



Report to Verify Efficiency Vermont 2021 Savings Claim

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Prepared for:

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Acronyms and Definitions

C&I	Commercial and industrial
CCF	Hundred cubic feet
EEC	Energy Efficiency Charge
EER	Energy Efficiency Ratio
EVT	Efficiency Vermont
GHG	Greenhouse Gas
GWh	Gigawatt hours
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/Rate	Residential energy simulation analysis model
RR	Realization rate
TEPF	Thermal Energy and Process Fuels
TRM	Technical Reference Manual
VEIC	Vermont Energy Investment Corporation

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Executive Summary

On April 1, 2022, 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 2021 to document its preliminary savings claim for year 2021 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 2021 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	66,608,128	97.1%	10,428	99.5%	7,488	95.8%

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 66.6 GWh, with a realization rate of 97.1% for the EVT portfolio.

This 97.1% 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 2020 claimed energy savings, which equaled 93.2 GWh with a realization rate of 98.4%.

At the 90% confidence level, the relative precision of the realization rates for energy savings (kWh) is $\pm 3.0\%$ for Commercial and Industrial/Multifamily (C&I/Multifamily) Custom Retrofit projects and $\pm 9.0\%$ for C&I/Multifamily Custom New Construction and Market Opportunity (NC/MOP) projects. The relative precision for the portfolio as a whole is $\pm 1.8\%$.

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	13,119,748	90.4%	1,559	100.6%	1,641	89.1%
Custom NC/MOP ^a	13,490,854	95.1%	1,793	96.8%	1,632	91.8%
Prescriptive Lighting	70,131	96.4%	18	96.7%	9	101.4%
Prescriptive Non-Lighting	321,564	99.9%	56	99.9%	18	100.0%
Efficient Products	72,534	100.0%	6	101.9%	16	102.4%
SMARTLIGHT	12,036,753	100.0%	1,363	100.0%	2,278	100.0%
Upstream Non-Lighting	3,040,116	100.8%	459	100.6%	189	101.4%
C&I Subtotal	42,151,700	95.5%	5,255	99.1%	5,784	94.7%
Residential						
Efficient Products	8,936,966	100.0%	1,590	100.0%	961	99.7%
Residential Retrofit/Low-Income Single-Family (LISF)	1,107,669	99.3%	260	99.8%	97	99.3%
Home Performance with ENERGY STAR (HPwES) ^a	67,754	100.0%	12	100.0%	0	N/A
Residential New Construction	411,254	93.2%	66	94.5%	12	92.8%
SMARTLIGHT	2,314,647	100.0%	692	100.0%	196	100.0%
Upstream Non-Lighting	11,618,140	100.0%	2,553	100.0%	438	100.0%
Residential Subtotal	24,456,428	99.8%	5,173	99.9%	1,704	99.7%
Total Portfolio	66,608,128	97.1%	10,428	99.5%	7,488	95.8%

^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 99.7%. The overall water savings realization rate is 91.6%.

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	10,014	100.4%	1,274	100.0%
Custom NC/MOP ^a	11,232	100.2%	3,143	100.2%
Prescriptive Lighting	-8	109.8%	0	N/A
Prescriptive Non-Lighting	723	100.0%	318	98.6%
Efficient Products	201	99.1%	0	N/A
SMARTLIGHT	-6,778	100.6%	0	N/A
Upstream Non-Lighting	1,774	100.0%	675	100.0%
C&I/Multifamily Subtotal	17,157	100.2%	5,410	100.0%
Residential				
Efficient Products	25,353	99.9%	85,759	91.3%
Residential Retrofit/LISF	8,772	99.8%	2,702	92.6%
HPwES ^b	7,827	100.0%	0	N/A
Residential New Construction	2,858	86.4%	708	72.2%
SMARTLIGHT	-21	99.9%	0	N/A
Upstream Non-Lighting	60,584	100.0%	0	N/A
Residential Subtotal	105,371	99.6%	89,169	91.1%
Portfolio Total	122,528	99.7%	94,578	91.6%

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

^b Claimed savings for custom measures in the HPwES program already include adjustments taken from a prior-year impact study. The applied realization rate is 65% for MMBtu savings. Prescriptive measures were evaluated using TRM methodologies.

