# Vermont Efficiency Portfolio

## Plan for Measurement and Verification of Demand Reduction Value from Energy Efficiency Resources

## FCA #1: New Resources

**Prepared by**
**Vermont Energy Investment Corporation**

**In partial fulfillment of the requirements for participation in the ISO New England Forward Capacity Market**

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This document is submitted to ISO New England in partial fulfillment of the requirements for the Forward Capacity Market. For questions or further information, please contact:

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# Section 1: Introduction

As providers of Efficiency Vermont services for the State of Vermont, the Vermont Energy Investment Corporation (VEIC) intends to participate in ISO New England's Forward Capacity Market by offering On-Peak, Energy Efficiency Demand Resources. This document provides a detailed review of the processes we will undertake for measurement and verification of the Energy Efficiency Demand Reduction provided by the Vermont Efficiency Portfolio as New Resources to the ISO for the Forward Capacity Market's Auction #1.

Efficiency Vermont, the nation's first statewide Energy Efficiency Utility (EEU), provides comprehensive energy efficiency services to households and businesses across Vermont. As operator of Efficiency Vermont since its inception in 2000, VEIC has extensive experience in planning for, delivering, and verifying the savings and demand reduction from energy efficiency programs and practices. The procedures outlined in this plan are designed to comply with the requirements and standards set forth by the ISO in Market Rule 1 and the Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (Manual M-MVDR; April 13, 2007). This Measurement and Verification plan augments our ongoing measure characterization, recording and tracking process, savings verification, and recurring evaluation studies as detailed in the following sections and the support documents included with this filing.

# Section 2: Project Information

## 2.1 General Description

The Vermont Efficiency Portfolio is a collection of energy efficiency measures to be installed in locations throughout Vermont from the beginning of May 2007 through the end of April 2010. The measures will be installed under the Vermont Energy Investment Corporation's (VEIC's) contract with the Vermont Public Service Board to operate a state-wide electric efficiency utility, commonly known and marketed as "Efficiency Vermont".[1] This portfolio of measures will result in On-Peak Demand Reduction as documented below and in the Vermont Efficiency Portfolio Qualifications Package. The portfolio includes both prescriptive and custom measures installed by customers and/or Efficiency Vermont staff and subcontractors in accordance with industry best practices. Market segments and end-uses that make up the portfolio are listed below in Tables 1 through 6.

## 2.2 Summary of Project Information

### (1) Project Name

Vermont Efficiency Portfolio

### (2) Project Sponsor's Market Participant Status

VEIC is a Market Participant

### (3) Demand Resource Type

On-Peak Demand Resource

### (4) Load Zone within which the Project will be located

Vermont

### (5) Project location; (6) types of facilities in which the measures, systems, processes, or strategies will be implemented; and (7) customer classes and end-uses served

Measures will be installed at locations throughout the state of Vermont, including in residential new construction and existing homes; in commercial and institutional buildings, both existing and new construction; and industrial buildings and process sites. Customer classes, markets, and end-uses will include those shown in Tables 1 through 6. Exact locations and specific measures to be installed will be determined throughout the ramp-up

[1] Although often referenced as the state-wide efficiency utility, Efficiency Vermont does not quite serve the entire state. The one exception is the city of Burlington. The Burlington Electric Department provides services identical to those of Efficiency Vermont – in close collaboration with VEIC – to the city of Burlington.

period as measures are installed in accordance with the Customer Acquisition Plan (filed as part of the portfolio Qualification Package). Demand savings are forecast to be acquired from market segments and end-uses in roughly the same mix as those installed in 2006. Our forecast of that mix is documented in Tables 1 through 6 below.

### (8) Types of measures that will be implemented

Energy Efficiency

### (9) Estimated Demand Reduction Value (kW) per customer class/end use

The Demand Reduction Value by market and end use as of June 1, 2010 is forecast in Tables 1 through 6. These values are based on actual portfolio performance for 2006, with adjustments made to our previous definitions of Summer Peak Demand (kW) and Winter Peak Demand (kW) to convert to ISO-defined peak hours. Each market/end-use category's relative (i.e., percent) contribution to the 2006 Total Demand Reduction was used to estimate the projected contribution for that category to the 2010 Total Demand Reduction value.

### (10) Estimated total Demand Reduction Value of the Project

40.028 MW

### (11) The date by which the Project Sponsor expects to reach commercial operation

This project was commercially operational on May 1, 2007. Efficiency measures included in this portfolio will be installed between that date and April 30, 2010. The savings associated with installed measures will be as follows:

As of October 27, 2008: 19.248 MW

As of August 31, 2009: 30.407 MW

As of June 1, 2010: 40.028 MW

### (12) Status under ISO generation interconnection procedures

N/A

### (13) Existing Capacity/ New Resources election for Forward Capacity Auction #1

All resources described in this manual are New Demand Resources for FCM #1

### (14) Description of the typical qualifications and experience of the Project Sponsor's Project team members and subcontractors that will be directly involved in Measurement and Verification activities

The Vermont Energy Investment Corporation (VEIC) is a non-profit organization with approximately 110 employees, most of whom work out of VEIC's Burlington, Vermont office. VEIC has acted as the Prime Contractor to the Vermont Public Service Board in delivering Efficiency Vermont services since its creation in 2000. The group of staff and subcontractors that VEIC has assembled over the past seven years to deliver these services has tremendous breadth and depth of knowledge and experience in energy efficiency program delivery and related measurement and verification issues. VEIC also has more than two decades of experience in consulting on demand-side management (DSM) program design, delivery, and evaluation. We have provided such consulting services in more than 20 different states, six Canadian provinces, China, and several other countries. Between both our work in Vermont and consulting projects throughout North America and beyond, we have developed extensive expertise in a wide range of measurement and verification activities, including: on-site building energy audits and technical assessments, detailed engineering estimates of savings, end-use metering, building simulation modeling, and billing analysis.

VEIC staff, in collaboration with the Vermont Department of Public Service and the Efficiency Utility Contract Administrator, developed the Efficiency Vermont Technical Reference Manual (TRM), which is widely referenced both within Vermont and in other states for savings estimates. A copy of the TRM is attached as Appendix C. We have also developed and maintain what many consider to be one of best data systems in the country for tracking, validating, and reporting savings. VEIC staff have also conducted assessments of energy savings potential in five northeastern states and provinces and conducted detailed reviews of such assessments in numerous others. Such assessments are typically built up from detailed technical assessments of sometimes hundreds of different efficiency measures. In addition, we have helped clients in a wide range of states and provinces with both evaluation planning and actually conducting evaluations of efficiency programs (including site inspections, billing disaggregation and analysis, building simulation modeling, engineering estimation, and statistical analysis).

The Department of Public Service (DPS) is an agency within the executive branch of Vermont state government. Its charge is to represent the public interest in matters regarding energy, telecommunications, water, and wastewater. The Department carries out this charge by:

- Representing the public interest in utility cases before the Public Service Board, federal regulatory agencies, and state and federal courts
- Providing long-range planning for the state's energy and telecommunications needs through the Vermont Electric Plan and the Comprehensive Energy Plan
- Ensuring that all Vermonters share in the benefits of modern communications through the Vermont Telecommunications Plan
- Promoting energy efficiency
- Administering federal energy programs

- Resolving utility customer complaints
- Informing the public about utility-related matters
- Making and administering contracts for the purchase of power on behalf of the state

As the public's advocate, the DPS is a separate agency from the Vermont Public Service Board, which serves as the quasi-judicial or decision-making authority in utility regulatory cases. The DPS is charged by the Vermont Public Service Board with providing formal evaluation of the state's energy efficiency utility (EEU) programs. Primarily through the use of third-party evaluation contractors, the DPS plays a major role in all EEU evaluation activities, including leading annual EEU efficiency savings verification, participating in measure characterization and technical saving definition processes, and contracting for and supervising program evaluation studies and state and regional technical evaluation support studies.

### (15) Specificity regarding measures to be installed

VEIC cannot know with certainty either the precise mix of efficiency measures to be installed under this portfolio or the exact locations at which they will be installed. However, given our extensive experience in implementing the kinds of programs that will lead to such installations in the future, accurate assumptions can be made regarding the kinds of measures that will be installed and the types of customers who will install them. We are also confident that we can forecast with a reasonable degree of accuracy what the installed mix of measures will be. Our forecast of projected savings – both by program or market type and by end use – is provided in Tables 1 through 6.

Prior to submitting the first Performance Report (as described in Section 13 of this plan), VEIC will provide to the ISO information that demonstrates that the products, services, systems, processes, and measures actually installed or affected are functionally equivalent to those described in this Measurement and Verification Plan.

**Table 1: Summary of Savings by Market**

| Markets | 2006 Actual | | | | 2010 Forecast | |
|---|---|---|---|---|---|---|
| | EVT Winter Peak kW | EVT Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW |
| Business New Construction | 599 | 957 | 564 | 982 | 2,569 | 5,172 |
| Business Existing Facilities | 2,776 | 3,401 | 2,903 | 3,527 | 13,263 | 18,557 |
| Residential New Construction | 293 | 410 | 348 | 404 | 1,586 | 2,126 |
| Existing Homes | 803 | 345 | 1,005 | 273 | 4,595 | 1,430 |
| Efficient Products | 3,173 | 3,377 | 3,944 | 2,422 | 18,015 | 12,743 |
| **Totals** | 7,644 | 8,490 | 8,764 | 7,608 | 40,028 | 40,028 |

Calculations of forecasted 2010 Demand Reduction Value in this and the following tables were made as follows:

- EVT Winter Peak (kW) and Summer Peak (kW) are based on actual measures installed in 2006 using our historical definitions of winter and summer peak.
- Conversions were made to ISO Winter and Summer Peak Hours definitions for these 2006 EVT numbers.
- Total Demand Reduction as of June 1, 2010 is 40.028. Support for this total value is based on past performance and forecasted budget and performance values and is outlined in the Vermont Efficiency Portfolio Demand Reduction Value Supporting Documentation (filed with ISO-NE as a part of the Vermont Efficiency Portfolio New Resources Qualifications Package, June 2007). Allocation of this Total Demand Reduction Value across markets and end-use categories in Tables 1 – 6 was made assuming capacity savings by end-uses will occur in the same relative proportions as those in 2006.

## Table 2: Business New Construction – Savings by End Use

| End Use | 2006 Actual | | | | 2010 Forecast | |
|---|---|---|---|---|---|---|
| | EVT Winter Peak kW | EVT Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW |
| Air Conditioning Efficiency | 7 | 210 | 41 | 212 | 186 | 1,117 |
| Compressed Air | 0 | 0 | 0 | 0 | 1 | 2 |
| Cooking and Laundry | 1 | 1 | 1 | 1 | 5 | 5 |
| Design Assistance | 60 | 113 | 50 | 117 | 227 | 617 |
| Hot Water Efficiency | 9 | 9 | 9 | 9 | 41 | 47 |
| Lighting | 425 | 543 | 354 | 566 | 1,612 | 2,973 |
| Motors and Controls | 44 | 27 | 46 | 27 | 207 | 143 |
| Other Efficiency | 3 | 3 | 3 | 3 | 12 | 16 |
| Other Fuel Switch | 1 | 1 | 1 | 1 | 4 | 4 |
| Refrigeration | 43 | 36 | 49 | 32 | 226 | 171 |
| Space Heat Efficiency | 0 | 0 | 0 | 0 | 1 | 0 |
| Thermal Shell | 3 | 13 | 5 | 13 | 24 | 70 |
| Ventilation | 3 | 1 | 5 | 1 | 23 | 7 |
| Water Conservation | 0 | 0 | 0 | 0 | 0 | 0 |
| **Totals** | 599 | 957 | 564 | 982 | 2,569 | 5,172 |

## Table 3: Business Existing Facilities – Savings by End Use

| End Use | 2006 Actual | | | | 2010 Forecast | |
|---|---|---|---|---|---|---|
| | EVT Winter Peak kW | EVT Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW |
| Air Conditioning Efficiency | 45 | 485 | 255 | 490 | 1,164 | 2,578 |
| Compressed Air | 436 | 527 | 438 | 576 | 2,000 | 3,029 |
| Cooking and Laundry | 5 | 4 | 4 | 4 | 19 | 20 |
| Design Assistance | 10 | 10 | 8 | 10 | 37 | 53 |
| Hot Water Efficiency | 8 | 7 | 4 | 3 | 19 | 15 |
| Hot Water Fuel Switch | 8 | 5 | 7 | 3 | 33 | 17 |
| Industrial Process Efficiency | 198 | 113 | 287 | 119 | 1,310 | 625 |
| Lighting | 1,492 | 1,861 | 1,238 | 1,935 | 5,657 | 10,178 |
| Motors & Controls | 273 | 283 | 284 | 284 | 1,300 | 1,497 |
| Other Efficiency | 22 | 25 | 22 | 27 | 101 | 143 |
| Other Fuel Switch | 13 | 15 | 13 | 16 | 61 | 84 |
| Refrigeration | 168 | 47 | 195 | 42 | 892 | 222 |
| Service | 4 | 0 | 4 | 0 | 17 | 0 |
| Space Heat Efficiency | 17 | 3 | 27 | 3 | 121 | 16 |
| Space Heat Fuel Switch | 66 | 0 | 102 | 0 | 465 | 3 |
| Thermal Shell | 2 | 4 | 4 | 4 | 16 | 19 |
| Ventilation | 6 | 7 | 9 | 9 | 43 | 46 |
| Water Conservation | 3 | 5 | 2 | 2 | 8 | 12 |
| **Totals** | 2,776 | 3,401 | 2,903 | 3,527 | 13,263 | 18,557 |

## Table 4: Residential New Construction – Savings by End Use

| End Use | 2006 Actual | | | | 2010 Forecast | |
|---|---|---|---|---|---|---|
| | EVT Winter Peak kW | EVT Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW |
| Air Conditioning Efficiency | 4 | 117 | 4 | 161 | 19 | 848 |
| Cooking and Laundry | 16 | 11 | 10 | 7 | 44 | 36 |
| Hot Water Fuel Switch | 22 | 17 | 20 | 12 | 90 | 62 |
| Lighting | 170 | 109 | 218 | 73 | 997 | 385 |
| Motors & Controls | 3 | 4 | 3 | 4 | 13 | 26 |
| Other Fuel Switch | 23 | 17 | 21 | 12 | 94 | 64 |
| Refrigeration | 10 | 10 | 10 | 10 | 44 | 52 |
| Space Heat Efficiency | 1 | 2 | 1 | 2 | 5 | 10 |
| Thermal Shell | 24 | 101 | 41 | 101 | 186 | 530 |
| Ventilation | 20 | 22 | 20 | 22 | 94 | 113 |
| **Totals** | 293 | 410 | 348 | 404 | 1,586 | 2,126 |

