WEST HILL ENERGY AND COMPUTING

Verification of Efficiency Vermont's PY2019 Energy Efficiency Portfolio for the ISO-NE Forward Capacity Market

Final Report

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Prepared for

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1 Introduction

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. 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]

Efficiency Vermont (EVT) bid its efficiency program portfolio into the FCM and submitted a measurement and verification (M&V) plan stating that the evaluation process in Vermont will comply with ISO-NE standards. 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 EVT and BED FCM claims are defined by both the ISO-NE standards and the EVT 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 to provide independent verification of EVT's energy efficiency portfolio. The PSD Evaluation Team, consisting of West Hill Energy, Cx Associates, GDS Associates, Lexicon Energy Consulting, and Energy Resource Solutions, 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 EVT's program year 2019 (PY2019) FCM bid and the results of this verification process. It also provides the 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).

The evaluation was designed to determine the appropriate realization rates (RRs) to be applied to EVT's estimated savings. The RRs given in this document were provided to EVT in May of 2021 and will be used to adjust EVT savings as reported to ISO-NE from July 1, 2020, until the completion of the next evaluation cycle.

[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.

The remainder of this report is divided into four sections: methods, results, compliance with ISO-NE standards, and conclusions. Additional detail about the components of portfolio savings can be found in EVT 2019 Annual Report.[2]

[2] *https://www.efficiencyvermont.com/Media/Default/docs/plans-reports-highlights/2020/2020 10 12_Efficiency Vermont_ 2019 Annual Report.pdf.*

2 Program Activity

2 Program Activity

For PY2020 evaluation cycle, the PSD Evaluation Team divided EVT's 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 and Industrial (C&I) Programs

EVT's C&I programs include custom and upstream programs. All custom C&I and multifamily projects were categorized as either retrofit or new construction (NC)/market opportunity (MOP). EVT also offers measures such as heat pumps, circulator pumps, heat pump water heaters, condensing units, and Smartlights through their upstream initiatives. A summary of savings by C&I group is provided in Table 1 below.

Table 1: Summary of C&I Projects

Group	Number of Sites	Energy Savings (kWh)	Winter Demand Savings (kW)	Summer Demand Savings (kW)
Retrofit	547	22,724,653	2,636	2,235
NC/MOP	1,124	11,048,538	1,569	1,256
Upstream	5,728	20,552,641	2,364	3,093
Total C&I Portfolio	7,399	54,325,832	6,568	6,584

2.1.1 Upstream Programs

Upstream initiatives are intended to promote energy efficiency by offering incentives to distributors who pass on the benefit to customers as a product discount. EVT has two major upstream initiatives:

1. Smartlights, which covers efficient lighting
2. Heating, ventilation, and air conditioning (HVAC) equipment upstream program.

These two upstream programs account for small percentage (~0.7%) of the entire portfolio.

The Smartlight Program is an upstream program implemented jointly by EVT and BED. Through this program, lighting distributors receive incentives enabling them to sell high-efficiency lighting to households and businesses in Vermont at a comparable cost to standard efficiency lighting.

EVT has been expanding upstream programs to include heat pump water heaters, cold climate heat pumps (CCHPs), high performance circulator pumps, and a few commercial refrigeration measures. Similar to the Smartlight Program, the incentives are provided through qualified distributors and manufacturers. In PY2019, the highest percentage of upstream measures were CCHP and circulator pumps.

2.2 Residential Sector

EVT 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 and CCHPs offered through EPP residential new construction (RNC) programs
Other Prescriptive Measures	Dishwashers, clothes washers, refrigerators, domestic hot water (DHW) pipe insulation, pool pumps, thermostats, and electronics offered through EPP, RNC, low-income, and residential retrofit programs
Home Performance with ENERGY STAR® (HPwES) Program	DHW measures, insulation, and air sealing measures provided through EVT's HPwES, which account for 0.3% of the residential portfolio
Home Energy Kits	Efficient lighting, advanced power strips, faucet aerators, low flow shower heads, pipe insulation, and DIY weatherization projects designed to save energy
REMRate NC Heating	Custom comprehensive RNC thermal shell heating savings estimated using REMRate modeling

