



WEST HILL ENERGY AND COMPUTING

Verification of Burlington Electric Department's Energy Efficiency Portfolio for Annual Savings Claim and the ISO-NE Forward Capacity Market

Final Report

Report Date: October 1, 2018

Program Year: 2016

Prepared For

The Vermont Department of
Public Service

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1 Introduction

The Burlington Electric Department (BED) is an efficiency utility in the State of Vermont providing efficiency programs and services to electric customers in its service territory. BED bid its Program Year (PY) 2016 efficiency program portfolio into the Independent System Operator of the New England (ISO-NE) Forward Capacity Market (FCM).

The Vermont Department of Public Service (DPS) is responsible for the evaluation and verification of BED's program-reported savings, which includes oversight of independent, third-party evaluation to meet FCM standards in accordance with the "Manual for Measurement and Verification of Demand Reduction Value", as well as conducting annual verification of energy, MMBtu savings, and TRB inputs for BED's portfolio. West Hill Energy and Computing, in partnership with Cx Associates, GDS Associates, Energy and Resource Solutions, and Lexicon Energy Consultants, were contracted to complete these evaluation activities.

The evaluation activities included sampling, site-specific measurement and verification (M&V), statistical analysis, and overall impact evaluation of BED's efficiency portfolio. This report describes the evaluation of BED's efficiency portfolio for Program Year 2016 and the results of this verification process. It also provides documentation supporting the Annual Certification of Accuracy of Measurement and Verification Documents, as specified under Section 14.2 in the ISO Manual.

This evaluation was designed to determine the appropriate realization rates to be applied to BED's estimated energy savings and demand reductions. These realization rates are applied to the program-reported savings estimating BED's verified savings. The realization rates given in this document will be used to adjust BED's savings reported to ISO-NE FCM from July 31, 2018 until the completion of the next evaluation cycle.

The remainder of this report is divided into the following sections: Methods, Results, and Conclusions. The components of BED's portfolio are described in BED's 2016 Annual Report.¹

¹ Burlington Electric Department 2016 Energy Efficiency Annual Report.



2 Methods

Each component of BED's portfolio was reviewed by the DPS evaluation team. The portfolio was divided according to the source of the coincidence factors (CFs). For the Commercial & Industrial (C&I) sector, site-specific M&V was conducted for a sample of projects. Verification of savings for residential measures consisted of comparing the program-reported savings to the prescriptive assumptions reviewed by the DPS and included in the Vermont "Technical Reference Manual" (TRM). For homes with a water or space-heating fuel switch, the DPS evaluation team analyzed the utility interval data, as per M-MVDR option C, to verify the prescriptive assumptions from the TRM. An overview of the analysis approach used for each program is provided below.

2.1 Commercial & Industrial (C&I)

This category includes all BED programs targeted to business and multifamily sectors. The projects in this category are Retrofit and New Construction (NC) or Market Opportunity (MOP). Projects were sorted into three strata based on maximum peak demand savings, i.e., the higher of the winter or summer peak kW reduction (see Table 1 below). All measures, including those using coincidence factors, stipulated from the recent C&I Lighting Load Shape Study completed by KEMA, were included in the sample frame.²

The smallest custom C&I projects (those accounting for a cumulative total of less than 3% of the claimed C&I savings) were excluded from the sample frame given that these projects would be just as costly to verify as larger projects, but have a much smaller contribution to the portfolio savings. The realization rate from the C&I Retrofit, NC and MOP programs was applied to these measures.

The MMBtu savings for projects in the C&I sample were also verified by the evaluation team when possible. Sampled projects with MMBtu savings fall into two categories: a few, new construction projects with large positive savings and projects with much smaller, negative savings, usually from the increased heat load due to more efficient lighting.

2.1.1 Sampling

The sampling plan for the C&I sector was developed by the West Hill Energy Evaluation Team. Sample sizes were designed to support stratified ratio estimation and meet the ISO-NE requirements for sampling precision ($\pm 10\%$ precision at the 80% confidence level). The sampling was conducted from BED's list of projects completed between January 1, 2016 and December 31, 2016. The sampling unit for this verification is the location, as defined by BED's Location ID. All measures installed during Program Year 2016 were considered for each location and specific locations were selected for review.