### Table 5: Existing Homes – Savings by End Use

| End Use | 2006 Actual | | | | 2010 Forecast | |
|---|---|---|---|---|---|---|
| | EVT Winter Peak kW | EVT Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW |
| Air Conditioning Efficiency | 0 | 11 | 0 | 15 | 0 | 80 |
| Cooking and Laundry | 2 | 1 | 1 | 1 | 5 | 4 |
| Hot Water Efficiency | 38 | 26 | 38 | 26 | 173 | 135 |
| Hot Water Fuel Switch | 284 | 182 | 250 | 126 | 1,144 | 667 |
| Lighting | 110 | 60 | 141 | 40 | 646 | 210 |
| Other Fuel Switch | 7 | 7 | 6 | 5 | 26 | 24 |
| Refrigeration | 56 | 54 | 53 | 56 | 244 | 293 |
| Space Heat Efficiency | 2 | 2 | 4 | 2 | 19 | 8 |
| Space Heat Fuel Switch | 275 | 0 | 463 | 0 | 2,117 | 0 |
| Space Heat Replacement | 6 | 0 | 11 | 0 | 49 | 0 |
| Thermal Shell | 21 | 0 | 36 | 0 | 165 | 0 |
| Ventilation | 2 | 2 | 2 | 2 | 7 | 9 |
| **Totals** | 803 | 345 | 1,005 | 273 | 4,595 | 1,430 |

### Table 6: Efficient Products – Savings by End Use

| End Use | 2006 Actual | | | | 2010 Forecast | |
|---|---|---|---|---|---|---|
| | EVT Winter Peak kW | EVT Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW | ISO Winter Peak kW | ISO Summer Peak kW |
| Air Conditioning Efficiency | 0 | 247 | 0 | 341 | 0 | 1,794 |
| Cooking and Laundry | 191 | 141 | 115 | 86 | 526 | 454 |
| Lighting | 2,975 | 2,982 | 3,822 | 1,988 | 17,458 | 10,458 |
| Refrigeration | 7 | 7 | 7 | 7 | 31 | 37 |
| **Totals** | 3,173 | 3,377 | 3,944 | 2,422 | 18,015 | 12,743 |

# Section 3: Project General Assumptions

## 3.1 General Description

As noted above, VEIC cannot specify either exactly which measures will be installed or in exactly which facilities they will be installed. Instead, we base our estimated Demand Reduction Value on extensive past experience with delivery of efficiency programs in Vermont, our estimates of savings in our most recent year of operation (calendar year 2006), the cost of acquiring those historical savings, current contractual savings goals, and energy efficiency program budgets that we expect to have in the future.[2] We generally assume that our savings yield – that is, our peak savings per dollar of spending – will be the same in the future as it was in the past.

This approach implicitly assumes that the individual measure savings assumptions that we have used in the past will apply in the future. Most of those assumptions (i.e., all but some elements of our custom measures) are documented in Appendix A and/or the Technical Reference Manual (TRM) attached as Appendix C. These assumptions include baseline energy consumption and connected loads, energy consumption and connected loads associated with efficiency measures, operating hours, load shapes, and measure lives.

The TRM identifies which variables are measured for prescriptive measures. For custom measures, it is, by definition, not possible to identify at this time all variables that will be measured or how they will be measured. Such determinations will be site specific, depending on the measure installed, the type of operation it is designed to affect, the type of building or facility into which it is installed, and other related variables. Custom measures account for approximately 50% of past and projected future peak demand savings. General elements typically measured for custom measures include baseline and post-measure installation equipment efficiency and capacity (usually based on equipment ratings and standards), equipment operational characteristics (based on customer reports, equipment logs, or direct monitoring), process changes (often based on customer reports), and measure life (usually based on manufacturer information and/or data available from the literature).

As Table 1 shows, in 2006 we generated 7.608 MW of summer peak savings (using ISO's definition of peak hours). Those savings were generated with a budget of $14.0 million – or an average yield of 0.54 first-year MW per million dollars of spending.[3] Our estimated demand reduction value of 40.028 MW will be generated by measures installed between the beginning of May 2007 and the end of April 2010.[4] Our budget over that 36-month period

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[2] VEIC operates Efficiency Vermont under a contract with the Vermont Public Service Board. Since the beginning in 2000, our contracts have been of three-year durations. Our current contract runs from 2006 through 2008. It was recently amended to accommodate increased funding in 2007 and 2008. The PSB has indicated that, for the purpose of estimating a Demand Reduction Value for the ISO's Forward Capacity Market, we should assume the 2008 funding levels will be in place in 2009 and 2010. In its first two contracts (2000 through 2002 and 2003 through 2005), VEIC exceeded all contractual energy and peak demand savings goals.

[3] Note that this is not what is often referred to as an average or levelized cost per MW because it does not account for the average life of the peak savings, which was greater than 11 years for the portfolio of measures installed by Efficiency Vermont in 2006.

[4] We plan to continue installing measures in months after April 2010. Measures installed in May of 2010 could count towards the demand reduction we deliver beginning June of 2010. However, we are conservatively assuming

will be approximately $74.9 million. Thus, the yield we are projecting is 0.53 first-year MW per million dollars of spending. The projected yield is slightly lower than our historical yield due to a very small amount of projected savings attrition associated with measures with very short lives that will be installed at the beginning of the period (e.g., May 2007) but no longer producing savings at the beginning of the commitment period (i.e., June 2010).

that we will not be able to record and document such measures in time to report them to the ISO in June. Thus, our Demand Reduction Value represents only savings we expect to generate through the end of April 2010.

# Section 4: Equipment, Measure, and Practice Detail

## 4.1 General Description

The Vermont Efficiency Portfolio consists of measures that will be installed at locations throughout the state of Vermont, including in residential new construction and existing homes; in commercial and institutional buildings, both existing and new construction; and industrial buildings and process sites. Measures to be installed will fall into the following end-use categories:

- Air Conditioning Efficiency
- Compressed Air
- Cooking and Laundry
- Design Assistance
- Hot Water Efficiency
- Hot Water Fuel Switch
- Lighting
- Motors & Controls
- Other Efficiency
- Other Fuel Switch
- Refrigeration
- Space Heat Efficiency
- Space Heat Replacement
- Thermal Shell
- Ventilation
- Water Conservation

Estimated contributions of these end-uses to total demand reduction, listed by market type, are shown above in Tables 1 through 6.

More detail on many of the specific types of measures that will be installed can be found in the Efficiency Vermont Technical Reference Manual (TRM) that is attached as Appendix C. The TRM documents all measures for which we use prescriptive estimates of savings, as well as some key elements of measures for which we develop custom savings estimates. It is updated periodically as new measures are introduced and/or new information is available regarding assumptions for existing measures. We will submit updated versions of the TRM to the ISO as part of updates to this M&V plan and/or at the time of submittal of our capacity claims.

# Section 5: Measurement and Verification Approach

## 5.1 General Description

Because of both the large number and wide variety of efficiency measures that make up the portfolio, a mix of measurement and verification approaches will be used to assess the validity of the portfolio's Demand Reduction Value. All efficiency measures installed by Efficiency Vermont are initially determined to be subject to either prescriptive or custom savings estimates, and the approaches to be undertaken in this M&V plan differ for these two categories of measures.

### 5.1.1 Approach to Prescriptive Measures

***Summary of Approach***

Prescriptive approaches are those typically used for measures sold, purchased, and installed in large numbers each year, in most cases moving to customers through "mass market" channels (e.g., retailers, vendors, contractors, builders). These are usually measures installed in residential and small commercial buildings. Such measures account for about half of the peak demand savings from this portfolio. The measurement and verification approach that we plan to use for prescriptive measures is Option A (Partially Measured Retrofit Isolation/Stipulated Measurement – as described in the ISO M-MVDR Section 5.2.1), augmented by engineering calculations and load shape analysis[5] (as described in ISO M-MVDR Section 5.4).[6] The number of prescriptive measures installed is directly measured through the processing of rebate forms or applications, hand tabulated by installers, or measured from retail receipts.

Assumptions for all of the portfolio's prescriptive measures and the sources of those assumptions are extensively documented in Efficiency Vermont's *Technical Reference User Manual* (TRM). The current version of the TRM is attached as Appendix C to this plan. As noted above, the TRM is updated periodically as new measures are introduced and/or new information is available regarding assumptions for existing measures. We will submit updated versions of the TRM to the ISO as part of updates to this M&V plan and/or at the time of submittal of our capacity claims.

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[5] In most cases, the load shapes used by VEIC to estimate peak demand savings were purchased from a firm, Regional Economic Research (RER), that had developed state-specific load shapes for numerous end uses. The load shapes were marketed under the trademark name "eShapes". RER was subsequently purchased by Itron, which continues to support the development, sale, and use of eShapes. There are a couple of key exceptions to our use of eShapes. Specifically, we use both residential and commercial lighting coincidence factors recently developed by RLW for state efficiency programs in the Northeast. We also plan to begin using a new room air conditioner coincidence factor that will be developed later in 2007 as part of a study RLW is conducting in the Northeast beginning June 2007.

[6] One possible future exception to this rule is that we may use a calibrated simulation model (ISO Option D) for calculating demand reductions resulting from HVAC, hot water, and/or thermal envelope measures installed in new homes. Savings from such measures have historically and are likely in the future to represent very small fractions of our total portfolio of savings.

The assumptions documented in the TRM include algorithms to calculate demand savings, specifications of baseline assumptions, measured or estimated quantities, load shape or coincidence factors, measure life, and any other necessary assumptions. These assumptions are derived from independent Vermont-specific evaluation studies, other independent evaluation studies (particularly from other parts of the Northeast),[7] manufacturers' equipment efficiency ratings, federal government assessments of equipment energy use, and other relevant sources. These assumptions are reviewed by the DPS and its expert consultant before being adopted. A standing technical advisory group (TAG) composed of Efficiency Vermont staff, Burlington Electric Department staff, the DPS and its consultants, and the EEU Contract Administrator meets whenever necessary to resolve differences of opinion, with the Contract Administrator generally serving as the final arbiter of any disputes.

As a means of summarizing the wealth of detail found in the Efficiency Vermont Technical Reference Manual, Appendix A of this M&V plan documents the information provided for six measures or groups of measures:

- Retail purchases of fluorescent light bulbs and fixtures
- Fluorescent light fixtures installed in new homes
- Fluorescent light fixtures installed in existing business facilities
- Retail purchases of efficient room air conditioners
- Retail purchases of efficient clothes washers
- Fuel-switching of residential electric water heaters

The first of these measure bundles – retail purchases of fluorescent light bulbs and fixtures – accounts for about 70% of all historical and projected future prescriptive peak demand savings. Together, the other five account for a little more than 20%. Thus, these six measures or measure bundles account for more than 90% of all prescriptive peak demand savings. The consolidation of measures into these categories is based not only on similar technology but also on similar basis for the savings estimates.

***Rationale for Approach***

Option A, augmented by engineering calculations and load shape analysis, is the most appropriate approach for documenting savings from prescriptive measures. Because the volume of the measures sold, purchased, and installed each year is quite high, the programs that we run to promote the measures rely on interactions with key trade allies – retailers, electricians, other product vendors, and builders – rather than individual customers. Such interactions are usually focused on providing customer rebates (which the trade allies use to entice consumers to purchase their products) and marketing support. Because we have little if any direct interaction with the customers installing the products themselves (except, in some cases, to mail them rebate checks), there is no direct opportunity to assess the impact

[7] Vermont, northeastern, and other evaluation studies upon which we rely generally rely on direct measurements of statistical samples of program participants to estimate average values for key savings variables.

of each and every installation in each individual building. More importantly, it would be impractical and highly uneconomic to attempt to do so. Site-specific assessments would, in most cases, cost far more than the entire efficiency measure itself. Finally, site-specific assessments are not necessary because an appropriate estimate of average savings over large numbers of customers – which is relatively easily achieved – provides good accuracy for total estimated savings.

This reality is recognized throughout the community of states and service providers running efficiency programs aimed as “mass markets”. Thus, the approach we are proposing to use is almost universally employed today to estimate savings from mass-market programs across North America.

### 5.1.2 Approach to Custom Measures

***Summary of Approach***

Custom measures are those for which site-specific estimates of savings are made. They are most commonly associated with efficiency measures installed in larger commercial buildings or industrial facilities. Savings from such measures account for the other half of all peak demand savings from this portfolio.

Our approach to documenting savings from custom measures will have two key components. The first is the development of site-specific estimates of peak demand savings by VEIC staff or subcontractors. The basis for such estimates will vary from measure to measure and customer to customer. Among the methods we will employ are building simulation modeling, end-use metering, whole facility metering, interviews with building operators to understand how energy consuming equipment is used, and engineering analysis. Often, a combination of methods is used. In other words, any or all of the four approved options outlined in the ISO Manual M-MVDR (Options A, B, C, and D, augmented by engineering analysis and/or load shape analysis) may be used. VEIC will apply the option selected for a particular project according to the requirements specified in Sections 5.2 through 5.5 of the M-MVDR. The estimates will then undergo internal reviews by peers and/or supervisors of the primary staff person responsible for initial estimates. After any adjustments to estimates have been made, the savings estimates are recorded in the Efficiency Vermont data tracking system.

The second key component begins with an assessment of the accuracy of the tracked savings. That assessment is based on detailed, independent third-party reviews of a statistically valid, stratified sample of custom measures. Such reviews will rely on additional end-use or whole-facility metering, where necessary. The reviews will ultimately develop a weighted average “realization rate” for peak demand savings. That realization rate will then be applied to the entire population of custom measures to adjust the total savings estimated from such measures.

A more detailed description of this approach is provided in Appendix B to this plan.