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 2022, 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 they were 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 July 1, 2022, 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 2020 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 refrigerator 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 Flex kW Capacity and Greenhouse Gas Emission Savings

During 2022, Efficiency Vermont began claiming Flex kW capacity and non-energy greenhouse gas (GHG) emission savings. Flex kW represents the amount of demand that could possibly be managed as the result of the installation of new controls or equipment. Non-energy GHG emission savings represent the CO₂-equivalent emission reduction of measures that reduce refrigerant leakage.

The PSD requested that the evaluation team include the following activities:

- Evaluate non-energy GHG emission savings in C&I/Multifamily custom projects by reviewing a sample of projects with non-energy GHG emission savings
- Advise PSD and EVT on information and data that will need to be collected to support evaluation of claimed Flex kW capacity installation in C&I/Multifamily custom projects
- Evaluate flex kW installation and non-energy GHG emission savings in prescriptive program groups using TRM methods

Cadmus has included a summary of flex kW and non-energy GHG emission 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 declined from 22.8 GWh in 2020 to 13.1 GWh in 2021. Custom Retrofit projects accounted for 29% of the C&I/Multifamily sector's evaluated kWh savings and 18% of the total portfolio's evaluated kWh savings, down from 36% and 24% for 2020, respectively.

This program comprised 265 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 265 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 2021, accounting for 32% of the C&I/Multifamily sector's evaluated kWh savings and 20% of the total portfolio's evaluated kWh savings. (In 2020, the program contributed 14% of the C&I/Multifamily sector evaluated savings and 9% of the total portfolio savings.) Electric energy savings increased from 9.5 GWh in 2020 to 13.5 GWh in 2021.

The program group included 241 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 22 projects for evaluation and estimated the population's total savings by applying the resulting realization rates to the population of 241 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 2021, from 0.7 GWh in 2020 to 0.4 GWh in 2021. The 2021 C&I/Multifamily Prescriptive projects accounted for 1% of the C&I/Multifamily sector kWh evaluated savings and 1% of the total portfolio's evaluated kWh savings, as in 2020.

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

Prescriptive Lighting savings fell from 244,504 kWh in 2020 to 70,131 kWh in 2021. Prescriptive Non-Lighting includes a variety of measures, such as HVAC, refrigeration, and compressed air. Claimed savings decreased for Non-Lighting measures, from 441,298 kWh in 2020 to 321,564 kWh in 2021.

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 2021 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 sharply in 2021, from 3,696,300 kWh in 2020 to only 72,534 kWh in 2021. The program group accounts for only 0.2% of the C&I/Multifamily sector's kWh savings and 0.1% of the total portfolio kWh savings in 2021, down from 6% and 4% in 2020, respectively.

C&I/Multifamily Efficient Products comprises lighting and non-lighting measures. Lighting accounted for 55% of kWh savings for the C&I/Multifamily Efficient Products in 2021. Non-lighting 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 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 decreased from 26.2 GWh in 2020 to 15.1 GWh in 2021, with 80% of savings resulting from SMARTLIGHT measures. The program accounted for 38% of the C&I/Multifamily sector kWh savings and 23% of the total portfolio's kWh savings, down from 43% and 29% in 2020, respectively.

Table 2 above 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 increased by 36% in 2021, up from 2.2 GWh in 2020 to 3.0 GWh in 2021. SMARTLIGHT claimed savings decreased to half its 2020 levels, falling from 24.0 GWh in 2020 to 12.0 GWh in 2021.

