

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

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1 Introduction

Burlington Electric Department (BED) bid its efficiency program portfolio into the Independent System Operator of the New England's (ISO-NE) Forward Capacity Market (FCM). To participate in the market, providers of energy efficiency resources must demonstrate that their efficiency savings are verified in compliance with the ISO-NE standards established for this purpose.¹ BED submitted a measurement and verification (M&V) plan stating that the evaluation process in Vermont will comply with ISO-NE standards and the Vermont Department of Public Service (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 plan. 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 BED's energy efficiency portfolio. This evaluation was also designed to include annual verification of energy, MMBtu savings, and total resource benefit (TRB) inputs for the BED portfolio. The PSD Evaluation Team, consisting of West Hill Energy, Cx Associates, Lexicon Energy Consulting, and DNV, implemented the FCM impact evaluation, including a statistical analysis, site-specific M&V, and overall evaluation of each component of the efficiency portfolio.

This report describes the evaluation of BED's program year (PY) 2020 FCM bid and the results of this verification process. It also provides documentation to support the Annual Certification of Accuracy of Measurement and Verification Documents, as specified in Section 17.2 of the ISO Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (M-MVDR, Revision 7, October 4, 2018).

This evaluation was designed to determine the 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, 2022, until the completion of the next evaluation cycle.

The remainder of this report is divided into the following sections: program activity, methods, results, compliance with ISO-NE Standards, and conclusions. The components of the portfolio are described in BED's 2020 Annual Report.²

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 2020 Energy Efficiency Annual Report.



2 Program Activity

BED bid its entire portfolio of energy efficiency initiatives into the FCM. For PY2020 evaluation cycle, the PSD Evaluation Team divided the portfolio into two categories, commercial and industrial (C&I) and residential. The C&I savings accounted for the largest portion of the portfolio savings with 62% and 83% of the winter and summer peak savings, respectively.

The following sections provide more details on the types of projects and evaluation methods used to verify C&I and residential savings.

2.1 Commercial and Industrial (C&I) Programs

The C&I category includes all BED programs targeted to businesses. In PY2020, C&I projects accounted for 62% and 83% of BED winter and summer portfolio peak savings, respectively. In BED's savings portfolio, all custom C&I projects are categorized as either retrofit or new construction/market opportunity (NC/MOP). BED also offers measures, such as heat pumps, circulator pumps, heat pump water heaters (HPWH), and LED lighting, 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.

Prior to PY2019, 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%.

For PY2020, custom and prescriptive measures accounted for 73% and 57% of BED reported C&I peak kW for winter and summer, respectively, with upstream programs accounting for the remainder. Table 2-1 provides a summary of PY2020 C&I savings by measure group.

TABLE 2-1: C&I PROGRAM REPORTED WINTER AND SUMMER PEAK REDUCTION

Measure Group	Program Reported Winter Peak kW	Program Reported Summer Peak kW	% Winter C&I Peak kW	% Summer C&I Peak kW
Smartlight	90.570	167.350	25%	43%
Custom and Prescriptive	265.117	222.795	73%	57%
Other Upstream Measures ¹	7.803	1.492	2%	0%
Total	363.490	391.636	100%	100%

¹ Measures include upstream cold climate heat pumps, HPWHs, and circulator pumps.

2.2 Residential Sector

BED offers residential energy efficiency upgrades and most of the program reported savings are entirely prescriptive. Table 2-2 provides a description of products offered through BED's residential programs.

TABLE 2-2: RESIDENTIAL MEASURE GROUPS

Measure Group	Description
Prescriptive Lighting	Lighting measures offered through the Efficient Products Program (EPP) and residential upstream initiatives
Prescriptive Heating, Ventilation and Air Conditioning (HVAC)	Room air conditioners (A/Cs) and cold climate heat pumps (CCHP) offered through EPP 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, low-income, and residential REB retrofit programs

Residential prescriptive lighting savings make up about 48% and 50% of the residential winter and summer peak savings, respectively. Table 2-3 provides the savings summary by measure group.

