



Report to Verify Efficiency Vermont 2016 Savings Claim

June 30, 2017

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Executive Summary

On April 1, 2017, 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 2016” to document its preliminary savings claim for year 2016 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 2016 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. Table 1 provides portfolio-wide realization rates for energy saved (kWh), winter peak demand reduction (kW), and summer peak demand reduction (kW).

Table 1. Portfolio 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
Portfolio Total	111,451,089	98.2%	19,717	99.0%	13,229	102.6%

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 2 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. Total claimed energy savings equaled 111.5 GWh, with a realization rate of 98.2%.

The EVT portfolio’s 98.2% 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 1.4% for Commercial & Industrial/Multifamily (C&I/Multifamily) Custom Retrofit projects and 2.7% for



C&I/Multifamily Custom New Construction and Market Opportunity (NC/MOP) projects. The relative precision for the portfolio as a whole is 0.5%.

Table 2. 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*	25,695,940	98.4%	4,692	96.3%	2,754	115.7%
Custom NC/MOP*	15,102,430	89.4%	1,835	103.6%	2,317	97.2%
Prescriptive Lighting	5,607,106	99.7%	909	100.0%	658	99.9%
Prescriptive Non-Lighting	1,293,381	100.2%	143	101.1%	142	100.0%
Smartlight**	11,810,173	100.0%	1,485	100.7%	2,159	101.1%
Upstream HVAC	465,562	98.8%	57	96.6%	56	100.0%
C&I Subtotal	59,974,591	96.7%	9,121	98.9%	8,086	104.9%
Residential						
Efficient Products	40,949,308	99.9%	8,341	99.0%	4,570	98.9%
Residential Retrofit/Low-Income Single-Family	1,466,625	107.3%	309	106.2%	109	107.1%
Home Performance with ENERGY STAR***	187,627	100.0%	86	100.0%	0	100.0%
Residential New Construction	1,443,599	91.7%	384	91.8%	134	92.7%
Smartlight	4,340,546	100.1%	1,075	100.1%	296	100.0%
Upstream HVAC	3,088,793	100.0%	400	97.1%	33	104.1%
Residential Subtotal	51,476,498	99.9%	10,596	99.0%	5,143	99.0%
Portfolio Total	111,451,089	98.2%	19,717	99.0%	13,229	102.6%

*These totals exclude any contributions from thermal energy and process fuels (TEPF)-funded measures.

**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.

Table 3 summarizes the reductions in fossil fuel MMBtu and water savings—the two TRB components. Realization rates fluctuate across program groups, but the overall realization rate remains high for MMBtu savings at 99.7%. One very large error in the Custom C&I NC/MOP program category lowered the overall realization rate for water savings to 56.8%. The water savings realization rate was close to 100% for most program groups.

Table 3. 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*	5,261	106.9%	38,459	100.0%
Custom NC/MOP*	19,072	99.0%	46,695	12.0%
Prescriptive Lighting	-2,368	99.9%	0	n/a
Prescriptive Non-Lighting	2,512	84.4%	147	117.2%
Smartlight**	-9,634	99.9%	0	n/a
Upstream HVAC	0	n/a	0	n/a
C&I/Multifamily Subtotal	14,842	98.6%	85,301	51.8%
Residential				
Efficient Products	-4,971	99.9%	7,516	100.0%
Residential Retrofit/Low Income Single Family	1,026	100.0%	1,610	102.1%
Home Performance with ENERGY STAR***	16,005	100.0%	1	100.0%
Residential New Construction	8,788	100.0%	628	100.5%
Smartlight	0	n/a	0	n/a
Upstream HVAC	38,559	100.0%	0	n/a
Residential Subtotal	59,406	100.0%	9,754	100.3%
Portfolio Total	74,249	99.7%	95,055	56.8%

*These totals exclude any contributions from TEPF-funded measures.

**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 a realization rate of 76% 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 comprises annual savings in fossil fuels and wood fuel (in MMBtu) and in water savings in hundreds of cubic feet (CCF).

Process

Work on the project began in early March of 2017, after EVT began providing Cadmus with project files on the largest custom C&I/multifamily projects. Mid-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, 2017, 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; see 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
- C&I/Multifamily 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 Heat Pump Water Heaters

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

As with the 2015 evaluation, the evaluation excluded all thermal energy and process fuels (TEPF)-funded measures from C&I/Multifamily Custom projects. These measures often fundamentally differ from measures funded by EVT, typically focusing on MMBtu savings and offering little or no kWh savings or peak demand reduction. Including them in this analysis might have made realization rates less accurate for EVT-funded measures. Accordingly, DPS requested that the evaluation team analyze the savings for TEPF-funded measures separately, by evaluating the savings of separate stratified samples. The evaluation team will report realization rates for these C&I/Multifamily Custom TEPF-funded savings in a separate document.



