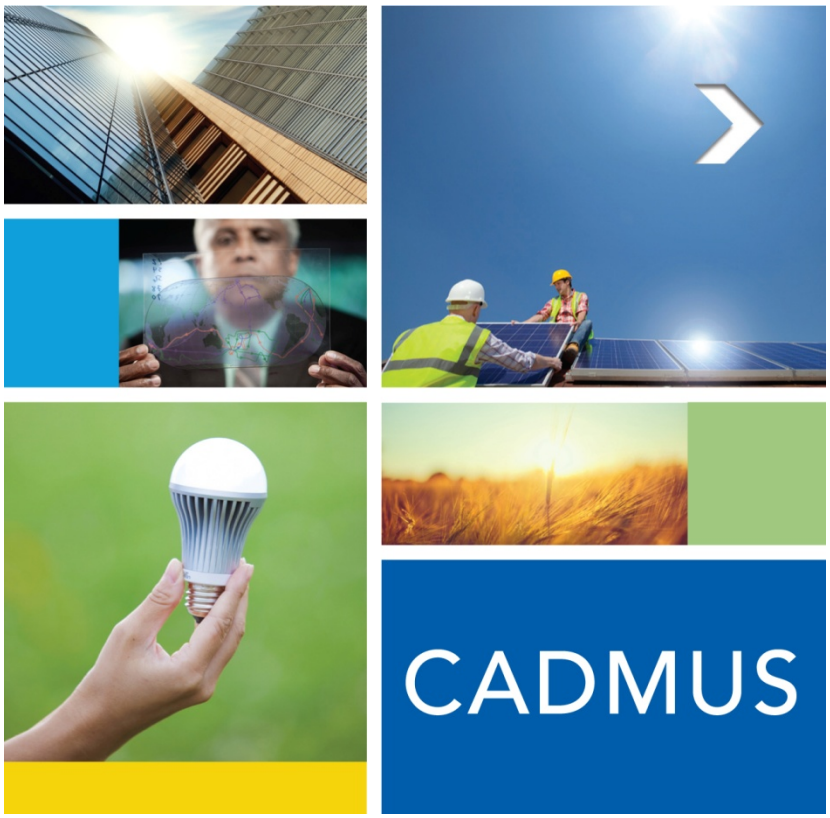

Report to Verify Efficiency Vermont 2015 Savings Claim

July 1, 2016

Vermont Department of Public Service
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Montpelier, VT 05620

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Acknowledgements

Cadmus thanks Barry Murphy at the Vermont Department of Public Service for his guidance throughout the project as well as all who contributed on behalf of Efficiency Vermont at the Vermont Energy Investment Corporation. We especially benefited from the knowledge and helpful contributions of Erik Brown, Bill Fischer, and Nikola Janjic.

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Executive Summary

On April 1, 2016, Vermont Energy Investment Corporation (VEIC), operating as Efficiency Vermont (EVT) under an order of appointment by the Public Service Board (PSB) to provide energy efficiency services to Vermont, submitted its "Savings Claim Summary 2015" to document its preliminary savings claim for year 2015 activities. To certify achieved savings towards VEIC's performance goals, the PSB requires the Vermont Department of Public Service (DPS) to verify the energy, coincident peak, and Total Resource Benefit (TRB) savings claimed by EVT. Through an RFP process, DPS selected Cadmus to complete the required verification. This report documents the findings and recommendations of this verification of the 2015 EVT savings claim.

This report summarizes the evaluation of the savings claimed for the entire EVT portfolio, including programs within commercial and industrial, multifamily, and single-family residential sectors.

As in previous years, this evaluation's short, three-month timeline and modest budget limited the effort to a desk review. Cadmus reviewed project files and an extensive database of measure data to accomplish the following:

- Verify that savings values and calculations had been applied correctly
- Calculate evaluated savings that incorporate any necessary corrections

Table 1 provides energy savings (kWh), winter peak demand savings (kW), and summer peak demand savings by program group.

Cadmus found some errors that resulted in higher-than-claimed savings and some that resulted in lower-than-claimed savings, but, in aggregate, evaluated savings nearly matched claimed savings for the entire portfolio: Total energy savings equaled 100.6 MWh, with a realization rate of 99.9%.

The EVT portfolio's 99.9% realization rate speaks well for EVT and for the efforts of VEIC, its implementer, in estimating and documenting savings. The realization rate proves particularly impressive considering the breadth and complexity of the EVT portfolio.

At the 90% confidence level, the relative precision of the realization rates for energy savings (kWh) is 3.4% for Commercial & Industrial/Multifamily (C&I/Multifamily) Custom Retrofit projects and 0.8% for C&I/Multifamily Custom New Construction and Market Opportunity (NC/MOP) projects. The relative precision for the portfolio as a whole is 0.6%.

Table 1. Electric Adjustment by Program Group

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
C&I and Multifamily						
Custom Retrofit*	18,526,757	103.4%	2,760	93.8%	2,089	90.2%
Custom NC/MOP*	15,002,920	95.8%	2,133	96.6%	2,516	97.2%
Prescriptive Lighting	5,912,371	98.9%	951	99.8%	586	100.0%
Prescriptive Non-Lighting	1,608,957	105.5%	188	107.5%	165	107.6%
Smartlight**	6,374,232	98.8%	833	98.6%	1,305	98.6%
Upstream HVAC	472,200	100.0%	24	100.0%	68	100.0%
C&I Subtotal	**47,897,436**	**99.9%**	**6,890**	**96.5%**	**6,730**	**95.8%**
Residential						
Efficient Products	42,459,497	99.9%	9,284	99.4%	4,942	96.9%
Residential Retrofit/Low Income Single Family	1,694,989	98.8%	366	99.9%	152	99.8%
Home Performance with ENERGY STAR***	120,824	100.0%	58	100.0%	-2	100.0%
Residential New Construction	988,967	99.3%	262	98.3%	90	97.7%
Smartlight	2,714,808	99.6%	651	99.8%	179	99.7%
Upstream HVAC	4,758,756	101.3%	857	98.6%	142	99.7%
Residential Subtotal	**52,737,841**	**100.0%**	**11,478**	**99.4%**	**5,503**	**97.2%**
Portfolio Total	**100,635,276**	**99.9%**	**18,368**	**98.3%**	**12,234**	**96.4%**

*These totals exclude any contributions from thermal energy and process fuels (TEPF)-funded measures but may include contributions from projects excluded from the sample frame because they achieved zero kWh savings.