***Rationale for Approach***

Given the diversity of measures that may be in the custom component, all four Options need to be considered. Multiple levels of review are appropriate given the range of complexity as well as technologies and applications.

As for the prescriptive measures, the overall approach – including verification and aggregate adjustment by evaluation – provides a sound estimate of savings for this program component as a whole and is widely used in the states and provinces seen as leaders in delivery and evaluation of efficiency programs. The verification sample is designed to achieve a target accuracy level consistent with the overall target of 80/10 precision.

## 5.2 Qualifications of Project Team

The M&V work associated with the portfolio will be undertaken by VEIC, the Vermont Department of Public Service (DPS), and the Efficiency Vermont Contract Administrator. Their roles will be as follows:

- **VEIC**: VEIC staff will develop all initial savings estimates. This includes first drafts of any changes to our Technical Reference Manual (TRM) and all initial estimates of savings from custom measures.

- **DPS**: DPS staff will be responsible for reviewing and critiquing all elements of the TRM, raising any unresolved disputes to the Contract Administrator for resolution. DPS staff will also conduct an annual savings verification process. This process has three key components: (1) ensuring that prescriptive savings included in the tracking system are consistent with the TRM; (2) overseeing expert evaluation contractors (under its employ) who will develop realization rates for custom measures; and (3) overseeing expert evaluation contractors (under its employ) who conduct specific evaluation studies (e.g., the recent RLW assessment of lighting coincidence factors and the current RLW study of room air conditioner coincidence factors) used to support or modify TRM prescriptive assumptions.

- **Contract Administrator**: The Contract Administrator is responsible for facilitating the resolution of disputes between VEIC and the DPS regarding measure savings assumptions and estimates. If resolution is not achieved, the Contract Administrator makes recommendations for the Board's consideration and ultimate resolution.

### 5.2.1 VEIC Qualifications

VEIC is a non-profit organization with approximately 110 employees, most of whom work out of VEIC's Burlington, Vermont office. VEIC has acted as the Prime Contractor to the Vermont Public Service Board in delivering Efficiency Vermont services since its creation in 2000. The group of staff and subcontractors that VEIC has assembled over the past seven years to deliver these services has tremendous breadth and depth of knowledge and experience in energy efficiency program delivery and related measurement and verification issues. VEIC also has more than two decades of experience in consulting on demand-side management (DSM) program design, delivery, and evaluation. We have provided such consulting services in more than 20 different states, six Canadian provinces, China, and several other countries. Between both our work in Vermont and consulting projects throughout North America and beyond, we have developed extensive expertise in a wide range of measurement and verification activities, including: on-site building energy audits and technical assessments, detailed engineering estimates of savings, end-use metering, building simulation modeling, and billing analysis.

VEIC staff, in collaboration with the Vermont Department of Public Service and the Efficiency Utility Contract Administrator, developed the Efficiency Vermont Technical Reference Manual (TRM), which is widely referenced both within Vermont and in other states for savings estimates. A copy of the TRM is attached as Appendix C. We have also developed and maintain what many consider to be one of best data systems in the country for tracking, validating, and reporting savings. VEIC staff have also conducted assessments of energy savings potential in five northeastern states and provinces and conducted detailed reviews of such assessments in numerous others. Such assessments are typically built up from detailed technical assessments of sometimes hundreds of different efficiency measures. In addition, we have helped clients in a wide range of states and provinces with both evaluation planning and actually conducting evaluations of efficiency programs (including site inspections, billing disaggregation and analysis, building simulation modeling, engineering estimation, and statistical analysis).

### 5.2.2 DPS Qualifications

The Vermont Department of Public Service (DPS), the public advocate for the State's energy matters, is charged by the Vermont Public Service Board with providing formal evaluation of the state's Energy Efficiency Utility (EEU) programs, including Efficiency Vermont activities. Primarily through the use of third-party evaluation contractors, the DPS plays a major role in all EEU evaluation activities, including annual EEU efficiency savings verification, measure characterization and technical saving definition processes, program evaluation studies, and state and regional technical evaluation support studies. The DPS conducts competitive solicitations to obtain expert energy efficiency evaluation services in fulfillment of its EEU evaluation activities. Funding for these services is provided through a budget amount from the proceeds of the Energy Efficiency Charge (EEC). Current and recent contractors include West Hill Energy and Computing, Inc., KEMA, RLW Analytics, and Dr. Martin Kushler.

The DPS EEU evaluation management and coordination is provided by DPS staff with expertise in energy efficiency programs and technologies and evaluation techniques and issues.

### 5.2.3 Contract Administrator Qualifications

The Energy Efficiency Utility Contract Administrator (CA) is an entity hired by the Public Service Board in a competitive bid process. Staff qualifications, related experience, personal references, and the cost proposal are considered in the Board's selection process. The contract term is for three years with an option to extend the contract for an additional three years.

Michael J. Wickenden is the current CA. His current contract runs through December 31, 2008. He holds a MS in Statistics (UVM, 1994), a M.ED in Education (UVM, 1989) and a BA in Psychology (Drew University, 1970). He has been awarded the CA contract since the Energy Efficiency Utility's inception in year 2000. Prior to becoming the CA, he was employed as the Energy Services Manager at Citizen's Utilities, Newport, VT in change of the administration of their Demand Side Management (DSM) Programs. Prior to that, he worked as a Statistical Analyst for Citizen's Utilities and provided DSM evaluation oversight and energy efficiency database development.

# Section 6: Establishing Baseline Conditions

## 6.1 General Description

We will define baseline conditions to be consistent with the ISO Manual M-MVDR requirement. Essentially, baseline conditions will be the equipment, operations, and associated electric demand (kW) that would have occurred during performance hours had the efficient measure not been installed.

## 6.2 Requirements for All Resources

Section 6.2 of the ISO Manual M-MVDR identifies a number of requirements for establishing baselines. Only items 1, 2, 4, 5, and 6 of those requirements may apply to the measures that will be part of this portfolio. Our approach to meeting those requirements will be as follows (identified by M-MVDR section number).

### 6.2.1 Projects involving variable load equipment or equipment whose operation is time-dependent or weather-dependent

Virtually all measures included in our portfolio are covered by this section. As required, we will calculate baseline conditions for every hour across the performance hours for such measures. This will be accomplished through one of a variety of possible approaches, including metering, interviews with building operators regarding use patterns and practices, application of end-use load shapes, and/or other appropriate means.

Baseline consumption is typically a function of two types of variables: (1) the characteristics of the equipment; and (2) patterns of use of the equipment. For measures that do not affect patterns of use (most efficiency measures, including replacements of standard equipment with similar but more efficient equipment), patterns of consumption across performance hours will be assumed to be the same for baseline and the more efficient equipment or product, with savings essentially a function of change in building loads or equipment connected kW. For efficiency measures that change patterns of use (e.g., variable frequency drives or economizers), our estimates of savings will reflect differences in operational patterns between baseline and the efficient condition.

### 6.2.2 Projects (a) actively controlled by project sponsor, facility personnel, or an energy management system; (b) involving variable load equipment or equipment whose operation is time- or weather-dependent; or (c) baseline conditions calculated on historical hourly load or output data

We are not sure if we will have any measures that are subject to the requirements of this section. If we do, they will likely represent a very small portion of our portfolio of savings. In such rare cases, we will demonstrate that the variance in the historical hourly load or output data used to calculate baseline conditions complies with the statistical reliability criteria in Section 7.2 of the M-MVDR.

### 6.2.4 Operating equipment either removed from service or whose usage is reduced during performance hours

Examples of measures removed from service in our portfolio include fuel-switching of electric space heating equipment, fuel-switching of electric water heaters, and removal of second refrigerators. As required in the M-MVDR, we will consider the baseline for such measures to be the kW load prior to the equipment removal. Estimates of baseline conditions for such measures will be based on review of manufacturer or government data on the equipment being removed, billing data analysis, load shape analysis, heat loss/gain analysis, and/or metering data – often a combination of such approaches.

Examples of equipment whose usage is reduced during performance hours include equipment affected by installation of a computerized Energy Management System (EMS) or heating and cooling equipment whose use is reduced as a result of thermal shell improvements. As required in the M-MVDR, we will consider the baseline for such measures to be the kW load in the absence of the new control system or thermal shell improvements.

### 6.2.5 Failed equipment replaced by more efficient equivalent or alternative strategy for delivering comparable output

This section covers a wide range of measures in our portfolio. As the M-MVDR requires, we define baseline conditions for such measures as the efficiency of the "standard" new piece of equipment that would otherwise have been purchased. In most cases, that "standard" is established by federal or state efficiency codes and standards. In cases which no codes or standards apply, we assess standard practice and assume that is the baseline.

### 6.2.6 Operating equipment replaced by more-efficient equivalent unit

This section covers what we commonly refer to as "early retirement". There are a several measures in our portfolio that meet this definition. As required in the M-MVDR, we will only claim the baseline to be less efficient than applicable federal or state codes or standards for new equipment if we use measurements of baseline conditions. Such measurements could come in one of several forms, including the use of manufacturer measurements, data and/or ratings; direct measurement by our staff of consumption by the baseline equipment in its facility; or extrapolations from measurements in appropriately similar applications.

## 6.3 Additional Requirements for New Construction/Major Renovations

Consistent with the ISO M-MVDR, we define baseline conditions for all residential new construction and major renovation measures to be either the applicable state code or federal product efficiency standard.

Commercial and industrial new construction and major renovation projects begun after January 1, 2007, will use the new Vermont Commercial Building Energy Standards as baseline.[8] Most projects (including virtually all large projects) begun before that date and

[8] This is Vermont's first official state commercial building code.

completed after May 1, 2007, and therefore contributing to this portfolio of savings, use the Vermont Act 250 efficiency guidelines as baseline. Such guidelines essentially served as the state building code for medium and large commercial projects prior to the state's adoption of its first building code. For smaller projects started before January 1, 2007 and completed after May 1, 2007 (and also therefore contributing to this portfolio of savings), we use standard practice – defined as ASHRAE 90.1 – as baseline.

As with all other key assumptions, these baselines will be adjusted over the life of the portfolio when necessary to reflect changes in best practice or any of the standards, codes, or data upon which they are based. These updates are part of our ongoing market assessment and measure characterization process to assure technical accuracy of our savings calculations.

In most cases, revisions to baselines will apply to new measures installed after the changes in standards occurred. The baseline for measures previously installed will continue to be the standard efficiency or equipment that would have been installed at that time. Baselines for previously installed equipment will be revised over the life of that equipment only if new information indicates that the previously assumed standard was incorrect, or if it is reasonable to assume that the baseline equipment would have been replaced by another standard within the timeframe of the efficient measure life.

# Section 7: Statistical Significance

## 7.1 General Description

The use of sampling for different components of the Vermont Efficiency Portfolio is detailed in Appendices A and B. Use and justification of reference documents is also described in those sections. In Section 7.2 we describe our compliance with the sampling requirements specified in the ISO Manual M-MVDR. In Section 7.3 we present our calculation of accuracy and precision for the portfolio as a whole. In Section 7.4, we address how bias is minimized in both statistical and engineering estimation.

## 7.2 Compliance with Requirements

### General Requirements

Sampling has not yet been conducted for all of the components that will be included in this claim. When the sampling is done, the documentation in support of the achieved savings will include the information specified in Section 7.2.1 of the ISO Manual M-MVDR.

### Sample-Size Requirements

(1) and (2) Components of the portfolio's Demand Reduction Value claim are based on statistical samples. We will design each sample size according to the following criteria:

- The portfolio as a whole will have a 10% relative precision at 80% confidence (80/10 precision) or better. The determination of portfolio precision is described in Section 7.3.
- To achieve the targeted portfolio-level precision, we will design samples to assure particular precision/confidence levels for individual programs. For most programs, the target will again be 80/10.
- To achieve the targeted program-level precision, we will design samples for specific parameters being measured to achieve particular precision/confidence levels. For many individual parameters the target precision will again be 80/10.

(3) All of the portfolio's sampling calculations will incorporate a plan to compensate for potential data loss through:

- Over sampling
- Sample-site replacement in the course of the study
- Demonstration that precision and confidence targets will still be met with a smaller sample size

(4) Bias minimization procedures are described in Section 7.4.

(5) In calculating sample sizes, the Coefficient of Variation (c.v.) we use to derive the required sample size will be the measured c.v. for the primary measurement including all its error components, based on prior experience.

(6) We will minimize bias associated with the pre-sampling assumptions regarding the c.v. (as it relates to sample size determination) by using conservative assumptions about its likely magnitude whenever we have limited experience with the parameters to be assessed through sampling. In the event that we under-estimate the c.v. for a particular study (and therefore obtain less statistical precision for the parameters being measured), we will compensate by obtaining greater precision in other sampling studies in order to assure that the total precision for the portfolio meets ISO's standards.

(7) We will base the assumed c.v. on prior experience in most cases, or on formulas for estimating the c.v. of a proportion, where appropriate. If a c.v. from prior Measurement and Verification or Measurement and Verification Reference Documents is not available for the primary measurement applicable to the segments of sites, installed measures, and/or strategy, we will use a default value for the initial c.v., not less than 0.5 for homogeneous samples (samples from populations that are uniform with respect to some criteria of classification) and 1.0 for heterogeneous samples (samples from populations that are variable with respect to some criteria of classification), until such time that a c.v. can be estimated from the sample population.

(8) Most of our sampling will involve stratification and/or ratio estimation to take advantage of supporting information for the population. In these cases we will use a c.v. appropriate to the estimation procedure and taking account of the added efficiency of the stratification and estimation methodology.

### Sample-Size Calculation and Recalibration

For simple random samples with large sample sizes and target 80/10 precision, we will use the formulas indicated in Section 7.2 of the Manual M-MVDR. For small sample sizes we will substitute for the indicated t-value (1.282) the critical value of the appropriate t-distribution (with degrees of freedom based on the sample size and number of parameters estimated from the data). We will calculate the achieved precision using the formulas indicated in Section 7.3 of the M-MVDR, with the same substitution of t-value if required.

For stratified random samples and/or ratio estimation, we will use the corresponding calculations that take into account the sample stratification and estimation procedure.

