighting calculator to estimate savings. Therefore, we could treat them the same as the other lighting measures in the sample.

Table 17: Non-Lighting Compliance with Protocol Selection Guideline

Option	Sector	Measures	Percent Compliant
1	Com/Ag	8	88%
	Industrial	21	100%
2	Commercial	25	48%
	Industrial	20	75%
ESRP		5	80%
Total for Non-Lighting		**79**	**75%**

3.4.2. Errors in Implementing Correctly Selected Protocols

Next, we looked at how well the program applied the M&V protocols. We focused on the sampled measures where the program had selected the correct protocol because it's not meaningful in the cases where the program had selected the wrong protocol. Further we focused on Non-Lighting and ESRP measures as the primary factors for changes in lighting savings had already been quantified (see Section 3.3.1). Therefore, this qualitative examination of protocol application errors was limited to Non-Lighting and ESRP measures where the program had adhered to the M&V protocol selection guide.

The objective of this examination was to determine whether there were errors in the program's savings estimation. We asked ourselves the narrow question of whether the program, following its own protocols, made any errors. We assigned each of the errors to one of the six key determinants of savings which are applicable to Non-Lighting and ESRP measures. For each of these determinants, we looked for errors in algorithm or input.

Keep in mind that this is a thought experiment about how the program did its work based on the information available at the time that the program estimated savings. This is different than the evaluation's analysis of factors that changed savings between the program report and our evaluation, which were described in Section 3.3. In that analysis, we considered all changes, including those we imposed based on information gathered by our team that was not available to the program.

We also have to emphasize that this is a qualitative examination of errors. For instance we may have noted an error in the hours of operation for a chiller. Perhaps, the number of holidays was not considered. This error might have a small effect on savings. Ideally, we would have quantified the impact on savings for each error noted. However, many of these errors are interacting and even if not, quantification would have required significant time for further modelling.

Table 18 shows the frequency of errors by Key Determinant. As shown in the table, for all domains, the highest error rate was found for the Load Profile determinant. ESRP had the highest incidence of errors for the Load Profile and Efficiency Profile determinants. Other than ESRP, the highest incidence of Load Profile errors (92%) was found for Option 2 Commercial measures. Even though some of these error rates are high, it is important to note that these errors do not necessarily imply substantial over or under estimation of savings. Multiple errors can lead to compensating changes in the savings estimate. When they are combined the final result may be close to the correct savings. In addition, errors may only cause small changes in savings.

Table 18: Errors in the Application of Correctly Selected Protocols

Option	Sector	Measures with Correctly Selected Protocols	Percent with Errors in Alogrithm or Input					
			Hours of Operation	Load Profile	Efficiency Profile	Connected Load	Weather	Production
1	Com/Ag	7	0%	43%	0%	29%	0%	0%
	Industrial	21	29%	38%	19%	14%	0%	0%
2	Commercial	12	17%	92%	25%	8%	17%	0%
	Industrial	15	13%	40%	33%	0%	0%	13%
ESRP		4	25%	100%	100%	75%	0%	75%
Total for Non-Lighting		**59**	**19%**	**54%**	**27%**	**15%**	**3%**	**8%**

3.4.3. IM Documentation Requirements

This evaluation relied on documentation and files prepared by the program. One principle followed in conducting the evaluation was to re-use as much as possible of this information to reduce the need for gathering data from end users. Some of this information is required by the IM. The information required by the IM is different for lighting and non-lighting measures.

Table 19 shows documentation required[42] by the IM (April, 1 2013, updated June 13, 2013) for Lighting measures and what percent of them were missing this documentation. For evaluation purposes, the calculators, cut sheets and invoices are useful because they provide more details on the lighting equipment installed and can be an aid in identifying the equipment when visiting the site, either for the evaluator or program staff.

We were able to obtain the lighting calculator for all measures from BPA and the Option 2 utilities, except one. We were unable to obtain invoices for 50% of the Option 1-Lighting measures. For Option 2 utilities, the IM requires manufacturer cut sheets and invoices to substantiate the entries made in the calculator for Option 2 lighting projects. Option 2 projects almost always had invoices, but a substantial share was missing cut sheets.

[42] These requirements come from p. 100 (lighting) in the IM.

Table 19: Lighting: Project Documentation Required by Implementation Manual

		Percent Missing		
Option	Sector	Lighting Calculator	Mfg Cut Sheets	Contract/Vendor Invoices
1	Com/Ag	0%	N/A	50%
	Industrial	0%	N/A	50%
2	Commercial	3%	16%	2%
	Industrial	0%	17%	4%

Table 20 shows the corresponding IM requirements for Non-Lighting measures and the percent of Non-Lighting measures that were missing these documents. Any of the required documentation may provide useful information for evaluation purposes. Most important to the evaluation are the invoices, project completion and description documentation.

Other than ESRP, we found the highest incidence of missing invoices for Option 1-Non-Lighting measures (Com/Ag 20% and Industrial 30%). In some cases, we found that the end users had documented costs, but that the actual invoices that substantiate the costs were not included. In addition, the completion version of the Custom Project Calculator was missing for 13% of Option 1-Com/Ag measures. Note that because of BPA's completion report review process, these documents likely all existed at the time of approval, but the lack of central document repository makes it difficult to recover them a year or more after a project has been completed.

For Option 2 projects, the most frequent area of missing documentation was the M&V plan, followed by invoices.

Table 20: Non-Lighting and ESRP: Project Documentation Required by Implementation Manual

Option	Sector	Contract/ Vendor Invoices	Custom Project Calculator -Proposal	Project Proposal Supporting Documenta-tion	Custom Project Calculator-Completion	Project Completion Supporting Documentation	M&V Plan[1]	Detailed Project Descriptions[2]
1	Com/Ag	20%	0%	0%	13%	25%	N/A	N/A
	Industrial	30%	0%	0%	0%	0%	N/A	N/A
2	Commercial	9%	N/A	N/A	N/A	N/A	20%	8%
	Industrial	5%	N/A	N/A	N/A	N/A	15%	0%
ESRP[3]		100%	N/A	0%	N/A	60%	N/A	N/A

[1] IM table 4.1.3 states that M&V Plan, pre/post measurement data, assumptions, and modeled or calculated data used to determine energy savings.

[2] IM table 4.1.3 includes baseline and operating conditions necessary to determine energy savings and B/C ratio, documentation showing how the projected NEB and O&M costs were calculated

[3] ESRP not mentioned in the Implementation Manual but we considered it to be subject to the IM requirements for non-lighting measures.

3.4.4. Documentation Useful for Evaluation

We also tried to obtain documentation that was useful to our evaluation but was not required by the IM. Working savings models and metering data were the two most important types of documentation. As shown in Table 21, working models were received for only 55% of Option 2-Industrial measures and 60% of ESRP measures. Metering data was received from all measures (where it had been recorded) except for Option 2, where it was received for 94% of measures.

Table 21: Non-Lighting and ESRP: Availability of Working Models and Metering Data

Domain		Working Savings Model		Metering Data	
Option	Sector	Requested	% Received	Requested	% Received
1	Com/Ag	8	88%	7	100%
	Industrial	21	81%	20	100%
2	Commercial	23	83%	18	94%
	Industrial	20	55%	16	94%
ESRP		5	60%	2	100%

3.4.5. TAP Assignment

Our findings regarding TAP assignment and its implications for evaluation sampling and program quality control are as follows:

1. The reporting system only has TAP codes for custom measures. Option 1 Lighting measures are not considered custom and thus no TAP codes were provided. BPA stores the lighting calculators for all Option 1 lighting projects. We were able to match all these to project records in the reporting system and thus knew that they were lighting measures. We had to assign TAP codes to each item in these lighting calculators so that we could implement our definition of a measure (see Section 2.1).
2. All Option 2 measures (Lighting and Non-Lighting) are treated as custom and it is left to those utilities to assign TAP codes. There seems to be little consistency in how Option 2 utilities define measures and apply TAP codes. In some cases, they combine measures with different TAP codes into a single measure with a single TAP code. One sampled measure had both lighting and non-lighting measures combined under a lighting TAP code.
3. We verified TAP for all sampled measures and found a substantial number of misclassifications, especially for Option 2 measures. As shown in Table 22, more than 40% of TAPs were misclassified for Option 2 measures. This did little harm to the integrity of the sample selection. However, TAP misclassification makes it difficult for the program to determine whether the correct M&V protocols are being applied. This is especially true for Option 2 projects where there is no control over how the utility defines and reports TAPs for each measure.

Table 22: Frequency of TAP Misclassification

Domain				With Misclassified TAPS	
Option	Measure Type	Sector	Measures	Measures	Percent
1	Lighting	Com/Ag	33	N/A	
		Industrial	9	N/A	
	Non-Lighting	Com/Ag	8	0	0%
		Industrial	21	2	10%
2	Lighting	Commercial	62	31	50%
		Industrial	24	11	46%
	Non-Lighting	Commercial	23	12	52%
		Industrial	20	8	40%
ESRP			5	N/A	
Site-Specific Portfolio			**205**	**64**	**31%**

4. Recommendations

In this section we provide recommendations on how to improve program operations and future evaluations.

4.1. Increasing Reliability of M&V Savings Estimates

1. **Avoid Embedded Realization Rates**. An Option 2 utility is applying realization rates to its individual measure savings estimates prior to reporting savings to BPA. We recommend against this practice, as it appears to be over-estimating savings for the Option 2 domains and creates systematic differences in savings reported to BPA. Best practice is to apply realization rates the total savings for a domain or portfolio rather than in the individual measure savings data maintained the reporting system.
2. **Avoid or Improve Simplified Saving Calculators**: Some Option 2 projects use "deemed" values or simplified calculators for Non-Lighting measures. These do not provide reliable site-specific estimates of savings. We recommend that BPA require site-specific savings estimates in accordance with BPA M&V protocols or that these calculators be upgraded to conform to the RTF guidelines for Standard Protocols.
3. **Clarify M&V Protocols related to Typical vs. First Year Savings**. The BPA M&V protocols are not clear about whether to estimate savings for typical conditions or for the first year after measure implementation. We recommend BPA determines which savings estimates are required. Then make changes to the BPA protocols to provide specific guidance on how to appropriately handle all parameters in the savings model to achieve the required savings estimates.
4. **Clarify Current Practice Baseline**. The M&V protocols are not aligned with RTF Guidelines on the definition of current practice baselines. We recommend BPA investigate the differences and determine the best method for aligning these definitions.
5. **Improve Quality Control for ESRP projects**. The savings for this domain are being overestimated, although this domain accounts for only 3% of the portfolio. We recommend BPA provide additional quality control review of M&V data collection and modelling for these projects.
6. **Improve Lighting Calculators**: The BPA and Option 2 lighting calculators are not consistent and they both lack key features. We recommend that BPA modify its calculator and require that Option 2 calculators include the following features:
    - TAP coding for all line items, i.e., groups of fixtures.
    - Use standardized space types.
    - Use CBSA building types and create standardized sub-building types if greater specificity is required to align with HVAC interaction factors.

- Improve new-construction functionality allowing for adjustable operation hours and space-specific lighting power density.
- Incorporate revised HVAC interaction factors, currently under development by BPA, in the BPA and Option 2 utility lighting calculators.
- Include entries for NEBs such as changes in O&M costs and include calculation of lifetime costs, benefits and the resultant TRC ratio.

4.2. Improving Program Documentation

The following recommendations are based on what we observed in the documentation obtained for the sample. Some portions of these recommendations may have already been implemented prior to the publication of this report.

1. **Investigate Opportunities for Reducing Reporting and QC Burden.** There may be opportunities for reducing the reporting and quality control burden for utilities and BPA staff. We recommend BPA undertake a review of the information needed during each phase of development for both Option 1 and Option 2 projects. The review should identify opportunities for reducing redundancy or unnecessary reporting and for developing tools that reduce the reporting effort and facilitate quality control.
2. **Require Working Models**. We could not obtain a working M&V model for some projects. This makes evaluation and BPA quality control much more difficult. We recommend requiring submission of working M&V models.
3. **Document M&V Protocol and Project Engineer**. Project documentation does not currently indicate what M&V protocol was used in estimating savings or the name of the assigned project engineer (BPA, utility or ESIP). We had to deduce the protocol that should have been used and infer what protocol was used from the supporting documentation. Therefore, we recommend that BPA require reporting of the M&V Protocol used for a project and the justification for its selection; as well as noting the project engineer that made these decisions. Additionally, the Option 2 utilities should all be documenting the M&V plan used for each project.
4. **Obtain and Store Project Invoices**. We could not obtain invoices for half of the Option 1 Lighting measures. The invoice provides important substantiation of what equipment was purchased. The data are important for evaluation and BPA quality control. We recommend that BPA consider ways to improve the collection and storage of invoices. End user documentation of costs should not be accepted in lieu of invoices that substantiate those costs.
5. **Improve Document Organization and Version Control**. Especially for Non-Lighting measures, project documentation has many components (e.g., meter data files, project application, project completion report, invoices and cut sheets) and it is difficult to determine how the data in this documentation are used in estimating savings. In addition, there may be multiple versions for some of these components. We recommend that documents be organized in a standardized folder structure. A best practice example is the

file structure used for ESRP sites. Old versions of any file should be stored in separate sub-folders. In addition, an analysis map should be included that indicates how each supporting data file is used in estimating savings.

