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

## Final Report

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# 1 Introduction

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

Efficiency Vermont (EVT) and Burlington Electric Department (BED) bid their respective efficiency program portfolios into the forward capacity market, and submitted detailed measurement and verification (M&V) plans that delineated how the evaluation process in Vermont will comply with ISO-NE standards. In both evaluation plans, the Vermont Department of Public Service (DPS; the Department) was charged with conducting the independent evaluation required by the ISO-NE standards.

The methods available to the Department to evaluate EVT and BED's FCM claims are defined by both the ISO-NE standards and the EVT and BED M&V plans. These standards are designed to result in a high degree of reliability for the resources purchased through the forward capacity market and represent a rigorous level of evaluation.

West Hill Energy and Computing was retained by the Department to provide independent verification of the custom commercial and industrial (C&I) efficiency initiatives for EVT and BED within the context of the FCM. With the assistance of four engineering firms, Cx Associates, GDS Associates, Lexicon Energy Consulting and Energy Resource Solutions, West Hill Energy has implemented the agreed upon M&V plans, including providing statistical analysis, site-specific M&V and overall impact evaluation of each efficiency portfolio.

This report describes the evaluation of BED's program year 2013 (PY13) 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 Section 14.2 in the ISO Manual.[1]

The evaluation was designed to determine the appropriate realization rates to be applied to the BED estimated savings. When applied, the resulting savings represent BED's verified savings. The realization rates given in this document will be used to adjust BED's savings reported to NE-ISO for the FCM from July 31, 2015 until the completion of the next evaluation cycle. This evaluation was also designed to provide a comprehensive impact evaluation of BED's savings for the purposes of Annual Savings Verification, including energy savings.

The remainder of this report is divided into the following sections: process, methods, results and conclusions. The components of BED's portfolio are described in BED's 2013 Annual Report.[2]

[1] *ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources Manual M-MVDR*, Revision: 5, Effective Date: November 8, 2013.
[2] Burlington Electric Department 2013 Energy Efficiency Annual Report.

# 2 Process

As with the initial FCM evaluation completed in 2010, the Department had primary responsibility for overall management of the verification process, including development and implementation of the sampling plan and final verification of each project in the sample. Due to the small population of C&I projects, the sampling approach for the C&I custom projects was relatively simple and a census sample of large projects (along with a random sample of small projects) was selected for verification.

The Department maintained overall management of the verification process and conducted metering on the selected C&I custom projects. The West Hill Energy evaluation team reviewed the project documentation, conducted metering, analyzed the metered data or developed alternative strategies as needed, and calculated the verified savings. As appropriate, recent studies meeting the NE-ISO standards were used to establish the coincidence factors for specific projects in the sample. For the stipulated lighting measures, the lighting load profile was reviewed to assess whether it was applicable to the project, and the quantity, baseline and efficient case assumptions were verified.

The verified savings were independently calculated for each project in the sample. A site-specific verification approach was developed for each project in accordance with the M-MVDR. Following verification, each project report was provided to BED allow an opportunity for clarification and a final check for errors and omissions before finalization. A list of the realization rates by project are provided in Appendix A and the project specific reports are attached as Appendix B.

For the C&I projects with standardized lighting profiles, coincidence factors were adopted from recent studies conducted for the Northeast Energy Efficiency Partnership (NEEP) and no metering was necessary. Measures in the residential sector are almost entirely prescriptive and the savings are estimated from the Vermont Technical Reference Manual (TRM). These savings were verified by comparing the BED's program reported savings to the TRM values.

# 3 Methods

BED bid its entire portfolio of energy efficiency initiatives into the FCM. The different initiatives and the verification approach are summarized in Table 1.