TABLE 2-3: RESIDENTIAL PROGRAM REPORTED ENERGY SAVINGS AND PEAK DEMAND REDUCTION

Measure Group	Program Reported Energy Savings (kWh)	Program Reported Winter Demand Savings (kW)	Program Reported Summer Demand Savings (kW)
Prescriptive Lighting	485,594	130.4	47.7
Smartlights	146,840	43.8	11.9
Prescriptive HVAC	334,128	60.4	9.8
Other Residential Measures	320,663	34.6	25.1
Total	1,287,226	269.1	94.5

3 Methods

The PSD Evaluation Team reviewed each component of the portfolio. The verification approach for each component was selected according to the types of measures and projects and the requirements specified in the ISO-NE M-MVDR. The evaluation categories and associated evaluation strategies are summarized in Table 3-1. Detailed sampling and evaluation methods for each measure group are discussed in subsequent sections.

TABLE 3-1: VERIFICATION STRATEGY BY MEASURE GROUP

Measure Group	Sampling Approach	Evaluation Approach	FCM M&V Option
Commercial and Industrial (C&I)			
Smartlight	Stratified random sampling	Conducted phone survey to determine hours of use (HOU), coincidence factors (CFs), and in-service rates (ISRs); metering was conducted for one site where the Vermont Load Shape Analysis ¹ (VLSA) could not be applied.	Option A
Custom and Prescriptive	No sampling conducted	Site-specific M&V, building management systems (BMS), and advanced metering infrastructure (AMI) analysis; contacted the customer to request additional information on equipment operation, schedules, Covid-19 Impacts, <i>etc.</i>	Options A through D
Upstream CCHP, HPWH and Circulator Pumps	No sampling necessary	Prescriptive review for all measures	Option A
Other ²	No sampling necessary	Applied average RRs from the C&I portfolio	Option A
Residential			
Prescriptive Lighting	No sampling necessary	Prescriptive assumptions	Option A
Prescriptive HVAC			
Other Residential Measures			

¹ Vermont Load Shape Analysis. Final Report. West Hill Energy & Computing. December 30, 2021.

² "Other" category is an oven with no peak savings

3.1 Commercial and Industrial (C&I)

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 project type.

The subsequent sections provide the sampling and evaluation approach for each measure group. One complication was the Covid-19 pandemic lockdown starting in March 2020; these issues are discussed at the end of this section.

3.1.1 Custom and Prescriptive Projects

As described in Section 2.1, BED custom and prescriptive projects accounted 46% and 45% of BED PY2020 reported C&I peak kW for winter and summer, respectively. There was a total of 19 locations with custom or prescriptive measures. The PSD Evaluation Team reviewed each custom and prescriptive project and identified how each site could be evaluated.

All eleven sampled custom and prescriptive entities were evaluated. Eleven entities were evaluated using the following methods: on-site M&V, building management systems (BMS), or advanced metering infrastructure (AMI) data. All measures associated with custom and prescriptive projects at these eleven locations were reviewed. In cases where additional information on equipment operation or schedules was required, the PSD Evaluation Team worked with BED to contact the site for a phone interview. These eleven locations consisted of the largest projects, which accounted for 99.7% and 99.6% of the total C&I custom and prescriptive winter and summer peak demand reduction, respectively.

Eight entities were not evaluated given that these sites would be just as costly to verify as larger sites but have a much smaller contribution to the portfolio savings. These 8 entities accounted for less than 0.4% of the C&I portfolio peak kW savings.

Of the eleven sampled entities, 6 had program reported MMBtu extra use and 1 had program reported MMBtu savings. The PSD Evaluation Team evaluated the MMBtu extra use or savings as part of the evaluation process. Table 3-2 provides a summary of the program reported and sample verified MMBtu.

TABLE 3-2: PROGRAM REPORTED MMBTU FOR THE C&I CUSTOM PROJECTS

Measure Group	Total Entities	Sampled Entities	Program Reported Total MMBtu Reduction	Program Reported Sample MMBtu Reduction
MMBtu Extra Use				
Custom & Prescriptive	28	8	-352	-342
MMBtu Savings				
Custom & Prescriptive	2	1	101	85

3.1.2 Upstream Smartlight Projects

Prior to PY2019, Smartlight projects were evaluated as part of the C&I custom and prescriptive projects. In PY2019 and PY2020, Smartlight measures accounted for a significant portion of the portfolio savings and were evaluated separately. In PY2020, Smartlight measures accounted for 33% and 44% of BED reported winter and summer peak kW, respectively. Similar to PY2019, the PSD Evaluation Team conducted a separate study to evaluate the Smartlight measures. The following section discusses the sampling and evaluation approach for Smartlight entities.

