Report to the Vermont Legislature

Independent Audit of the Reported Energy and Capacity Savings and Cost-Effectiveness of Vermont Energy Efficiency Utility Programs

Submitted by the Vermont Public Utility Commission

August 23, 2023

VERMONT
PUBLIC UTILITY COMMISSION

I. Introduction and Statutory Basis

Vermont law requires an independent audit every three years of the energy efficiency programs approved by the Public Utility Commission. Pursuant to 30 V.S.A. § 209(f)(12), with respect to all energy efficiency programs approved under Section 209, the Commission shall:

> Require verification, on or before January 1, 2003, and every three years thereafter, by an independent auditor of the reported energy and capacity savings and cost-effectiveness of programs delivered by any entity appointed by the Commission to deliver energy efficiency programs under subdivision (d)(2) of this section.

In fulfilment of this requirement, the Public Utility Commission contracted with Michaels Energy for the independent audit of energy efficiency program years 2017-2020.[1] Michaels Energy produced two documents, which are attached. The first document is a Legislative report that summarizes the findings and recommendations of the independent audit. The second document is a management letter that describes in detail the audit's objectives, methodology, findings, and recommendations.

Vermont's energy efficiency programs are administered by Efficiency Vermont, Vermont Gas Systems, Inc., and the City of Burlington Electric Department. The independent auditor concludes that, for the 2017-2020 program years, the programs were cost-effective, the claimed energy and capacity savings are accurate and verifiable, the technical reference manual is technically sound and comprehensive, and the evaluation reports generally conform with industry standard practices.

[1] There is a necessary lag between the end of a program year and the commencement of an audit because an energy efficiency utility's program savings must first be verified by the Vermont Department of Public Service ("Department"). The Department's verification report becomes part of the record that is subject to the audit.

MichaelsEnergy

Independent Audit 2017-2020

Report to the Legislature

6/29/2023

In partnership with:

Optimal Energy, an NV5 Company

Vermont Public Utility Commission

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Montpelier, VT 05620

Contents

Introduction

In January 2022, the Vermont Public Utility Commission (the Commission) selected the team of Michaels Energy and Optimal Energy (the Michaels Team) to serve as the Independent Auditor of the 2017-2020 reported savings and cost-effectiveness of programs delivered by the Vermont Energy Efficiency Utilities (EEUs) pursuant to 30 V.S.A § 209(f)(12). The EEUs include Efficiency Vermont (EVT), the City of Burlington Electric Department (BED), and Vermont Gas Systems, Inc. (VGS), which deliver electric, natural gas, and thermal-energy-and-process-fuel ("TEPF") energy efficiency services to residential and business customers in the State of Vermont.

Vermont Energy Investment Corporation (VEIC) serves as the statewide EEU known as Efficiency Vermont under an order of appointment issued by the Commission in 2016 in Case No. 8455. BED and VGS serve as EEUs under the order of appointments issued by the Commission in 2018 in Case No. 8606 and 2015 in Case No. 7676, respectively. The order of appointments for all three EEUs were most recently amended in 2019 in Case No. 18-2867-INV. Additional amendments to the VEIC order of appointment were approved in 2021 in Case No. 21-0838-PET. Oversight of the EEU programs is assigned to the Commission by Vermont law. The Department of Public Service (the Department) serves as the state's energy office and as the public advocate in proceedings before the Commission.

The programs reviewed in this report include all energy efficiency initiatives implemented by the EEUs from January 1, 2017, through December 31, 2020. This document serves as the Report to the Legislature.

Audit Objectives

The Commission identified six objectives for the Independent Auditor to review, including:

1. The cost-effectiveness of each of the EEUs' programs,
2. The reported energy and capacity savings achieved by Efficiency Vermont, BED, and VGS,
3. The Technical Reference Manual (which is a basis for the EEU's savings claims) and the process for managing and updating it,
4. The database and other information compiled by each EEU that are used to develop and track savings claims and project costs,
5. The procedures and methods used in the Department's savings claims verification process, and
6. Any other relevant information, including information developed through the Department's programmatic evaluation, when appropriate.

Overview of the EEU Programs

From 2017 through 2020, the three EEUs implemented a variety of energy efficiency programs that save residential and non-residential Vermont customers money and energy in their homes and businesses. Similar to past independent audits, these can be grouped into the following categories:

Residential Sector

- Residential New Construction
- Efficient Products
- Existing Homes

Commercial & Industrial Sector

- Business New Construction
- Business Existing Facilities

As shown in Table 1, during the 2017-2020 period, the energy efficiency initiatives implemented by EVT, BED, and VGS resulted in 627,245 MWh of energy savings, 103,542 kW of winter demand reduction, 72,310 kW of summer demand reduction, and 302,581 Mcf in natural gas savings.[1]

Table 1. Annual Results, Total EEU Portfolio

Year	MWh	Summer kW	Winter kW	Mcf (Natural Gas)
2017	184,022	19,546	30,666	60,951
2018	147,327	18,905	25,321	65,718
2019	120,412	13,907	20,396	81,491
2020	175,484	19,953	27,159	94,421
Total	627,245	72,310	103,542	302,581

Note: Totals excluded TEPF projects.

Table 2 shows the annual savings achieved by the thermal energy and process fuels (TEPF) projects from EVT and BED.

Table 2. MMBtu Savings, TEPF Projects

Year	Efficiency VT	Burlington Electric Department
2017	213,103	131
2018	177,625	286
2019	128,273	120
2020	97,338	38
Total	616,339	575

Methodology and Process Review

The Michaels Team reviewed the data tracking, evaluation, and TAG process currently in place for the Vermont EEUs and the Department of Public Service (the Department) to assess the current processes and identify areas for improvement. The Michaels Team reviewed the full 2017-2020 audit period data for all three EEUs.

[1] Note that these totals do not include TEPF projects.

For our review of the reported energy and capacity savings, we submitted a data request for program tracking data used in the savings calculations for each year under study. Using this data, the Michaels Team conducted the following activities:

- Checked the data for simple calculation or reference errors,
- Confirmed that the correct savings values and appropriate calculation parameters (e.g., hours of use) from the TRM were used for prescriptive measures, and
- Identified non-TRM measures and verified that the sources for non-TRM values were appropriately documented.

The Michaels Team reviewed a sample of custom projects and the recommended adjustments and assessed reasonableness. We also reviewed the sampling process used to meet the desired precision targets.

The Michaels Team also reviewed the Vermont TRM. This included a review of the deemed savings values and inputs in the TRM and a review of the processes for managing and updating the TRM through the Technical Advisory Group (TAG). The TAG provides a forum for the research and approval of new or revised measures to include in the TRM. Through interviews with staff at EVT, BED, VGS, and other applicable stakeholders and a review of documentation and notes from the TAG, the Michaels Team evaluated the process for managing and updating the TRM through the TAG.

TRM Review

The TRM is a key component of Vermont's energy efficiency implementation and evaluation process. The TRM contains characterizations of over 100 different prescriptive measures that cover a variety of end uses across the residential, commercial, industrial, low-income, and multi-family sectors. For each measure, the TRM includes a description of the baseline and efficient equipment, the methods, assumptions, and algorithms used to calculate energy savings, and other information such as load shapes, net savings factors, lifetimes, and measure costs.

To evaluate the TRM, the Michaels Team reviewed the deemed savings values, engineering parameters, and other inputs and documentation of these inputs to ensure that they are correctly referenced to appropriate literature and primary research with a Vermont-specific focus. We also reviewed savings adjustment factors such as free ridership, spillover, persistence, and line losses to ensure they are current, reasonable, and appropriately documented. The Michaels Team compared the information in the Vermont TRM to TRMs in comparable jurisdictions (including New York, Maine, Illinois, Wisconsin, Minnesota, and the Mid-Atlantic region) and to relevant industry literature, evaluations, and engineering best practices.

The Michaels Team found the current version of the Vermont TRM to be technically sound and comprehensive, aligning with findings in previous audits. The deemed savings values are generally well-documented, reasonable, and consistent with other jurisdictions. Savings for most measures are algorithm-based, which is usually a more accurate savings-calculation methodology than deemed values as it allows for specific customer inputs. Many measures use Vermont-specific assumptions or, if unavailable, values from comparable jurisdictions.