² *C&I Lighting Load Shape Project FINAL Report*. Prepared for the Northeast Energy Efficiency Partnerships' Regional Evaluation, Measurement and Verification Forum by KEMA, Middletown, CT. July 19, 2011

Measures may have been installed through the Retrofit, MOP, or NC programs and measures were sometimes installed under multiple programs in some locations, i.e., a participant at a selected location may have installed measures under both the Retrofit and MOP programs. The sampling frame included all C&I projects (both prescriptive and custom). Multifamily projects were found to be a small part of the portfolio and were verified under the residential sector.

Size categories were used to ensure the sample is representative of the population. The stratification variable for determining the size was the higher of the two estimated coincident peak demand savings values, referred to as "max kW" throughout the rest of this document. Locations with the smallest estimated max kW, accounting for 3% of the C&I total savings claim, were omitted from the sample as they were too small to evaluate.

The initial round of sampling was conducted using the complete sample frame of 2016 participants. The largest projects (with max kW savings greater than 20 kW) fell into the census stratum and all were evaluated. The remaining projects (with max kW savings between 0.4 kW and 20 kW) were assigned to three strata based on size, as shown in Table 1 below.

TABLE 1: SAVINGS BY SIZE STRATA

Size Stratum	Number of Locations	Number in Sample	Total Max kW
0	229	0	29
1	199	6	128
2	60	6	170
3	21	6	207
4	7	7	315
Totals	516	26	848

As is common in conducting field work, some locations selected through the sampling process were not able to be verified. BED removed one project from the sample frame and will claim the savings in PY2017. A total of four locations were dropped from the sample for the following reasons:

1. Savings could not be verified for two projects because pre-metering was not provided for occupancy sensors and, based on participant interviews, there were no alternative uncontrolled spaces to be used as proxy.
2. Summer metering could not be completed for one project and there were substantial issues with winter metering resulting in an inability to verify measure savings.
3. One project was dropped because the site contact was non-responsive.

As reasons for dropping these projects are not related to the realized savings, these dropped projects would not be expected to introduce non-response bias to the overall results.



One of the ramifications of aggregating activity by location was some locations were the same site of multiple projects, covering a wide range of measures and not all of the measures could be metered or verified by other means. Overall, the number of measures unable to be verified within evaluated projects was quite small. After removing the four dropped projects, 99% of the max kW included in the sample was verified to FCM standards.

2.1.2 Realization Rate

The savings realization rate (RR) is the ratio of evaluated energy savings to the program's reported savings. The RR represents the percentage of program-estimated savings that is actually achieved based on the results of the evaluation M&V analysis. The RR for all C&I projects was calculated as follows:

$$RR = \frac{\sum_{i=1}^n w_i y_i}{\sum_{i=1}^n w_i x_i}$$

Where

RR is the realization rate (ratio estimator)

i represents the location ID number

n is the total number of verified locations in the sample

w_i is the expansion weight (the total number of locations in the stratum divided by the number of verified locations in the stratum)

y_i is the verified savings for location i

x_i is the original claimed savings for location i

The basis for these calculations and the method for calculating the variance are provided in *The California Evaluation Framework*.³

2.2 Residential

The residential sector savings are almost entirely prescriptive and calculated using assumptions reviewed by the DPS and included in the VT Technical Reference Manual (TRM). The TRM contains engineering algorithms for prescriptive savings, developed based on relevant data and studies on measures installed by past program participants in Vermont. Claimed savings for kWh, winter and summer kW, as well as MMBTU savings, were checked against TRM values.

³ TecMarket Works, et. al. *The California Evaluation Framework*. Project Number: K2033910. Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004, pages 327 to 339 and 361 to 384.

Residential Prescriptive Lighting: This component represents the lighting products sold through the Efficient Products Program. The source of the coincidence factors is the NMR lighting study. A fraction of these products are assumed to be purchased by commercial establishments. For this portion of the residential prescriptive lighting, coincidence factors were based on the KEMA C&I Lighting Load Shape Study. As commercial establishments typically have air conditioning, a cooling bonus was applied to reflect the lower cooling consumption due to the reduction in internal gains from the efficient lighting.

