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

## Final Report

**Prepared for the**
**Vermont Department of**
**Public Service**

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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.[1]

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 (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 circumscribed 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 far more rigorous type of evaluation than has previously been conducted on Vermont's efficiency portfolios.

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 three engineering firms, Cx Associates, GDS Associates and Lexicon Energy Consulting, West Hill Energy implemented the M&V Plan, including providing statistical analysis, site-specific M&V and overall impact evaluation of EVT's efficiency portfolio.

This report describes the evaluation of EVT's 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 (M-MVDR, October 1, 2007) and in Section 14.2 of EVT's M&V Plan (June 15, 2008).

The evaluation was designed to determine the appropriate realization rates to be applied to EVT's estimated savings. When applied, the resulting savings represent EVT's verified savings. The realization rates given in this document will be used to adjust EVT's savings reported to NE-ISO for the FCM from July 1, 2010 until the completion of the next evaluation cycle.

The remainder of this report is divided into the following sections: process, methods, results and conclusions. The components of EVT's portfolio are described in EVT's 2007 and 2008 Annual Reports.[2]

[1] *ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources Manual M-MVDR*, Revision: 1, Effective Date: October 1, 2007, pg. INT-3

[2] *Efficiency Vermont Year 2007 Annual Report*, October 15, 2008; *Efficiency Vermont Annual Report 2008*, Fall, 2009; available at www.efficiencyvermont.com.

# 2 Process

EVT's M&V plan identified the Department as the entity responsible for conducting independent assessment of EVT's FCM claims. EVT, the Department, and the Public Service Board Contract Administrator engaged in lengthy discussions to determine the scope of the work and the division of responsibilities between parties. These initial meetings were the forum for developing the structure of the sampling plan, which was designed to include stratification by size of the projects, defined as the higher value of the winter or summer coincident peak kW reduction. The parties also agreed that a census of the large projects would be verified.

Through these initial meetings, it was determined that the Department would have the primary responsibility for metering small and medium projects, in addition to the overall management of the verification process as envisioned in EVT's M&V plan. For the projects that fell into the small and medium strata, the Department's contracted engineers reviewed the project documentation, developed metering plans where appropriate, installed and retrieved the meters, analyzed the meter data, and calculated the verified savings.

As agreed, EVT conducted metering of large projects and provided the metered data to the Department for analysis. The process included the development of site-specific metering plans and the metering of the census strata of large projects. EVT agreed to provide the M&V plans to the Department for review and comment prior to starting the metering, as time constraints allowed. Each large project was also assigned to a review engineer on the Department's evaluation team. This engineer reviewed EVT's project documentation, analyzed any metering data that was collected by EVT, and independently calculated the verified savings for the project. Based on the study conducted by RLW Analytics[3] regarding load shapes for commercial lighting, lighting applications that could use stipulated coincidence factors were identified and these projects did not need to be metered.

The verified savings were independently calculated for each project (large, medium and small) in the sample. Site-specific project reports were developed, and sent to EVT to provide an opportunity for clarification and a final check for errors and omissions. The project reports were then finalized and are included in Appendices E, F and G of this report. The project-specific realization rates are listed in Appendix A.

# 3 Methods

Efficiency Vermont bid its entire portfolio of energy efficiency initiatives into the FCM. The different initiatives and the verification approach are summarized in Table 1. The residential custom initiatives represented an extremely small part of EVT's portfolio and a substantial hurdle in meeting ISO-NE's FCM requirements. For example, the savings for space heat fuel switches are calculated using house-specific inputs, and verification would require selecting a sample and then conducting site visits for the sample. Since the electric space heat had already been removed, there was no possibility of metering the electric use and no clear

[3] *Coincidence Factor Study Residential and Commercial & Industrial Lighting Measures*. Prepared for New England State Program Working Group (SPWG) by RLW Analytics, Middletown, CT. Spring, 2007

approach to calculating peak demand savings. Consequently, savings from these initiatives were not verified for the FCM claim. It is important to note that these initiatives are expected to save energy and peak demand; they were not verified solely due to the difficulty and expense in determining the savings in a manner that meets the ISO-NE standards.

**Table 1: FCM Sampling Strategy by EVT Initiative**

| EVT Initiative | FCM Verification Sampling Strategy | 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 |
| *Custom Customer Credit* | All projects reviewed | Options A through D |
| *Stipulated Lighting* | No sampling; stipulated coincidence factors were applied | Option A |
| | | |
| *Residential* | | |
| Prescriptive Lighting | 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 |
| Custom | Savings not verified for FCM | None |

West Hill Energy and Computing, Inc. conducted the evaluation of the custom C&I sector. This component of the evaluation involved drawing a sample of projects and conducting the metering and analysis. The realization rates for the C&I sector are based on EVT's activity in program years 2007 and 2008.

The verified residential sector savings were entirely prescriptive, using assumptions that have been reviewed by the DPS and included in EVT's "Technical Reference Manual" (TRM). With the application of the coincident factors from the recent studies by RLW Analytics, the residential prescriptive measures met the standard described in EVT's M&V plan. No sampling was necessary for the residential sector. The realization rates for the residential sector were calculated for each program year, due to the variety of issues that arose during the different periods.

