



# Report to Verify Efficiency Vermont 2018 Savings Claim

Revised July 1, 2019

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## Acknowledgements

Cadmus thanks Barry Murphy at the Vermont Department of Public Service for his guidance throughout the project as well as all who contributed on behalf of Efficiency Vermont at the Vermont Energy Investment Corporation.



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## Executive Summary

On April 1, 2019, Vermont Energy Investment Corporation (VEIC), operating as Efficiency Vermont (EVT) under an order of appointment by the Public Utility Commission (PUC) to provide energy efficiency services to Vermont, submitted its “Savings Claim Summary 2018” to document its preliminary savings claim for year 2018 activities. To certify achieved savings towards VEIC’s performance goals, the PUC requires the Vermont Department of Public Service (PSD) to verify the energy, coincident peak, and Total Resource Benefit (TRB) savings claimed by EVT. Through an RFP process, PSD selected Cadmus to complete the required verification. This report documents the findings and recommendations of this verification of the 2018 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	127,090,750	97.7%	21,631	99.5%	17,306	98.1%

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 (kW) 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 127.1 GWh, with a realization rate of 97.7%.

The EVT portfolio’s 97.7% realization rate speaks well for EVT and for the efforts of VEIC, its implementer, in estimating and documenting savings.

At the 90% confidence level, the relative precision of the realization rates for energy savings (kWh) is 11.7% for Commercial & Industrial/Multifamily (C&I/Multifamily) Custom Retrofit projects and 2.5% for C&I/Multifamily Custom New Construction and Market Opportunity (NC/MOP) projects. The relative precision for the portfolio as a whole is 2.0%. Although within the target precision of 15% at 90% confidence, the 11.7% relative precision for Custom Retrofit project is higher than in previous years. This



resulted primarily from a low realization rate of 28% for energy savings from one project in a stratum with three projects.

**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*	22,743,898	90.0%	2,825	90.5%	2,805	92.7%
Custom NC/MOP*	13,743,573	95.8%	1,776	98.8%	1,969	94.1%
Prescriptive Lighting	13,375,627	99.8%	2,425	100.0%	1,825	100.0%
Prescriptive Non-Lighting	482,334	95.5%	67	94.4%	63	94.3%
Efficient Products	16,428,530	100.0%	1,507	100.5%	3,036	99.6%
Smartlight	16,303,771	100.0%	1,573	100.0%	3,069	100.0%
Upstream HVAC	580,464	100.0%	-43	31.5%	13	123.7%
<b>C&amp;I Subtotal</b>	<b>83,658,197</b>	<b>96.5%</b>	<b>10,131</b>	<b>97.5%</b>	<b>12,779</b>	<b>97.4%</b>
<b>Residential</b>						
Efficient Products	36,616,930	99.9%	10,176	99.7%	3,961	99.2%
Residential Retrofit/Low-Income Single-Family	1,191,115	100.0%	279	98.8%	104	100.1%
Home Performance with ENERGY STAR***	140,332	100.0%	34	100.0%	1	100.0%
Residential New Construction	867,580	99.6%	229	99.8%	80	99.7%
Smartlight	4,691,673	100.0%	1,416	100.0%	392	100.0%
Upstream HVAC (+ HP water heaters)	-75,076	100.0%	-633	69.4%	-10	-165.9%
<b>Residential Subtotal</b>	<b>43,432,553</b>	<b>99.9%</b>	<b>11,500</b>	<b>101.4%</b>	<b>4,527</b>	<b>99.9%</b>
<b>Portfolio Total</b>	<b>127,090,750</b>	<b>97.7%</b>	<b>21,631</b>	<b>99.5%</b>	<b>17,306</b>	<b>98.1%</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 108.6%. The overall water savings realization rate was 94.8%.