Residential Prescriptive HVAC: Efficient air conditioners are also offered through the Efficient Products initiatives. The source of the coincidence factors is the RLW Analytics Residential HVAC study.

Residential Prescriptive Other eShapes: The Efficient Products initiative also includes a range of other Energy Star appliances and electronics, including dishwashers, clothes washers, and refrigerators. In addition, some prescriptive measures are installed through the residential custom initiatives, including hot water conservation measures. For these measures, the coincidence factors were developed from Itron's eShapes 8760 load profile data, developed from audits of approximately 20,000 homes in the 1990s. While the load profiles are based on older data, the extensive nature of the data collection would be extremely costly to reproduce for measures that represent about 3% of the energy savings in BED's portfolio.

Residential Prescriptive Other non-eShapes: These measures include a few other miscellaneous products offered through the Efficient Products initiative (such as dehumidifiers), as well as a limited number of items installed through the residential custom initiatives (such as domestic hot water pipe insulation and tank wraps). These coincidence factors, based on engineering estimates, were reviewed and found to be reasonable. Similar to the eShapes discussed above, these measures constitute a small percentage of BED's overall portfolio (approximately 6%).

Residential Hot Water Fuel Switches: The Department's evaluation team conducted a separate analysis of the savings for hot water fuel switch measures using AMI data installed during PY2014 and these results were applied to the PY2016 projects. AMI data was collected for 27 homes with domestic hot water fuel switches and savings were estimated from a pre-/post-analysis of use during the ISO-NE peak hours. A whole building analysis was also conducted for one space heating fuel switch. More details are provided in Appendix E.

A summary of the residential measures separated, according to the source of the load profile, is provided in Table 2 below.

TABLE 2: RESIDENTIAL LOAD PROFILE SOURCES

Load Profile	Source	Percent of Total Portfolio	
		Winter kW	Summer kW
Prescriptive Lighting	NMR lighting study ⁴	50%	20%
Prescriptive Lighting w/Cooling Bonus	NMR lighting study, KEMA C&I Load Shape study for cooling bonus ⁵	1%	2%
Prescriptive HVAC	RLW Analytics Residential HVAC study ⁶	3%	0%
Prescriptive Other eShapes ¹	Itron's eShapes 8760 load profile data, based on detailed analyses of approximately 20,000 homes in the 1990's ^a	2%	2%
Prescriptive Other non-eShapes ¹	Engineering estimates ^b	5%	6%
AMI Analysis	AMI data analysis ^c	3%	1%
Residential as % of Total Portfolio		63%	32%

a While the load profiles are based on older data, the extensive nature of the data collection would be extremely costly to reproduce for measures that represent a small fraction of EVT's portfolio.

b It would also be costly to develop load profiles from primary research for these measures and they constitute a small percentage of EVT's overall portfolio.

c AMI data analysis was conducted for space and water heating measures as part of the PY2014 evaluation. The load profiles were applied to PY2016 measures. More details of the analysis are provided in Appendix E.

⁴ "Northeast Residential Lighting Hours-of-Use Study (R3)". Prepared by NMR Group Inc. and DNV GL, Somerville, MA. May 5, 2014

⁵ "C&I Lighting Load Shape Project FINAL Report." Prepared for the Regional Evaluation, Measurement and Verification Forum by KEMA Inc. July 19, 2011.

⁶ "Coincidence Factor Study Residential Room Air Conditioners." Prepared for NE State Program Working Group (SPWG) by RLW Analytics, Middletown, CT. June 23, 2008



3 Results

The portfolio results are presented below, followed by results for the C&I and residential sectors.

3.1 Portfolio Results

The sections below cover the results for electric energy (kWh), peak demand reduction and fossil fuel (MMBtu) savings.

3.1.1 Electric Energy

The realization rates and relative precision for BED's energy savings are provided in Table 3. The portfolio kWh realization rate is 108%, with a relative precision of 5% at the 80% confidence level.