**Savings reflect only Smartlight products sold for C&I installation.

***Savings claimed for the HPwES program already included adjustments taken from a prior-year's impact study. EVT applied realization rates of 86% for kWh and for both kW values. A 76% realization rate applied to MMBtu savings.

Table 2 summarizes the reductions in fossil fuel MMBtu and water savings—the two TRB components. Realization rates fluctuate across program groups, but overall realization rates remain high at 97.8% for MMBtu savings and 100% for water.

Table 2. TRB Adjustments by Program Group

Program Group	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
C&I and Multifamily				
Custom Retrofit*	8,109	92.1%	1,796	100.0%
Custom NC/MOP*	48,159	99.5%	5,200	99.1%
Prescriptive Lighting	-1,943	97.4%	0	100.0%
Prescriptive Non-Lighting	2,861	100.3%	193	134.2%
Smartlight**	-4,556	112.4%	0	100.0%
Upstream HVAC	0	100.0%	0	100.0%
C&I/Multifamily Subtotal	**52,631**	**97.3%**	**7,190**	**100.3%**
Residential				
Efficient Products	-4,917	78.6%	13,466	100.0%
Residential Retrofit/Low Income Single Family	414	114.5%	2,462	99.7%
Home Performance with ENERGY STAR***	19,027	100.0%	0	100.0%
Residential New Construction	9,527	78.8%	648	96.6%
Smartlight	0	100.0%	0	100.0%
Upstream HVAC	2,547	122.0%	0	100.0%
Residential Subtotal	**26,598**	**98.7%**	**16,576**	**99.8%**
Portfolio Total	**79,228**	**97.8%**	**23,766**	**100.0%**

*These totals exclude any contributions from TEPF-funded measures but may include contributions from projects excluded from the sample frame because they achieved zero kWh savings.

**Savings reflect only Smartlight products sold for C&I installation.

***Savings claimed for the HPwES program already included adjustments taken from a prior-year's impact study. EVT applied realization rates of 86% for kWh and for both kW values. A 76% realization rate applied to MMBtu savings.

Introduction

The annual Efficiency Vermont (EVT) savings claim verification addresses several needs, but the effort's primary purpose is to calculate realization rates for energy (kWh) and for winter and summer peak demand reduction (kW). After the evaluation team submits final realization rates, EVT applies these realization rates to its claimed savings numbers to arrive at actual gross savings estimates, which are used to calculate net savings and, ultimately, cost-effectiveness.

The savings claim evaluation also results in realization rates used to calculate Total Resource Benefits (TRB). TRB comprise annual savings in fossil fuels and wood fuel (MMBtu) and in water savings in hundreds of cubic feet (CCF).

Process

Work on the project began in mid-March of 2016, when EVT began providing Cadmus with project files on the largest custom C&I/Multifamily projects. At the end of March, EVT provided a database documenting savings for the entire portfolio. Cadmus queried this database to generate datasets needed to evaluate each program. After receiving the database, Cadmus sampled projects as necessary and requested files for the sampled projects.

During the course of the project, Cadmus provided savings reports for custom C&I/Multifamily projects as analysts completed them. This allowed EVT adequate time to provide relevant feedback within the short timeline of the evaluation.

The final version of this report, submitted by the July 1, 2016, deadline, documents all findings.

Scope

The short timeline and the budget for the project limited evaluation activities to a desk review of EVT's energy efficiency activities. Cadmus reviewed project files and an extensive database of claimed measure data to verify that savings values and calculations had been applied correctly, and to calculate evaluated savings that incorporate any necessary corrections. The evaluation did not include conducting surveys or site visits to verify the installation or correct operation of products or to verify baseline conditions. Similarly, no metering was performed, though the evaluation used available Advanced Metering Infrastructure (AMI) data to verify and adjust savings where practical for evaluated custom commercial and industrial projects.

The verification evaluated only gross savings at the meter. Factors such as freeridership, spillover, and line losses fall beyond the scope of this evaluation and were not considered.

Evaluating the methods used in the Vermont Technical Reference User Manual (TRM) also extended beyond project scope, as did a rigorous review of Efficiency Vermont's implementation of TRM methods. Any rigorous review of the EVT database itself also exceeded project scope. That said, Cadmus notified

EVT during the project of any errors found in the TRM or its application by EVT. Cadmus also provided high-level recommendations in the Recommendations section of this report.

Program Groups

Consistent with prior practice, Cadmus represented EVT programs in eight program groups. This report presents findings within the program groups and program tracks shown below:

- Commercial & Industrial/Multifamily (C&I/Multifamily) Custom Retrofit
- C&I/Multifamily Custom New Construction/Market Opportunity
- C&I/Multifamily Prescriptive
  - Prescriptive Lighting
  - Prescriptive Non-Lighting
- Commercial & Industrial Upstream
  - Smartlight
  - Upstream HVAC
- Residential Efficient Products
- Residential Retrofit/Low-Income Single-Family
  - Retrofit/Low-Income Single-Family
  - Home Performance with ENERGY STAR
- Residential New Construction
- Residential Upstream
  - Smartlight
  - Upstream HVAC and HP Water Heaters

Differences Relative to 2014 Evaluation

As a default, Cadmus maintained consistency with the prior-year's approach when structuring the evaluation, but some differences warrant discussion.