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

Residential Efficient Products continued its decline in savings in 2021, falling from 12.4 GWh in 2020 to 8.9 GWh in 2021. Residential Efficient Products provided 37% of the evaluated kWh savings for the residential sector and 14% of the total portfolio's evaluated kWh savings.

As with other program groups that saw declines, the drop in electric energy savings resulted largely from much lower savings from lighting measures, which fell from 8.5 GWh in 2020 to 1.4 GWh in 2021. Claimed savings for non-lighting measures increased from 3.9 GWh in 2020 to 7.5 GWh in 2021. Non-lighting measures included ENERGY STAR appliances and room air conditioners, heat pump water heaters, advanced thermostats, and others.

All 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 above reports combined savings for Residential Single-Family Retrofit and LISF and reports savings for HPwES separately. Claimed savings for the three tracks combined was 1.2 GWh for 2021, up

from 0.3 GWh in 2020. Savings accounted for 5% of the residential sector’s evaluated kWh savings and 2% 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 air sealing and insulation measures. In 2021, EVT largely completed transitioning the HPwES program to use prescriptive rather than custom measures. Prescriptive measures accounted for all electric energy savings in 2021 and all but 0.3% of MMBtu savings.

As with 2020 savings, EVT applied a 65% realization rate to HPwES custom measure MMBtu savings. Because this realization rate was applied before EVT claimed savings and to remain consistent with previous-year evaluations, Cadmus passed through HPwES claimed savings at a 100% realization rate for custom measures. Cadmus evaluated savings for prescriptive 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 94% of energy savings for the program in 2021. 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 6% 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. As with other lighting program components, claimed savings for residential SMARTLIGHT declined in 2021, from 7.0 GWh in 2020 to 2.3 GWh in 2021. SMARTLIGHT measures accounted for 17% of claimed kWh savings for the Residential Upstream program group, down from 41% in 2020

The Upstream Non-Lighting component accounted for 49% of the 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*). These Upstream Non-Lighting MMBtu savings resulted primarily from TEPF-funded measures for installation of wood or wood pellet stoves.

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 22 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 36% of the total C&I/Multifamily Custom Retrofit kWh savings and 46% 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	70	17,596	127	0	0	685,034	0%
	1	17,597	43,879	53	4	95,015	1,654,341	6%
	2	43,880	101,996	48	4	269,339	3,183,806	8%
	3	101,997	243,889	26	4	600,577	3,839,616	16%
	4	243,890	612,377	11	11	3,756,951	3,756,951	100%
Subtotal				265	23	4,721,882	13,119,748	36%
C&I/ Multifamily Custom NC/MOP	0	-6,749	18,698	135	0	0	943,633	0%
	1	18,699	51,432	48	4	137,138	1,736,441	8%
	2	51,433	126,870	31	4	294,930	2,526,625	12%
	3	126,871	302,835	17	4	717,678	3,199,432	22%
	4	302,836	919,177	10	10	5,084,725	5,084,725	100%
Subtotal				241	22	6,234,471	13,490,854	46%
Total				506	45	10,956,353	26,610,603	41%

^a This represent 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 1 in the NC/MOP program group, the expansion weight of 12.0 results from dividing 48 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	127	0	0
	1	53	4	13.25
	2	48	4	12.00
	3	26	4	6.50
	4	11	11	1.00
C&I/Multifamily Custom NC/MOP	0	135	0	0
	1	48	4	12.00
	2	31	4	7.75
	3	17	4	4.25
	4	10	10	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) and summer demand reduction (kW) within the C&I/Multifamily Custom Retrofit program group. Adjustments slightly increased winter demand reduction (kW).

