



Report to Verify Efficiency Vermont 2022 Savings Claim

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Acronyms and Definitions

C&I	Commercial and industrial
CCF	Hundred cubic feet
EEC	Energy Efficiency Charge
UMP	Uniform Methods Project
EVT	Efficiency Vermont
GHG	Greenhouse Gas
GWh	Gigawatt hours
HOU	Hours of use
HPwES	Home Performance with ENERGY STAR
HVAC	Heating, ventilation, and air conditioning
kW	Kilowatt
kWh	Kilowatt hours
LISF	Low-Income Single-Family
MMBtu	Million British thermal units
NC/MOP	New Construction and Market Opportunity
NREL	National Renewable Energy Laboratory
PSD	Vermont Department of Public Service
PUC	Public Utility Commission
REM/ <i>Rate</i>	Residential energy simulation analysis model
RR	Realization rate
TEPF	Thermal Energy and Process Fuels
TRM	Technical Reference Manual
UMP	Uniform Methods Project
VEIC	Vermont Energy Investment Corporation

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Executive Summary

On April 1, 2023, Vermont Energy Investment Corporation (VEIC), which administers 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 2022 to document its preliminary savings claim for year 2022 activities. To certify achieved savings toward VEIC’s performance goals, the PUC requires the Vermont Department of Public Service (PSD) to verify the energy, coincident peak, and total resource benefit savings claimed by EVT.

This report presents the findings of Cadmus’ verification of the 2022 EVT savings claim. Cadmus also makes recommendations for improvements in the methodology and processes for delivering EVT energy efficiency programs.

Cadmus evaluated the savings claimed for the entire EVT portfolio of programs in the commercial and industrial (C&I), multifamily, and single-family residential sectors. Table 1 provides portfolio-wide realization rates for energy saved (kWh) and winter 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	81,583,700	96.9%	12,732	96.7%	10,509	97.7%

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 reduction (kW), and summer peak demand reduction (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 81.6 GWh, with a realization rate of 96.9% for the EVT portfolio.

This 96.9% realization rate speaks well for EVT and for the efforts of VEIC, its implementer, in estimating and documenting savings. The realization rate is slightly lower than identified during review of the 2021 claimed energy savings, which equaled 66.6 GWh with a realization rate of 97.1%.

At the 90% confidence level, the relative precision of the realization rates for energy savings (kWh) is $\pm 9.6\%$ for Commercial and Industrial/Multifamily (C&I/Multifamily) Custom Retrofit projects and $\pm 1.9\%$ for C&I/Multifamily Custom New Construction and Market Opportunity (NC/MOP) projects. The relative precision for the portfolio as a whole is $\pm 1.5\%$.

Table 2. Electric Adjustment by Program Group

Program Group	Energy Saved		Winter kW Reduction		Summer kW Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
C&I and Multifamily						
Custom Retrofit ^a	13,932,776	84.0%	1,589	88.8%	1,774	85.0%
Custom NC/MOP ^a	24,642,509	98.9%	3,584	94.1%	3,979	102.0%
Prescriptive Lighting	75,070	97.9%	50	29.2%	69	18.7%
Prescriptive Non-Lighting	211,113	100.1%	25	100.1%	18	100.1%
Efficient Products	39,262	100.0%	5	100.0%	6	100.0%
SMARTLIGHT	15,314,702	99.7%	1,734	100.0%	2,898	100.0%
Upstream Non-Lighting	2,834,519	100.7%	452	100.7%	167	100.9%
C&I Subtotal	57,049,952	95.6%	7,439	94.3%	8,911	97.3%
Residential						
Efficient Products	8,550,276	100.0%	1,550	100.0%	906	99.9%
Residential Retrofit/Low-Income Single-Family (LISF)	495,301	98.8%	115	99.7%	76	99.3%
Home Performance with ENERGY STAR (HPwES)	57,714	100.0%	11	99.1%	0	n/a
Residential New Construction	404,678	100.2%	114	103.8%	9	104.6%
SMARTLIGHT	2,156,887	100.0%	645	100.0%	182	100.0%
Upstream Non-Lighting	12,868,891	100.1%	2,859	100.1%	424	100.2%
Residential Subtotal	24,533,747	100.0%	5,293	100.1%	1,597	100.0%
Total Portfolio	81,583,700	96.9%	12,732	96.7%	10,509	97.7%

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

Table 3 summarizes the reductions in fossil fuel MMBtu and water savings—the two total resource benefit components. Realization rates fluctuate across program groups, but the overall MMBtu realization rate remains high at 116.4%. The overall water savings realization rate is 98.3%.

Table 3. Total Resource Benefit Adjustments by Program Group

Program Group	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
C&I and Multifamily				
Custom Retrofit ^a	13,143	194.3%	11,083	100.0%
Custom NC/MOP ^a	4,006	99.7%	4,084	100.0%
Prescriptive Lighting	-30	100.0%	0	n/a
Prescriptive Non-Lighting	1,008	100.0%	265	98.3%
Efficient Products	404	100.0%	0	n/a
SMARTLIGHT	-8,603	100.2%	0	n/a
Upstream Non-Lighting	3,737	100.1%	630	100.0%
C&I/Multifamily Subtotal	13,665	190.5%	16,063	100.0%
Residential				
Efficient Products	25,236	100.0%	90,452	99.4%
Residential Retrofit/LISF	9,282	100.0%	1,880	94.2%
HPwES	4,047	100.0%	0	n/a
Residential New Construction	2,232	96.8%	696	103.9%
SMARTLIGHT	-17	100.0%	0	n/a
Upstream Non-Lighting	20,378	100.0%	0	n/a
Residential Subtotal	61,158	99.9%	93,027	99.3%
Portfolio Total	74,823	116.4%	109,090	99.4%

^a These totals exclude any contributions from TEPF-funded measures.

Introduction

The annual EVT savings claim verification addresses several needs, but the primary purpose is to calculate realization rates for energy savings (kWh) and for winter and summer peak demand reduction (kW). EVT applies these realization rates to its claimed savings to arrive at actual gross savings estimates, which it uses to calculate net savings and cost-effectiveness.

The savings claim evaluation also determines the realization rates used to calculate the Total Resource Benefit savings, which comprise annual savings in fossil fuels and wood fuel (in MMBtu) and in water savings in hundreds of cubic feet (CCF).

Process

Verification began in February 2023, after EVT provided Cadmus with project files for the largest custom C&I/Multifamily sector projects. By mid-March, EVT provided a database documenting savings for the entire portfolio. Cadmus queried this database to generate the datasets needed to evaluate each program. Cadmus sampled C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom New Construction/Market Opportunity projects as necessary and requested files for the sampled projects.

Cadmus submitted savings reports for each project as it was completed to give EVT adequate time to provide relevant feedback in the short timeline of the evaluation.

The final version of this report, submitted by the June 23, 2023, deadline, documents all findings.

Scope

The evaluation involved 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 surveys or site visits to verify the installation or the correct operation of products or to verify baseline conditions. Nor was any metering performed, though Cadmus used available advanced metering infrastructure data or other metering data to verify and adjust savings where practical for evaluated custom commercial and industrial projects.