Program Groups

Program groups for the 2015 evaluation remained similar to those used in the 2014 effort, but dialogue among Cadmus, the Department of Public Service (DPS), and EVT led to several changes:

- The Custom Commercial & Industrial Multifamily (C&I/Multifamily) Retrofit and New Construction and Market Opportunity (NC/MOP) program groups currently omit projects that comprise only prescriptive measures.
- Custom C&I/Multifamily program groups include C&I/Multifamily projects that comprise custom measures of any type, including lighting.
- The C&I/Multifamily Prescriptive program group replaces C&I/Multifamily Stipulated Lighting. The new Prescriptive group includes C&I/Multifamily projects and rebate purchases.

Custom C&I/Multifamily Retrofit and NC/MOP Sampling Unit

For the 2015 evaluation, Cadmus sampled and analyzed Custom C&I/Multifamily savings by project rather than by site. Projects can span multiple sites, and energy-saving efforts for one site can comprise multiple projects.

Sampling by project simplified the request of project files from EVT. Sampling by site instead may have provided a potential benefit of allowing greater insight into possible interactive effects between measures from separate projects. Especially given the short timeline of this project, the evaluation team believed that any such benefit would be small in practice and would easily be outweighed by the more efficient use of limited resources allowed by sampling and analyzing at the project level.

Project Funding Considerations

Evaluating savings across the EVT portfolio required making choices about how to treat measures and projects funded by sources other than EVT.

Thermal Energy and Process Fuels

Discussions with DPS, EVT, and Cadmus led to the elimination of all Thermal Energy and Process Fuels (TEPF)-funded measures from Custom C&I/Multifamily projects for this evaluation. These measures often fundamentally differ from measures funded by EVT, typically focusing on MMBtu savings and offering little or no kWh or peak demand reduction. Including them in this analysis might have made realization less accurate for EVT-funded measures. Because of the different nature of TEPF-funded measures, realization rates calculated in this evaluation effort should not be applied to these measures.

Community Energy & Efficiency Development Fund

Some projects are fully or partially funded by the Community Energy & Efficiency Development (CEED) Fund. Previous-year evaluations found similar realization rates for projects funded in whole or part by the CEED Fund and those not receiving such funds. Accordingly, Cadmus did not eliminate measures funded by the CEED Fund or evaluate them separately but did verify that CEED projects were represented.

Methods

Cadmus used a range of methods to calculate evaluated savings and realization rates for each program track and group. The following sections describe the overall approach used for each program group. This section also documents methodologies used for sampling and for calculating realization rates for sampled program groups.

Commercial & Industrial/Multifamily Custom Retrofit

C&I/Multifamily Custom Retrofit projects accounted for 40% of C&I/Multifamily sector kWh savings and 19% of total portfolio kWh savings. This program comprised 298 complex projects not funded by TEPF and with non-zero savings in at least one of the evaluated savings categories. Projects ranged from relatively simple lighting retrofits to complex industrial processes.

Given the complexity and size of these custom projects, evaluating savings within the budget and timeline required sampling. Cadmus designed a sample to yield at least the 10% relative precision at 90% confidence customary for program evaluations; the design resulted in the selection of 34 projects. Realization rates calculated based on this sample were applied to the population of 298 projects to estimate population total savings. Additional details follow in the Sampling section.

The evaluation process for each project involved reviewing project files provided by EVT. Analysts examined calculation inputs, assumptions, methods, and documentation to assess whether or not the savings estimates were reasonable. For some projects with available electric metering data, analysts compared pre- and post-installation energy usage to assess the accuracy of savings estimates.

Commercial & Industrial/Multifamily Custom NC/MOP

C&I/Multifamily Custom NC/MOP projects accounted for 30% of C&I/Multifamily sector kWh savings and 14% of total portfolio kWh savings, with 231 projects meeting the evaluation criteria. As with the C&I/Multifamily Retrofit category, projects varied considerably in complexity and size, with the largest projects comprising hundreds of measures.

Cadmus used a sampling approach for this program group similar to that used for C&I/Multifamily Custom Retrofit: the team selected a random sample of 27 projects for evaluation and then estimated population total savings by applying the resulting realization rates to the population of 231 projects.

The evaluation process for each project also closely resembled that used for Custom Retrofit projects, though pre- and post-installation metering data were not available for new construction.

Commercial & Industrial/Multifamily Prescriptive

The C&I/Multifamily Prescriptive program group contributed 16% of C&I/Multifamily sector kWh savings and 8% of total portfolio kWh savings. Table 1 reports savings for two components—Prescriptive Lighting and Prescriptive Non-Lighting. Prescriptive Non-Lighting includes a variety of measures, such as HVAC, refrigeration, and compressed air.

All measures in this program group were prescriptive. To evaluate claimed savings, Cadmus generated savings estimates using methods defined for each measure by the Vermont TRM. Where EVT relied on deemed values defined by the TRM rather than TRM methods requiring more inputs, Cadmus used the same deemed values.

For the purpose of estimating savings, EVT and Cadmus assumed that 90% of lighting measures were purchased for C&I use and 10% were purchased for residential. This assumption led to calculating savings using C&I TRM methods for 90% of Prescriptive Lighting measures in this program track and Residential TRM methods for 10%.

Commercial & Industrial/Multifamily Upstream

Measures in the C&I/Multifamily Upstream program group made up 14% of C&I/Multifamily sector kWh savings and 7% of total portfolio kWh savings. Table 1 reports savings in two components—Smartlight and Upstream HVAC.