## 3.1 Sampling

The sampling plan for the C&I projects was developed through collaboration between EVT and the Department and is attached to this report as Appendix B. Sample sizes were designed to support stratified ratio estimation. Given the time frame required to be able to

complete the metering and site-specific M&V, the parties agreed to base the realization rates on projects completed during program years 2007 and 2008. (The next evaluation cycle will focus on projects complete during program year 2009.)

The sampling ratios were developed using EVT's list of completed projects from January 1, 2007 through April 30, 2008. This approach was based on the underlying premise that the distribution of savings among the projects completed during these sixteen months would be representative of projects completed during the entire two year period, as is supported by EVT's consistent delivery of services throughout the period. The realization rates presented in this report for the custom C&I sector will be applied to EVT's peak demand savings to determine the FCM verified savings reported to ISO-NE until new values are established in the next evaluation.

The sampling unit for this verification was a project/end use. The group of projects under consideration for sampling were all C&I projects (both prescriptive and custom), including multifamily projects. As noted above, EVT and the DPS stipulated the coincident peak factors for lighting efficiency measures based in a number of types of businesses, e.g., retail, groceries, etc., for small- and medium-sized projects. Consequently, lighting measures with stipulated coincident peak factors were separated from the remainder of the C&I and multifamily projects. The final sample frame included all C&I and multifamily projects with non-stipulated measures.

For retrofit measures, the FCM sample design assumed that the DPS would attempt to conduct pre-installation metering for retrofit projects whenever possible. Thus, the sampling process consisted of two major components:

- after-the-fact sampling of completed projects
- real-time sampling for retrofits projects in the pipeline (to obtain pre-installation metering data)

The next subsections cover stratification, the definition of the sampling framed for completed project and real-time sampling, the implementation of the sampling for completed projects and real-time sampling, and sampling issues.

### 3.1.1 Stratification

The stratification variables, issues associated with those variables, and the final stratification approach are summarized in Table 2. The primary stratification variable was the higher of the two estimates of coincident peak reduction (summer and winter) for each sampling unit (project and end use). The higher of the two coincident peak values is referenced as "max kW" throughout the rest of this document. Any project/end use with an estimated maximum peak reduction of less than 0.8 kW was omitted from the sample as too small to evaluate.

**Table 2: Summary of Sampling Approach and Stratification Plan**

| Stratification Variable | Issues | Stratification Categories |
|---|---|---|
| **Type of Market** | 1) Baselines are defined according to whether the project is retrofit or NC/MOP.<br>2) Retrofit projects may require pre-installation metering. | Two categories: Retrofit and NC/MOP |
| **Project Size** | 1) Small, medium and large projects tend to generate different types of errors and uncertainties.<br>2) FCM bid is for both summer and winter peak demand reduction, so the defining the size of the projects is not straightforward. | Three categories: small, medium, large, based on the higher of the winter or summer peak reduction ("max kW") |
| **End Use** | 1) Measures within specific end uses tend to have the same sources of uncertainty and require similar metering strategies.<br>2) C&I custom projects address a wide range of end uses, and many end uses have only a few projects. | Three categories: lighting, HVAC and other |
| **Seasonality** | 1) Demand reductions are claimed separately for the winter and summer performance hours.<br>2) Some measures are non-seasonal and can be verified at any time.<br>3) Other measures, particularly HVAC and refrigeration, tend to have weather-dependent savings that need to be verified during the specific winter or summer peak period. | Two categories: summer/non-seasonal and winter |

The stratification approach was the same for the entire sample. Due to the timing of the sampling and the decision to pursue real-time sampling, the cut offs for each stratum were defined prior to the start of the sampling process based on the initial data set provided by EVT, which included completed projects from January 1, 2007 through April 30, 2008. Each element of the stratification plan is described in more detail below.

Sampling unit: The sampling unit was a project/end use with three end use categories, i.e., lighting, HVAC (heating, ventilation and air conditioning) and other measures ("REST"). Once the project/end use was selected, the DPS team verified only the measures relating to that project and end use, rather than the comprehensive verification of all measures associated with the project. Measures that could have interactive effects with the selected end use were also reviewed.

Market Type: Samples were selected separately for two broad program groups:

- retrofit projects where pre- and post-installation metering may be possible, and
- market opportunity (MOP) and new construction (NC) projects where only post-installation metering could be implemented.

The retrofit projects included C&I retrofit, farm, and low income and market rate multifamily initiatives. The MOP and NC projects include custom MOP, non-lighting prescriptive MOP projects, NC and also the relatively new Lighting Plus initiative, which was based on the assumption that it would not be possible to pre-meter these projects since they are retrofit projects with a short lead time.

Size: Size categories are used to ensure that the sample was representative of the population. Projects with a max kW greater than or equal to 0.8 kW and less than 5.0 kW were classified as small, projects equal to or greater than 5.0 kW and less than 35.0 kW were classified as medium, and projects with maximum demand savings of 35.0 kW or higher were classified as large.

