



# Report to Verify Efficiency Vermont 2017 Savings Claim

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## Executive Summary

On April 1, 2018, 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 2017” to document its preliminary savings claim for year 2017 activities. To certify achieved savings towards VEIC’s performance goals, the PSB requires the Vermont Department of Public Service (PDS) to verify the energy, coincident peak, and Total Resource Benefit (TRB) savings claimed by EVT. Through an RFP process, PDS selected Cadmus to complete the required verification. This report documents the findings and recommendations of this verification of the 2017 EVT savings claim.

This report summarizes the evaluation of 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	127,960,812	98.3%	23,244	97.1%	16,853	98.2%

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 128.0 GWh, with a realization rate of 98.3%.

The EVT portfolio’s 98.3% 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 1.6% for C&I/Multifamily Custom New Construction and Market Opportunity (NC/MOP) projects. The relative precision for the portfolio as a whole is 0.3%.



**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
<b>C&amp;I and Multifamily</b>						
Custom Retrofit*	25,658,832	96.6%	3,680	92.6%	3,216	91.8%
Custom NC/MOP*	14,296,978	94.4%	2,012	97.0%	1,747	100.7%
Prescriptive Lighting	8,298,763	99.8%	1,336	100.0%	1,175	100.2%
Prescriptive Non-Lighting	1,024,115	100.2%	137	100.7%	126	100.0%
Smartlight	15,431,315	98.4%	2,337	93.8%	2,633	98.1%
Upstream HVAC	657,386	100.0%	80	100.0%	80	100.0%
<b>C&amp;I Subtotal</b>	<b>65,367,389</b>	<b>97.0%</b>	<b>9,583</b>	<b>95.0%</b>	<b>8,977</b>	<b>96.7%</b>
<b>Residential</b>						
Efficient Products	61,314,153	99.6%	13,772	98.6%	7,430	99.7%
Residential Retrofit/Low-Income Single-Family	9,128,003	100.6%	2,182	101.2%	632	103.6%
Home Performance with ENERGY STAR®**	191,264	100.0%	84	100.0%	1	100.0%
Residential New Construction	1,246,775	97.9%	354	97.5%	125	97.8%
Smartlight	2,151,338	96.9%	532	96.9%	146	96.9%
Upstream HVAC (+ HP water heaters)	-11,438,109	100.0%	-3,262	100.1%	-460	98.8%
<b>Residential Subtotal</b>	<b>62,593,423</b>	<b>99.6%</b>	<b>13,661</b>	<b>98.6%</b>	<b>7,875</b>	<b>100.0%</b>
<b>Portfolio Total</b>	<b>127,960,812</b>	<b>98.3%</b>	<b>23,244</b>	<b>97.1%</b>	<b>16,853</b>	<b>98.2%</b>

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

\*\*Claimed savings for the Home Performance with ENERGY STAR program already include adjustments taken from a prior-year impact study. Applied realization rates are 86% for kWh and 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 100.6%. The overall water savings realization rate was 103.2%.

**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
<b>C&amp;I and Multifamily</b>				
Custom Retrofit*	2,429	100.3%	-1,281	100.0%
Custom NC/MOP*	4,585	102.9%	3,033	101.6%
Prescriptive Lighting	-4,034	100.9%	0	n/a
Prescriptive Non-Lighting	2,038	100.0%	289	102.4%
Smartlight	-10,707	98.2%	0	n/a
Upstream HVAC	0	n/a	0	n/a
<b>C&amp;I/Multifamily Subtotal</b>	<b>-5,688</b>	<b>94.8%</b>	<b>2,041</b>	<b>102.6%</b>
<b>Residential</b>				
Efficient Products	-5,778	86.8%	15,922	100.2%
Residential Retrofit/Low-Income Single-Family	1,571	100.0%	2,519	124.0%
Home Performance with ENERGY STAR**	13,036	100.0%	0	n/a
Residential New Construction	8,327	100.0%	683	100.4%
Smartlight	0	n/a	0	n/a
Upstream HVAC (+ HP water heaters)	162,736	100.0%	0	n/a
<b>Residential Subtotal</b>	<b>179,891</b>	<b>100.4%</b>	<b>19,123</b>	<b>103.3%</b>
<b>Portfolio Total</b>	<b>174,203</b>	<b>100.6%</b>	<b>21,164</b>	<b>103.2%</b>

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

\*\*Claimed savings for the Home Performance with ENERGY STAR program already include adjustments taken from a prior-year impact study. The applied realization rate is 76% for 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 2018, after EVT began providing Cadmus with project files on the largest custom C&I/multifamily projects. In late 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 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, 2018, deadline, documents all findings.