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

Also beyond the scope was an evaluation of the methods used in the Vermont Technical Reference User Manual (TRM) or a rigorous review of EVT's implementation of TRM methods and the EVT database. Nevertheless, Cadmus notified EVT of any errors found in the TRM or its application by EVT.

Cadmus also provided high-level recommendations for improving methods and processes (see this report's *Recommended Improvements* section).

Program Groups

The project organizes EVT programs in nine program groups. This report presents findings within the following program groups and program components.

Commercial and industrial programs

- C&I/Multifamily Custom Retrofit
- C&I/Multifamily Custom NC/MOP
- C&I/Multifamily Prescriptive
 - Prescriptive Lighting
 - Prescriptive Non-Lighting
- C&I/Multifamily Efficient Products
- C&I/Multifamily Upstream
 - SMARTLIGHT
 - Upstream Non-Lighting (formerly Upstream HVAC)¹

Residential programs

- Residential Efficient Products
- Residential Retrofit/Low-Income Single-Family (LISF)
 - Retrofit/LISF
 - Home Performance with ENERGY STAR (HPwES)
- Residential New Construction
- Residential Upstream
 - SMARTLIGHT
 - Upstream Non-Lighting (formerly Upstream HVAC)²

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.

As with the 2016 through 2021 savings claims verifications, this report excludes from C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP projects all measures funded by thermal energy and process fuels (TEPF). These measures, which focus on MMBtu savings and offer little or no energy (kWh) savings or peak demand (kW) reduction, are often fundamentally different than measures funded

¹ The C&I/Multifamily Upstream Non-Lighting component supports installation of efficient commercial appliances, HVAC equipment, heat pump water heaters, and refrigeration equipment.

² The Residential Upstream Non-Lighting component primarily supports installation of efficient circulator pumps, cold-climate heat pumps, heat pump water heaters, and pellet and wood stoves.

by the Electric Energy Efficiency Charge (EEC). Including such measures in this analysis might have made realization rates less accurate for EEC-funded measures.

Accordingly, the PSD requested that the evaluation team analyze the savings for TEPF-funded measures separately, by evaluating the savings of separate stratified samples. Cadmus has included a summary of savings and realization rates for these TEPF-funded projects in *Appendix A*.

Evaluation of Energy Savings Account Pilot Projects

During 2022, Efficiency Vermont began piloting an Energy Savings Account program. This program allows business customers to conduct energy efficiency projects themselves, leaving calculations and project data collection up to the business.

The PSD requested that the evaluation team evaluate energy savings of a sample of projects from the pilot. Cadmus has included a summary of ESA evaluation results in *Appendix B*.

Methods

Cadmus used a range of methods to calculate evaluated savings and realization rates for each program group and component. This chapter describes the overall approach used for each program group. It also documents the methodologies used for sampling and for calculating the realization rates for the sampled program groups.

Commercial and Industrial/Multifamily Custom Retrofit

Electric savings from C&I/Multifamily Custom Retrofit projects increased from 13.1 GWh in 2021 to 13.9 GWh in 2022. Custom Retrofit projects accounted for 21% of the C&I/Multifamily sector's evaluated kWh savings and 15% of the total portfolio's evaluated kWh savings, down from 29% and 18% for 2021, respectively.

This program comprised 229 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 23 projects. Cadmus applied realization rates calculated for this sample to the population of 229 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. Cadmus examined calculation inputs, assumptions, methods, and documentation to assess whether the savings estimates were reasonable. For some projects with available electric metering data, Cadmus analysts compared pre- and post-installation energy usage to assess the accuracy of savings estimates.

Commercial and Industrial/Multifamily Custom New Construction and Market Opportunity

C&I/Multifamily Custom NC/MOP projects showed strong performance in 2022, accounting for 45% of the C&I/Multifamily sector's evaluated kWh savings and 31% of the total portfolio's evaluated kWh savings. (In 2021, the program contributed 32% of the C&I/Multifamily sector evaluated savings and 20% of the total portfolio savings.) Electric energy savings increased from 13.5 GWh in 2021 to 24.6 GWh in 2022.

The program group included 207 projects that met the evaluation criteria. As with the C&I/Multifamily Custom Retrofit category, C&I/Multifamily Custom NC/MOP projects varied considerably in complexity and size, with the largest projects comprising hundreds of measures.

Cadmus used a sampling approach for this program group similar to that used for C&I/Multifamily Custom Retrofit. Cadmus selected a random sample of 21 projects for evaluation and estimated the population's total savings by applying the resulting realization rates to the population of 207 projects.

The evaluation process for each C&I/Multifamily Custom NC/MOP project also closely resembled that used for C&I/Multifamily Custom Retrofit projects, although pre- and post-installation metering data were not available for new construction.

Commercial and Industrial/Multifamily Prescriptive

Claimed savings for the C&I/Multifamily Prescriptive program group continued to decline in 2022, from 0.4 GWh in 2021 to 0.38 GWh in 2022. The 2022 C&I/Multifamily Prescriptive projects accounted for 1% of the C&I/Multifamily sector kWh evaluated savings and 0.5% of the total portfolio's evaluated kWh savings, similar to 2021.

Table 2 reports savings for two components—Prescriptive Lighting and Prescriptive Non-Lighting.

Prescriptive Lighting savings increased from 70,131 kWh in 2021 to 75,070 kWh in 2022. Prescriptive Non-Lighting includes a variety of measures, such as HVAC, refrigeration, and compressed air. Claimed savings decreased for Non-Lighting measures, from 321,564 kWh in 2021 to 211,113 kWh in 2022.

All measures in this program group were prescriptive. To evaluate claimed savings, Cadmus generated savings estimates using equations and assumptions defined for each measure by the Vermont TRM, along with necessary equipment-specific values provided in the measures tracking data (for example, lamp wattage or equipment efficiency). Where EVT relied on deemed savings provided by the TRM for energy savings (kWh), demand reduction (kW), MMBtu savings, and/or water savings (rather than TRM methods requiring more inputs), Cadmus used the same deemed savings except where using TRM calculations led to significantly different savings.

As with all prescriptive measures (whether using deemed savings or equations with more inputs), the 2022 TRM also identifies a load shape to use for each C&I/Multifamily Prescriptive measure. Cadmus applied the winter and summer coincidence factors from each load shape to the appropriate load reduction for each measure to calculate the winter and summer coincident peak demand reduction.

Commercial and Industrial/Multifamily Efficient Products

Savings from the C&I/Multifamily Efficient Products program group declined in 2022, from 72,534 kWh in 2021 to 39,262 kWh in 2022. The program group accounts for only 0.1% of the C&I/Multifamily sector's kWh savings and 0.05% of the total portfolio kWh savings in 2022.

C&I/Multifamily Efficient Products comprised only non-lighting measures in 2022. These measures included equipment such as advanced thermostats, pool pumps, heat pump water heaters, and clothes dryers.

All C&I/Multifamily Efficient Products measures were prescriptive. For these measures, EVT relied on deemed savings defined by the TRM (rather than on TRM methods requiring more inputs), and Cadmus used the same deemed savings except where using TRM calculations led to significantly different savings.