Seasonality: Two categories were defined, i.e., projects/end use with a predominant summer peak reduction or non-seasonal (defined as roughly equivalent winter and summer peak kW reduction), and projects/end use with a predominant winter peak reduction.

### 3.1.2 Definitions of the Completed Projects and Real-Time Sampling Frames

For retrofit projects, obtaining pre-installation metering data can provide critical information for determining the baseline. For this reason, the sample design incorporated real-time sampling to obtaining this pre-installation data if possible. Given that the savings for MOP and NC projects are estimated from a hypothetical baseline (such as code standards), it is unnecessary (and sometimes impossible) to collect pre-installation metering data. Accordingly, the sampling for these projects was conducted after the projects were completed and post-installation metering was performed. Since the sampling occurs after the fact, these projects can be correctly categorized by size.

For retrofit measures, the FCM sample design assumed that the DPS would attempt to conduct pre-installation metering for retrofit projects whenever possible. Since lighting efficiency measures are dependent on the hours of use, baseline and efficient conditions, there is no need to conduct pre-installation metering unless a change in hours of use is expected. Fixture replacements would not generally be expected to affect hours of use, although lighting controls by definition change the hours of use. Given that pre-installation metering tends to be expensive as well as being more difficult to sample and to implement, lighting efficiency (fixture replacements) projects were separated from lighting controls, and retrofit projects were sampled with lighting efficiency measures as part of the completed project sample. However, lighting control measures for retrofit projects were included within the other measure category (REST) rather than with the lighting measures.

The final disposition of the market groups and end uses into the complete project and real-time sampling frames is described below. As discussed in Section 3.1.4, the real-time sampling was conducted only for the list of pipeline projects provided by EVT through December of 2008. Subsequently, the retrofit sample was filled with completed projects.

**Table 3: Definition of Sample Frames for Completed Projects and Real-Time Sampling**

| Sample Frame | Market Group | End Uses |
|---|---|---|
| Completed Projects | NC/MOP | All |
| | Retrofit | Lighting efficiency |
| Real-Time Sampling | Retrofit | HVAC and REST (including lighting controls); sample supplemented with completed projects to obtain required sample sizes |

### 3.1.3 Sampling of Completed Projects

The sampling was conducted in two distinct stages, due to the need complete field measurements within the verification schedule. The first stage included completed projects from January 1, 2007 through April 30, 2008, and the second stage covered the remainder of program year 2008. The cut offs for the strata were developed prior to sampling based on the data provided for the first round of sampling.

For the completed projects, the sample was selected using the standard statistical process, i.e., the projects/end use were assigned to strata, a random number was assigned to each project/end use, the projects were ordered by the random number and the desired number of projects were then selected from the top of each group.

### 3.1.4 Real-time Sampling

For retrofit projects where both pre- and post-installation metering was possible, EVT developed and provided a list of projects in the pipeline for sampling prior to project completion, the Early Measure Tracking ("EMT") list. Projects in the HVAC and REST measure categories were sampled in this manner.

This sampling was done in three stages during the summer and fall of 2008 (July, October and November). At the end of 2008, EVT informed the Department that the EMT reports were not complete and many projects were missing. In addition, the Department became concerned that the projects in the pipeline would not complete within the required time frame, did not require pre-installation metering or could not be metered for other reasons. Consequently, no further projects were selected from the EMT list and the retrofit sample was filled out with retrofit projects completed during 2008.

Real-time sampling was conducted for HVAC and REST retrofit projects that had not yet been completed. The overall sampling process was refined after the EMT reports had been designed, adding an additional layer of complexity to the selection process. Consequently, some manipulation of the data was required to put it in the correct format for sample selection.

The sampling selection was further complicated by the fact that the early measure tracking report, by definition, includes only a part of the sampling frame, i.e., there will continue

to be new projects coming into the pipeline and the characteristics of these projects cannot be predicted with certainty. In the early measure tracking report, the number of projects in any given cell (e.g., HVAC, small, winter) was too small to apply the sampling rates and obtain a reasonable sample. To address this issue, the sampling was done using systematic sampling, a form of cluster sampling often used when the sampling is begun prior to complete definition of the sampling frame. If the sampling is conducted carefully, the resulting sample can be analyzed using the same methods as a random sample.[4]

The systematic sampling process was designed to ensure that all of the strata were adequately represented in the final sample. The process was conducted as follows:

1. The projects were ordered by end use, size and season.
2. The sampling ratio was used to determine the number of projects to select in each end use.
3. The projects were assumed to be selected evenly throughout the sample, and the number of projects to skip between each selected project was calculated.
4. A random number from 1 to the number of projects to skip was chosen.
5. The projects were selected by first skipping the random number (from step 4) and then skipping the specified number of projects to obtain the desired sample size (calculated in step 3).

For HVAC projects, three projects were skipped and then every fifth project was selected. The skip pattern for the "rest" projects was five projects initially passed over and then every sixth project was selected. The sample was reviewed to ensure that the skip pattern did not consistently miss periodic activity in the sample frame, such as resulting in a sample with no predominantly winter peaking projects.