TABLE 3: REALIZATION RATES AND SAMPLING PRECISION FOR ENERGY SAVINGS

Program Group/ Load Profile Group	BED Program Reported kWh Savings	Realization Rate	Savings as % of Total Portfolio	Relative Precision at the 80% Confidence Level
<i>C&I Sector</i>				
Retrofit/NC/MOP	1,857,206	107%	51%	10%
<i>Residential Sector</i>				
Prescriptive Lighting	1,207,535	127%	33%	6%
Prescriptive Lighting Commercial	35,076	96%	1%	3%
Prescriptive HVAC	115,278	100%	3%	10%
Prescriptive Other eShapes	105,400	138%	3%	50%
Prescriptive Other non- eShapes	236,907	8%	6%	0%
AMI Data Analysis	123,490	96%	3%	0%
Totals	3,680,892	108%	100%	5%

3.1.2 Peak Demand Reduction

Tables 4 and 5 show the realization rates and relative precision for the peak kW reduction, verified for the FCM component of the evaluation. The portfolio-wide realization rates for winter and summer peak kW are 122% and 111%, respectively. The ISO-NE standards require sampling precision at the 80/10 confidence/precision level for the entire portfolio. The relative precision of the verified savings in BED's portfolio is 7% for both winter and summer peak kW reduction, which meets this requirement.

TABLE 4: REALIZATION RATES AND SAMPLING PRECISION FOR WINTER PEAK KW REDUCTION

Program Group/ Load Profile Group	BED Program Reported Peak kW Reduction	Realization Rate	Savings as % of Total Portfolio	Relative Precision at the 80% Confidence Level
<i>C&I Sector</i>				
Retrofit/NC/MOP	209	122%	37%	7%
<i>Residential Sector</i>				
Prescriptive Lighting	282	133%	50%	14%
Prescriptive Lighting Commercial	5	102%	1%	6%
Prescriptive HVAC	18	100%	3%	0%
Prescriptive Other eShapes	9	220%	2%	50%
Prescriptive Other non- eShapes	26	7%	5%	0%
AMI Data Analysis	14	90%	3%	0%
<i>Totals</i>	563	122%	100%	7%



TABLE 5: REALIZATION RATES AND SAMPLING PRECISION FOR SUMMER PEAK kW REDUCTION

Program Group/ Load Profile Group	BED Program Reported Peak kW Reduction	Realization Rate	Savings as % of Total Portfolio	Relative Precision at the 80% Confidence Level
<i>C&I Sector</i>				
Retrofit/NC/MOP	266	108%	68%	10%
<i>Residential Sector</i>				
Prescriptive Lighting	78	140%	20%	14%
Prescriptive Lighting Commercial	9	102%	2%	2%
Prescriptive HVAC	0	100%	0%	10%
Prescriptive Other eShapes	9	212%	2%	50%
Prescriptive Other non-eShapes	23	13%	6%	0%
AMI Data Analysis	5	98%	1%	0%
<i>Totals</i>	390	111%	100%	7%

For the C&I custom sample, the relative precision was calculated from the sample. For the residential lighting and HVAC, the appropriate studies (NMR Lighting Study and RLW Residential HVAC Study) specified the relative precision for the coincidence factors.

In some cases, the relative precision was estimated based on the available information, as discussed below.

- The coincident factors for a variety of small residential measures were based on Itron's eShapes 8760 load profile data, developed from audits of approximately 20,000 homes in the 1990's.⁷ While the load profiles are based on older data, the extensive nature of the data collection would be extremely costly to reproduce for measures representing less than 3% of BED's portfolio. The relative precision could not be determined, so a proxy value of 0.50 was used.
- For a few other residential measures, the load profiles were based on engineering assumptions and the relative precision could not be determined. These coincident factors were reviewed and found to be within a reasonable range. As no sampling was conducted, there is no sampling error associated with these measures. These measures constitute a very small percentage of BED's overall portfolio (under 6% of the winter and summer peak kW savings).

⁷ About half of the roughly 20,000 audits were conducted on site, with the remainder based on a mail survey. Building simulations were performed based on the data collected through the audits to determine the load profiles. Overall, the audits were distributed throughout the country, although some states and utilities had more audit activity than others.