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	13,120	90.4%	1,559	100.6%	1,641	89.1%

^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. Cadmus provided detailed reports for all projects in the largest-savings stratum and summary reports for other projects that required adjustments to the PSD and EVT during the evaluation process. 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	
464631	4	292,423	100.0%	98.1%	98.1%	Corrected load shape
495708	4	378,156	96.2%	96.6%	96.0%	Corrected compressor energy efficiency ratio (EER) and corrected installed quantity of doors based on invoice review
501460	4	436,522	99.8%	99.8%	99.5%	Corrected fixture quantities based on invoice review
512986	4	612,377	99.2%	103.0%	109.8%	Corrected load shape and adjusted fixture quantities based on invoice review
512331	4	252,569	97.2%	96.4%	96.4%	Corrected the EER of the baseline chiller
501964	3	189,630	100.0%	331.6%	244.4%	Updated custom load shape calculation methodology
514243	3	83,492	78.9%	181.0%	0.0%	Adjusted motor load factor and corrected load shape
504443	2	71,236	38.0%	38.0%	38.0%	Reduced leak reduction based on pre- and post-implementation flow data

EVT Project ID	Stratum	Gross Claimed kWh	Realization Rate			Reason for Adjustment
			kWh	Winter kW	Summer kW	
515435	2	56,807	80.0%	80.0%	80.0%	Reduced savings to account for uncertainty because of missing documentation
518927	1	30,000	40.8%	3.3%	78.1%	Used TRM methodology due to lack of documentation to support provided calculations
518315	1	18,717	91.8%	91.7%	91.9%	Reduced fixture quantities based on project documentation

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 lower evaluated winter and 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	13,491	95.1%	1,793	96.8%	1,632	91.8%

^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	
494445	4	525,466	99.5%	98.6%	97.5%	Adjusted fan motor load profile
497775	4	345,352	96.9%	92.6%	84.0%	Reduced lighting savings to account for uncertainty because of missing documentation
510263	4	312,034	97.2%	99.9%	87.9%	Adjusted wattages to DLC values and corrected load shape
511149	4	348,464	50.0%	50.6%	52.7%	Reduced savings to account for uncertainty because of lack of documentation

EVT Project ID	Stratum	Gross Claimed kWh	Realization Rate			Reason for Adjustment
			kWh	Winter kW	Summer kW	
514059	4	919,177	90.0%	90.0%	N/A	Reduced lighting savings to account for uncertainty because of missing and unclear documentation
519380	3	147,461	100.0%	105.3%	105.3%	Corrected peak load calculation
481812	3	204,505	97.9%	91.9%	55.7%	Corrected calculation methodology
504928	3	222,014	100.0%	262.7%	262.8%	Corrected load shape
487049	3	143,698	101.3%	100.5%	100.1%	Rounding differences only
498973	2	65,416	99.2%	99.2%	99.2%	Adjusted compressor kW/ton to match CAGI sheet
513925	2	70,760	97.0%	N/A	97.0%	Adjusted fan efficiency and power based on testing reports
512328	2	104,251	74.0%	49.3%	49.3%	Corrected horsepower and type of installed compressor, used the CAGI sheet to get a load profile, and constructed the baseline load profiles using UMP guidance
514759	2	54,242	100.0%	104.0%	111.0%	Adjusted demand reduction based on TMY3 temperature bins
509061	1	30,355	83.0%	76.5%	89.2%	Reduced lighting savings to account for uncertainty and removed ductless heat pump savings because of missing documentation; corrected summer and winter demand reduction
519484	1	50,225	100.0%	119.7%	N/A	Corrected load shape
508953	1	27,438	99.9%	121.4%	75.8%	Corrected load shape and other aspects of demand reduction calculations

Commercial and Industrial/Multifamily Prescriptive

In the C&I/Multifamily Prescriptive program group, evaluated savings tracked fairly closely with reported savings for lighting and non-lighting. 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	70,131	96.4%	18	96.7%	9	101.4%
Prescriptive Non-Lighting	321,564	99.9%	56	99.9%	18	100.0%
Total	391,694	99.3%	74	99.1%	27	100.5%

For lighting measures, most of the 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. Adjustments to

non-lighting measures resulted primarily from claimed savings calculations using a value of 2.22 for an input instead of the TRM value of 2.

