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

Final Report

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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 four engineering firms, Cx Associates, GDS Associates, Lexicon Energy Consulting and Energy Resource Solutions, and Carole Welch, 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 BED's FCM bid and the results of this verification process, as well as the Department's verification of BED's annual claimed savings. 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, Revision 2, June 1, 2010) and in Section 12-B of BED's M&V Plan (June 15, 2008).

The evaluation was designed to determine the appropriate realization rates to be applied to BED's estimated savings for the purposes of determining the peak demand savings for FCM and also for BED's annual savings verification. 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 1, 2011 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 BED's portfolio are described in BED's 2009 Annual Report.[2]

[1] *ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources Manual M-MVDR*, Revision: 2, Effective Date: June 1, 2010, pg. INT-3

[2] Burlington Electric Department 2009 Energy Efficiency Annual Report

2 Process

As with the initial FCM evaluation completed in 2010, the Department had the primary responsibility the overall management of the verification process, including development and implementation of the sampling plan and final verification of each project in the sample. The C&I projects were stratified by the size of the project in terms of the claimed kW peak reduction. Due to the small population of C&I projects, the sampling approach was relatively simple and a census sample of large projects (along with a random sample of small projects) was selected for the verification. As appropriate, recent studies meeting the NE-ISO standards were used to establish the coincidence factors for specific projects in the sample.

For the projects that fell into the randomly selected 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. BED conducted metering of the large projects in the census strata and provided the metered data to the Department for analysis. Each large project was also assigned to a review engineer on the Department's evaluation team. The process included a collaborative approach to the development of site-specific metering plans, with input from the Department's contracted engineers and from BED. The engineer assigned by the Department reviewed BED's project documentation, analyzed any metering data that was collected by BED, and independently calculated the verified savings for the project.

The verified savings were independently calculated for each project (large and small) in the sample. Site-specific project reports were developed, and provided to BED to provide an opportunity for clarification and a final check for errors and omissions. The project reports were then finalized. A list of the realization rates by project are provided in Appendix A and the project-specific reports are attached as Appendix C.

3 Methods

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

Table 1: FCM Sampling Strategy by BED Initiative

BED Initiative	FCM Verification Sampling Strategy	ISO M&V Option
C&I		
Retrofit, NC and MOP	Sample selected per ISO standards	Options A through D
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

The West Hill Energy Team conducted the evaluation of the custom C&I sector. The verified residential sector savings were prescriptive and used assumptions that have been reviewed by the DPS and are included in EVT's "Technical Reference Manual" (TRM), which is also used by BED. With the application of the coincident factors from the recent studies by RLW Analytics, the residential prescriptive measures met the standard described in BED's M&V plan.

3.1 Sampling

The sampling plan for the C&I sector was developed through collaboration between BED and the Department. Sample sizes were designed to support stratified ratio estimation. The sampling was conducted from BED's list of completed projects from January 1, 2009 through December 31, 2009.

The sampling unit for this verification is the location as defined by BED's location ID. All measures installed during program year 2009 were considered for each location, and specific locations were selected for review. This approach was selected due to the availability of interval meter (IM) data for many of BED's large projects. To be able to use the IM data, the program activity was aggregated to reflect all measures installation at the location.

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 coincident peak values, referenced as "max kW" throughout the rest of this document. Location ID's with an estimated maximum peak reduction of below the specified limit were omitted from the sample as too small to evaluate.

The initial round of sampling was conducted using the complete sample frame of 2009 participants. Projects with a max kW greater than or equal to 0.8 kW and less than 10.0 kW were classified as small, projects equal to or greater than 10.0 kW were classified as large. A

random selection of eight (8) small projects was chosen and a census of the nine (9) largest projects was added to the sample.

Table 2 shows the distribution of savings in the size categories and the savings associated with the completed reviews. The completed sample covered about 68% of the total kWMax savings claimed by BED.