Validation of Reported Energy Savings and Costs

The Michaels Team reviewed and validated the energy savings (kWh), summer and winter demand reduction (kW), and natural gas savings (Mcf) reported by the EEUs for program years 2017 through 2020. We verified the savings amounts reported by the independent evaluator for each program year by reviewing an extract of each EEU's program tracking database and replicating the savings amounts listed. Our team also reviewed each EEU's evaluation report for those years.

Cost-Effectiveness Analysis

The Michaels Team found that each EEU's programs were cost-effective for each program year (2017-2020) using the Program Administrator Cost Test (PACT), Total Resource Cost Test (TRC), and Vermont Societal Cost Test (SCT). Table 3 below shows the portfolio level cost-effectiveness for all four evaluation years, for each EEU, and for all EEUs combined. For each test, the cost-effectiveness ratio shows the present value of benefits divided by the present value of costs of the program. For example, a benefit-cost ratio of 2.0 indicates $2 in benefits for every $1 in costs.

Table 3. Overall Cost-Effectiveness, Total EEU Portfolio

EEU	Program Administrator Cost Test (PACT)	Total Resource Cost Test (TRC)	Societal Cost Test (SCT)
Efficiency VT – Electric	2.32	1.93	3.45
Efficiency VT – TEPF	2.58	1.35	2.26
Burlington Electric Department – Electric	2.36	1.76	3.13
Burlington Electric Department – TEPF	1.02	0.66	1.10
Vermont Gas	4.65	1.82	3.15
Total	2.46	1.77	3.11

The EEUs' efficiency programs from 2017 to 2020 were cost-effective, with a TRC of 1.77, an SCT of 3.11, and a PACT of 2.46. This is slightly higher than the cost-effectiveness ratios found in the 2014-2016 evaluation, which gives a TRC of 1.47, an SCT of 2.2, and a PACT of 2.60. Table 4 below shows the total costs and benefits under each test. As seen, the four program years produced almost $800 million in total net benefits.

Table 4. Combined EEU Cost-Effectiveness Results for 2017-2020

	Benefits (2017$)	Costs (2017$)	Net Benefits (2017$)	Benefit /Cost Ratio
PACT	$740,300,619	$300,724,739	$439,575,880	2.46
TRC	$740,300,619	$418,956,149	$321,344,470	1.77
SCT	$1,171,511,629	$377,060,534	$794,451,094	3.11

Recommendations

Much like past audits, the 2017-2020 EEU program audit found that the efficiency programs in Vermont appear to be well run. Specifically:

- The TRM document is technically sound, reasonable, and comprehensive. Stakeholders find the TAG process for updating the TRM transparent and collaborative.
- The evaluation reports generally conform to industry standard practices.
- The savings estimates are accurate and generally consistent with the TRM.

Our review of the TRM, savings estimates, evaluation reports, and program processes uncovered several areas for improvement, summarized in the recommendations below.

- Evaluators should look to increase the number of in-person or virtual site visits to verify the calculation inputs and assumptions used for savings calculations. Although a site visit is preferable, evaluators can also reach out to site contacts for brief interviews to verify project specifics.

- The evaluation teams appear to rely entirely on International Performance Measurement and Verification Protocol (IPMVP) Option A (Retrofit Isolation: Key Parameter Measurement) unless the implementer used another approach. While Option A is a suitable methodology, some projects may benefit from using Option C (Whole Facility Measurement) more regularly, particularly where uncertainty or savings estimates relative to the total consumption are high.

- In some cases, evaluators applied arbitrary penalties to projects that lacked sufficient documentation to provide a more conservative savings estimate. However, this practice was not applied consistently. If evaluators wish to use this approach, we recommend formalizing and documenting this practice to ensure consistency across projects.

- While we did not uncover any systematic issues with the TRM, we did identify many minor issues that should be updated in future versions. EVT and the TAG should review the measure-specific findings in Appendix A of the 2017-2020 Independent Audit Management Letter and include the relevant recommendations in the queue for updates in the next version of the TRM. In particular, the Michaels Team's review found that the TRM's current methodology for the variable speed drive measure likely overstates savings, especially for demand savings, and we recommend that the TAG prioritize the review of this measure.

- Our review of net savings factors found that the free ridership values are often lower than in many other jurisdictions. We recommend that evaluators review the net savings factors of high-impact measures and measures with significant recent market changes and consider conducting new free ridership and spillover research to update the net savings factors as needed.

- The independent auditor recommends that BED compresses its reporting schedule to better align with the plans of other EEUs. The current large gap between the end of the program year and the completion of the evaluation report significantly reduces the usefulness of the evaluation results as they cannot be used to help make program adjustments for the following year.

- Evaluations should begin as early as possible, even before the program year is complete, to ensure rigorous methods can be applied. We suggest using sampling projects in waves so that some can be evaluated earlier and enough data can be collected if needed. An earlier start may also ensure that BED's verification reports can be completed earlier.

- EEUs should address recommendations included in the evaluation reports. Many suggestions appear year after year, indicating that the issues still need to be resolved.

- The Commission should continue to monitor EVT's role as TAG administrator to avoid potential conflicts of interest.

Independent Audit 2017-2020

Management Letter

3/10/2023

In partnership with:

Vermont Public Utility Commission

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1. Executive Summary

In January 2022, the Vermont Public Utility Commission (the Commission) selected the team of Michaels Energy and Optimal Energy (the Michaels Team) to serve as the Independent Auditor of the 2017-2020 reported savings and cost-effectiveness of programs delivered by the Vermont Energy Efficiency Utilities (EEUs) pursuant to 30 V.S.A § 209(f)(12). The EEUs include Efficiency Vermont (EVT), the City of Burlington Electric Department (BED), and Vermont Gas Systems, Inc. (VGS), which deliver electric, natural gas, and thermal-energy-and-process-fuel ("TEPF") energy efficiency services to residential and business customers in the State of Vermont.

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The programs reviewed in this report include all energy efficiency initiatives implemented by the EEUs during the period of January 1, 2017, through December 31, 2020. This document serves as the Report to the Legislature.

1.1 Audit Objectives

The Commission identified six objectives for the Independent Auditor to review, including:

- The cost-effectiveness of each of the EEUs' programs (Section 5);
- The reported energy and capacity savings achieved by Efficiency Vermont, BED, and VGS (Section 4);
- The Technical Reference Manual (which is a basis for the EEU's savings claims) and the process for managing and updating it (Section 3);
- The database and other information compiled by each EEU that are used to develop and track savings claims and project costs;
- The procedures and methods used in the Department's savings claims verification process; and
- Any other relevant information, including information developed through the Department's programmatic evaluation, when appropriate.

This document outlines the results of this review and describes the methodology used by the Michaels Team.

1.2 Overview of the EEU Programs

From 2017 through 2020, the three EEUs implemented a variety of energy efficiency programs that save residential and non-residential Vermont customers money and energy in their homes and businesses. Similar to past independent audits, these can be grouped into the following categories:

Residential Sector

- Residential New Construction
- Efficient Products
- Existing Homes

Commercial & Industrial Sector

- Business New Construction
- Business Existing Facilities

As shown in Table 1, during the 2017-2020 period, the energy efficiency initiatives implemented by EVT, BED, and VGS resulted in 627,245 MWh of energy savings, 103,542 kW of winter demand reduction, 72,310 kW of summer demand reduction, and 302,581 Mcf in natural gas savings.[1]

Table 1. Annual Results, Total EEU Portfolio

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Note: Totals also excluded TEPF projects.

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Table 2. MMBtu Savings, TEPF Projects

Year	Efficiency VT	Burlington Electric Department
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2019	128,273	120
2020	97,338	38
Total	616,339	575

[1] Note that these totals do not include TEPF projects.

1.3 TRM and Process Review

The Michaels Team reviewed the Vermont TRM. This included both a review of the deemed savings values and inputs in the TRM as well as a review of the processes for managing and updating the TRM through the Technical Advisory Group (TAG).

1.4 Validation of Reported Energy Savings

The Michaels Team reviewed and validated the energy savings (kWh), summer and winter demand reduction (kW), and natural gas savings (Mcf) reported by the EEUs for program years 2017 through 2020. We verified the savings amounts reported by the independent evaluator for each program year by reviewing an extract of each EEU's program tracking database and replicating the savings amounts listed. Our team also reviewed each EEU's evaluation report for those years.

