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

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Prepared for

The Vermont Public Service Department

Prepared by

West Hill Energy and Computing

In partnership with Cx Associates, ERS (now DNV), GDS Associates, and Lexicon Energy Consulting

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1 Introduction

In 2006, the Independent System Operator of the New England electric grid (ISO-NE) created a Forward Capacity Market (FCM) to ensure that the region has sufficient capacity to meet its peak demand needs. This market-based initiative allows for demand resources, including energy efficiency, to compete directly with generation resources to provide capacity. In order to participate in the market, providers of energy efficiency resources must demonstrate that their energy savings are verified in compliance with the ISO-NE standards established for this purpose.[1]

Burlington Electric Department (BED) bid its Program Year (PY) 2019 efficiency program portfolio into the ISO-NE FCM and submitted measurement and verification (M&V) plans stating that the evaluation process in Vermont will comply with ISO-NE standards. The Vermont Public Service Department (Department or PSD) was charged with conducting the independent evaluation required by the ISO-NE standards. The methods available to the Department to evaluate BED's FCM claims are defined by both the ISO-NE standards and the BED M&V plans. These standards are designed to result in a high degree of reliability for the resources purchased through the FCM and represent a rigorous level of evaluation.

The Department contracted with West Hill Energy and Computing ("West Hill Energy") to provide independent verification of the custom commercial and industrial (C&I) efficiency initiatives for BED within the context of the FCM. This evaluation was also designed to include annual verification of energy, MMBtu savings, and total resource benefit (TRB) inputs for the BED portfolio. With the assistance of four engineering firms, Cx Associates, GDS Associates, Lexicon Energy Consulting, and Energy Resource Solutions, West Hill Energy has implemented the FCM impact evaluation including a statistical analysis, site-specific M&V, and overall evaluation of each efficiency portfolio.

The evaluation activities included sampling, site-specific M&V, statistical analysis, and overall impact evaluation of the BED efficiency portfolio. This report describes the evaluation of the BED efficiency portfolio for PY2019 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 15.2 in the ISO Manual.

This evaluation was designed to determine the appropriate realization rates (RRs) to be applied to BED's estimated energy savings and demand reductions. These RRs are applied to the program-reported savings to determine BED's verified savings. The RRs given in this document will be used to adjust BED's savings reported to ISO-NE FCM from July 31, 2020, 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 the portfolio are described in BED's 2019 Annual Report.[2]

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[1] *ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources Manual M-MVDR*, Revision: 7, Effective Date: October 4, 2018.
[2] Burlington Electric Department 2019 Energy Efficiency Annual Report.

2 Program Activity

For the PY2019 evaluation cycle, the PSD Evaluation Team divided the portfolio into two categories, C&I (including multifamily) and residential. The following sections provide more details on the types of projects completed for each sector.

2.1 Commercial & Industrial (C&I)

This category includes all BED programs targeted to business and multifamily sectors. In PY2019, C&I projects accounted for 42% and 73% of BED winter and summer portfolio peak savings, respectively.

In BED's savings portfolio, all custom C&I and multifamily projects are categorized as either retrofit or new construction (NC)/market opportunity (MOP). BED also offers measures such heat pumps, circulator pumps, heat pump water heaters (HPWH), and Smartlight measures through their upstream initiatives. The Smartlight Program is implemented jointly by BED and Efficiency Vermont (EVT). Through this program, lighting distributors receive incentives enabling them to sell high-efficiency lighting at a comparable cost to standard efficiency lighting.

In previous program years, the C&I savings were mostly custom and prescriptive. For example, in PY2018, custom and prescriptive savings accounted for approximately 70% of the C&I peak savings with upstream programs accounting for the remaining 30%. However, in PY2019, the BED C&I portfolio was substantially different in the following ways:

1. Custom and prescriptive projects accounted for only 19% and 14% of BED reported C&I peak kW for winter and summer, respectively, with upstream programs accounting for the remainder.

2. The upstream Smartlight Program accounted for the largest percentage of the BED PY2019 C&I portfolio. Smartlight measures were 77% and 85% of BED reported winter and summer peak kW, respectively.

3. Upstream HPWH, circulator pumps, heat pumps, and appliances contributed less than 5% of the C&I portfolio savings.

Table 1 below provides a summary of PY2019 C&I savings by project type.