3.1.2.1 Sampling

Smartlight measures are counted under several different programs. The sample frame included measures from both the C&I and residential programs. The Smartlight measures were identified in the project description field in BED's database.³ The sample sizes were set at a level designed to exceed the minimum required to estimate savings at the 80/10 confidence/precision.

For PY2020, the sampling unit was the entity as Smartlight measures were sometimes installed at different locations but under the control of one company; therefore, having the sampling conducted on the entity allowed the PSD Evaluation Team to focus survey questions on installations known to the respondent in charge of purchasing Smartlight measures for the multiple locations. Table 3-3 provides a summary of the sampling approach.

TABLE 3-3: UPSTREAM SMARTLIGHT SAMPLING APPROACH

Sampling Component	Description	Comments
Population Size	169 entities	All upstream Smartlights were included in the population.
Sample Frame	100 entities	Projects with maximum kW reduction less than 0.151 kW were removed from the sample frame. These projects accounted for 4% or less of the program reported peak savings.
Stratification	Size, determined by the higher value of the kW peak reduction (winter or summer)	Sample sizes were calculated using an error ratio of 0.696 based on the error ratio from previous evaluations.
Primary Sampling Unit	Entity	The entity was the sampling, <i>i.e.</i> , if a company has multiple locations, all locations were treated as one entity.
Target Sample Size	30	Random selection was applied to stratum 1, 2 and 3 entities. A census of the largest projects was reviewed.

The results of the Smartlight sampling are shown in Table 3-4.

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

TABLE 3-4: SMARTLIGHT SAMPLE OVERVIEW

Size Stratum	Total Number of Entities	Sampled Entities	%kW Winter	%kW Summer
0	69	0	4%	3%
1	73	12	23%	21%
2	21	12	28%	29%
3	6	6	45%	47%

The PSD Evaluation Team conducted a phone survey between October 2021 and March 2022 to verify in-service rates (ISRs), facility types, facility hours of operation, and operational changes due to Covid-19. Company name and address fields in the distributor spreadsheets were used to look up phone numbers on the internet. An incentive of \$25 was offered to respondents who completed the survey.

The specifics of the analysis are described briefly below:

- Baseline wattages were based on less efficient, lumen-equivalent lamps.
- The efficient case determined from the manufacturers' specifications for the purchased Energy Star-qualified lamps.
- The ISR for commercial applications was estimated from the phone survey.
- The Vermont Load Shape Analysis⁴ (VLSA) load profiles were applied to commercial purchases based on the type of facility. See Appendix D.
- Metering was conducted for one site where the VLSA could not be applied.
- University Vermont's (UVM) prior FCM metering was applied to all Smartlight measures purchased by the university.
- The Northeast Residential Hours of Use Study⁵ was used to determine CFs and hours of use (HOU) for Smartlights installed in residential single family and multifamily in-unit facilities.
- ISR for residential Smartlights was taken from 2018 Vermont Technical Advisory Group (TAG) Agreement, as specified in the Technical Reference Manual (TRM).

The PSD Evaluation Team also calculated verified MMBtu extra use for commercial interior lighting. A detailed Smartlight report is provided in Appendix C.

⁴ Vermont Load Shape Analysis. Final Report. West Hill Energy & Computing. December 30, 2021. Included as Appendix D.

⁵ Northeast Residential Lighting Hours-of-Use Study; NMR Group, Inc. May 5, 2014

3.1.3 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 2020 TRM.

3.1.4 Covid-19 Impacts on Analysis Methods

Due to the Covid-19 pandemic lockdown, some facilities went out of business, closed temporarily, or cut back their hours of operation. The approach to selecting and analyzing sites was conducted on a site-by-site basis, as explained in Table 3-5.

TABLE 3-5: APPROACH TO COVID-19 IMPACTS

COVID-19 Impact	Approach	Disposition
None	Proceed as usual	Include in sample
Temporary	Assess whether there is an effective approach to normalize use, production, etc.	If effective approach to address change, include in sample; otherwise, remove from sample and replace with an alternate.
Permanent	Assess whether baseline use can be estimated based on post-install conditions	If baseline can be adjusted, include in sample; otherwise, remove from sample and replace with an alternate.