Majority of the residential sector savings is from prescriptive lighting, which makes up about 75% and 72% 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	35,145,233	8,472	3,466
Prescriptive HVAC	4,815,226	1,173	125
Other Prescriptive Measures	5,910,662	677	938
Home Performance with ENERGY STAR® Program	212,594	29	0
Home Energy Kits	3,819,636	887	313
REMRate NC Heating	373,471	60	0
Total	50,276,821	11,299	4,842

3 Methods

3 Methods

EVT 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 M-MVDR.[3] The portfolio was divided according to the source of the coincidence factors. The evaluation categories and associated verification strategies are summarized in Table 4. Each of the evaluation categories are discussed in subsequent sections.

TABLE 4: FCM VERIFICATION STRATEGY BY EVT INITIATIVE

EVT Initiative	Sampling Approach	ISO M&V Option
C&I and Multifamily		
Custom Retrofit	Sample selected per ISO standards	Options A through D
Custom NC/MOP	Sample selected per ISO standards	Options A through D
Stipulated Lighting[1]	Sample selected per ISO standards	Option A
Smartlight Program	Prescriptive assumptions, no sampling necessary	Option A
Other Upstream Measures[2]	No sampling necessary	Option A
Residential		
Prescriptive Lighting	Prescriptive assumptions, no sampling necessary	Option A
Prescriptive HVAC	Prescriptive assumptions, no sampling necessary	Option A
Other Prescriptive Measures	Prescriptive assumptions, no sampling necessary	Option A
Home Performance with ENERGY STAR®	Prescriptive assumptions, no sampling necessary	Option A
Home Energy Kits	Prescriptive assumptions, no sampling necessary	Option A
REMRate New Construction Heating	Prescriptive assumptions, no sampling necessary	Option A
Efficient Pool Pumps	Census attempt; no sampling necessary	Option C

[1] RRs in Appendix C were applied to PY2019 small and medium projects savings claim to calculate PY2019 evaluated savings.
[2] HVAC measures in PY2019 include CCHPs, refrigeration condensing units, circulator pumps, and heat pump water heaters.

[3] *ISO New England Manual for Measurement and Verification of On-Peak Demand Resources and Seasonal Peak Demand Resources*, Revision: 7, Effective Date: October 4, 2018.

3.1 Commercial and Industrial (C&I)

All custom projects were categorized as either retrofit or NC/MOP. Within each of these categories, projects were sorted into four strata based on magnitude of maximum peak demand savings. This component of the evaluation involved drawing a sample of projects then performing site-specific M&V in accordance with the ISO-NE M-MVDR. The following section provides additional detail on the sampling approach.

3.1.1 Sampling

From PY2012 to PY2017, the full C&I custom portfolio was evaluated on a three-year cycle and the sampling was conducted for the portfolio. In the alternate years, only large projects (as defined by the previous sampling plan) were evaluated. In PY2015, the portfolio was evaluated, including small, medium, and large projects. In PY2018, only large projects were evaluated due to logistical issues with the evaluation contract.

The evaluation of PY2019 was started in 2020, when the Covid-19 pandemic began. Under these circumstances, EVT, the Department, and West Hill Energy agreed that EVT and evaluation staff should not go on site to meter equipment. This requirement was particularly problematic for the small and medium projects, as whole building evaluation strategies are less likely to be effective for these smaller projects. Consequently, the parties agreed that only the large projects would be evaluated for PY2019.[4]

In PY2016 and PY2017, large projects were evaluated using the stratum cut off from the PY2015 sampling and the RRs from PY2015 were applied to the small and medium projects as the underlying projects were similarly distributed. However, in PY2018 and PY2019, the savings distribution changed such that applying the PY2015 cut off for large projects would result in less than 15% of the savings being evaluated under stratum 4. Therefore, for PY2019 the PSD Evaluation Team lowered the stratum cut off for the largest strata for both NC/MOP and retrofit projects. Additional details on how the projects were stratified is provided below.

As was done in PY2015, the smallest custom C&I projects (winter and summer peak kW of less than 0.80 kW for retrofit and less than 0.4 for NC/MOP) were excluded from the sample frame since these projects, in aggregate, represented less than 1% of the C&I portfolio savings but would be just as costly to verify as other larger projects. The RR from the sampled projects was applied to these measures.