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*	11,462	103.8%	975	100.0%
Custom NC/MOP*	8,945	91.2%	2,637	100.0%
Prescriptive Lighting	-4,365	99.7%	0	n/a
Prescriptive Non-Lighting	1,004	100.3%	274	98.2%
Efficient Products	-11,353	99.9%	0	n/a
Smartlight	-11,153	100.1%	0	n/a
Upstream HVAC	5,556	113.4%	0	n/a
<b>C&amp;I/Multifamily Subtotal</b>	<b>97</b>	<b>533.9%</b>	<b>3,885</b>	<b>99.8%</b>
<b>Residential</b>				
Efficient Products	11,389	98.8%	10,187	93.0%
Residential Retrofit/Low-Income Single-Family	3,777	100.0%	2,189	99.5%
Home Performance with ENERGY STAR**	8,757	100.0%	0	n/a
Residential New Construction	8,599	99.7%	472	71.6%
Smartlight	-10	318.9%	0	n/a
Upstream HVAC (+ HP water heaters)	47,216	114.1%	0	n/a
<b>Residential Subtotal</b>	<b>79,729</b>	<b>108.1%</b>	<b>12,848</b>	<b>93.3%</b>
<b>Portfolio Total</b>	<b>79,826</b>	<b>108.6%</b>	<b>16,733</b>	<b>94.8%</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 2019, after EVT began providing Cadmus with project files on the largest custom C&I/multifamily projects. By 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 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, 2019, 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 or other metering 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***

The project organizes EVT programs in nine program groups—the eight included in the evaluations for previous years plus one new program group for 2018— C&I/Multifamily Efficient Products. 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 Efficient Products
- 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 and 2017 savings claims verifications, 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 (kW) reduction. Including them in this analysis might have made realization rates less accurate for EVT-funded measures. Accordingly, the Vermont Department of Public Service (PSD) 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.



## 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 25% of the C&I/Multifamily sector’s evaluated kWh savings and 16% of the total portfolio’s evaluated kWh savings. This program comprised 307 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 22 projects. Realization rates calculated based on this sample were applied to the population of 307 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 16% of the C&I/Multifamily sector’s evaluated kWh savings and 11% of the total portfolio’s evaluated kWh savings, with 262 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 23 projects for evaluation and estimated the population’s total savings by applying the resulting realization rates to the population of 262 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 17% of the C&I/Multifamily sector’s kWh evaluated savings and 11% 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 Efficient Products***

For the 2018 program year, EVT created a separate program track for the portion of Efficient Products sales identified as going into commercial, industrial, or multifamily sites. The program track provided claimed energy savings of 16.4 GWh, all from lighting measures. The program group accounted for 20% 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 Efficient Products 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.

### ***Commercial & Industrial/Multifamily Upstream***

Claimed savings for the C&I/Multifamily Upstream program group increased to 16.9 GWh for 2018 from 16.1 GWh for 2017, 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 accounted for 21% of the C&I/Multifamily sector's kWh savings and 14% of the total portfolio's kWh savings.

In contrast to 2017, when the Upstream HVAC component comprised only one measure—synchronous motor evaporator fans—the program included several for 2018, including cold climate heat pumps, heat pump water heaters, BLPM circulator pumps, and others. Cold climate heat pumps had a net negative impact on energy savings of roughly 0.3 GWh, because some replaced fossil-fuel heating systems.

As with the C&I/Multifamily Prescriptive and Efficient Products program groups, 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 36.6 GWh, claimed savings for Residential Efficient Products accounted for more savings than any other program group. Residential Efficient Products provided 84% of the evaluated kWh savings for the residential sector and 29% of the total portfolio's evaluated kWh savings.

All Residential Efficient Products measures were prescriptive, with 90% of savings provided by LED fixtures and replacement lamps. Other measures include ENERGY STAR appliances, heat pump water heaters, low-flow showerheads and faucet aerators, thermostats, 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 encompasses 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 was 1.3 GWh for 2018, down from 9.3 GWh for 2017. Savings accounted for 3% of the residential sector’s evaluated kWh savings and 1% of the total portfolio’s evaluated kWh savings.

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. Consistent with the approach used in previous years, Cadmus accepted savings from these custom measures at a 100% realization rate.

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 and 1% of the total portfolio’s savings. Custom thermal measures such as insulation generated 95% of kWh savings for the program in 2018, up from 52% in 2017. 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.

Approximately 5% of Residential New Construction kWh savings resulted from prescriptive measures, such as ENERGY STAR appliances. Cadmus produced evaluated savings estimates using methods defined for each measure in the Vermont TRM.

### ***Residential Upstream***

Table 2 shows Residential Upstream savings for two program tracks: Residential Smartlight and Upstream HVAC. The great majority of Residential Upstream savings resulted from prescriptive lighting measures. Cadmus generated savings using methods defined in the Vermont TRM.