TABLE 1: BED PY2019 SAVINGS BY TYPE OF INITIATIVE

Project Type	BED Reported Winter Peak kW	BED Reported Summer Peak kW	% Winter C&I Peak kW	% Summer C&I Peak kW
Smartlight	172.328	324.977	77%	85%
Custom & Prescriptive	42.415	54.819	19%	14%
Other Upstream Measures[1]	9.258	1.208	4%	<1%
Other[2]	0.292	0.281	0%	<1%
Total	224.293	381.285	100%	100%

[1]Other Upstream measures includes circulator pumps, heat pumps, and HPWH.
[2]"Other" category includes appliances such as clothes dryers, washers, and motor controls with no peak savings.

2.2   Residential Sector

BED offers residential energy efficiency upgrades and most of the program reported savings are almost entirely prescriptive. Table 2 below provides a summary description of products offered through residential initiatives.

TABLE 2: SUMMARY OF RESIDENTIAL SECTOR INITIATIVES

Initiative	Description
Residential Prescriptive Lighting	Lighting measures offered through the Efficiency Products Program (EPP) and residential upstream initiatives
Residential Prescriptive HVAC	Room air conditioners (A/Cs) and cold climate heat pumps (CCHP) offered through EPP and Residential New Construction (RNC) and Residential Existing Buildings (REB) programs
Other Residential Measures	Clothes washers, clothes dryers, refrigerators, pool pumps, dehumidifiers, circulator pumps, exhaust fans, and electronics offered through EPP, RNC, low-income and residential REB retrofit programs
Residential NC Custom	Custom residential NC thermal shell electric and natural gas heating savings estimated using The Vermont Certified Homes Energy Savings Calculation Tool

Most of the residential savings is from prescriptive lighting, which makes up about 93% and 84% of the residential winter and summer peak savings, respectively. The table below provides the savings summary by initiative.

TABLE 3: SUMMARY OF RESIDENTIAL SECTOR SAVINGS

Initiative	Energy Savings (kWh)	Winter Demand Savings (kW)	Summer Demand Savings (kW)
Prescriptive Lighting	1,187,046	293.558	119.411
Prescriptive HVAC	68,058	12.316	2.122
Other Residential Measures	95,918	7.095	19.895
Residential NC Custom	4,392	1.263	0.000
Total	1,355,414	314.233	141.43

3 Methods

BED bid its entire portfolio of energy efficiency initiatives into the FCM. Each component of the portfolio was reviewed by the PSD Evaluation Team. The verification approach for each component was selected according to the types of measures and projects and the requirements specified in the ISO-NE Manual for Measurement and Verification of On-Peak Demand Resources (M-MVDR). The portfolio was divided according to the source of the coincidence factors. The evaluation categories and associated evaluation strategies are summarized in Table 4. Detailed sampling and evaluation methods for each project type are discussed in subsequent sections.

TABLE 4: FCM VERIFICATION STRATEGY BY EVT INITIATIVE

Project Type	Sampling Approach	Evaluation Approach	ISO M&V Option
C&I Sector			
Smartlight	Smartlight with prior FCM metering: Census, no sampling conducted	Applied past FCM metering coincidence factors and in-service rates (ISRs) to determine savings	Options A
	Smartlight without prior FCM metering: Stratified random sampling per ISO standards	Conducted phone survey to determine hours of use (HOU), coincidence factors, and ISRs	
Custom & prescriptive	No sampling conducted	Used past site metering, building management systems (BMS), modeling, and trend data to determine coincidence factors and HOU Contacted the customer to request additional information on equipment operation, schedules, *etc*.	Options A through D
Upstream CCHP			Option A
Upstream HPWH	No sampling necessary	Prescriptive review for all measures	Option A
Upstream Circulator Pumps			Option A
Other[1]	No sampling necessary	Applied average RRs from the C&I portfolio	
Residential			Option A
Prescriptive Lighting			Option A
Prescriptive HVAC	No sampling necessary	Prescriptive assumptions	Option A
Other Residential Measures			Option A
Residential NC			Option A

[1]"Other" category includes appliances such as clothes dryers, washers, and motor controls with low peak savings. Peak savings are too small (<0.1%) and on-site measurement was required to verify savings.

3.1   Commercial and Industrial (C&I)

All C&I projects were divided into three categories: custom and prescriptive, upstream Smartlight, and other upstream measures. The sampling and evaluation approach was different for each type of project.