Prior to developing the analysis plans for each site, the PSD Evaluation Team investigated the Covid-19 impacts on a site-by-site basis, as listed below.

1. Initial AMI analysis to determine facility-wide pre- and post-period usage changes
2. Internet business search to identify closures or change in operations
3. Initial customer survey to verify status of operations and Covid-19 impacts on operating hours.

For each site, the PSD Evaluation Team chose the FCM-compliant method that took site-specific requirements into account. Option C whole-building analysis approach was limited to sites without a substantial change in operation and/or with sufficient data to remove periods of atypical operation. Pre-analysis plans providing details on the metering and analysis methods were provided to BED for review and comment.

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 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 (site)

n is the total number of verified locations in the sample

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

y_i is the verified savings for site i

x_i 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.⁶

3.2 Residential

BED program reported residential savings are almost entirely prescriptive and calculated using assumptions that have been reviewed by the PSD and included in the Vermont TRM.

Verification of savings for residential measures consisted of comparing the program reported savings to the prescriptive assumptions in the Vermont TRM. The TRM contains engineering algorithms for prescriptive savings developed from relevant studies and BED's 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 AMI 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 3-6.

⁶ Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures, Chapter 11. Prepared for National Renewable Energy Laboratory. September 2011 – September 2016.

TABLE 3-6: RESIDENTIAL LOAD PROFILE SOURCES

Measure Category	Source of Coincidence Factor	Percent of Residential Portfolio	
		Winter kW	Summer kW
Prescriptive Lighting	NEEP residential lighting study ¹ , NEEP C&I load shape study for cooling bonus ²	48%	51%
Prescriptive HVAC	Residential Room Air Conditioner Coincidence (RAC) Factor study ³ , Vermont Residential CCHP Study ⁴	33%	14%
Other Residential Measures	Engineering estimates ⁵ , AML data analysis for efficient pool pumps	19%	36%
Residential as % of Total Portfolio		31%	15%

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.

4 Electric Savings

The sections below cover the results for electric energy (kWh) and peak demand kW reduction.

4.1 Electric Energy Savings and Demand Reduction

The RRs and relative precision for BED's energy savings are provided in Table 4-1. The portfolio kWh RR is 90.3% with a relative precision of 2.6% at the 90% confidence level.

TABLE 4-1: REALIZATION RATES AND SAMPLING PRECISION FOR ENERGY SAVINGS

Measure Group	BED Program Reported kWh Savings	RR	PSD Verified kWh Savings	Relative Precision
C&I				
Custom and Prescriptive	1,786,895	93.0%	1,662,562	0.0%
Smartlight	1,033,350	75.9%	784,580	9.0%
Other Upstream Measures	65,671	100.3%	65,895	0.0%
Residential				
Prescriptive Lighting	338,754	100.2%	339,566	6.0%
Prescriptive HVAC	334,128	100.9%	337,249	10.4%
Other Residential Measures	320,663	100.7%	311,477	0.9%
Portfolio Total	3,879,461	90.3%	3,501,329	2.6%

Table 4-2 and Table 4-3 show RRs and relative precision for the peak kW reduction. The portfolio RR for winter peak kW is 101.7% and for summer peak kW is 84.1%. The relative precision of the verified savings in the BED portfolio is 3.1% and 3.6% at the 80% confidence level for the winter and summer peak kW reduction, respectively, which exceeds the FCM requirements.