Cold climate heat pumps (CCHPs) and heat pump water heaters continued strong performance this year, dominating Upstream HVAC. More than half of the CCHP measures replaced fossil-fuel systems, causing



negative energy and demand savings for the program group as a whole. Roughly 20% of heat pump water heaters replaced fossil-fuel models, but heat pump water heaters overall contributed strong net positive kWh savings.

Upstream HVAC accounted for 54% of the MMBtu savings of the portfolio, not including C&I/Multifamily custom project savings funded by TEPF, which are not included in this report.

## 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 22 projects from the Custom Retrofit program and 23 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 46% of the total C&I/Multifamily Custom Retrofit kWh savings and 48% 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	-39,978	39,514	201	0	0	2,210,838	0%
	1	40,064	95,476	45	3	135,904	2,859,804	5%
	2	97,126	181,613	30	3	452,630	4,007,394	11%
	3	187,147	398,730	18	3	1,083,681	4,850,856	22%
	4	449,211	944,658	13	13	8,815,007	8,815,007	100%
<b>Subtotal</b>				<b>307</b>	<b>22</b>	<b>10,487,222</b>	<b>22,743,898</b>	<b>46%</b>
NC/MOP	0	0	17,152	132	0	0	890,098	0%
	1	17,440	49,044	65	4	106,205	2,046,801	5%
	2	49,373	105,967	39	3	200,869	2,949,996	7%
	3	108,743	207,500	13	3	514,428	2,064,185	25%
	4	240,588	805,627	13	13	5,792,494	5,792,494	100%
<b>Subtotal</b>				<b>262</b>	<b>23</b>	<b>6,613,996</b>	<b>13,743,573</b>	<b>48%</b>
<b>TOTAL</b>				<b>569</b>	<b>45</b>	<b>17,101,218</b>	<b>36,487,471</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 10.00 results from dividing 30 by 3.

**Table 5. Expansion Weight by Stratum**

Program Group	Stratum	Total Number of Projects*	Projects in Sample	Expansion Weight
Retrofit	0	201	0	0
	1	45	3	15.00
	2	30	3	10.00
	3	18	3	6.00
	4	13	13	1.00
NC/MOP	0	132	0	0
	1	65	4	16.25
	2	39	3	13.00
	3	13	3	4.33
	4	13	13	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

Cadmus used the equation provided above to calculate the realization rate for each savings component (such as kWh, winter demand reduction, and summer demand reduction) of each program group (C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP).

When Cadmus applied the same equation to the MMBtu savings component of the Custom Retrofit program group, however, the method produced a realization rate that did not yield a reasonable estimate, because of the interaction of negative and positive MMBtu savings. Accordingly, Cadmus applied the equation above separately to projects with negative MMBtu savings and positive MMBtu savings. Cadmus then applied the realization rate for projects with negative MMBtu savings to the claimed MMBtu values of all such projects in the population to estimate total negative evaluated MMBtu savings. Cadmus applied the realization rate for projects with positive MMBtu savings to the claimed MMBtu values for all projects with positive savings to estimate the total positive evaluated MMBtu savings. Finally, the team calculated the overall realization rate for each program group by summing the total estimated negative and positive evaluated savings and dividing that sum by the total negative and positive claimed MMBtu savings.



## 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 lower evaluated 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	22,744	90.0%	2,825	90.5%	2,805	92.7%

\*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 PSD 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
463680	4	481,198	94.9%	68.1%	68.8%	Reduced savings because of insufficient documentation; reported savings appear to use wrong load reduction value.
464080	4	545,118	41.4%	77.9%	77.9%	Adjusted motor load and runtime assumptions using operational data
466393	4	887,267	119.8%	113.2%	80.5%	Used custom calculations instead of TRM deemed values
467362	4	568,526	95.2%	68.9%	68.9%	Eliminated double-counted savings for pressure reduction
469903	4	944,658	78.2%	93.6%	89.3%	Reduced lighting hours of use and percent savings from heater controls
469904	4	449,211	78.5%	95.7%	91.0%	Eliminated anti-sweat heater control savings because of lack of documentation

EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
469947	4	801,762	100.0%	100.0%	100.0%	Used current MMBtu calculation methodology
471641	4	593,377	99.9%	173.8%	129.1%	Corrected load shape for facility type; used current MMBtu calculation methodology
474685	4	920,659	87.0%	87.4%	85.8%	Reduced lighting hours of use and percent savings from heater controls
475819	4	863,917	82.7%	83.7%	87.0%	Reduced lighting hours of use and percent savings from heater controls
451730	3	398,730	99.8%	99.7%	100.3%	Used current MMBtu calculation methodology
475299	3	318,333	28.2%	38.4%	26.5%	Multiple adjustments, including large adjustment to estimated savings from setbacks
480484	2	179,899	99.7%	183.0%	125.9%	Adjusted coincidence factors and corrected the heating efficiency value
467458	1	49,600	93.9%	98.9%	98.9%	Used custom VFD modeling tool and degraded baseline motor efficiency
471303	1	42,827	99.9%	100.3%	100.5%	Used current MMBtu calculation methodology

### **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 lower evaluated winter and 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	13,744	95.8%	1,776	98.8%	1,969	94.1%

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



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 PSD 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
449781	4	319,006	97.2%	150.1%	35.6%	Adjusted assumptions and corrected demand reduction calculations
456739	4	544,012	88.0%	102.8%	80.2%	Updated the flow profiles for the glycol and chilled water loops
458955	4	805,627	95.0%	95.0%	95.0%	Reduced savings because of insufficient metering data
468763	4	434,857	57.7%	37.4%	100.0%	Reduced savings because of relocated snow making guns
468827	4	675,341	98.0%	91.0%	83.2%	Eliminated demand reduction for variable-speed fans
469420	4	339,536	100.0%	80.5%	76.7%	Reported savings appeared to use wrong demand reduction value and did not apply coincidence factors
476065	4	443,014	85.3%	123.5%	102.6%	Multiple adjustments
478987	4	240,588	100.2%	100.6%	99.8%	Added heating penalty for some lighting measures
481846	4	252,104	98.2%	98.4%	98.5%	Used custom calculations for VFD savings
449817	3	206,505	98.7%	77.8%	96.4%	Adjusted assumptions; reported savings appeared to use wrong load reduction value
454549	3	170,355	79.3%	75.4%	83.6%	Adjusted inputs; reported savings appeared to use wrong values
454249	2	58,099	96.6%	100.0%	99.9%	Corrected EER value and added lighting heating penalty
455843	2	51,899	100.0%	100.0%	100.0%	Added lighting heating penalty and corrected appliance MMBtu savings
468099	2	90,871	99.1%	96.2%	95.8%	Corrected coincidence factors and one kWh savings value
474337	1	24,975	115.7%	n/a	110.9%	Used custom calculations and included winter demand savings

EVT Project ID	Stratum	Gross Claimed kWh	kWh RR	Winter kW RR	Summer kW RR	Reason for Adjustment
475660	1	25,503	100.0%	87.6%	110.8%	Reason for demand reduction discrepancies unclear

### Commercial and Industrial/Multifamily Prescriptive

In the C&I/Multifamily Prescriptive program group, evaluated savings tracked closely with reported savings for lighting and within 6% for non-lighting. 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	13,375,627	99.8%	2,425	100.0%	1,825	100.0%
Prescriptive Non-Lighting	482,334	95.5%	67	94.4%	63	94.3%
<b>Total</b>	<b>13,857,962</b>	<b>99.7%</b>	<b>2,493</b>	<b>99.8%</b>	<b>1,888</b>	<b>99.8%</b>

Adjustments to non-lighting measures mostly resulted from claimed savings values that appeared to use values from the 2017 TRM instead of the 2018 TRM, although most measures used 2018 TRM values

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

### Commercial and Industrial/Multifamily Efficient Products

Realization rates for C&I/Multifamily Efficient Products measures stayed closed to 100% for each savings component. Table 11 summarizes adjustments to kWh and winter and summer kW.

Table 11. C&I/Multifamily Efficient Products Adjustments

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Efficient Products	16,428,530	100.0%	1,507	100.5%	3,036	99.6%

Notable adjustments were necessary to only two measures with relatively low quantities—LED outdoor fixtures and linear LED replacement lamps. With LED outdoor fixtures, claimed savings used values different from 2018 TRM deemed savings values. With linear LED replacement lamps, the deemed values in the 2018 did not use the leakage rate factor, which Cadmus incorporated with evaluated savings.