One complication in evaluating PY2019 was the Covid-19 pandemic lockdown starting in March 2020; these issues are discussion further in the following section. The subsequent sections provide the sampling and evaluation approach for each project type.

3.1.1   Covid-19 Impacts on Analysis Methods

The Covid-19 pandemic lockdown started in March 2020 and complicated the savings analysis for some sites. As on-site metering was precluded, the site-specific analyses were conducted using pre-existing meter data, advanced metering interface (AMI) data, and building management systems (BMS) data.

As some businesses closed temporarily or cut back their hours of operation, the analysis approach was to review AMI, BMS, and/or monthly billing data to assess whether there were substantial changes in operation at the site. If so, the period showing a substantial change (typically a sharp reduction in use during the spring of 2020) was removed from the analysis. If the consumption data could not be interpreted to determine the period or magnitude of the Covid-19 impacts, the PSD Evaluation Team contacted the site to gather additional information on equipment operation or schedules.

3.1.2   Custom and Prescriptive Projects

As described in Section 2.1, BED custom and prescriptive projects accounted for a smaller percentage of the PY2019 C&I portfolio compared to previous FCM evaluations. There were a total of 35 locations with custom or prescriptive measures. The PSD evaluation team reviewed each custom and prescriptive project and identified those that could be evaluated without going on site.

Fourteen locations were evaluated by relying on BMS or trend data, modelling, and past FCM metering to determine winter and summer coincidence factors. All measures associated with custom and prescriptive projects at these fourteen locations were reviewed. In cases where additional information on equipment operation or schedules is required, the PSD evaluation team worked with BED to contact the site for a phone interview. These fourteen locations consisted of the larger projects and accounted for 73% and 82% of the total C&I custom and prescriptive winter and summer peak demand reduction, respectively, or about 13% of the peak C&I portfolio savings.

Twenty-one locations were not evaluated because evaluating measures for these sites would have required on-site metering. These twenty-one locations had small lighting and controls projects that accounted for less than 5% of the peak C&I portfolio savings.

3.1.3   Upstream Smartlight Projects

In prior FCM evaluations, Smartlight projects were evaluated as part of the C&I custom & prescriptive projects. However, in PY2019, Smartlight measures accounted for 77% and 85% of BED reported winter and summer peak kW, respectively. Since the Smartlight Program

accounted for the largest percentage of the BED PY2019 C&I portfolio, the PSD Evaluation Team conducted a separate study to evaluate the Smartlight measures.

Due to Covid-19 restrictions, the PSD evaluation team could not complete on-site measurement and verification. Therefore, verified savings for Smartlight measures were based on past FCM metering and on-site data, stipulated profiles, and phone surveys. For PY2019, the sampling unit was the entity *i.e.*, if a company has multiple locations, all locations were treated as one entity. This definition of the sampling unit was selected because Smartlight measures were sometimes installed at different locations, but they were under the control of one company. Therefore, having the sampling conducted on the entity allowed the evaluation team to focus survey questions on installations known to the respondent in charge of purchasing Smartlight measures for the multiple locations.

The PSD evaluation team split Smartlight measures into two categories:

1. Entities that were metered during past FCM evaluations
2. Entities without prior meter data

Company name and address fields in the distributor spreadsheets were used to match location IDs to entities. Summary of the Smartlight program savings by category is shown in Table 5 below.

TABLE 5: SMARTLIGHT PROGRAM SAVINGS

Category	kW Win	kW Sum	% kW Win C&I Portfolio	% kW Sum C&I Portfolio
Entities with prior FCM meter data	76.084	149.316	34%	39%
Entities **without** prior FCM meter data	96.244	175.662	43%	46%
Total	172.328	324.977	77%	85%

The following sections provide sampling and evaluation approach for the two Smartlight categories.

3.1.3.1 Entities with Prior FCM Meter Data

This group included 20 entities that were metered in past FCM evaluations. A census of these projects was evaluated. As shown in Table 5 above, the twenty entities account for 34% and 39% of the winter and summer peak C&I portfolio savings, respectively. Previous data collected during FCM evaluation included facility type, hours of use (HOU), in-service rates (ISRs), and winter and summer coincidence factors. This data was be used to verify energy savings for each entity.