The resulting sample covered all of the cells in the strata, most with multiple projects. Since impacts of uncompleted projects or the inability to meter in a timely manner was likely to affect particular categories unevenly, the sample rate was doubled to allow for attrition without jeopardizing the precision of the final sample.

In practice, real-time sampling was highly problematic and yielded few benefits. Some projects were completed before the pre-installation metering could be conducted, some projects did not move forward to completion, and a number of selected retrofit projects did not require pre-installation metering to establish the baseline. Of the 23 projects/end use selected through real-time sampling, seven (7) are included in the final sample used to estimate the realization rates. The Department's evaluation team was unable to conduct pre-installation metering on any of these projects. Four EMT projects were not completed in 2008, and pre-installation metering has been conducted on two. If these projects were completed in 2009, they will be included in the next FCM evaluation.

### 3.1.5 Sampling Issues

Due to the timing and complexity of the sampling process, a number of anomalies arose. Two specific issues are explored in more detail below: changes in size categories between the initial and final samples and the designation of end use categories.

Retrofit projects sampled through the EMT process and 2008 projects selected during the first stage of the FCM sampling were chosen before the projects had been through EVT's internal quality check and finalization of savings claim. Thus, the projects were designated to their

[4] Lohr, Sharon L. *Sampling: Design and Analysis*. Duxbury Press, 1999, pp. 42-43 and 159-161.

respective size categories based on preliminary information; this process was particularly problematic for the EMT projects where little information was available. As a result, some of the projects in the population and in the sample were found to be in a different size category when the final 2008 savings claims were available.

There seem to be two factors that contributed to projects moving between size categories:

- adjustments in savings between the EVT's initial data set and cleaned final data set
- some variations in the projects and measures identified for use of the stipulated lighting profiles

Approximately 91% of the 2008 MOP/NC projects and 83% of the retrofit projects were correctly categorized by size in the original sampling. The lower percentage for the retrofit projects was largely due to the EMT projects (with 67% correctly characterized). Within the sample frame, there were three projects that moved from one size category to another. Two projects were initially in the small or medium categories and later found to be in the "too small to evaluate" category; one project was originally in the medium category and moved to the large category. As is consistent with the sampling plan, these projects were kept in the stratum designated in the original sampling.

The second issue relates to the assignment of the end use categories, which was based on EVT's measure codes. However, these measure codes were not designed for this purpose and did not always result in the correct outcome. For example, motor measures were placed in the "REST" category, but some motors were used in HVAC applications. It also turned out that a few lighting efficiency measures had the measure code for lighting controls, which placed them in the "REST" category for retrofit projects. These issues were minor, and easily resolved within the context of the project review.

End use assignments were particularly problematic for the “Lighting Plus” initiative. The initiative is a turn key operation designed to facilitate the installation of efficiency lighting in existing C&I buildings. EVT's contractor does a walk through, makes recommendations and performs the installations. These retrofit projects were initially placed in the MOP/NC group due to the lack of potential for pre-installation metering. However, the lighting control measures were inadvertently categorized in the other measure group (REST). Thus, Lighting Plus projects were in the NC/MOP group and the lighting control measures were categorized as "REST" rather than "Lighting." Since the end use stratification was designed to ensure that the sample included a broad range of end uses, this small anomaly is not expected to have an effect on the final realization rates.

## 3.2 Analysis and Calculation of Realization Rates

The realization rates were calculated according to the method described in detail in the California Evaluation Framework,[5] based on comparing EVT's original claimed savings to the Department's verified FCM savings. The realization rates presented in the document are based on EVT's activity in program years 2007 and 2008, unless otherwise noted.

[5] 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. Pages 327 to 339 and 361 to 384.

## 3.3 Attrition

As is common in conducting field work, some projects were selected through the sampling process but could not be verified for a variety of reasons. For the small and medium projects, the attrition rate was reasonably low, as 68 of the selected 72 projects/end use were verified. The large projects turned out to be more problematic, as explained below.

### 3.3.1 Small and Medium Projects

Seventy-two projects/end use were selected for verification in the two lower size strata (small and medium). Of these projects, the DPS evaluation team was unable to complete verification for four project/end uses. The reasons these projects were dropped are given below.

- One project was a lighting upgrade at a Vermont State office complex consisting of twelve buildings. There was no documentation in the files regarding the locations of the efficient lamps. Following numerous communications with the appropriate State agency, the DPS evaluation team determined that the specific lighting products installed as part of this project could not be identified for metering.
- Two projects were server upgrades, one at a bank and the other at a large insurance company. It was not possible to meter these projects, and there was insufficient information in the project files to verify the peak savings by other methods.
- The fourth project was initially intended to be verified through interval meter data provided by the electric utility. However, further investigation indicated that this approach was not a feasible strategy for this project.

The small number of projects removed from the sample (about 6%) suggests that eliminating these projects was unlikely to introduce bias to the results.