1.5 Cost-Effectiveness Analysis

The Michaels Team found that each EEU's programs were cost-effective for each program year (2017-2020) according to each of the three applicable tests. Table 8 below shows the portfolio level cost-effectiveness for all four evaluation years, for each EEU and total. For each test, the cost-effectiveness ratio shows the present value of benefits divided by the present value of costs of the program. A benefit-cost ratio of 2.0, for examples, indicates $2 in benefits for every $1 in costs. Nearly all EEU programs are cost effective in each program year evaluated, as well as overall.

Table 3. Overall Cost-Effectiveness, Total EEU Portfolio

EEU	Program Administrator Cost Test (PACT)	Total Resource Cost (TRC)	Societal Cost Test (SCT)
Efficiency VT – Electric	2.32	1.93	3.45
Efficiency VT – TEPF	2.58	1.35	2.26
Burlington Electric Department – Electric	2.36	1.76	3.13
Burlington Electric Department – TEPF	1.02	0.66	1.10
Vermont Gas	4.65	1.82	3.15
Total	2.46	1.77	3.11

1.6 Recommendations

Similar to past audits, the audit of the 2017-2020 EEU programs found that the efficiency programs in Vermont appear to be well run. Specifically:

- The TRM document is technically sound, reasonable, and comprehensive. Stakeholders find the TAG process for updating the TRM to be transparent and collaborative.
- The evaluation reports generally conform to industry standard practices.
- The savings estimates are accurate and generally consistent with the TRM.

Our review of the TRM, savings estimates, evaluation reports, and program processes uncovered several areas for improvement, summarized in the recommendations below.

- Evaluators should look to increase the number of in-person or virtual site visits to verify the calculation inputs and assumptions used for savings calculations. Although a site visit is preferable, evaluators can also reach out to site contacts for brief interviews to verify project specifics.

- The evaluation teams appear to rely entirely on International Performance Measurement and Verification Protocol (IPMVP) Option A (Retrofit Isolation: Key Parameter Measurement) unless the implementer used another approach. While Option A is a suitable methodology, some projects may benefit from using Option C (Whole Facility Measurement) more regularly, particularly where uncertainty is higher, or savings estimates relative to the total consumption is high.

- In some cases, evaluators applied arbitrary penalties to projects that lacked sufficient documentation to provide a more conservative savings estimate. However, this practice was not applied consistently. If evaluators wish to use this approach, we recommend formalizing and documenting this practice to ensure consistency across projects.

- While we did not uncover any systematic issues with the TRM, we did identify many minor issues that should be updated in future versions. EVT and the TAG should review the measure-specific findings in Appendix A and include the relevant recommendations in the queue for updates in the next version of the TRM. In particular, the Michaels Team's review found that the TRM's current methodology for the variable speed drive measure likely overstates savings, especially for demand savings, and we recommend that the TAG prioritize review of this measure.

- Our review of net savings factors found that the free ridership values are often lower than in many other jurisdictions. We recommend that evaluators review the net savings factors of high impact measures and measures with significant recent market changes and consider conducting new free ridership and spillover research to update the net savings factors as needed.

- The independent auditor recommends that BED compresses their reporting schedule to better align with the schedules of other EEUs. The current large gap in time between the end of the program year and completion of the evaluation report significantly reduces the usefulness of the evaluation results as they cannot be used to help make program adjustments for the following year.

- Evaluations should begin as early as possible, even before the program year is complete to ensure rigorous methods can be applied. We suggest using sampling projects in waves so that some can be evaluated earlier and enough data can be collected, if needed. An earlier start may also ensure that BED's verification reports can be completed earlier.

- EEUs should address recommendations included in the evaluation reports. Many recommendations appear year after year, indicating that the issues still need to be resolved.

- The Commission should continue to monitor EVT’s role as TAG administrator to ensure that potential conflicts of interest are avoided.

2. Methodology and Process Review

The Michaels Team reviewed the data tracking, evaluation, and TAG process currently in place by the Vermont EEUs and the Department of Public Service (the Department) to assess the current processes and identify areas for improvement. The Michaels Team reviewed data from the full 2017-2020 audit period for all three EEUs.

2.1 Review of Reported Energy and Capacity Savings

The Michaels Team conducted a review of the reported energy and capacity savings. The primary purpose of this task was to replicate the annual reported energy and capacity savings achieved by each EEU.

As the first step, we submitted a data request for program tracking data used in the savings calculations for each year under study.

Using this data, the Michaels Team conducted the following activities:

- Checked the data for simple calculation or reference errors;
- Confirmed that the correct savings values and appropriate calculation parameters (e.g., hours of use) from the TRM were used for prescriptive measures; and
- Identifying non-TRM measures and verifying that the sources for non-TRM values are appropriately documented.

For custom projects, contractors implementing the project calculate savings. The program evaluator pulls a sample of those to verify gross savings. The Michaels Team reviewed a sample of custom projects and the recommended adjustments and assessed reasonableness. We also reviewed the sampling process used to meet the desired precision targets.

2.2 TRM Review

The Michaels Team also reviewed the Vermont TRM. This included both a review of the deemed savings values and inputs in the TRM as well as a review of the processes for managing and updating the TRM through the Technical Advisory Group (TAG).

2.2.1 Review of TRM Inputs and Deemed Savings Values

The Michaels Team conducted the following activities:

- Comparison of deemed savings values, engineering parameters, and other inputs (e.g., effective useful life and incremental cost) with those included in TRMs from comparable jurisdictions as well as with applicable industry literature and evaluations;
- Review of documentation of these inputs to ensure that they are correctly referenced to appropriate literature and primary research with a Vermont-specific focus; and
- Review of savings adjustment factors such as free ridership, spillover, persistence, and line losses to ensure that they are current and appropriately documented.

2.2.2 Technical Advisory Group Process Review

The TAG provides a forum for search and approval of new or updated measures to include in the TRM. The Michaels Team reviewed the process for managing and updating the TRM through the TAG through the following activities:

- Interviews of staff at EVT, BED,VGS, and other applicable stakeholders to review the processes for managing and updating the TRM through the TAG; and
- Review of documentation and notes from the TAG.

2.3 Review of Department Savings Verification Process

As part of the interviews with EEU staff and stakeholders conducted in the TAG Process Review task, the Michaels Team also investigated the procedures and methods used in the Department's savings claim verification process. As part of this task, we also reviewed findings and recommendations from previous audits and determine if they have been fully, partially, or not adopted.

2.4 Cost-Effectiveness Analysis

The Michaels Team calculated the cost-effectiveness for each of the EEU's programs for each year of the evaluation cycle (2017-2020) using the Program Administrator Cost Test (PACT), Total Resource Cost Test (TRC), and the Vermont Societal Cost Test (SCT). We ran the analysis using Optimal Energy's Portfolio Screening Tool (PST), an Excel-based tool developed and refined over decades of cost-effective analyses for energy efficiency and renewable energy programs for utilities across the country. The PST is specifically tailored to cost-effectiveness analyses in the energy efficiency sector and can readily handle many of the subtleties involved in these types of screenings, including time differentiated avoided costs, inputs and outputs by sector, early retirement retrofit baseline shifts, and non-resource benefits. We use methodology described in the California Standard Practice Manual, with inputs selected to reflect Vermont-specific practices. Specifically, a risk adjustment has been made meant to recognize the lower risk of efficiency compared to supply-side investment serves to lower the costs in the SCT compared to the TRC.

3. TRM Review

The TRM is a key component of the energy efficiency implementation and evaluation process in Vermont. The TRM contains characterizations of over 100 different prescriptive measures that cover a variety of end uses across the residential, commercial, industrial, low-income, and multi-family sectors. For each measure, the TRM includes a description, the baseline and efficient equipment, and the methods, assumptions, and algorithms used to calculate energy savings, as well as other information such as load shapes, net savings factors, lifetimes, and measure costs.

To evaluate the TRM, the Michaels Team reviewed the deemed savings values, engineering parameters, and other inputs as well as documentation of these inputs to ensure that they are correctly referenced to appropriate literature and primary research with a Vermont-specific focus. We also reviewed savings adjustment factors such as free ridership, spillover, persistence, and line losses to ensure that they are current, reasonable, and appropriately documented. The Michaels Team compared the information in the Vermont TRM to TRMs in comparable jurisdictions (including New York, Maine, Illinois, Wisconsin, Minnesota, and the Mid-Atlantic region) as well as to applicable industry literature, evaluations, and engineering best practices.