- For the residential hot water and heating fuel switch measures, the analysis was done using AMI data. No sampling was done for these measures, so the relative sampling precision is 0%.
- For the residential prescriptive lighting products, the reduction in Watts and in-service rates are based on the Northeast Energy Efficiency Partnership (NEEP) Residential Lighting Strategy.⁸ Verified lighting coincidence factors were based on the recent NMR lighting study (2014)⁹. Thus, the residential lighting savings are composed of three components with values derived from two different studies (NEEP, 2012 and NMR, 2014). The relative precision from the 2014 NMR report was used as the overall precision for the residential lighting, as the NEEP study does not report this parameter.

The majority of the program-reported MMBtu are extra use associated with fuel switching and the heating penalty for commercial lighting measures.

TABLE 6: REALIZATION RATES FOR MMBTU SAVINGS

Program Group	BED Program Reported MMBtu Savings	DPS Verified MMBtu Savings	Realization Rate
<i>C&I Sector</i>			
Retrofit/NC/MOP	-513	-694	135%
<i>Residential Sector</i>			
Prescriptive	779	946	121%
<i>Totals</i>	-1,486	-1,361	92%

⁸ Northeast Residential Lighting Strategy, Prepared by Energy Futures Group for NEEP, March 2012

⁹ NMR Lighting Study, 2014, page IX



3.2 C&I Results

Tables 7 through 9 provide the realization rates and population for the C&I custom projects in the BED portfolio. Stratum 1 contains the small projects and Stratum 4 the large projects. The realization rates in the final row reflect the overall realization for the C&I custom projects and are also provided in Tables 7 through 9.

TABLE 7: ENERGY REALIZATION RATES BY SIZE FOR C&I CUSTOM PROJECTS

Size Stratum	Total Number of Projects	Projects in Sample	Mean of Program BED Reported kWh Savings	Mean of DPS Verified kWh Savings	Realization Rate
1	199	5	2,659	2,275	86%
2	60	4	9,910	9,399	95%
3	21	5	27,498	39,300	143%
4	7	6	172,096	180,942	105%
Total	287	20			107%

TABLE 8: WINTER kW PEAK REALIZATION RATES BY SIZE FOR C&I CUSTOM PROJECTS

Size Stratum	Total Number of Projects	Projects in Sample	Mean of BED Program Reported kW Reduction	Mean of DPS Verified kW	Realization Rate
1	199	5	0.34	0.35	105%
2	60	4	1.15	1.59	138%
3	21	5	4.10	4.83	118%
4	7	7	24.23	19.35	121%
Total	287	21			121%



TABLE 9: SUMMER PEAK REALIZATION RATES BY SIZE FOR C&I CUSTOM PROJECTS

Size Stratum	Total # of Projects	Projects in Sample	Mean of BED Program Reported kW Reduction	Mean of DPS Verified kW	Realization Rate
1	199	5	0.57	0.26	46%
2	60	4	1.31	0.99	75%
3	21	5	4.37	5.63	129%
4	7	7	18.60	26.59	143%
Total	287	21			108%

Table 10 shows the realization rate for the fossil fuel savings included in the sample. 20 of the 24 projects in the sample had MMBtu extra use, possibly due to interactive effects (waste heat). Five UVM projects could not be verified because the location of the Smartlights, and a few other lighting measures, could not be identified. Two projects had no MMBtu savings or extra use. The RR's for the projects with extra use are given below.

TABLE 10: MMBTU REALIZATION RATES BY SIZE FOR C&I CUSTOM PROJECTS

Size Stratum	Total Number of Projects	Projects in Sample	Mean of BED Program Reported MMBtu Reduction	Mean of DPS Verified MMBtu Reduction	Realization Rate
Projects with MMBtu Savings					
3	1	1	12.6	12.6	100%
Total Savings	1	1	12.6	12.6	100%
Projects with MMBtu Extra Use					
1	9	5	-1.9	-1.9	101%
2	7	2	-9.0	-9.1	101%
3	7	4	-17.4	-34.0	136%
4	6	5	-79.7	-136.0	171%
Total Extra use	29	16	-526.1	-707.1	134%



As seen in the table above, the realization rates vary across size strata. The two most common reasons for the difference in realized savings are listed below.

- Operating schedules were found to be different from what the participant reported to BED; this impacts both total hours of operation and coincident peak factors.
- Incorrect baseline or efficient case kW values were used, in particular for lighting measures.