### 3.3.2 Large Projects

Among the 2007 and 2008 completed projects, there were 103 projects/end use in the large stratum, with either winter or summer peak savings of 35 kW or more. EVT was responsible for conducting the metering for these projects where appropriate, and 14 of the 45 projects identified for metering were completed. For some projects, metering was not necessary as coincidence factors from the RLW lighting study could be applied; this strategy was used for 38 projects.

Of the 103 projects/end use, the DPS evaluation team completed verification on 81. The reasons for removal are explained below.

- Thirty (30) projects identified by EVT and the Department for direct measurement were not successfully metered by EVT within the required time period. Of these thirty projects, sixteen (16) were verified by other methods and fourteen (14) could not be verified.
- Snowmaking projects represented a particular challenge in that there is often not a clear method for direct measurement that would meet ISO standards and provide reliable savings estimates, particularly after the project has been completed.

- For three projects, alternative methods were identified for verification, but the DPS evaluation team concluded that the available information did not support an ISO-compliant analysis.

Table 4 below lists the reasons for removal and the associated peak demand savings for each category.

**Table 4: Disposition of Large Projects**

| Reason | Number of Project/End Uses | Winter Peak KW Savings | Summer Peak kW Savings |
|---|---|---|---|
| Verification Completed | 81 | 5,399 | 5,823 |
| Projects/end use removed | | | |
| No metering | 14 | 581 | 1,247 |
| Snowmaking | 5 | 435 | 0 |
| Insufficient documentation | 3 | 92 | 329 |
| Total Large Projects/End Use | 103 | 6,541 | 7,444 |

The possibility of bias resulting from the removal of these large project was investigated through conducting a sensitivity analysis. If the realization rate for the removed projects was 0.20 higher or lower than the verified large projects, the overall realization rate for the custom C&I projects would change by 0.02 or less. A Monte Carlo simulation was run to assess the distribution of realization rates. Twenty-two projects were randomly selected from the 81 verified large projects, and the realization rate calculated. The simulation was run 1,000 times and the results were compared. This analysis showed that over 90% of the random groups of 22 large projects were within 0.20 of the actual realization rate calculated for all 81 projects. In other words, this result demonstrated that a difference in realization rates of over 0.20 represents a degree of variation found in less than 10% of the random groups of 22 projects.

Given the results of this sensitivity analysis and the fact that EVT used the same strategies and QC process for estimating savings from both the unverified and verified projects, it seems unlikely that the realization rate for the twenty-two unverified projects would be more than 0.20 above or below the realization rate for the verified projects, suggesting that bias due to the removal of these projects from the calculation of the realization rate is quite small or nonexistent.

# 4 Results

To determine the realization rates and calculating relative precision, EVT's portfolio was divided into components based on the verification strategy and source of the coincident peak factors. Each of these components is defined below.

Custom Retrofit: This category includes projects associated with EVT's retrofit initiatives in the business and multifamily sectors. Peak demand savings were determined through sampling and verified by the Department of Public Service as part of the C&I custom evaluation. Measures using stipulated coincidence factors from the RLW lighting study were removed from the sample frame.

Custom NC/MOP: Projects associated with EVT's new construction and market opportunities initiatives in the business and multifamily sectors are covered in this component of EVT's portfolio. The same process for verification was used as described above for the C&I retrofit component of EVT's portfolio.

Customer Credit: The Customer Credit program encompasses the efficiency improvements at a large industrial firm. The firm installs the efficiency measures and provides documentation to EVT. All of these large projects were included in the C&I custom verification.

Stipulated Lighting: Custom and prescriptive lighting measures in business types covered by the RLW Lighting Study prepared for the NE utilities in accordance with ISO-NE FCM guidelines.

C&I Measures Not Sampled: These are the very small C&I custom projects (winter and summer peak kW of less than 0.80 kW). Given that these projects in aggregate represented a small percentage of EVT's portfolio (less than 1%) and would be just as costly to verify as other projects, they were excluded from the C&I sample frame. The weighted average realization rate from the C&I Retrofit and NC/MOP components was used for these measures. Since EVT uses the same procedures for estimating savings and conducting QC for these projects as the sampled projects, it seems reasonable to apply the same realization rate.

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 (2007).

Residential Prescriptive Lighting with Cooling Bonus: This component represents the percentage of lighting products sold through the Efficient Products Program that were purchased by commercial establishments. The source of the coincidence factors is the RLW lighting study (2007) and the RLW residential HVAC study (2008).

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.

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 and fuel

switches. For these measures, the coincidence factors were developed from Itron's eShapes, discussed in more detail below.

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 DHW pipe insulation and tank wraps. These coincidence factors were based on engineering estimates, as discussed further below.

The realization rates and relative precision for all components of EVT's portfolio are provided in Table 4 and Table 5. The ISO standards require sampling precision at the 80/10 confidence/precision level for the entire portfolio. The relative precision of EVT's portfolio is 6.5% for winter peak kW reduction and 6.7% for the summer peak at the 80% confidence level, substantially exceeding the ISO requirement.