3.1 Summary Review

The Michaels Team found the current version of the Vermont TRM to be technically sound and comprehensive which aligns with findings in previous audits. The deemed savings values are generally well-documented, reasonable, and consistent with other jurisdictions. Savings for most measures are algorithm-based, which is generally a more accurate savings-calculation methodology than deemed values as it allows for specific customer inputs. Many measures use Vermont-specific assumptions or, if unavailable, values from comparable jurisdictions.

3.1.1 TRM Technical Accuracy

The Michaels Team conducted an in-depth review of common, high-impact measures to assess the technical accuracy of the TRM. Appendix A provides a list of the reviewed measures with recommended updates based on our review. In most cases, our recommendations are minor and call out updating assumptions based on more recent standards. It is likely that many of these issues would be identified as part of the TAG's normal process of reviewing measures at least every three years. One exception is the variable frequency drive measure. The Michaels Team's review found that the TRM's current methodology likely overstates savings, especially for demand savings, and we recommend that the TAG prioritize review of this measure.

3.1.2 Review of Savings Adjustment Factors

The Michaels Team also reviewed the savings adjustment factors in the TRM, such as free ridership, spillover, persistence, and line losses to ensure that they are current and appropriately documented. In most cases, we found the adjustment factors used in the TRM to be in line with industry averages. Our review of net savings factors found that the free ridership values are often lower than in many other jurisdictions. We recommend that evaluators review the net savings factors of high impact measures and measures with significant recent market changes and consider conducting new free ridership and spillover research to update the net savings factors as needed.

In particular, the free ridership values for residential heat pumps (centrally ducted air source heat pumps and variable speed mini-split heat pumps) in the Efficiency Vermont TRM (0.10 and 0.19, respectively) are generally lower than other TRMs in New England. The free ridership values for these measures range from 0.23 for air source central heat pumps in Massachusetts to ductless heat pumps in 0.42 in Maine. While the year of the research does not seem to correlate highly with the level of free ridership, the free ridership values for heat pumps in the Efficiency Vermont TRM are based on a 2014-2015 study and we recommend updating these values with new research.

3.1.3 Technical Advisory Group Process Review

The purpose of the TAG is to provide a forum for research and approval of new or updated measures to include in the TRM. The Michaels Team reviewed the process for managing and updating the TRM with the TAG through interviews with EEU staff and review of notes and materials from the TAG.

The TAG process has been in place for several program cycles and has not changed significantly since the previous independent audit. The TAG is led by VEIC (as part of EVT) and the TRM document is publicly available and owned by the State of Vermont. EVT continues to serve as the primary administrator and manager of the TAG and TRM process. In this capacity, EVT: facilitates the TAG meetings, including scheduling monthly meetings, requesting input for and developing agendas for these meetings, and creating and distributing meeting materials; implements the TAG-approved updates to the TRM document; and manages the electronic database version of the TRM.

The TAG meets monthly to discuss issues related to the TRM. Attendees consist of EVT, VGS, BED, the Department, and the Department's independent evaluator. Interviewed stakeholders find that the current TAG process is well run and results in good discussion among the various parties. This process has been fine-tuned over many years. The areas for improvement suggested by the EEUs are relatively minor and are mostly related to the need for improved timely communication and review among stakeholders. The use of an online TRM was praised as it allows for timely updates to the drafts.

The TAG develops updates to the TRM regularly to add new measures, update assumptions, incorporate evaluation recommendations, and incorporate changes to ENERGY STAR, codes, and standards. As in past years, measures are reviewed for potential update if there have been evaluation recommendations or changes in codes and standards that impact measure assumptions, or if the measure has not been reviewed or updated over the past three years. In practice, most high-impact measures are reviewed and updated annually. New measure characterizations are created whenever a new technology is ready for implementation if savings will be claimed through a prescriptive process.

If a measure is flagged for update, the TAG process is as follows:

1. Any TAG member may develop proposals for updates to the TRM.
2. The updated proposal is circulated to all TAG members for review.
3. TAG members discuss the proposed update and come to a mutually agreed-upon decision.
4. The TAG-proposed update or addition is reviewed by external reviewers including the independent evaluator.
5. EVT implements the corresponding update to the TRM.

As noted in previous independent audits, EVT's role as the manager of the TAG process may introduce a conflict of interest. As the largest EEU and most active in the TRM update process, EVT has a vested interest in maximizing savings for its programs' energy efficiency projects.

Despite this concern, all parties see the TAG as a very transparent process and EVT is seen as an objective manager of the TRM process.

4. Validation of Reported Savings

The Michaels team reviewed the electric energy savings, winter and summer demand reduction, and cost values included in the evaluation reports for EVT and BED for program years 2017-2020. The audit also covered gas savings for VGS for this period.

4.1.1 Reported Savings

The Michaels team verified all savings values as reported by the independent evaluator for each program year and for each EEU. We requested and received a copy of each EEU's program participant database and replicated the savings amounts listed.

During the audit period, The Cadmus Group and West Hill Energy and Computing were the independent evaluators contracted by the Department to review and verify annual project savings for EVT and BED, respectively. Energy and Resource Services (ERS) conducted this evaluation for VGS in 2017, while NMR Group was VGS's evaluator in 2018 to 2020.

Overall, the Michaels Team was able to review and replicate savings for each EEU to within a small margin of error. The replicated energy savings, winter demand savings, and summer demand savings for EVT and BED are shown in Table 4, Table 5, and Table 6, respectively.

Table 4. Energy (MWh) Savings Verification Summary, Combined EEU Portfolio

	EVT			BED		
Program	**Reported Energy Saved (MWh)**	**Calculated Energy Saved (MWh)**	**% of Reported Value**	**Reported Energy Saved (MWh)**	**Calculated Energy Saved (MWh)**	**% of Reported Value**
Residential New Construction	5,582	5,582	100%	425	439	103%
Existing Homes	23,586	23,588	100%	1,001	1,022	102%
Efficient Products	226,064	226,103	100%	5,979	6,154	103%
Residential Total	***255,232***	***255,273***	***100%***	***7,405***	***7,615***	***103%***
Business New Construction	30,043	30,043	100%	3,932	4,110	103%
Business Existing Facilities	321,738	321,751	100%	8,895	9,394	105%
C&I Total	***351,780***	***351,795***	***100%***	12,828	13,504	***105%***
Portfolio Total	**607,012**	**607,067**	**100%**	***20,233***	***21,119***	**104%**

Table 5. Winter Demand (kW) Savings Verification Summary, Combined EEU Portfolio

	EVT			BED		
Program	**Reported Energy Saved (kW)**	**Calculated Energy Saved (kW)**	**% of Reported Value**	**Reported Energy Saved (kW)**	**Calculated Energy Saved (kW)**	**% of Reported Value**
Residential New Construction	1,047	1,047	100%	74	76	102%
Existing Homes	5,325	5,325	100%	172	175	102%
Efficient Products	52,349	52,349	100%	1,294	1,332	103%
Residential Total	***58,721***	***58,721***	***100%***	***1,540***	***1,582***	***103%***
Business New Construction	4,041	4,041	100%	546	551	101%
Business Existing Facilities	37,732	37,732	100%	963	1,020	106%
C&I Total	***41,773***	***41,773***	***100%***	***1,509***	***1,571***	***104%***
Portfolio Total	**100,494**	**100,494**	**100%**	**3,048**	**3,154**	**104%**

Table 6. Summer Demand (kW) Savings Verification Summary, Combined EEU Portfolio

	EVT			BED		
Program	**Reported Energy Saved (kW)**	**Calculated Energy Saved (kW)**	**% of Reported Value**	**Reported Energy Saved (kW)**	**Calculated Energy Saved (kW)**	**% of Reported Value**
Residential New Construction	550	550	100%	30	30	101%
Existing Homes	1,721	1,721	100%	39	40	103%
Efficient Products	20,606	20,606	100%	483	497	103%
Residential Total	***22,877***	***22,877***	***100%***	***552***	***567***	***103%***
Business New Construction	4,316	4,316	100%	668	675	101%
Business Existing Facilities	42,720	42,720	100%	1,177	1,210	103%
C&I Total	***47,036***	***47,036***	***100%***	***1,845***	***1,885***	***102%***
Portfolio Total	**69,913**	**69,913**	**100%**	**2,397**	**2,452**	**102%**

Table 7 shows the natural gas savings for VGS in 2017 through 2020. Note that EVT and BED programs also resulted in non-TEPF natural gas savings during this time, but VGS accounted for the vast majority (87%) of total savings.