Commercial and Industrial/Multifamily Upstream

Claimed savings for the C&I/Multifamily Upstream program group increased from 15.1 GWh in 2021 to 18.1 GWh in 2022, with 84% of savings resulting from SMARTLIGHT measures. The program accounted for 33% of the C&I/Multifamily sector kWh savings and 23% of the total portfolio's kWh savings, down from 38% and steady at 23% in 2021, respectively.

Table 2 reports claimed savings for the group's two components—SMARTLIGHT and Upstream Non-Lighting.

The C&I/Multifamily Upstream Non-Lighting component comprises a wide variety of measures, such as natural refrigerant, commercial appliances, brushless permanent magnetic circulator motors, cold climate heat pumps, condensing units, evaporator fan motors and units, and heat pump water heaters. Claimed savings for the non-lighting measures decreased by 7% in 2022, down from 3.0 GWh in 2021 to 2.8 GWh in 2022. SMARTLIGHT claimed savings increased by 28% of its 2021 levels, rising from 12.0 GWh in 2021 to 15.3 GWh in 2022.

All C&I/Multifamily Upstream measures were prescriptive. Cadmus generated savings estimates using methods the Vermont TRM defines for each measure. For the Upstream measures, EVT relied on deemed savings defined by the TRM (rather than TRM methods requiring more inputs), and Cadmus used the same deemed savings except where using TRM calculations led to significantly different values.

Residential Efficient Products

Savings for Residential Efficient Products held fairly steady in 2022, falling slightly from 8.9 GWh in 2021 to 8.6 GWh in 2022. Residential Efficient Products provided 35% of the evaluated kWh savings for the residential sector and 11% of the total portfolio's evaluated kWh savings.

Savings for each component of the program group—Efficient Products Lighting and Efficient Products Non-Lighting—also showed little change relative to 2021. Savings from lighting measures declined from 1.4 GWh in 2021 to 1.1 GWh in 2022. Claimed savings for non-lighting measures decreased slightly from 7.5 GWh in 2021 to 7.4 GWh in 2022. Non-lighting measures included ENERGY STAR appliances and room air conditioners, heat pump water heaters, advanced thermostats, and others.

The great majority of Residential Efficient Products measures were prescriptive. Cadmus generated savings estimates using methods defined for each measure by the Vermont TRM. For the Residential Efficient Products measures, EVT relied on deemed savings defined by the TRM (rather than TRM methods requiring more inputs), and Cadmus used the same deemed savings.

Residential Retrofit/Low-Income Single-Family

The Residential Retrofit/LISF program group encompasses three program tracks—Residential Single-Family Retrofit, LISF, and HPwES.

Table 2 reports combined savings for Residential Single-Family Retrofit and LISF and reports savings for HPwES separately. Claimed savings for the three tracks combined was 0.6 GWh in 2022, down from

1.2 GWh in 2021. Savings accounted for 2% of the residential sector’s evaluated kWh savings and 1% of the total portfolio evaluated kWh energy savings.

For prescriptive measures, Cadmus estimated savings using methods defined for each measure in the Vermont TRM. Where EVT relied on deemed savings defined by the TRM (rather than TRM methods requiring more inputs), Cadmus used the same deemed savings. Consistent with the approach used in previous years, Cadmus accepted savings from custom measures in this program group at a 100% realization rate.

The HPwES program is funded primarily by TEPF and comprises prescriptive air sealing and insulation measures. Cadmus evaluated savings for all HPwES measures using TRM methods.

Residential New Construction

Residential New Construction accounted for 2% of the residential sector’s evaluated kWh and 1% of the total portfolio savings. Custom thermal measures such as insulation generated 92% of energy savings for the program in 2022. 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 8% of Residential New Construction kWh savings resulted from prescriptive measures, such as ENERGY STAR appliances. Cadmus estimated evaluated savings for these prescriptive measures using methods defined for each measure in the Vermont TRM.

Residential Upstream

Table 2 shows savings for the two Residential Upstream program components—SMARTLIGHT and Upstream Non-Lighting. Savings for residential SMARTLIGHT declined slightly from 2.3 GWh in 2021 to 2.2 GWh in 2022. SMARTLIGHT measures accounted for 14% of claimed kWh savings for the Residential Upstream program group.

Savings for the Upstream Non-Lighting component increased from 11.6 GWh in 2021 to 12.9 GWh in 2022. Measures include heat pump water heaters, circulator pumps, ducted air-source heat pumps, and ductless mini-split heat pumps, with heat pump equipment often displacing oil- or wood-burning equipment. The Non-Lighting component accounted for 27% of MMBtu savings of the portfolio (not including C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP project savings funded by TEPF, which are documented separately in *Appendix A*), down from 49% in 2021.

For Residential Upstream measures, EVT relied on deemed savings defined by the TRM (rather than TRM methods requiring more inputs), and Cadmus used the same deemed savings.

Sampling

Cadmus developed a sampling plan for the C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP groups based on the Uniform Methods Project Sample Design and Cross-Cutting Protocols chapter.³

Sample Frame

Cadmus used project numbers to identify the population and sampling units for C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP. The evaluation examined the projects' total reported non-TEPF-funded 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 this 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 within each stratum based on the mean and standard deviation of reported energy savings. Cadmus then calculated sample sizes based on the coefficient of variation, the population size, and the 80% confidence and $\pm 20\%$ precision targets within each stratum. For each program group as a whole, the minimum confidence and precision target was 90%/ $\pm 15\%$.

The sample design yielded samples of 23 C&I/Multifamily Custom Retrofit projects and 21 C&I/Multifamily Custom NC/MOP projects. To focus evaluation resources on projects that produced the highest savings and contributed the most to program totals, Cadmus evaluated a census of the largest projects (Stratum 4) and none of the smallest projects (Stratum 0). Overall, sampled projects accounted for 48% of the total C&I/Multifamily Custom Retrofit kWh savings and 63% of the total C&I/Multifamily Custom NC/MOP kWh savings.

³ Cadmus (M. Sami Khawaja, Josh Rushton, and Josh Keeling). April 2013. *Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. "Chapter 11: Sample Design Cross-Cutting Protocols." Prepared for the National Renewable Energy Laboratory. NREL/SR-7A30-53827. <https://www.energy.gov/sites/prod/files/2013/11/f5/53827-11.pdf>

Table 4. Overview of the Sample

Program Group	Stratum	Pop. Min kWh	Pop. Max kWh	Total Projects ^a	Projects in Sample	Sample kWh Total	Pop. kWh Total	% Sample kWh per Stratum Pop.
C&I/ Multifamily Custom Retrofit	0	-906	21,113	119	0	0	869,442	0%
	1	21,114	52,815	48	4	136,304	1,751,668	8%
	2	52,816	114,547	31	4	277,264	2,307,813	12%
	3	114,548	245,953	20	4	676,955	3,390,236	20%
	4	245,954	1,939,741	11	11	5,613,617	5,613,617	100%
Subtotal				229	23	6,704,140	13,932,776	48%
C&I/ Multifamily Custom NC/MOP	0	0	34,682	116	0	0	1,024,338	0%
	1	34,683	88,733	43	4	212,896	2,443,551	9%
	2	88,734	225,936	27	4	527,723	3,685,034	14%
	3	225,937	496,655	12	4	1,346,491	3,946,581	34%
	4	496,656	7,508,542	9	9	13,543,005	13,543,005	100%
Subtotal				207	21	15,630,115	24,642,509	63%
Total				436	44	22,334,255	38,575,285	58%

^a This represents the number of projects with non-zero kWh, winter peak demand reduction, summer peak demand reduction, 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. Cadmus applied these weights 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 3 in the NC/MOP program group, the expansion weight of 3.0 results from dividing 12 by 4.