[4] For PY2020, small, medium, and large projects will be evaluated.

The main features of the PY2019 sampling process for the C&I projects are summarized below.

- The same strategy used for the FCM PY2015 impact evaluation was applied to the PY2019 evaluation for two broad program types, retrofit and NC/MOP. This distinction was made due to the different approaches to establishing the baseline (previous equipment versus energy code or federal standard). Multifamily projects were included with the C&I projects.
- The largest projects completed as retrofits (with max peak kW greater than 55kW) and the largest NC/MOP projects (with max peak kW greater than 49kW) fell into the census stratum. All measures associated with the site and program types were included.
- The primary variable for establishing the size strata was the maximum of the winter and summer peak kW reduction.
- For strata 1 through 3, the RRs from the PY2015 FCM evaluation were applied.
- For stratum 4 (containing the largest projects), all measures were evaluated, including lighting measures using stipulated coincidence factors.
- Expansion weights were calculated based on the number of evaluated sites.

For small and medium projects, lighting measures using the stipulated coincidence factors were removed from the sample frame and evaluated separately to be consistent with the PY2015 sampling strategy.

3.1.2 Summary of Custom C&I Sites

Table 5 below shows the number of sites in each of these categories and the energy and peak savings within each stratum. As is consistent with the PY2015 sampling plan, the primary sampling variable was defined as the higher value of the winter or summer kW. This sampling variable was selected to ensure reliable results for both winter and summer peak kW reduction.

TABLE 5: SUMMARY OF CUSTOM C&I AND MULTIFAMILY PROJECTS

Group	Number of Sites	Energy Savings (kWh)	Winter Demand Savings (kW)	Summer Demand Savings (kW)
Retrofit	547	22,724,653	2,636	2,235
NC/MOP	1,124	11,048,538	1,569	1,256
Total Custom C&I Portfolio	1,671	33,773,191	4,205	3,491

3.1.3 Covid-19 Impacts on Analysis Methods

The Covid-19 pandemic lockdown started in March 2020 and complicated the 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 system (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.

3.1.4 C&I Stipulated Lighting

A substantial portion of the savings from C&I lighting projects have stipulated lighting profiles, *i.e.*, the PSD and EVT have agreed to use a rigorous, regional study as the source of the coincidence factors.[5] The stipulated lighting profiles are applied by business type, such as retail, office, *etc.*

Although the coincidence factors are stipulated, there are other sources of error that could have an impact on the magnitude of the savings:

1. The in-service rate (ISR), defined as the percentage of program reported efficient lighting products that were actually installed.
2. The reduction in kW load due to the installation of the efficient lighting

[5] 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. The use of an incorrect stipulated lighting profile, *i.e.*, using the office profile for a retail space.

The PSD Evaluation Team conducted an evaluation of stipulated lighting for PY2012 to address these issues. Complete details of the methods and results can be found in Appendix C, which contains the ISO-NE-compliant evaluation report for this component of EVT's portfolio.[6] The RRs in the Appendix C study were applied to the PY2019 stipulated lighting savings for small and medium projects to calculate the PY2019 evaluated savings.[7]

The PY2012 stipulating lighting study divided projects with stipulated coincidence factors into three groups, retrofit, MOP, and NC to accommodate the different baselines and methods used for each of these groups. Sampling was conducted independently for each of these three groups following the guidelines laid out in the M-MVDR.

For the retrofit and MOP projects, telephone surveys were conducted, followed by site visits to the surveyed businesses. For NC projects, only site visits were conducted. Information obtained from the telephone surveys and site visits was combined with secondary data (such as manufacturers' specifications) and EVT's detailed project-level data to calculate the peak kW reduction at each site.

3.1.5 Smartlight Program

The Smartlight Program is an upstream program implemented jointly by EVT and BED. Through this program, lighting distributors receive incentives enabling them to sell high-efficiency lighting to households and businesses in Vermont at a comparable cost to standard efficiency lighting.

The residential/commercial split reflects EVT's strategy of applying sector-specific savings assumptions to its lighting program. EVT's estimate of the percent of lighting products installed in residential locations was updated based on the information provided in the distributors' spreadsheets.