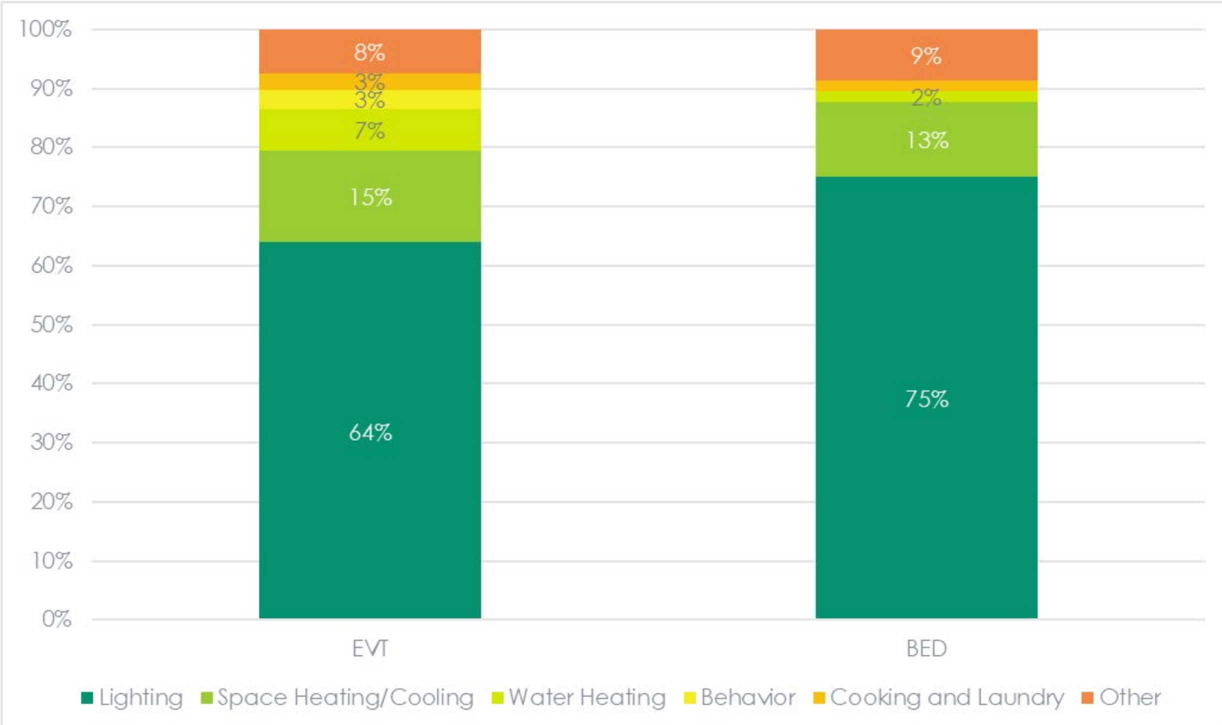
Table 7. Natural Gas (Mcf) Savings Verification Summary, Vermont Gas Systems

Program	VGS		
	Reported Energy Saved (Mcf)	**Calculated Energy Saved (Mcf)**	**% of Reported Value**
Residential New Construction	34,315	34,315	100%
Existing Homes	74,260	74,260	100%
Residential Total	***108,575***	***108,575***	***100%***
Business New Construction	63,191	63,191	100%
Business Existing Facilities	92,491	92,491	100%
C&I Total	***155,681***	***155,681***	***100%***
Portfolio Total	**264,256**	**264,256**	**100%**

Savings from commercial and industrial (C&I) measures accounted for approximately 60% of the 2017-2020 EEU portfolio. The share of C&I savings was highest for BED (63%) and very similar for EVT and VGS (58% and 59%, respectively). These shares are similar to those reported in the previous audit.

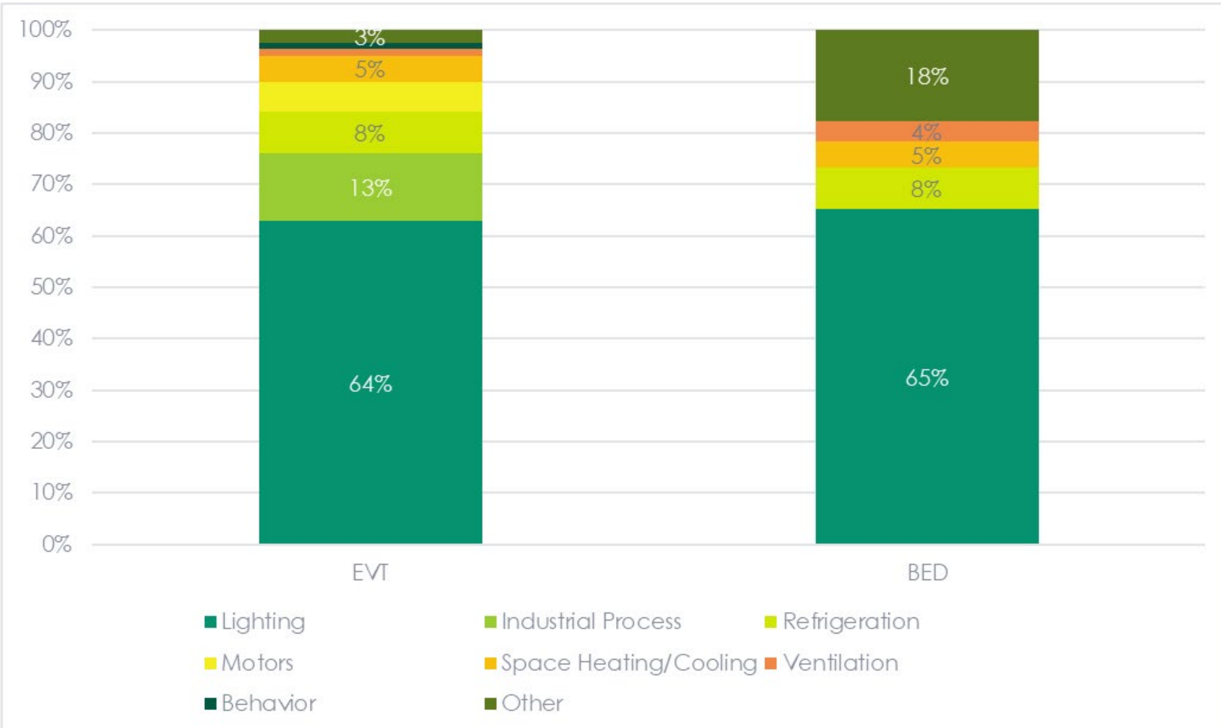
Lighting accounts for the largest share of electric savings for EVT and BED, as shown in Figure 1. This share has decreased for EVT since the last audit, from 74% to 64%, but lighting's contribution to residential electric savings for BED has not changed notably from 76% in 2014-2016.

Figure 1. Share of Residential Electric (kWh) Savings by End Use, 2017-2020



Lighting also accounts for the majority of C&I savings for both EVT and BED (64% and 65%, respectively). This represents a notable increase in the share of savings for lighting compared to the previous audit, when the shares were 41% and 34%, respectively. For EVT, the share of savings from industrial process efficiency decreased from 33% in 2014-2016 to 13%.

Figure 2. Share of Commercial and Industrial Electric (kWh) Savings by End Use, 2017-2020



As expected, the savings for VGS were dominated by heating (35%), heat recovery (12%), water heating (11%), and shell measures (10%).

4.1.2 Evaluation Report Review

The Michaels Team reviewed the evaluation reports for each EEU for 2017 through 2020. For each report, we reviewed the methodology, sampling plan, and adjustment to savings to ensure that the evaluation approaches were reasonable and appropriate and adhered to industry best practices.

Notably, only the BED evaluations discussed the impact of Covid-19 on the evaluation methodology and results in detail. This was likely because the evaluations of EVT and VGS relied heavily on desk reviews and calculation of prescriptive measures using TRM values.

Overall, the evaluation reports appear to be adequate for reporting savings and are generally well done. While our review uncovered some areas for improvement, described below, we did not find any major issues in the verification process.

Efficiency Vermont

Cadmus conducted the EVT evaluations from 2017 to 2020. The portfolio realization rates for these years ranged from 98% to 99% for kWh, 97% to 101% for winter kW, and 98% to 102% for summer kW. These realization rates indicate that the initial savings estimates provided by EVT are reasonable and are receiving the normal amount of adjustment as a result of the evaluation process.