### *Scope*

The evaluation is 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 incorporated 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 the project's scope, as did a rigorous review of EVT's implementation of TRM methods. Any rigorous review of the EVT database itself also exceeded the project's 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 this report's Recommended Improvements section).

## ***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 2016 evaluation, this 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 energy (kWh) savings or peak demand reduction. Including them in this analysis might have made realization rates less accurate for EVT-funded measures. Accordingly, the Vermont Department of Public Service (PDS) 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 and Efficiency Development Fund**

The Community Energy & Efficiency Development (CEED) Fund fully or partially funds some projects. Previous 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 39% of the C&I/Multifamily sector's evaluated kWh savings and 20% of the total portfolio's evaluated kWh savings. This program comprised 578 complex projects with non-TEPF-funded savings in at least one evaluated savings category. 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 15% relative precision at the 90% confidence level customary for program evaluations; the design resulted in the selection of 26 projects. Realization rates calculated based on this sample were applied to the population of 578 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 21% of the C&I/Multifamily sector's evaluated kWh savings and 11% of the total portfolio's evaluated kWh savings, with 222 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 the C&I/Multifamily Custom Retrofit: the team selected a random sample of 22 projects for evaluation and estimated the population's total savings by applying the resulting realization rates to the population of 222 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 15% of the C&I/Multifamily sector's kWh evaluated savings and 7% of the total portfolio's 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***

Claimed savings for the C&I/Multifamily Upstream program group increased to 16.1 GWh for 2017 from 12.3 GWh for 2016, with 96% of savings resulting from Smartlight measures. Table 2 reports claimed savings for the group’s two components—Smartlight and Upstream HVAC. The program group as a whole accounted for 25% of the C&I/Multifamily sector’s kWh savings and 13% of the total portfolio’s kWh savings.

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 61 GWh, claimed savings for Residential Efficient Products increased by 20 GWh relative to 2017 and accounted for more savings than any other program group. Residential Efficient Products provided 83% of the evaluated kWh savings for the residential sector (not including the strong negative savings for Upstream HVAC) and 49% of the total portfolio’s evaluated kWh savings.

All Residential Efficient Products measures were prescriptive, with 95% of savings provided by LED replacement lamps. Other measures include ENERGY STAR appliances, heat pump water heaters, low-flow showerheads 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. Claimed savings for the three tracks combined grew dramatically relative to 2016 savings, increasing to 9.3 GWh for 2017 from 1.7 GWh for 2016. Savings accounted for 13% of the residential sector’s evaluated kWh savings (not including the strong negative savings from Upstream HVAC) and 7% of the total portfolio’s evaluated kWh savings.

Growth in the Retrofit/LISF program group comes mainly through custom measures. Custom measures provided 82% of Retrofit/LISF claimed kWh savings in 2017 (compared with 11% in 2016) and accounted for 6% of total portfolio savings. Consistent with the approach used in previous years, Cadmus accepted savings from these custom measures at a 100% realization rate.

For prescriptive measures, 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.

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.

### ***Residential New Construction***

Residential New Construction accounted for 2% of the residential sector's evaluated kWh (not including strong negative savings from Upstream HVAC) and 1% of the total portfolio's savings. Approximately one-half of Residential New Construction kWh savings (48%) 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 52% 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***

Table 2 shows Residential Upstream savings for two program tracks: Residential Smartlight and Upstream HVAC. Cold climate heat pumps (CCHPs) dominated Upstream HVAC this year, and nearly half of the CCHP measures replaced fossil-fuel systems, causing strong negative energy and demand savings for the program group as a whole. Heat pump water heaters replacing fossil-fuel models also contributed to negative savings. The Upstream HVAC track also included high-efficiency circulator pumps.

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.<sup>1</sup>

### 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 the projects' total reported non-TEPF-sponsored kWh savings to determine projects eligible for sampling. Cadmus removed projects 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 sample design for each program group. Cadmus defined stratum boundaries according to the projects' 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, the population size, and the 80/20 confidence precision targets within each stratum. For each program group as a whole, the minimum confidence precision target was 90/15.