TABLE 4-2: REALIZATION RATES AND SAMPLING PRECISION FOR WINTER PEAK kW REDUCTION

Measure Group	BED Program Reported kW Savings	RR	PSD Verified kW Savings	Relative Precision
C&I				
Custom and Prescriptive	265.117	89.1%	236.111	0.0%
Smartlight	134.374	114.0%	153.249	10.0%
Other Upstream Measures	7.803	101.2%	7.895	0.0%
Residential				
Prescriptive Lighting	86.558	100.1%	86.679	13.9%
Prescriptive HVAC	60.408	134.7%	81.342	0.0%
Other Residential Measures	34.553	97.3%	33.613	0.0%
Totals	588.812	101.7%	598.890	3.1%

TABLE 4-3: REALIZATION RATES AND SAMPLING PRECISION FOR SUMMER PEAK kW REDUCTION

Measure Group	BED Program Reported kW Savings	RR	PSD Verified kW Savings	Relative Precision
C&I				
Custom and Prescriptive	222.795	91.9%	204.717	0.0%
Smartlight	179.227	70.9%	127.020	9.0%
Other Upstream Measures	1.492	111.1%	1.656	0.0%
Residential				
Prescriptive Lighting	35.795	100.2%	35.866	14.1%
Prescriptive HVAC	9.819	122.8%	12.057	10.4%
Other Residential Measures	25.134	101.2%	17.541	6.7%
Total Portfolio	474.261	84.1%	398.858	3.6%

4.2 C&I Results

The following sections provide additional details about the C&I electric energy and peak demand savings.

Table 4-4 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 4-2 through 4-3. The RRs for each project are provided in Appendix A.

TABLE 4-4: C&I REALIZATION RATES BY MEASURE GROUP

Measure Group ¹	kWh		kW Winter		kW Summer	
	RR	% of Total Portfolio	Winter kW	Summer kW	RR	% of Total Portfolio
Smartlight	75.9%	26.6%	114.0%	22.8%	70.9%	37.8%
Custom and Prescriptive	93.0%	46.1%	89.1%	45.0%	91.9%	47.0%
Upstream CCHP	101.4%	0.5%	135.0%	0.6%	151.9%	0.1%
Upstream HPWH	100.0%	0.4%	100.0%	0.4%	100.0%	0.2%
Upstream Circulator Pumps	100.0%	0.8%	44.8%	0.3%	100.0%	0.0%

¹ One oven measure is not included in this table as it had no program reported peak kW savings.

As shown in Table 4-4, the RRs vary by measure group. The most common reasons for the difference in realized savings are listed below:

- Corrections were made to the model inputs for one project that accounted for 46% and 35% of the C&I winter and summer peak savings, respectively. This correction resulted in a reduction of 50% for the location.
- Some Smartlight measures reported as being installed in commercial buildings in the BED database were found to be installed in residential properties.
- BED characterized a few EPP projects as residential when they were commercial.
- Operating schedules were different from what the participant reported to BED; this affects both total hours of operation and coincidence peak factors.
- For one grocery store project, pre/post AMI analysis was conducted which resulted in higher savings than the lighting power density (LPD) analysis approach that was applied by BED.
- BED made an error in the Upstream CCHP program and claimed the same low kW load for all heat pumps regardless of the size of the heat pump.

As shown in Table 4-4, the summer peak kW reduction has the lowest RR as compared to both the winter peak kW and kWh savings. The primary reason is BED's mischaracterization of some C&I Smartlight residential installations as commercial.

Smartlight traceability is challenging due to the wide range of channels that can be used to purchase the lamps. Though distributors recorded these projects as a commercial installation in the Smartlight database, the PSD Evaluation Team found that some efficiency upgrades were

installed at residential properties, which was also discussed in previous evaluations. BED has been working to address this issue, and the percentage of projects mistakenly recorded as commercial has been decreasing consistently for each subsequent program year.

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. Residential savings contribute about 31% to the total winter kW reduction and 15% to the summer kW for the entire BED portfolio. As shown in Table 4-5, there were minor discrepancies in applying the TRM values which resulted in small adjustments being made to the program reported residential savings.

TABLE 4-5: RESIDENTIAL REALIZATION RATES BY MEASURE GROUP

Measure Group	kWh		kW Winter		kW Summer	
	RR	% of Total Portfolio	RR	% of Total Portfolio	RR	% of Total Portfolio
Prescriptive Lighting	100.2%	8.7%	100.1%	14.7%	100.2%	7.5%
Prescriptive HVAC	100.9%	8.6%	134.7%	10.3%	122.8%	2.1%
Other Residential Measures	97.1%	8.3%	97.3%	5.9%	69.8%	5.3%
Total	99.5%	25.6%	111.1%	30.8%	92.5%	14.9%

4.3.1 Residential Prescriptive Lighting

The assumptions for residential prescriptive lighting 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. Verified CFs were based on the NEEP residential lighting study conducted in 2014. The RRs for residential lighting were 100% for both the winter and the summer.