6. **Document Project Specifications**. We found that it is often difficult to understand the exact specifications for measures. This is important for evaluation and BPA quality control. We recommend that key system specifications are included in the documentation, e.g. photos of nameplates and cut sheets. For cut sheets, indicate which specific make and model is used by the measure. Consider requiring cut sheets for Option 1 Lighting measures unless power measurements are taken for the affected equipment.
7. **Document Milestone Dates**. We found it is often difficult to deduce important milestone dates in the current documentation. Such dates are critical to determining which data are relevant to the measure baseline and efficient-case energy use. Important dates include: start of implementation, final inspection, commissioning completion, M&V data collection start and end. We recommend that these dates be included in the project documentation.
8. **Improve TAP Coding**. TAP coding is not being done for Option 1 Lighting measures. In addition, consistent rules are not being applied to custom measures, including Option 1 Non-Lighting and all Option 2 measures. This makes it difficult to determine what M&V protocols should apply. In some cases, projects that contain multiple measures are not being appropriately divided into separate measures with distinct TAP codes. We recommend that BPA develop and enforce quality control procedures for TAP coding. These procedures should require that projects comprising multiple TAPs be entered as a series of TAP-specific measures. In addition, TAP codes should be modified so there is a single TAP for Lighting Power Density changes.

4.3. Conducting Future Evaluations

1. **Align evaluation procedures with M&V protocols**. As noted above, the BPA M&V protocols need additional clarifications regarding typical vs first-year savings and current practice baselines. Once BPA clarifies these factors, we recommend that future evaluation protocols are consistent with them.
2. **Consider Faster or Real-Time Evaluation**. We found that this evaluation was hampered by the long duration from project completion to evaluation. We recommend that BPA consider conducting a more streamlined evaluation process that uses recent projects. A further improvement would be to conduct “real-time” evaluation on current projects that would allow evaluation to work closely with project engineers. The evaluators could advise on the implementation of M&V protocols, work with the project engineer in implementing evaluation protocols for sampled measures, and advise on the collection of baseline data useful for both M&V and evaluation.
3. **Require and Simplify End User Contact**. Per BPA direction, this evaluation tried to limit the number of end user sites visited and relied in some cases only on program documentation. This made it difficult to confirm the current condition of measures and whether there were any relevant changes during the first year of measure operation. This also led to utility and

end user contact protocols that were complex and difficult to enforce and track. We recommend that end user contact protocols be simplified and that future evaluations plan to make contact with all sampled end users, including as needed telephone calls, email or site visits.

4. **Improve Tracking of Utility and End-user Contact**. For some sampled measures, we failed to notify utilities when the site visit was scheduled. We recommend future evaluations institute better tracking systems to ensure that this does not happen.
5. **Ensure all Site-Specific projects are included in evaluation**. Due to reporting system issues, this evaluation did not include SIS or Energy Smart Grocer custom projects, although they both have site-specific savings measures. BPA should ensure that any future evaluations of site-specific savings include all measures using standard protocols and any regional programs tracked out of the primary BPA reporting system.

TECHNICAL APPENDICES

A. Definitions of Key Terms

We rely on the following definitions of key terms throughout this report.

Reporting System

BPA uses its reporting system to track projects completed by public power utilities under various programs and initiatives. For Option 1 utilities, BPA has detailed custom project proposals and completion reports in its system (Option 1 Custom Project Calculator). Option 2 utilities report high-level project information into the BPA system periodically (Option 2 Custom Project Calculator).

Domain

Domains are components of the portfolio. They are defined by Option (utilities are Option 1 or 2 for M&V purposes), Measure Type (Lighting, Non-Lighting, or Energy Smart Reserve Projects), and Sector (Industrial and Commercial or the combination of commercial and agricultural for Option 1 utilities).

Option 1

Under Option 1, BPA manages the bundle of energy savings from custom projects. This requires that BPA manage the portfolio risk for both project performance and cost-effectiveness. Often, BPA is involved throughout the project lifecycle by providing technical support, M&V implementation, approval of projects and oversight/evaluation.

Option 2

Under Option 2, the customers manage the bundle of savings from their custom projects. This entails the customers managing the risk of project performance and cost-effectiveness by conducting all aspects of M&V and custom project quality control (e.g., project proposal and project completion documentation review) internally.

Energy Smart Reserve Power (ESRP)

ESRP is an energy efficiency incentive program for irrigation districts, hydroelectric facilities, substations, fish hatcheries and other facilities that access reserved power directly from the Federal Columbia River Power System (FCRPS).

Project

A project is a phase of work at an end user location that improves energy efficiency. An end-user is the customer of a BPA utility. The project tracking data records a date when the project is complete. The data also contains information such as the name of the end user, the location where the work was carried out, and other data critical to this evaluation. End users may authorize the completion of many phases of work, each of which is tracked as a separate project in the BPA reporting system.

Measure

A measure is a collection of items, within a project, that have the same Technology/Activity/Practice (TAP) description. The BPA reporting system uses a standardized taxonomy (Technology/Activity/Practice) for classifying measures. For many projects, BPA or utility staff assigns one of eighty-six Technology/Activity/Practice (TAP) descriptions to each item of work comprising a project. For Option 1 lighting, the evaluation team assigned TAP based on the data in the BPA lighting calculators. For example, lighting projects may have many items describing specific lamp and ballast combinations, but all of them would be assigned the TAP code indicating “Lamps/Ballasts.”

Project Engineers

Project engineers assist in the identification, development, savings estimation, cost-effectiveness analysis, measurement and verification and quality control review of projects. Project engineers may be BPA staff, utility staff, or staff of BPA or utility project implementation contractors. For the purposes of this evaluation, project engineers are not staff or contractors employed by the end users, even though the end user workforce may have played an important role in the development of a project.

M&V Model

This M&V model (an algorithm or calculation procedure) is the model used by project engineers to estimate savings for the measures that comprise a project. The BPA lighting calculator is an example of such a model. Models for other measures might be building simulation models such as eQUEST, custom-engineered or standardized spreadsheet calculators, and custom regression models (such as those developed using ECAM).

Reported Savings

The savings estimated by the project engineers and entered in the BPA reporting system. These savings are based on the M&V model. Please note that the BPA system uses the term “estimated savings” for the savings estimated at the proposal stage and “actual savings” for the savings at the completion report stage. Reported Savings are based on the “actual savings” field in the reporting system[43]. “Actual savings” is busbar savings; equal to 1.09056 times site savings.

Evaluation Model

This is the model selected by our evaluation team to re-estimate savings for sampled measures. The same types of models as listed above for the M&V models are possible. Please note that although the evaluation model may differ from the M&V model, this does not necessarily mean that the M&V model was inappropriate for the project. Therefore, there may be cases where a more reliable model is used in evaluation of a sampled measure, even though that model would not be cost-effective for M&V on all measures.

Evaluation Savings

The savings estimated by the evaluation team. These savings are based on the evaluation model and rely on best practical data collection and savings estimation practices, as laid out in the Guidelines, and informed by evaluator experience.

[43] Note that BPA is in the process of changing the word “actual” to “verified” for reporting purposes.

The evaluation estimated the savings achieved during the first year of measure operation. If any of the evaluation data collection occurs more than one year after the measure was complete, it may indicate failures in the measure performance that are relevant to measure lifetime and not to the first-year savings. Evaluation savings estimates reflect the conditions of the measure during the first year of operation.

Realization rate

Realization rate is the ratio of evaluation savings to reported savings. Realization rates greater than one mean that we found more savings than was reported.

Key Determinants

Key determinants influence the savings from a measure. The evaluation considered the following key determinants.

- **Connected load.** Baseline or efficient-case rated kW demand and/or the quantity of the equipment.
- **Efficiency profile.** Part-load impacts on demand profile, including VFDs and HVAC interaction factors.
- **Hours of operation.** Baseline or efficient-case schedule of operation for a measure.
- **Load Profile.** Level and frequency of dimming for lighting measures. For Non-Lighting measures this category includes commercial building occupancy rates and changes not captured by other categories of key determinants.
- **Production** (non-lighting only). Number of production units per unit of time.
- **Weather** (non-lighting only). Weather-based data used for weather-sensitive measures, such as dry and wet-bulb temperatures, or heating and cooling degree-days.

Reasons for change

What we changed which caused a modification to one or more key determinants and ultimately savings. We assigned all reasons to one of the three following categories.

- **Algorithm.** These include changes in the model used to calculate savings such as the change to using the BPA 3.1 calculator for lighting measures or additional parameters added to a bin model, billing regression, or engineering calculation.
- **Input.** This would indicate that the value for the key determinant in the project documentation was correct but the value entered in the savings calculation did not match what was in the documentation. It could also indicate that the key determinant in the project documentation did not match what was found during the site visit

The only exception to the definitions of Input is that all changes to hours of operation for lighting were labeled Input changes because the original lighting calculator served as the project documentation.

Measure Baseline

Measure savings must be determined against clearly defined baseline conditions. The RTF Guidelines define two possible baseline conditions, which are used in this evaluation plan:

- **Current Practice**. A current practice baseline is used if the measure affects systems, equipment or practices that are at the end of their useful life. The baseline is defined by the recent typical choices of the end user in purchasing new equipment and services. Current practice baseline is also used for new construction projects where there is no pre-existing systems, equipment or practices.
- **Pre-Conditions**. A pre-conditions baseline is used when the measure-affected equipment or practice still has remaining useful life. The baseline is defined by the existing condition at the end user site just prior to the delivery of the measure.

ProCost Model

ProCost is a spreadsheet tool, developed by the Northwest Power and Conservation Council, which computes Regional measure lifecycle cost-effectiveness. ProCost uses Regional economic and power system assumptions that are updated with each Council Power Plan.

Measure Lifetime

Measure lifetime, according to the RTF Lifetime Guideline, is defined as the median number of years during which at least half the deliveries of a measure are in place and operable, i.e., producing savings. For example, consider the installation of 100 VFDs on pumps. If the VFDs were regularly inspected for many years it would be possible to determine when each one became inoperable (failed mechanically or electrically or was removed from service). The lifetime for the measure would be the median number of years to measure failure, i.e., no longer producing savings. An estimate of measure lifetime is a required input to ProCost.

Incremental Costs and Benefits

When a measure is delivered, costs are incurred and benefits realized, e.g., value of electricity savings and other non-electric benefits such as changes in operations and maintenance expenses. Only incremental costs and benefits are used in estimating a life cycle costs and benefits.

A measure’s incremental costs and benefits are those incurred in the efficient case delivery, beyond what is required to establish and maintain the baseline condition. For a pre-condition baseline, the baseline does not involve any change and thus baseline costs and benefits are zero. In this case, incremental costs and benefits are equal to the efficient case costs and benefits. For measures with a current practice baseline, the baseline condition does require a change and therefore has costs and benefits. In this case, the incremental costs are the difference between the efficient case and the baseline case delivery.

NEBs (Non-Electric Benefits)

Non-electric benefits are defined as any benefit, positive or negative that is not captured by the value of the electric savings or the measure incremental cost. NEBs include changes caused by the measure in the costs of operation and maintenance or other utilities such as gas, water or wastewater. Further explanation of these benefits can be found in the RTF Guidelines (Guidelines for the Estimation of Incremental Measure Costs and Benefits).

Total Resource Cost (TRC) Test

Perspective of cost-effectiveness testing that includes all cost and benefits of a measure, regardless of who pays for or receives them. BPA uses the definition of the TRC test consistent with the Northwest Power and Conservation Council.

B. Site-Specific Saving Estimation

This appendix describes how we estimated saving for lighting and non-lighting measures.

B.1. Lighting Measures

The following methods were used in estimating lighting savings.