The sample design yielded samples from 26 projects from the Custom Retrofit program and 22 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 within 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 40% of the total C&I/Multifamily Custom Retrofit kWh savings and 59% of the total C&I/Multifamily Custom NC/MOP kWh savings.

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

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	-1,744	16,933	376	0	0	1,170,260	0%
	1	17,254	48,990	85	4	175,312	2,717,918	6%
	2	49,758	107,055	59	3	194,636	4,265,872	5%
	3	108,766	333,243	43	4	766,615	8,323,431	9%
	4	352,561	1,499,986	15	15	9,181,351	9,181,351	100%
<b>Subtotal</b>				<b>578</b>	<b>26</b>	<b>10,317,914</b>	<b>25,658,832</b>	<b>40%</b>
NC/MOP	0	7	17,568	111	0	0	855,785	0%
	1	17,658	47,364	55	4	116,974	1,703,687	7%
	2	48,247	108,996	33	3	199,515	2,379,262	8%
	3	109,006	208,600	11	3	530,271	1,733,384	31%
	4	241,167	2,285,842	12	12	7,624,861	7,624,861	100%
<b>Subtotal</b>				<b>222</b>	<b>22</b>	<b>8,471,621</b>	<b>14,296,978</b>	<b>59%</b>
<b>TOTAL</b>				<b>800</b>	<b>48</b>	<b>18,789,535</b>	<b>39,955,810</b>	<b>47%</b>

\*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 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 19.67 results from dividing 59 by 3.



**Table 5. Expansion Weight by Stratum**

Program Group	Stratum	Total Number of Projects*	Projects in Sample	Expansion Weight
Retrofit	0	376	0	0
	1	85	4	21.25
	2	59	3	19.67
	3	43	4	10.75
	4	15	15	1.00
NC/MOP	0	111	0	0
	1	55	4	13.75
	2	33	3	11.00
	3	11	3	3.67
	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’s total savings (based on the expansion weights), evaluated savings for each sampled project, and 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 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 in winter and summer kW reduction within the C&I/Multifamily Custom Retrofit program group.

**Table 6. C&I/Multifamily Custom Retrofit Electric Adjustments**

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed MWh	Realization Rate	EVT Gross Claimed kW*	Realization Rate	EVT Gross Claimed kW*	Realization Rate
Custom Retrofit	25,659	96.6%	3,680	92.6%	3,216	91.8%

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

Table 7 lists all sampled C&I/Multifamily Custom Retrofit projects that the evaluation team identified as requiring project-specific adjustments and includes a summary of those adjustments. Cadmus provided detailed reports for all projects in the largest-savings stratum to PDS and EVT 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 realization rates for the program group as a whole.

**Table 7. Sampled C&I/Multifamily Custom Retrofit Projects with Adjustments**

EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
466207	1	43,549	92.5%	n/a	n/a	Adjusted calculations to use the correct chilled water flow rate for AHU-16
460956	2	72,458	90.3%	88.2%	90.7%	Adjusted the assumed full-load motor load factor from 85% to 75%
461946	3	186,475	100.0%	55.5%	53.8%	Adjusted peak demand reductions to match results from the RTU analysis workbooks
465137	3	237,062	95.0%	95.0%	90.0%	Reduced lamp counts by 5% to account for uncertainty, because of lack of documentation
451221	4	1,026,988	80.3%	72.4%	n/a	Adjusted baseline conditions based on pre-implementation meter data



EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
454103	4	369,942	98.1%	99.8%	99.8%	Reduced savings by 5% for lighting upgrades not supported by invoices to account for uncertainty
455386	4	1,499,986	90.5%	96.9%	100.2%	Adjusted savings to correct faulty assumptions regarding compressor operations
457732	4	725,966	100.0%	86.1%	74.8%	Corrected several calculation inputs
458466	4	655,049	98.3%	98.3%	98.3%	Reduced savings to account for uncertainty in the hours-of-use reduction provided by occupancy sensors
458838	4	554,666	101.1%	103.1%	98.8%	Corrected an assumption regarding the chiller operating curve
460320	4	387,513	93.7%	100.1%	85.1%	Eliminated cooling interactive effects
461321	4	465,444	77.9%	74.3%	57.0%	Adjusted savings to use available AMI analysis rather than prescriptive methods
462217	4	506,508	95.0%	95.0%	95.0%	Reduced lamp counts by 5% to account for uncertainty due to lack of documentation

### **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 winter demand reduction, but also resulted in slightly higher summer 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 MWh	Realization Rate	EVT Gross Claimed kW*	Realization Rate	EVT Gross Claimed kW*	Realization Rate
Custom NC/MOP	14,297	94.4%	2,012	97.0%	1,747	100.7%

Table 9 lists all sampled C&I/Multifamily Custom NC/MOP projects that the evaluation team identified as requiring project-specific adjustments. The table includes a summary of adjustments for each project.