As with the C&I/Multifamily Prescriptive program group, all C&I/Multifamily Upstream measures were prescriptive. Cadmus generated savings estimates using methods the Vermont TRM defines for each measure. Where EVT relied on deemed values defined by the TRM rather than TRM methods requiring more inputs, Cadmus used the same deemed values.

All Smartlight measures assigned to this savings category were purchased for C&I use, so no split was applied to calculate some savings with Residential TRM assumptions.

Residential Efficient Products

With evaluated energy savings of 43,435 MWh, Residential Efficient Products accounted for more savings than any other program group. Efficient Products provided 81% of the kWh savings for the residential sector and 42% of total portfolio kWh savings.

All Residential Efficient Products measures were prescriptive. Measures included CFL and LED replacement lamps, ENERGY STAR appliances, heat pump water heaters, low-flow shower heads and faucet aerators, and others. As with other prescriptive measures, Cadmus generated savings estimates using methods defined for each measure by the Vermont TRM.

Residential Retrofit/Low-Income Single-Family

The Residential Retrofit/Low-Income Single-Family (LISF) program comprised three program tracks: Residential Single-Family Retrofit, LISF, and Home Performance with ENERGY STAR (HPwES). Table 1 reports savings separately for Retrofit/LISF and HPwES. Together, savings accounted for 3% of residential sector kWh savings and 2% of total portfolio kWh savings.

The HPwES program is funded exclusively by TEPF and comprised only custom measures, such as insulation and air sealing. Prior to claiming savings, EVT applied an 86% realization rate, taken from a previous-year impact study, to all HPwES kWh and kW savings. EVT applied a 76% realization rate to

MMBtu savings. Because these realization rates were applied before claiming savings and to remain consistent with previous-year evaluations, Cadmus passed through HPwES claimed savings at a 100% realization rate.

Prescriptive measures generated most savings for the Retrofit and LISF program tracks. Cadmus estimated savings using methods defined for each measure in the Vermont TRM. Where EVT relied on deemed values defined by the TRM rather than TRM methods requiring more inputs, Cadmus used the same deemed values.

Custom measures accounted for 14% of the savings for Retrofit and LISF programs combined and 0.2% of total portfolio savings. Consistent with the approach in previous-years, Cadmus accepted savings from these custom measures at a 100% realization rate.

Residential New Construction

Residential New Construction accounted for 2% of residential sector kWh savings and 1% of total portfolio savings. Approximately one-half of Residential New Construction kWh savings (53%) resulted from prescriptive measures such as ENERGY STAR appliances and energy-efficient lighting. Cadmus produced evaluated savings estimates using methods defined for each measure in the Vermont TRM.

Custom thermal measures such as insulation generated the remaining 47% of savings. As mandated by the Vermont TRM, savings for these measures were determined by comparing the results of a REM/rate model of the house as built with those from a model corresponding to a house constructed to code. To evaluate claimed savings, Cadmus generated REM/rate results using inputs (such as insulation levels) provided by EVT.

Residential Upstream

The Residential Upstream program group provided 14% of the residential sector kWh savings and 7% of total portfolio savings. Table 1 breaks savings out into two program tracks: Residential Smartlight and Upstream HVAC. The Upstream HVAC track primarily included cold-climate heat pumps, high-efficiency circulator pumps, and heat pump water heaters.

The great majority of Residential Upstream savings derived from prescriptive measures. Cadmus generated savings using methods defined in the Vermont TRM. The evaluation team accepted savings for custom solar hot water heating measures at a 100% realization rate.

Sampling

Cadmus developed a sampling plan for the C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP groups as described below, based on the Uniform Methods Project Sample Design and Cross-Cutting Protocols chapter.[1]

Sample Frame

Cadmus used project numbers to identify the population and sampling units for each C&I/Multifamily program group—Custom Retrofit and Custom NC/MOP. The evaluation examined project total reported energy savings and project total reported non-TEPF-sponsored kWh savings to determine projects eligible for sampling. This removed projects from the sample frame if funded by TEPF or exhibiting zero kWh savings.

Stratified Random Sample

Cadmus used a stratified random sample design for the evaluation, similar to that used for the previous evaluation. Table 3 provides an overview of the sample design for each program group. Cadmus defined stratum boundaries according to project total reported kWh savings. Table 3 lists the savings range within each stratum as the population minimum and maximum kWh. Cadmus calculated the coefficient of variation (CV) within each stratum, based on the mean and standard deviation of reported energy savings. The evaluation calculated sample sizes based on the CV, population size, and 80/20 confidence precision targets within each stratum. For each program group as a whole, the minimum confidence precision target was 90/10.

The sample design yielded sample sizes of 34 projects from the Custom Retrofit program and 27 projects from the NC/MOP program. To focus evaluation resources on projects that produced the highest savings and contributed the most to program totals, the Cadmus team evaluated a census of projects in the strata with the largest projects; the team evaluated no projects in the strata with the smallest projects (Stratum 0). Overall, sampled projects accounted for 48% of the total C&I/Multifamily Custom Retrofit kWh savings and 50% of the total C&I/Multifamily Custom NCMOP kWh savings.

The total sample size of 61 projects in this evaluation was somewhat smaller than the 68 projects used in the previous evaluation because the population was smaller—529 instead of 2,605. The smaller population partly resulted from a decision to remove prescriptive projects from the C&I/Multifamily custom program group.