Model Selection

Program lighting calculators included two earlier versions of BPA's lighting calculator and four Option 2 utility calculators. As prescribed by the evaluation plan, we used BPA's 3.1/3.3 lighting calculator (with an adjusted baseline) for this evaluation. The calculator was used in creating two models for each lighting measure:

- **Program Model**: This model recreated, as closely as possible, the original inputs from the program calculator. We used this model to confirm that we had not misrepresented any of the items in the program calculator. This also allowed us to quantify the impact of changing from the program calculator to the new evaluation model.
- **Evaluation Model**: The inputs to this model were based on the data we collected from program documentation, discussion with project engineers, interviews with end users and building occupants, metering of operating hours, and inspection of fixture counts, fixture wattages, and control inputs.

New construction (lost opportunity) lighting projects were encountered for Option 2 measures. Some of these program calculators utilized baseline energy code lighting power allowance (LPA) values and hours of operation *by space use type*. By contrast, BPA's 3.1 calculator allows only one whole building kW value entry for total code baseline LPA and one kW value for total efficient lighting. Additionally, annual hours of operation for the 3.1 calculator are from a lookup table that allows only one value for annual hours of operation by building use type. We found that the 3.1 calculator did not allow us to reliably estimate savings for these new construction measures. The BPA engineering team was consulted and the solution was to use BPA's 3.3 calculator in retrofit mode and enter the row by row entries for the proposed fixture types and quantities with corresponding space use type operating hours. Code baseline LPAs were forced into the calculator by creating 'existing' fixture input wattages that replicated code baseline LPA values.

BPA allows large Option 1 lighting projects to follow the custom project path. A small number of these were present in the evaluation sample but they received the same treatment as the other Option 1 and Option 2 lighting projects.

Baseline Adjustment

We modified the BPA 3.1 calculator to alter the arithmetic baseline function[44], an operation used to discount baseline lamp wattage for lamp types, such as T-12s, which are being phased out under the federal Energy Policy Act (EPAct), and incandescent lamps, which have tighter efficacy requirements under the Energy Independence and Security Act (EISA). This modification was needed as neither EPAct nor EISA were fully in effect for the full evaluation timeframe of FY2012-13. This calculator modification serves to preserve the same lighting baseline as the earlier BPA calculator versions (2.2 and 2.3) found in the evaluation sample and the Option 2 utility calculators. Accordingly, this allows the evaluation sample sites to receive full savings credit for baseline fixtures potentially affected by the EPAct and EISA legislation.

Verify Project Characteristics

During our site visit we confirmed the following:

- Project start and completion dates.
- Type of baseline controls or equipment that was replaced.
- That space use type indicated in the program calculator was representative of the actual space type observed.
- Determine if any changes have been made to the lighting system since the project was completed and when they occurred.

Determing Connected Load (Capacity)

We collected data on the sampled measure's connected load characteristics: fixture quantities, fixture type, lamp wattage, and ballast type.

- Fixture wattage:
  - Baseline fixture types documented in the program calculator were generally accepted. We asked facility personnel for information on the baseline system and occasionally found that baseline fixture types that were removed or retrofit differed from the project documentation, in which case the new information was used.
  - Efficient wattages were determined from the BPA calculator lookup tables. For Option 2 utility calculators, these wattages were subject to verification through product cut sheets usually found in the program files or other research if cut sheets were missing. Mapping Option 2 fixture types to the BPA calculator was straightforward although wattages frequently were slightly different due to differences in each calculator's fixture wattage lookup table.
- Fixture quantities: Fixture counts were made during the site visit. In instances where there were more fixtures than practical to count while on an escorted site visit, sampling was done by space use types and overall savings impact to get a representative count of fixtures.

[44] ArithBaseline table and associated code in the BPA 3.1 calculator

- Baseline fixture counts were usually accepted unless site personnel or onsite observations indicated a difference in baseline counts from what the program calculator indicated.
- Efficient fixture count was based on onsite observations.

Meter Hours of Operation

We followed the protocols below to determine when metering was required and how that data was processed to estimate evaluation hours of operation.

- **24/7 lighting**: As part of the phone interview or site visit, we interviewed site personnel knowledgeable in lighting system operations. As a general rule, if the site contact indicated the lights were never turned off, we accepted that statement, did not install light metering equipment, and entered 8,760 hours of operation for that lighting equipment.
- **Exterior photocell controlled lighting:** We inspected photocell controlled lighting (on/off photocells only, with no timer or occupancy sensors present) for general working condition and discussed its operation with the site contact. If we concluded the photocell controls were operating reliably, the associated fixtures were classified as exterior lighting and assigned 4,380 hours of operation.
- **All other[45] lighting**. If the measure was uncontrolled except for manual switching we metered with light loggers. If the lighting was controlled by a timer, we inspected the timer and its programming. We consulted the end user as needed and determined whether the timer was reliable. If we determined that it was reliable we computed hours of operation based on the timer programming, otherwise we installed light loggers.

  Power metering was used instead of lighting loggers in the following circumstances:

  - Exterior lighting with occupancy control and/or bi-level dimming. When dimming-only controlled circuits could be isolated, an equivalent full load hour's value was derived from the data.
  - Interior lighting circuits with daylight dimming. When dimming-only controlled circuits could be isolated, an equivalent full load hour's value was derived from the data.
  - High bay lighting where it was impractical to place loggers near the fixture.

Baseline hours of operation were usually taken from the program calculator. Adjustments were sometimes made based on information from program documentation or interviews with end users or occupants.

Whether light logging or power metering was used to determine evaluation operating hours, the raw meter data was compiled, sorted by day type, and annual hours of operation calculated taking into account information collected from the site on schedules, holidays, and other factors. For controlled lighting, the uncontrolled annualized hours of operation were entered

[45] The program metered baseline and efficient hours of operation for some measures. We used this data where it was available and reliable in lieu of additional metering.

into the evaluation model by space use type, then the percent reduction in hours was entered into the control section of calculator so that the resulting net hours of operation equaled the annualized logger hours for that space.

The number and location of meters/loggers deployed at each site was not subject to a strict sampling protocol but was left up to the judgement of the our staff to meter a representative sample of fixtures and space use types within the facility. In some cases, we elected not to meter smaller areas and fixtures of less significance. In those instances, hours of operation information from facility staff and/or occupants were used to provide hours of operation for the evaluation model. Additionally, interviews with onsite personnel provided valuable information to help us define space use types and to describe facility operations with regard to lighting system operation.

Adjust for HVAC Interactions

We collected HVAC system, fuel type, and building type data at each site. Those data were used to select the appropriate interaction factor. We noted some differences between the BPA calculators, the Option 2 calculators, and the RTF Table of Lighting HVAC Interaction Factors by Building. Nonetheless, the HVAC interaction factors used by the evaluation were based on those in BPA's current calculator.

B.2. Non-Lighting Measures

We used many different methods to collect data and estimate savings for non-lighting measures.

HVAC

HVAC measures typically involved improvements to system controls, building envelopes, or heating, cooling and ventilation device efficiency. Estimating savings for these measures involved collecting performance specifications for efficient and baseline systems, operation data in the form of trend logs or true power metering, building set-point data and weather data in the form of typical meteorological year (TMY3) or if possible and appropriate, site logged dry-bulb temperature data. Models were developed which relate HVAC performance to dry bulb temperature for both baseline and efficient systems. Energy savings was the difference in energy consumption of the two systems performing under the same weather conditions.

Compressed Air

Compressed air measures typically involved installation of higher efficiency compressors and system control strategy improvements. Compressor operation is typically driven by process demands and system leaks. Compressor power, operational set-points, performance specifications such as Compressed Air and Gas Institute performance curves, and, when possible, airflow data were used to estimate energy consumption of baseline and efficient systems. When baseline power data was not available, compressor performance curves were used to map baseline operation to first-year airflow conditions. Energy savings was the difference in energy consumption between the baseline and efficient compressor operation.

Refrigeration

Refrigeration measures typically involved improved refrigeration system control strategies, compressor and fan improvements, and refrigeration envelope improvements. Analysis of these systems involved data collection of operational and performance data of key components such as refrigeration compressors, evaporator fans, floating set-point controllers, and dry bulb temperatures. In some cases a total building metering approach was applied which characterized the contribution of the refrigeration system to total building energy consumption for baseline and efficient periods as a function of production and weather. Baseline performance was then normalized to efficient conditions using production and weather data. If reliable first-year weather data could not be acquired, TMY3 data from the nearest weather station was used. Energy savings was the difference in system energy consumption between the baseline and efficient systems assuming first-year refrigeration load and weather conditions.

Motors and Drives

Motor and drive measures typically involved installation of VFD drives and high efficiency motors. Estimation of motor and drive energy savings was primarily achieved through estimation of motor and drive load profiles. Typically end-use metering was performed to develop characteristic load and performance profiles for baseline and efficient systems. Characteristic curves such as pump and fan curves were used when appropriate to estimate performance profiles. Savings was based on the difference in performance between the efficient and baseline systems when operating in the first-year load conditions.

Industrial Process

Industrial process measures encompassed a wide variety of process improvements. These improvements could be anything from load reductions on existing devices to replacement of older devices with newer more efficient ones. For some measures, we modelled the performance of affected systems and equipment to represent the effects of the efficiency measure on the process's energy consumption. Other measures were modelled using billing and production data. In either case, energy savings was the difference in energy consumption between the baseline and efficient systems operating under the first-year production conditions.

Irrigation

There was one irrigation measure which involved pump system improvements including the installation of gravity feed piping, a booster pump, and trim pump. Baseline and efficient-case end-use metering data was used to estimate first year savings with the baseline system normalized to first year irrigation conditions using evaporation rate and crop water consumption data provided by the site contact.

Energy Smart Reserve Projects

Energy Smart Reserve Project (ESRP) measures typically involved water delivery efficiency improvements within irrigation districts that served to both reduce pump plant energy consumption and increase water availability for hydro-electric power production. Savings estimates for these measures involved first calculating water savings according to documented canal seepage models and then estimating the resulting pump and hydro-electric energy savings based on deemed values for energy savings per acre-foot of reduced water usage. One other ESRP measure required analysis of total billed energy combined with a range of system specific control parameters normalized to first-year operation and production.

C. Findings for Each Sampled Site

This appendix lists the evaluation findings for each measure.

C.1. Lighting

Table 23: Sampled Lighting Measures

Option	Sector	Building Type	Funder	ID	Reported Savings (kWh)	Reali-zation Rate	Case Weight	Total Resource Cost Test
1	Com/Ag	Other	BPA	LCC005359_CLILB82046	4,023	0.98	241.38	0.68
1	Com/Ag	Other	BPA	LCC001844_CLILB82045	7,783	0.67	241.38	2.92
1	Com/Ag	Other	BPA	LCC003748_CLILB82045	10,168	0.60	241.38	1.28
1	Com/Ag	Office	BPA	LCC004351_CLILB82046	10,471	1.05	241.38	1.86
1	Com/Ag	Retail	BPA	LCC004730_CLILB82045	14,174	1.23	241.38	1.87
1	Com/Ag	Other	BPA	LCC004490_CLILB82045	15,182	0.97	241.38	3.97
1	Com/Ag	Other	BPA	LCC000747_CLILB82045	17,524	1.11	99.13	5.42
1	Com/Ag	Warehouse	BPA	LCC005813_CLILB82045	20,514	0.75	99.13	3.56
1	Com/Ag	School	BPA	LCC005835_CLILB82045	27,229	0.88	99.13	0.93
1	Com/Ag	Office	BPA	LCC005344_CLILB82046	35,720	0.98	99.13	6.44
1	Com/Ag	University	BPA	LCC004497_CLILB82045	38,174	1.03	99.13	1.72
1	Com/Ag	Retail	BPA	LCC000619_CLILB82045	43,176	1.01	99.13	2.52
1	Com/Ag	Grocery	BPA	LCC005726_CLILB82045	51,359	0.70	99.13	2.80
1	Com/Ag	Other	BPA	LCC004287_CLILB82046	54,225	1.23	31.00	2.95
1	Com/Ag	Other	BPA	LCC005122_CLILB82045	55,973	1.19	31.00	5.26
1	Com/Ag	Retail	BPA	LCC003261_CLILB82045	64,077	0.97	31.00	3.72
1	Com/Ag	Other	BPA	LCC004489_CLILB82045	81,346	0.94	31.00	6.73
1	Com/Ag	School	BPA	LCC005454_CLILB82045	81,877	1.02	31.00	3.10
1	Com/Ag	School	BPA	LCC004643_CLILB82045	96,259	1.02	31.00	2.79
1	Com/Ag	Other	BPA	LCC003900_CLILB82045	152,198	1.01	31.00	2.36
1	Com/Ag	Retail	BPA	LCC002574_CLILB82045	159,773	0.83	31.00	4.02
1	Com/Ag	Other	BPA	LCC001934_CLILB82045	180,337	0.58	6.00	3.16
1	Com/Ag	Retail	BPA	LCC006033_CLILB82045	182,488	1.01	6.00	2.50
1	Com/Ag	Other	BPA	LCC003234_CLILB82045	189,616	0.99	6.00	16.08
1	Com/Ag	Office	BPA	LCC001941_CLILB82045	189,943	1.00	6.00	5.67
1	Com/Ag	Other	BPA	LCC005489_CLILB82045	218,073	1.00	6.00	1.03
1	Com/Ag	School	BPA	LCC003579_CLILB82045	236,391	0.68	6.00	1.78
1	Com/Ag	School	BPA	LCC003592_CLILB82045	374,358	0.64	6.00	1.29
1	Com/Ag	Hospital	BPA	LCC000729_CLILB82045	822,598	0.49	2.00	1.24
1	Com/Ag	Other	BPA	LCC006035_CLILB82045	1,795,706	0.86	2.00	2.64
1	Com/Ag	Other	BPA	LCC003287_CLILB82045	2,753,888	0.96	2.00	1.56