Table 5. Expansion Weight by Stratum

Program Group	Stratum	Total Projects ^a	Projects in Sample	Expansion Weight
C&I/Multifamily Custom Retrofit	0	119	0	0
	1	48	4	12.00
	2	31	4	7.75
	3	20	4	5.00
	4	11	11	1.00
C&I/Multifamily Custom NC/MOP	0	116	0	0
	1	43	4	10.75
	2	27	4	6.75
	3	12	4	3.00
	4	9	9	1.00

^a This represents the number of projects with non-zero kWh, winter peak demand reduction, summer peak demand reduction, 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 same equation to calculate the realization rate for each savings component (such as energy savings [kWh] and winter and summer demand reduction [kW]) of the C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP program groups.

To avoid interactions of negative and positive MMBtu savings, Cadmus applied the same equation 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 savings 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 savings for all projects with positive savings to estimate the total positive evaluated MMBtu savings. Finally, Cadmus 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

Cadmus made 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 energy savings (kWh), winter demand reduction (kW), and summer demand reduction (kW) within the C&I/Multifamily Custom Retrofit program group.

Table 6. Commercial and Industrial/Multifamily Custom Retrofit Adjustments

Program Group	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed MWh ^a	Realization Rate	EVT Gross Claimed kW ^a	Realization Rate	EVT Gross Claimed kW ^a	Realization Rate
Custom Retrofit	13,933	84.0%	1,589	88.8%	1,774	85.0%

^a These totals exclude any contributions from TEPF-funded measures.

Table 7 lists all sampled C&I/Multifamily Custom Retrofit projects that Cadmus identified as requiring project-specific adjustments and includes a summary of those adjustments. During the evaluation process, Cadmus provided the PSD and EVT with detailed reports for all projects in the largest-savings stratum and summary reports for other projects that required adjustments. As described in this report’s *Sampling* section, Cadmus then used evaluated and claimed savings for each project in the sample to calculate realization rates for the program group as a whole.

Table 7. Sampled Commercial and Industrial/Multifamily Custom Retrofit Projects with Adjustments

EVT Project ID	Stratum	Gross Claimed kWh	Realization Rate			Reason for Adjustment
			kWh	Winter kW	Summer kW	
522887	4	1,939,741	93.1%	109.8%	93.1%	Updated baseline and efficient fixture wattages updated based on federal standards
516493	4	467,218	59.6%	59.6%	59.6%	Reduced leak reduction savings based on provided data
464631	4	462,689	90.4%	91.4%	91.7%	Improved bin analysis resulted in lower HOU and savings
518852	4	458,541	93.5%	95.0%	95.0%	Corrected savings per model outputs and reduced savings to account for uncertainty because of missing documentation
512986	4	404,703	20.7%	20.2%	88.5%	Corrected savings error caused by error in the savings calculation tool
526742	4	371,919	94.6%	96.3%	96.6%	Corrected fixtures quantities based on project invoices
495403	4	336,487	85.0%	84.9%	85.0%	Reduced savings to account for uncertainty because of unsubstantiated model inputs
501041	4	256,673	31.9%	n/a	31.5%	Adjusted HOU based on provided data and corrected a unit conversion
523366	4	283,871	134.3%	184.2%	181.6%	Increased savings based on analysis of meter data

EVT Project ID	Stratum	Gross Claimed kWh	Realization Rate			Reason for Adjustment
			kWh	Winter kW	Summer kW	
521748	4	251,629	100.0%	99.1%	99.1%	Adjusted HOU used for demand savings
530939	3	123,105	99.9%	99.9%	99.9%	Corrected deemed MMBtu savings value per TRM
497456	3	227,000	50.0%	50.0%	50.0%	Reduced savings to account for uncertainty because of inadequate documentation
508349	2	56,192	22.0%	43.6%	43.6%	Reduced HOU based on analysis of meter data
511482	2	75,909	116.1%	116.0%	114.3%	Adjusted hot water design temperature from 110F to 120F
396129	2	80,256	56.0%	56.7%	52.7%	Reduced fixture quantities based on provided invoices and used TRM defaults for some inputs
526098	1	48,280	97.8%	110.9%	97.5%	Adjusted lamp wattages to match defaults and updated the load-shape coincidence factors
518341	1	34,520	80.0%	80.0%	80.0%	Reduced savings to account for uncertainty associated with using ultrasonic leak detection flow savings

Commercial and Industrial/Multifamily Custom New Construction and Market Opportunity

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

Table 8. Commercial and Industrial/Multifamily Custom New Construction and Market Opportunity Adjustments

Program Group	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed MWh ^a	Realization Rate	EVT Gross Claimed kW ^a	Realization Rate	EVT Gross Claimed kW ^a	Realization Rate
Custom NC/MOP	24,643	98.9%	3,584	94.1%	3,979	102.0%

^a These totals exclude any contributions from TEPF-funded measures.

Table 9 lists all sampled C&I/Multifamily Custom NC/MOP projects that Cadmus identified as requiring project-specific adjustments and 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, along with summary reports for other projects that required adjustments. As described in this report’s *Sampling* section, Cadmus used evaluated and claimed savings for each project in the sample to calculate realization rates for the program group as a whole.

Table 9. Sampled Commercial and Industrial/Multifamily Custom New Construction and Market Opportunity Projects with Adjustments

EVT Project ID	Stratum	Gross Claimed kWh	Realization Rate			Reason for Adjustment
			kWh	Winter kW	Summer kW	
517948	4	7,508,542	99.0%	99.0%	99.0%	Applied minor adjustments based on rerun of model
499510	4	1,213,091	111.1%	110.5%	110.5%	Removed the 90% operation testing factor
512518	4	1,170,669	99.5%	64.2%	96.4%	Aligned HOU with the milking schedule
521770	4	696,392	94.2%	100.0%	100.0%	Corrected a modeling error
495320	4	617,762	101.7%	108.5%	108.3%	Updated HOU to align with data center cooling hours
513154	4	609,951	100.0%	126.9%	126.9%	Corrected deemed savings
525640	3	447,746	100.0%	56.4%	177.3%	Corrected transposed load-shape factors
528201	3	328,104	91.6%	88.8%	89.4%	Adjusted savings inputs based on operation notes and aligned BIN hours to TMY data
496479	3	259,662	100.0%	99.1%	99.1%	Calculated demand savings using actual operating hours instead of load-shape hours
527955	2	124,210	107.2%	113.5%	102.2%	Corrected wattages based on specification sheets and used TRM assumptions for inputs with no justification
526153	2	147,156	100.0%	89.8%	89.8%	Calculated demand savings using actual operating hours
515821	1	60,900	97.5%	97.2%	97.5%	Used provided fan curves instead of default values
518836	1	55,065	100.0%	100.1%	100.0%	Corrected calculations related to dimming controls
517120	1	39,298	45.1%	40.0%	42.1%	Adjusted baseline to match federal standard

Commercial and Industrial/Multifamily Prescriptive

In the C&I/Multifamily Prescriptive program group, evaluated energy savings tracked closely with reported savings, but apparent calculation errors with some lighting measures caused relatively low realization rates for winter and summer demand savings overall. Table 10 summarizes adjustments to energy savings and winter and summer demand reduction.