**Table 5: Realization Rates and Sampling Precision for Winter Peak kW Reduction**

| | Original EVT Claimed Peak kW Reduction | Realization Rate | Savings as % of Total Portfolio | Relative Precision |
|---|---|---|---|---|
| C&I and Multifamily | | | | |
| Custom Retrofit | 7,582 | 70.6% | 19.4% | 8.5% |
| Custom NC/MOP | 6,148 | 83.1% | 15.7% | 13.5% |
| Custom Customer Credit | 2,718 | 82.0% | 7.0% | 0.0% |
| Stipulated Lighting | 4,288 | 118.8% | 11.0% | 9.3% |
| C&I Custom Not Sampled | 280 | 76.2% | 0.7% | 100.0% |
| Residential | | | | |
| Prescriptive Lighting | 12,709 | 108.4% | 32.5% | 15.8% |
| Prescriptive Lighting w/Cooling Bonus | 3,965 | 112.7% | 10.1% | 15.8% |
| Prescriptive HVAC | 0 | 100.0% | 0.0% | 0.0% |
| Prescriptive Other eShapes | 1,009 | 96.5% | 2.6% | 50.0% |
| Prescriptive Other non-eShapes | 71 | 100.0% | 0.2% | 0.0% |
| Custom | 311 | 0.0% | 0.8% | 0.0% |
| Totals | 39,080 | | | 6.5% |

**Table 6: Realization Rates and Sampling Precision for Summer Peak kW Reduction**

| | Original EVT Claimed Peak kW Reduction | Realization Rate | Savings as % of Total Portfolio | Relative Precision |
|---|---|---|---|---|
| C&I and Multifamily | | | | |
| C&I Custom Retrofit | 7,935 | 73.4% | 22.3% | 10.6% |
| C&I Custom NC/MOP | 7,433 | 67.3% | 20.9% | 14.3% |
| C&I Custom Customer Credit | 2,527 | 83.1% | 7.1% | 0.0% |
| Stipulated Lighting | 4,800 | 111.0% | 13.5% | 3.7% |
| C&I Custom Not Sampled | 314 | 70.5% | 0.9% | 100.0% |
| Residential | | | | |
| Prescriptive Lighting | 3,989 | 94.7% | 11.2% | 17.6% |
| Prescriptive Lighting w/Cooling Bonus | 7,202 | 94.9% | 20.3% | 17.6% |
| Prescriptive HVAC | 610 | 97.3% | 1.7% | 10.4% |
| Prescriptive Other eShapes | 614 | 93.3% | 1.7% | 50.0% |
| Prescriptive Other non-eShapes | 130 | 100.0% | 0.4% | 0.0% |
| Custom | 7 | 0.0% | 0.0% | 0.0% |
| Totals | 35,560 | | | 6.7% |

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 coincidence factors for the stipulated lighting were taken from the RLW study; the relative precision shown in the tables above was the highest value for the various business types.
- 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.[6] 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 3% of EVT'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 EVT's overall portfolio (less than 1%).

[6] 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.

The residential lighting savings are composed of three components with values derived from two different studies (NMR, 2004 and RLW, 2007). Each component has a relative precision associated with it. The overall precision was calculated using the method described in EVT's M&V Plan.[7] 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 sampled independently, 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. These values were assumed to be a worst case scenario for the FCM requirement of precision at the 80% confidence level. The NMR precision values are the same as used in EVT's M&V Plan submitted to ISO-NE.[8]

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 for winter and summer, respectively.[9] Thus, the combined relative precision for the prescriptive residential lighting was calculated to be 15.8% and 17.6% for winter and summer peak demand reductions.

The remainder of this section covers issues affecting multiple programs, custom C&I results, C&I stipulated lighting results, residential results and timing issues.

## 4.1 Cross-Program Issues

The realization rates incorporate corrections to a number of systematic errors that affect multiple programs, as listed below.

- The demand savings for measures installed before June 30, 2007 were calculated based on winter and summer peak hour definitions that were not consistent with the ISO peak periods. EVT recalculated the winter and summer kW savings to comply with the ISO-NE winter and summer peak period definitions.
- The assumed impact of lighting power reduction on air conditioning loads in C&I measure tracks (cooling bonus) was modified to reflect current A/C efficiencies and be consistent with the method described in the RLW Analytics lighting study. Please refer to Appendix D for the assumptions used in the calculation of the Department's verified savings.
- In 2008 and 2009, a computer error resulted in incorrect kW load and/or coincident values for prescriptive motor measures.

[7] *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.

[8] As noted in Efficiency Vermont's M&V Plan (page 7-4), in some cases a single value was selected where the NMR report had the results broken out into segments by technology. The selected value was chosen as a conservative estimate of the precision for the combined applications.

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

- Incorrect measure assumptions for some C&I prescriptive lighting measures were found to have been applied in 2007 and 2008.

These and other minor errors were corrected and are reflected in the realization rates presented above.

## 4.2 Custom C&I Results

Table 7 through Table 10 provide the realization rates and population for the projects in the EVT portfolio. Stratum 1 contains the smallest projects and Stratum 3 the largest. (Please refer to Section 4.1.1 for the definition of the size categories.)