Option	Sector	Building Type	Funder	ID	Reported Savings (kWh)	Reali-zation Rate	Case Weight	Total Resource Cost Test
1	Com/Ag	Other	BPA	LCC005960_CLILB82045	4,355,003	1.01	1.00	9.01
1	Com/Ag	Other	BPA	LCC005959_CLILB82045	4,470,961	1.03	1.00	8.49
1	Industrial	Manufacturing	BPA	LCI000215_ILILB83047	2,724	0.76	109.00	6.67
1	Industrial	Manufacturing	BPA	LCI000266_ILILB83047	48,417	1.06	109.00	3.85
1	Industrial	Manufacturing	BPA	LCI000445_ILILB83047	73,274	1.08	29.50	4.03
1	Industrial	Warehouse	BPA	LCI000331_ILILB83047	91,807	1.01	29.50	4.35
1	Industrial	Other	BPA	LCI000217_ILILB83048	337,881	0.88	9.50	1.23
1	Industrial	Other	BPA	LCI000412_	557,168	0.64	9.50	23.87
1	Industrial	Manufacturing	BPA	1RI001800_ILILB83048	1,059,750	1.05	3.00	4.95
1	Industrial	Manufacturing	BPA	LCI000111_ILILB83048	1,279,487	0.91	3.00	4.41
1	Industrial	Manufacturing	BPA	2593_ILILB83046	3,424,196	1.04	1.00	5.49
2	Commercial	Office	BPA	2RC007498_CLILB82045	7,957	1.04	110.00	2.93
2	Commercial	Office	BPA	2RC007199_CLILB82041	8,179	0.53	110.00	4.88
2	Commercial	Other	BPA	2RC006052_CLILC82050	8,295	1.46	36.50	1.05
2	Commercial	Grocery	BPA	2RC001895_CLILB82041	8,753	1.08	77.00	1.29
2	Commercial	Manufacturing	BPA	2RC005984_CLILB82045	9,109	0.69	36.50	1.61
2	Commercial	Retail	BPA	2RC002918_CLILB82048	9,764	0.77	77.00	2.29
2	Commercial	Other	BPA	2RC007106_CLILB82045	11,594	1.20	114.25	1.42
2	Commercial	Other	BPA	2RC002693_CLILB82048	12,267	1.02	77.00	2.38
2	Commercial	Other	BPA	2RC005252_CLILB82046	13,232	1.04	114.25	3.21
2	Commercial	Manufacturing	BPA	2RC003105_CLILB82048	13,331	0.40	77.00	1.26
2	Commercial	Retail	BPA	2RC002148_CLILB82046	15,171	1.35	114.25	5.39
2	Commercial	Warehouse	BPA	2RC007419_CLILB82041	16,629	1.40	36.50	5.90
2	Commercial	Other	BPA	2RC005316_CLILB82045	17,139	2.23	114.25	4.65
2	Commercial	Manufacturing	BPA	2RC006165_CLILB82046	17,729	0.98	36.50	1.61
2	Commercial	Other	Utility	2RC007676_CLILB82046	21,287	1.05	61.00	2.38
2	Commercial	Office	BPA	2RC004221_CLILC82051	21,729	1.16	62.25	1.16
2	Commercial	Retail	BPA	2RC002825_CLILB82048	22,929	1.29	61.00	3.11
2	Commercial	Retail	BPA	2RC002904_CLILB82048	27,994	1.10	61.00	8.57
2	Commercial	Other	BPA	2RC006948_CLILB82046	28,102	1.37	62.25	8.63
2	Commercial	Retail	BPA	2RC005230_CLILB82046	30,325	1.14	62.25	5.57
2	Commercial	Other	BPA	2RC003332_CLILB82046	34,834	-0.35	62.25	-0.78
2	Commercial	Other	Utility	2RC002705_CLILB82048	38,340	1.00	29.00	1.90
2	Commercial	Other	Utility	2RC006237_CLILB82044	45,212	1.06	14.25	4.61
2	Commercial	Office	Utility	2RC007055_CLILB82046	52,166	0.97	30.00	0.92
2	Commercial	Other	BPA	2RC001871_CLILB82045	54,989	1.65	29.00	5.53
2	Commercial	Retail	Utility	2RC005450_CLILB82046	55,393	0.96	29.00	1.76
2	Commercial	Manufacturing	BPA	2RC005980_CLILB82045	64,195	0.74	14.25	2.81

Option	Sector	Building Type	Funder	ID	Reported Savings (kWh)	Realization Rate	Case Weight	Total Resource Cost Test
2	Commercial	School	Utility	2RC006235_CLILB82044	79,225	0.58	14.25	0.70
2	Commercial	Retail	Utility	2RC002754_CLILB82048	85,139	1.48	9.75	5.61
2	Commercial	Hotel/Motel	BPA	2RC005336_CLILB82045	85,447	1.46	30.00	4.44
2	Commercial	Retail	Utility	2RC003032_CLILB82048	86,556	0.94	9.75	4.35
2	Commercial	Retail	BPA	2RC006051_CLILB82041	89,316	1.49	14.25	4.12
2	Commercial	Office	Utility	2RC002192_CLILB82045	96,290	1.40	30.00	3.11
2	Commercial	Retail	Utility	2RC001999_CLILB82046	106,450	0.77	9.75	2.19
2	Commercial	Other	BPA	2RC007180_CLILC82049	116,908	0.82	15.00	6.43
2	Commercial	Other	BPA	2RC003235_CLILB82046	116,932	0.93	30.00	3.75
2	Commercial	School	Utility	2RC005989_CLILB82044	124,467	0.57	8.75	1.05
2	Commercial	Manufacturing	Utility	2RC006007_CLILB82045	130,434	1.04	8.75	4.37
2	Commercial	Manufacturing	Utility	2RC006249_CLILB82045	132,514	0.98	8.75	2.99
2	Commercial	Other	BPA	2NC005273_	146,647	1.04	11.25	0.18
2	Commercial	Retail	BPA	2RC004130_CLILB82046	148,849	0.53	11.25	6.28
2	Commercial	Warehouse	BPA	2RC005992_CLILB82046	154,235	1.29	8.75	5.74
2	Commercial	Office	Utility	2RC002002_CLILB82045	169,215	1.10	9.75	2.93
2	Commercial	Warehouse	Utility	2RC003051_CLILB82048	187,225	1.07	6.00	3.70
2	Commercial	University	BPA	2RC007230_CLILB82048	215,849	0.88	15.00	1.38
2	Commercial	Grocery	BPA	2NC004158_	219,278	0.76	11.25	40.39
2	Commercial	Grocery	Utility	2NC004151_	230,532	0.90	11.25	22.34
2	Commercial	Hospital	BPA	2RC007401_CLILB82046	257,784	0.97	5.50	2.29
2	Commercial	Retail	Utility	2RC002976_CLILB82048	268,410	1.42	6.00	5.63
2	Commercial	Other	Utility	2RC005519_CLILB82046	302,119	0.98	6.00	1.50
2	Commercial	Other	Utility	2RC003317_CLILB82045	309,776	1.19	3.00	1.51
2	Commercial	Warehouse	Utility	2RC004233_CLILB82045	393,232	1.45	3.00	10.00
2	Commercial	Retail	Utility	2RC002978_CLILB82048	402,730	1.05	1.00	3.49
2	Commercial	Office	Utility	2RC003345_CLILB82045	416,034	1.11	3.00	1.87
2	Commercial	Retail	Utility	2RC003423_CLILB82045	442,425	1.37	3.00	4.42
2	Commercial	Retail	Utility	2RC006221_CLILB82041	462,878	1.71	5.50	8.38
2	Commercial	Other	Utility	2RC002033_CLILB82045	478,737	0.71	1.00	1.29
2	Commercial	University	Utility	2RC006223_CLILB82044	535,394	1.03	2.33	2.46
2	Commercial	University	Utility	2RC006129_CLILB82044	859,968	1.10	2.33	2.12
2	Commercial	Office	BPA	2RC007417_CLILB82046	1,061,116	0.95	2.33	-2.60
2	Commercial	Office	Utility	2NC003409_	1,127,579	1.99	1.00	1.06
2	Commercial	Other	Utility	2RC003331_CLILB82045	3,269,086	1.21	1.00	1.26
2	Industrial	Manufacturing	BPA	2RI002830_ILILB83048	8,638	1.61	13.00	2.91
2	Industrial	Manufacturing	BPA	2RI002859_ILILB83050	11,119	1.31	13.00	4.60
2	Industrial	Retail	BPA	2RI002880_ILILB83048	16,123	1.45	13.00	2.71

Option	Sector	Building Type	Funder	ID	Reported Savings (kWh)	Reali-zation Rate	Case Weight	Total Resource Cost Test
2	Industrial	Manufacturing	Utility	2RI006001_ILILB83044	21,332	0.96	2.00	1.83
2	Industrial	Manufacturing	BPA	2RI001880_ILILB83043	21,847	0.61	13.00	1.28
2	Industrial	Manufacturing	BPA	2RI007415_ILILB83047	23,939	1.29	2.00	3.78
2	Industrial	Manufacturing	BPA	2RI005302_ILILB83047	72,356	0.97	5.00	6.61
2	Industrial	Other	BPA	2RI003430_ILILB83047	74,973	0.83	5.00	2.01
2	Industrial	Other	BPA	2RI003415_ILILB83047	81,321	0.93	5.00	2.86
2	Industrial	Manufacturing	Utility	2RI006091_ILILB83044	104,038	1.19	2.00	1.85
2	Industrial	Manufacturing	Utility	2RI003294_ILILB83047	105,120	0.96	2.50	0.90
2	Industrial	Manufacturing	BPA	2RI003764_ILILB83046	123,927	0.86	1.00	2.54
2	Industrial	Manufacturing	Utility	2RI001888_ILILB83048	138,781	1.02	2.17	8.19
2	Industrial	Manufacturing	Utility	2RI003297_ILILB83047	152,133	1.16	2.50	4.73
2	Industrial	Manufacturing	Utility	2RI006025_ILILB83044	172,015	0.79	2.00	2.90
2	Industrial	Manufacturing	Utility	2RI003141_ILILB83050	181,428	1.07	2.17	13.89
2	Industrial	Manufacturing	Utility	2RI005382_ILILB83048	251,613	1.04	2.17	2.34
2	Industrial	Manufacturing	Utility	2RI001889_ILILB83048	262,194	0.97	2.17	8.32
2	Industrial	Manufacturing	BPA	2NI007679_	295,101	0.82	2.17	9.07
2	Industrial	Manufacturing	Utility	2RI003285_ILILB83047	422,356	1.23	1.00	3.51
2	Industrial	Manufacturing	Utility	2RI002951_ILILB83048	667,884	0.94	2.17	6.79
2	Industrial	Manufacturing	Utility	2RI004694_ILILB83047	799,277	0.97	1.00	3.62
2	Industrial	Manufacturing	Utility	2RI004199_ILILB83047	1,027,335	1.19	1.00	9.00
2	Industrial	Manufacturing	BPA	2RI003013_ILILB83048	1,180,541	1.08	1.00	3.35