Table 10. Commercial and Industrial/Multifamily Prescriptive Adjustments

Program Component	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Prescriptive Lighting	75,070	97.9%	50	29.2%	69	18.7%
Prescriptive Non-Lighting	211,113	100.1%	25	100.1%	18	100.1%
Total	286,184	99.5%	75	53.1%	87	35.7%

For lighting measures, most of the energy savings reduction resulted from one adjustment: Cadmus used the actual efficient lamp wattage from the measure product description as an input to the TRM savings equation rather than the blended deemed efficient wattage provided in the TRM.

A larger adjustment affected all lighting fixture (as opposed to lamp) measures: Claimed savings calculations appeared to calculate basic fixture load reduction correctly but to apply load-shape values incorrectly. This resulted in Prescriptive Lighting winter and summer demand reduction realization rates of 29.2% and 18.7%, respectively, and overall Prescriptive winter and summer demand reduction realization rates of 53.1% and 35.7%.

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

Commercial and Industrial/Multifamily Efficient Products

Realization rates for C&I/Multifamily Efficient Products measures stayed at 100% for energy savings and winter and summer demand reduction. Table 11 summarizes adjustments for each of these components.

Table 11. Commercial and Industrial/Multifamily Efficient Products Adjustments

Program Group	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Efficient Products	39,262	100.0%	5	100.0%	6	100.0%

In 2022, Efficient Products comprised only non-lighting measures. Adjustments were necessary with only one measure, because of rounding differences in applying load shapes to calculate winter and summer demand savings.

Cadmus provided information about measure-level adjustments to PSD and EVT as part of the evaluation and quality control 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 for energy savings and winter and summer demand reduction.

Table 12. Commercial and Industrial/Multifamily Upstream Adjustments

Program Component	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
SMARTLIGHT	15,314,702	99.7%	1,734	100.0%	2,898	100.0%
Upstream Non-Lighting	2,834,519	100.7%	452	100.7%	167	100.9%
Total	18,149,222	99.8%	2,186	100.2%	3,065	100.0%

Evaluated energy savings differed from claimed savings for two SMARTLIGHT measures, because claimed savings applied a waste-heat factor and indoor HOU value to savings for an LED outdoor fixture and an incorrect HOU value for a second fixture.

More Upstream Non-Lighting measures required adjustment, with the net effect being an increase to energy savings and winter and summer demand reduction. Examples of required corrections include TRM deemed savings values that had been incorrectly calculated, deemed savings values applied for the wrong fuel type, and deemed savings values applied for the wrong equipment capacity range. For two evaporator motor measures, Cadmus calculated savings using TRM inputs and methodology, instead of the claimed savings approach of using a weighted average based on three temperature bins.

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

Residential Efficient Products

Realization rates remained close to 100% for the lighting and non-lighting components of Residential Efficient Products. Table 13 summarizes the necessary adjustments to energy savings and winter and summer demand reduction.

Table 13. Residential Efficient Products Electric Adjustments

Program Component	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Lighting	1,106,142	99.8%	309	99.9%	95	99.5%
Non-Lighting	7,444,134	100.0%	1,241	100.0%	811	100.0%
Total	8,550,276	100.0%	1,550	100.0%	906	99.9%

In the lighting component, only two measures received notable corrections. For one measure, claimed savings used incorrect deemed savings values. For a second measure, claimed savings used custom calculations instead of the prescriptive methods used for Efficient Products; Cadmus reduced savings for the calculated values to account for uncertainty, because confirming the custom calculations was not practical.

No non-lighting measures required significant adjustments.

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

Residential Retrofit/Low-Income Single-Family

Evaluated energy savings tracked fairly closely with claimed savings for the Residential Retrofit/LISF program group overall. Table 14 summarizes the necessary adjustments.

Table 14. Residential Retrofit/Low Income Single Family Adjustments

Program Component	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Residential Retrofit/LISF	495,301	98.8%	115	99.7%	76	99.3%
HPwES	57,714	100.0%	11	99.1%	0	N/A
Total	553,015	99.0%	125	99.6%	76	99.3%

Most notable adjustments to energy savings and winter and summer demand reduction occurred in LISF measures. With two early-replacement refrigerator measures, claimed savings appeared to sum annual savings for the initial and remaining savings periods instead of using saving for only the initial period. For two early-replacement refrigerator measures, claimed savings used the remaining savings value instead of the initial period value. Within the HPwES component, the only notable adjustment corrected an apparent typo in an input used to calculation winter demand reduction.

As shown in Table 15, Cadmus evaluated MMBtu savings at 100% for the Residential Retrofit/LISF and HPwES components.

Measures in the LISF track accounted for all water savings. The realization rate of 94.2% for water savings results partly from a large rounding error for a faucet aerator/flow restrictor measure and from an unexplainably erroneous savings value for an early-replacement clothes washer measure.

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

Table 15. Residential Retrofit/ Low-Income Single-Family Total Resource Benefit Adjustments

Program Component	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Residential Retrofit/LISF	9,282	100.0%	1,880	94.2%
HPwES	4,047	100.0%	0	N/A
Total	13,329	100.0%	1,880	94.2%

Residential New Construction

Residential New Construction received minor adjustments to all savings components. Table 16 summarizes the necessary adjustments to energy savings and winter and summer demand reduction.

Table 16. Residential New Construction Adjustments

Program Group	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Residential New Construction	404,678	100.2%	114	103.8%	9	104.6%

As shown in Table 17, adjustments were necessary for both custom and prescriptive measures. Savings adjustments for prescriptive measures resulted primarily from using TRM calculations for one drain water heat recovery measure and correcting the deemed savings values for seven ENERGY STAR dishwashers, for which claimed savings incorrectly used low-income savings values.

With custom measures, some projects used notably different energy savings than indicated by the REM/Rate model, which Cadmus corrected. Beginning in 2022, EVT stopped using REM/Rate modeled load reduction in calculating winter and summer demand reduction, because the modeled load reduction values did not appear to be correct. Instead, EVT now calculates the load reduction by dividing the modeled energy savings by the assumed full load hours of the equipment and then applies the appropriate load-shape factors. Cadmus found this approach acceptable but found that for some projects, EVT calculated demand reduction using the REM/Rate load reduction values. Cadmus corrected savings for these projects to use the newer methodology.