There was more variation in realization rates for individual programs, but all were reasonable and typical for the type of programs. In some cases, the evaluators found realization rates for programs that were outliers. For example, the C&I Upstream HVAC program had a very low realization rate in 2018 (31.5%) for winter kW and a relatively high realization rate for summer kW (123.7%). In these cases, the evaluators generally did a good job of explaining the reasons for adjustment and the issues appear to resolve in the next evaluation. Additionally, the instances of programs with large discrepancies in realization rates represented very small shares of portfolio savings, so the effect on the portfolio's overall realization rate was minimal.

The 2017-2020 Efficiency Vermont custom C&I projects were evaluated primarily with desk reviews with a high level of rigor. In the cases where the evaluation team found issues or discrepancies with the implementor's approach or calculations, they made adjustments that generally appeared to be well justified and reasonable.

The Michaels Team does note that the evaluation team did not appear to do any site visits to verify calculation inputs or assumptions, nor did they appear to reach out to site contacts for brief phone interviews to validate savings calculations. Future evaluations would benefit from site visits, virtual site tours (using video technology), or interviews to validate inputs or assumptions.

The Independent Auditor has two concerns with the evaluation approach and methodology.

1. The evaluation teams applied somewhat arbitrary penalties to projects that lacked sufficient documentation to fully validate the energy savings. For instance, if installed lighting quantities could not be verified with contractor invoices, the evaluation team typically reduced savings by 5% to account for this uncertainty. This uncertainty reduction was used regularly, although not universally, and adjustment levels ranged from 5-15%. In other cases, such as lighting hours of use, the evaluation teams often noted that there was uncertainty around the assumption used, and suggested metering be used in the future to better determine values, but no uncertainty penalty was applied. The Michaels Team recommends formalizing and documenting this practice as much as possible to ensure uncertainty adjustments are applied consistently.
2. The evaluation teams appear to rely entirely on International Performance Measurement and Verification Protocol (IPMVP) Option A (Retrofit Isolation: Key Parameter Measurement) unless the implementer used Option B (Retrofit Isolation: All Parameter Measurement) or Option C (Whole Facility Measurement). While Option A is a suitable methodology, some projects may benefit from using Option C more regularly, particularly where uncertainty is higher, or savings estimates relative to the total consumption is high.

Vermont Gas Systems

Energy & Resource Solutions (ERS) conducted the 2017 evaluation for VGS and NMR Group conducted the evaluations in 2018 to 2020. The portfolio realization rates for these years ranged from 82% to 109% for Mcf of natural gas. These realization rates indicate that the initial savings estimates provided by VGS are reasonable and are receiving the normal amount of adjustment as a result of the evaluation process.

The 2017-2020 VGS's custom projects were also evaluated primarily with desk reviews. Any issues and discrepancies with the implementor's approach or calculations, resulted in adjustments that generally appeared to be well justified and reasonable. Adjustments were also consistent from one project to another across similar measure types. The evaluator's report format and approach were generally easy to follow and understand.

Similar to Efficiency Vermont, the evaluation team did not appear to do any site visits to verify calculation inputs or assumptions and did few interviews with customers to validate savings calculations. Future evaluations would benefit from site visits, virtual site tours (using video technology), or interviews to validate inputs or assumptions.

The Michaels Team identified several concerns with the evaluation approach and methodology.

1. The evaluators should describe the baseline and efficient scenarios in more detail to avoid confusion. For example, some baseline and efficient scenarios had different capacities. The common practice is to make these the same where possible. (project PY19CER03 as an example).
2. The evaluation team compares baseline and proposed usage calculations to billed usage in some cases, but not all. The Michaels Team recommends doing this when possible to determine if the savings are reasonable. Additionally, when doing a billing analysis, the evaluation team should attempt to use 12 months of baseline data and 12 months of post-case data to maximize accuracy of the model. One example listed (project number CSR2) had a post period of only September 2016 to March 2017.
3. In many cases the evaluators stated "there was an incorrect conversion that leads to a realization rate of…" or "using input capacity rather than output capacity overstates energy savings resulting in a realization rate of…" For future evaluations, we suggest that the evaluators give more details such as the conversion that was used and what replaced it.

Burlington Electric Department

The West Hill Energy & Computing Team conducted the evaluations for BED from 2017 to 2020. The portfolio realization rates for these years ranged from 90% to 110% for kWh, 92% to 113% for winter kW, and 84% to 118% for summer kW. These ranges are typical for a small program with a large share of custom measures. These realization rates indicate that the initial savings estimates provided by BED are reasonable and are receiving the normal amount of adjustment as a result of the evaluation process.

As with previous audits, the independent auditor continues to be concerned with the timing of the completed evaluation reports, which were typically completed more than a year after the end of the program year. This large gap in time significantly reduces the usefulness of the evaluation results as they cannot be used to help make program adjustments for the following year. We recommend that the BED reporting schedule be compressed to better align with the reporting schedules of the other EEUs.

The 2017-2020 BED Custom projects were also evaluated. The evaluation team performed on-site verification visits with meter installations for a subset of sampled projects.[2] They supplemented those visits with desk reviews and interviews and in some cases the customer's building automation system data was collected and used. In PY2019 and PY2020, the Covid-19 pandemic resulted in changes to hours of operations and, in some cases, business closures. The valuation team investigated the Covid-19 impacts on a site-by-site basis and used an appropriate analysis method.

During evaluation, any found issues and discrepancies with the implementor's approach or calculations resulted in adjustments made using data collected through meter installation or by building automation system. These adjustments generally appeared to be well justified and reasonable and consistent from one project to another across similar measure types and across program years. The evaluator's report format and approach were generally easy to follow and understand and there was clear written explanation of baseline and efficient cases, results, and algorithms used as well as metering approach and any issues encountered.

The Michaels Team noted the following concerns with the evaluation approach and methodology.

1. Many of the custom projects were in three main categories: Lighting, HVAC, and New Construction. For the lighting projects, the evaluator made changes most frequently to the coincident factor or the hours of operation. The coincident factor adjustment was made using metered data and adjusted away from a TRM value. In the metered cases, a clear explanation of how the evaluator calculated the new coincident factor would be helpful. Using metered data is a good approach as long as it can be backed with good execution. One example: 83058 – the major adjustment to savings came from metered data, however the evaluator says that of the 13 meters deployed, 1 was lost and 5 were "missing key data". Therefore, we question if there was enough data to make the adjustment from the TRM variables used by the implementors.
2. In at least one case, savings were adjusted because the facility operation changed as a result of the COVID pandemic. The only major change to the savings for this project results from a reduction in operating hours due to the pandemic. It appears that the pandemic effect was a common issue encountered during interviews or on-site verification, but the pandemic adjustments to operation should not be adjusted-for unless the change is permanent.
3. For new construction measures where models were updated, we request that more information be provided by the evaluation team in the future, such as the modeling software used and the inputs in question and their adjustments. In many cases the percent changes were described but not the changed inputs that caused the savings adjustment.

[2] In PY2019 and PY2020, Covid-19 prevented the evaluator from conducting site visits due to business closures or restrictions. In these cases, the evaluator used BMS or trend data, modeling, and past metering to determine peak coincidence factors.

5. Cost-Effectiveness Analysis

5.1 Overview

The Michaels Team calculated the cost-effectiveness for each EEU and each year of the evaluation cycle (2017-2020) according to the Program Administrator Cost Test (PACT), Total Resource Cost Test (TRC), and the Vermont Societal Cost Test (SCT). We ran the analysis using Optimal Energy's Portfolio Screening Tool (PST), an Excel-based tool developed and refined over decades of cost-effective analyses for energy efficiency and renewable energy programs for utilities across the country. The PST is specifically tailored to cost-effectiveness analyses in the energy efficiency sector and can readily handle many of the subtleties involved in these types of screenings, including time-differentiated avoided costs, inputs and outputs by sector, early retirement retrofit baseline shifts, and non-resource benefits. We use methodology described in the California Standard Practice Manual, with inputs selected to reflect Vermont-specific practices.

Based on our review of the EEU savings claims, each EEU's programs were cost-effective for each program year (2017-2020) according to each of the three applicable tests. Table 8 below shows the portfolio-level cost-effectiveness for all four evaluation years, for each EEU and total. For each test, the cost-effectiveness ratio shows the present value of benefits divided by the present value of costs of the program. A benefit cost ratio of 2.0, for examples, indicates $2 in benefits for every $1 in costs. As seen, all EEU programs are cost effective in each program year evaluated, as well as overall.