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

**Commercial and Industrial/Multifamily Upstream**

As shown in Table 12, evaluated savings for the C&I/Multifamily Upstream measures tracked closely with claimed savings overall, with an energy realization rate of 100.0%. Winter and summer peak demand reductions (kW) for Upstream HVAC are well off 100%, at 31.5% for winter and 123.7% for summer, but the small magnitude of these savings gives them little effect on the program group realization rates.

**Table 12. 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	16,303,771	100.0%	1,573	100.0%	3,069	100.0%
Upstream HVAC	580,464	100.0%	-43	31.5%	13	123.7%
<b>Total</b>	<b>16,884,235</b>	<b>100.0%</b>	<b>1,530</b>	<b>101.9%</b>	<b>3,082</b>	<b>100.1%</b>

The realization rate for Smartlight energy savings was below 100% primarily because claimed savings for LED outdoor fixtures appeared to incorporate a waste heat factor, which should not be used for unheated spaces.

All notable adjustments with Upstream HVAC measures related to cold climate heat pumps. Claimed savings for these measures appeared to use a different load reduction (kW) value than provided in the 2018 TRM, resulting in realization rates between 75% and 92% for winter summer peak demand reduction. The 31.5% realization rate for the winter KW reduction is mathematically correct but results from the small magnitude of net negative savings, with negative demand reduction from cold climate heat pumps overall more than offsetting positive demand savings from heat pump water heaters, efficient blower fans, and other measures.

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

**Residential Efficient Products**

No notable adjusts were necessary for Efficient Products lighting measures. Realization rates also remained close to 100% for most non-lighting measures, but the realization rate for winter peak demand reduction fell to 87.2% for non-lighting measures overall. Table 13 summarizes the necessary adjustments.



**Table 13. 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	32,947,307	100.0%	9,915	100.0%	2,714	100.0%
Non-Lighting	3,669,623	99.3%	261	87.2%	1,247	97.5%
<b>Total</b>	<b>36,616,930</b>	<b>99.9%</b>	<b>10,176</b>	<b>99.7%</b>	<b>3,961</b>	<b>99.2%</b>

Non-lighting measures requiring adjustments included clothes washers, for which evaluated savings were consistently at 87% of claimed savings. With advanced thermostats, claimed savings appeared to use winter and summer coincidence values from the 2017 TRM and omitted claimed savings for systems with gas heat.

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

### ***Residential Retrofit/Low-Income Single-Family***

Only a small percentage of measures required adjustments for energy savings or demand reduction 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 14 summarizes the necessary adjustments.

**Table 14. 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	1,191,115	100.0%	279	98.8%	104	100.1%
HPwES	140,332	100.0%	34	100.0%	1	100.0%
<b>Total</b>	<b>1,331,446</b>	<b>100.0%</b>	<b>312</b>	<b>98.9%</b>	<b>105</b>	<b>100.1%</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 15, 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. Measures in the residential retrofit or LISF tracks accounted for all water savings.



**Table 15. 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	3,777	100.0%	2,189	99.5%
HPwES	8,757	100.0%	0.0	
<b>Total</b>	<b>12,535</b>	<b>100.0%</b>	<b>2,189</b>	<b>99.5%</b>

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

### **Residential New Construction**

As shown in Table 16, Residential New Construction received only minor adjustments to energy savings and demand reduction overall.

**Table 16. 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	867,580	99.6%	229	99.8%	80	99.7%

Custom thermal measures (such as insulation and air sealing) produced 95% of energy savings for the Residential NC program group in 2018. As shown in Table 17, adjustments to prescriptive measures accounted for all net adjustment in energy and demand savings for the Residential NC program group.

Savings adjustments resulted from eliminating claimed savings for faucet aerators, which were not identified in the TRM as a new construction measure; correcting unit energy savings values for some measures; and rounding error.

**Table 17. 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	40,985	91.3%	14	96.6%	8	97.1%
Residential NC Custom	826,595	100.0%	215	100.0%	72	100.0%
<b>Total</b>	<b>867,580</b>	<b>99.6%</b>	<b>229</b>	<b>99.8%</b>	<b>80</b>	<b>99.7%</b>

As shown in Table 18, custom thermal measures accounted for nearly all Residential NC MMBtu savings, while prescriptive measures generated all water savings.

