

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

Prepared for
Vermont Department of Public Service

Prepared by:

West Hill Energy & Computing

205 Main St, Suite 14

Brattleboro VT, 05301

(802) 246-1212

In partnership with Cx Associates,
and Lexicon Energy Consulting



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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 and Lexicon Energy Consulting, 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) 2021 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, 2023, 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.

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 Program Activity

BED bid its entire portfolio of energy efficiency initiatives into the FCM. For PY2021 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 52% 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 PY2021, C&I projects accounted for 52% 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 PY2021, custom and prescriptive measures accounted for 50% and 41% 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 PY2021 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
Custom and Prescriptive	93.0	104.4	50%	41%
Smartlight	83.1	150.7	45%	59%
Upstream Cold Climate Heat Pumps (CCHP)	10.6	1.1	6%	0%
Total	186.7	256.2	100% ¹	100%

¹ Total of individual categories greater than 100% due to rounding.

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 (ACs) and 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 42% and 39% 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	239,991	71.5	19.9
Prescriptive HVAC	7,254	0.0	5.2
Upstream CCHP	329,445	80.0	8.2
Other Residential Measures	188,464	20.1	18.3
Total	765,154	171.6	51.6

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 the requirements specified in the ISO-NE M-MVDR.² 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	Census	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, etc.	Options A through D
Upstream CCHP	Census attempt	Site specific AMI analysis with metering of a subset (census attempt)	Options B and C
Other ²	No sampling necessary	Applied average RRs from the C&I portfolio	Option A
Residential			
Prescriptive Lighting	Census	Prescriptive review for all measures	TRM
Prescriptive HVAC			
Other Residential Measures			
Upstream CCHP	Census	Site specific AMI analysis of all sites with AMI data available	Option C

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

² "Other" category is an oven with only kWh savings and no peak demand reduction.

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.

² Op. cit., ISO-NE

The subsequent sections provide the sampling and evaluation approach for each measure group. One complication was the Covid-19 pandemic 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 for 50% and 41% of BED PY2021 program reported C&I peak kW for winter and summer, respectively. A total of 39 locations with custom or prescriptive measures were verified. These eleven locations consisted of the largest projects, accounting for 97% and 98% of the total C&I custom and prescriptive winter and summer peak demand reduction, respectively.

The PSD Evaluation Team reviewed each custom and prescriptive project and identified how each site could be evaluated. The measures installed at the eleven custom and prescriptive locations were evaluated using the following methods: on-site M&V, building management systems (BMS), or advanced metering infrastructure (AMI) data. All measures 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. The site level reports from these 11 locations are included in Appendix B

Twenty-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 28 entities accounted for less than 3% of the C&I peak winter and summer kW reduction.

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 sizable portion of the portfolio savings and were evaluated separately. In PY2021, Smartlight measures accounted for 45% and 59% of BED program-reported C&I winter and summer peak kW, respectively. Similar to PY2019 and PY2020, 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 PY2021, the sampling unit was the entity as Smartlight measures were sometimes installed at various 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

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

installations known to the respondent in charge of purchasing Smartlight measures for the multiple locations. Table 3-2 provides a summary of the sampling approach.

TABLE 3-2: UPSTREAM SMARTLIGHT SAMPLING APPROACH

Sampling Component	Description	Comments
Population Size	162	All upstream Smartlight measures were included in the population.
Sample Frame	105	Projects accounting for less than 3% of the program reported peak savings were removed from the sample frame. The maximum kW reduction was than 0.152 kW for the removed projects.
Stratification	Size, determined by the higher value of the kW peak reduction (winter or summer)	Sample sizes were calculated using an error ratio of 0.79 based on the error ratio from previous evaluations.
Primary Sampling Unit	Entity	The entity was the sampling unit, <i>i.e.</i> , if a company has multiple locations, all locations were treated as one entity.
Target Sample Size	47	Random selection was applied to stratum 1, 2 and 3 entities. A census of the entities with the largest savings was reviewed.

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

TABLE 3-3: SMARTLIGHT SAMPLE OVERVIEW

Size Stratum	Total Number of Entities	Sampled Entities	%kW Winter	%kW Summer
0	57	0	3%	3%
1	73	19	24%	23%
2	23	19	29%	30%
3	9	9	44%	44%

3.1.2.2 Smartlight Evaluation Approach

The PSD Evaluation Team conducted a phone survey between October 2022 and March 2023 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.

3.1.2.3 Smartlight Analysis

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 F.
- Timer settings were confirmed for one site where the VLSA could not be applied.
- University of 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 Smartlight measures installed in residential single family and multifamily in-unit facilities.
- ISR for residential Smartlight measures 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 E.