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% or above 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	72,534	100.0%	6	101.9%	16	102.4%

Notable adjustments were necessary to three measures with relatively low quantities—LED outdoor fixtures and some variants of LED directional bulbs and advanced thermostats. With LED outdoor fixtures, claimed savings calculations applied an inappropriate demand waste heat factor. With two variants of LED directional bulbs, evaluated savings correct an apparent error in TRM winter and summer demand reduction (kW) values. With four advanced thermostat variants, claimed savings calculations used an inappropriate heat consumption value, used kW values for the wrong variant, or omitted necessary equation components.

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, with realization rates of just above 100% 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	12,036,753	100.0%	1,363	100.0%	2,278	100.0%
Upstream Non-Lighting	3,040,116	100.8%	459	100.6%	189	101.4%
Total	15,076,869	100.2%	1,821	100.1%	2,468	100.1%

The realization rate for Upstream Non-Lighting winter and summer peak demand reduction were greater than 100% because Cadmus calculated savings for two evaporator motor measures using TRM

inputs and methodology. Claimed savings used a TRM deemed value that is a weighted average based on three temperature bins, which were not defined in the 2020 TRM.

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	1,417,636	100.1%	417	100.1%	114	97.6%
Non-Lighting	7,519,329	99.9%	1,173	100.0%	847	99.9%
Total	8,936,966	100.0%	1,590	100.0%	961	99.7%

In the lighting component, four LED grow light measures used the deemed savings for the wrong wattage and/or used an inappropriate load shape. With several other lighting measures, small differences between evaluated and claimed savings resulted from rounding differences.

Non-lighting measures requiring significant adjustments included three variants of ENERGY STAR clothes washers, for which claimed savings appeared to use inappropriate input assumptions. Claimed savings for four heat pump water heater variants appeared to use incorrect deemed savings or inputs.

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 close with claimed savings with the Residential Retrofit/LISF program group overall, with most adjustments resulting from small rounding errors. 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	1,107,669	99.3%	260	99.8%	97	99.3%
HPwES	67,754	100.0%	12	100.0%	0	N/A
Total	1,175,423	99.3%	272	99.8%	97	99.3%

All notable adjustments to energy savings and winter and summer demand reductions occurred in LISF measures. With two early replacement refrigerator measures, claimed savings calculations used the

deemed savings for a different variant. With two early replacement ENERGY STAR freezer measures, claimed savings appeared to use the sum of values for the first three years and the remaining measure life.

As shown in Table 15, Cadmus evaluated MMBtu savings at 99.8% for the Residential Retrofit/LISF component and 100% for the HPwES components. EVT applied a 65% realization rate to MMBtu savings for all HPwES custom measures before claiming savings.

Measures in the LISF track accounted for all water savings. The realization rate of 92.6% for water savings results from large rounding error with deemed savings for two faucet aerator/flow restrictor measures; large savings discrepancies with two ENERGY STAR clothes washer voucher measures, which did not use deemed savings provided in the 2021 TRM; and claimed savings' use of deemed savings for the wrong home energy efficiency kit.

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	8,772	99.8%	2,702	92.6%
HPwES	7,827	100.0%	0	N/A
Total	16,598	99.9%	2,702	92.6%

Residential New Construction

Residential New Construction received significant 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	411,254	93.2%	66	94.5%	12	92.8%

As shown in Table 17, adjustments were necessary for both custom and prescriptive measures. Savings adjustments for prescriptive measures resulted primarily from eliminating claimed savings for faucet aerators, which were not identified in the TRM as a new construction measure, and from correcting unit energy savings for an ENERGY STAR dishwasher measure.

With custom measures, the evaluation showed that roughly 25% of projects used notably different savings than indicated by the REM/*Rate* model. EVT investigated the issue and found that modeling runs for these projects inadvertently used an older baseline file, which created the savings discrepancy.