**Table 3-1: FCM Verification Strategy by BED Initiative**

| BED Initiative | Sampling Approach | ISO M&V Option |
|---|---|---|
| *Commercial & Industrial (C&I)* | | |
| Retrofit, New Construction (NC) and Market Opportunity (MOP) | Sample selected per ISO-NE FCM standards | Options A-D |
| *Residential* | | |
| Prescriptive Lighting | Prescriptive assumptions, no sampling necessary | Option A |
| Prescriptive Lighting, Commercial | Prescriptive assumptions, no sampling necessary | Option A |
| Prescriptive HVAC | Prescriptive assumptions, no sampling necessary | Option A |
| Prescriptive Other eShapes | Prescriptive assumptions, no sampling necessary | Option A |
| Prescriptive Other non-eShapes | Prescriptive assumptions, no sampling necessary | Option A |
| Hot Water Fuel Switches | Sample analyzed using AMI data | Option C |

The DPS evaluation team conducted the M&V of custom C&I sector projects. Savings for residential sector projects were based on prescriptive assumptions that have been reviewed by the DPS and are included in the Vermont "Technical Reference Manual" (TRM). For homes with prescriptive domestic hot water fuel switch savings, utility interval data was analyzed, as per M-MVDR option C, to verify the prescriptive assumptions. Each component of BED's portfolio was reviewed by the DPS evaluation team, with the appropriate verification approach balancing stringent precision targets with time and budget constraints. An overview of the initiatives is provided below.

**C&I Retrofit, NC and MOP:** This category includes projects associated with BED's programs in the business and multifamily sectors. Projects were sorted into three strata based on maximum peak demand savings (see Table 3-2 below). Measures using coincidence factors stipulated from the recent C&I Lighting Load Shape Study completed by KEMA were included the sample frame.[3]

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

**Residential Prescriptive Lighting:** This component represents the lighting products sold through the Efficient Products Program. The source of the coincidence factors is the RLW Analytics lighting study.[4] A fraction of these products are assumed to be purchased by

[3] *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

[4] *Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures.*

commercial establishments. For this portion of the residential prescriptive lighting, coincidence factors were based on the KEMA C&I Lighting Load Shape Study.[5] As commercial establishments typically have air conditioning, a cooling bonus was applied to reflect the lower cooling consumption due to the reduction in internal gains from the efficient lighting.

**Residential Prescriptive HVAC:** Efficient air conditioners are also offered through the Efficient Products initiatives. The source of the coincidence factors is the RLW Analytics residential HVAC study.[6]

**Residential Prescriptive Other eShapes:** The Efficient Products initiative also includes a range of other Energy Star appliances and electronics, including dishwashers, clothes washers, and refrigerators. In addition, some prescriptive measures are installed through the residential custom initiatives, including hot water conservation measures. For these measures, the coincidence factors were developed from Itron's eShapes 8760 load profile data, developed from audits of approximately 20,000 homes in the 1990s.[7] While the load profiles are based on older data, the extensive nature of the data collection would be extremely costly to reproduce for measures that represent about 1% of the energy savings in BED's portfolio.

**Residential Prescriptive Other non-eShapes:** These measures include a few other miscellaneous products offered through the Efficient Products initiative (such as dehumidifiers), as well as a limited number of items installed through the residential custom initiatives, such as domestic hot water pipe insulation and tank wraps. These coincidence factors, based on engineering estimates, were reviewed and found to be reasonable. Similar to the eShapes discussed above, these measures constitute a small percentage of BED's overall portfolio (approximately 3%).

**Residential Hot Water Fuel Switches:** The Department conducted a separate analysis of the savings for hot water fuel switch measures using AMI data for a whole building approach. AMI data was collected for 28 homes and savings were estimated from a pre/post analysis of use during the ISO-NE peak hours. More details are provided in Appendix F.

## 3.1 Sampling

The sampling plan for the C&I sector was developed by the Department. Sample sizes were designed to support stratified ratio estimation and meet the ISO-NE requirements for sampling precision (±10% precision at the 90% confidence level). The sampling was conducted from BED's list of projects completed between January 1, 2013 and December 31, 2013. The sampling unit for this verification is the location as defined by BED's location ID. All measures

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Prepared for NE State Program Working Group (SPWG) by RLW Analytics, Middletown, CT. Spring, 2007

[5] *Op. cit.*, KEMA, 2011.

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

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

installed during program year 2013 were considered for each location, and specific locations were selected for review.

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

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

The initial round of sampling was conducted using the complete sample frame of 2013 participants. The largest projects (with max kW savings greater than 16 kW) fell into the census stratum and were all evaluated. The remaining projects (with max kW savings less than 16 kW) were assigned to three strata based on size, as shown in Table 3-2 below.