To estimate savings from the Smartlight measures, the PSD Evaluation Team compared the program reported C&I Smartlight savings against EVT's Technical Reference Manual (TRM). The RRs from the analysis are provided in Appendix D.

3.1.6 HVAC Upstream Program

In PY2019, the highest percentage of upstream measures were CCHPs and circulator

[6] "Verification of Efficiency Vermont's Stipulated Lighting Portfolio for the ISO-NE Forward Capacity Market." Prepared by [7] West Hill Energy and Computing for VT PSD, March 2015.

[7] For the largest stratum (size 4), all measures were evaluated, including lighting measures using stipulated coincidence factors.

pumps. EVT reported sales of 693 CCHPs and 728 circulator pumps. However, the HVAC upstream measures account for small percentage (~0.7%) of the portfolio. To verify HVAC upstream program savings, the evaluation team compared program reported savings against the Vermont TRM.

3.1.7 C&I Attrition

Of the sites in the census stratum, all 22 were verified. For two sites, post-period data beyond Covid-19 March 2020 lockdown was required to accurately estimate savings. Without sufficient post-period data, the uncertainty of the analysis for the two sites was high. As a result, the peak winter savings could not be verified for a sports arena and summer peak savings could not be verified for the efficiency projects at a college.

3.1.8 Calculation of Realization Rates

The RR is the ratio of verified energy savings to the program's reported savings. The RR represents the percentage of program-estimated savings that is actually achieved based on the results of the evaluation M&V analysis. The RR was calculated as follows:

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

Where,

b is the realization rate (ratio estimator)

i represents the project number

n is the total number of verified projects in the sample

w_i is the expansion weight for project i

y_i is the verified savings for project i

x_i is the program reported savings for project i

The basis for these calculations and the method for calculating variances are provided in the Uniform Methods Project.[8]

The sampling weights were adjusted for non-response and the RRs were applied to the population based on the percent of the kW peak savings in each stratum.[9]

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

[9] "Sampling: Design and Analysis". Lohr, Sharon L., Duxbury Press, 1999, pages 268-269.

3.2 Residential

EVT program-reported residential sector savings are almost entirely prescriptive and calculated using assumptions that have been reviewed by the PSD and included in the TRM. The TRM contains engineering algorithms for prescriptive savings developed from relevant studies and EVT's data on measures installed by past program participants. The approach used for each of the measure categories is described briefly in the sections below.

TABLE 6: RESIDENTIAL LOAD PROFILE SOURCES

Measure Category	Source of Coincident Factor	Percent of Residential Portfolio	
		Winter kW	Summer kW
Residential Prescriptive Lighting	NEEP Residential Lighting Study[1], NEEP C&I Load Shape Study for Cooling Bonus[2]	75%	72%
Residential Prescriptive HVAC	Residential Room Air Conditioner Coincidence (RAC) Factor study[3] Vermont Residential CCHP Study[4]	10%	3%
Other Residential Measures	Engineering estimates[5], AMI data analysis for efficient pool pumps	6%	19%
Home Performance with ENERGY STAR® Program	VT Thermal Study[6]	0%	0%
Home Energy Kits	Engineering estimates[7]	8%	6%
REMRate NC Heating	Engineering estimates[7]	1%	0%
Residential as % of Total Portfolio		60%	38%

[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 VT PSD by the Cadmus Group Inc. November 3, 2017.
[5] While the load profiles for appliances such as dishwashers, clothes washers and refrigerators are based on older data (Itron's eShapes 8760 load profile data, based on detailed analyses of approximately 20,000 homes in the 1990's), the extensive nature of the data collection would be extremely costly to reproduce for measures that represent a small fraction of EVT's portfolio.
[6] "Impact Evaluation of Efficiency Vermont's Home Performance with ENERGYSTAR, Program Years 2014-2016", Prepared for Vermont PSD by West Hill Energy & Computing, September 10, 2018.
[7] It would be costly to develop load profiles from primary research for these measures that constitute a small percentage of the overall portfolio.