C.2. Non-Lighting

Table 24: Sampled Non-Lighting Measures

Option	Sector	End Use	Funder	ID	Reported Savings (kWh)	Reali-zation Rate	Case Weight	Total Resource Cost Test
1	Com/Ag	HVAC	BPA	1CE000125_CHVHI92033	42,273	3.31	45.50	1.65
1	Com/Ag	HVAC	BPA	1CS000251_CHVEN92016	88,408	1.11	45.50	2.43
1	Com/Ag	Motors/Drives	BPA	2281_CMDMC82059	105,086	1.00	17.00	4.93
1	Com/Ag	HVAC	BPA	1CS000282_CHVHC82020	135,554	1.00	17.00	1.77
1	Com/Ag	HVAC	BPA	1RCS000033_CHVHI82026	393,413	0.89	8.50	15.85
1	Com/Ag	HVAC	BPA	1864_CHVHI82026	512,521	1.08	8.50	8.84
1	Com/Ag	Irrigation	BPA	1AS000062_AIRMS84033	773,197	1.00	3.50	1.96
1	Com/Ag	HVAC	BPA	2398_CHVHC82020	1,444,135	0.77	3.50	5.94
1	Industrial	Motors/Drives	BPA	1NI004549_IMDMC93060	68,754	1.00	17.33	3.88
1	Industrial	Motors/Drives	BPA	1RI002074_IMDCI83094	79,999	1.12	17.33	1.66
1	Industrial	Motors/Drives	BPA	2392_IMDPF83096	107,879	1.00	17.33	1.63
1	Industrial	Motors/Drives	BPA	2194_IMDMC83060	165,403	1.07	17.33	19.27
1	Industrial	Refrigeration	BPA	1844_IRERI83082	203,761	0.99	17.33	1.13
1	Industrial	Motors/Drives	BPA	1IS000172_IMDPF83095	264,173	1.00	17.33	1.73
1	Industrial	Refrigeration	BPA	1RIS000019_IRERC83080	399,812	1.00	7.17	1.36
1	Industrial	Motors/Drives	BPA	1IS000172_IMDPF83061	414,632	1.61	7.17	4.63
1	Industrial	Process Loads	BPA	1IS000234_IPLPF83069	479,602	1.00	7.17	2.62
1	Industrial	Process Loads	BPA	1NI004578_IPLPL93066	487,878	0.97	7.17	3.44
1	Industrial	Motors/Drives	BPA	1IS000016_IMDPF83096	761,445	0.93	7.17	1.86
1	Industrial	Compressed Air	BPA	1IS000217_ICACC83002	812,986	0.85	7.17	4.14
1	Industrial	Motors/Drives	BPA	1IE000128_IMDMC93060	1,585,534	1.13	4.00	4.4
1	Industrial	Motors/Drives	BPA	1IS000112_IMDPF83096	1,947,354	0.88	4.00	7.06
1	Industrial	Process Loads	BPA	1RI000481_IPLPL83066	2,322,533	0.89	4.00	4.23
1	Industrial	Compressed Air	BPA	1RIE000103_ICACI83093	2,867,301	0.94	4.00	2.64
1	Industrial	HVAC	BPA	2712_IHVHC93024	3,713,810	0.65	2.00	1.69
1	Industrial	Refrigeration	BPA	2552_IRERI83085	3,753,197	1.37	2.00	4.03
1	Industrial	Process Loads	BPA	1IS000233_IPLPF83069	4,344,223	0.95	2.00	4.38
1	Industrial	Process Loads	BPA	1RIS000026_IPLPF83097	5,944,381	0.98	2.00	5.69
1	Industrial	Process Loads	BPA	1RIS000029_IPLPC83064	8,328,313	1.00	1.00	5.06
2	Commercial	HVAC	BPA	2RC003763_CHVEN82017	6,482	1.35	38.00	1.65
2	Commercial	HVAC	BPA	2RC003691_CHVHI82033	6,839	0.69	38.00	0.92
2	Commercial	HVAC	BPA	2RC007098_CHVHI82030	19,959	1.13	26.00	8.88
2	Commercial	HVAC	BPA	2NC007065_CHVEN92017	20,269	1.59	26.00	1.88
2	Commercial	HVAC	Utility	2RC003416_CHVHC82021	72,126	1.37	17.00	1.52
2	Commercial	Motors/Drives	BPA	2RC002980_CMDMC82059	72,414	1.00	18.00	2.76
2	Commercial	HVAC	Utility	2RC003357_CHVHC82021	93,369	1.42	17.00	3.07
2	Commercial	HVAC	Utility	2RC003021_CHVHC82022	106,616	0.86	18.00	2.11
2	Commercial	Process Loads	Utility	2RC004738_CPLPL82067	176,634	1.31	12.00	0.96
2	Commercial	Process Loads	BPA	2RC002031_CMDPF82100	181,969	1.00	5.50	5.27

Option	Sector	End Use	Funder	ID	Reported Savings (kWh)	Reali-zation Rate	Case Weight	Total Resource Cost Test
2	Commercial	HVAC	Utility	2RC002032_CMDPF82060	194,730	0.60	5.50	0.54
2	Commercial	HVAC	BPA	2RC007130_CHVHI82025	252,409	1.12	12.00	15.76
2	Commercial	HVAC	Utility	2RC003356_CHVHC82021	297,614	1.35	6.00	1.91
2	Commercial	HVAC	Utility	2RC007070_CHVHI82030	313,722	0.97	6.00	3.77
2	Commercial	HVAC	BPA	2RC005003_CHVHC82022	365,420	1.12	4.00	4.59
2	Commercial	Motors/Drives	Utility	2NC002027_CMDPF92100	393,633	0.00	2.33	0
2	Commercial	HVAC	Utility	2RC003025_CPLPC82066	479,897	0.76	2.33	1.08
2	Commercial	HVAC	BPA	2RC005297_CHVHI82102	523,238	1.19	2.00	8.46
2	Commercial	Motors/Drives	Utility	2RC002972_CMDMC82059	595,616	1.06	2.33	1.82
2	Commercial	Multiple	BPA	2NC005052_CMDMC92056	634,187	0.97	4.00	8.01
2	Commercial	Multiple	Utility	2RC007073_CHVHI82038	837,316	1.86	2.00	2.3
2	Commercial	HVAC	Utility	2NC005281_CHVHI92102	1,235,298	1.19	1.00	2.84
2	Commercial	Multiple	Utility	2NC003401_CHVEN92017	1,892,814	1.05	1.00	0.65
2	Industrial	Compressed Air	Utility	2RI007636_ICACI83003	22,849	0.12	4.25	0.15
2	Industrial	Compressed Air	BPA	2NI002068_ICACI93008	29,463	1.52	4.25	4.15
2	Industrial	Process Loads	BPA	2NI003767_IPLPL93066	41,618	0.92	5.67	2.98
2	Industrial	Compressed Air	Utility	2RI003407_ICACI83004	44,548	0.76	3.25	3.65
2	Industrial	Process Loads	Utility	2RI003298_IPLPL83066	51,474	1.25	3.25	1.57
2	Industrial	Process Loads	BPA	2RI004160_IPLHR83063	68,797	0.51	3.25	0.77
2	Industrial	Refrigeration	BPA	2RI001949_IRERI83083	98,694	0.43	4.25	1.09
2	Industrial	Process Loads	BPA	2RI004998_IPLPL83066	109,434	0.83	5.67	7.87
2	Industrial	Motors/Drives	Utility	2RI001986_IMDPF83061	176,970	1.13	4.25	0.82
2	Industrial	Compressed Air	BPA	2RI005046_ICACI83004	187,512	0.34	5.67	10.13
2	Industrial	Refrigeration	Utility	2RI003404_IRERC83079	218,988	1.00	3.25	1.55
2	Industrial	Refrigeration	BPA	2RI002165_IRERC83079	245,120	1.00	2.67	2.06
2	Industrial	Compressed Air	Utility	2RI003407_ICACI83010	281,041	0.77	2.67	3.73
2	Industrial	Process Loads	BPA	2RI004153_IPLHR83063	289,217	1.93	2.67	4.78
2	Industrial	Motors/Drives	Utility	2RI002161_IMDMO83056	523,001	0.49	1.50	0.67
2	Industrial	Refrigeration	Utility	2RI002165_IRERI83085	791,877	1.00	1.50	2.16
2	Industrial	Refrigeration	Utility	2RI002957_IRERC83080	955,331	1.05	1.00	3.28
2	Industrial	HVAC	Utility	2RI004706_IHVHC83024	2,492,282	1.33	1.00	13.03
2	Industrial	Compressed Air	BPA	2RI005033_ICACI83004	3,433,394	1.00	1.00	4.07
2	Industrial	Process Loads	Utility	2NI003073_IMDPF93096	3,965,682	1.09	1.00	>>1

C.3. Energy Smart Reserve Projects (ESRP)

Table 25: Sampled ESRP Measures

ID	Reported Savings (kWh)	Reali-zation Rate	Case Weight	Total Resource Cost Test
12ES-11291_	728,645	0.88	4.50	4.72
12ES-11287_	1,487,109	0.85	4.50	2.15
12ES-11285_	3,917,054	0.39	1.00	1.49
12ES-11298_	6,349,785	-0.03	1.00	-1.69
11ES-11253_	8,266,369	0.51	1.00	6.20