## 7.3 Accuracy and Precision for the Portfolio

Statistical sampling is used for several components in the savings calculations. For prescriptive measures, the sampling approaches and resulting component precision are described in the source documents cited in Appendix A for each measure. For custom measures, the sampling approach is described in Appendix B.

Below, we summarize the precision of key savings components. We then describe how the portfolio-level precision is calculated from the component precision estimates.

### Precision for key components

For the prescriptive measures in the portfolio, the savings calculation is generally a variant of the following[9]:

Coincident kW savings = (number installed) × (in-service rate) × (Δwatts) × (CF)

Statistical estimation or verification may be used for any or all of these factors. For factors that are not estimated or verified based on statistical samples or analysis, the relative precision is ±0%. That is, the precision measures the uncertainty associated with random selection or observation. While there may be non-random errors, these are not reflected in the precision. To ensure overall accuracy of the savings estimates, we follow procedures specified in the M-MVDR to minimize bias in both sampling and estimation. Bias minimization is discussed in the next subsection.

The table below summarizes the worst-case statistical precision at 80% confidence for the main savings components for the seven categories of savings in this claim. The basis for these worst-case estimates is described below.

**Table 7: Worst-Case Relative Statistical Precision**

| Sector | Measure | Worst-case statistical precision at 80% confidence | | | | |
|---|---|---|---|---|---|---|
| | | Count | In service rate | Delta watts | Coincidence-diversity factor | Savings |
| | | | | | | |
| Residential | Lighting | 0% | 7.2% | 3.6% | ** | |
| Residential | NC lighting | 0% | 0% | 0% | ** | |
| Residential | Res Ltg **Total** | 0% | 6.9% | 3.5% | 3.6% | 14.0% |
| | | | | | | |
| Commercial | Lighting | 0% | 0% | 0% | 5.6% | 5.6% |
| Residential | Room AC | 0% | 0% | 0% | 10.0% | 10.0% |
| Residential | Clothes Washer | | | | | 0% |
| Residential | WH fuel switch | | | | | 0% |
| Other prescriptive | | | | | | 75% |
| Custom | Custom | | | | | 10% |

** CF taken from the same survey – samples not independent; aggregate precision used
Statistical sampling/ estimation not involved

- **Counts:** Counts are determined as accurately as possible from tracking data and are not subject to statistical estimation. Relative precision is therefore set at ±0%.
- **In-service rate:** In-service rates were determined for residential lighting based on an onsite study sample (Nexus Market Research, 2004). New construction installations

[9] The savings estimates for some measures, such as clothes washers and fuel switching, use a somewhat different, thought functionally equivalent, formula that substitutes (annual kWh) × (peak kW/ kWh ratio) for the Δwatts × CF in the equation above. However, those estimates do not involve statistical estimation and do not affect the statistical precision calculation.

were 100% verified, so that relative precision based on direct observation is ±0%. For other measures, in-service rates have not been determined via sample verification. Relative precision for other measures is therefore set to ±0%.

- **Delta Watts:** Difference in watts between efficient and base case equipment was determined for residential lighting based on the same study sample as determined in-service rates and load shapes. For new construction lighting, the delta watts is based on standards and not subject to statistical estimation. For other measures, the change in watts is based on technology specifications not subject to statistical verification.

- **Coincidence/diversity factor:** This factor is determined from load shapes based on metering samples for residential and commercial lighting. For residential Room Air Conditioners, a regional study to be completed in 2007 will provide the coincidence factor to a precision of at least 80/10. For other measures, the factor is based on load shapes assumed or borrowed from other sources, which represent the best information currently available.

For some of the values in the table, a rough estimate was taken from the source documents, to provide a single value where different values were reported by technology, segment, and/or season, or where sample sizes relevant for a particular component were not explicitly given. The assumptions used in such cases were conservative.

## Precision for Residential lighting factors

We have two residential lighting components in the portfolio. For general lighting, a single sample provided the data for statistical estimates of in-service rates, delta watts, and coincidence-factor. For Residential New Construction, the same coincidence factor is used as for CFLs, a separate study determined the delta watts, and in-service rates are known with certainty based on a 100% verification study.

To determine the relative precision for residential lighting, we first determine the aggregate precision for each factor. The aggregate precision for the sum of several components is calculated as

$$p_T = [\Sigma_{i=1}^{c} (p_i Y_i / Y_T)^2]^{1/2}$$

where $Y_i$ is the savings for component i, and subscript 'T' indicates the total over c components. This formula is valid as long as the estimates for the separate components i are independent. This requirement holds for the in-service rates and delta watts, which were determined by separate studies. However, the coincidence factor was determined by a single study applied to both measures. This factor is therefore assigned to the combination of the two.

## Precision for the product of the factors

The precision $p_M$ of the product of several factors f is calculated using the following approximations:

- If the multiplicative factors f are all independently estimated (e.g., derived from entirely unrelated studies and samples), the overall precision is

$$p_M \simeq [\Sigma_{f=1}^{m} (p_f^{\ 2})]^{1/2}$$

- On the other hand, if all the factors are perfectly correlated, the overall precision is approximated by

$$p_M \simeq \Sigma_{f=1}^{m} p_f$$

For residential lighting, all three factors with statistical estimates came from the same sample. As a worst case, we calculate the precision for the residential lighting as a whole as if all these factors—in-service, delta watts, and coincidence—were perfectly correlated. This assumption very likely overstates the uncertainty of the resulting savings estimate as measured by the relative precision level.

For the commercial lighting and residential room ACs, there is only one statistically estimated factor, the coincidence factor. The relative precision of the product is therefore the relative precision of this factor.

For clothes washers and fuel switching there are no statistically estimated factors. Hence, the relative precision for these components is ±0%.

For the final, small component of the savings constituting this claim, there are a large number of small measures. We assume that the overall precision of these components is no worse than 75%.

## Portfolio-level precision

Under the assumptions described above, the aggregate worst-case relative precision for the portfolio as a whole is calculated using the same formula as indicated above for the precision for a sum of independent components. After the residential lighting measures are combined, the portfolio savings is the sum of independently estimated components.

Results are summarized in the table below. Even under the worst-case assumptions used, the portfolio has an overall precision of 10% or better at 80% confidence.

**Table 8: Overall Portfolio Precision**

| Sector | Measure | Savings | | % Portfolio Savings | | Worst-case Precision @ 80% conf |
|---|---|---|---|---|---|---|
| | | W kW | S kW | % W kW | % S kW | |
| | | | | | | |
| Residential | Lighting | 3,822 | 1,988 | 44% | 26% | |
| Residential | NC lighting | 218 | 73 | 2% | 1% | |
| Residential | Res Ltg **Total** | 4,040 | 2,061 | 46% | 27% | 14.0% |
| | | | | | | |
| Commercial | Lighting | 204 | 334 | 2% | 4% | 5.6% |
| Residential | Room AC | -- | 341 | 0% | 4% | 10.0% |
| Residential | Clothes Washer | 115 | 86 | 1% | 1% | 0% |
| Residential | WH fuel switch | 250 | 126 | 3% | 2% | 0% |
| Other prescriptive | | 237 | 252 | 3% | 3% | 75.0% |
| Custom | Custom | 3,918 | 4,408 | 45% | 58% | 10.0% |
| **Total** | | 8,764 | 7,608 | 100% | 100% | |
| Portfolio Precision at 80% confidence (worst case) | | | | 8.1% | 7.4% | |

Statistical sampling/ estimation not involved

This estimate is based on savings in prior year programs. We anticipate similar results, using similar analysis, for the new portfolio.

## 7.4 Approach to Bias Minimization

### Bias minimization

Parameters used in calculating savings and potential sources of bias are as follows:

- Counts of units installed. These are determined from tracking data with quality control procedures. We consider these values to have no bias.

- Manufacturer's specifications. These values are subject to industry regulation. We consider them to have no bias.

- Directly measured factors. Bias from these measurements derive primarily from two sources:

  1. Metering-related bias is minimized by following good practices with respect to variables measured (Section 9), accuracy of monitoring equipment (Section 10), monitoring frequency and duration (Section 11), and data management (Section 12).

  2. Bias associated with extrapolation from what was measured to the conditions relevant to the savings estimate. Bias minimization for these factors is addressed below under "engineering estimation."

- Statistically measured factors. Bias minimization for these factors is addressed below under "Statistical sampling and estimation."

### Statistical Sampling and Estimation

We will use the following steps are used to minimize bias related to statistical sampling and estimation.

1. Select projects for monitoring and verification at random within sampling cells.
2. Ensure high levels of compliance by participants with the monitoring and verification process for the selected projects. As described in Appendix B, most of the sampling will occur as part of the program delivery and administration process as well as in the course of post-program evaluation. Compliance with metering for both the internal verification steps and evaluation is required for program participation. For the lighting load shape study that is the basis for the residential coincidence factors, a separate document describing steps taken to minimize sample bias is being prepared by the study authors.
3. For real-time sample selection, set clear-cut procedures for selecting projects for monitoring, and require high-level approval for any exceptions. Verify compliance with this process as part of the evaluation.
4. Use estimation techniques (including weighting and standard error calculation) that are consistent with the sample design. That is, develop and apply weights that appropriately expand each sampling cell to the relevant population, and account for any differential sampling rates in the completed sample.
5. If regression methods are used to determine calibration factors or realization rates, conduct tests and determine appropriate corrections, as needed, for effects of outliers, serial correlation, model misspecification, and missing data.
6. Any sampling or estimation conducted as part of the independent evaluation has adhered and will adhere to the California Evaluation Protocols (TecMarket Works, 2004). These Protocols specify appropriate testing and bias mitigation procedures.

### Engineering Estimation

Non-statistical error or bias can result from the fixed inputs or assumptions made for factors and parameters that are not directly verified. General methods we use to limit the potential for bias or systematic error associated with the inputs include the following.

- Use the best available information
- Aim for the best estimate, but if anything, use assumptions that are conservative in terms of their effect on savings estimate

- Explicitly consider and, where there is a good basis for adjustment, correct for factors known to be potential sources of bias in engineering calculations. Examples include the following:

    a. Burnout (savings from replacement are less than calculated because a fraction of old lamps were burned out and not drawing full power, but new ones are not burned out)

    b. Differences between building operating hours and equipment operating hours and ramp-up schedules

    c. Short term vs. long term metering

    d. Weather effects on metered data

    e. Standard practice vs. regulatory standards

- Unless we have a good basis for correcting for these potential errors, we will not introduce subjective bias corrections. Such corrections can create more unknown error.

- The site-specific metering plans developed for a custom project will explicitly address the issues identified in Section 7.1.1(3) of the M-MVDR:

    a. accuracy and calibration of the measurement tools

    b. measurement error

    c. engineering model bias

    d. modeler bias

    e. deemed parameter bias

    f. meter bias

    g. sensor placement bias

    h. sample selection bias or non-random selection of equipment and/or circuits to monitor

# Section 8: Demand Reduction Value Calculations

## 8.1 General Description

Demand Reduction Value attained during the applicable Performance Hours for each measure in the Vermont Efficiency Portfolio will be determined following the methodologies set out in Appendix A and Appendix C (the TRM) for prescriptive measures and Appendix B for custom projects. Those three Appendices describe equations and formulas, assumptions, equipment specifications, measurement data, and other factors that will be used – to the extent such parameters are known today. They (together with other sections of this plan) also describe the process we will use to develop or refine elements of the demand reduction value whose parameters cannot be precisely known today.

For prescriptive measures, most of the factors identified in Section 8.1 of the ISO Manual M-MVDR are known today (again, see Appendix A and the TRM). The most important exceptions are quantities installed and manufacturers' equipment specifications, which cannot be known until the equipment in question has been installed. One other exception is the room air conditioner coincidence factor, which will be known following completion of the RLW study that has just begun (expected to be completed by the end of 2007).

For custom measures, none of the factors will be known until the measures are installed. Calculations for individual projects will be subject to an internal quality control process described in Appendix B and in the Efficiency Vermont Project Review and Documentation Guidelines. Third-party independent verification and validation will be conducted for a sample of custom projects. The aggregate custom project savings will be adjusted by the realized rate determined for this sample (as described in Appendix B).

The realization rate that will be used to adjust custom savings to verified levels will be calculated on an annual basis (consistent with our existing savings verification process, meaning results are typically available in early Summer) starting in 2009 (for measures installed in 2008).[10] In our reports to ISO regarding savings achieved, we will apply the most recent realization rate to all custom measures installed since the period covered by the previous realization rate analysis. For example, if we complete our realization rate studies on July 1 of each year, all of the custom project savings included in our report to the ISO on savings delivered as of June 1, 2010 will be adjusted using the 2009 realization rates – the only such rates developed to that point. However, again assuming new realization rates are available in time to affect reporting, beginning with our report to the ISO in July of 2010, we will use the 2009 realization rate only for custom measures installed between May 2007 and December 2008 and use the newly completed 2010 realization rate to adjust savings from custom measures installed between January 2009 and June 2010.

One set of prescriptive measures, those in the Building Existing Facilities (BEF) Prescriptive initiative, are verified in a process identical to the verification process for Business Custom and Business New Construction Projects. That is, a realization rate is calculated from a random sample of BEF Prescriptive projects and applied to all BEF Prescriptive project

[10] Since the ISO will not approve this plan until October 2007, it will not be possible to have collected data in the Summer of 2007 for the development of a realization rate in 2008.

level savings claims. BEF Prescriptive initiatives involve projects in which every measure is prescriptive in nature. This distinguishes them from Business Custom or Business New Construction initiatives, whose projects may contain a mix of prescriptive and custom measures.

Residential projects, either prescriptive, custom, or some mix of prescriptive and custom measures, are verified by a different process. Residential prescriptive measures savings are compared with TRM saving estimates. Individual and or systematic errors are identified and corrected. Residential custom project measure savings are individually verified and adjusted as needed.

## 8.2 Specific Requirements

Section 8.2 of the ISO's Manual M-MVDR describes five specific requirements that must be met in developing a reported monthly demand reduction value. Our approach to addressing each of these is described below (identified by M-MVDR section number).

### 8.2.1, 8.2.4, & 8.2.5 Relative precision targets for the project, including sampling

Our demand reduction value will achieve a relative precision of 10% at an 80% confidence interval. Our portfolio does consist of multiple sites and measures. Our demand reduction value will be based, in part, on measured data from samples. Both our approach to sampling and our approach to ensuring a relative precision of 10% at an 80% confidence interval are described in Section 7 and Appendix B to this plan.