**Table 7: Realization Rates for Custom C&I Retrofit for Winter kW Peak**

| Size Stratum | Total # of Projects | Projects in Sample | Mean of EVT Claimed kW | Mean of DPS Verified kW | Realization Rate |
|---|---|---|---|---|---|
| 1 | 263 | 8 | 1.59 | 0.83 | 0.52 |
| 2 | 244 | 16 | 9.02 | 6.39 | 0.71 |
| 3 | 64 | 49 | 45.88 | 33.49 | 0.73 |
| Total | 571 | 73 | | | 0.706 |

**Table 8: Realization Rates for C&I MOP/New Construction for Winter kW Peak**

| Size Stratum | Total # of Projects | Projects in Sample | Mean of EVT Claimed kW | Mean of DPS Verified kW | Realization Rate |
|---|---|---|---|---|---|
| 1 | 652 | 15 | 1.24 | 0.74 | 0.6020 |
| 2 | 315 | 23 | 11.96 | 11.08 | 0.9267 |
| 3 | 35 | 21 | 29.80 | 19.69 | 0.6606 |
| Total | 1002 | 59 | | | 0.8306 |

**Table 9: Realization Rates for Custom C&I Retrofit for Summer kW Peak**

| Size Stratum | Total # of Projects | Projects in Sample | Mean of EVT Claimed kW | Mean of DPS Verified kW | Realization Rate |
|---|---|---|---|---|---|
| 1 | 263 | 8 | 1.60 | 0.16 | 0.10 |
| 2 | 244 | 17 | 10.09 | 7.04 | 0.70 |
| 3 | 64 | 49 | 46.00 | 39.35 | 0.86 |
| Total | 571 | 74 | | | 0.73 |

**Table 10: Realization Rates for C&I MOP/New Construction for Summer kW Peak**

| Size Stratum | Total # of Projects | Projects in Sample | Mean of EVT Claimed kW | Mean of DPS Verified kW | Realization Rate |
|---|---|---|---|---|---|
| 1 | 652 | 15 | 1.80 | 1.01 | 0.56 |
| 2 | 315 | 26 | 16.52 | 11.81 | 0.72 |
| 3 | 35 | 23 | 35.91 | 21.74 | 0.61 |
| Total | 1002 | 64 | | | 0.67 |

As can be seen from these tables, the realization rates range from a low of 67% to a high of 83% for the various C&I market sectors. As discussed earlier, some of this reduction is due to systematic corrections to the measure portfolio. Some of the other common reasons for the difference in realization rates are listed below.

- The equipment was not operating as expected.
- Operating schedules were found to be different from what the participant reported to EVT.
- Efficient equipment was found not to be in use due to changes in the manufacturing cycle.
- Assumptions about the use of baseline equipment were found to be different than expected.
- The recent economic downturn reduced or eliminated the use of installed measures.

The realization rates by project are provided in Appendix A and the project-specific reports are compiled in Appendices E, F and G.

These types of adjustments are commonly found in the process of conducting an impact evaluation. The evaluation was not designed to directly measure the economic effects of recent events on EVT savings portfolio. However, it may be assumed that as the economy improves, equipment installed through the program may see increased use. To the extent this occurs, there may be some understatement of actual savings.

## 4.3 C&I Stipulated Lighting

The RLW lighting study was used as the source for coincidence factors for custom and prescriptive C&I lighting, as appropriate. EVT and the Department reviewed the RLW study and agreed to apply the findings to the following business types:

- Grocery
- Medical (Hospital)
- Office (including medical office)
- Restaurant
- Retail
- Warehouse (excepting 24 hour distribution centers)
- Multifamily – residential spaces

EVT developed blended coincidence factors for C&I prescriptive lighting based on the historical distribution of business types that participated in the C&I prescriptive lighting initiative. This analysis was reviewed and approved by the Department and is described in Appendix C.

For the 2007 and 2008 installations, EVT reviewed the custom C&I projects and determined the business type. This process was conducted at the project-level for PY2007 and at the measure-level for PY2008. These designations were provided to the Department and the measures were removed from the Department's sample frame for the C&I custom verification, with the exception of large projects. Any project with summer or winter peak savings of 35 kW or more was included in the large project stratum of Department's sample and reviewed on an individual basis.

Since other coincidence factors were in use during the 2007 and 2008 program years, EVT recalculated the peak savings using the RLW values for the designated business types and this modification represents the primary source of the adjustments for this component of EVT's portfolio. In addition, systematic errors in the prescriptive C&I assumptions were corrected, as discussed in Section 5.1.

The other major inputs into the kW reduction are the connected load kW reduction and the fixture counts. EVT conducted QC on all C&I projects, including a peer review process for projects with substantial savings. In general, EVT used manufacturers' spec sheets or default assumptions to estimate the change in the kW. The default values have been reviewed by the Department and found to be reasonable and consistent with industry standards. As indicated in EVT's M&V plan, the fixture counts in EVT's central data tracking system are assumed to be correct and without bias.

## 4.4 Residential Results

The prescriptive residential measures in EVT's portfolio are described in the TRM submitted as part of the EVT's M&V Plan. For the prescriptive lighting products, the reduction in Watts and in-service rates are based on the results of a market research 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).