D. Factors Changing Non-Lighting Savings

D.1. HVAC

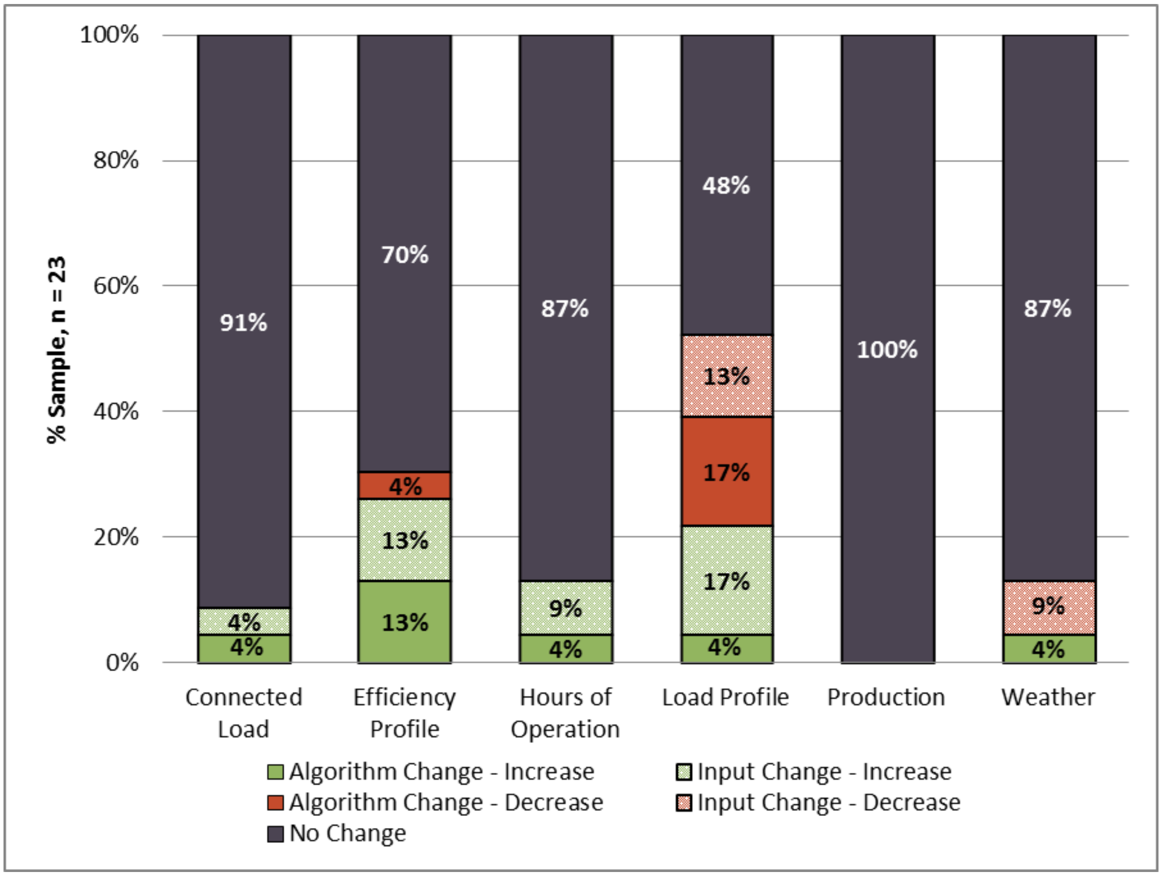

Figure 25: HVAC: Factors Changing Non-Lighting Savings

D.2. Compressed Air

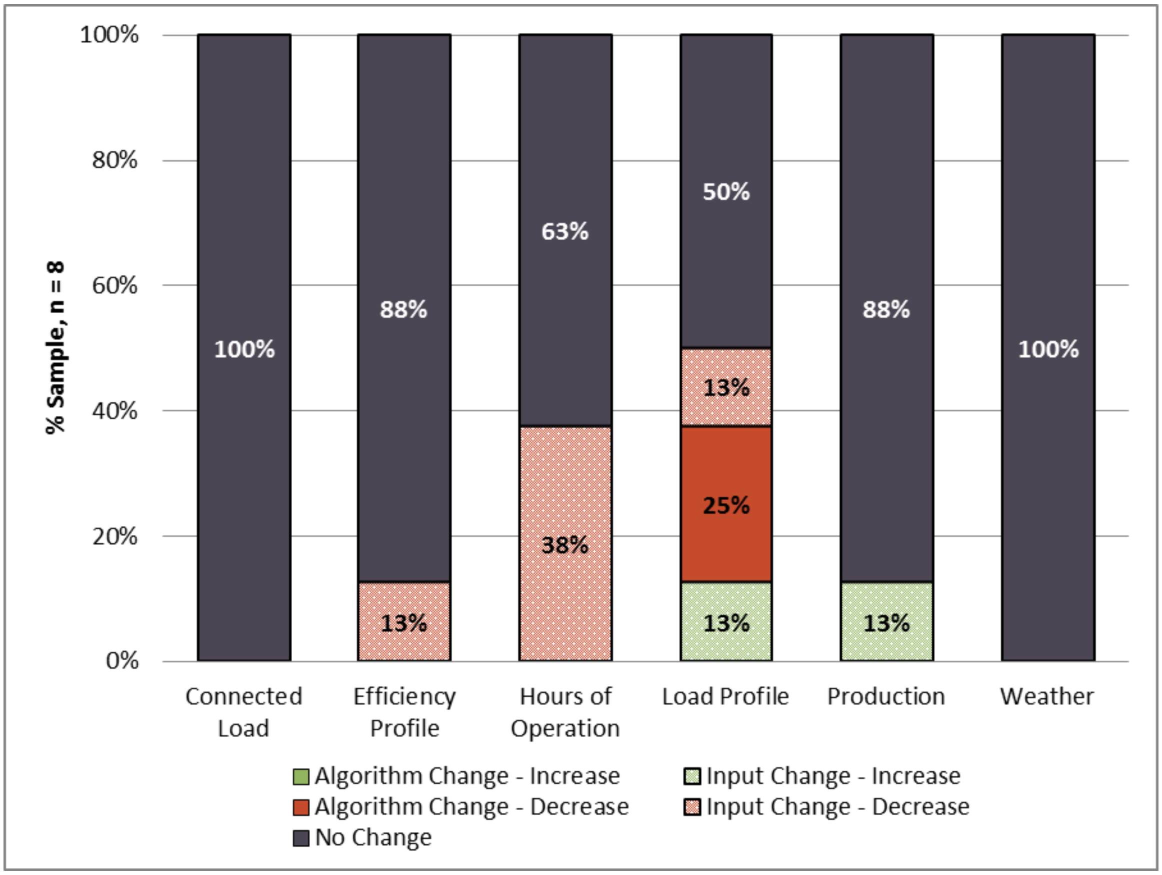

Figure 26: Compressed Air: Factors Changing Non-Lighting Savings

D.3. Motors/Drives

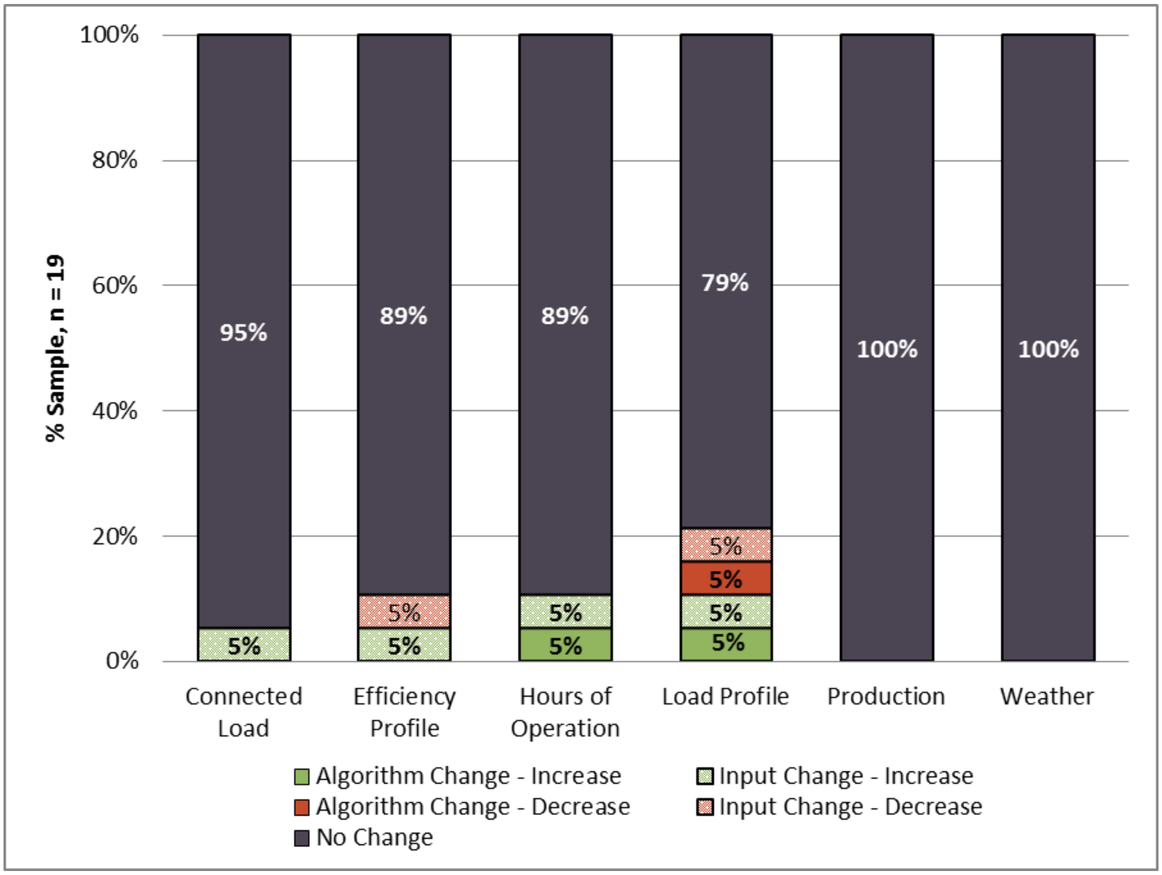

Figure 27: Motors/Drives: Factors Changing Non-Lighting Savings

D.4. Process Loads

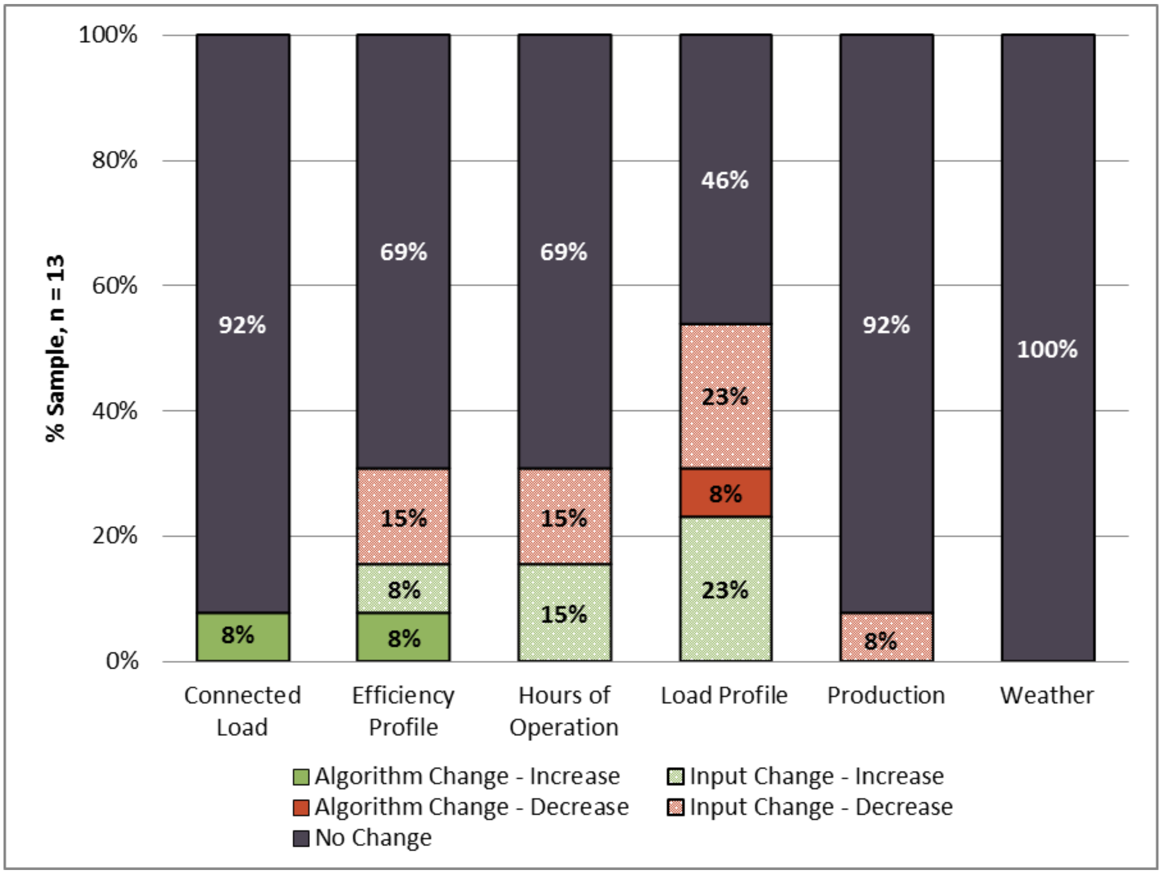

Figure 28: Process Loads: Factors Changing Non-Lighting Savings

D.5. Refrigeration

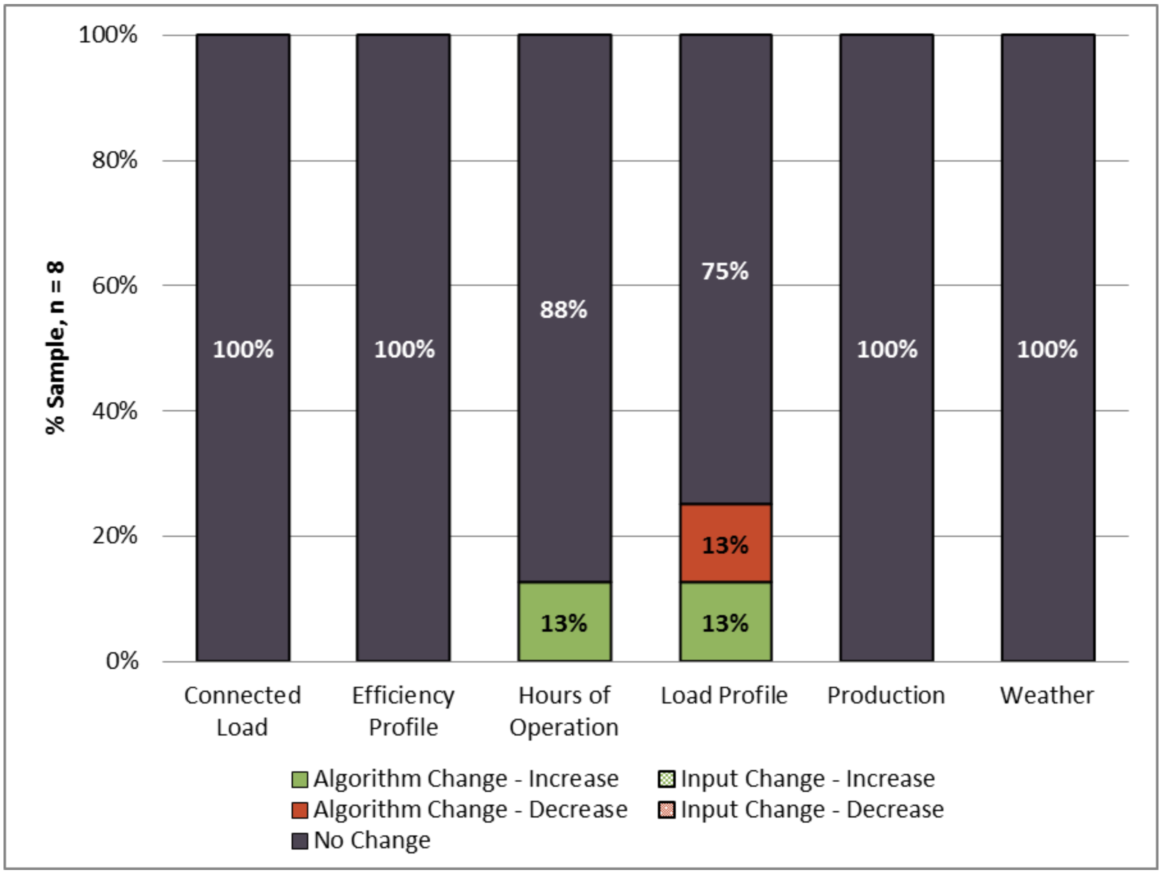

Figure 29: Refrigeration: Factors Changing Non-Lighting Savings

E. ESTIMATING STUDY LEVEL RESULTS

E.1. Electrical Savings

The calculation of the savings realization rate uses the stratified ratio estimator approach as presented below[46].