4 Results

4 Results

The RRs and relative precision for all components of EVT's portfolio are provided in Tables 7 and 8. The FCM standards require sampling precision at the 80/10 confidence/precision level for the entire portfolio. The relative precision of the portfolio is 7.1% for winter and 4.1% for summer peak reduction at the 80% confidence level, exceeding the FCM requirement.

Table 7: RRs and Sampling Precision for Winter Peak kW Reduction

	EVT Program Reported Peak kW Reduction	Realization Rate	PSD Verified Peak kW Reduction	Relative Precision
C&I and Multifamily				
Retrofit	2,636	69%	1,824	24.3%
NC/MOP	1,569	78%	1,219	6.7%
Stipulated Lighting	836	88%	735	3.0%
Smartlight	2,179	101%	2,201	17.7%
CCHP	120	100%	120	0.0%
Refrigeration	43	100%	43	0.0%
Circulator Pumps	7	100%	7	0.0%
Heat Pump Water Heaters	14	100%	14	0.0%
Residential				
Lighting Prescriptive	7,743	100%	7,739	13.9%
Lighting Prescriptive wCB	729	100%	730	3.0%
Prescriptive A/C	0	100%	0	0.0%
Other Prescriptive Measures	677	103%	698	0.0%
Efficient Pool Pumps	0	100%	0	0.0%
CCHPs	1,173	100%	1,173	12.1%
Home Energy Kits	887	100%	887	0.0%
Residential REMRate Heating	60	14%	9	0.0%
HPwES	29	37%	11	18.0%
Totals	18,702	93%	17,398	7.1%

TABLE 8: RRS AND SAMPLING PRECISION FOR SUMMER PEAK KW REDUCTION

	EVT Program Reported Peak kW Reduction	Realization Rate	PSD Verified Peak kW Reduction	Relative Precision
C&I and Multifamily				
Retrofit	2,235	84%	1,876	12.9%
NC/MOP	1,256	95%	1,197	2.8%
Stipulated Lighting	1,286	86%	1,106	3.0%
Smartlight	3,043	102%	3,104	10.6%
CCHP	12	100%	12	0.0%
Refrigeration	30	100%	30	0.0%
Circulator Pumps	0	100%	0	0.0%
Heat Pump Water Heaters	7	100%	7	0.0%
Residential				
Lighting Prescriptive	1,996	100%	1,995	14.1%
Lighting Prescriptive wCB	1,470	100%	1,470	3.0%
Prescriptive A/C	7	100%	7	10.4%
Other Prescriptive Measures	576	100%	575	0.0%
Efficient Pool Pumps	362	14%	49	15.0%
CCHPs	118	100%	118	23.5%
Home Energy Kits	313	100%	313	0.0%
Residential REMRate Heating	0	100%	0	0.0%
HPwES	0	100%	0	0.0%
Totals	12,713	94%	11,859	4.1%

The relative precision for the C&I custom sample was calculated from the sample. In some cases, the relative precision was estimated based on the available information, as discussed below.

- The relative precision for C&I stipulated lighting was based on the PSD Evaluation Team PY2012 Stipulated Study attached as Appendix C.[10]
- The coincidence factors for Smartlights were taken from the Northeast Energy Efficiency Partnership (NEEP) C&I load shape study; [11] the relative precision shown in the tables above was the highest value for the various business types.
- The coincidence factors for a variety of small residential measures were based on Itron's eShapes 8760 load profile data from the 1990s. The precision for this study is unknown.
- Savings for residential CCHPs were based on a previous impact evaluation of CCHPs in Vermont.[12]
- AMI analysis was carried out for swimming pool circulation pumps. There was no sampling conducted, hence there is no sampling error associated with these measures. However, the variability in the results was reflected in the relative precision.
- For a few other residential measures and the other upstream C&I measures, the load profiles were based on engineering assumptions. Since no sampling was conducted, there is no sampling error associated with these measures.

The residential lighting savings were calculated based on the peak coincident factors from the 2014 NEEP residential lighting study (2014).[13] The ISR was based on values agreed upon from the 2018 Vermont Technical Advisory Group (TAG) Agreement, as specified in the TRM. Baseline wattages were based on less efficient, lumen-equivalent lamps. The efficient case was Energy Star-qualified lamps.