3.1.3.2 Entities without Prior Metering

The remaining Smartlight projects without prior FCM metering were sampled separately. Most of the projects in this category were small, but the entire category accounted for 43% and 46% of the C&I portfolio winter and summer peak, respectively. As shown in Table 6 below, entities were divided into four strata. The primary variable for establishing the size strata was the maximum of the BED reported winter and summer peak kW reduction.

A stratified random sample was selected. The smallest strata that accounted for 2% of the population and was not included in the sample. The sample sizes were calculated to exceed the minimum required to estimate savings at the 80/10 confidence/precision level.

TABLE 6: SMARTLIGHT SAMPLE OVERVIEW

Stratum	Total Number of Entities	Sampled Entities	% kW Winter	% kW Summer
0	140	0	2%	2%
1	112	7	18%	18%
2	31	7	16%	15%
3	16	7	19%	18%

The strategy was to conduct a phone survey to determine the in-service rate, hours of use, and any Covid-19 impacts on hours of operation. BED provides Smartlight distributor files with addresses, fixture model numbers, and location names.

3.1.4   Other Upstream Projects

Other upstream measures included heat pumps, circulator pumps, and HPWH sold through BED's upstream initiatives. Sampling was not necessary for these upstream measures as the evaluation of these projects required checking the claimed savings against the 2019 TRM.

3.1.5   Calculation of Realization Rates

The savings 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 achieved based on the results of the evaluation M&V analysis. The RR for each C&I site 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 sites in the sample

wi is the expansion weight (the total number of sites in the stratum divided by the number of verified sites in the stratum)

yi is the verified savings for site i

xi is the original claimed savings for site i

The basis for these calculations and the method for calculating variances are provided in the *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*.[3]

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[3] *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 11.* Prepared for National Renewable Energy Laboratory. September 2011 – September 2016

3.2   Attrition

The majority of the sampled sites selected for BED's FCM 2019 sample were verified. Twenty-one locations with custom and prescriptive measures were not included in the evaluation sample because the PSD Evaluation Team could not conduct on-site metering due to Covid-19 restrictions. These twenty-one locations had small lighting and controls projects that accounted for less than 5% of the peak C&I portfolio savings.

3.3   Residential

BED program reported residential sector savings are almost entirely prescriptive and calculated using assumptions that have been reviewed by the PSD and included in the EVT Technical Reference Manual (TRM). Verification of savings for residential measures consisted of comparing the program-reported savings to the prescriptive assumptions reviewed by the PSD and included in the Vermont TRM. The TRM contains engineering algorithms for prescriptive savings developed from relevant studies and EVT's own data on measures installed by past program participants. For the residential pool pump measure in the efficient products program, the PSD Evaluation Team applied PY2018 results based on analyses of utility interval data, as per M-MVDR option C, to verify the prescriptive assumptions from the TRM.

A summary of the residential measures separated according to the source of the load profile is provided in Table 7 below. The approach used for each of the measure categories is described briefly in the sections below.

TABLE 7: RESIDENTIAL LOAD PROFILE SOURCES

Measure Category	Source of Coincidence Factor	Percent of Total Portfolio	
		Winter kW	Summer kW
Prescriptive Lighting	NEEP residential lighting study[1], NEEP C&I load shape study for cooling bonus[2]	55%	23%
Prescriptive HVAC	Residential Room Air Conditioner Coincidence (RAC) Factor study[3], Vermont Residential CCHP Study[4]	2%	0%
Other Residential Measures	Engineering estimates[5], AMI data analysis for efficient pool pumps	1%	4%
Residential NC Custom	Engineering estimates[6]	0%	0%
Residential as % of Total Portfolio		58%	27%

[1] Northeast Residential Lighting Hours-of-Use Study. Prepared by NMR Group, Inc. and DNV GL. Somerville, MA. May 5, 2014.

[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.

[3] Coincidence Factor Study Residential Room Air Conditioners. Prepared for the Northeast Energy Efficiency Partnerships' New England Evaluation and State Program Working Group by RLW Analytics, Middletown, CT. June 23, 2008.

[4] Evaluation of Cold Climate Heat Pumps in Vermont. Prepared for the Vermont PSD by the Cadmus Group Inc. November 3, 2017.

[5] 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 the BED portfolio.

[6] It would be costly to develop load profiles from primary research for these measures and they constitute a small percentage of BED's overall portfolio.