Stratified Random Samples

Using Equation 1, the sample-based realization rate was calculated for each study or other domain of interest.

$$b = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i x_i} \qquad (1)$$

where:

b	=	*the realization rate of the study or domain being summarized*
w_i	=	*case weight for measure i in stratum h* (N_h/n_h)
y_i	=	*sample evaluated savings for measure i*
x_i	=	*sample savings reported for measure i*
N_h	=	*stratum population*
n_h	=	*stratum sample size*

E.2. Relative Precision

To determine the relative precision for each study or domain of interest, first the standard error was calculated using Equation 2[46, 47].

$$\delta(b) = \frac{\sqrt{\sum_{i}^{n} w_i (w_i - 1) e_i^2}}{\sum_{i=1}^{n} w_i x_i} \sqrt{1 - \frac{n}{N}} \qquad (2)$$

where:

[46] TecMarket, W. (2004). The California Evaluation Framework. Rosemead: Southern California Edison Company.

[47] Taylor, J. R. (1997). An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements. Sausalito: University Science Books.

$$e_i = y_i - bx_i$$

n = the sample size of the study or domain being summarized

N = the population of the study or domain being summarized

Next, the 90% confidence interval (*CI*) around the savings realization rate, b, is calculated in Equation 3 by multiplying the appropriate t-statistic by the standard error of the savings realization rate, *δ*(b).

$$CI = b \pm (1.645 \times \delta(\mathrm{b})) \quad (3)$$

Finally, the 90% relative precision (*rp*) of the savings realization rate was calculated, as shown in Equation 4, by multiplying the t-statistic by the standard error of the savings realization rate, *δ*(b) and dividing by the savings realization rate, b.

$$rp = 1.645 \frac{\delta(b)}{b} \quad (4)$$

In Figure 30, we provide an example of the above calculations for one of the domains, Option 1-Industrial-Non-Lighting.

Record	x = Reported Savings	y = Evaluation Savings	Size Stratum	nh = Stratum Sample Size	Nh = Stratum Popula-tion	w = Nh/nh	wx = Weighted Reported Savings	wy = Weighted Evaluation Savings	e = y - b*x	w*(w-1)*e^2
1	79,999	89,873	1	6	104	17.33	1,386,651	1,557,799	10857.78738	33376406798
2	165,403	177,618	1	6	104	17.33	2,866,986	3,078,712	14249.2384	57483105030
3	68,754	68,754	1	6	104	17.33	1,191,742	1,191,736	845.2483287	202267243.4
4	107,879	107,878	1	6	104	17.33	1,869,908	1,869,885	1325.514964	497423368.1
5	264,173	264,746	1	6	104	17.33	4,578,997	4,588,931	3822.166438	4135957845
6	203,761	202,594	1	6	104	17.33	3,531,863	3,511,629	1338.735896	507395640.2
7	812,986	694,428	2	6	43	7.17	5,826,402	4,976,734	-108559.4096	5.20838E+11
8	414,632	665,676	2	6	43	7.17	2,971,529	4,770,678	256143.5497	2.89958E+12
9	761,445	710,973	2	6	43	7.17	5,457,025	5,095,307	-41107.35075	74680403570
10	487,878	474,272	2	6	43	7.17	3,496,462	3,398,949	-7605.96489	2556679632
11	479,602	481,306	2	6	43	7.17	3,437,148	3,449,360	7602.505574	2554354522
12	399,812	399,812	2	6	43	7.17	2,865,322	2,865,319	4916.903478	1068442229
13	2,867,301	2,700,116	3	4	16	4	11,469,206	10,800,464	-131920.564	2.08836E+11
14	1,585,534	1,799,526	3	4	16	4	6,342,134	7,198,104	233492.8816	6.54227E+11
15	1,947,354	1,704,516	3	4	16	4	7,789,416	6,818,064	-218887.6357	5.74942E+11
16	2,322,533	2,077,245	3	4	16	4	9,290,132	8,308,980	-216723.1398	5.63627E+11
17	3,713,810	2,424,347	4	4	8	2	7,427,621	4,848,694	-1243787.398	3.09401E+12
18	4,344,223	4,117,176	4	4	8	2	8,688,446	8,234,352	-173617.3607	60285975845
19	5,944,381	5,801,489	4	4	8	2	11,888,762	11,602,978	-69782.02374	9739061675
20	3,753,197	5,130,802	4	4	8	2	7,506,394	10,261,604	1423765.347	4.05422E+12
21	8,328,313	8,328,313	9	1	1	1	8,328,313	8,328,313	102429.3789	0

Confidence	t	n = Study Sample Size	N = Study Population	∑(wx)	∑(wy)	b = ∑(wy)/ ∑(wx)	δ(b) = √(∑(w*(w-1)*e^2))/ ∑(wx) *√(1-n/N)	Confidence Interval = b +/- t*δ(b)	Relative Precision = t*δ(b)/b
90%	1.645	21	226	118,210,460	116,756,592	0.99	0.03	(0.94, 1.04)	5%

Figure 30: Example of Calculations for One Domain

E.3. Life Cycle Cost-Effectiveness

For each sampled measure, we used ProCost[48] to estimate the lifetime sum of costs and benefits. We verified, or re-estimated as necessary, key inputs to ProCost including incremental measure cost, measure life, O&M costs and other non-electric benefits. Relatively few evaluation resources were applied to estimating these inputs, as they were assigned a low priority in the evaluation plan.

To calculate the Total Resource Cost test for each domain, the sample case weights were used to calculate an appropriately weighted sum of costs and benefits. We also calculated the Total Resource Cost test for each sampled measure excluding any non-electric benefits.

[48] 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.

F. Sample Design

Table 26: Properties of Sample Strata

					Reported Savings Bound		Measures		
Option	Measure Type	Sector	Study	Stratum	Lower	Upper	Sample	Popula-tion	Case Weight
1	Lighting	Com/Ag	Opt1LightingCom/Ag	1	2,563	16,884	8	1,931	241.4
1	Lighting	Com/Ag	Opt1LightingCom/Ag	2	16,887	52,413	8	793	99.1
1	Lighting	Com/Ag	Opt1LightingCom/Ag	3	52,541	167,706	8	248	31.0
1	Lighting	Com/Ag	Opt1LightingCom/Ag	4	167,732	766,104	8	48	6.0
1	Lighting	Com/Ag	Opt1LightingCom/Ag	5	794,822	2,753,888	4	8	2.0
1	Lighting	Com/Ag	Opt1LightingCom/Ag	8	-889	2,562	0	815	0
1	Lighting	Com/Ag	Opt1LightingCom/Ag	9	4,355,003	4,470,961	2	2	1
1	Lighting	Industrial	Opt1LightingIndustrial	1	0	66,978	2	218	109.0
1	Lighting	Industrial	Opt1LightingIndustrial	2	67,637	292,511	2	59	29.5
1	Lighting	Industrial	Opt1LightingIndustrial	3	295,153	788,124	2	19	9.5
1	Lighting	Industrial	Opt1LightingIndustrial	4	1,059,750	3,239,992	2	6	3.0
1	Lighting	Industrial	Opt1LightingIndustrial	9	3,424,196	3,424,196	1	1	1
1	Non-Lighting	Com/Ag	Opt1NonLightingCom/Ag	1	12,128	88,408	2	91	45.5
1	Non-Lighting	Com/Ag	Opt1NonLightingCom/Ag	2	91,498	302,968	2	34	17.0
1	Non-Lighting	Com/Ag	Opt1NonLightingCom/Ag	3	306,386	705,363	2	17	8.5
1	Non-Lighting	Com/Ag	Opt1NonLightingCom/Ag	4	773,197	1,832,036	2	7	3.5
1	Non-Lighting	Com/Ag	Opt1NonLightingCom/Ag	8	0	11,894	0	51	0
1	Non-Lighting	Industrial	Opt1NonLightingIndustrial	1	58,515	368,075	6	104	17.3
1	Non-Lighting	Industrial	Opt1NonLightingIndustrial	2	372,029	1,189,383	6	43	7.2
1	Non-Lighting	Industrial	Opt1NonLightingIndustrial	3	1,195,686	2,867,301	4	16	4.0
1	Non-Lighting	Industrial	Opt1NonLightingIndustrial	4	3,414,810	5,944,381	4	8	2.0
1	Non-Lighting	Industrial	Opt1NonLightingIndustrial	8	0	58,330	0	54	0
1	Non-Lighting	Industrial	Opt1NonLightingIndustrial	9	8,328,313	8,328,313	1	1	1
2	Lighting	Commercial	Opt2RemainingLightingCommercial	1	2,146	50,384	2	220	110.0
2	Lighting	Commercial	Opt2RemainingLightingCommercial	2	52,108	774,598	2	30	15.0
2	Lighting	Commercial	Opt2RemainingLightingCommercial	8	109	2,124	0	52	0
2	Lighting	Commercial	Opt2Util1LightingCommercial	1	4,828	21,630	4	457	114.3
2	Lighting	Commercial	Opt2Util1LightingCommercial	2	21,729	51,818	4	249	62.3
2	Lighting	Commercial	Opt2Util1LightingCommercial	3	51,976	117,773	4	120	30.0
2	Lighting	Commercial	Opt2Util1LightingCommercial	4	118,398	286,123	4	45	11.3
2	Lighting	Commercial	Opt2Util1LightingCommercial	5	290,663	999,504	4	12	3.0
2	Lighting	Commercial	Opt2Util1LightingCommercial	8	253	4,782	0	147	0
2	Lighting	Commercial	Opt2Util1LightingCommercial	9	1,127,579	3,269,086	2	2	1
2	Lighting	Commercial	Opt2Util2LightingCommercial	1	4,441	17,308	4	308	77.0
2	Lighting	Commercial	Opt2Util2LightingCommercial	2	17,310	37,541	3	183	61.0
2	Lighting	Commercial	Opt2Util2LightingCommercial	3	37,761	82,885	3	87	29.0
2	Lighting	Commercial	Opt2Util2LightingCommercial	4	83,943	181,290	4	39	9.8
2	Lighting	Commercial	Opt2Util2LightingCommercial	5	184,125	353,591	3	18	6.0
2	Lighting	Commercial	Opt2Util2LightingCommercial	8	49	4,386	0	88	0
2	Lighting	Commercial	Opt2Util2LightingCommercial	9	402,730	478,737	2	2	1
2	Lighting	Commercial	Opt2Util3LightingCommercial	1	7,682	40,556	4	146	36.5
2	Lighting	Commercial	Opt2Util3LightingCommercial	2	40,635	117,485	4	57	14.3
2	Lighting	Commercial	Opt2Util3LightingCommercial	3	122,219	239,885	4	35	8.8