[1] *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*, Chapter 11: Sample Design Cross-Cutting Protocols

Table 3. Overview of the Sample

Program Group	Stratum	Pop. Min kWh	Pop. Max kWh	Total Projects*	Projects in Sample	Sample kWh Total	Pop. kWh Total	% Sample kWh per Stratum Pop.
Retrofit	0	0	8,812	78	0	0	311,897	0%
	1	8,814	56,361	146	10	281,408	3,760,111	7%
	2	56,723	240,240	59	9	983,570	6,816,816	14%
	3	269,364	1,057,202	15	15	7,637,934	7,637,933	100%
Subtotal				**298**	**34**	**8,902,912**	**18,526,757**	**48%**
NC/MOP	0	-419	7,111	58	0	0	192,407	0%
	1	7,127	21,932	57	4	48,923	756,257	6%
	2	22,446	67,350	58	4	166,506	2,258,722	7%
	3	68,243	270,112	46	7	1,048,102	5,624,773	19%
	4	285,788	1,018,058	12	12	6,170,760	6,170,760	100%
Subtotal				**231**	**27**	**7,434,291**	**15,002,920**	**50%**
TOTAL				**529**	**61**	**16,337,203**	**33,529,676**	**49%**

*The number of projects with non-zero kWh, winter peak demand, summer peak demand, MMBtu, or water savings not provided by TEPF-funded measures.

Calculation of Realization Rates

Table 4 shows the sample weights calculated for each sample stratum. These weights were applied to the savings for each sampled project to estimate population total savings. The expansion weights equal the ratio of the total number of projects in each stratum to the number of sampled projects in that stratum. For example, for Stratum 2 in the retrofit program group, an expansion weight of 6.56 results from dividing 59 by 9.

Table 4. Expansion Weight by Stratum

Program Group	Stratum	Total Number of Projects*	Projects in Sample	Expansion Weight
Retrofit	0	78	0	0
	1	146	10	14.60
	2	59	9	6.56
	3	15	15	1.00
NC/MOP	0	58	0	0
	1	57	4	14.25
	2	58	4	14.50
	3	46	7	6.57
	4	12	12	1.00

*Number of projects with non-zero kWh, winter peak demand, summer peak demand, MMBtu, or water savings not provided by TEPF-funded measures.

Using the following equation, Cadmus calculated realization rates for the population total savings based on the expansion weights, the evaluated savings for each sampled project, and the claimed savings for each sampled project:

$$\text{Realization Rate} = \frac{\sum_{\text{sample}} w_{h(i)} * y_i}{\sum_{\text{sample}} w_{h(i)} * x_i}$$

Where:

Realization Rate = the ratio of evaluated savings to claimed savings
h = stratum number
i = project number
$w_{h(i)}$ = expansion weight of stratum for project i
y_i = evaluated savings for project i
x_i = claimed savings for project i

Adjustments

Evaluation and EVT QC activities identified necessary adjustments in each program group, though realization rates remained close to 100% for the portfolio as a whole. This section summarizes adjustments made within each program group.

Commercial and Industrial/Multifamily Custom Retrofit

As shown in Table 5, savings adjustments resulted in higher evaluated kWh savings within the C&I/Multifamily Custom Retrofit program group and somewhat lower winter and summer peak demand reduction.

Table 5. C&I/Multifamily Custom Retrofit Electric Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Custom Retrofit	18,526,757	103.4%	2,760	93.8%	2,089	90.2%

Table 6 lists all sampled C&I/Multifamily Custom Retrofit projects that the evaluation team identified as needing project-specific adjustments and includes a summary explaining why each project required adjustments. Cadmus provided detailed reports for all projects in the largest-savings stratum to DPS and EVT during the evaluation process. As described in the Sampling section of this report, evaluated and claimed savings for each project in the sample then were used to calculate realization rates for the program group as a whole.

Table 6. Sampled C&I/Multifamily Custom Retrofit Project with Adjustments

EVT Project ID	Project	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
430452	Milton High School	1	24,025	95.6%	360.9%	487.4%	Fan electrical energy savings and peak demand reduction adjusted, based on available metering data.
432367	T.J. Maxx in St. Albans	1	15,244	541.5%	230.8%	134.0%	No calculations submitted for this project. Savings calculated using AMI data for pre- and post-installation periods, normalized based on outside air dry bulb temperatures.
433847	NSK Steering Systems	2	71,017	97.9%	98.2%	98.3%	Input wattage for LED fixtures corrected, based on the equipment cut sheet.
434994	National Life	2	229,097	53.6%	51.5%	56.0%	Results for four unmetered units adjusted to account for

EVT Project ID	Project	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
	Insurance Company						the much smaller area served by each unmetered unit (150 sq. ft.) than served by each metered unit (1,350 sq. ft.).
410659	Barre City	3	402,881	88.2%	90.0%	n/a	Fixture counts adjusted.
430874	Columbia Forest Products	3	325,473	100.0%	87.2%	87.2%	Demand savings adjusted to reflect actual logged operation during peak grid demand periods rather than TRM coincident factors and average demand savings.
431124	St. Michael's College	3	554,554	102.0%	100.8%	101.3%	Fixture counts and lamp input wattage adjusted.
435264	C&S Wholesale Grocers	3	1,057,202	137.8%	112.9%	112.9%	Operating hours and occupancy savings factor corrected for the refrigerated warehouse.
437271	Cersosimo Lumber Mill	3	1,052,067	119.7%	119.7%	119.7%	Baseline calculations and inputs adjusted to more accurately represent baseline energy usage.
437282	Mount Snow	3	635,934	94.3%	92.7%	66.7%	Savings from DDC thermostat installation excluded because of no accompanying description or calculations of control methods to be implemented with the thermostats.
438881	Cabot Creamery	3	339,669	90.1%	100.0%	n/a	Demand penalty included for temperature bins where the system will operate at a higher discharge pressure than the baseline.
443331	Kohl's South Burlington LED Retrofit	3	329,832	91.0%	91.1%	91.0%	Fixture counts and lamp input wattage adjusted.

EVT Project ID	Project	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
444009	Waterbury Village Market	3	328,645	58.2%	49.4%	39.1%	Input to Refrigeration Analysis Tool corrected, based on relevant compressor performance documents.
445316	Vermont Country Store	3	269,364	111.9%	100.0%	100.0%	Calculations corrected to incorporate the efficiency of the baseline motors.
448156	Question Wood Pellets	3	810,451	99.0%	20.6%	20.6%	Demand calculation corrected to provide a more realistic estimation of demand reduction.