Table 2: Savings by Size Strata

Size Stratum	Total # of Locations	# in Sample	# Completed	Total kWMax	Completed Sample kWMax
Tiny	34	0	0	6.583	0.000
Small	41	8	8	138.946	37.065
Large	9	9	8	221.779	212.021
Totals	84			367.308	249.086

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. As can be seen in Table 2, the DPS team completed verification for eight (8) of the small projects. One project in the initial sample could not be verified and was replaced by another randomly-selected project. Eight (8) of the nine (9) projects in the large census stratum were verified. The dropped project could not be verified because it was not possible to measure the baseline operating conditions.

One of the ramifications of aggregating activity by location ID was that some projects covered a wide range of projects and measures and not all of the measures could be metered or verified by other means. For the max kW, the FCM verification covered 85% or more of the total BED claimed savings for 14 of the 16 completed projects.

4 Results

To determine the realization rates and calculating relative precision, BED'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 NC/MOP/Retrofit: Projects associated with BED'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 in which stipulated coincidence factors from the RLW lighting study could be applied were removed from the sample frame.

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 represent a small percentage of BED's portfolio (2%) and would be just as costly to verify as other projects, they were excluded from the C&I sample frame. The realization rate from the C&I Retrofit/NC/MOP components was used for these measures. Since these savings are such a small part of the portfolio, this assumption will not affect the results for the overall portfolio.

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 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, it includes some measures that were 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 BED's portfolio are provided in Table 3 and Table 4. The ISO 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 10.2% for winter peak kW reduction and 9.1% for the summer peak, which meets the ISO requirement. The relative precision of the verified energy savings is 9.9% at the 90/10 confidence/precision level.

Table 3: Realization Rates and Sampling Precision for Winter Peak kW Reduction

	Original BED Claimed Peak kW Reduction	Realization Rate	Savings as % of Total Portfolio	Relative Precision
C&I and Multifamily				
Custom	267	108.6%	42%	7.3%
C&I Custom Not Sampled	-1	108.6%	0%	0.0%
Residential				
Prescriptive Lighting	194	104.0%	31%	15.8%
Prescriptive Lighting with Cooling Bonus	57	89.3%	9%	15.8%
Prescriptive Other eShapes	112	100.0%	18%	30.0%
Prescriptive Other non-eShapes	5	100.0%	1%	0.0%
Prescriptive HVAC	0	0.0%	0%	0.0%
Totals	634	103.9%	100%	7.9%

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

	Original BED Claimed Peak kW Reduction	Realization Rate	Savings as % of Total Portfolio	Relative Precision
C&I				
C&I Custom	304	96.0%	56%	14.6%
C&I Custom Not Sampled	7	96.0%	1%	0.0%
Residential				
Prescriptive Lighting	53	104.0%	10%	17.6%
Prescriptive Lighting with Cooling Bonus	110	71.0%	20%	17.6%
Prescriptive Other eShapes	52	100.0%	10%	30.0%
Prescriptive Other non-eShapes	7	100.0%	1%	0.0%
Prescriptive HVAC	8	16.7%	1%	10.4%
Totals	540	91.0%		9.6%

Table 5: Realization Rates and Sampling Precision for Annual Energy (kWh) Savings

	Original BED Claimed Annual kWh Savings	Realization Rate	Savings as % of Total Portfolio	Relative Precision
C&I				
Retrofit/NC/MOP	3,039	68.1%	65%	14.3%
C&I Custom Not Sampled	105	68.1%	2%	0.0%
Residential				
Prescriptive Lighting	676	104.0%	14%	18.5%
Prescriptive Lighting with Cooling Bonus	489	73.3%	10%	0.0%
Prescriptive Other eShapes	306	100.0%	7%	30.0%
Prescriptive Other non-eShapes	54	100.0%	1%	0.0%
Prescriptive HVAC	3	37.1%	0%	10.0%
Totals	4,672	76.3%	100%	9.9%

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.[3] 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 0.30 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 (less than 1%).