Cadmus provided PDS 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 used to calculate 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
460181	1	28,042	100.5%	100.0%	97.0%	Adjusted economizer savings calculations to use the correct efficiency value and corrected inputs for RTU, based on AHRI values
462028	1	21,857	95.0%	95.0%	n/a	Reduced fixture counts by 5% to account for uncertainty due to lack of documentation
461997	2	65,581	98.0%	96.8%	99.3%	Corrected HVAC inputs based on cutsheets and adjusted hours of use for a few spaces
459470	3	168,898	85.0%	90.2%	91.2%	Adjusted calculation inputs for walk-in cooler evaporator fan motors and night covers to match the 2017 TRM
465441	3	208,600	100.1%	99.8%	98.2%	Adjusted hours of operation for interior lighting
386692	4	1,406,288	94.3%	97.3%	n/a	Reduced savings for measures not supported by documentation to account for uncertainty
435828	4	2,285,842	82.9%	103.0%	103.0%	Adjusted various baseline assumptions and inputs
454599	4	974,935	75.0%	75.0%	n/a	Reduced savings based on post-implementation inspections and to account for uncertainty
458401	4	286,718	88.5%	88.1%	88.2%	Reduced savings for lighting measures not supported by documentation to account for uncertainty, and eliminated duplicate measures
459471	4	281,692	100.3%	100.0%	99.4%	Eliminated cooling interactive effects for exterior lighting fixtures and updated TRM source for night curtains measure
461416	4	381,251	101.3%	94.8%	94.8%	Modified calculation inputs based on project documentation



EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
465073	4	282,100	94.3%	94.2%	n/a	Adjusted calculations to use snow distribution specific to the resort and to use a more accurate compressed air system efficiency
468303	4	423,619	129.6%	131.5%	131.2%	Increased savings based on metering analysis

### **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	8,298,763	99.8%	1,336	100.0%	1,175	100.2%
Prescriptive Non-Lighting	1,024,115	100.2%	137	100.7%	126	100.0%
<b>Total</b>	<b>9,322,878</b>	<b>99.8%</b>	<b>1,473</b>	<b>100.0%</b>	<b>1,301</b>	<b>100.1%</b>

Few prescriptive lighting measures received adjustments, such as correcting a waste heat factor applied to savings for refrigerated case lighting and removing a waste-heat-factor from calculation of exterior lighting control. For a small number of prescriptive non-lighting measures, adjustments included correcting EER/SEER values and correcting values with too few significant digits.

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

### **Commercial and Industrial/Multifamily Upstream**

As shown in Table 11, the evaluation team made significant savings adjustments in the C&I/Multifamily Upstream program. Evaluated realization rates are 98.4% for energy, 94% for winter kW reduction, and 98.1 for summer kW reduction.

**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	15,431,315	98.4%	2,337	93.8%	2,633	98.1%
Upstream HVAC	657,386	100.0%	80	100.0%	80	100.0%
<b>Total</b>	<b>16,088,701</b>	<b>98.4%</b>	<b>2,417</b>	<b>94.0%</b>	<b>2,713</b>	<b>98.1%</b>

C&I/Multifamily Smartlight measures accounted for all adjustments in this program group. Some adjustments to kWh and kW savings resulted from errors in the TRM’s deemed savings values for solid-state LED fixtures, which were calculated with an in-service rate (ISR) of 0.98 instead of 0.9 for commercial measures and 0.95 for residential. These errors, discovered through dialog between Cadmus and EVT, caused errors in the measure tracking savings for several measures, though in some cases the transfer of values to the database also appeared to introduce error. Cadmus also adjusted winter kW savings for commercial interior lighting to eliminate cooling interactive effective effects during heating season. This step is included in EVT’s intended methodology but was not completed during calculation of claimed savings.