Commercial and Industrial/Multifamily Custom NC/MOP

As shown by the realization rates in Table 7, adjustments to the C&I/Multifamily Custom NC/MOP program group resulted in somewhat lower evaluated savings.

Table 7. C&I/Multifamily Custom NC/MOP Electric Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Custom NC/MOP	15,002,920	95.8%	2,133	96.6%	2,516	97.2%

Table 8 lists all sampled C&I/Multifamily Custom NC/MOP projects that the evaluation team identified as needing project-specific adjustments. The table includes a summary of why adjustments for each project were necessary. Cadmus provided DPS and EVT with detailed reports for all projects in the largest-savings stratum during the evaluation process. As described in this report's Sampling section, evaluated and claimed savings for each project in the sample were then used to calculate the realization rates for the program group as a whole.

Table 8. Sampled C&I/Multifamily Custom NC/MOP Projects with Adjustments

EVT Project ID	Project	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
442610	Vermont Cranberry Company	1	7,986	96.6%	96.4%	96.7%	Number and wattage of proposed freezer evaporative fans adjusted, based on nameplate data.
449784	Cummins Electric	2	30,538	52.5%	58.2%	88.0%	Calculation input correction increased allowable baseline

EVT Project ID	Project	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
							wattage by more than 1,000% for fixtures at five exterior doors.
429593	50 Eastwood Drive	3	175,154	87.3%	89.9%	97.0%	Baseline lighting burn hours and energy consumption corrected in one of the basement lighting areas.
437141	Vermont Army National Guard	3	179,573	93.4%	90.9%	92.9%	Fixture counts adjusted to match post-implementation verification notes.
437998	Tech Vault Server Room	3	183,015	87.2%	80.6%	81.3%	Inputs corrected, including number of cooler units and two VFD inputs.
438413	Finney Crossing Apartments	3	129,858	84.3%	85.7%	87.2%	Number of installed LED fixtures corrected.
402070	Vermont Public Health Laboratory	4	697,621	125.6%	100.0%	100.0%	Baseline inputs corrected for eQuest simulation.
407818	Southwestern Vermont Healthcare Chiller Plant and AHU EEMs	4	342,142	103.4%	n/a	103.4%	Calculations corrected to incorporate fan efficiency and to include appropriate conversion factors.
416214	Hermitage Holdings Base Lodge	4	317,913	90.6%	100.0%	100.0%	Minimum temperature at which chiller VFD pumps would run increased to 60°F; Chiller EER corrected.
418651	Middlebury College Field House	4	616,537	97.2%	95.8%	96.0%	Fixture counts and lamp input wattages adjusted as necessary; inputs to TRM and custom engineering calculations corrected.
425832	NSK Steering Systems	4	285,788	85.0%	107.8%	107.7%	Baseline compressor part-load control corrected from modulating to load/unload; summer and winter kW demand savings adjusted to reflect metered operation during peak demand periods.

EVT Project ID	Project	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
428032	Burke Mountain Ski Area Hotel	4	1,018,057	107.3%	107.7%	94.4%	Assumptions corrected about usage of two-pump systems and exponents used for VFDs; lamp wattage updated for many fixtures.
429623	Manchester Hotel	4	600,680	97.5%	100.0%	100.0%	Inputs adjusted, such as pounds of food dried and pounds of ice made each day.
430438	Essex Junction Wastewater Treatment Plant	4	772,692	95.7%	113.2%	113.2%	Results determined through analysis of AMI data.
435612	Keurig Green Mountain	4	409,741	121.2%	125.1%	99.8%	Performance curve of installed air compressor unit used instead of a generic curve.
437600	Capital Candy	4	513,012	69.3%	91.8%	72.9%	Inputs to calculation of savings corrected for the hot gas defrost measure.
440732	Hannaford Brothers	4	310,703	99.1%	98.7%	97.0%	Freezer count adjusted to match the number in the analysis file.

Commercial and Industrial/Multifamily Prescriptive

In the C&I/Multifamily Prescriptive program group, savings for prescriptive lighting measures were adjusted slightly down. Demand reduction remained virtually unchanged. Savings for prescriptive non-lighting measures were adjusted upward. Table 9 summarizes adjustments to kWh and winter and summer kW.

Table 9. C&I/Multifamily Prescriptive Electric Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Prescriptive Lighting	5,912,371	98.9%	951	99.8%	586	100.0%
Prescriptive Non-Lighting	1,608,957	105.5%	188	107.5%	165	107.6%
Total	**7,521,328**	**100.3%**	**1,139**	**101.1%**	**752**	**101.7%**

Most prescriptive lighting measures received an adjustment, primarily due to one issue: as identified independently by Cadmus and EVT during evaluation, the EVT savings databases rounded TRM wattage inputs to the nearest whole number for many lighting measures, creating rounding error.

For prescriptive non-lighting measures, the evaluation team adjusted energy savings or demand reduction on 13 measures for which savings estimates generated using Vermont TRM assumptions differed from EVT database values. The evaluation adjustments resulted in a net increase in gross energy saved and in winter and summer demand reduction.

Cadmus provided information about measure-level adjustments to DPS and EVT as part of the evaluation and QC processes.

Commercial and Industrial/Multifamily Upstream

As shown in Table 10, the evaluation team made minor adjustments to savings in the C&I/Multifamily Upstream program.