### 8.2.2 Baseline adjustments to reflect operating conditions during performance hours

Our determination of baseline values will reflect operating conditions at the time of the performance hours. Our approach to establishing baselines is summarized in Section 6 of this plan.

### 8.2.3 Formulas including modifying factors for coincidence factors, realization rates, measure lives, equipment failure rates, etc.

Our calculation of our demand reduction value will address a variety of factors, including those listed in Section 8.2 (3) of the M-MVDR, that could affect actual savings during the performance hours. As noted above, we will be making extensive use of load shapes, metering, and/or other appropriate methods to ensure that we are correctly reporting savings for on-peak performance hours. We will also be explicitly calculating realization rates for custom projects (see Appendix B) and claiming only savings that have been adjusted by such rates. We will also adjust reported savings to account for measures that have reached the end of their useful lives. In addition, we recognize that some efficiency measures can be expected to fail, be removed by the customer before the end of their lives, or – even though purchased – never be installed. As the algorithms for retail purchases of fluorescent lighting products in Appendix A and the TRM show, we explicitly adjust savings downward (through the use of an "in service rate" factor) in such cases.

# Section 9: Monitoring Parameters and Variables

## 9.1 General Description

We will count, record, and maintain data for all efficiency measures that we cause to be installed through our programs. The specific data collected will include all of the parameters identified in Section 9.2 of the ISO M-MVDR with a few exceptions. First, in some cases, precise data on things such as age of an existing appliance will have to be estimated because it will not be precisely knowable. Such estimation will be based on knowledge of the equipment (i.e., when such equipment was manufactured), customer records, customer interviews, and/or other appropriate sources. Second, in some cases we will rely on samples to obtain data on the average features (e.g., lighting wattage) of efficiency measures installed. Finally, we will collect HVAC or other major electric consuming equipment serial numbers whenever they are both readily available and prove necessary to document or validate efficiency levels or measure savings. We have found that such information is often not readily available, and is usually not necessary or helpful for such purposes. In such cases, we will record manufacturer efficiency ratings and capacity for the installed equipment as an alternative.

In general, data on HVAC, lighting, and other major electric consuming equipment specifications will be collected from equipment rebate applications or (less frequently) from on-site, post-installation inspections by our staff. Variables affecting savings from building envelop measures will generally be collected from plans developed by architects, developers, builders, and/or contractors; diagnostic tests conducted by such professionals and reported to us on program forms; and/or site assessments or post-installations inspections conducted by our own staff.

Where weather data are necessary to estimate savings, we will generally rely on data for Burlington, Vermont (usually the only city in Vermont for which readily available and extensive historic weather files exist). We will either use data from the National Climatic Data Center, data embedded in widely used building simulation models, or other equally reliable data sources.

VEIC has developed, has maintained, and will continue to maintain a central tracking system that records and stores data relevant to each efficiency measure installed in Vermont under our Efficiency Vermont contract. This tracking system is discussed further in Section 12.

# Section 10: Measurement Equipment Specifications

## 10.1 General Description

Because we do not yet know exactly which measures will be installed or in which building or facility they will be installed, we cannot provide specifics regarding which types of monitoring and/or data recording devices will be installed pursuant to this M&V plan. However, we will ensure that both all such devices and the approaches used to install them will be consistent with (or exceed) the standards set forth by the ISO in Section 10 of its M-MVDR. We will hold to such standards both for the work of our own staff and the work of any contractors hired to conduct studies used to support the measurement and verification of our actual demand reduction value (including the listing of such requirements in both RFPs and contracts for such studies).

# Section 11: Monitoring Frequency and Duration

## 11.1 General Description

In this section, we address monitoring frequency and duration for variables that must be monitored over a period of time, in particular those data required for determination of load shapes or coincidence factors. Other factors required for the savings calculation include measure counts, installation rates, and baseline and efficient equipment input capacity (installed kW), output capacity (eg, tons), and efficiency levels. Such parameters are measured on a one-time basis, with quality control checks. Determination of these parameters is described in Section 6, Appendices A and B, and the documents referenced there. Maintenance of these parameters is described in Section 12.

### Prescriptive Measures

Load shapes for the measures accounting for the majority of the prescriptive savings will be based on completed and pending regional metering studies. For other prescriptive measures, the load shapes will be based on existing load shape libraries that represent the best currently available information. The regional studies include the following:

- For residential and commercial/industrial lighting coincidence factors: *Development of Common Demand Impacts Standards for Energy Efficiency Measures/ Programs for the ISO Forward Capacity Market (FCM)*, RLW 2007
- A forthcoming regional study of residential HVAC use
- A possible future regional study of commercial/industrial HVAC use

The lighting study was based on analysis of lighting logger data collected by various parties for impact evaluation and load shape development in service territories within the New England Region, between 1999 and 2006. Lighting logger data typically records lighting start and stop times. Thus, the time scale is continuous, meaning observations at arbitrarily fine intervals could be determined from it.

The forthcoming regional studies will specify monitoring at 15-minute intervals, or finer. HVAC conditioning loads will be monitored for all affected months.

### Custom Measures

For custom measures, monitoring requirements will be determined based on the measure type and size. In general, measures with very large demand savings will always be monitored. A sample of smaller measures will also be monitored.

The monitoring frequency will be 15-minute intervals or finer in all cases. In some cases, where the kW used when equipment is running is a constant, start/stop time loggers will be used for monitoring. This type of data effectively provides load information at arbitrarily fine intervals. For some custom measures, the reference load shape for corresponding prescriptive measures may be used, if applicable.

The duration of monitoring will depend on the measure technology and application. The types of monitoring that will be conducted for different kinds of applications are discussed in Appendix B. General compliance with the requirements of Section 11 of the M-MVDR is indicated below.

## 11.2 Specific Requirements

All monitoring conducted for purposes of verifying our demand reduction will comply with the requirements of Section 11 of the M-MVDR. Specifically,

- The duration and frequency of metering and monitoring will be sufficient to ensure an accurate representation of the amount of electrical demand consumed or generated both without and after project installation and during Performance Hours.

- For Projects using Option B methodology described in Section 5.2 of the M-MVDR, the direct measurement of electrical demand or generation will be made using interval metering equipment that satisfies the requirements described in Section 10.

- All measurements will be taken at typical system conditions within the time periods and frequency that demonstrate coincidence with the Performance Hours as defined in the Market Rules.

- For weather-dependent loads and associated demand reductions, monitoring will be conducted over time periods that span the ISO peak periods relevant to the measure as well as more moderate periods. Weather models will be fit to the metered data to determine the savings during normal weather conditions of the ISO Performance hours.

If the load reduction and pattern of operation in the absence of the measure can be determined based on the load pattern with the measure installed, monitoring will be conducted only post-installation. If the load reduction pattern requires monitoring of replaced equipment prior to replacement, monitoring will be conducted both pre- and post-installation, for sufficient duration to support calculation of the load reduction during the Performance Hours.

# Section 12: Data Validation, Retention, and Management

## 12.1 Data Collection and Management

VEIC has developed, has maintained, and will continue to maintain a central tracking system that records data relevant to each efficiency measure installed in Vermont under our Efficiency Vermont contract. Nearly 90 data fields are currently maintained for each Efficiency Vermont installed measure (the KITT Database Reference Manual is included as a supporting document). In addition to technical information (including peak demand reductions), for all projects generating savings greater than 10 kW at an individual facility (i.e., those affected by the requirements in ISO M-MVDR Section 12.2 (1)), the tracking system links efficiency measures to their physical location in the state, the installing customer's address, the customer's distribution utility, and their utility account number(s). The same also applies for most measures installed in buildings generating less than 10 kW of savings (i.e., those affected by ISO M-MVDR Section 12.2 (2)).[11] These practices will continue.

All information for Efficiency Vermont reporting purposes comes and will continue to come directly from the tracking systems. The Efficiency Vermont tracking system recently was cited as "highly effective" by the Vermont Department of Public Service evaluator, KEMA (attached as supporting documents).

## 12.2 Data Validation

### 12.2.1 Data Tracking System

VEIC will continue to maintain a set of analysis and data loading tools that check for and eliminate the potential for error of data entry. In addition, VEIC has historically and will continue to conduct extensive data quality control to check for and eliminate errors in reporting. These checks include:

- Monthly reconciliation reports between the accounting system and the tracking system
- Data validation reports – special reports that seek out errors for correction
- Project completeness reports – special reports to ensure all project information is complete

[11] One important exception to this rule is cases in which programs provide "upstream" incentives to manufacturers or retailers to sell efficient measures in the state (e.g., rebates for local grocery stores for selling compact fluorescent light bulbs). With "upstream" incentives, unlike with customer rebates that require submission of forms with customer information, VEIC may not know which customers installed the measures. In such cases, we allocate participants to different geographic areas defined by zip code, using information regarding the client base of the upstream market actor (e.g., the store), distributions of participants from the same store or region when customer rebates were used in the past, or other appropriate indicators. Information can then be determined for participants in each distribution utility territory.

- Annual reporting clean-up process – special reviews and systems that have been established to ensure all data are accurate for reporting

Users of the data systems all receive extensive training. Detailed descriptions of these systems are contained in the KITT Database Reference Manual and Efficiency Vermont KITT Primer (attached as supporting documents).

### 12.2.2 Field Data

VEIC employs a number of quality-control procedures to ensure both that measures are installed in a manner consistent with specifications and that estimated measure savings are accurate.

Site inspections are a valued method for verifying that agreed-upon or expected efficiency measures are installed in completed Vermont projects. Final inspections will be regularly performed for all non-prescriptive (custom) projects in the Business Energy Services sector, both for New Construction and Existing Facilities projects.

In addition to regular Efficiency Vermont inspections, quality check inspections will be conducted. A Quality Check Inspection is defined as a site inspection performed post-project completion by a program staff person who is not directly involved in the original delivery of program services. Projects are selected from all project types and are scheduled to ensure review of the work done by each Project Manager within VEIC's Business Energy Services group – the group responsible for efficiency programs targeting commercial and industrial customers – at least once a year. The inspections will ensure the functionality of the equipment installed, verify conditions used to calculate savings, and ascertain the level of customer satisfaction. They will also represent an opportunity for the inspector to address any issues the customer might have with the equipment.

In residential buildings, VEIC will conduct final inspections for a large fraction of heating fuel switches, Home Performance projects, and new construction projects. Additional inspections are conducted for our Low Income Single Family (LISF) program. This program works in partnership with Vermont's weatherization agencies to provide energy efficiency services to low-income households. All completed LISF projects will receive final inspections from weatherization agency personnel to assess the quality of energy improvements, with results passed on to VEIC.

### 12.2.3 Validated Savings Estimates

VEIC employs a variety of processes for reviewing savings estimates. These are described in Section 14 and Appendix B of this plan.

### 12.2.4 Data from Evaluation Activities

In addition to VEIC's internal data validation procedures, all evaluation studies upon which we will rely for key inputs to savings estimates will be required to validate the data used to develop such estimates. Also, all interval data collected will be subject to data validation, editing and estimation procedures, consistent with those outlined for individual site monitoring under Section 12.2 (4) of the ISO M-MVDR.

## 12.3 Data Retention

All data will be maintained until the end of measure life, or for a minimum of one year after the resource is permanently de-listed or retired from the Forward Capacity Market.

# Section 13: Performance Reporting

## 13.1 General Description

VEIC will submit information on the total Demand Reduction Value (MWh) during the Performance Hours applicable to the Vermont Efficiency Portfolio on a monthly basis.

VEIC will satisfy the ISO's reporting requirements by reporting:

(1) on a monthly basis the total Demand Reduction Value (MWh) during the Performance Hours applicable to the Vermont Efficiency Portfolio in the Obligation Month

(2) the Demand Reduction Values (MWh) for the Vermont Efficiency Portfolio according to the ISO's published Settlement schedule

(3) any revised Demand Reduction Values (MWh) for the Vermont Efficiency Portfolio according to the schedule defined by ISO

(4) & (5) These reports will be made in a format defined by the ISO using a software application and electronic interface as defined by the ISO

Consistent with ISO M-MVDR Sections 13.2 (6), (7), and (8), VEIC will also provide to the ISO in our June 2010 report all work sheets, engineering calculations, reference materials, results of metering used to develop our custom project realization rates, and other data necessary to support our demand reductions, including assumptions regarding baseline conditions, as well as a certification that samples that were used comply with the ISO's statistical precision requirements. We will also provide a schedule of measure life decay for measures planned to be part of our Demand Reduction Value and corresponding replacement measures of equal capacity value to maintain the approved Demand Reduction Value. Such materials and certifications are expected to be applicable for many subsequent months. Thus, rather than file the same voluminous material every month, we will send the ISO any updated materials available and applicable in subsequent months (e.g., updates to the TRM or new custom project realization rates) and reference the previously submitted documents. We believe this approach will be the most expeditious for the ISO's review process. However, in all cases we will comply with specific ISO reporting requirements.

# Section 14: Independence and Auditing

## 14.1 General Description

### 14.1.1 DPS Independent Measure Verification

Vermont legislation (30. V.S.A § 209) authorizing the creation of an Energy Efficiency Utility (EEU) and funded through an Energy Efficiency Charge (“EEC", or “wires charge”) requires that the Board “[p]rovide for the independent evaluation of programs delivered” under this section. In its Order of 9/30/99 in Docket No. 5980, the Board approved a Memorandum of Understanding between the Department of Public Service (DPS), Vermont’s electric utilities, and a number of other parties. In the MOU, the parties agreed (in ¶ 11) that the Department was to “provide for formal evaluation of the Core Programs and any other System-wide programs approved by the Board for EEU implementation. This evaluation will include but not necessarily be limited to assessment of market transformation accomplishments, with accompanying proposals for program change.”