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 44% of C&I/multifamily sector evaluated kWh savings and 23% of total portfolio evaluated kWh savings. This program comprised 339 complex projects with non-TEPF-funded 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 30 projects. Realization rates calculated based on this sample were applied to the population of 339 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 23% of C&I/multifamily sector evaluated kWh savings and 12% of total portfolio evaluated kWh savings, with 265 projects meeting the evaluation criteria. As with the C&I/Multifamily Custom 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 26 projects for evaluation and then estimated population total savings by applying the resulting realization rates to the population of 265 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 12% of C&I/multifamily sector kWh evaluated savings and 6% of total portfolio evaluated kWh savings. Table 2 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.

Commercial & Industrial/Multifamily Upstream

Measures in the C&I/Multifamily Upstream program group made up 21% of C&I/multifamily sector kWh savings and 11% of total portfolio kWh savings. Table 2 reports claimed savings for the group’s 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.

Residential Efficient Products

With evaluated energy savings of more than 40 GWh, Residential Efficient Products accounted for more savings than any other program group. Residential Efficient Products provided 80% of the evaluated kWh savings for the residential sector and 37% of total portfolio evaluated 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 2 reports combined savings for Residential Single-Family Retrofit and LISF; it reports savings for HPwES separately. Together, savings from all three tracks accounted for 3% of residential sector evaluated kWh savings and 2% of total portfolio evaluated 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 EVT claimed 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 Single-Family 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 11% of the savings for Single-Family 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 3% of residential sector evaluated kWh savings and 1% of total portfolio savings. Approximately one-half of Residential New Construction kWh savings (52%) 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 48% 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 evaluated kWh savings and 7% of total portfolio evaluated savings. Table 2 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 resulted from prescriptive measures. Cadmus generated savings using methods defined in the Vermont TRM.

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 non-TEPF-sponsored kWh savings to determine projects eligible for sampling. Cadmus removed projects

¹ M. Sami Khawaja et al., *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*, [Chapter 11: Sample Design Cross-Cutting Protocols \(National Renewable Energy Laboratory, 2013\)](#)



from the sample frame if they exhibited zero non-TEPF-funded kWh, winter kW, summer kW, MMBtu, and water savings.

Stratified Random Sample

Cadmus used a stratified random sample design for the evaluation, similar to that used for the previous evaluation. Table 4 provides an overview of the sample design for each program group. Cadmus defined stratum boundaries according to project total reported non-TEPF-sponsored kWh savings. Table 4 lists the savings range for 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. Cadmus then 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 samples of 30 projects from the Custom Retrofit program and 26 projects from the NC/MOP program. To focus evaluation resources on projects that produced the highest savings and contributed the most to program totals, Cadmus evaluated a census of projects in the strata with the largest projects (Stratum 4); 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 NC/MOP kWh savings.

Table 4. 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	1	25,357	169	0	0	1,713,604	0%
	1	25,774	67,901	85	4	164,275	3,667,091	4%
	2	68,415	184,794	51	5	684,249	5,607,361	12%
	3	191,400	281,364	17	4	897,822	4,015,549	22%
	4	319,126	1,606,891	17	17	10,692,321	10,692,336	100%
Subtotal				339	30	12,438,667	25,695,940	48%
NC/MOP	0	-1,744	22,116	133	0	0	1,135,985	0%
	1	22,587	57,391	66	4	139,141	2,336,862	6%
	2	57,707	125,126	39	4	292,469	3,175,325	9%
	3	127,143	174,813	13	4	572,647	1,869,949	31%
	4	205,284	1,369,784	14	14	6,584,309	6,584,309	100%
Subtotal				265	26	7,588,565	15,102,430	50%
TOTAL				604	56	20,027,233	40,798,370	49%

*Provides 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 5 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 10.2 results from dividing 51 by 5.

Table 5. Expansion Weight by Stratum

Program Group	Stratum	Total Number of Projects*	Projects in Sample	Expansion Weight
Retrofit	0	169	0	0
	1	85	4	21.25
	2	51	5	10.20
	3	17	4	4.25
	4	17	17	1.00
NC/MOP	0	133	0	0
	1	66	4	16.50
	2	39	4	9.75
	3	13	4	3.25
	4	14	14	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

The evaluation team identified necessary adjustments in each program group, though realization rates for all savings categories except water 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 6, savings adjustments resulted in lower evaluated kWh savings and winter kW reduction within the C&I/Multifamily Custom Retrofit program group and somewhat higher summer peak demand reduction.