4 Results

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

4.1 Portfolio Results

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

4.1.1 Electric Energy

The RRs and relative precision for BED's energy savings are provided in Table 8. The portfolio kWh RR is 94% with a relative precision of 6.4% at the 90% confidence level.

TABLE 8: REALIZATION RATES AND SAMPLING PRECISION FOR ENERGY SAVINGS

Program Group/ Load Profile Group	BED Program Reported kWh Reduction	Realization Rate	PSD Verified kWh Reduction	Relative Precision at the 90% Confidence Level
C&I Sector				
Smartlight	1,743,005	81%	1,411,229	11.4%
Custom & prescriptive	591,401	117%	692,230	0.0%
Upstream CCHP	39,369	119%	46,803	0.0%
Upstream HPWH	7,754	100%	7,754	0.0%
Upstream Circulator Pumps	26,916	100%	26,916	0.0%
Other[1]	7,063	91%	6,408	0.0%
Residential				
Prescriptive Lighting	1,187,046	101%	1,202,398	11.7%
Prescriptive HVAC	68,058	100%	68,003	10.4%
Other Residential Measures	95,918	89%	85,309	0.0%
Residential NC	4,392	92%	4,034	0.0%
Totals	3,770,921	94%	3,551,084	6.4%

[1]"Other" category includes appliances such as clothes dryers, washers, and motor controls with low peak savings.

4.1.2 Peak Demand Reduction

Table 9 and Table 10 show the RRs and relative precision for the peak kW reduction verified for the FCM component of the evaluation. The portfolio-wide RR for winter peak kW is 110% and for summer peak kW is also 86%. The relative precision of the verified savings in the BED

portfolio is 6.9% and 5.6% for the winter and summer peak kW reduction, respectively, which exceeds the FCM requirements.

TABLE 9: REALIZATION RATES AND SAMPLING PRECISION FOR WINTER PEAK kW REDUCTION

Program Group/ Load Profile Group	BED Program Reported Winter Peak kW Reduction	Realization Rate	PSD Verified Winter Peak kW Reduction	Relative Precision at the 90% Confidence Level
C&I Sector				
Smartlight	169.1	110%	185.2	8.4%
Custom & Prescriptive	45.7	153%	70.0	0.0%
Upstream CCHP	6.3	183%	11.4	0.0%
Upstream HPWH	1.2	100%	1.2	0.0%
Upstream Circulator Pumps	1.8	100%	1.8	0.0%
Other[1]	0.3	120%	0.4	0.0%
Residential				
Prescriptive Lighting	293.6	102%	298.5	11.7%
Prescriptive HVAC	12.3	100%	12.3	0.0%
Other Residential Measures	7.1	103%	7.3	0.0%
Residential NC	1.3	100%	1.3	0.0%
Totals	538.5	110%	589.3	6.9%

[1]"Other" category includes appliances such as clothes dryers, washers, and motor controls with low peak savings.

TABLE 10: REALIZATION RATES AND SAMPLING PRECISION FOR SUMMER PEAK kW REDUCTION

Program Group/ Load Profile Group	BED Program Reported Summer Peak kW Reduction	Realization Rate	PSD Verified Summer Peak kW Reduction	Relative Precision at the 90% Confidence Level
C&I Sector				
Smartlight	318.4	74%	236.8	7.9%
Custom & Prescriptive	61.4	111%	68.3	0.0%
Upstream CCHP	0.6	205%	1.2	0.0%
Upstream HPWH	0.6	100%	0.6	0.0%
Upstream Circulator Pumps	0.0	100%	0.0	0.0%
Other[1]	0.3	81%	0.2	0.0%
Residential				
Prescriptive Lighting	119.4	104%	124.7	12.4%
Prescriptive HVAC	2.1	92%	1.9	10.4%
Other Residential Measures	19.9	64%	12.8	0.0%
Residential NC	0.0	100.0%	0.0	0.0%
Totals	522.7	86%	446.7	5.6%

[1]"Other" category includes appliances such as clothes dryers, washers, and motor controls with low peak savings.

4.1.3   Fossil Fuel Savings

BED claims fossil fuel savings for measures that reduce the use of fossil fuels in addition to recording extra fuel use for fuel switching and the waste heat penalty for commercial lighting measures. These MMBtu impacts are separated into measures with savings and measures with extra use. The RRs for the whole portfolio are shown in Table 11.