**Table 3-2: Savings by Size Strata as Sampled**

| Size Stratum | Total # of Locations | # in Sample | Total Max kW | Sample Max kW |
|---|---|---|---|---|
| 0 | 176 | 0 | 18.30 | 0.00 |
| 1 | 136 | 8 | 122.55 | 9.74 |
| 2 | 26 | 8 | 177.64 | 41.63 |
| 3 | 5 | 5 | 295.18 | 295.18 |
| Totals | 343 | 21 | 613.67 | 346.55 |

As is common in conducting field work, some locations that selected through the sampling process were not able to be verified. As part of the PY13 evaluation, projects comprised of entirely of Smartlight measures at the University of Vermont (UVM) were selected to be included in the sample. Due to the size of the campus, the evaluation team could not conclusively identify the installation location of the lighting, meaning savings could not be verified. The failure of deployed metering equipment at a second location, the Intervale Farmer Equipment Company, prevented the evaluation team from verifying savings for that project. Table 3-3 outlines the impacts of the drops on the total verified savings.

A large project at Fletcher Allen Health Care (FAHC) was moved into a separate stratum from the rest of the projects for the following reasons:

1. The verified savings from the project are from a comprehensive upgrade of the ventilation system, the only measure of its type in the portfolio, so the realization rate is not representative of the rest of the C&I projects.
2. The FAHC project accounts for over 20% of the C&I savings, so it has a large impact on the overall realization rate.
3. This project has a much higher realization rate than any of the other projects in the portfolio; additional detail is provided in Appendix B.

The decision to put this project in its own stratum was made to allow direct reporting of the realization rates for the more standard C&I measures. This change had very little impact on the portfolio wide realization rate.

**Table 3-3: Verified Sample Summary**

| Size Stratum | Number of Locations In Sample | Number of Locations Completed | Original Sample kW Max | Remaining Sample kW Max After Excluding Drops | Verified Sample kW Max |
|---|---|---|---|---|---|
| 1 | 8 | 8 | 9.74 | 9.74 | 9.74 |
| 2 | 8 | 6 | 41.63 | 32.58 | 32.50 |
| 3 | 4 | 4 | 182.63 | 182.63 | 180.62 |
| FAHC | 1 | 1 | 112.55 | 112.55 | 88.71 |
| Total | 21 | 18 | 346.55 | 337.49 | 311.57 |

One of the ramifications of aggregating activity by location was that some locations were the site of multiple projects covering a wide range of measures and not all of the measures could be metered or verified by other means. Overall, the number of measures unable to be verified within evaluated projects was quite small. After removing the two dropped projects, 92% of the max kW included in the sample was verified to FCM standards.

## 3.2 Realization Rate

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

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

where,

RR is the realization rate (ratio estimator)
*i* represents the location ID number
*n* is the total number of verified locations in the sample
$w_i$ is the expansion weight (the total number of locations in the stratum divided by the number of verified locations in the stratum)
$y_i$ is the verified savings for location *i*
$x_i$ is the original claimed savings for location *i*

The basis for these calculations and the method for calculating the variance are provided in *The California Evaluation Framework.*[8]

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

# 4 Results

The realization rates and relative precision for BED's energy savings are provided in Table 4-1. The portfolio realization rate is 102.4% with a relative precision of 7.0% at the 80% confidence level.

**Table 4-1: Realization Rates and Sampling Precision for Energy Savings**

| | BED Program Reported kWh Savings | Realization Rate | Savings as % of Total Portfolio | Relative Precision at the 80% Confidence Level |
|---|---|---|---|---|
| C&I | | | | |
| Retrofit/NC/MOP | 3,121,078 | 89.9% | 44.3% | 15.3% |
| Fletcher Allen Health Care | 881,686 | 161.1% | 12.5% | 0.0% |
| C&I Not Verified | 74,630 | 89.9% | 1.1% | 15.3% |
| C&I Total | 4,077,393 | 105.3% | 57.9% | 21.7% |
| Residential | | | | |
| Prescriptive Lighting | 1,745,983 | 98.6% | 24.8% | 6.0% |
| Prescriptive Lighting Commercial | 687,933 | 99.7% | 9.8% | 3.4% |
| Prescriptive HVAC | 5,458 | 100.6% | 0.1% | 10.4% |
| Prescriptive Other eShapes | 85,630 | 96.9% | 1.2% | 50.0% |
| Prescriptive Other non-eShapes | 230,267 | 100.1% | 3.3% | 0.0% |
| Hot Water Fuel Switches | 207,600 | 90.5% | 2.9% | 23.3% |
| Totals | 7,040,264 | 102.4% | 100% | 7.0% |

Table 4-2 and Table 4-3 show the realization rates and relative precision for the peak kW savings, verified for the FCM component of the evaluation. The portfolio-wide realization rates for winter and summer peak kW are 105.1% and 89.4%, respectively. The ISO-NE standards require sampling precision at the 80/10 confidence/ precision level for the entire portfolio. The relative precision of the verified savings in BED's portfolio is 7.2% for winter peak kW reduction and 7.5% for the summer peak, which meets this requirement.