The DPS has provided these EEU evaluation services since the start of EEU implementation in the year 2000. The DPS EEU Evaluation Plan for the three-year (2006-2008) contract cycle allocates $925,000 for third-party impact evaluation activities, which includes contractor costs for the annual EEU savings verification process. The total EEU evaluation budget in this plan totals $2.3 million for the three-year period 2006 through 2008.[12]

**Table 9: DPS EEU Evaluation Available Funds**

| | 2006 | 2007 | 2008 | 3-Year Total |
|---|---|---|---|---|
| Budget | $677,000 | $692,000 | $708,000 | $2,077,000 |
| Carryover | $236,676 | | | |
| Total | $913,676 | $692,000 | $708,000 | $2,313,676 |

These funds are used to pay the costs of independent evaluation contractors whose services are procured through a competitive process. The cost of DPS staff time devoted to EEU evaluation activities is in addition to this amount.

The overall objectives are as follows:

1. Verify the annual savings and total resource benefit claims made by the EEU, as provided for in the contract between Efficiency Vermont and the PSB.
2. Assess the impact of specific measures or initiatives where significant uncertainty exists and/or where the savings contribution is large.

[12] The DPS evaluation budget for the 2009 to 2011 contract period has not yet been established, but is likely to be comparable to, if not slightly greater than, that for the current contract.

3. Conduct market studies to characterize and assess current conditions in discreet energy efficiency markets identified by stakeholders and in prior evaluation studies and reports.

The Public Service Board also has directed that the DPS use a portion of the revenues anticipated from the FCM to pay for additional impact evaluation studies that may be necessary for EEU participation in the ISO-FCM. It is not known at this time the magnitude of those expenditures.

### 14.1.2 DPS Annual Verification Process

The contract between the PSB and VEIC for Efficiency Vermont services provides for the DPS to annually review and verify Efficiency Vermont’s annualized MWh, summer and winter coincident peak capacity reductions, and total resource benefits claimed in its annual “Preliminary Results and Savings Estimate Report”. After Efficiency Vermont submits its claim on April 1 of each year, the Department and its consultants conduct a two- to three-month process of in-depth review and investigation and issue a report and recommendation to the EEU Contract Administrator. The Contract Administrator then makes a recommendation to the PSB regarding the appropriate savings Efficiency Vermont may claim for the reporting year. The PSB subsequently certifies the performance results.

The Department’s review is provided in part through a contract awarded in a competitive process most recently conducted in early 2007. West Hill Energy & Computing, Inc., which has provided these services since 2001, was the successful bidder and is currently providing services under a two-year contract with an option for a two-year renewal.

### 14.1.3 Additional Triennial Review of Savings

A second independent audit of the energy and capacity savings is required by 30 V.S.A. §209(e)(12). It was first completed in 2002 and is required to be performed every three years thereafter. The audit focuses on a review of the methods used by Efficiency Vermont to collect data and estimate program energy savings and the methods used by the DPS to verify Efficiency Vermont’s claimed savings. The latest audit was competed in December 2005 and reviewed program years 2002, 2003, and 2004. A copy of that report is available upon request.

Among the findings of that audit were:

- The Efficiency Vermont estimates of Annual Energy and Capacity Savings, as verified and adjusted by the Department, are reliable and unbiased estimates of program savings.

- Vermont data collection and analysis procedures are appropriate and include effective quality assurance checks. The Department has developed effective procedures for verifying Efficiency Vermont savings estimates.

## 14.2 Specific Requirements

VEIC will cooperate in any and all unannounced audits or tests of the Vermont Efficiency Portfolio conducted by the ISO to verify its compliance with the requirements as set forth in Market Rule 1 and Manual M-MVDR. VEIC will allow the ISO to audit testing and calibration records and to order and witness the testing of metering and measurement equipment installed pursuant to the Vermont Efficiency Portfolio's approved Measurement and Verification Plan.

VEIC understands that it will be responsible for all expenses associated with installing, maintaining, calibrating, and testing the metering, data recording, and measurement equipment installed pursuant to the Vermont Efficiency Portfolio's approved Measurement and Verification Plan.

VEIC will provide to the ISO an Annual Certification of Accuracy of Measurement and Verification Documents, verified by an independent third-party auditor, with a statement certifying that the Vermont Efficiency Portfolio, for which the Project Sponsor is requesting compensation, continues to perform in accordance with the submitted Measurement and Verification Documents reviewed by the ISO in accordance with the Market Rules. This annual certification will be provided by the DPS as part of the annual savings verification process.

# Section 15: Measurement and Verification Supporting Documents

A few of the studies upon which VEIC relies for assumptions regarding a portion of our savings are more than five years old (as identified by publication date below). In all such cases, the cited studies or reports fit into one of these categories:

- They provide the most appropriate data for a given application – for example, the DOE study of residential water heating consumption and energy use done in the 1990s is an appropriate reference for estimating savings for hot water fuel switching because most water heaters replaced were installed in the 1990s or early 2000s, prior to a new field study that went into effect in 2004)

- They address parameters unlikely to have changed significantly and are the best and most-recent available information – for example, load shapes reflecting times of day of typical use of residential water heaters or other appliances

## Future Studies

VEIC is a participating member of the New England State Program Working Group (SPWG), facilitated by the Northeast Energy Efficiency Partnership (NEEP), which provided input to ISO-NE in the development of its M-MVDR. The SPWG includes all publicly funded program administrators in the New England states and staff from each state public utility commission and the Massachusetts' energy office. The SPWG continues to work to develop regional technical references and documents to support member M&V Plans for the ISO Forward Capacity Market. SPWG members intend to continue working together to: a) identify information/data needs that will support M&V Plans; and b) commission and perform studies jointly on a regional basis through shared resources. These regional technical references/documents will be used as appropriate to update SPWG member M&V plans associated with FCA-1 and subsequent M&V plans.

## Supporting Documentation included with this filing

*Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures*. GDS Associates, 2007

*Development of Common Demand Impacts Standards for Residential, Commercial and Industrial Lighting Measures/ Programs for the ISO Forward Capacity Market (FCM).* RLW Analytics, 2007

*Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs.* Nexus Market Research and RLW Analytics, 2004

*KITT Database Reference Manual* and *Efficiency Vermont KITT Primer* – Efficiency Vermont data tracking and reporting system references

*Business Energy Services Project Review and Documentation Guidelines*. Efficiency Vermont, 2007

*Final Report: Phase 2 Evaluation of the Efficiency Vermont Business Programs*. RLW Analytics and KEMA, 2006

*Final Report: Phase 2 Evaluation of the Efficiency Vermont Residential Programs*. KEMA, 2005

## Supporting Documentation available publicly or from VEIC upon request

*ENERGY STAR® Clothes Washers Key Product Criteria.* U.S. DOE, 2007
http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers

*ENERGY STAR® Program Requirements for Room Air Conditioners*. U.S. DOE, 2005
http://www.energystar.gov/ia/partners/product_specs/program_reqs/roomac_prog_req.pdf

*The California Evaluation Framework. Project Number: K2033910.* Prepared for the California Public Utilities Commission and the Project Advisory Group. TecMarket Works, et. al., 2004.
http://www.tecmarket.net/ca_eval_framework.htm

*Residential Energy Consumption Survey: Household Energy Consumption and Expenditures 2001.* Energy Information Administration, 2001
http://www.eia.doe.gov/emeu/recs/recs2001/publicuse2001.html

*Final Rule Technical Support Document: Energy Efficiency Standards for Consumer Products: Clothes Washers.* U.S. Department of Energy, 2000
http://www.eere.energy.gov/buildings/appliance_standards/residential/clwash_0900_r.html

*Technical Support Document: Energy Efficiency Standards for Consumer Products: Residential Water Heaters.* U.S. Department of Energy, 2000
http://www.eere.energy.gov/buildings/appliance_standards/residential/waterheaters.html

*Technical Support Document for Energy Conservation Standards for Room Air Conditioners.* Prepared for U.S. Department of Energy. Lawrence Berkeley National Laboratory, 1997
http://www.eere.energy.gov/buildings/appliance_standards/residential/room_ac.html

*Calculating Lighting and HVAC Interactions.* Robert Rundquist et al., ASHRAE Journal, 1993

*Residential Energy Consumption Survey: Household Energy Consumption and Expenditures 1990.* Energy Information Administration, 1993
http://www.eia.doe.gov/emeu/recs/93publicuse.html

*eShapes* 8760 End-use Load Shapes for Vermont. Itron, 2007

# Section 16: Responsible Parties

The following parties will be responsible for these aspects of the Project and its Measurement and Verification Plan:

### Project Management

Vermont Energy Investment Corporation (VEIC)

### Measure Implementation

VEIC

### Measure Operation and Maintenance

VEIC's customers (and VEIC)

### Measurement Equipment Calibration and Testing

VEIC and the Vermont Department of Public Service (DPS)

### Monthly Demand Reduction Value Calculations

VEIC

### Data Validation, Retention, and Management

VEIC

### Monthly Performance Reporting

VEIC

### Independent Project Auditing

DPS and the Vermont Public Service Board, through the Energy Efficiency Utility Contract Administrator

### Quality Assurance

VEIC

# Appendix A: Prescriptive Measure-Group M&V Plans

As a means of summarizing the wealth of detail found in the Efficiency Vermont Technical Reference Manual (given in its entirety as Appendix C), Appendix A of this M&V plan provides information on savings calculations and M&V methodologies for six groups of efficiency measures:

- ENERGY STAR Lighting – Retail Sales
- ENERGY STAR Lighting – Residential New Construction
- Commercial and Industrial Lighting – Business Existing Facilities
- ENERGY STAR Room Air Conditioner – Retail Sales
- ENERGY STAR Clothes Washer – Retail Sales
- Electric Domestic Hot Water System Fuel Switch

The first of these measure bundles – retail purchases of fluorescent light bulbs and fixtures – accounts for about 70% of all historical and projected future prescriptive peak demand savings. Together, the other five account for more than 20%. Thus, these six measures or measure bundles account for more than 90% of all prescriptive peak demand savings. The consolidation of measures into these categories is based not only on similar technology but also on similar basis for the savings estimates.

The assumptions documented in the TRM and in the summaries below include algorithms to calculate demand savings, specifications of baseline assumptions, measured or estimated quantities, load shape or coincidence factors, measure life, and any other necessary assumptions. In each case, a table is given that indicates the basis for the values for these assumptions. Full citations for all publications listed as sources are given in Section 15 above and are available from VEIC upon request.

# A.1 ENERGY STAR Lighting – Retail Sales

**Description**

Efficient light bulbs and lighting fixtures purchased through retail outlets and put into service in residential or commercial settings. Uses include:

- An existing incandescent screw-in bulb is replaced with a lower wattage ENERGY STAR qualified compact fluorescent screw-in bulb
- An existing lighting fixture with incandescent bulbs is replaced by an ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps in an interior or exterior setting
- An existing table lamp with an incandescent bulb is replaced by a table lamp wired for exclusive use with a pin-based compact fluorescent lamp
- An existing floor lamp with incandescent bulbs is replaced by a dedicated ENERGY STAR floor lamp wired for exclusive use with pin-based compact fluorescent lamps
- A halogen or incandescent torchieres is replaced by a high efficiency ENERGY STAR fluorescent torchiere

**ISO NE M&V Method**

Option A – Partially Measured Retrofit Isolation/Stipulated Measurement

**Algorithm**

**Total Demand Reduction**

Total demand reduction (kW) = # units installed × per unit demand reduction × On-peak coincidence factor
= # units purchased × ISR × ΔWatts /1000 × WHF × CF

Where:

| | |
|---|---|
| ISR | = In-service rate (% of rebated units that actually get used) |
| ΔWatts | = estimate of average connected load savings ($Watts_{base} – Watts_{eff}$ ) |
| $Watts_{base}$ | = baseline connected load |
| $Watts_{eff}$ | = efficient connected load |
| WHF | = Waste heat factor to account for cooling savings from efficient lighting |
| | = {1 + ($SPACE_{cooled}$ × OFFSET% / COP)} (from Rundquist et al., ASHRAE Journal 1993) |
| $SPACE_{cooled}$ | = percentage of space that is mechanically cooled at time of summer peak (assumed to be zero for residential spaces) |
| OFFSET% | = percentage of lighting that needs to be mechanically cooled |
| COP | = estimate of coefficient of performance for cooling system |
| CF | = on-peak coincidence factors for commercial and residential, winter and summer peaks |

**Measure Life**

Regional Lighting and HVAC Measure Life Report, GDS 2007

## Measurement and Verification Plan: ES Lighting – Retail Sales

<table>
<tr><th rowspan="2">Efficiency Measure</th><th colspan="8">M&V Basis for Values for Savings Algorithm</th></tr>
<tr><th># Purchased</th><th>ISR</th><th>ΔWatts</th><th>$SPACE_{cooled}$</th><th>OFFSET%</th><th>COP</th><th>$CF_{winter}$</th><th>$CF_{summer}$</th></tr>
<tr><td>CFL bulbs - residential</td><td rowspan="12">Measured data<br>Customer, retailer, manufacturer, or other relevant market actor indicates manufacturer, model purchased, and where possible, ultimate use (residential or commercial) on rebate form, through sales records, or other appropriate documentation. Information collected and aggregated by EVT tracking system. Data from the previous year is used to predict current year’s installations.</td><td colspan="2" rowspan="6">Statistical sampling<br>Regional Residential Lighting Study, Nexus 2004</td><td colspan="3" rowspan="6">N/A</td><td colspan="2" rowspan="12">Statistical sampling<br>Regional Lighting CF Study, RLW 2007</td></tr>
<tr><td>Int. fixtures - residential</td></tr>
<tr><td>Ext. fixtures - residential</td></tr>
<tr><td>Table lamp residential</td></tr>
<tr><td>Floor lamp residential</td></tr>
<tr><td>Torchiere residential</td></tr>
<tr><td>CFL bulbs - commercial</td><td rowspan="6">Engineering estimate*</td><td rowspan="6">Statistical sampling<br>Regional Residential Lighting Study, Nexus 2004**</td><td colspan="3" rowspan="6">Engineering estimates<br>Rundquist et al., ASHRAE Journal, 1993</td></tr>
<tr><td>Int. fixtures - commercial</td></tr>
<tr><td>Ext. fixtures - commercial</td></tr>
<tr><td>Table lamp commercial</td></tr>
<tr><td>Floor lamp commercial</td></tr>
<tr><td>Torchiere commercial</td></tr>
</table>

* Conservative assumption
** Consist with data on product wattage from rebate forms.