Table 17. Residential New Construction Adjustments by Measure Type

Measure Type	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Residential New Construction Prescriptive	20,561	100.5%	7	100.4%	4	100.3%
Residential New Construction Custom	384,117	100.1%	106	104.0%	5	108.2%
Total	404,678	100.2%	114	103.8%	9	104.6%

As shown in Table 18, custom thermal measures accounted for the great majority of Residential New Construction MMBtu savings, and prescriptive measures generated all water savings. The low realization rate for prescriptive MMBtu savings resulted primarily from some low-flow showerhead installations reporting MMBtu savings in homes with electric water heating. The water savings realization rate is slightly elevated because of rounding differences.

Table 18. Residential New Construction Total Resource Benefit Adjustments

Measure Type	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Residential New Construction Prescriptive	187	59.9%	696	103.9%
Residential New Construction Custom	2,045	100.2%	0	n/a
Total	2,232	96.8%	696	103.9%

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

Residential Upstream

The Residential Upstream program group achieved realization rates of 100% for SMARTLIGHT and just above 100% for Upstream Non-Lighting. Table 19 summarizes savings and realization rates for electric

energy and winter and summer demand reduction. No major adjustments were necessary for SMARTLIGHT or Upstream Non-Lighting. With Upstream Non-Lighting, claimed savings for three measures used deemed savings that did not match the TRM values, but correcting these values had only a small, positive effect on savings.

Table 19. Residential Upstream Adjustments

Program Component	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
SMARTLIGHT	2,156,887	100.0%	645	100.0%	182	100.0%
Upstream Non-Lighting	12,868,891	100.1%	2,859	100.1%	424	100.2%
Total	15,025,778	100.1%	3,504	100.1%	606	100.1%

As shown in Table 20, neither program component required significant adjustments in MMBtu savings.

Table 20. Residential Upstream Total Resource Benefit Adjustments

Program Component	MMBtu Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
SMARTLIGHT	-17	100.0%	0	N/A
Upstream Non-Lighting	20,378	100.0%	0	N/A
Total	20,361	100.0%	0	N/A

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

Recommended Improvements

The 96.9% energy (kWh) realization rate for the EVT portfolio speaks well for EVT and for the efforts of its implementer, 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 to its methods and processes. Cadmus provides the following recommendations in the spirit of contributing to that effort.

Custom Commercial, Industrial, and Multifamily Projects

Cadmus conducted detailed evaluations of non-TEPF-funded measures for 44 custom projects, based on extensive project files submitted by EVT. Individual project reports submitted by Cadmus included recommendations related to calculating savings from specific types of equipment, such as variable frequency drives, snowmaking systems, and refrigerated cases. The following discussions and recommendations apply to a broader range of technologies and projects.

The first two recommendations provided below are new for this year. The other recommendations have been made previously, and most have resulted in incremental improvements each year. Cadmus believes that much more progress could be made and that improvements could be achieved more quickly. Some projects meet or exceed best practices around project documentation, but a large number of projects do not.

Regularly evaluate calculation tools for accuracy.

For at least two projects, errors found in calculation tools resulted in significant differences in savings. In one case, the claimed savings estimate was nearly ten times the evaluated savings. Cadmus recommends regularly conducting quality control on these tools by implementing a testing procedure and adding flags where savings estimates are much higher than reasonable for a given measure (i.e., 50% or higher).

Conduct in-house reviews of third-party savings estimates.

For one project, EVT accepted savings estimates from an audit report conducted by a third-party auditor. Project files did not include a calculation workbook, equipment specifications, operating parameters, or verification photos. Additionally, these savings estimates were whole numbers rounded to the nearest thousand kWh savings. Cadmus recommends insisting on a higher level of rigor when determining claimed savings. The basis of claimed savings should always be transparent and well documented.

The remaining nine recommendations for C&I custom projects have been made in previous years.

Consistently collect invoices for installed equipment.

Cadmus continues to strongly encourage EVT to require invoices for all installed equipment to support savings calculations and provide adequate information for third-party verification. For new construction projects where itemized invoices are difficult to obtain, stamped as-built drawings are also acceptable for verification. Cadmus noticed a significant improvement in 2022; however, there were still instances where invoices were not provided. Verification requires itemized invoices for all equipment, as well as submittals and/or detailed 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. The evaluation team requested invoices and other necessary documentation when these were missing for a project or measure.

Consistently document baseline equipment and operating conditions.

Cadmus noted improvement in the documentation of baseline and operating conditions during the 2022 evaluation and encourages EVT to continue its efforts to improve this documentation. Documentation of baseline equipment should include photos of manufacturer nameplates where possible. Reasonable efforts should be made to also document operational characteristics such as hours of use, loading, pressure (for example, with compressed air), and other details.

If baseline equipment run time or other relevant operational data are in doubt, pre-installation metering should be performed, particularly for projects expected to provide large savings. For this evaluation, for projects with inadequate documentation of baseline conditions, Cadmus relied on baseline assumptions in the TRM where appropriate and made reasonable assumptions where necessary using experience and engineering judgment. Savings for some projects could not be estimated with reasonable confidence, so Cadmus reduced savings by a nominal percentage to account for uncertainty.

Document existing equipment and operating conditions.

Similar to our recommendation for baseline equipment and operating conditions, Cadmus strongly recommends collecting all existing equipment nameplates and operating parameters relevant to energy savings calculations for installed projects. For example, if a measure is expected to generate savings for space conditioning, then nameplate data (at minimum) should be collected for the relevant HVAC equipment. If a steam trap repair or replacement project results in steam savings, then the corresponding boiler nameplate, efficiency, and operating parameters should be collected to verify the savings resulting from the repair. Although not part of the installed project, the boiler has a direct impact on savings. Cadmus did not note a significant improvement in documentation of existing equipment and operating conditions in 2022.

Avoid using 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 inputs rather than TRM assumptions and should document the source of these 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 project equipment is always preferable to using generic performance curves. Cadmus did not note a significant improvement in not relying on TRM assumptions in 2022.

Improve post-installation verification and measurement practices.

EVT should continue to strengthen its use of post-installation metering and site visits to support a more accurate understanding of actual savings. EVT should base claimed savings on analysis of the meter data, if available, rather than using the meter data simply for information purposes. Cadmus did not note an improvement in the amount of metered data provided; however, more post-installation photos were provided than in previous years.

Consistently provide thorough overview documentation.

Cadmus recommends that EVT continue to work toward consistently providing thorough project overviews that include all information necessary for an experienced analyst to readily understand the project scope, how savings were calculated, what inputs and assumptions informed these calculations, and what documentation supports these inputs and assumptions. If including all of this information in the overview is impractical, the overview should reference the project documents that provide the necessary information. For larger projects with more than 10 measures, EVT should create a summary document with a description and associated savings for each measure (or each type of measure in a large C&I/Multifamily Custom NC/MOP project) along with a list of relevant documents. Where practical, all associated measure documents should be organized in individual folders in the online SharePoint site. Cadmus did not note a significant improvement in providing thorough project overviews in 2022.

Simplify and clarify appropriate use of load shapes.

With some lighting measures the appropriate use of load shapes and correct method of accounting for interactive effects remains unnecessarily complex and insufficiently documented.