**Table 4-2: Realization Rates and Sampling Precision for Winter Peak kW Reduction**

| | BED Program Reported Peak kW Reduction | Realization Rate | Savings as % of Total Portfolio | Relative Precision at the 80% Confidence Level |
|---|---|---|---|---|
| C&I | | | | |
| Retrofit/NC/MOP | 376 | 106.1% | 29.3% | 10.4% |
| Fletcher Allen Health Care | 85 | 225.0% | 6.6% | 0.0% |
| C&I Not Verified | 9 | 106.1% | 0.7% | 10.4% |
| C&I Total | 470 | 127.7% | 36.6% | 14.7% |
| Residential | | | | |
| Prescriptive Lighting | 568 | 100.8% | 44.2% | 13.9% |
| Prescriptive Lighting Commercial | 71 | 102.4% | 5.5% | 5.7% |
| Prescriptive HVAC | 0 | 100.0% | 0.0% | 0.0% |
| Prescriptive Other eShapes | 31 | 101.1% | 2.4% | 50.0% |
| Prescriptive Other non-eShapes | 19 | 100.0% | 1.5% | 0.0% |
| Hot Water Fuel Switches | 126 | 43.5% | 9.8% | 20.5% |
| Totals | 1,284 | 105.1% | 100% | 7.2% |

**Table 4-3: Realization Rates and Sampling Precision for Summer Peak kW Reduction**

| | BED Program Reported Peak kW Reduction | Realization Rate | Savings as % of Total Portfolio | Relative Precision at the 80% Confidence Level |
|---|---|---|---|---|
| C&I | | | | |
| Retrofit/NC/MOP excluding BIA | 368 | 80.0% | 41.2% | 16.5% |
| Fletcher Allen Health Care | 89 | 136.5% | 9.9% | 0.0% |
| C&I Not Verified | 8 | 80.0% | 0.9% | 16.5% |
| C&I Total | 464 | 90.8% | 52.0% | 23.3% |
| Residential | | | | |
| Prescriptive Lighting | 173 | 98.9% | 19.4% | 14.1% |
| Prescriptive Lighting Commercial | 144 | 100.3% | 16.1% | 2.2% |
| Prescriptive HVAC | 22 | 18.8% | 4 | 10.4% |
| Prescriptive Other eShapes | 6 | 102.3% | 0.7% | 50.0% |
| Prescriptive Other non-eShapes | 20 | 101.2% | 2.3% | 0.0% |
| Hot Water Fuel Switches | 64 | 48.5% | 7.1% | 22.1% |
| Totals | 892 | 89.4% | 100% | 7.5% |

For the C&I custom sample, the relative precision was calculated from the sample. The two studies done by RLW Analytics (lighting and residential HVAC) specified the relative precision for the coincidence factors. In some cases, the relative precision was estimated based on the available information, as discussed below.

- The coincident factors for a variety of small residential measures were based on Itron's eShapes 8760 load profile data, developed from audits of approximately 20,000 homes in the 1990's.[9] 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 less than 10% of BED's portfolio. The relative precision could not be determined, so a proxy value of 0.50 was used. Given the large sample size, this proxy value is assumed to be substantially larger than the actual relative precision.
- For a few other residential measures, the load profiles were based on engineering assumptions and the relative precision could not be determined. These coincident factors were reviewed and found to be within a reasonable range. Since no sampling was conducted, there is no sampling error associated with these measures. These measures constitute a very small percentage of BED's overall portfolio (1% of the winter and summer peak kW savings).

For the residential prescriptive lighting products, the reduction in Watts and in-service rates are based on the results of a market study conducted by Nexus Marketing Research.[10] This was a regional study prepared for the New England Energy Efficiency Partnership (NEEP). Verified lighting coincidence factors were based on the recent RLW lighting study (2007)[11].