The relative precision in the NEEP residential lighting study was reported at the 90% confidence level and subsequently adjusted to the 80% confidence level. The relative precision for the prescriptive residential lighting from the NEEP residential lighting study was about 14% for both winter and summer peak demand reductions at the 80% confidence level.

[10] "Verification of Efficiency Vermont's Stipulated Lighting Portfolio for the ISO-NE Forward Capacity Market." Prepared by West Hill Energy and Computing for VT PSD, March 2015.
[11] 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.
[12] "Evaluation of Cold Climate Heat Pumps in Vermont." Prepared for the Vermont PSD by the Cadmus Group Inc. November 3, 2017.
[13] NMR Lighting Study, 2014, page IX.

The remainder of this section summarizes custom C&I results, C&I stipulated lighting results, and residential results.

4.1 C&I Custom Results

The distribution of PY2019 projects, along with program reported and verified savings and RRs, are provided below in Tables 9 through Table 12. Stratum 1 contains the smallest projects and Stratum 4 the largest.

TABLE 9: REALIZATION RATES FOR CUSTOM C&I RETROFIT FOR WINTER KW PEAK

Size Stratum	Total 2019 Projects	Evaluated Projects	Mean of EVT Program Reported kW	Mean of PSD Evaluated kW	Realization Rate
1	142	7	2.026	1.626	80%
2	67	7	13.373	4.656	35%
3	32	7	40.201	29.808	74%
4	12	10	70.763	64.386	91%
Total	253	31			69%

TABLE 10: REALIZATION RATES FOR C&I NC/MOP FOR WINTER KW PEAK

Size Stratum	Total 2019 Projects	Evaluated Projects	Mean of EVT Program Reported kW	Mean of PSD Evaluated kW	Realization Rate
1	272	7	0.550	0.561	102%
2	99	7	3.868	2.700	70%
3	49	7	17.524	12.479	71%
4	9	9	50.211	42.031	84%
Total	429	30			78%

TABLE 11: REALIZATION RATES FOR CUSTOM C&I RETROFIT FOR SUMMER KW PEAK

Size Stratum	Total 2019 Projects	Evaluated Projects	Mean of EVT Program Reported kW	Mean of PSD Evaluated kW	Realization Rate
1	142	7	2.388	0.936	39%
2	67	7	4.001	4.218	105%
3	32	7	35.585	31.671	89%
4	12	11	64.976	53.035	81%
Total	253	32			84%

TABLE 12: REALIZATION RATES FOR C&I NC/MOP FOR SUMMER KW PEAK

Size Stratum	Total 2019 Projects	Evaluated Projects	Mean of EVT Program Reported kW	Mean of PSD Evaluated kW	Realization Rate
1	272	7	0.369	0.253	67%
2	99	7	2.068	1.954	95%
3	49	7	16.890	13.506	80%
4	9	8	65.147	67.611	104%
Total	429	29			95%

As can be seen in the tables above, the RRs for the C&I market sectors vary from 35% to 105%. Some of the common reasons for the difference in RRs are listed below.

- Baseline assumptions were found to be incorrect., *e.g.*, EVT characterized the baseline for a farm as TRM metal halides whereas the site reported a 1-for-1 replacement for T8 fixtures.
- Schedule, operating parameters, or production levels were mischaracterized, *e.g.*, EVT claimed summer demand savings for a dehumidifier in a sports arena that was not being used during the summer.
- Some NC projects were incorrectly characterized as retrofit, *e.g*, EVT characterized a project as retrofit where more than 10% of the facility lighting had been replaced, indicating that the 2015 Vermont Commercial Building Energy Standards Code applied.

These types of adjustments are commonly found in the process of conducting an impact evaluation. RRs by project are provided in Appendix A and the project-specific reports are compiled in Appendix B.

4.2 C&I Stipulated Lighting Results

The overall RR for all stipulated lighting was 88% for winter and 86% for summer peak periods with a relative precision of 3% for both the summer and the winter. These results are based on the 2015 Stipulated Lighting Study in Appendix C. Additional details about the RR by project type are provided in the table below.