4.3.2 Residential Prescriptive HVAC

The RR for prescriptive room air conditioners was based on the Residential Room Air Conditioner (RAC) CF study conducted in 2008. The previous impact evaluation of CCHP installations in Vermont covered the vast majority of the prescriptive savings and the RR from this study was applied to PY2020 CCHPs. BED claimed the same low kW load for all residential heat pumps regardless of the size of the heat pump. This error is the major reason behind the high summer RR of 123%.

4.3.3 Other Residential Measures

Other residential measures include appliances such as dishwashers, clothes washers, and refrigerators account for less than 6% of the total portfolio. The load profiles were based on engineering estimates as the extensive nature of the data collection would be extremely costly to reproduce for measures that represent a small fraction of BED's portfolio. BED correctly applied the TRM to most of the appliances.

The major reason behind the summer RR of 69.8% is due to an adjustment to the efficient pool pumps savings. The PSD Evaluation Team completed an advanced metering infrastructure (AMI) analysis to verify efficient pool pumps savings for PY2018 and these results were applied to the PY2020 pool pumps. The pool pump analysis showed a RR of 34%. BED applied TRM 2020 savings which have not been updated and are substantially overestimated. Further details on the findings are provided in Appendix C. The RRs in Appendix C's efficient pool pumps study were applied to the PY2020 reported savings to calculate the evaluated savings.

4.4 Fossil Fuel Savings

BED claims impacts for measures that reduce the use of fossil fuels through efficiency measures or increase fossil fuel use through fuel switching or applying the waste heat penalty to 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 4-6.

TABLE 4-6: MMBTU REALIZATION RATES

Program	BED Program Reported MMBtu Savings	PSD Verified MMBtu Savings	RR
MMBtu Extra Use			
C&I	-950	-606	59.1%
Residential	-95	-96	101.5%
Total	-1,045	-702	61.0%
MMBtu Savings			
C&I	135	1,208	892.2%
Residential	301	299	99.2%
Total	431	1,350	320.9%

Overall, BED overclaimed the extra use for the waste heat penalty and substantially underclaimed the MMBtu savings. While BED's program reported net MMBtu savings showed substantial extra use, the PSD Evaluation Team found substantial savings. The main reason for the adjustments to BED reported MMBtu was that one site with MMBtu savings increased by

over 900%, due to the inclusion of the natural gas savings from the ventilation project that were not reported by BED.

For lighting measures, 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.

4.4.1 C&I MMBtu Savings

Table 4-7 shows the RR for MMBtu savings from fossil fuels by C&I measure group. MMBtu extra use was due to interactive effects between lighting and space heating (waste-heat penalty). One entity in the custom and prescriptive sample had MMBtu savings. Appendix B provides reports by BED location ID with information on the differences between BED program reported and PSD verified MMBtu savings.

TABLE 4-7: C&I MMBTU REALIZATION RATES

Measure Group	BED Program Reported MMBtu Reduction	PSD Verified MMBtu Reduction	RR
MMBtu Extra Use			
Smartlight	-575	-387	67.4%
Custom and Prescriptive	-352	-193	55.0%
Other Upstream Measures	-24	-24	100.0%
Total	-950	-605	63.7%
MMBtu Savings			
Custom and Prescriptive	101	1,208	1,191.2%
Other Upstream Measures	34	34	100.0%
Total	135	1,241	917.3%

The reasons for MMBtu adjustments include the following:

- MMBtu savings increased over 900% at one site, changing from extra use to savings of natural gas due to the inclusion of the natural savings from a ventilation project. BED did not report these savings.
- For three facilities, lighting operating schedules were different from what the participants reported to BED resulting in lower verified MMBtu extra use

Overall, differences in operating schedule resulted in the largest difference between the BED program reported and PSD-verified MMBtu extra use for lighting measures

4.4.2 Residential Results

Table 4-8 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.