Table 8. Overall Cost-Effectiveness

EEU	PACT	TRC	SCT
Efficiency VT – Electric	2.32	1.93	2.45
Efficiency VT – TEPF	2.58	1.35	2.26
Burlington Electric Department – Electric	2.36	1.76	3.13
Burlington Electric Department – TEPF	1.02	0.66	1.10
Vermont Gas	4.65	1.82	3.15
Total	2.46	1.77	3.11

5.2 Cost-Effectiveness Tests and Inputs

Cost-effectiveness screening evaluates whether the net present value (NPV) of the benefits of energy efficiency programs outweigh the costs of the programs. Cost-effectiveness can be evaluated from a variety of perspectives, including:

- Utility's or program administrator's perspective – using the Program Administrator Cost Test (PACT);

- Resource perspective– using the Total Resource Cost (TRC) Test; and
- Overall Societal perspective – using the Societal Cost Test (SCT).

Each test result is expressed as a ratio of the NPV of benefits divided by the NPV of costs. A value greater than 1.0 indicates that benefits exceed costs, and the program is cost-effective. The specific benefits and costs included in each test depend on the perspective the test is intended to look at, as well as some jurisdiction specific factors. Each of the three tests is described further below.

5.2.1 Program Administrator Cost Test (PACT)

The Program Administrator Cost Test (PACT) measures cost-effectiveness from the utility perspective. The costs include all costs incurred by the EEU in running the efficiency programs, including incentive costs, administrative costs, and evaluation costs. The benefits include money saved by the energy systems via the efficiency programs, namely through avoided energy, capacity, and gas costs.

5.2.2 Total Resource Cost Test (TRC)

The Total Resource Cost Test (TRC) measures cost-effectiveness from a combined perspective of participants and non-participants. The costs include all incremental expenditures incurred as a result of the efficiency program – meaning all costs from the program administrator cost test plus any additional contributions from program participants. Benefits include all resource savings, including avoided electric, gas, fossil fuel, and water, as well as any measurable avoided operation and maintenance costs from the efficient equipment. In Vermont, the TRC test also includes pre-defined energy externalities.

5.2.3 Vermont Societal Cost Test

The Societal Cost Test (SCT) looks at cost-effectiveness from a total societal perspective. It is typically similar to the TRC, but includes additional non-energy benefits and externalities. In Vermont, a risk adjustment meant to recognize the lower risk of efficiency compared to supply-side investment serves to lower the costs in the SCT compared to the TRC. In addition, benefits in the SCT test are greater than benefits in the TRC test, due to a multiplier used to recognize the existence of non-energy benefits from energy efficiency.

5.2.4 Cost-Effectiveness Inputs

Optimal largely relied on the EVT and VGS 2017-2020 screening tools to populate the global inputs to Optimal’s PST used to calculate portfolio level cost-effectiveness. Table 9 below summarizes the key global inputs and provides the source for the values.

Table 9. Cost-Effectiveness Input Values and Sources

Input	Value	Source
Real Discount Rate	3%	EVT Screening Tool
Future Inflation Rate	2%	EVT Screening Tool
Avoided Electric Energy Costs	Varies	EVT Screening Tool
Avoided Electric Capacity Costs	Varies	EVT Screening Tool
Avoided Gas Costs	Varies	VGS Screening Tool
Avoided Fossil Fuel Costs	Varies	EVT Screening Tool
Risk Adjustment for SCT	10%	EVT Screening Tool
Environmental Externalities	Varies	EVT and VGS Screening Tools
Non-Energy Benefits	15%	EVT Screening Tool
Line Losses	Varies	EVT Screening Tool
EVT and BED Program Data	Varies	Program Tracking Database
VGS Program Data	Varies	VGS Screening Tool

5.3 Cost-Effectiveness Results

This section presents detailed results of cost-effectiveness screening for each EEU, as well as combined results.

5.3.1 Combined EEU Portfolio

As a whole, the EEUs' efficiency programs from 2017 to 2020 were cost-effective, with a TRC of 1.77, an SCT of 3.11, and a PACT of 2.46. This is slightly higher than the cost-effectiveness ratios found in the 2014-2016 evaluation, which gives a TRC of 1.47, an SCT of 2.2, and a PACT of 2.60. The table below shows the total costs and benefits under each test. As seen, the four program years produced almost $800 million in total net benefits.

Table 10. Combined EEU Cost-Effectiveness Results for 2017-2020

	Benefits (2017$)	Costs (2017$)	Net Benefits (2017$)	Benefit /Cost Ratio
PACT	$740,300,619	$300,724,739	$439,575,880	2.46
TRC	$740,300,619	$418,956,149	$321,344,470	1.77
SCT	$1,171,511,629	$377,060,534	$794,451,094	3.11

5.3.2 Efficiency Vermont

Table 11 summarizes the cost-effectiveness, by sector, of Efficiency Vermont's electric projects. As seen, each sector passes all three cost-effectiveness tests. The net benefits from these programs reflect a large majority of the total.

Table 11. Cost-Effectiveness Results for Efficiency Vermont's Electric Projects

		Benefits (2017$)	Costs (2017$)	Net Benefits (2017$)	Benefit/Cost Ratio
Res	PACT	$237,445,977	$114,742,956	$122,703,022	2.07
	TRC	$237,445,977	$128,527,339	$108,918,638	1.85
	SCT	$387,176,393	$115,674,605	$271,501,788	3.35
C&I	PACT	$276,842,949	$107,089,543	$169,753,406	2.59
	TRC	$276,842,949	$137,467,544	$139,375,404	2.01
	SCT	$439,175,129	$123,720,790	$315,454,339	3.55
Total	PACT	$514,288,926	$221,832,498	$292,456,428	2.32
	TRC	$514,288,926	$265,994,883	$248,294,043	1.93
	SCT	$826,351,522	$239,395,395	$586,956,127	3.45

Table 12 gives the same information for EVT's delivered fuel (TEPF) projects. These projects are also cost-effective for each sector and test.

Table 12. Efficiency Vermont TEPF Cost-Effectiveness Results

		Benefits (2017$)	Costs (2017$)	Net Benefits (2017$)	Benefit/Cost Ratio
Res	PACT	$90,462,599	$46,053,242	$44,409,357	1.96
	TRC	$90,462,599	$86,481,971	$3,980,628	1.05
	SCT	$135,649,798	$77,833,774	$57,816,024	1.74
C&I	PACT	$59,164,389	$12,047,138	$47,117,251	4.91
	TRC	$59,164,389	$24,145,870	$35,018,519	2.45
	SCT	$89,651,477	$21,731,283	$67,920,194	4.13
Total	PACT	$149,626,988	$58,100,380	$91,526,608	2.58
	TRC	$149,626,988	$110,627,841	$38,999,147	1.35
	SCT	$225,301,275	$99,565,057	$125,736,218	2.26

5.3.3 Burlington Electric Department

Burlington Electric Department's electric programs were also cost-effective for each sector and test. The table below presents the detailed results. The TEPF savings are slightly cost-effective using the PACT and SCT tests, but not cost-effective using the TRC test. However, these results are to be expected given the low level of participation and savings associated with TEPF savings.

Table 13. Burlington Electric Department Electric Cost-Effectiveness Results

		Benefits (2017$)	Costs (2017$)	Net Benefits (2017$)	Benefit/Cost Ratio
Res	PACT	$7,032,276	$3,203,180	$3,829,096	2.20
	TRC	$7,032,276	$3,282,909	$3,749,367	2.14
	SCT	$11,584,502	$2,954,618	$8,629,884	3.92
C&I	PACT	$13,759,452	$5,623,536	$8,135,916	2.45
	TRC	$13,759,452	$8,557,037	$5,202,415	1.61
	SCT	$21,760,789	$7,701,333	$14,059,456	2.83
Total	PACT	$20,791,728	$8,826,716	$11,965,012	2.36
	TRC	$20,791,728	$11,839,946	$8,951,782	1.76
	SCT	$33,345,291	$10,655,952	$22,689,339	3.13

Table 14. Burlington Electric Department TEPF Cost-Effectiveness Results

		Benefits (2017$)	Costs (2017$)	Net Benefits (2017$)	Benefit/Cost Ratio
Res	PACT	$171,892	$165,318	$6,573.92	1.04
	TRC	$171,892	$258,830	-$86,938.51	0.66
	SCT	$258,566	$232,947	$25,619.17	1.11
C&I	PACT	$9,971	$12,425	-$2,453.74	0.80
	TRC	$9,971	$18,274	-$8,303.34	0.55
	SCT	$14,725	$16,447	-$1,721.89	0.90
Total	PACT	$181,862	$177,742	$4,120.18	1.02
	TRC	$181,862	$277,104	-$95,241.85	0.66
	SCT	$273,291	$249,394	$23,897.28	1.10

5.3.4 Vermont Gas Systems

The table below presents the cost-effectiveness results for Vermont Gas's efficiency programs. We do not present sector level results for VGS, due to the availability of cost data. We recommend that Vermont Gas track this information in the future.