TABLE 13: REALIZATION RATES RESULTS[1]

Program Type	Winter kW Realization Rate	Winter Relative Precision	Summer kW Realization Rate	Summer Relative Precision
Custom Retrofit	88%	7%	84%	6%
Prescriptive	88%	6%	87%	9%
New Construction	92%	8%	92%	9%
Total	88%	3%	86%	3%

[1] "Verification of Efficiency Vermont's Stipulated Lighting Portfolio for the ISO-NE Forward Capacity Market." Prepared by West Hill Energy and Computing for VT PSD, March 2015. (Appendix C of this report)

4.3 Residential Results

The next two sections describe the adjustments made to the residential prescriptive and efficient pool pumps.

4.3.1 Prescriptive Measures

The prescriptive residential measures in EVT's portfolio are characterized in the TRM. Verified lighting coincidence factors were based on the NEEP residential lighting study conducted in 2014, air conditioner coincidence factors were based on the Residential RAC factor study of residential room air conditioners conducted in 2008,[14] and CCHP

[14] "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.

coincidence factors were based on the Vermont Residential CCHP Study.[15] The Vermont Thermal Study was used to calculate the RR for electric space heat measures.[16]

The PSD Evaluation Team compared the program reported savings to the TRM for these measures. The RRs were 100% for both the winter and the summer for all residential lighting. The RR for prescriptive room air conditioners was based on the Residential RAC factor study.[17] There was no adjustment made to the residential prescriptive CCHP water heaters because EVT correctly applied the load profiles from the TRM, which are based on the Vermont Residential CCHP Study.[18]

4.3.2 Efficient Pool Pumps AMI Analysis

In 2018, EVT completed efficient pool pump upgrades at 291 sites. These projects replaced existing swimming pool circulation pumps with new efficient pumps. The PSD Evaluation Team completed an AMI analysis to verify efficient pool pumps savings. Further details on the findings are provided in Appendix E. The RRs in the Appendix E efficient pool pumps study were applied to the PY2019 reported savings to calculate the evaluated savings.

As discussed in Appendix E, AMI data for each project 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 air conditioner (AC) usage between the pre and post period.

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

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

[16] "Impact Evaluation of Efficiency Vermont's Home Performance with ENERGYSTAR, Program Years 2014-2016", Prepared for Vermont PSD by West Hill Energy & Computing, September 10, 2018. https://publicservice.vermont.gov/sites/PSD/files/documents/WHEC_EVTHPwES_IE_FinalDraftReport_100318_CLEAN.pdf.

[17] *Ibid.*

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

5 Compliance with ISO-NE Standards

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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 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 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 that have been incorporated in the Vermont TRM. The TRM was compiled and is regularly updated 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, 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.

5.2 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. 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 all, random sampling was conducted. These issues are described in more detail in the site-specific project reports.

In Section 7.2, the manual requires the overall portfolio meet the 80/10 confidence/precision standard. As discussed above, the verification of EVT's portfolio exceeds that standard, with a relative precision of 7.1% for winter and 4.1% for summer peak reduction.

Section 7.2 also specifies the need to minimize bias. Bias relating to the three components of EVT's portfolio is explored briefly below.

- For C&I custom sites, stratified ratio estimation was used to identify the sample and random sampling was conducted for the small projects. Statistical methods meeting the ISO guidelines were applied and the sample sites were selected to reflect the population as a whole.
- In the analysis of the C&I custom measures, the PSD 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 PSD Evaluation Team left the savings unverified.
- 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 lighting study[19] 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.

5.3 Section 10, Measurement Equipment Specifications

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

5.4 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 NEEP study for C&I lighting, the Residential RAC factor study for residential air conditioning, the NEEP residential lighting study for residential lighting, and the

[19] 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.

previous impact evaluation of CCHP installations in Vermont cover the vast majority of the prescriptive savings. 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 measures used either Itron's eShapes or engineering estimates, as described previously. The kW reduction estimated by using Itron's eShapes and engineering estimates account for less than 2.2% of the total portfolio and thus the greater uncertainty associated with the load profiles was considered to be acceptable.

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.

6 Conclusions

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The PSD Evaluation Team completed its independent verification of EVT peak demand reduction. EVT's M&V plan, as submitted to ISO-NE, was the foundation for the sampling plan and verification activities conducted by the Department. The RRs were estimated from EVT's activity in PY2019. The M&V plan was followed and the results of the evaluation are consistent with the FCM standards, as specifically discussed in this document.