Option	Measure Type	Sector	Study	Stratum	Reported Savings Bound Lower	Reported Savings Bound Upper	Measures Sample	Measures Popula-tion	Case Weight
2	Lighting	Commercial	Opt2Util3LightingCommercial	4	243,542	462,878	2	11	5.5
2	Lighting	Commercial	Opt2Util3LightingCommercial	5	535,394	1,529,084	3	7	2.3
2	Lighting	Commercial	Opt2Util3LightingCommercial	8	745	7,636	0	54	0
2	Lighting	Industrial	Opt2RemainingLightingIndustrial	9	123,927	123,927	1	1	1
2	Lighting	Industrial	Opt2Util1LightingIndustrial	1	11,006	81,321	3	15	5.0
2	Lighting	Industrial	Opt2Util1LightingIndustrial	2	91,712	170,684	2	5	2.5
2	Lighting	Industrial	Opt2Util1LightingIndustrial	8	1,019	9,370	0	8	0
2	Lighting	Industrial	Opt2Util1LightingIndustrial	9	422,356	1,027,335	3	3	1
2	Lighting	Industrial	Opt2Util2LightingIndustrial	1	7,863	106,677	4	52	13.0
2	Lighting	Industrial	Opt2Util2LightingIndustrial	2	109,132	667,884	6	13	2.2
2	Lighting	Industrial	Opt2Util2LightingIndustrial	8	1,796	7,318	0	13	0
2	Lighting	Industrial	Opt2Util2LightingIndustrial	9	1,180,541	1,180,541	1	1	1
2	Lighting	Industrial	Opt2Util3LightingIndustrial	1	21,332	63,375	2	4	2.0
2	Lighting	Industrial	Opt2Util3LightingIndustrial	2	78,782	172,015	2	4	2.0
2	Non-Lighting	Commercial	Opt2RemainingNonLightingCommercial	1	4,580	167,629	2	76	38.0
2	Non-Lighting	Commercial	Opt2RemainingNonLightingCommercial	2	312,642	1,802,697	2	8	4.0
2	Non-Lighting	Commercial	Opt2RemainingNonLightingCommercial	8	285	4,362	0	40	0
2	Non-Lighting	Commercial	Opt2Util1NonLightingCommercial	1	16,678	62,986	2	52	26.0
2	Non-Lighting	Commercial	Opt2Util1NonLightingCommercial	2	63,540	143,713	2	34	17.0
2	Non-Lighting	Commercial	Opt2Util1NonLightingCommercial	3	146,764	254,370	2	24	12.0
2	Non-Lighting	Commercial	Opt2Util1NonLightingCommercial	4	257,649	469,004	2	12	6.0
2	Non-Lighting	Commercial	Opt2Util1NonLightingCommercial	5	522,307	1,036,080	2	4	2.0
2	Non-Lighting	Commercial	Opt2Util1NonLightingCommercial	8	88	16,429	0	24	0
2	Non-Lighting	Commercial	Opt2Util1NonLightingCommercial	9	1,235,298	1,892,814	2	2	1
2	Non-Lighting	Commercial	Opt2Util2NonLightingCommercial	1	6,447	106,616	2	36	18.0
2	Non-Lighting	Commercial	Opt2Util2NonLightingCommercial	2	106,875	332,660	2	11	5.5
2	Non-Lighting	Commercial	Opt2Util2NonLightingCommercial	3	393,633	1,025,845	3	7	2.3
2	Non-Lighting	Commercial	Opt2Util2NonLightingCommercial	8	1,149	6,230	0	17	0
2	Non-Lighting	Industrial	Opt2RemainingNonLightingIndustrial	1	31,113	584,662	3	17	5.7
2	Non-Lighting	Industrial	Opt2RemainingNonLightingIndustrial	8	11,784	27,027	0	3	0
2	Non-Lighting	Industrial	Opt2RemainingNonLightingIndustrial	9	3,433,394	3,433,394	1	1	1
2	Non-Lighting	Industrial	Opt2Util1NonLightingIndustrial	1	25,811	218,988	4	13	3.3
2	Non-Lighting	Industrial	Opt2Util1NonLightingIndustrial	2	245,120	487,670	3	8	2.7
2	Non-Lighting	Industrial	Opt2Util1NonLightingIndustrial	3	523,001	791,877	2	3	1.5
2	Non-Lighting	Industrial	Opt2Util1NonLightingIndustrial	8	6,351	25,487	0	5	0
2	Non-Lighting	Industrial	Opt2Util1NonLightingIndustrial	9	2,492,282	2,492,282	1	1	1
2	Non-Lighting	Industrial	Opt2Util2NonLightingIndustrial	1	22,391	522,372	4	17	4.3
2	Non-Lighting	Industrial	Opt2Util2NonLightingIndustrial	8	2,007	13,567	0	7	0
2	Non-Lighting	Industrial	Opt2Util2NonLightingIndustrial	9	955,331	3,965,682	2	2	1
ESRP	ESRP	ESRP	Energy Smart Reserve Projects	1	194,618	1,569,331	2	9	4.5
ESRP	ESRP	ESRP	Energy Smart Reserve Projects	8	14,858	94,189	0	3	0
ESRP	ESRP	ESRP	Energy Smart Reserve Projects	9	3,917,054	8,266,369	3	3	1

G. Utility and End User Contact Protcols

The evaluation team will adhere to the following protocol for the site-specific savings impact evaluation.

G.1. Utility Notification of Sample and Utility Project Webinar

1. Utilities will be notified by the BPA EER via email (with a cc to [BPA Evaluation Manager]) that at least one project in their territory has been selected in the evaluation sample. Initial email will contain an attachment with basic information about sampled projects and will request the following from utilities: primary utility contact for the evaluation and availability for initial Webinar (approximately 1 week after initial email, subsequent as needed).
2. Utilities will email to their BPA EER the primary utility contact for the evaluation. BPA will share this information with [Evaluation Contractor].
3. BPA will hold Webinars for all primary utility contacts to review the evaluation process in general and this end user contact protocol. Option 1 and Option 2 meetings will be separate due to differences in data provision processes.
4. Any utility submitting data directly to [Evaluation Contractor]may negotiate and execute with [Evaluation Contractor] a non-disclosure agreement that meets the utility's requirements for protecting end user information[49]. Alternatively, utilities may send requested data to their EER or BPA project manager for transmittal to [Evaluation Contractor] and have confidence that data will be protected under the language of BPA's existing contract with the evaluation firm.

G.2. Data Request: Project file requests

Option 1 Utilities

1. For all sampled custom projects, BPA will provide completion report files. For sampled lighting projects, BPA will provide the lighting calculator. BPA will provide these to [Evaluation Contractor] through a secure FTP site. For Industrial sites, BPA will work with Energy Smart Industrial to collect additional data or calculation files and upload these to the secure FTP site. For non-industrial custom projects, BPA will request any additional files from internal BPA engineers.
2. If BPA or Energy Smart Industrial files do not include all of the project documentation for some sites, the BPA embedded EER (cc to [BPA Evaluation Manager], EER and COTR) will send a revised sample list that includes a description of the needed files. Files requested

[49] Please note that BPA has a contract with [Evaluation Contractor] that requires data protection of the data. Therefore, this NDA may be most useful to utilities that provide data directly to the evaluation team (e.g., Option 2 utilities).

may include lighting calculator cost data, end-user payment data (if industrial or partial self-funded custom project) and any other files needed such as raw data files or calculation files. The utilities will also be asked to revise or add the contact information for their internal project contact.

3. Within two weeks of the request from BPA EER, the utility will upload the required files to the secure FTP site or email them to the [Evaluation Contractor] contact. [Evaluation Contractor] will assist each utility in using the FTP site for secure uploads.
4. Utilities are responsible for notifying their internal project contacts that they may be interviewed by [Evaluation Contractor] regarding the sampled projects.

Option 2 Utilities

[Evaluation Contractor] will directly request all project files for the Option 2 samples and will include direction on the types of files needed, including but not limited to program applications, field notes, drawings, photographs, functional M&V models, metering data, product specification sheets. This request will be conducted as a single "batch" for each Option 2 utility.

1. Within three weeks of receiving the list of sampled projects from their BPA EER, utilities will upload required files for the primary sample to the secure website, placing them in the folder created for each project. Within six weeks, they will upload the replacement sample. The EMS sample may be uploaded following the replacement sample. Later dates may be requested and will be accommodated if possible.
2. Utilities should indicate internal project contact for each project. If a third-party contractor is involved in the project, the utility will determine whether that firm may be contacted by [Evaluation Contractor].
3. [Evaluation Contractor] will follow up directly with Option 2 utility primary contacts if data are missing.

G.3. Interview Internal (Utility/BPA) Project Contacts

Following file review, the [Evaluation Contractor], will contact the internal (i.e., BPA/ESI/utility) project contacts to learn more about the project, on an ad hoc basis as needed. No notification will be made to BPA EER or [BPA Evaluation Manager]. The internal project contact will be the primary engineer for custom projects or the most knowledgeable internal staff about the project for lighting calculators. The discussion with the internal project contact will:

1. Answer questions regarding the project or files.
2. Obtain information needed for the evaluation that was not found in the project files.
3. If end user contact will still be required, this discussion will provide critical information on the history of the project and circumstances at the site and will help identify the least intrusive approach for obtaining data needed for the evaluation.

G.4. Inform Utilities: Supplemental Data Needed from End-Users

1. For Option 1 utilities, the BPA embedded EER (cc to [BPA Evaluation Manager], EER, and COTR) will email utilities with sampled sites that need additional supplemental data at least two weeks prior to the earliest date of initial end user contact. For Option 2 utilities, [Evaluation Contractor] will work directly with the primary utility contact, with a cc to BPA EER and [BPA Evaluation Manager]. An initial data request will include all measures in the primary sample. For Option 1 utilities, the BPA EER will send notification for supplemental data needs for any replacement sites (i.e., those needed to replace sites in the primary sample that refuse to participate). These requests will be one site at a time. The data needs will be appended to the initial sample list and will include the following information:
    a. Description of the data needed from the end user and proposed method for obtaining that data.
    b. Estimate of the time required from the end user's staff to complete the data collection, including all phases of the data collection, e.g., telephone interview, participation in inspection or metering.
    c. Two week time frame within which the evaluation team will make initial contact with the end user
    d. End-user initial point of contact (name and phone number)
    e. Evaluation lead firm and, if possible, the site engineer.
2. Within 2 weeks of receiving the notification email from BPA, the utility may:
    a. Make the first contact to the end-user. The evaluation team would like, if possible, for the utility to make the first contact to the end-user. The utility may use the recommended email script and project overview[50]. Please cc or let [BPA Contact] and [Evaluation Contractor Contact] from [Evaluation Contractor] know when the contact has been made. If Andrew or John has not heard from the utility within 2 weeks of the notification, we will assume that you prefer to have the evaluation team make the first customer contact (see Section G.5 below). If needed, the utility can request a delay in the evaluation schedule and the evaluation team will try our best to accommodate the request. Without request from the utility to delay, the evaluation will continue per the schedule in the notification email.

       Five business days after the initial email to the utility, if there has been no response from the utility contact, [Evaluation Contractor] will send an email to the utility with a reminder that the time frame for contacting the end user is close to ending and if their

[50] [Evaluation Contractor] will provide a script and a 1 to 2 page written summary with BPA's logo. The summary will describe the background and purpose of the evaluation, introduce [Evaluation Contractor], state that results will only be used to improve future practices, and state that individual end user data will be protected.

intention is not to contact the end-user to please communicate that to the evaluation team.

   b. Notify [BPA and Evaluation Contractor Contacts] if the utility recommends an adjustment or addition of recommended names and contact information for the end-user initial point of contact. Please let them know if you have any additional comments, questions, concerns. Also let them know if you would like to attend an evaluation site-visit.

3. If a site-visit is scheduled, [Evaluation Contractor] will notify the utility of the scheduled date/time, as soon as the evaluation team knows. (Please note the evaluation team will be flexible with the facility schedule). The utility may attend the site-visit.
4. In addition to the formal communication outlined above, BPA and [Evaluation Contractor] will notify utilities of any issues or anomalies with sites on an ad hoc basis, as needed. This is to ensure that utilities have early and open communication on any issues they need to be aware of with sites.

G.5. End-user Contact and Supplemental Data Collection

1. Within the timeframe notified in Section G.4 above, [Evaluation Contractor] will call (this may be preceded with an introductory email) the end-user initial point of contact to brief them on the study, the specific projects or measures that have been sampled, and the additional data that is required to complete the evaluation.
2. [Evaluation Contractor] will work with the end user to determine the most efficient methods for acquiring the data, and will determine who on the end user staff will be involved and when the telephone or site visit activities can be conducted.
3. In all cases, [Evaluation Contractor] will notify the utility (with a cc to BPA embedded EER and [BPA Evaluation Manager]) about the schedule for data collection agreed to with the end user, so that they can participate.
4. If the data collection involves a site visit, [Evaluation Contractor] will work with the contact to determine what is needed to access the relevant portions of the site. This may include special clothing, safety training, other training, or background checks and security authorization. They will work with the end user to meet all site access requirements.
5. As needed, non-disclosure agreements will be executed between [Evaluation Contractor] and the end user.
   a. Once all end user requirements have been satisfied, the site visit will proceed.
   b. A few days prior to any site visit, [Evaluation Contractor] will contact the end user to confirm arrangements for the site visit. If any arrangements are changed, they will notify the utility.
6. If [Evaluation Contractor] receives a request from an end user for the site-specific study results, they will respond by saying “Please contact your utility for detailed evaluation information”. They will notify the utility of this request (with cc to BPA embedded EER and

[BPA Evaluation Manager]) and the utility may provide the site-specific results at their discretion.

7. Once the evaluation work is complete for each utility's sampled projects or measures, and [Evaluation Contractor] is ready to begin work on the draft report the findings, the SBW will notify the utilities that the site-specific results are ready for their review. A secure download link to site workbooks will be emailed to utilities if they request to see the results. The findings will be contained in an Excel workbook for each measure studied. Utilities may provide comments on any aspect of the findings to the evaluation team.