## A.2 ENERGY STAR Lighting – Residential New Construction

**Description**

Efficient light bulbs and lighting fixtures installed in new homes, either by direct installation, purchased by the builder or contractor, or purchased by the consumer. Uses include:

- A compact fluorescent lamp is used in place of an incandescent bulb in an interior or exterior fixture
- An ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps is used in place of a lighting fixture with incandescent lamp(s). Categories of fixtures include:
  - Interior surface fixtures, including surface ceiling and surface wall fixtures
  - Interior recessed fixtures
  - Other interior fixtures, including chandelier/pendent, Direct Install lamp, floor lamp, post lamp, table lamp, track light, and under -cabinet fixtures
  - Exterior fixtures, including fixtures in the following exterior locations: post lamp, recessed ceiling, surface ceiling, and surface wall
- A generic linear fluorescent tube fixture(s) replaces an incandescent interior lighting fixture - includes surface ceiling and surface wall fixtures using a linear fluorescent tube

Baseline for each measure is the less-efficient fixture that gives equivalent lumen output as the efficient product

**ISO NE M&V Method**

Option A – Partially Measured Retrofit Isolation/Stipulated Measurement

**Algorithm**

**Total Demand Reduction**

Total demand reduction (kW) = # units installed × per unit demand reduction × On-peak coincidence factor
= # units installed × $\Delta$Watts /1000 × CF

where:

$\Delta$Watts = estimate of average connected load savings ($Watts_{base} - Watts_{eff}$)
$Watts_{base}$ = baseline connected load
$Watts_{eff}$ = efficient connected load
CF = on-peak coincidence factors for commercial and residential, winter and summer peaks

Note: The in-service rate (% of measures that actually get used) is assumed to be 1.0 for these measures, as rebates are provided only for measures installed as the home is constructed.

**Measure Life**

Regional Lighting and HVAC Measure Life Report, GDS 2007

## Measurement and Verification Plan: ES Lighting – Residential New Construction

| Efficiency Measure | M&V Basis for Values for Savings Algorithm | | | | |
|---|---|---|---|---|---|
| | # Installed | $Watts_{base}$ | $Watts_{eff}$ | $CF_{winter}$ | $CF_{summer}$ |
| **RNC CFL bulbs - interior** | **Measured data** Information about actual installations collected on-site by project managers and entered into tracking system. Data from the previous year is used to predict current year's installations. | **Engineering estimate*** | **Manufacturer's data** Actual historical wattage installed | **Statistical sampling** Regional Lighting CF Study, RLW 2007 | |
| **RNC CFL bulbs - exterior** | | | | | |
| **RNC surface fixtures - interior** | | | | | |
| **RNC recessed fixtures - interior** | | | | | |
| **RNC other fixtures - interior** | | | | | |
| **RNC fixtures - exterior** | | | | | |
| **RNC fixtures – linear tube** | | | | | |

* Based on manufacturer's data of wattage of baseline with equivalent lumen output

# A.3 Commercial and Industrial Lighting – Business Existing Facilities

## Description

Efficient lighting fixtures put into service in commercial or industrial interior or exterior settings to replace less-efficient fixtures and rebated through prescriptive programs. The following are included:

- An existing incandescent screw-in bulb is replaced with a lower wattage ENERGY STAR qualified compact fluorescent screw-in bulb
- An existing lighting fixture with incandescent bulbs is replaced by an ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps
- A T5 fluorescent fixture replaces a less-efficient T8 or metal halide fixture
- A high-performance T8 fixture replaces a standard T8 or T12 fixture
- A metal halide fixture replaces a less-efficient halogen fixture

Baseline for each measure is the less-efficient fixture that gives equivalent lumen output as the efficient product

## ISO NE M&V Method

Option A – Partially Measured Retrofit Isolation/Stipulated Measurement

## Algorithm

**Total Demand Reduction**

Total demand reduction (kW) = # units installed × per unit demand reduction × On-peak coincidence factor
= # units purchased × ISR × ΔWatts /1000 × WHF × CF

Where:

| | |
|---|---|
| ISR | = In-service rate (% of rebated units that actually get used) |
| ΔWatts | = estimate of average connected load savings ($Watts_{base} – Watts_{eff}$ ) |
| $Watts_{base}$ | = baseline connected load |
| $Watts_{eff}$ | = efficient connected load |
| WHF | = Waste heat factor to account for cooling savings from efficient lighting |
| | = {1 + ($SPACE_{cooled}$ × OFFSET% / COP)} |
| $SPACE_{cooled}$ | = percentage of space that is mechanically cooled |
| OFFSET% | = percentage of lighting that needs to be mechanically cooled |
| COP | = estimate of coefficient of performance for cooling system |
| CF | = on-peak coincidence factors for commercial/industrial winter and summer peaks |

## Measure Life

Regional lighting and HVAC measure life study, GDS 2007

## Measurement & Verification Plan: Commercial & Industrial Lighting – Business Existing Facilities

<table>
<tr><th rowspan="2">Efficiency Measure</th><th colspan="9">M&V Basis for Values for Savings Algorithm</th></tr>
<tr><th># Purchased</th><th>ISR</th><th>$Watts_{base}$</th><th>$Watts_{eff}$</th><th>$SPACE_{cooled}$</th><th>OFFSET%</th><th>COP</th><th>$CF_{winter}$</th><th>$CF_{summer}$</th></tr>
<tr><td>CFL bulbs</td><td rowspan="5">Measured data<br>Customers, vendors, or other relevant market actors indicate manufacturer and model purchased and ultimate use through rebate form, sales receipt, through sales records, or other appropriate documentation. Information collected and aggregated by EVT tracking system. Data from the previous year is used to predict current year's installations.</td><td rowspan="5">Engineering estimate*</td><td rowspan="5">Stipulated factor<br>Manufacturer's data; baseline with equivalent lumen output</td><td rowspan="5">Stipulated factor<br>Manufacturer's data, actual wattage installed</td><td rowspan="5" colspan="3">Engineering estimates<br>Rundquist et al., ASHRAE Journal, 1993</td><td rowspan="5" colspan="2">Statistical sampling<br>Regional Lighting CF Study, RLW 2007; 8760 load shapes, Itron 2007</td></tr>
<tr><td>CFL fixture</td></tr>
<tr><td>T5 fixture</td></tr>
<tr><td>High-performance T8 fixture</td></tr>
<tr><td>HID fixture</td></tr>
</table>

* Conservative assumption

# A.4 ENERGY STAR Room Air Conditioner – Retail Sales

## Description

Retail sales of efficiency room air conditioners (units with an output less than or equal to 18,000Btu meeting minimum qualifying efficiency established by ENERGY STAR Program) for use in residential or commercial settings

## ISO NE M&V Method

Option A – Partially Measured Retrofit Isolation/Stipulated Measurement

## Algorithm

**Total Demand Reduction**

Total demand reduction (kW) = # units installed × per unit demand reduction × On-peak coincidence factor

$$= \#\ \text{units purchased} \times \{cap_{eff} / (EER_{base} \times 1000) - cap_{eff} / (EER_{eff} \times 1000)\} \times CF$$

where:

| | |
|---|---|
| per unit demand reduction | = average per unit demand reduction (across all currently available efficient products, evenly weighted) |
| | = average of baseline connected load kW (across all currently available efficient products, evenly weighted) – average of efficient connected load kW (across all currently available efficient products, evenly weighted) |
| baseline connected load (kW) | = $cap_{eff} / (EER_{base} \times 1000)$ |
| efficient connected load (kW) | = $cap_{eff} / (EER_{eff} \times 1000)$ |
| $cap_{eff}$ | = capacity of installed equipment (in kBtu/h) |
| $EER_{base}$ | = EER of baseline equipment |
| $EER_{eff}$ | = EER of installed equipment |
| CF | = on-peak coincidence factors for commercial and residential summer peak |

## Measure Life

Regional Lighting and HVAC Measure Life Report, GDS 2007

## Measurement and Verification Plan: ES Room Air Conditioner – Retail Sales

| Efficiency Measure | M&V Basis for Values for Savings Algorithm | | | | |
|---|---|---|---|---|---|
| | **# Purchased** | **$cap_{eff}$ (kBtu/h)** | **$EER_{base}$** | **$EER_{eff}$** | **$CF_{summer}$** |
| **Room A/C - residential** | **Measured data** Customer, retailer, manufacturer, or other relevant market actor indicates manufacturer, model purchased, and where possible, ultimate use (residential or commercial) on rebate form. Information from rebate forms collected and aggregated by EVT tracking system. Data from the previous year is used to predict current year's installations. | **Stipulated factor** Manufacturer's data* | **Minimum Federal Standards** DOE 2005 | **Stipulated factor** Manufacturer's data* | **Statistical sampling** Regional study to be completed in 2007 |
| **Room A/C - commercial** | | | | | |

* Manufacturers must self-test their equipment according to the US Department of Energy test procedure defined in 10 CFR 430, Subpart B, Appendix F (effective Nov. 16, 2005). Technical support documents for efficiency standards for room air conditioners can be found at http://www.eere.energy.gov/buildings/appliance_standards/residential/room_ac.html

# A.5 ENERGY STAR Clothes Washer – Retail Sales

## Description

Retail sales of clothes washers exceeding minimum qualifying efficiency standards established under ENERGY STAR Program and put into residential settings, including new construction

## ISO NE M&V Method

Option A – Partially Measured Retrofit Isolation/Stipulated Measurement

## Algorithm

**Total Demand Reduction**

Total demand reduction (kW) = # units installed × per unit energy reduction (kWh)
× peak demand:annual energy savings ratio
= # units purchased × [ ($cu.ft_{eff}$ / $MEF_{base}$) – ($cu.ft_{eff}$ / $MEF_{eff}$ )] × #cycles
× [({DryerSav % × ElecDryer %} + {DHWSav % × Elec DHW %} + Machine saving %) ]
× peak kW/kWh ratio

where:

| | |
|---|---|
| per unit energy reduction | = average kWh savings per cycle (across all currently available efficient products, weighted by products purchased in 2005) × #cycles × savings allocation across end-use and customer fuel type |
| kWh savings per cycle | = baseline kWh – efficient kWh |
| baseline kWh | = $cu.ft_{eff}$ / $MEF_{base}$ |
| efficienct kWh | = $cu.ft_{eff}$ / $MEF_{eff}$ |
| $cu.ft_{eff}$ | = capacity of clothes washer ($ft^3$) |
| $MEF_{base}$ | = MEF of baseline equipment |
| $MEF_{eff}$ | = MEF of installed equipment |
| #cycles | = number of cycles per year |
| savings allocation across end-use & customer fuel type | = allocation of saving according to electricity consumption percent by end-use and allocated to electric savings for electric end-uses |
| DryerSav % | = percent of savings consumed by removing remaining moister during dryer cycle |
| ElecDryer % | = percent of customers with electric dryer |
| DHWSav % | = percent of savings consumed by heating water for clothes washing |
| ElecDHW % | = percent of customers with electric DHW |
| MachineSav % | = percent of savings consumed by clothes washer machine operation |
| peak kW/kWh ratio | = avg. coincident peak kW during ISO performance hours / avg. annual energy consumption |

## Measure Life

Technical Support Document: Clothes Washers, DOE 2000

## Measurement and Verification Plan: ES Clothes Washer – Retail Sales

| Efficiency Measure | M&V Basis for Values for Savings Algorithm | | | | |
|---|---|---|---|---|---|
| | # Purchased | $cu.ft_{eff}$ | $MEF_{base}$ | $MEF_{eff}$ | #cycles |
| **ES Clothes Washer** | **Measured data** Customer, retailer, or other relevant market actor indicates manufacturer and model purchased and ultimate use (residential or commercial) on rebate form. Information from rebate forms collected and aggregated by EVT tracking system. Data from the previous year is used to predict current year's installations. | **Stipulated factor** Manufacturer's data | **Minimum Federal Standards** DOE 2007[13] | **Stipulated factor** Manufacturer's data | **Statistical sampling** RECS 2001 |

| Efficiency Measure | M&V Basis for Values for Savings Algorithm | | | | | |
|---|---|---|---|---|---|---|
| | DryerSav% | ElecDryer% | DHWSav% | ElecDHW% | MachineSav% | Peak kW/kWh ratios |
| **ES Clothes Washer** | **Engineering analysis** DOE 2000[14] | **Measured data** Customers indicate fuel type for clothes drying on rebate form. Information from rebate forms collected and aggregated by EVT tracking system | **Engineering analysis** DOE 2000 | **Measured data** Customers indicate fuel type for water heating on rebate form. Information from rebate forms collected and aggregated by EVT tracking system | **Engineering analysis** DOE 2000 | **Stipulated Factor** 8760 load shapes, Itron 2007 |

13 2007 MEF values from DOE – at:http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers
14 DOE Clothes Washer Technical Support Document is located at:
http://www.eere.energy.gov/buildings/appliance_standards/residential/clwash_0900_r.html
Energy and water savings estimates are located in Chapter 4, Engineering Analysis, Table 4.1, Page 4-5
http://www.eere.energy.gov/buildings/appliance_standards
/residential/pdfs/chapter_4_engineering.pdf

## A.6 Electric Domestic Hot Water System Fuel Switch

**Description**
An electric domestic hot water heater is replaced with a fossil fuel-based domestic hot water heater that meets the DOE minimum efficiency standards.

**ISO NE M&V Method**
Option A – Partially Measured Retrofit Isolation/Stipulated Measurement

**Algorithm**

**Total Demand Reduction**
Total demand reduction (kW) = # units installed × per unit energy reduction (kWh)
× peak demand : annual energy savings ratio

where:

ΔkWh = per unit kWh savings (across all currently available efficient products, based on water heating fuel and household size)
peak kW/kWh ratio = avg. coincident peak kW during ISO performance hours / avg. annual energy consumption

**Measure Life**

Engineering estimate – based on DOE Appliance Standards: Residential Water Heaters, 2000

**Measurement and Verification Plan: Electric Domestic Hot Water Fuel Switch**

| Efficiency Measure | M&V Basis for Values for Savings Algorithm | | |
|---|---|---|---|
| | **# Purchased** | **ΔkWh** | **Peak kW/kWh ratios** |
| **DHW Fuel Switch** | **Measured data**<br>Information about actual installations collected on-site by project managers and entered into tracking system. | **Engineering estimate***<br>DOE 2000;<br>RECS 1993, 2001 | **Stipulated factor**<br>8760 load shapes,<br>Itron 2007 |

* Hot water energy consumption based on RECS 1993 formula using Vermont inputs from Census data, verified with DOE national efficiency standards analysis (DOE 2000); calibrated to house size using 2001 RECS data

# Appendix B: Sampling Plan for Custom Projects

## B.1 General Approach

A custom measure or group of measures installed at a particular site is referred to in much of this documentation as a "project." This custom project is a component of the total savings portfolio which is treated as a single Project by the ISO. To avoid confusion, we use the term "portfolio" to refer to the collection of all measures and custom projects submitted as this ISO Project; we use the term "project" to refer to a particular installation or group of installations that is an element in this portfolio.