Table 10. C&I/Multifamily Upstream Electric Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Smartlight	6,374,232	98.8%	833	98.6%	1,305	98.6%
Upstream HVAC	472,200	100.0%	24	100.0%	68	100.0%
Total	**6,846,432**	**98.9%**	**857**	**98.7%**	**1,373**	**98.7%**

C&I Smartlight measures accounted for all adjustments in this program group. The evaluation team adjusted energy savings or demand reduction on 14 measures for which savings values generated using Vermont TRM assumptions differed from EVT database values. The adjustments generally resulted from differences between TRM and EVT database values for the given measures. For example, with one T8 lighting measure with an especially high number of installations, the EVT database used a wattage value of 24 for the energy-efficient lamp instead of 25 watts, making the power reduction 4 watts per lamp rather than 3 watts.

As part of the evaluation and QC processes, Cadmus provided information about measure-level adjustments to DPS and EVT.

Residential Efficient Products

The evaluation team identified necessary adjustments to several lighting and appliance measures within the Efficient Products program group, but the adjustments largely offset one another, resulting in realization rates for energy savings and demand reduction close to 100%. Table 11 summarizes the necessary adjustments.

Table 11. Efficient Products Electric Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Efficient Products	42,459,497	99.9%	9,284	99.4%	4,942	96.9%

Adjustments to residential lighting products proved minimal and appeared to result from rounding error and, in some cases, database inputs that mixed values from commercial and residential TRM assumptions. Database values for some lamps sold in packs of two or four appeared to claim savings for a single lamp.

Claimed savings for heat pump water heaters were underreported by roughly 20%, because the EVT database mistakenly used values from a previous TRM version. This change had relatively little impact on the overall realization rate for Efficient Products because heat pump water heaters accounted for a small percentage of savings. Demand reduction for ENERGY STAR clothes washers was significantly overstated because of an apparent discrepancy between TRM and database values, though again this had relatively little impact on overall realization rates for Efficient Products.

Cadmus provided information about measure-level adjustments to DPS and EVT as part of the evaluation and QC processes.

Residential Retrofit/Low-Income Single-Family

Overall, only minor adjustments were necessary to realization rates for energy savings and demand reduction for the Residential Retrofit/LISF program group. Table 12 summarizes the necessary adjustments.

Table 12. Residential Retrofit/Low Income Single Family Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Residential Retrofit/ LISF	1,694,989	98.8%	366	99.9%	152	99.8%
HPwES	120,824	100.0%	58	100.0%	-2	100.0%
Total	**1,815,813**	**98.8%**	**424**	**99.9%**	**150**	**99.8%**

As discussed earlier in this report, EVT applies an 86% realization rate to energy savings and demand reduction for all HPwES projects before claiming savings. Cadmus accepted those claimed savings with a realization rate of 100%.

Heat pump water heater measures accounted for the largest adjustments within the Residential Retrofit and LISF program tracks. As with efficient products, claimed savings for heat pump water heaters

apparently differed from evaluated savings because the EVT database mistakenly used values from a previous version of the TRM.

Cadmus provided information about measure-level adjustments to DPS and EVT as part of the evaluation and QC processes.

Residential New Construction

As shown in Table 13, Residential New Construction received only minor adjustments to energy savings and demand reduction.

Table 13. Residential New Construction Electric Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Residential New Construction	988,967	99.3%	262	98.3%	90	97.7%

Custom thermal measures such as insulation and air sealing produced 47% of energy savings for the Residential NC program group. As shown in Table 14, adjustments to these custom measures effectively accounted for all net adjustment in energy savings for the Residential NC program group. Prescriptive measures contributed to demand reduction adjustments, partly because database values overstated demand reduction for ENERGY STAR clothes washers by a factor of three.

Table 14. Residential New Construction Electric Adjustments by Measure Type

Measure Type	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Residential NC Prescriptive	525,308	100.0%	139	98.5%	45	96.2%
Residential NC Custom	463,659	98.5%	123	98.1%	45	99.1%
Total	**988,967**	**99.3%**	**262**	**98.3%**	**90**	**97.7%**

TRB adjustments to Residential New Construction contributed considerably to the MMBtu adjustment for the portfolio as a whole. Custom thermal measures within Residential NC accounted for 9,405 MMBtu savings of the 79,228 portfolio total (about 12%) and had a realization rate of 78.5%. The chief contributor was an error in interpreting REM/rate results: in some cases, a conversion from cords of wood to MMBtu was applied to REM/rate results where no conversion was needed.

Table 15. Residential NC TRB Adjustments by Measure Type

Measure Type	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Residential NC Prescriptive	122	100.2%	648	96.6%
Residential NC Custom	9,405	78.5%	0	0.0%
Total	**9,527**	**78.8%**	**648**	**96.6%**

Cadmus provided information about measure-level adjustments to DPS and EVT as part of the evaluation and QC processes.

Residential Upstream

Adjustments to the Residential Upstream program group were minor. Table 16 provides energy savings and demand reduction realization rates for residential Smartlight measures and Upstream HVAC measures.

Table 16. Residential Upstream Electric Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Smartlight	2,714,808	99.6%	651	99.8%	179	99.7%
Upstream HVAC	4,758,756	101.3%	857	98.6%	142	99.7%
Total	**7,473,564**	**100.7%**	**1,508**	**99.1%**	**322**	**99.7%**

Smartlight adjustments were driven partly by rounding error and partly by relatively large differences in one measure: for LED Decorative lighting, the EVT database appeared to use TRM values for omnidirectional rather than decorative lighting.

Adjustments for the non-lighting portion of Residential Upstream can be attributed mostly to the previously discussed issue with heat pump water heaters: the EVT database mistakenly used values from a previous TRM version.

As part of the evaluation and QC processes, Cadmus provided information about measure-level adjustments to DPS and EVT.

Recommended Improvements

The 99.9% realization rate for the EVT portfolio as a whole speaks well for EVT and for the efforts of its implementer, Vermont Energy Investment Corporation (VEIC), in estimating and documenting savings. The realization rate is particularly impressive considering the breadth and complexity of the EVT portfolio.