Thus, the residential lighting savings are composed of three components with values derived from two different studies (NMR, 2009 and RLW, 2007). Each component has a relative precision associated with it. The overall precision was calculated using the method described in BED's M&V Plan.[12] The in-service rate (ISR) and delta Watts were estimated from the same sample, and thus the worst-case precision was estimated as if the factors were perfectly correlated, i.e., the combined precision was additive. The RLW and NMR studies were independent, allowing the combined precision from the NRM and RLW studies to be calculated by the following formula:

$$p = \sqrt{(p_{NMR}^2 + p_{RLW}^2)}$$

The relative precision in the NMR study was report at the 90% confidence level. The combined precision for the ISR and delta Watts from the NRM study was 10.8. The precision for the RLW coincidence factors was reported to be 4.5% and 6.1% at the 80% confidence level

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

[10] *Residential Lighting Markdown Impact Evaluation,* Nexus Market Research, RLW Analytics, and GDS Associated, January 20, 2009

[11] RLW Lighting Study, 2007, pages 13 and 14

[12] *Vermont Efficiency Portfolio: Plan for Measurement and Verification of Demand Reduction Value from Energy Efficiency Resources*. Prepared by the Vermont Energy Investment Corporation for submission to ISO New England. June 15, 2007. Pages 7-4 to 7-5.

for winter and summer, respectively.[13] Thus, the combined relative precision for the prescriptive residential lighting was calculated to be 11.7% and 12.4% for winter and summer peak demand reductions.

## 4.1 C&I Results

Tables 4-4 through 4-6 provide the realization rates and population for the C&I custom projects in the BED portfolio. Stratum 1 contains the small projects and Stratum 3 the large projects. The realization rates in the final row reflect the overall realization for the C&I custom projects and are also provided in Table 4-1.

**4-4: Energy Realization Rates by Size for C&I Custom Projects**

| Size Stratum | Total Number of Projects | Projects in Sample | Mean of Program BED Reported kWh Savings | Mean of DPS Verified kWh Savings | Realization Rate |
|---|---|---|---|---|---|
| 1 | 136 | 8 | 7,307 | 6,453 | 0.883 |
| 2 | 26 | 6 | 31,081 | 37,648 | 1.211 |
| 3 | 4 | 4 | 238,784 | 155,497 | 0.651 |
| Total | 167 | 19 | | | 105.3 |

**Table 4-5: Winter kW Peak Realization Rates by Size for C&I Custom Projects**

| Size Stratum | Total Number of Projects | Projects in Sample | Mean of BED Program Reported kW Reduction | Mean of DPS Verified kW | Realization Rate |
|---|---|---|---|---|---|
| 1 | 136 | 8 | 0.88 | 0.92 | 1.045 |
| 2 | 26 | 6 | 4.46 | 5.64 | 1.264 |
| 3 | 4 | 4 | 34.25 | 30.93 | 0.903 |
| Total | 167 | 19 | | | 1.277 |

**Table 4-6: Summer Peak Realization Rates by Size for C&I Custom Projects**

| Size Stratum | Total # of Projects | Projects in Sample | Mean of BED Program Reported kW Reduction | Mean of DPS Verified kW | Realization Rate |
|---|---|---|---|---|---|
| 1 | 136 | 8 | 1.00 | 0.91 | 0.910 |
| 2 | 26 | 6 | 3.64 | 4.17 | 1.146 |
| 3 | 4 | 4 | 30.27 | 12.26 | 0.405 |
| Total | 167 | 19 | | | 0.908 |

[13] RLW Lighting Study, 2007, pages 13 and 14.

As can be seen from these tables the realization rates vary significantly across size strata. Some of the common reasons for the difference in realized savings are listed below.

- Operating schedules were found to be different from what the participant reported to BED; this impacts both total hours of operation and coincident peak factors.
- Adjustment of exterior LED baselines to a lumen equivalent method.
- Estimates of baseline and efficient case kW were used, rather than standard reference values or site specific values.

## 4.2 Residential Results

The assumptions for these measures are documented in the TRM and applied to the specific measures by BED. Thus, discrepancies are usually due to errors in applying the TRM values. As the summary of adjustments by load profile in Table 4-7 illustrates, total DPS verified energy savings were 1.1% less than BED claimed. DPS verified winter and summer peak demand savings were 0.9% more and 5.1% less, respectively, than BED claimed.