Upstream HVAC measures accounted for only 4% of kWh savings for the C&I/Multifamily Upstream program group overall and comprised only one measure –Synchronous Motor Evaporator Fan. Evaluated savings matched claimed savings for all savings components.

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

**Residential Efficient Products**

The evaluation team identified necessary adjustments measures within the Residential Efficient Products program group, though realization rates for energy saved and summer kW reduction remained close to 100%. Winter kW reduction fell slightly more, to 98.6% 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	58,456,020	99.6%	13,516	98.5%	6,640	99.6%
Non-Lighting	2,858,133	100.3%	256	102.4%	790	100.4%
<b>Total</b>	<b>61,314,153</b>	<b>99.6%</b>	<b>13,772</b>	<b>98.6%</b>	<b>7,430</b>	<b>99.7%</b>

The lighting adjustments described for the C&I/Multifamily Upstream program also applied to several Efficient Products lighting measures: Errors in TRM deemed values lead to adjustments to kWh and kW values, and Cadmus removed cooling interactive effects from lighting measures identified as



commercial. With non-lighting measures, evaluated savings topped 100% because of zero claimed savings for some thermostat measures and because of apparent errors in the claimed kW reduction for some high-efficiency dryers.

Cadmus provided information about measure-level adjustments to PDS 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. Most discrepancies between claimed and evaluated savings appeared to result from rounding error or from claimed-savings calculations using values from a previous-year TRM. Table 13 summarizes the necessary adjustments.

**Table 13. Residential Retrofit/Low Income Single Family 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 Retrofit/LISF	9,128,003	100.6%	2,182	101.2%	632	103.6%
HPwES	191,264	100.0%	84	100.0%	1	100.0%
<b>Total</b>	<b>9,319,267</b>	<b>100.6%</b>	<b>2,266</b>	<b>101.2%</b>	<b>634</b>	<b>103.6%</b>

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 100% realization rate.

As shown in Table 14, the HPwES program accounted for most Residential Retrofit/LISF MMBtu savings. EVT applied a 76% realization rate to MMBtu savings for all HPwES projects before claiming savings.

**Table 14. Residential Retrofit/LISF TRB Adjustments**

Program Group	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Residential Retrofit/LISF	1,571	100.0%	2,519	124.0%
HPwES	13,036	100.0%	0	n/a
<b>Total</b>	<b>14,607</b>	<b>100.0%</b>	<b>2,519</b>	<b>124.0%</b>

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

### **Residential New Construction**

As shown in Table 15, Residential New Construction received relatively minor adjustments to energy savings and demand reduction.

**Table 15. 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	1,246,775	97.9%	354	97.5%	125	97.8%

Custom thermal measures (such as insulation and air sealing) produced 52% of energy savings for the Residential NC program group. As shown in Table 16, adjustments to prescriptive measures accounted for all net adjustment in energy and demand savings for the Residential NC program group.

Savings adjustments resulted primarily from eliminating claimed savings for linear fluorescent lighting, which no longer appears to be a viable measure; correcting demand savings for low-income clothes washer measures; and correcting the ISR used in calculating savings for one of the LED lighting measures.

**Table 16. 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	599,050	95.6%	178	95.0%	56	95.3%
Residential NC Custom	647,725	100.0%	175	100.0%	69	100.0%
<b>Total</b>	<b>1,246,775</b>	<b>97.9%</b>	<b>354</b>	<b>97.5%</b>	<b>125</b>	<b>97.8%</b>

As shown in Table 17, custom thermal measures accounted for nearly all Residential NC MMBtu savings, while prescriptive measures generated all water savings.

**Table 17. Residential New Construction TRB Adjustments**

Measure Type	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Residential NC Prescriptive	135	100.0%	683	100.5%
Residential NC Custom	8,191	100.0%	0	n/a
<b>Total</b>	<b>8,327</b>	<b>100.0%</b>	<b>683</b>	<b>100.4%</b>

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

### **Residential Upstream**

As mentioned earlier in this report, energy and demand savings were strongly negative for the Residential Program group as a whole, because of strong negative savings by cold climate heat pumps



and heat pump water heaters that replaced fossil-fuel equipment. Table 18 provides energy savings and demand reduction realization rates for Residential Smartlight and Upstream HVAC measures.