BED also made an error by claiming extra use for cold climate heat pumps instead of savings.

3.3 Residential Results

This section covers the adjustments made to residential measures. The residential results are separated into two categories (prescriptive and custom measures), due to the two analysis methods used to calculate the verified savings and realization rates.

3.3.1 Residential Prescriptive Measures

The assumptions for these measures are documented in the TRM and applied to the specific measures by BED. Thus, discrepancies are usually due to errors in applying the TRM values. As the summary of adjustments by load profile in Table 11 illustrates, total DPS verified energy and winter peak kW savings were 8% and 24% more than BED claimed, respectively. The percentage adjustment to the summer peak kW was 18%.

TABLE 11: RESIDENTIAL ADJUSTMENTS BY LOAD PROFILE CATEGORY

Program Group	Adjustment			Percentage Change to BED Claimed Savings		
	kWh	Winter Peak kW	Summer Peak kW	kWh	Winter Peak kW	Summer Peak kW
Prescriptive Lighting Residential	321,953	93.258	30.751	27%	33%	39%
Prescriptive Lighting Commercial	-1,575	0.097	0.177	-4%	2%	2%
Prescriptive HVAC	0	0.363	0.889	0%	2%	-
Prescriptive Other eShapes	39,860	11.111	10.125	-38%	120%	111%
Prescriptive Other non-eShapes	-217,876	-24.345	-20.202	-92%	-93%	-87%
Total	142,361	80.484	21.740	8%	24%	18%

As the residential prescriptive savings contribute more than 40% to the total summer kW reduction for BED’s portfolio, the discrepancies in applying the TRM values had a substantial impact on the overall RR for the portfolio, particularly for winter and summer peak kW reduction. BED applied incorrect TRM to some of the lighting, clothes washer, and dryer measures. In some cases, BED applied commercial kW reduction to residential measures. The DPS adjusted all savings to match TRM 2016.

Table 12 shows the realization rate for the residential fossil fuel savings. The assumptions for these measures are documented in the TRM and applied to the specific measures by BED. The discrepancies between the claimed and verified savings are due to BED errors in applying TRM values. The DPS evaluation team utilized TRM 2016 to update kWh savings, causing an adjustment in the MMBtu savings.



TABLE 12: MMBTU REALIZATION RATES FOR RESIDENTIAL PRESCRIPTIVE PROJECTS

Measure	Quantity	BED Program Reported MMBtu	DPS Verified MMBtu	Realization Rate
Building envelope	4	185	185	100%
Clothes washer/dryer	195	-8	3	-33%
Cold climate heat pump	69	-27	-27	100%
Screw based LED lamps	39	-4	-1	26%
Space heating	1	3	3	100%
Water heating fuel switch	12	-181	-141	78%
Heat pump water heater	14	-38	-39	101%
Low flow faucet aerator, showerhead and pipe wrap	140	39	39	100%
Smartlights	6,480	-114	-	0%
Commercial CFL	196	-26	-26	100%
Total	7,178	779	946	121%

The reasons for MMBtu adjustments include the following:

- BED claimed MMBtu extra use for Smartlight residential lighting measures. Residential indoor lighting has no MMBtu savings.
- The DPS evaluation team updated LED screw-based bulb baseline and efficient case to match TRM 2016.
- For hot water fuel switches, the DPS evaluation team applied the realization rate from the AMI analysis of energy savings to the MMBtu savings.
- For some of the clothes washers, BED values did not match any of the TRM 2015 or TRM 2014 assumptions. It was not possible to match up all entries directly to the TRM 2016, as BED did not clearly identify the washers as front- or top-loading. In such cases, the DPS assumed weighted average of front- and top-loading.

3.3.2 Residential Custom Measures

This category included domestic hot water conservation measures and space heat fuel switches. The results from AMI analysis of PY2014 residential water and space heating measures were applied to the PY2016 claimed savings to determine the verified savings. DPS adjustments resulted in 10% decrease in the winter peak savings and 2% decrease in summer peak savings from the prescriptive values used by BED. The energy savings decreased by 4%.