Errors in the application of the prescriptive assumptions were identified through the Department's annual savings verification process, and these corrections were incorporated into the realization rates. Savings associated with the following measures were adjusted:

- Energy Star A/C (2007 and 2008)
- Energy Star refrigerators (2008)
- Energy Star clothes washers (2007)
- Direct Install CFL's (2007 and 2008)

These issues are detailed in the Department's reports to the Energy Efficiency Utility Contract Administrator for program years 2007 and 2008.

## 4.5 Timing

The realization rates presented in the tables above are all based on EVT's activity during the 2007 and 2008 program years. However, some of the systematic errors described above in Section 5.1 relate only to specific periods, i.e., when the errors were identified, they were

[10] *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 ResidentialLighting Programs.* Nexus Market Research and RLW Analytics, 2004

corrected on a forward-going basis. For example, all of the load profiles applied after June 30, 2007 were adjusted to reflect the ISO peak periods, and thus no adjustment would be necessary for activity in program year 2008 and forward.

The timing factor affects the various component of EVT's portfolio in different ways. For the C&I custom projects, the systematic errors represented a small part of the realization rate. Thus, the C&I custom realization rates presented in this report will be applied until the results of the next FCM verification are available. The systematic errors are a larger part of the residential and C&I prescriptive adjustments, and the realization rates for these measures will be adjusted accordingly for measures installed in program years 2009 and 2010. The realization rates by program year are given in Table 11. The residential prescriptive and stipulating lighting realization rates may be adjusted, depending on future corrections made to EVT's central data tracking system.

**Table 11: Realization Rates for PY 2009 and 2010**

| | Winter Peak kW Reduction | | Summer Peak kW Reduction | |
|---|---|---|---|---|
| | **PY 2009** | **PY 2010** | **PY 2009** | **PY 2010** |
| C&I and Multifamily | | | | |
| C&I Custom Retrofit* | 73.4% | 73.4% | 73.4% | 73.4% |
| C&I Custom NC/MOP* | 67.3% | 67.3% | 67.3% | 67.3% |
| C&I Custom Customer Credit* | 83.1% | 83.1% | 83.1% | 83.1% |
| Stipulated Lighting | 100.0% | 100.0% | 100.0% | 100.0% |
| C&I Custom Not Sampled* | 70.5% | 70.5% | 70.5% | 70.5% |
| Residential | | | | |
| Prescriptive Lighting | 99.8% | 99.8% | 99.8% | 99.8% |
| Prescriptive Lighting w/Cooling Bonus | 100.0% | 91.8% | 100.0% | 91.8% |
| Prescriptive HVAC | 100.0% | 97.1% | 100.0% | 97.1% |
| Prescriptive Other eShapes | 100.7% | 101.3% | 100.7% | 101.3% |
| Prescriptive Other non-eShapes | 100.0% | 100.0% | 100.0% | 100.0% |
| Custom | 0.0% | 0.0% | 0.0% | 0.0% |

* PY 2007/2008 realization rates will be applied until the results of the next FCM evaluation are available.

## 4.6 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&E plan was developed for each project that was consistent with the ISO requirements. Most of the ISO requirements are directly relevant to the C&I custom sample and are discussed in that context. The ISO requirements are listed in reference to the section in the 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.

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. Random sampling was conducted for all projects with too many circuits or measures to meter. 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 EVT's portfolio exceeds that standard with a precision of 6.5% and 6.8% for winter and summer peak reduction, respectively.

This section also discussed the need to minimize bias. Bias relating to the three components of EVT's portfolio that make up 95% or more of the peak kW reduction is explored briefly below.

- For the C&I custom sample (Retrofit, NC/MOP and Customer Credit), a potential source of bias was the removal of some large projects that could not be verified to the ISO standard, as explained in more detail in Section 5.2 above. A sensitivity analysis indicated the inclusion of unverified large projects is unlikely to affect the results.
- 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 RLW coincidence factors for the stipulated C&I lighting is appropriate since there are many stipulated lighting projects covering a wide variety of applications and the RLW sample also included a broad range of applications. Thus, the application of the RLW coincidence factors to the stipulated C&I lighting projects 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 a very limited number of cases for the C&I custom projects, the metering was not conducted by the Department's evaluation team and it was not possible to determine the metering

equipment used. In other 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 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; otherwise it was dropped. A number of the large projects were determined to be unverifiable through this process. 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, Option A was applied, using verifiable load shapes and assumptions based on recent, statistically sound studies as discussed above. The recent RLW studies for lighting and HVAC prepared for NEEP cover the vast majority of the residential prescriptive savings. The other measures used either Itron's eShapes or engineering estimates, as described in above in this section. 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 less than 1% of the total portfolio, and thus the greater uncertainty associated with the load profiles was considered to be acceptable.

# 5 Conclusions

The Department completed its independent verification of EVT's 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 realization rates are based on EVT's activity in program years 2007 and 2008. The M&V plan was followed and the results of the evaluation are consistent with the ISO standards, as specifically discussed in this document.

# 6 References

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