**Table 4-7: Residential Adjustments by Load Profile Category**

| | Adjustment | | | Percentage Change to BED Claimed Savings | | |
|---|---|---|---|---|---|---|
| | kWh | Winter Peak kW | Summer Peak kW | kWh | Winter Peak kW | Summer Peak kW |
| Prescriptive Lighting Residential | (25,035) | 4.291 | (1.919) | -1.4% | 0.8% | -1.1% |
| Prescriptive Lighting Commercial | (1,904) | 1.686 | 0.417 | -0.3% | 2.4% | 0.3% |
| Prescriptive HVAC | 33 | - | (17.549) | 0.6% | 0.0% | -81.2% |
| Prescriptive Other eShapes | (2,619) | 0.322 | 0.140 | -3.1% | 1.1% | 2.3% |
| Prescriptive Other non-eShapes | 322 | (0.007) | 0.235 | 0.1% | 0.0% | 1.2% |
| Total | (29,203) | 6.292 | (18.675) | -1.1% | 0.9% | -5.1% |

The reasons for adjustments fell into the following broad categories:

- Calculation errors
- In-service rate (ISR) adjustments
- Load profile adjustment
- Measure characterization update per 2013 TRM

Additional details about the specific measures adjustments can be found in Appendix D.

## 4.3 DHW Fuel Switches

The DHW fuel switches were analyzed separately from the rest of the prescriptive measures using AMI data. This resulted in an over 50% decrease in the demand savings from the prescriptive values used by BED while the energy savings only decreased slightly.

| | Adjustment | | | Percentage Change to BED Claimed Savings | | |
|---|---|---|---|---|---|---|
| | kWh | Winter Peak kW | Summer Peak kW | kWh | Winter Peak kW | Summer Peak kW |
| Hot Water Fuel Switch | (19,718) | (71.173) | (32.825) | -9.5% | -56.5% | -51.5% |

## 4.4 Compliance with ISO-NE Standards

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

**Section 6, Establishing Baseline Conditions:** As specified in the manual, the baseline conditions for retrofit projects are the pre-existing conditions. If the pre-existing conditions could not be determined, then the applicable state code, federal product efficiency standard or standard practice (if more stringent than the state or federal requirement) should be used. For market opportunity projects, the baseline is the applicable state code, federal product efficiency standard or standard practice (if more stringent than the state or federal requirement).

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

The same principles were applied in developing the deemed savings values and standard savings estimation algorithms that have been incorporated in the Vermont Technical Reference Manual (TRM). The TRM has been compiled based on applicable state code, federal product efficiency standards, or standard practice through the work of the Technical Advisory Group (TAG), which includes representatives of the Department, 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.

**Section 7, Statistical Significance:** For engineering-based, direct measurement, the ISO manual required strategies to control for bias, such as the accuracy and calibration of the measurement tools, sensor placement bias, and sample selection bias or non-random

selection of equipment and/or circuits to monitor. The site-specific M&V plans described the relevant issues for each project and discussed the methods used to mitigate bias. These issues are described in more detail in the site-specific project reports.

In Section 7.2, the manual requires that the overall portfolio meet the 80/10 confidence/precision standard. As discussed above, the verification of BED's portfolio meets that standard with a precision of 7.2% for winter peak reduction and 7.5% for the summer peak reduction.

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

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

**Section 10, Measurement Equipment Specifications:** The Department used RLW's *Review of ISO New England Measurement and Verification Equipment Requirements* (April 24, 2008) to identify the ISO-compliant metering equipment. In some situations, approved metering equipment was used at the lower boundary of the range of kW or current as there was no alternative equipment that met the ISO-NE standard.

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

**Section 5, Acceptable Measures and Verification Methodologies:** This section describes the specific allowable methods, Options A through D. Engineering algorithms are permitted if supplemented with on-site data collection. Verifiable load shapes may be applied if based on "actual metering, load research, and/or simulation modeling" (Section 5.4.2).

For the residential prescriptive measures (with the exception of hot water fuel switching), Option A was applied, verifiable load shapes and assumptions based on

recent, statistically sound studies were available for most of the measures. The recent RLW studies for lighting and HVAC prepared for NEEP cover the vast majority of the residential prescriptive savings. For hot water fuel switching, Option C was used.