Water heating conservation measures accounted for over 40% of both summer and winter kW savings of the measures in this category. The remainder of the space heating energy and winter peak savings came from circulator pumps at 29 sites and insulation upgrades at 4 sites.

TABLE 13: WATER AND SPACE HEATING FUEL SWITCH ADJUSTMENTS

Measure Group	Adjustment			Percentage Change to BED Claimed Savings		
	kWh	Winter Peak kW	Summer Peak kW	kWh	Winter Peak kW	Summer Peak kW
Hot water conservation and space heating measures	-4,889	-1.483	-0.103	-4%	-10%	-2%



4 Compliance with ISO-NE Standards

This section covers the compliance of the verification results with the ISO-NE standards. For the residential prescriptive measures, the assumptions are supported by recent, statistically-sound studies. For the custom C&I projects, an individual M&V plan was developed for each project, consistent with the ISO-NE requirements. Most of the ISO-NE requirements are directly relevant to the C&I custom sample and discussed in that context. The ISO-NE requirements are listed in reference to the section in the manual.

4.1 Section 5, Acceptable Measures and Verification Methodologies

This section describes the specific, allowable methods, Options A through D. Engineering algorithms are permitted if supplemented with on-site data collection. Verifiable load shapes may be applied if based on "actual metering, load research, and/or simulation modeling" (Section 5.4.2).

For the residential prescriptive measures (with the exception of hot water fuel switching), Option A was applied, verifiable load shapes and assumptions based on recent, statistically sound studies were available for most of the measures. The recent NMR study for lighting and RLW study for HVAC prepared for NEEP cover the vast majority of the residential prescriptive savings. For hot water fuel switching, Option C was used.

The other measures used either Itron's eShapes or engineering estimates, as described above. While the Itron eShapes are based on data over five years old, they also represent a highly detailed survey of residential use impossible to duplicate within a reasonable time frame and budget. The kW reduction estimated by the use of engineering algorithms accounts for only 3% of the total portfolio, thus the greater uncertainty associated with the load profiles was considered to be acceptable.

4.2 Section 6, Establishing Baseline Conditions

As specified in the manual, the baseline conditions for retrofit projects are the pre-existing conditions. If the pre-existing conditions could not be determined, then the applicable state code, federal product efficiency standard or standard practice (if more stringent than the state or federal requirement) should be used. For market opportunity projects, the baseline is the applicable state code, federal product efficiency standard or standard practice (if more stringent than the state or federal requirement).

These principles were consistently applied to the custom C&I projects and documented in the individual project reports. In a few cases, there was no clear code or standard. In these situations, the Department's evaluation team researched the standard practice and developed the baseline using the best available information.

The same principles were applied in developing the deemed savings values and standard savings estimation algorithms incorporated in the Vermont Technical Reference Manual (TRM).



The TRM has been compiled based on applicable state code, federal product efficiency standards, or standard practice through the work of the Technical Advisory Group (TAG), which includes representatives of the Department, BED, EVT, and industry experts. Use of the TRM for establishing baseline information for prescriptive measures thus represents one means of meeting the requirements outlined in Section 6.

4.3 Section 7, Statistical Significance

For engineering-based, direct measurement, the ISO manual required strategies to control for bias, such as the accuracy and calibration of the measurement tools, sensor placement bias, and sample selection bias or non-random selection of equipment and/or circuits to monitor. The site-specific M&V plans described the relevant issues for each project and discussed the methods used to mitigate bias. These issues are described in greater detail in the site-specific project reports.

In Section 7.2, the manual requires the overall portfolio meet the 80/10 confidence/precision standard. As discussed above, the verification of BED's portfolio meets that standard with a precision of 7% for winter peak reduction and 7% for the summer peak reduction.

This section also discussed the need to minimize bias. Bias relating to the three components of BED's portfolio making up over 80% of the peak kW reduction is explored briefly below.