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	26,662	81.1%	8	92.8%	5	93.4%
Residential New Construction Custom	384,592	94.0%	58	94.8%	7	92.4%
Total	411,254	93.2%	66	94.5%	12	92.8%

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. As noted above, Cadmus eliminated savings for faucet aerators, which were not identified in the TRM as a new construction measure. Eliminating these savings led to the relatively low realization rates for MMBtu and water savings from prescriptive measures. With custom measures, the REM/Rate baseline version issue noted above caused the relatively low realization rate for MMBtu savings.

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	113	70.4%	708	72.2%
Residential New Construction Custom	2,744	87.1%	0	N/A
Total	2,858	86.4%	708	72.2%

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 both program group components—SMARTLIGHT and 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.

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	2,314,647	100.0%	692	100.0%	196	100.0%
Upstream Non-Lighting	11,618,140	100.0%	2,553	100.0%	438	100.0%
Total	13,932,787	100.0%	3,245	100.0%	634	100.0%

As shown in Table 20, neither program component required significant adjustments in MMBtu savings. With SMARTLIGHT, the MMBTU savings for only measure was slightly off because of rounding differences.

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	-21	99.9%	0	N/A
Upstream Non-Lighting	60,584	100.0%	0	N/A
Total	60,563	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 97.1% 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 in 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 45 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 refrigerators. The following discussion and recommendations apply to a broader range of technologies and projects.

Most of these recommendations have been made previously and 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.

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. 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 2021 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 effort 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 its 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.)

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.

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.

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, 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, organize all associated measure documents in individual folders in the online SharePoint site.

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.

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

EVT has improved on 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 where 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 where multiple measure savings are being calculated.

Use more robust methods to determine compressed air leak savings

For compressed air leak reduction projects, we recommend 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 and, 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.

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.

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. Cadmus noted lingering discrepancies in significant digits in the 2021 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 the 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.

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 2022. We encourage EVT to create full documentation of the new database structure in a format that will be easily accessible for the 2022 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.

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	-42,911	100.0%	3	99.4%	-20	99.3%
Custom NC/MOP	-11,701	99.9%	-4	0.0%	-2	0.0%

*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	58,479	94.4%	988	N/A
NC/MOP	3,518	97.9%	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	7	113	70	0	0	3,161	0%
	1	114	299	16	3	560	2,733	20%
	2	300	795	19	3	2,173	10,439	21%
	3	796	2,380	13	3	3,602	16,880	21%
	4	2,381	4,483	7	7	25,266	25,266	100%
Subtotal				125	16	31,601	58,479	54%
C&I/ Multifamily Custom NC/MOP	0	1	12	3	0	0	14	0%
	1	13	160	5	2	80	292	27%
	2	161	1,394	4	4	3,211	3,211	100%
	Subtotal			12	6	3,291	3,518	94%
Total				137	22	34,892	61,996	56%

*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	70	0	0
	1	16	3	5.33
	2	19	3	6.33
	3	13	3	4.33
	4	7	7	1.00
C&I/ Multifamily Custom NC/MOP	0	3	0	0
	1	5	2	2.50
	2	4	4	1.00
	3	70	0	0

*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
498086	4	N/A	N/A	N/A	4,483.00	84.9%	Eliminated assumed increase in chip boiler use
514391	4	N/A	N/A	N/A	4,239.00	97.3%	Reduced savings to account for uncertainty because of missing boiler efficiency documentation, and corrected mislabeled steam pressures and orifice diameters
512096	4	N/A	N/A	N/A	2,684.00	92.2%	Reduced savings to account for uncertainty because of missing boiler efficiency documentation and used more-precise modeling parameters
501865	4	N/A	N/A	N/A	2,500.00	58.8%	Reduced savings to account for uncertainty because of missing oven efficiency documentation and other key inputs, and corrected mathematical error
518201	3	N/A	N/A	N/A	921.00	77.1%	Reduced savings to account for uncertainty because of missing boiler efficiency documentation and removed savings for one undocumented steam trap
505104	3	N/A	N/A	N/A	1,704.50	101.7%	Updated boiler efficiency based on an average of three data points rather than a single data point
509136	2	N/A	N/A	N/A	705.40	95.1%	Reduced savings to account for uncertainty because of missing project documentation, such as invoices