**Table 18. 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	72	66.9%	472	71.6%
Residential NC Custom	8,528	100.0%	0	0.0%
<b>Total</b>	<b>8,599</b>	<b>100.0%</b>	<b>472</b>	<b>71.6%</b>

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

**Residential Upstream**

Energy and demand savings were negative for the Upstream HVAC program group but positive for Residential Upstream as a whole, because of strong savings from residential Smartlight measures. Table 19 provides energy savings and demand reduction realization rates for Residential Smartlight and Upstream HVAC measures.

**Table 19. 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	4,691,673	100.0%	1,416	100.0%	392	100.0%
Upstream HVAC	-75,076	100.0%	-633	69.4%	-10	-165.9%
<b>Total</b>	<b>4,616,597</b>	<b>100.0%</b>	<b>783</b>	<b>124.7%</b>	<b>381</b>	<b>107.2%</b>

Energy and demand adjustments to Smartlight measures were minor, primarily resulting from correcting deemed savings values with linear replacement lamps. With Upstream HVAC, winter demand reduction adjustments resulted from the use of 2017 TRM coincidence factors for two measures and from the use of different load reduction values than provided in the 2018 TRM for cold climate heat pumps. The same cold climate heat pump issue also resulted in summer demand reduction adjustments.

The same fuel-conversion cold-climate heat pumps that created large negative electricity savings for the Upstream HVAC program group generated large MMBtu savings, which are summarized in Table 20. Upstream HVAC measures account for 54% of evaluated MMBtu savings for the EVT portfolio.

**Table 20. Residential Upstream TRB Adjustments**

Program Group	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Smartlight	-10	318.9%	0	n/a
Upstream HVAC	47,216	114.1%	0	n/a
<b>Total</b>	<b>47,206</b>	<b>114.1%</b>	<b>0</b>	<b>n/a</b>



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

## Recommended Improvements

The 97.7% 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 45 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 strongly 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 for all equipment, as well as submittals and/or detailed and comprehensive equipment photos where practical 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. Where invoices or other necessary documentation for a given project were missing and could not be provided by EVT, Cadmus reduced savings or denied savings altogether.

#### **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. For projects with inadequate documentation of baseline conditions, Cadmus relied on baseline assumptions provided in the TRM where appropriate and used experience and engineering judgement to make reasonable assumptions. In some cases where savings could not be estimated with reasonable confidence, Cadmus reduced savings by a nominal percentage to account for uncertainty.

#### **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 this information in the overview proves impractical, the overview should reference additional project documents that provide the necessary information.

### **Improve Online Tracker Calculation Methods**

As discussed during the evaluation, Cadmus found several C&I custom projects for which claimed load reduction values differed considerably from calculated values provided with project documentation, which caused erroneous winter and summer peak demand reduction values to also be reported. Cadmus and EVT identified the cause as a fault in the implementation of the online project tracker: Rather than taking the load reduction as a primary input, the online tracker reportedly used the calculated energy savings (kWh) for each measure and then divided by a default hours of use to back out load reduction (kW), to which coincidence factors were then applied to calculate the winter and summer demand reduction values. Where the default hours of use also differed from the custom value for the project and were not corrected, the backed-out kW values were not accurate. Cadmus recommends correcting this issue in a way that does not rely on default inputs and backed-out values. VEIC reported during the project that a fix was underway.

### **Ensure Consistency of Methods**

For some lighting projects, which accounted for a large percentage of savings, Cadmus and EVT determined that MMBtu savings were being calculated with the method in use for 2017 rather than a new equation EVT implemented beginning in 2018. Cadmus recommends continuing and strengthening efforts to ensure that claimed savings calculations use the values and equations in effect during the applicable program year.

### ***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 a few remaining significant digit issues in the 2018 tracking data, particularly with MMBtu savings or calculated values.

#### **Ensure All Measures Use Updated TRM Values**

Cadmus noted a small but substantial number of measures for which claimed savings used deemed values or coincidence factors from the 2017 TRM instead of the 2018 TRM. Some measures used load reduction values that could not be identified in either the 2017 or 2018 TRM. Cadmus recommends continuing and strengthening efforts to ensure that values are updated as necessary each year for all measures.

#### **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.



**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.