For the residential 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.[4] 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).

Thus, 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

[3] 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.

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

precision associated with it. The overall precision was calculated using the method described in BED's M&V Plan.[5] 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 samples 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. 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 BED's M&V Plan submitted to ISO-NE.[6]

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.[7] 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.

4.1 Cross-Program Issues

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

- The assumed impact of lighting power reduction on air conditioning loads in the commercial lighting included as part of the Efficient Products program 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 B for the assumptions used in the calculation of the Department's verified savings.
- Incorrect measure assumptions for some residential prescriptive measures were found to have been applied in 2009.

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

4.2 C&I Results

Tables 5 and 6 provide the realization rates and population for the projects in the BED portfolio. Stratum 1 contains the small projects that were sampled and Stratum 2 the large projects. The realization rates in the final row (Total) reflect the overall realization for the C&I

[5] *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.

[6] 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.

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

custom projects and are also provided in Tables 3 and 4 above. (Please refer to Section 3.1 for the definition of the size categories.)

Table 6: Realization Rates by Size for C&I for Winter kW Peak

Size Stratum	Total # of Projects	Projects in Sample	Mean of BED Claimed kW	Mean of DPS Verified kW	Realization Rate
1	41	8	2.35	1.93	0.82
2	9	8	18.34	22.72	1.24
Total	50	16			1.09

Table 7: Realization Rates by Size for C&I for Summer kW Peak

Size Stratum	Total # of Projects	Projects in Sample	Mean of BED Claimed kW	Mean of DPS Verified kW	Realization Rate
1	41	8	3.48	2.38	0.68
2	9	8	17.07	20.78	1.22
Total	50	16			0.96

As can be seen from these tables the realization rates range from a low of 68% to a high of 124% across the size strata. Some of the common reasons for the difference in realized savings are listed below.

- The equipment was not operating as expected.
- Operating schedules were found to be different from what the participant reported to BED.
- Assumptions about the use of baseline equipment were found to be different than expected.
- Some of the claimed efficient light fixtures were not found on site.

4.3 Residential Results

Generally, the realization rates for the residential prescriptive measures are close to 1.0. 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.

Residential prescriptive lighting has a winter peak realization rate of 104% and summer peak of about 91%. These variations are due to changes in the load profiles and estimation of the cooling bonus for commercial CFL's. BED assumes that a percentage of the CFL's purchased through the Efficient Products program are installed in commercial locations, and the cooling bonus is applied to these purchases. For these purchases, the load profiles were modified to be consistent with the blended commercial lighting profile developed by EVT from the RLW 2007 study and the cooling bonus was modified to reflect current A/C efficiencies and to be consistent with the method described in the RLW Analytics lighting study. (Please refer to Appendices B and C.)[8]

[8] The blended commercial coincidence factors were based on the types of businesses installing lighting measures through EVT's initiatives. Since there is no site-specific information about the commercial establishments

Assumptions for the other prescriptive residential measures are described in the TRM. A few minor errors in the application of the prescriptive assumptions were identified, and these corrections were incorporated into the realization rates.

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&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. 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 7.9% and 9.6% for winter and summer peak reduction, respectively.
>
> This section also discussed the need to minimize bias. Bias relating to the three components of BED's portfolio that make up 90% or more of the peak kW reduction is explored briefly below.
>
> - The estimated savings for residential prescriptive lighting are unlikely to be biased since the deemed savings are based on recent market studies.

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purchasing CFL's through the Efficient Products program and EVT's programs reach a broad spectrum of Vermont businesses, EVT's blended ratio was assumed to be the best available estimate for the coincidence factors.

- The use of the RLW coincidence factors to some C&I lighting measures is appropriate since the RLW 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 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, 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 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 standards, as specifically discussed in this document. The realization rates are based on BED's activity in program year 2009.

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