**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
501261	2	N/A	N/A	N/A	1,393.50	135.3%	Reduced burner efficiency to a more conservative 82% but increased estimated savings from reduced exhaust air
509073	2	N/A	N/A	N/A	1,000.00	56.0%	Used the TRM methodology instead of relying on an supplier's unsupported estimate of fuel usage
514759	2	N/A	N/A	N/A	619.50	80.0%	Reduced savings to account for uncertainty because of missing product documentation and eliminated claimed demand reduction

Appendix B. Flexible Load Management and Refrigerant Management Findings

This appendix provides findings for the Flexible Load Management and Refrigerant Management programs.

Table B-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	1,175	N/A*	69,543,972	87.4%
Custom NC/MOP	25	N/A*		
Prescriptive Lighting				
Prescriptive Non-Lighting			1,303,338	100.0%
Efficient Products				
SMARTLIGHT				
Upstream Non-Lighting			41,184	100.0%
C&I Subtotal	1,200	N/A*	70,888,494	87.7%
Residential				
Efficient Products			184,805	100.0%
Residential Retrofit/Low-Income Single-Family (LISF)	9	N/A*		
Home Performance with ENERGY STAR (HPwES)				
Residential New Construction				
SMARTLIGHT				
Upstream Non-Lighting				
Residential Subtotal	9	N/A*	184,805	100.0%
Total Portfolio	1,209	N/A*	71,073,298	87.7%

*The 2021 savings claim verification did not evaluate claimed flexible load.

Table B-2. Overview of the Sample of Projects with Refrigerant Management Savings

Program Group	Stratum	Population Min GHG	Population Max GHG	Total Number of Projects	Projects in Sample	Sample GHG Total	Population GHG Total	% Sample GHG per Stratum Population
C&I/ Multifamily Custom	0	317	663,849	9	0	0	1,320,380	0%
	1	663,850	2,060,169	7	2	2,471,433	9,251,688	27%
	2	2,060,170	4,419,807	8	2	5,283,633	25,463,777	21%
	3	4,419,808	6,046,839	6	6	33,508,127	33,508,127	100%
Total				30	10	41,263,193	69,543,972	59%

Table B-3. Expansion Weight by Stratum for Projects with Refrigerant Management Savings

Program Group	Stratum	Total Number of Projects	Projects in Sample	Expansion Weight
C&I/ Multifamily Custom	0	9	0	0
	1	7	2	3.50
	2	8	2	4.00
	3	6	6	1.00

Table B-4. Commercial and Industrial/Multifamily Custom Projects with Refrigerant Management Savings Adjustments

EVT Project ID	Stratum	Claimed GHG Savings (lbs. CO2e)	Evaluated GHG Savings (lbs. CO2e)	GHG Savings RR	Reason for Adjustment
515443	3	6,046,839	4,837,471	80.0%	Reduced savings to account for uncertainty, because of missing project documentation
515449	3	5,348,190	4,278,551	80.0%	Reduced savings to account for uncertainty, because of missing project documentation
515432	3	5,984,322	4,786,017	80.0%	Reduced savings to account for uncertainty, because of missing project documentation
515435	3	5,414,181	4,331,344	80.0%	Reduced savings to account for uncertainty, because of missing project documentation
515446	2	2,084,475	1,667,579	80.0%	Reduced savings to account for uncertainty, because of missing project documentation
515440	1	1,171,578	937,261	80.0%	Reduced savings to account for uncertainty, because of missing project documentation
515439	1	1,299,855	1,039,885	80.0%	Reduced savings to account for uncertainty, because of missing project documentation

Appendix C. 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 D. 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 E. 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 F. 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.