The EVT methodology for dealing with cooling interactive effects with some custom lighting measures serves as a good example. EVT multiplies the demand reduction by a waste heat factor to account for cooling interactive effects as it calculates the gross kW values. Although the TRM does not document

this requirement, to avoid overstating winter demand reduction these kW values must then be divided by the same waste heat factor when calculating winter demand reduction to remove the cooling interactive effects (which do not apply in winter).

Cadmus strongly recommends that cooling interactive effects always be applied appropriately either through a single load shape or by applying a waste heat factor only for summer demand reduction values, rather than using the current method of having to remove the value when calculating winter kW reduction. Cadmus also recommends that EVT clarify in the TRM which load shape or shapes to apply in other instances where interactive effects are in play, such as with grocery lighting and grocery refrigerated case lighting. Cadmus did not note a significant improvement in simplifying and clarifying the use of load shapes in 2022.

Continue to improve clarity of analysis files and calculation workbooks for all projects.

EVT has improved at providing analysis files and calculation workbooks that were used to calculate claimed savings. There were fewer cases than in previous evaluation years where Cadmus had to request calculation files. However, Cadmus recommends that EVT improve the clarity and uniformity of calculation workbooks. There were multiple projects for which several calculation files were provided from previous attempts to claim savings. These files should be archived. Cadmus also recommends providing savings summary sheets on workbooks in which multiple measure savings are being calculated. Cadmus did not note a significant improvement in the clarity of analysis files and calculation workbooks in 2022.

Use more robust methods to determine compressed air leak savings.

For compressed air leak reduction projects, Cadmus recommends using the system leak-down test as highlighted in the UMP Compressed Air Protocol to estimate the combined loss (cfm) of compressed air leaks. The implementer can use this approach in the pre- and post-case to estimate the effect of leak fixes in the system. In cases where the system leak-down test is impractical, the implementer should estimate flow by measuring compressor power and correlating this to flow using CAGI sheets or standard flow tables. Compressor power should be measured during nonproduction periods, and all non-leak air consumption should be discounted from the data to determine actual leak volume. Lastly, the most accurate approach is to measure actual flow rate in the pre- and post-nonproduction periods and discount for any non-leak air users. Installing flow meters can sometimes be invasive and prove impractical; hence, the two prior methods are more common approaches. Ultrasonic leak detectors are good for identifying leaks and estimating savings at a high level; however, the three approaches detailed above provide a more accurate way of estimating leak loss. Cadmus noted an improvement over previous evaluations in the accuracy of compressed air leak reduction savings calculation approaches, but some projects continue to use less-accurate approaches.

Prescriptive Measures

For seven of the nine program groups defined for this evaluation, most or all of the savings resulted from prescriptive measures. For prescriptive measures, the TRM documents deemed savings 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 in calculating claimed savings for prescriptive measures.

Evaluating the methods used in the TRM falls beyond the scope of this evaluation, 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. Both recommendations have been made in previous years.

Ensure database values provide as many significant digits as the TRM.

Continue efforts to ensure that the measure-tracking data, claimed savings calculations, and TRM use the same number of significant digits for per-unit deemed savings, kW load reduction, coincidence factors, and other values. For the 2022 evaluation, Cadmus noted lingering discrepancies in significant digits in the 2022 tracking data and TRM. For some measures, Cadmus found that the online version of the TRM provided more significant digits than the PDF version, and in those cases we used the online TRM value.

Increase rigor in applying the TRM methods when practical.

Cadmus recommends that EVT increase the use of TRM methods that account for differences in baseline conditions and efficient products when practical and make less use of broadly defined deemed savings. Using more rigorous TRM methods may require that EVT collect and manage additional data about baseline conditions and equipment installed. Cadmus did not note increased rigor in TRM methods in 2022.

Database Review and Dataset Generation

EVT provided database tables relevant to the evaluation early in the project cycle to allow Cadmus to construct analysis datasets. Cadmus applauds the extensive, high-quality documentation provided with the database, which proved sufficient to allow an experienced database analyst or developer to readily understand the database content and structure.

Update database documentation.

Cadmus understands that EVT may be making major changes to the tracking database during 2023. We encourage EVT to create full documentation of the new database structure in a format that will be easily accessible for the 2023 evaluation. A data dictionary or map that relates any new field names to the existing field names would provide welcome assistance in converting to the new tracking database.

Appendix A. Thermal Energy and Process Fuels Findings

This appendix provides findings for C&I/Multifamily Custom Retrofit and C&I/Multifamily Custom NC/MOP savings that are funded by TEPF. Cadmus evaluated a stratified random sample of projects with TEPF-funded measures and applied weights to extrapolate findings to the population of projects.

As documented in evaluation reports for some sampled projects, Cadmus noted an unusual contradiction in how biomass consumption is handled with TEPF-funded measures. Specifically, when replacing a fossil-fuel boiler with a biomass boiler, EVT claims the entire MMBtu of displaced fuel usage as savings, without subtracting the MMBtu consumption of the biomass boiler. This policy reportedly reflects that biomass is considered a renewable resource in Vermont. In an apparent contradiction, however, other measures can claim biomass MMBtu savings by reducing load on biomass systems. With some 2022 projects, the contradictory policies led to an obvious exaggeration in MMBtu savings, to the point that claimed MMBtu savings exceeded estimated baseline consumption. This happened because all or most boiler fuel consumption was considered eliminated because of the shift away from fossil fuel usage, and then additional MMBtu savings were claimed for insulation measures.

Cadmus encourages the PSD and EVT to revisit how biomass consumption should be handled moving forward. Cadmus holds that if MMBtu savings is defined to include reductions in biomass load, which has historically been the case, then the consumption of new biomass boilers should also be accounted for even when those boilers replace fossil fuel systems. One potential solution is to define two MMBtu components—one for fossil fuels and one for renewable fuels.

Table A-1. Electric Adjustments by Program Group for Projects with TEPF-Funded Savings

Program Group	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh*	Realization Rate	EVT Gross Claimed kW*	Realization Rate	EVT Gross Claimed kW*	Realization Rate
Custom Retrofit	92,543	75.8%	12	-589.8%	12	114.3%
Custom NC/MOP	-351	100.0%	0	100.0%	0	100.0%

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

Table A-2. MMBtu and Water Savings by Program Group for Projects with TEPF-Funded Savings

Program Group	Energy Saved		Water Saved	
	EVT Gross Claimed MMBtu*	Realization Rate	EVT Gross Claimed CCF*	Realization Rate
Retrofit	31,530	98.2%	0	n/a
NC/MOP	9,997	97.7%	0	n/a

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

Table A-3. Overview of the Sample of Projects with TEPF-Funded Savings

Program Group	Stratum	Pop. Min MMBtu	Pop. Max MMBtu	Total Projects*	Projects in Sample	Sample MMBtu Total	Pop. MMBtu Total	% Sample MMBtu per Stratum Pop.
C&I/ Multifamily Custom Retrofit	0	0	103	42	0	0	1,460	0%
	1	104	227	20	3	488	2,922	17%
	2	228	465	11	3	1,009	3,569	28%
	3	466	985	11	3	2,336	8,293	28%
	4	986	4,392	7	7	15,286	15,286	100%
Subtotal				91	16	19,119	31,530	61%
C&I/ Multifamily Custom NC/MOP	0	2	72	3	0	0	102	0%
	1	73	2,729	6	6	9,895	9,895	100%
Subtotal				9	6	9,895	9,997	99%
Total				100	22	29,014	41,527	70%