The other measures used either Itron's eShapes or engineering estimates, as described above. While the Itron eShapes are based on data that is 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. The kW reduction estimated by the use of engineering algorithms account for only 2% of the total portfolio, and thus the greater uncertainty associated with the load profiles was considered to be acceptable.

## 4.5 Issues to be Addressed Prospectively

The next two sections describe the adjustments made to the residential prescriptive and residential custom measures.

### 4.5.1 TRM Updates

EVT updates the TRM on an annual basis for some measures. For some measures, savings were being claimed based upon TRM assumptions from PY12 or earlier. The Department suggests that BED further review its process for ensuring that all TRM updates are incorporated into the estimation of savings.

### 4.5.2 The Smartlight Program

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

The traceability for these fixtures is challenging for a number of reasons. The first challenge has to do with collecting information from the distributors. In some cases, the product may be purchased directly by the end user and installed in the reported location, purchased and installed elsewhere, or purchased and put in storage for future replacement of existing lamps. Lamps may also be purchased by a contractor for installation at a customer's site or for future sales. Distributors attempt to gather information about the installation address for the fixtures but are not always successful.

Since the incentives are paid to the distributors, end users are often not aware that they are participating in the program. Without a reference point of participation, like filling out a rebate form, end users have difficulties identifying the specific lighting that was purchased and where it was installed. Since end users were often unaware that they were participating in the program, it was not always possible to identify specifically where the lighting was installed. Both UVM and FAHC purchased large quantities of lamps but were not able to provide sufficient detail on installation in order to be able to verify savings for these measures.

### 4.5.3 Prescriptive Lighting Values

BED has been combining actual efficient lighting wattages with assumed TRM baseline wattages for many prescriptive lighting measures. While the evaluation team appreciates BED's efforts to use more accurate inputs, changing only the efficient assumption results in wattage reductions that are either too low or too high on an individual measure basis. A portfolio average that is lower than the TRM average for the efficient products would result in an overstatement of savings as compared to the TRM. Likewise a portfolio average higher than TRM assumptions would provide a lower savings estimate.

The effects of this practice were exacerbated in exterior lighting installations. As discussed in the *Verification of EVT 2013 Claimed Annual MWh Savings, Coincident Summer*

*and Winter Peak Savings and Total Resource Benefit (TRB),*[14] the TRM efficient product category for LED exterior lighting ranges from 30 to 75W and crosses technology thresholds on an efficacy basis.

As part of the TRM process moving forward, the size of lighting categories and lighting baselines should be adjusted to result in a comparison of products that provide equivalent lumens. This issue is currently being addressed in the Technical Advisory Group (TAG).

### 4.5.4 DHW Fuel Switch Prescriptive Values

The AMI analysis of the DHW fuel switches showed that the demand savings are substantially overstated. BED's source of the kW savings is no clear, as the TRM characterization only includes kWh savings. The BED kW savings value is also assumed for all installations, regardless of the number of bedrooms or claimed energy savings. The TRM characterization should be reviewed and updated to include a more accurate demand savings value, ideally with values based on household size and based on actual consumption.

[14] Verification of EVT 2013 Claimed Annual MWh Savings, Coincident Summer and Winter Peak Savings and Total Resource Benefit (TRB), Final Report., Submitted to the Department of Public Service by West Hill Energy and Computing, Inc. July 2014 p.32.

# 5 Conclusions

The Department completed its independent verification of BED's peak demand reduction. BED's M&V plan as submitted to ISO-NE was the foundation for the sampling plan and verification activities conducted by the Department. The M&V plan was followed and the results of the evaluation are consistent with the ISO-NE standards, as specifically discussed in this document. The realization rates reflect BED's activity in program year 2013.

BED's energy savings were also evaluated for annual savings verification. As has been done in the past, the residential savings verification consisted of comparing BED's program reported savings to the TRM values. BED's overall energy savings realization rate is 102.4%. The FAHC project is a driver of the portfolio-wide realization rate. When this project is removed, the overall realization rate is 93.5%, and the C&I realization rate drop from 105.3% to 89.9%. In any case, these realization rates suggest that BED's estimates of energy and peak demand savings are pretty accurate on average.

# 6 References

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