TABLE 11: REALIZATION RATES FOR MMBTU SAVINGS

Program	BED Portfolio Reported MMBtu Savings	BED Sample Reported MMBtu Savings[1]	PSD Verified MMBtu Savings	Realization Rate
MMBtu Extra Use				
C&I Sector[1]	-1,329	-1,267	-805	64%
Residential Sector	-181	-181	-181	100%
Total	-1,510	-1,448	-986	68%
MMBtu Savings				
C&I Sector	963	913	952	104%
Residential Sector	256	256	252	98%
Total	1,220	1,170	1,204	103%

[1] BED characterized all the C&I Smartlight projects as having the commercial #101 load profile. Some of the projects were completed in residential facilities where there is no heating penalty in the TRM.

The biggest driver behind the differences between BED reported MMBtu extra use and PSD verified extra use is mischaracterization of the lighting load profiles. BED characterized majority of the lighting measures as having the commercial load profile, although they were actually installed in residential buildings. The PSD Evaluation Team updated the load profiles to match the facility type.

4.2   C&I Results

The following sections provide additional details about the C&I electric savings followed by the fossil fuel MMBtu savings.

4.2.1   Electric Savings

Table 12 provides a summary of the RRs and population for the C&I custom sites in the BED portfolio. The RRs in the final row reflect the overall realization for the C&I custom sites and are also provided in Tables 8 through 10 above. The RRs for each project are provided in Appendix A.

TABLE 12: ENERGY REALIZATION RATES BY SIZE FOR C&I CUSTOM SITES

	kWh		kW Winter		kW Summer	
Project Type	**RR**	**% of Total Portfolio**	**RR**	**% of Total Portfolio**	**RR**	**% of Total Portfolio**
Smartlight Entities with Prior Metering	50%	21%	77%	14%	47%	27%
Smartlight Entities without Prior Metering	106%	26%	134%	18%	97%	34%
Custom & Prescriptive	117%	16%	153%	8%	111%	12%
Upstream CCHP	119%	1%	183%	1%	205%	0%
Upstream HPWH	100%	0%	100%	0%	100%	0%
Upstream Circulator Pumps	100%	1%	100%	0%	100%	0%
Other[1]	91%	64%	120%	42%	81%	73%

[1]"Other" category includes appliances such as clothes dryers, washers, and motor controls with low peak savings (<0.1%). The RRs were estimated to be the same as the average RRs of the other C&I categories.

As shown in Table 12 above, the RRs vary by project type. The most common reasons for the difference in realized savings are listed below:

o   Incorrect baseline or efficient case kW values were used for Smartlight measures.

o   Some Smartlight measures reported as being installed in commercial buildings in the BED database were found to be installed in residential properties.

o   Operating schedules were found to be different from what the participant reported to BED; this affects both total hours of operation and coincident peak factors.

o   For one NC grocery store project, BED applied overly conservative estimated inputs for the refrigeration and building system, which resulted in much higher verified savings.

o   In a few cases, BED understated prescriptive savings by not multiplying the kW load by the quantity of the fixtures installed.

As shown in Table 12, the PSD Evaluation Team's adjustments resulted in summer savings having the lowest RR compared to both the winter and kWh. The primary reason for the adjustments made to the summer peak savings is due to BED mischaracterizing some C&I Smartlight residential installations as having the TRM 2019 commercial #101 load profile. Smartlight traceability is challenging due to the wide range of channels that can be used to purchase the lamps. Though distributors had been recorded these projects as a commercial installation in the Smartlight database, the evaluation team found that the efficiency upgrades were installed at residential properties.

4.2.2   Fossil Fuel Savings

Table 13 shows the RR for MMBtu savings from fossil fuels for sites included in the sample. Seventy-three entities in the FCM19 sample had MMBtu extra use due to interactive effects between lighting and space heating (waste heat penalty). Two entities in the sample had MMBtu

savings. RRs for the entities are provided in Table 13 below. Appendix B provides reports by BED location ID with information on the differences between BED program reported and PSD verified MMBtu savings.