3.1.3 C&I Heat Pumps

The C&I heat pumps included a total of 29 heat pumps installed across 17 sites. These projects were analyzed with a combination of AMI data and short-term metering at 8 sites. No sampling was done as AMI data was provided for all locations and the metering was a census attempt. A detailed explanation of the analysis is included in Appendix C.

3.1.4 MMBtu Savings and Extra Use

The Smartlight and custom and prescriptive programs accounted for the MMBtu extra use. The PSD Evaluation Team verified the MMBtu extra use or savings as part of the analysis of the sampled projects. Table 3-4 provides a summary of the program reported and sample verified MMBtu.

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

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

TABLE 3-4: PROGRAM REPORTED MMBTU FOR THE C&I SECTOR

Measure Group	Total Entities	Sampled Entities	Program Reported Total MMBtu Reduction	Program Reported MMBtu Reduction in Sample
MMBtu Extra Use				
Smartlight	196	47	-499	-312
Custom and Prescriptive	5	2	-219	-105
Total	201	49	-717	-417
MMBtu Savings				
Custom and Prescriptive	5	3	2,168	2,098
Total	5	3	2,168	2,098

3.1.5 Covid-19 Impacts on Analysis Methods

Due to the Covid-19 pandemic, some facilities went out of business, closed temporarily, or cut back their hours of operation. Although the evaluation occurred after the primary impacts of Covid-19, there were some sites where the baseline was impacted and some sites with permanent changes due to the pandemic. These changes were accounted for in the analysis as needed. The approach to analyzing the sampled 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.

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.

3.1.6 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 largely 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 upstream CCHPs and pool pump measure⁷ in the EPP, the PSD Evaluation Team Option C, using AMI data to verify the prescriptive assumptions from the TRM. Details of the CCHP AMI analysis are provided in Appendix D.

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.

⁷ BED paid an incentive for one pool pump in PY2021. The PSD Evaluation Team applied results from the PY2018 Verification of Burlington Electric Department's Energy Efficiency Portfolio for Annual Savings Claim and the ISO-NE Forward Capacity Market. The analysis is included in Appendix G of this report.

A summary of the residential measures separated according to the source of the load profile is provided in Table 3-6.

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	20%	6%
Prescriptive HVAC	Residential Room Air Conditioner Coincidence (RAC) Factor study ³	0%	2%
Other Residential Measures	Engineering estimates ⁴ , AMI data analysis for efficient pool pumps ⁵	6%	6%
Upstream CCHP	AMI analysis of all sites with available and complete data	22%	3%
Residential as % of Total Portfolio		48%	17%

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 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.

⁵ The pool pump AMI analysis was done as part of the PY2018 evaluation and is included in Appendix G.

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 68% with a relative precision of 6.6% 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	982,202	85%	831,048	16%
Smartlight	790,256	59%	469,598	7%
Upstream CCHP	42,506	24%	10,096	14%
Residential				
Prescriptive Lighting	239,991	60%	144,565	6%
Prescriptive HVAC	7,254	83%	6,008	10%
Other Residential Measures	188,464	95%	178,242	0%
Upstream CCHP	329,445	36%	117,832	9%
Portfolio Total	2,580,118	68%	1,757,389	6.6%

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 75.2% and for summer peak kW is 92.1%. The relative precision of the verified savings in the BED portfolio is 5.9% and 6.9% 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	93.0	113%	105.4	14%
Smartlight	83.1	84%	70.2	8%
Upstream CCHP	10.6	14%	1.5	14%
Residential				
Prescriptive Lighting	71.5	60%	43.2	14%
Prescriptive HVAC	0.0	100%	0.0	0%
Other Residential Measures	20.1	99%	19.8	0%
Upstream CCHP	80.0	37%	29.5	15%
Totals	358.3	75.2%	269.6	5.9%

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	104.4	117%	122.4	19%
Smartlight	150.7	55%	82.3	4%
Upstream CCHP	1.1	474%	5.1	11%
Residential				
Prescriptive Lighting	19.9	60%	11.9	14%
Prescriptive HVAC	5.2	94%	4.9	10%
Other Residential Measures	18.3	94%	17.1	0%
Upstream CCHP	8.2	487%	39.7	12%
Total Portfolio	307.7	92.1%	283.5	6.9%

4.2 C&I Results

The following sections provide 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	kWh		kW Winter		kW Summer	
	RR	% of Total Portfolio	RR	Summer kW	RR	% of Total Portfolio
Smartlight	59%	31%	84%	23%	55%	49%
Custom and Prescriptive	85%	38%	113%	26%	117%	34%
Upstream CCHP	24%	2%	14%	3%	474%	0%
Total		70%		52%		83%

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:

- Errors in the Smartlight measures due to the incorrect version of the TRM being used to calculate savings.
- A TRM error found overstating the savings for the high efficiency evaporator measure which impacted 3 projects.
- 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 for the refrigeration and lighting measures than the analysis by BED.
- The heating usage (impacting kWh and winter kW) was much lower while the cooling usage was higher than the TRM assumptions for the Upstream CCHP program.