*Number of projects with non-zero kWh, winter peak demand, summer peak demand, MMBtu, or water savings provided by TEPF-funded measures

Table A-4. Expansion Weight by Stratum for Projects with TEPF-Funded Savings

Program Group	Stratum	Total Number of Projects*	Projects in Sample	Expansion Weight
C&I/ Multifamily Custom Retrofit	0	42	0	0
	1	20	3	6.67
	2	11	3	3.67
	3	11	3	3.67
	4	7	7	1.00
C&I/ Multifamily Custom NC/MOP	0	3	0	0
	1	6	6	1.00

*Number of projects with non-zero kWh, winter peak demand, summer peak demand, MMBtu, or water savings provided by TEPF-funded measures

Table A-5. TEPF-Funded Commercial and Industrial/Multifamily Custom Retrofit Projects with Adjustments

EVT Project ID	Stratum	kWh RR	Winter kW RR	Summer kW RR	Gross Claimed MMBtu	MMBtu RR	Reason for Adjustment
517811	4	n/a	n/a	n/a	4,392.1	98.6%	Reduced operating hours based on project documentation
527437	4	n/a	n/a	n/a	2,889.4	98.1%	Reduced operating hours based on project documentation
516548	4	n/a	n/a	n/a	1,050.8	132.0%	Increased fuel oil usage based on delivery data
507632	4	n/a	n/a	n/a	1,679.0	104.1%	Applied geographically appropriate HDD ratio, which increased HDD
514564	4	n/a	n/a	n/a	1,112.5	96.7%	Reduced savings to account for uncertainty because of lack of fuel oil data
518972	4	95.0%	94.3%	94.5%	1,000.0	99.3%	Reduced savings to account for uncertainty because of lack of electricity consumption data and blower door results
518216	3	n/a	n/a	n/a	586.0	96.9%	Reduced savings to account for uncertainty because of lack of fuel oil data
512530	3	n/a	n/a	n/a	825.8	76.3%	Corrected calculations for gas load at the boilers
517537	2	152.1%	n/a	n/a	365.9	100.0%	Increased kWh penalty by removing an inappropriate penalty adjustment factor

Table A-6. TEPF-Funded Commercial and Industrial/Multifamily Custom New Construction and Market Opportunity Projects with Adjustments

EVT Project ID	Stratum	kWh RR	Winter kW RR	Summer kW RR	Gross Claimed MMBtu	MMBtu RR	Reason for Adjustment
495573	1	n/a	n/a	n/a	2,641.8	94.7%	Increased estimated load of pre-existing kerosene boiler in the efficient condition
511328	1	n/a	n/a	n/a	1,669.3	94.8%	Adjusted pump hp based on pump curves

Appendix B. ESA Pilot Findings

This appendix provides findings for the ESA Pilot. Cadmus evaluated savings for all three projects completed by the beginning of the evaluation in Q2 2023, including one project that closed in 2023. The tables here show realization rates for these initial three projects overall as well as the realization rates for each project.

As noted in the evaluation report for project 501240, Cadmus disagrees with an approach approved during the initial project application process. Specifically, rather than claim electric penalties for a fuel switch from fossil fuel to electricity, the project deducted the electric penalty from the fossil fuel savings. Cadmus honored this decision, based on input from the Vermont PSD, but strongly disagrees with this methodology. In future projects of this nature, Cadmus recommends recognizing electric penalties as electric penalties, which will provide a more accurate estimate of the true energy and demand impacts of the project.

Table B-1. Electric Adjustments for ESA Pilot Projects

Program Group	Energy Saved		Winter Demand Reduction		Summer Demand Reduction	
	EVT Gross Claimed kWh	Realization Rate	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed kW	Realization Rate
Custom Retrofit	1,099,171	95.1%	104	91.0%	117	92.0%

Table B-2. MMBtu and Water Savings for ESA Pilot Projects

Program Group	Energy Saved		Water Saved	
	EVT Gross Claimed MMBtu	Realization Rate	EVT Gross Claimed CCF	Realization Rate
Retrofit	3,889	100.0%	0	n/a

Table B-3. ESA Pilot Project Realization Rates

EVT Project ID	Gross Claimed kWh	Gross Claimed MMBtu	Realization Rate				Reason for Adjustment
			kWh	Winter kW	Summer kW	MMBtu	
491353	480,153	0.0	100.0%	100.5%	100.4%	n/a	Recalculated occupancy sensor demand reduction based on provided wattages and operating hours for each fixture
501240	0	3,888.7	n/a	n/a	n/a	100.0%	No adjustments needed
514469	619,018	0.0	91.4%	81.7%	81.7%	n/a	Updated baseline and post-retrofit fixture wattages based on federal code.

Appendix C. Flexible Load Management and Refrigeration Management Findings

This appendix provides findings for the Flexible Load Management and Refrigerant Management programs. For the 2022 evaluation, Cadmus did not evaluate claimed flexible load or custom project or custom measure savings for Refrigerant Management. As shown in the table below, Cadmus evaluated prescriptive non-energy GHG measure savings, where applicable, using TRM methodologies.

Table C-1. Flexible Load and Refrigerant Management Savings by Program Group

Program Group	Flexible Load		Non-Energy GHG	
	EVT Gross Claimed kW	Realization Rate	EVT Gross Claimed lbs. CO2e	Realization Rate
C&I and Multifamily				
Custom Retrofit	254	n/a*	134,148,902	n/a*
Custom NC/MOP	0	n/a*	27,742,973	n/a*
Prescriptive Lighting				
Prescriptive Non-Lighting			44,148	101.6%
Efficient Products				
Smartlight				
Upstream HVAC			29,146	100.0%
C&I Subtotal	254	n/a*	161,965,168	n/a*
Residential				
Efficient Products	6		422,727	100.0%
Residential Retrofit-LISF			922	n/a*
Home Performance with ENERGY STAR				
Residential New Construction				
Smartlight				
Upstream HVAC				
Residential Subtotal	6	n/a*	423,649	n/a*
Portfolio Total	260	n/a*	162,388,817	n/a*

*The 2022 savings claim verification did not evaluate flexible load. Nor did it evaluate Refrigerant Management savings from custom projects or measures.

Appendix D. Commercial and Industrial/Multifamily Custom Retrofit Project Reports

A document that is 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, in the sample of projects with savings funded by the Vermont energy efficiency charge

Appendix E. Commercial and Industrial/Multifamily Custom New Construction and Market Opportunity Project Reports

A document that is 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, in the sample of projects with savings funded by the Vermont energy efficiency charge.

Appendix F. Commercial and Industrial/Multifamily Custom Retrofit Project Reports for Thermal Energy and Process Fuels Funding

A document that is 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, in the sample of projects with savings funded by TEPF.

Appendix G. Commercial and Industrial/Multifamily Custom New Construction and Market Opportunity Project Reports for Thermal Energy and Process Fuels Funding

A document that is 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, in the sample of projects with savings funded by TEPF.