TABLE 13: MMBTU REALIZATION RATES FOR C&I CUSTOM SITES

Type	Total Number of Entities	Entities in Sample	BED Program Reported MMBtu Reduction	PSD Verified MMBtu Reduction	Realization Rate
Entities with MMBtu Savings	10	2	913	952	104%
Entities with MMBtu Extra Use	322	73	-1,267	-805	64%

The reasons for MMBtu adjustments include the following:

o BED applied commercial MMBtu extra use to Smartlight that were identified by the PSD Evaluation Team as being installed in residential properties. The TRM does not claim any MMBtu extra use for residential lighting.

o In a few cases, BED understated MMBtu extra use by not multiplying the kW load by the quantity of the fixtures installed.

Overall, the BED program-reported and PSD-verified MMBtu extra use for lighting were quite close for commercial facilities.

4.3 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 RRs. Each section covers the electric savings followed by the fossil fuel MMBtu savings.

4.3.1 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 14 illustrates, total PSD verified energy savings were 0.3% higher than BED claimed. Winter peak kW savings were 2% higher and summer peak kW savings were 1% less than BED claimed.

TABLE 14: RESIDENTIAL ADJUSTMENTS BY LOAD PROFILE CATEGORY

Project Type	kWh		kW Winter		kW Summer	
	RR	% of Total Portfolio	RR	% of Total Portfolio	RR	% of Total Portfolio
Prescriptive Lighting	101%	31%	102%	55%	104%	23%
Prescriptive HVAC	100%	2%	100%	2%	92%	0%
Other Residential Measures	89%	3%	102%	1%	64%	4%
Residential NC Custom	92%	0%	100%	0%	100%	0%

Residential savings contribute about 58% to the total winter kW reduction and 27% to the summer kW for the entire BED portfolio. As shown in Table 14 above, there were minor discrepancies in applying the TRM values which resulted in small adjustments being made to the reported residential savings.

Table 15 shows the RR for the residential fossil fuel savings. The assumptions for these measures are documented in the TRM. The discrepancies between the claimed and verified savings are due to BED errors in applying TRM values. The PSD Evaluation Team utilized TRM 2019 to update kWh savings causing an adjustment in the MMBtu savings.

TABLE 15: MMBTU REALIZATION RATES FOR RESIDENTIAL PRESCRIPTIVE PROJECTS

Measure	BED Program Reported MMBtu	PSD Verified MMBtu	Realization Rate
Clothes washer	45.540	41.170	90%
CCHP	35.410	35.410	100%
Clothes dryer	1.682	1.670	99%
Commercial LED lighting	-181.253	-180.640	100%
HPWH	35.579	35.579	100%
Space heating fuel switch	50.887	50.887	100%
Residential NC Custom	87.300	87.300	100%
Total	75.145	71.376	95%

MMBtu savings adjustments were made to the clothes washers and dryers. For these measures, BED applied TRM 2018 values to clothes dryers and washers. The PSD Evaluation Team updated the baseline and efficient case to match TRM 2019.

4.3.2   Residential Pool Pumps AMI Analysis

In 2018, BED completed efficient pool pump upgrades at 12 sites. These sites replaced existing swimming pool circulation pumps with new efficient pumps. The PSD Evaluation Team completed an advanced metering infrastructure (AMI) analysis to verify efficient pool pumps

savings. Further details on the findings are provided in Appendix C. The RRs in the Appendix C efficient pool pumps study were applied to the PY2019 reported savings to calculate the evaluated savings.

As discussed in Appendix C, AMI data was provided for 10 out of the 12 sites. Savings were estimated from a pre-/post-analysis. AMI data for each site was analyzed individually to determine kWh and summer kW savings. As pool pumps are a retrofit measure, the demand savings were calculated as the difference in average peak kW demand in the peak hours between the pre- and post-installation periods. Since this AMI analysis includes the entire house load, adjustments were made to limit the impacts of any changes in A/C usage between the pre- and post-period.

The results of the PSD Evaluation Team's analysis indicated that the TRM kW reduction was overstated due to smaller or more efficient baseline pumps. Further details on the findings are provided in Appendix C.

5 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 that was consistent with the ISO requirements. Most of the ISO requirements are directly relevant to the C&I custom sample and are discussed in that context. The ISO requirements are listed in reference to the section in the M-MVDR.

5.1 Section 5, Acceptable Measures and Verification Methodologies

This section describes the specific allowable methods, Options A through D. For the C&I custom projects, Options A through D were selected on a site-by-site basis. All sites were evaluated using one of these options.