TABLE 4-8: RESIDENTIAL MMBTU REALIZATION RATES

Measure	BED Program Reported MMBtu	PSD Verified MMBtu	RR
Clothes Dryer	-3.860	-7.700	199.5%
Clothes Washer	69.980	69.980	100.0%
Commercial LED Lighting	-43.686	-40.835	100.0%
Dishwasher	2.838	2.877	101.4%
Heat Pump Water Heater	24.090	35.540	100.0%
Space Heating Fuel Switch	152.661	152.661	100.0%
Thermostat	4.472	4.470	100.0%
Total	206.495	216.993	99.5%

MMBtu savings adjustments were made to the clothes washers and dryers. For these measures, BED applied values from an unknown source to clothes washers and dryers. The PSD Evaluation Team updated the baseline and efficient case to match TRM 2020.

5 Compliance with ISO-NE Standards

This section covers the compliance of the verification results with ISO-NE standards. For residential prescriptive measures, the assumptions are supported by recent, statistically sound studies. For custom C&I projects, an individual M&V plan was developed for each project that was consistent with ISO requirements. Most of the ISO requirements are directly relevant to the C&I custom sample and are discussed in that context. 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 prescriptive measures using verifiable load shapes and assumptions based on recent, statistically sound studies, as discussed above. The VLSA and NEEP study for C&I lighting, the RAC factor study for residential air conditioning, the NEEP residential lighting study for residential lighting, and the previous impact evaluation of CCHP installations in Vermont cover the vast majority of the prescriptive savings. For swimming pool circulator pumps, the FCM-compliant AMI analysis conducted for the PY2018 impact evaluation was applied.

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.

The other measures used engineering estimates, as described previously. The kW reduction was estimated by using engineering estimates account for less than 5% of the total portfolio and thus the greater uncertainty associated with the load profiles was considered to be acceptable.

5.2 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) was 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 projects and documented in the individual project reports. In a few cases, there was no clear code or standard. In these situations, the PSD 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 that have been 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 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 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. If the site-specific M&V approach required metering and there were too many circuits or measures to meter, random sampling was conducted. These issues are described in more detail in the site-specific project reports, which are compiled in Appendix B.

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 3.1% for winter and 3.6% 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.

- For the analysis of the C&I custom measures, the PSD Evaluation Team verified all projects except for the smallest ones account for less than 1% of the peak savings. Bias from the Covid-19 pandemic lockdown was avoided by carefully reviewing every project and eliminating the post-period months affected by changes in operation due to the lockdown, where appropriate.
- The estimated savings for prescriptive measures are unlikely to be biased since the deemed savings are based on recent market studies.
- For C&I Smartlight, stratified ratio estimation was used to identify the sample for a phone survey to estimate the ISR. Statistical methods meeting the ISO guidelines were applied and the sample sites were selected to reflect the population as a whole.

The use of CFs from the VLSA study to quantify the demand savings of some C&I lighting measures is appropriate, since the sample included Vermont facilities metered during prior FCM years and covered a broad range of applications. The study provides either Vermont-specific CFs or support for continuing to use the previous NEEP lighting study⁷ CFs and allows continued use of standardized CFs in lieu of metering. Thus, the application of the VLSA study would not be expected to introduce a bias. The VLSA study is attached in Appendix D.

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

⁷ 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.

- For a few residential measures, the load profiles were based on engineering assumptions and the relative precision could not be determined. These CFs 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 account for less than 5% of BED's overall portfolio.
- For the residential pool pump measure, the analysis was done using AMI data. All homes with pool pumps and sufficient AMI data were used, so the relative sampling precision is 0% and the results are unbiased.

5.4 Section 10, Measurement Equipment Specifications

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

6 Conclusions

The PSD 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 discussed in this document.



7 References

Burlington Electric Department 2020 Energy Efficiency Annual Report, Burlington Electric Department, 585 Pine Street, Burlington, VT.

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.

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.

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

Impact Evaluation of Efficiency Vermont's Home Performance with ENERGYSTAR, Program Years 2014-2016, Prepared for the Vermont PSD by West Hill Energy and Computing, September 10, 2018.

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.

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

Review of ISO New England Measurement and Verification Equipment Requirements. Prepared for Prepared for the Northeast Energy Efficiency Partnerships' Evaluation and State Program Working Group by RLW Analytics, April 24, 2008.

Sampling: Design and Analysis. Lohr, Sharon L. Duxbury Press, 1999.

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