Only one of the 11 C&I custom and prescriptive sites experienced substantial impacts from COVID-19.

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.

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 48% to the total winter kW reduction and 17% to the summer kW for the entire BED portfolio. As shown in Table 4-5, there were major discrepancies in applying the TRM values for the lighting measures due the use of savings values from outdated measure categorizations. The Upstream CCHP was adjusted based on an AMI analysis, which resulted in a significant reduction in kWh and kW winter but an increase in kW summer savings. Consequently, the RRs reflect substantial adjustments 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	60%	9%	60%	20%	60%	6%
Prescriptive HVAC	83%	0%	100%	0%	94%	2%
Other Residential Measures	95%	7%	99%	6%	94%	6%
Upstream CCHP	36%	13%	37%	22%	487%	3%
Total		30%		48%		17%

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. In PY2021, BED consistently applied outdated TRM characterization to the residential lighting measures, which substantially overstated the savings. The RRs for residential lighting were 60% for both the winter and the summer peak kW reduction.

4.3.2 Other Residential Measures

Other residential measures include appliances such as dishwashers, clothes washers, and refrigerators account for less than 7% 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.

4.3.3 Upstream CCHP

The upstream CCHP measures were analyzed using AMI data. The majority (269 of the 272 sites) with residential heat pumps were MOP measures so the savings were calculated using the post installation temperature dependent heating and cooling load. The AMI analysis showed much lower effective full load hours than the assumptions used in the Vermont TRM and about a quarter of homes showed no sign of heating use. This resulted in a substantial reduction in the kWh and winter kW savings. The AMI analysis showed a much higher summer peak coincidence factor (CF) than the 4% assumed by the heat pump loadshape in the Vermont TRM, resulting in a 487% RR for the summer kW.

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	-717	-412	58.4%
Residential	-62	-68	109.2%
Total	-779	-480	62.5%
MMBtu Savings			
C&I	2,168	2,085	96.8%
Residential	418	399	95.7%
Total	2,585	2,484	96.6%

Overall, BED overclaimed the extra use for the waste heat penalty while the reported MMBtu savings were within 5% of the verified savings. The main reason for the adjustments to BED reported MMBtu was due to the reduction of program reported energy savings from lighting measures resulting in overstatement of the corresponding extra MMBtu use.

4.4.1 C&I MMBtu Results

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). Three entities 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	-499	-312	62.6%
Custom and Prescriptive	-219	-100	48.2%
Total	-717	-412	58.4%
MMBtu Savings			
Custom and Prescriptive	2,168	2,085	96.8%
Total	2,168	2,085	96.8%

The reasons for MMBtu adjustments include the following:

- Smartlight savings were overclaimed resulting in a corresponding overstatement of the MMBtu extra use.
- 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 MMBtu Results

Table 4-8 shows the RR for 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	4.578	3.458	75.5%
Clothes Washer	95.6	72.86	76.2%
Commercial LED Lighting	-1.745	-0.55	31.5%
Heat Pump Water Heater	12.5	9.63	77.0%
Space Heating Fuel Switch	214.122	214.122	100.0%
Thermostat	3.84	5.5048	143.4%
Shell Savings	26.38	26.38	100.0%
Total	355	331	93.3%

The lowest RR was related to application of outdated TRM characterizations for lighting, which affected the MMBtu savings due to the application of the waste heat factor for measures assumed to be installed in commercial settings.

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 AC and the NEEP residential lighting study for residential lighting cover the vast majority of the prescriptive savings.

The residential upstream CCHPs were analyzed using Option C with AMI data. The commercial upstream CCHPs were verified with a combination of Option A and Option C, including direct metering for Option A and AMI data analysis for Option C. For swimming pool circulator pumps, the FCM-compliant AMI analysis conducted for the PY2018 impact evaluation was applied. Details of the AMI Analysis for Swimming Pool Pumps are provided in Appendix G.

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 timeframe and budget.

The other measures used engineering estimates, as described previously. The kW reduction was estimated by using engineering estimates to account for 6% or less 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 5.9% for winter and 6.9% for summer peak reduction.

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

- For the analysis of C&I custom and prescriptive measures, the PSD Evaluation Team verified all projects except for the smallest accounting for 3% or less of the peak savings. Bias from the Covid-19 pandemic was avoided by carefully reviewing every project and eliminating the post-period months affected by changes in operation due to the pandemic, where appropriate.
- The estimated savings for residential 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.
- For upstream CCHPs (commercial and residential), census attempts were made to include all participants with these measures in the analysis.

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 study⁸ 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 F.

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 6% of BED's winter and summer kW peak reduction for the entire portfolio.

5.4 Section 10, Measurement Equipment Specifications

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

⁸ 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 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

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