Option A was applied to the prescriptive measures using verifiable load shapes and assumptions based on recent, statistically sound studies, as discussed above. The Northeast Energy Efficiency Partnership (NEEP) study for C&I lighting, the residential HVAC study for residential A/C, the NEEP residential lighting study for lighting and the previous impact evaluation of CCHP installations in Vermont cover the vast majority of the prescriptive savings. While several of the studies were completed more than 5 years ago, they represent robust and defensible analyses with large sample sizes that cannot be reproduced within a reasonable time frame and budget.

For swimming pool circulator pumps, Option C was applied using AMI data for a whole building approach and savings were estimated from a pre/post-analysis of use during the ISO-NE peak hours. The other prescriptive measures used either Itron's eShapes or engineering estimates, as described previously.[4] The kW reduction estimated by using Itron's eShapes and engineering estimates account for less than 2% of the total portfolio and thus the greater uncertainty associated with the load profiles was considered acceptable.

5.2 Section 6, Establishing Baseline Conditions

As specified in the ISO 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 MOP 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 sites and documented in the individual project reports. In a few cases, there was no clear code or standard. In these

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[4] While the Itron eShapes are based on data over five years old, they also represent a highly detailed survey of residential use that would be impossible to duplicate within a reasonable time frame and budget.

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 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.

5.3 Section 7, Statistical Significance

For engineering-based, direct measurement, the ISO manual requires 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. For PY2019, site visits could not be conducted, so the evaluation team relied on previous FCM metering, BMS/trend and AMI data. All previous FCM metering was conducted based on site-specific M&V plans that described the relevant issues for each project and discussed the methods used to mitigate bias.

In Section 7.2, the manual requires the overall portfolio meet the 80/10 confidence/precision standard. As discussed above, the verification of the BED portfolio exceeds that standard with a relative precision of 6.9% for winter and 5.6% for summer peak reduction.

Section 7.2 also specifies the need to minimize bias. Bias relating to the three components of the BED C&I portfolio is explored briefly below.

- o For C&I Smartlight, all entities with prior FCM metering were included for evaluation. For entities without prior FCM meter data, stratified ratio estimation was used to identify the sample and random sampling was conducted within each stratum. Statistical methods meeting the ISO guidelines were applied and the sample sites were selected to reflect the population.

- o In the analysis of the C&I custom measures, the evaluation team avoided bias from the Covid-19 pandemic lockdown by eliminating the post-period months affected by changes in operation due to the lockdown. In cases where there was insufficient post-period data before or after the pandemic lockdown, the evaluation team left the savings unverified.

- o The estimated savings for prescriptive measures are unlikely to be biased since the deemed savings are based on recent market studies.

The use of the stipulated coincidence factors from the NEEP C&I lighting study[5] to quantify the demand savings of some C&I lighting measures is appropriate, since the NEEP 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 NEEP coincidence factors would not be expected to introduce a bias.

Bias relating to the BED residential portfolio is explored briefly below.

- o For a few residential measures, the load profiles were based on engineering assumptions and the relative precision could not be determined. These coincidence 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 2% of the winter and summer peak kW savings).

- o For the residential pool pump measure, the analysis was done using AMI data. No sampling was done for these measures, so the relative sampling precision is 0%.

- o For the residential prescriptive lighting products, the reduction in Watts and ISRs are based on the NEEP Residential Lighting Strategy.[6] Verified lighting coincidence factors were based on the 2014 NEEP residential lighting study.[7] Thus, the residential lighting savings are composed of three components with values derived from two different studies (NEEP, 2012 and NEEP, 2014).

5.4 Section 10, Measurement Equipment Specifications

The PSD Evaluation Team verified that its metering equipment meets requirements of the FCM M-MVDR.

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[5] The stipulated profiles include grocery store, hospital, office, restaurant, retail and warehouse indoor lighting. *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.
[6] *Northeast Residential Lighting Strategy*, Prepared by Energy Futures Group for NEEP, March 2012.
[7] *Northeast Residential Lighting Hours-of-Use Study.* Prepared by NMR Group, Inc. and DNV GL, 2014, page IX.

6 Conclusions and Recommendations

The West Hill Energy Evaluation Team completed its independent verification of the BED peak demand reduction on behalf of the Department. The BED 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.

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