For custom measures, the general approach to savings verification is as follows.

1. As part of program operations, savings at the time of the ISO Summer and Winter peak periods are estimated for each individual project. These estimates use engineering formulas. For measures that will have interactive effects among multiple systems, simulation modeling may be used, particularly in new construction applications. Efficient and baseline equipment capacity and efficiency ratings are key inputs. Other inputs that may be used include operational patterns indicated by customers, load shapes for the market segment from an existing load shape library, EMS logs if available, and monitoring data collected for the project.

2. These estimates go through a series of internal reviews at EVT. Steps in this review process are described under "Gross Savings Verification Approaches" below. This internal review process has been revised in the past few years based on feedback to EVT from DPS in its oversight role. Below, we describe further enhancements in the form of increased levels of monitoring conducted on a sample basis as part of program operations.

3. As part of program evaluation, an aggregate adjustment to the overall custom program savings is developed by an independent third-party evaluator. This adjustment is based on the following steps.

    a. A sample of projects is selected, stratified by size (savings magnitude) and other characteristics.

    b. The savings is verified for the projects in the sample. The verification involves a combination of document review, onsite inspection, and metering. Details depend on the project characteristics. Some types of projects involve clear-cut engineering calculations with existing load shapes. Some are more complex and require more intense analysis and/or collection and analysis of project-specific monitoring data. Approaches for different project types are described below. A change planned from prior practice is that increased levels of monitoring will be conducted as part of program operations. The evaluation will use monitoring data collected by the program as well as its own monitoring data.

    c. The realization rate is calculated as the ratio of the average verified savings to the average tracked savings. Both the numerator and denominator averages are calculated over the verified sample, and sample expansion weights consistent with the sample design are applied in both averages. In some cases a regression relationship rather than the direct ratio of averages from the sample may be used to determine the relationship between the average of all tracked savings and the average verified savings.

d. The total of the tracked savings is multiplied by the realization rate to determine program-level verified savings[15]. This is the estimate of what the total verified savings would have been if all projects had been subject to the full verification process, rather than just a sample.

e. Statistical properties based on the sample design and the variability observed in the data provide estimates of the statistical accuracy of the overall estimate.

### Issues

This general approach requires attention to several issues or potential concerns. These issues include

- What is the rationale for statistical sampling from diverse projects? In particular, how is it possible to project savings for a very diverse set of projects from a sample of projects, many of which may be nothing like the remainder?
- How should the sample be designed?
- How are peak period savings determined given a particular savings algorithm?
- What is the verification process for the selected projects?

These issues are addressed in the remainder of this Appendix.

Additional related issues that affect prescriptive as well as custom components are discussed in Section 7. These issues include bias minimization and determination of portfolio level precision.

## B.2 Statistical estimation for diverse projects

### Validity of general approach

Statistical sampling for prescriptive measures selects a sample of similar projects to represent the full population of measures implemented through a program. By contrast, custom projects are necessarily non-homogenous. The sample used to determine the realization rate may have no measures that are similar to a particular project in the population.

Nevertheless, this approach provides a valid estimate, with valid precision calculation, of the savings for the population as a whole. The realization rate may not be correct for many

[15] Realization rates may be applied to the entire population of savings, or realization rates for each stratum may be applied to all savings within that stratum.

particular projects in the population, and is not intended to be. This rate is expected to be approximately correct for the total of all custom projects, within the bounds and reliability set by the reported precision and confidence level.

Projects do not need to be similar for the realization rate approach to be valid. Statistical sampling and estimation approaches are valid whether the population being sampled from is very homogenous or very diverse. However, a population of more diverse projects require larger sample sizes to achieve statistically reliable estimates for the population.

Appropriate sample design can improve the reliability for a given total sample size, or reduce the required sample size for a given level of reliability. Stratified sampling methods are designed to deal with diversity and to provide efficient (cost-effective) sampling for heterogeneous populations. The standard errors and associated precision appropriately indicate how reliable the estimates are, assuming bias is minimal. Similar approaches are common practice for evaluation of custom programs.

### Sample design

The sample design strategy used for custom projects consists in general of the following steps:

1. Stratify the projects. At a minimum, projects have been and will be stratified by savings magnitude. Other stratification variables that have been used and may be used in the future include program component and measure type, end use, or technology category.

2. Estimate the relative variability of the ratio of verified to tracked savings within the different sampling cells, based on prior experience.

3. Estimate the relative cost of verifying savings for projects in different cells.

4. Allocate sampling points to the cells according to standard statistical formulas to minimize the cost subject to the precision targets.

Specific procedures and formulas used are taken from the California Protocols and from standard textbooks.

This approach allocates the sample to cells such that those with larger total savings, and higher uncertainty/variability tend to have more of the sample. However, the sample allocation is reduced for those that are more expensive to verify.

This approach typically results in very large projects being selected with certainty. That is, very large projects are all targeted for inclusion in the sample. If all targeted projects are successfully verified, the very large projects contribute no sampling uncertainty to the total verified savings.

The approach also tends to result in relatively large fractions of population savings being included in the verification sample.

In prior evaluation efforts, annual kWh was used as the basis for size stratification. In future evaluations, ISO coincident peak kW will be the size measure for stratification.

### Real-time sampling for monitoring

For some types of monitoring, it will be necessary to select samples in "real time" as the program progresses. That is, projects must be selected for the monitoring sample as an ongoing part of program operations, rather than waiting until the end of a program year and selecting the entire sample at one time from the full population of projects. Reasons this ongoing selection is needed are

- Pre-installation metering may be required
- Monitoring must be accomplished during critical seasons to determine coincident peak impacts.

This ongoing sampling is required for monitoring only. Additional projects that do not require monitoring will be selected for other types of review and verification. Additional projects will also be selected for monitoring that does not need to be completed immediately.

To accomplish ongoing selection for in-program monitoring, the following steps are used.

1. Determine the sampling rates by sampling cell (project type/technology and size) based on prior experience. That is, determine what the sample stratification and allocation would be if the distribution of projects this year is similar to last year's, adjusted if needed for known program / participation changes.
2. For each type of technology and size level, rules are set for what types of monitoring are needed. Examples of rules that might be used include:
   a. All projects with savings > x included in sample
   b. Projects of size range x to y have 1/5 chance of inclusion
   c. Projects involving controls require 2 weeks of pre-installation monitoring and 6 weeks of post-installation monitoring
   d. Projects involving only efficiency change require post-installation monitoring only, and must capture cold weather and shoulder weather
   e. Projects involving only lighting measures where load shapes are adequately estimated in the regional study do not require any monitoring
   f. Projects with no weather-related or seasonal variation do not require monitoring until the evaluation phase
3. As each project is accepted into the program, the program administrator determines if the project requires in-program monitoring and arranges for the monitoring and associated site-level analysis to be done, based on the rules established.

The real-time sampling process has not been implemented to date, but will be used going forward. Our initial estimate is that 42 completed custom projects will need to be monitored to provide a precision level of 80/10 for the custom component as a whole. This sample size is based on an assumed coefficient of variation (c.v.) of 0.5. Our prior experience in general indicates this c.v. assumption or smaller is appropriate for custom projects with the stratified sampling and ratio estimation planned. We will review the sample variation from prior studies to determine specific appropriate c.v. assumptions for the sample allocation.

### Integration of In-Program Monitoring with Evaluation

In essence, the rules defined at step 2 divide the projects into three high-level sampling strata:

1. Projects for which all or a sample will be monitored by the program administrator
2. Projects for which all or a sample will be monitored by the evaluator
3. Projects for which no monitoring will be required, but for which a sample will be selected for verification review by the evaluator.

Each of these strata is further divided into finer sampling cells based on size and technology type. Sampling rates for in-program monitoring will be set for these cells based on the overall sample design, using assumed proportions of projects and savings in each cell and assumed variability based on prior years experience. Sampling rates for evaluation monitoring and verification will be based on savings estimates for the actual projects in the evaluated program year, with variability still based on prior year experience.

The third-party independent evaluator will

- Review the appropriateness of the in-program sampling, monitoring, and analysis procedures
- Review the administrator's compliance with these procedures
- Select additional sites for monitoring that did not require early monitoring as part of program administration (High level stratum 2)
- Select additional sites for verification review that did not require monitoring (High-level stratum 3)
- Verify the savings calculations for each site that had either in-program or post-program monitoring conducted, as well as for non-monitored sites selected for verification
- Calculate a realization rate from the overall sample

In calculating the overall realization rate, the program evaluator will combine the verified savings estimates from all three high-level strata.

### Realization rate calculation

The realization rates are calculated from the verification samples as the ratio of the average verified savings to average tracked savings in the sample. Each of these averages is weighted according to the expansion weights based on the sample design. Details of the calculations and associated standard error calculations follow standard practice as described in standard texts.

The realization rate is the estimated ratio of verified to tracked savings for the population. This rate is calculated from a sample drawn from the population of interest. Total savings for the population is then estimated by multiplying the realization rate by the total savings in the tracking data, using the same tracking data used to draw the sample and compute the realization rate. Improved estimates for specific projects that were developed as part of the verification process are not used to change the tracking data. Rather, the realization rate provides an aggregate adjustment for all projects, including those that were in the verification sample and those that were not.

## B.3 Peak savings determination

Peak kW savings are determined for the ISO system summer and winter peak hours. Coincident peak kW savings are determined by a variety of ways:

- Determine the maximum diversified kW savings, then apply a coincidence factor
- Determine the reduction in installed capacity, then apply a coincidence-diversity factor
- Determine annual savings, then determine the fraction of annual savings that occurs during the average system peak hour
- Directly determine the average savings at the system peak hours

All of these approaches rely in some way on an impact load curve—the impact of the measure at each hour of the year. For measures that affect efficiency only, and not timing of equipment use, the impact load curve can be assumed to have the same shape as the end use load shape. For measures that affect timing, the measure impact curve must be directly developed.

For past savings achievements, load shapes used have generally been based on the TRM, though some have been individually measured. Many of the load shapes in the TRM are based on regional studies or load shape libraries from past load research and others on engineering analyses. In the future, more projects will be individually metered to determine appropriate load shapes; in addition, new regional studies will be completed as a basis for some (i.e., HVAC) load shapes.

When metering is conducted for a specific project, the metering approach will vary according to the type of measure and how it is applied. Methods to be used for different conditions are indicated below.

1. Fixed load, stable operating schedule (e.g., lighting not represented by standard shapes under #2)

    a. Customer-reported schedule

    b. EMS logs if available

    c. Short-term on-off monitoring covering peak period(s) if EMS logs not available for adequate period

    d. Use customer-reported patterns to estimated annual pattern from short-term

2. Variable load, stable pattern over time

    a. Short-term load monitoring

    b. EMS logs if available

3. Variable load, weather dependent pattern

    a. Load monitoring over extreme and moderate weather conditions

    b. Modeling to determine normal-condition energy savings and CF

4. Variable load, inconsistent patterns without seasonality

    a. monitor long enough to capture typical distribution

5. Variable load, seasonally varying but inconsistent

    a. Short-term monitoring with seasonal adjustment based on customer-reported differences in use by season

    b. Long-term monitoring if no predictable patterns

## B.4 Gross Savings Verification Approaches

Savings verification occurs at several levels of detail, and is conducted by multiple parties.

1. All projects are reviewed as part of program administration. The type of review conducted depends on the size, type, and complexity of the project. Details on this review process as currently operated are provided in Efficiency Vermont's *Business Energy Services Project Review and Documentation Guidelines* (January 22, 2007 – attached as supporting documentation). Some of these operations will be modified to incorporate more monitoring as part of program administration, as indicated above. Levels of review include:

    a. Project pre-review, conducted by EVT prior to approval of incentive. Primarily for large projects.

b. Third-party review and assistance, conducted on behalf of EVT by an outside technical expert. Primarily for measures that are large, complex, unproven, and/or for which the EVT team lacks adequate internal expertise.

c. Pre- and post-installation metering, conducted under the direction of EVT. In the past, primarily for large, complex, and/or uncertain measures, or those that could be replicable once proven. Also used in other cases where data can easily be retrieved from a building energy management system or process control system. In the future, monitoring will also be conducted by the program on a sampling basis as described above under Real Time Sampling for Monitoring.

d. Technical peer review, conducted by a second qualified EVT manager all large projects.

e. Analysis Methodology review, conducted by an EVT manager, typically the technical peer reviewer, on all large and/or complex projects.

2. The program is evaluated by an independent third party.

a. The third party evaluation includes review of the documentation and savings estimates for a sample of individual projects. The sample is designed to provide at least 80/10 accuracy for the total demand savings at the ISO coincident peaks for the group of custom projects as a whole. The required sample size and sample allocation are based on procedures outlined in the California Protocols and in standard statistical texts. Variance assumptions for sample size and allocation determination are based on prior years' experience.

b. The evaluator develops a realization rate based on the sample and applies this realization rate to the full population of projects to determine total program savings.

Elements addressed by the internal verification process include

- Installation verification
- Baseline verification
- New equipment efficiency verification
- Operating hours determination
- Impact load shape determination
- Measure life determination

## B.5 Specific Assumptions Used

Specific assumptions and algorithms used to calculate savings are described in the Efficiency Vermont TRM Manual (Appendix C) for standard kinds of technologies. For technologies not covered by these general categories, assumptions and algorithms are determined on a case-by-case basis.

# Appendix C: Efficiency Vermont
# Technical Reference User Manual