References

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

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.

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.

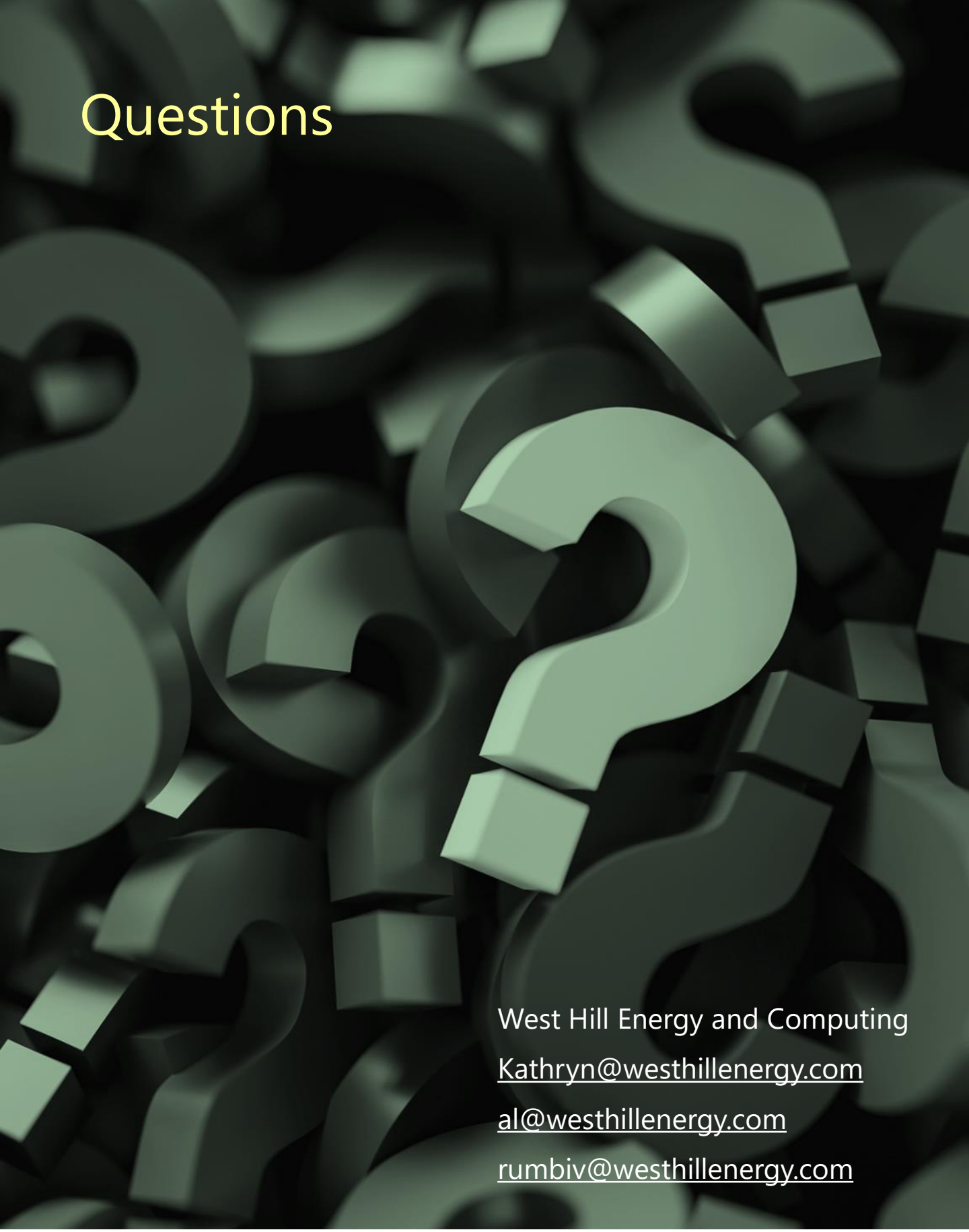
Northeast Residential Lighting Hours-of-Use Study. Prepared by NMR Group, Inc. and DNV GL. Somerville, MA. May 5, 2014.

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.

Questions



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