Table 6. 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	25,695,940	98.4%	4,692	96.3%	2,754	115.7%

Table 7 lists all sampled C&I/Multifamily Custom Retrofit projects that the evaluation team identified as needing project-specific adjustments and includes a summary of those 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 7. Sampled C&I/Multifamily Custom Retrofit Project with Adjustments

EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
439855	1	50,531	94.1%	94.1%	94.1%	Corrected fixture count based on invoice.
446972	1	35,645	99.3%	99.3%	n/a	Reduced baseline fixture wattage per lookup table in the Custom Analysis Tool (CAT) file.
455274	1	45,859	94.9%	100.0%	n/a	Removed savings attributable to a separate, refrigeration measure.
460923	1	32,240	88.2%	88.2%	n/a	Recalculated savings to correct undocumented calculations.
421050	2	181,800	128.3%	n/a	-2990.0%	Adjusted assumptions and inputs to match values in the commissioning report and meter data. The summer kW RR is negative because claimed savings were negative.
428123	2	121,851	103.0%	100.0%	100.0%	Used different calculation model.

EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
435002	2	127,200	105.4%	102.2%	n/a	Adjusted connected load and "off" times for the heaters based on detailed invoice.
451185	3	269,773	102.1%	100.0%	101.8%	Corrected baseline fixture quantity.
401454	4	495,152	68.0%	90.3%	90.3%	Adjusted compressor load assumptions based on metered data and corrected full load demand (kW) based on the Compressed Air and Gas Institute (CAGI) sheet.
420449	4	1,201,167	91.4%	90.5%	n/a	Adjusted the shack heater input demand to match value in photos.
430436	4	553,702	102.4%	101.9%	101.6%	Included motor efficiency for evaporator fan cycling measure in evaluation calculations.
433110	4	902,030	100.0%	105.3%	105.0%	Adjusted coincidence factor.
438292	4	649,752	82.6%	81.0%	82.6%	Adjusted operating hours based on meter data.
439923	4	669,570	50.9%	35.4%	35.4%	Adjusted operating hours based on meter data.
442144	4	567,900	107.6%	104.4%	95.2%	Adjusted hours of use, removed waste-heat factor for exterior fixtures, and used different load shape for refrigeration and outdoor lighting.
447075	4	447,824	32.7%	100.0%	0.0%	Factored in existing gas use and eliminated billing analysis savings not attributable to this project.
447288	4	330,098	92.0%	100.0%	n/a	Calculated savings using post-installation cfm requirements for baseline and efficient compressors, and using CAGI compressor curves.
448053	4	366,439	93.0%	111.1%	111.1%	Adjusted operating hours based on meter data.
449445	4	1,606,891	109.5%	118.4%	n/a	Corrected demand (kW) for heaters based on nameplate data.
455026	4	556,694	100.0%	100.0%	n/a	Added summer demand reduction.



EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
461960	4	766,643	99.9%	100.0%	n/a	Minor discrepancies between reported savings and values in the project files.

Commercial and Industrial/Multifamily Custom NC/MOP

As shown by the realization rates in Table 8, adjustments to the C&I/Multifamily Custom NC/MOP program group resulted in lower evaluated kWh savings and summer demand reduction but higher winter demand reduction.

Table 8. 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	15,102,430	89.4%	1,835	103.6%	2,317	97.2%

Table 9 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 the adjustments for each project. As noted for project 447863, the evaluation team eliminated large reported water savings for a rooftop AC unit (42,461 CCF), which EVT confirmed was an error.

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

EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
448375	1	47,832	101.4%	101.3%	101.8%	Reduced quantity of installed lighting fixtures. Adjusted HVAC efficiencies to match values in the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certificates.
456564	1	27,610	95.5%	96.9%	94.9%	Adjusted HVAC efficiencies and capacities to match AHRI certificate values.

EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
459004	1	23,796	92.7%	146.5%	93.8%	Adjusted lighting hours of use. Adjusted HVAC inputs based on values in heating analysis and AHRI certificate.
451371	2	76,443	39.1%	n/a	39.1%	Adjusted compressed air load profiles to reduce operating hours at higher airflow loads.
457011	2	63,265	79.4%	77.9%	100.0%	Recalculated savings using the floating head pressure algorithm in Pennsylvania's 2016 TRM.
440051	3	146,832	44.5%	220.9%	266.1%	Corrected variable refrigerant flow (VRF) baseline values. Corrected numerous equipment inputs based on specification sheets.
450965	3	144,490	100.0%	105.3%	105.3%	Corrected minor discrepancies between reported savings and values in the project files.
459750	3	154,183	39.8%	79.3%	79.5%	Developed a new demand profile and adjusted operating hours based on metered data presented in the energy savings report.
430277	4	206,185	100.6%	100.0%	88.4%	Corrected the efficiency of the installed chiller and removed summer peak savings for the dry cooler.
439485	4	502,013	87.7%	74.6%	100.0%	Adjusted heat recovery chiller capacity and the COP using the Vermont TRM. Eliminated double-counted savings.
442497	4	276,744	95.0%	94.2%	93.2%	Adjusted the heat gain baseline value for refrigeration case doors.
444637	4	515,359	96.4%	100.0%	101.4%	Corrected minor discrepancies between reported savings and values in the project files.
444939	4	268,671	100.0%	188.8%	131.3%	Adjusted coincidence factor based on plant schedule.
446215	4	224,192	75.8%	68.3%	80.9%	Adjusted the fan efficiency of the energy recovery ventilator and the flow rate for the low-flow shower nozzles.



EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
447863	4	264,180	100.0%	132.7%	102.9%	Adjusted coincidence factor based on store's schedule. Eliminated large claimed water savings for rooftop AC unit.
451498	4	522,612	80.9%	77.5%	81.1%	Estimated savings using results from the most recent similar project instead of averaging the results of three.
459470	4	210,043	99.4%	99.6%	99.7%	Adjusted savings from Zero Energy doors.

Commercial and Industrial/Multifamily Prescriptive

In the C&I/Multifamily Prescriptive program group, evaluated savings tracked closely with reported savings in every savings category. Table 10 summarizes adjustments to kWh and winter and summer kW.

Table 10. 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	5,607,106	99.7%	909	100.0%	658	99.9%
Prescriptive Non-Lighting	1,293,381	100.2%	143	101.1%	142	100.0%
Total	6,900,487	99.8%	1,052	100.1%	800	99.9%

Few prescriptive lighting measures received adjustments. Examples of adjustments include removing a waste-heat-factor from the calculation of exterior lighting controls, correcting a wattage to the value provided in the TRM, and using the correct in-service ratio.

Adjustments to a small number of prescriptive non-lighting measures included correcting EER/SEER values and, in one case, correcting the conversion from gallons to CCF of water savings.

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 11, the evaluation team made minor adjustments to savings in the C&I/Multifamily Upstream program.

Table 11. 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	11,810,173	100.0%	1,485	100.7%	2,159	101.1%
Upstream HVAC	465,562	98.8%	57	96.6%	56	100.0%
Total	12,275,735	100.0%	1,542	100.6%	2,215	101.1%

C&I/Multifamily Smartlight measures accounted for most adjustments in this program group. Evaluated kWh savings matched claimed kWh savings for most measure groups but differed for LED Smartlight Commercial measures, where claimed savings were based on previous-year TRM values. Minor differences between evaluated and claimed savings occurred on more measures for winter and summer peak demand reduction and MMBtu savings, where EVT appeared in some cases to be using different loadshapes than specified in the TRM or applying the loadshapes to different load values. In nearly all cases with such discrepancies, evaluated savings were higher than claimed savings.

Upstream HVAC measures accounted for only 4% of the kWh savings of the C&I/Multifamily Upstream program group overall. Evaluated savings matched claimed savings for all measures except water-source heat pumps, where EVT applied a conversion incorrectly and used calculations that depart from TRM methodologies. The conversion error and the differences in methodology result in realization rates of roughly 180% for kWh savings and 5,000% for winter kW reduction but have little effect on overall realization rates, because of the small number of affected measures.

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 Residential 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 12 summarizes the necessary adjustments.

Table 12. Residential 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
Lighting	37,479,070	100.0%	7,961	99.9%	3,756	100.2%
Non-Lighting	3,470,239	99.4%	380	80.4%	814	92.8%
Total	40,949,308	99.9%	8,341	99.0%	4,570	98.9%

Adjustments to residential lighting products proved minimal. Discrepancies appeared to result from rounding error and use of slightly different per-unit values in some cases.



As with the 2015 evaluation, claimed savings for clothes washers were three times the evaluated savings, indicating a likely error. The evaluation team also corrected several additional, less notable errors, but these changes had relatively little impact on the overall realization rate 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

Only a small percentage of measures required adjustments in the Residential Retrofit/LISF program group, though these had a fairly large impact on realization rates. Table 13 summarizes the necessary adjustments.