Cadmus understands that, as a company entrusted with implementing energy efficiency programs on behalf of Vermonters, EVT strives for continual improvements in its methods and processes. The evaluation team provides the following recommendations in the spirit of contributing to that effort.

Custom Commercial, Industrial, and Multifamily Projects

Cadmus performed detailed evaluations of 61 custom projects, based on extensive project files submitted by EVT. Individual project reports included recommendations related to calculating savings from specific types of equipment, such as variable frequency drives (VFDs) and refrigeration. The following recommendations apply to a broader range of technologies and projects.

Consistently Provide Thorough Overview Documentation

EVT staffers and outside analysts would benefit from EVT consistently providing thorough project overviews. Overviews should include all information necessary for an experienced analyst to quickly understand project scope, how savings were calculated, what inputs and assumptions informed those calculations, and what documentation supports those inputs and assumptions. Where including all of this information in the overview proves impractical, the overview should reference additional project documents that provide the necessary information.

Improve Organization of Project Files

Cadmus recommends implementing a system of organizing and labeling project files and folders to make it easier for internal and external parties to understand and use information stored for each custom project. Organization also can be improved by clearly labeling multiple versions of one file and by loading manufacturer cut sheets and other key documents into the workbook used to calculate savings for a given measure.

Consistently Provide and Document All Relevant Inputs

The evaluation team encourages EVT to continue improving the capability to accurately estimate and evaluate project savings by working to ensure all relevant inputs are provided for each measure and that all inputs are supported by a source document or a reference to that source. Where inputs have been based on assumptions, those assumptions and the rationale behind them should be clearly documented.

Avoid Use of TRM Assumptions

Cadmus encourages EVT to continue its efforts to reduce its reliance on TRM values for custom projects. Wherever practical, EVT should base calculations on actual input values rather than TRM assumptions. For custom projects, actual values should be readily available from drawings, cut sheets, nameplates,

product invoices, and other documentation. Similarly, using performance curves for the specific equipment involved is always preferable to using generic performance curves.

Improve Post-Installation Verification and Measurement

EVT should continue to strengthen its use of post-installation metering and site visits to allow a more accurate understanding of actual savings.

Prescriptive Measures

Most or all savings from six of the eight program groups defined for this evaluation resulted from prescriptive measures. For prescriptive measures, the Vermont TRM documents deemed savings values per unit of product or measure installed, or it defines how savings should be calculated for each unit using available inputs. As indicated by a realization rate very close to 100% for most prescriptive program groups, Cadmus found little room for overall improvements while evaluating claimed savings for the prescriptive measures.

Evaluating the methods used in the Vermont TRM falls beyond the scope of this project, as does rigorous review of how Efficiency Vermont implements TRM methods to calculate claimed savings. The following recommendations identify a few areas in which the accuracy of claimed savings calculations may be improved using current methods.

Increase Rigor in Applying the TRM Methods When Practical

Cadmus recommends increasing the use of TRM methods that account for differences in baseline conditions and the products themselves when practical, and making less use of deemed values. In some cases, using more-rigorous TRM methods would require collecting and managing more data about baseline conditions and the equipment installed.

Ensure Consistent Implementation of TRM Values

Cadmus found relatively few errors in EVT's application of the TRM to arrive at database values and recommends that EVT continue to strengthen and refine its internal quality assurance processes to minimize such errors.

Ensure Database Values Allow as Many Significant Digits as the TRM

Cadmus recommends ensuring that the database per-unit values match the number of significant digits provided by values in the TRM. During the evaluation, EVT noted that it was aware of this and was implementing a fix.

Custom Residential Measures

Custom measures in the Residential New Construction, HPwES, and Low-Income Single Family-Retrofit program tracks drive only a small percentage of residential savings—1.6%. As discussed, EVT applies realization rates determined through a prior impact analysis to arrive at the HPwES program's claimed savings. The Residential NC program track determines savings through REM/rate analysis.

Though their small impact on overall realization rates makes it difficult to justify extensive analysis and verification efforts for these custom measures, Cadmus offers the following recommendations.

Apply Impact Analysis Results to All Residential LISF Custom Measures

Cadmus recommends conducting billing analysis studies to determine realization rates for custom measures in the residential LISF track where budget and priorities allow. Predetermined realization rates are already applied to HPwES measures, and this approach could be used with custom measures outside of HPwES if billing analysis is performed to establish representative realization rates.

Database Review and Dataset Generation

EVT provided database tables relevant to the evaluation early in the project cycle to allow construction of analysis datasets. Cadmus applauds the extensive, high-quality documentation provided with the database, which easily proves sufficient for an experienced database analyst or developer to quickly understand the database content and structure. Recommendations follow.

Update Database Documentation

Cadmus recommends updating documentation to bring it into sync with the present database structure. Modifying workflow to require updating documentation with planned changes prior to implementing those changes helps ensure that documentation remains current.

Provide Datasets by Program or Program Track

EVT provided a large subset of its relational database to Cadmus rather than providing datasets created for each program or program track. Having developed datasets for the 2015 evaluation, Cadmus is well placed moving forward to continue using this approach. As a long-term recommendation, however, Cadmus suggests that EVT use its extensive knowledge of the database and programs to provide targeted datasets and relevant portions of the EVT relational database. This would provide greater efficiency for outside organizations while continuing the laudable transparency of the current approach.

Appendix A. Commercial & Industrial/Multifamily Custom Retrofit Project Reports

A document available as a separate attachment provides a report for each census-stratum project that required adjustments in the C&I/Multifamily Custom Retrofit program group.

Appendix B. Commercial & Industrial/Multifamily Custom NC/MOP Project Reports

A document available as a separate attachment provides a report for each census-stratum project that required adjustments in the C&I/Multifamily Custom NC/MOP program group.