**Table 18. 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	2,151,338	96.9%	532	96.9%	146	96.9%
Upstream HVAC	-11,438,109	100.0%	-3,262	100.1%	-454	100.0%
<b>Total</b>	<b>-9,286,772</b>	<b>100.7%</b>	<b>-2,730</b>	<b>100.7%</b>	<b>-308</b>	<b>101.5%</b>

Adjustments to the Residential Upstream program group were relatively minor, with the great majority coming from Smartlight measures. The Smartlight adjustments resulted from the same TRM deemed savings errors mentioned earlier in this report: TRM deemed energy and savings for solid-state LED fixtures were calculated using an ISR of 0.98 instead of 0.9 for commercial measures and 0.95 for residential. Cadmus corrected savings for the Residential Upstream lighting measures using an ISR of 0.95.

The same fuel-conversion cold-climate heat pumps and heat pump water heaters that created large negative electricity savings generated large claimed MMBtu savings, which are summarized in Table 19. These savings account for more than 90% of MMBtu savings for the EVT portfolio.

**Table 19. Residential Upstream TRB Adjustments**

Program Group	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Smartlight	0	n/a	0	n/a
Upstream HVAC	162,736	100.0%	0	n/a
<b>Total</b>	<b>162,736</b>	<b>100.0%</b>	<b>0</b>	<b>n/a</b>

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

## Recommended Improvements

The 98.3% energy (kWh) realization rate for the EVT portfolio 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 48 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, snowmaking systems, and refrigerators. The following discussion and recommendations apply to a broader range of technologies and projects.

#### **Consistently Collect Invoices for Installed Equipment**

Cadmus encourages EVT to require invoices for all installed equipment, to provide support for savings calculations and adequate information for third-party verification. Verification of installed equipment requires itemized invoices, submittals, and/or detailed and comprehensive 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 Baseline Equipment and Operating Conditions**

Similarly, Cadmus stresses the importance of documenting the existing equipment—the equipment in use before installation of the energy-efficient equipment—as well as baseline operating conditions. If the measure is expected to generate savings for space conditioning, then nameplate data (at minimum) should be collected for the relevant HVAC equipment. If baseline equipment runtime or other relevant operational data are at all in doubt, pre-installation metering should be performed, particularly for projects expected to provide large savings.

#### **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 should document the source of those inputs. For custom projects, actual values should be readily available from equipment invoices, as-built drawings, cut sheets, nameplates, meter data, 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. Where such data are available, claimed savings should be based on analysis of the meter data rather than simply using the meter data for information purposes.

### **Consistently Provide Thorough Overview Documentation**

Cadmus recommends that EVT continue to work towards 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 Clarity of Project File Organization**

Multiple versions of the CAT file were sometimes included in project files, with each version providing somewhat different savings for the same measures. Sometimes CAT files from previous years were included, which also created confusion. Cadmus recommends that EVT store outdated CAT files in an archive folder to avoid confusion. EVT could also improve the clarity of project documentation by ensuring that the relevant project overview documentation is easy to find.

### ***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. Cadmus noted remaining significant digit issues in the 2017 tracking data, particularly with MMBtu savings.

### **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 under-documented adjustments. The EVT methodology for dealing with cooling interactive

effects with lighting measures serves a good and timely example of an approach that can cause confusion both outside of and within EVT: For upstream lighting measures, the EVT TRM provides deemed kW values, which must then be multiplied by winter and summer coincidence factors to arrive at peak winter and summer kW savings. For commercial variants of these measures, EVT multiplies the demand reduction by a waste heat factor to account for cooling interactive effects as it calculates the deemed kW values. These deemed kW values then must be divided by the waste heat factor when calculating winter demand reduction, to remove the cooling interactive effects. EVT failed to remove the cooling interactive effects from 2017 winter kW claimed savings, which lends strength to our recommendation to simplify how cooling interactive effects are handled. We recommend that the cooling interactive effects be applied appropriately through the load shapes themselves, or that a waste heat factor be applied to account for cooling interactive effect when calculating summer kW values (rather than having to remove the value when calculating winter kW reduction).

### **Ensure Consistent Implementation of TRM Values**

Aside from the error with waste heat factors mentioned above, Cadmus found relatively few errors in EVT's application of the TRM to arrive at database values. We recommend 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.

### ***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.

### **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, 2016, 2017 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.