Table 13. 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	1,466,625	107.3%	309	106.2%	109	107.1%
HPwES	187,627	100.0%	86	100.0%	0	100.0%
Total	1,654,252	106.5%	395	104.9%	109	107.1%

Much of the difference between evaluated and claimed savings occurred for LED screw-base lamps, partly because of their relatively large number. The evaluation team used per-unit savings values from the 2016 TRM to evaluate savings, rather than the previous-year TRM values used by EVT. Using the current-year values increased evaluated savings and realization rates. Most other adjustments corrected rounding issues.

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%.

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 14, Residential New Construction received substantial adjustments to energy savings and demand reduction.

Table 14. 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	1,443,599	91.7%	384	91.8%	134	92.7%

Custom thermal measures such as insulation and air sealing produced 48% of energy savings for the Residential NC program group. As shown in Table 15, adjustments to prescriptive measures accounted for all net adjustment in energy and demand savings for the Residential NC program group.

Most of the energy savings adjustment resulted from an issue with LED recessed surface and pendant downlight measures: reported savings were based on Residential Efficient Products and Smartlight deemed savings values rather than Residential New Construction values. The baseline lamp wattage for new construction measures assumes the home is required to install 75% high efficacy lighting (50 lumens per watt), which substantially lowers the baseline wattage (and savings) for new construction lamps.

Table 15. 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	753,002	84.1%	197	84.0%	63	84.5%
Residential NC Custom	690,597	100.0%	187	100.0%	71	100.0%
Total	1,443,599	91.7%	384	91.8%	134	92.7%

As shown in

Table 16, custom thermal measures account for nearly all Residential NC MMBtu savings, while prescriptive measures generate all water savings.

Table 16. Residential New Construction 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	124	100.0%	628	100.5%
Residential NC Custom	8,664	100.0%	0	0.0%
Total	8,788	100.0%	628	100.5%



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 17 provides energy savings and demand reduction realization rates for Residential Smartlight measures and Upstream HVAC measures.

Table 17. 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	4,340,546	100.1%	1,075	100.1%	296	100.0%
Upstream HVAC	3,088,793	100.0%	400	97.1%	33	104.1%
Total	7,429,339	100.1%	1,475	99.3%	329	100.4%

Smartlight adjustments were driven mostly by the use of previous-year TRM values for claimed values for some LED lighting measures.

Adjustments for Upstream HVAC were necessary due to rounding issues and a discrepancy in winter demand reduction inputs for the boiler circulator pump measures.

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

Recommended Improvements

The 98.2% 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.

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 non-TEPF funded measures for 56 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 and refrigerators. The following discussion and recommendations apply to a broader range of technologies and projects.

During this year's evaluation Cadmus noted admirable improvement in the thoroughness of project overviews and in the organization of project files—both areas of focus in the 2015 evaluation report recommendations. We offer the following remaining recommendations:

Consistently Document Installed Equipment

Cadmus encourages EVT to continue striving to document all installed equipment sufficient to allow verification. Verification of installed equipment requires itemized invoices, submittals, and/or equipment photos to document the installed equipment and any relevant control settings. Blueprints and design specifications document the basis of design only and are not sufficient for verification.

Consistently Document Existing Equipment

Similarly, Cadmus stresses the importance of documenting the existing equipment—the equipment in use before installation of the energy-efficient equipment. If the measure is expected to generate savings for space conditioning, then nameplate data (at minimum) should be collected for the relevant HVAC equipment.

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 and to document the source of those inputs. For custom projects, actual values should be readily available from as-built 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 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 EVT 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:

Ensure Database Values Allow as Many Significant Digits as the TRM Does

Cadmus recommends ensuring that the database per-unit values match the number of significant digits provided by values in the TRM. EVT largely addressed this problem in the 2016 tracking data, but a small number of rounding issues remain.

Simplify and Clarify Calculation Methods

EVT calculates claimed savings using relatively straightforward TRM methods for most prescriptive measures, but in some few cases calculations depart from TRM methods by using different calculation methods or undocumented adjustments. Cadmus encourages EVT to ensure that all prescriptive-measure calculation methods and inputs conform to the TRM, whether that requires changing the calculation method or updating the TRM.

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.

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.

Custom Residential Measures

Custom measures in the Residential New Construction, HPwES, and Retrofit LISF program tracks drive only a small percentage of residential savings. 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.

Cadmus also recommends performing another billing analysis on the HPwES program as budget and priorities allow, to update the realization rates applied to those savings.

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 to allow an experienced database analyst or developer to quickly understand the database content and structure. Cadmus also noted that EVT updated the data dictionary to reflect the presentation database structure, as recommended in the 2015 report.

Update Database Documentation

Cadmus recommends continually updating documentation to keep it into sync with the 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 and 2016 evaluations, 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 to outside organizations using the data 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.