- For C&I custom projects, stratified ratio estimation was used to identify the sample and random sampling was conducted for the small projects. The locations dropped from the sample due to logistical hurdles were reviewed and there was no indication the projects completed differed in any substantial way from the sample as a whole. Since statistical methods meeting the ISO guidelines were applied and the sample projects were selected to reflect the population as a whole, there is nothing to suggest the results for the C&I custom projects are biased.
- The estimated savings for residential prescriptive lighting are unlikely to be biased since the deemed savings are based on recent market studies.
- The use of the coincidence factors from the KEMA lighting study to quantify the demand savings of some C&I lighting measures is appropriate, since the KEMA sample included a broad range of applications and the coincidence factors represent average values for these specific types of businesses. Thus, the application of the KEMA coincidence factors would not be expected to introduce a bias.

4.4 Section 10, Measurement Equipment Specifications

The Department used RLW's *Review of ISO New England Measurement and Verification Equipment Requirements* (April 24, 2008) to identify the ISO-compliant metering equipment. In some situations, approved metering equipment was used at the lower boundary of the range of kW or current, as there was no alternative equipment meeting the ISO-NE standard.



In these cases, the Department's evaluation team carefully reviewed the results and assessed the validity of the data to decide whether or not the project could be verified. If the evaluator concluded the data could be used to develop reliable estimates without introducing an unacceptable level of uncertainty to the results, the project was kept in the sample. These situations are clearly discussed in the individual project reports.



5 Issues to be Addressed Prospectively

This section describes issues that came up during the evaluation.

5.1 The Smartlight Program

The Smartlight program is an upstream program implemented jointly by BED and EVT. Through this program, lighting distributors receive incentives enabling them to sell high-efficiency lighting at a comparable cost to standard efficiency lighting. Providing incentives to distributors is a potentially effective strategy of increasing the adoption of efficient technology in a cost-effective manner. Unfortunately, this added layer makes it substantially more difficult to verify the savings.

The traceability for these fixtures is challenging due to the wide range of channels that can be used to purchase the lamps, such as the following:

- Products may be purchased directly by the end user and installed in the reported location
- Products may be purchased and installed elsewhere
- Products may be purchased and put in storage for future replacement of existing lamps
- Lamps may also be purchased by a contractor for installation at a customer's site or for future sales

Distributors attempt to gather information about the installation address for the fixtures, but are not always successful.

In addition, since the incentives are paid to the distributors, end users are often unaware they are participating in the program. Without a reference point for participation, such as filling out a rebate form, end users have difficulties identifying the specific lighting purchased and where it was installed.

The spreadsheet provided to the evaluation team contains the installation date, installation address, and model numbers. Smartlights fixtures are easier to locate in facilities that only buy a handful of lighting fixtures. With facilities such as UVM, that purchase large quantities of fixtures, identifying the exact location of the installation becomes difficult. Without location information, the evaluation team could not verify UVM Smartlights projects.

In 2017, BED made an effort to match up the program database to the Smartlight spreadsheet, which significantly reduced the time spent on data preparation. For future evaluations, the DPS evaluation team recommends a change in strategy. Two suggestions are as follows:

- Improve the Smartlight program tracking database to include the specific building and space type where Smartlights are being installed
- Apply an adjustment factor to the Smartlight measures to account for the inability to verify their location



If the latter strategy is adopted, the DPS evaluation team recommends the Department conducts a statewide Smartlight study that can be applied to future evaluations.

5.2 Updating TRM Characterizations

In PY2015 and PY2016, the West Hill Energy Team found BED often seems to use outdated TRM measure characterizations or unknown sources for prescriptive savings. This was common for EnergyStar refrigerators and clothes washers. The overall impact in PY2016 was usually a large upward adjustment or a small downward adjustment. Verifying the TRM characterizations are correctly applied would be a relatively simple way to reduce the uncertainty in the portfolio.



6 Conclusions

The West Hill Energy Evaluation Team completed its independent verification of BED's peak demand reduction on behalf of the Department. BED's M&V plan, as submitted to ISO-NE, was the foundation for the sampling plan and verification activities conducted by the Department. The M&V plan was followed and the results of the evaluation are consistent with the ISO-NE standards, as specifically discussed in this document. The realization rates reflect BED's activity in program year 2016.

BED's energy savings were also evaluated for annual savings verification. As has been done in the past, the residential savings verification consisted of comparing BED's program reported savings to the TRM values. BED's portfolio-level energy savings realization rate is 108%.



7 References

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