Table 15. Vermont Gas Cost-Effectiveness Results

		Benefits (2017$)	Costs (2017$)	Net Benefits (2017$)	Benefit/Cost Ratio
Total	PACT	$55,592,976	$11,965,144	$43,627,832	4.65
	TRC	$55,592,976	$30,493,478	$25,099,498	1.82
	SCT	$86,513,541	$27,444,131	$59,069,410	3.15

6. Recommendations

Similar to past audits, the audit of the 2017-2020 EEU programs found that the efficiency programs in Vermont appear to be well run. Specifically:

- The TRM document is technically sound, reasonable, and comprehensive. Stakeholders find the TAG process for updating the TRM to be transparent and collaborative.
- The evaluation reports generally conform to industry standard practices.
- The savings estimates are accurate and generally consistent with the TRM.

Our review of the TRM, savings estimates, evaluation reports, and program processes uncovered several areas for improvement, summarized in the recommendations below.

- Evaluators should look to increase the number of in-person or virtual site visits to verify the calculation inputs and assumptions used for savings calculations. Although a site visit is preferable, evaluators can also reach out to site contacts for brief interviews to verify project specifics.

- The evaluation teams appear to rely entirely on International Performance Measurement and Verification Protocol (IPMVP) Option A (Retrofit Isolation: Key Parameter Measurement) unless the implementer used another approach. While Option A is a suitable methodology, some projects may benefit from using Option C (Whole Facility Measurement) more regularly, particularly where uncertainty is higher, or savings estimates relative to the total consumption is high.

- In some cases, evaluators applied arbitrary penalties to projects that lacked sufficient documentation to provide a more conservative savings estimate. However, this practice was not applied consistently. If evaluators wish to use this approach, we recommend formalizing and documenting this practice to ensure consistency across projects.

- While we did not uncover any systematic issues with the TRM, we did identify many minor issues that should be updated in future versions. EVT and the TAG should review the measure-specific findings in Appendix A and include the relevant recommendations in the queue for updates in the next version of the TRM. In particular, the Michaels Team's review found that the TRM's current methodology for the variable speed drive measure likely overstates savings, especially for demand savings, and we recommend that the TAG prioritize review of this measure.

- Our review of net savings factors found that the free ridership values are often lower than in many other jurisdictions. We recommend that evaluators review the net savings factors of high impact measures and measures with significant recent market changes and consider conducting new free ridership and spillover research to update the net savings factors as needed.

- The independent auditor recommends that BED compresses their reporting schedule to better align with the schedules of other EEUs. The current large gap in time between the end of the program year and completion of the evaluation report significantly reduces the usefulness of the evaluation results as they cannot be used to help make program adjustments for the following year.

- Evaluations should begin as early as possible, even before the program year is complete to ensure rigorous methods can be applied. We suggest using sampling projects in waves so that some can be evaluated earlier and enough data can be collected, if needed. An earlier start may also ensure that BED's verification reports can be completed earlier.

- EEUs should address recommendations included in the evaluation reports. Many recommendations appear year after year, indicating that the issues still need to be resolved.

- The Commission should continue to monitor EVT's role as TAG administrator to ensure that potential conflicts of interest are avoided.

Appendix A | Detailed TRM Review

Table 16. Residential TRM Measure Review

ID	Measure	Comments

IV-J-2 c	Advanced Thermostat	• The Independent Auditor suggests considering updating the mix of manual to programmable thermostats.
		• The Independent Auditor recommends several updates to the file "VGS TRM Advanced T-Stat_CRS_O6202022.docx":
		  ○ The measure is based on data from 2015. We recommend updating the measure based on a more recent source, if available.
		  ○ We also recommend adding language from the EVT TRM about what other features beyond programmable temperature settings are included, such as occupancy detection, arrival/departure times, etc.
		  ○ It does not appear that the ResTStats_Tool allows heat pumps to be selected for calculations despite being listed in the default tables. It is missing from the drop down in cells C12/13. Also, selecting "unknown heating type" appears to break the annual electric savings and demand savings calculation.
		  ○ The savings value does not match the EVT TRM value of 1.91%. We suggest either making these values consistent or documenting why they are not the same.
		  ○ The tool appears to be missing capacity and FLH for new construction. We recommend adding these values into the tool.

CI-LAU-CACD	Multi Family Commor Area Clothes Dryer	• It appears that the number of cycles per year per unit (112) is based on a study that found residents using common area laundry do 2.16 loads per week. However, the number of loads per week for a common area dryer would likely be higher because there is likely more than one resident using common area equipment in a multi-family building. We suggest reviewing this assumption and updating it if needed based on the number of residents using the common area dryer.
CR-HVAC-CDHPR	Ducted Air Source Heat Pump (Retrofit)	• In future updates, the Independent Auditor recommends incorporating the most recent version of the NEEP Heat Pump QPL. • Consider requiring the energy efficient SEER to match the market opportunity SEER of 15.6 or greater. SEER 14 is code.

ID	Measure	Comments
IV-A-2 d	ENERGY STAR Clothes Dryer	• The Independent Auditor suggests updating this measure for ENERGY STAR 1.1 specifications. The CEF should be updated for both the baseline and efficient equipment to match the ENERGY STAR 1.1 specifications.
IV-G-2 b	Ultra Efficient LCD Monitors	• This measure should be using the ENERGY STAR Display Specification v8 after May 2, 2019.
IV-I-1 c	ENERGY STAR Heat Pump Water Heater	• Consider binning the savings based on gallon capacity of the water heaters, since the savings tend to differ based on volume and draw pattern of the heaters. This also aligns with the UEF rating comparison ruling from DOE. • The Independent Auditor recommends updating the measure to include the Uniform Energy Factor (UEF) of the equipment, the current efficiency standard for water heaters. Energy Factor is no longer used per December 2016 DOE ruling. o With this in mind, savings need to be updated to use UEF rating and sizing. • The Independent Auditor suggests specifying "Current Energy Star Specifications" or a specific version.
IV-K-1 a	Low-E Storm Windows	• Consider including minimum emissivity and solar heat gain coefficient (SHGC) values
R-RFG-FRER e	Freezer Early Replacement	• Consider updating the specifications to a more recent version, such as Version 5.1 Consumer Refrigeration Products.
RS-LAU-CKLW c	Efficient Clothes Dryers	• The Independent Auditor suggests adding capacity sizes to the tiers.
RS-MLT-ESRPP c	ENERGY STAR Retail Products Platform	• Consider updating all ENERGY STAR specifications to the most recent version
	VGS Residential Instantaneous Hot Water Heater	• The setpoint for 130°F seems high compared to standard practice. The Independent Auditor recommends 120°F for instantaneous DHW. • The average number of people per household is different than other VGS residential water heating measures. The Independent Auditor recommends updating these to the current value of 2.28 from 2016-2020 to be consistent.
	VGS Residential Indirect Single Family Water Heating System	• The average number of people per household is different than other VGS residential water heating measures. The Independent Auditor recommends updating these to the current value of 2.28 from 2016-2020 to be consistent.
	VGS Residential Hot Water End Use Low Flow Shower Head	• The average number of people per household is different than other VGS residential water heating measures. The Independent Auditor recommends updating these to the current value of 2.28 from 2016-2020 to be consistent.

ID	Measure	Comments
	VGS Residential Hot Water End Use Low Flow Faucet Aerator	• The average number of people per household is different than other VGS residential water heating measures. The Independent Auditor recommends updating these to the current value of 2.28 from 2016-2020 to be consistent.

Table 17. Commercial & Industrial TRM Measure Review

ID	Measure	Comments
I-E-12c	Floating Head Pressure Control	• The unknown type/temp is just the average between (remote and self-contained) & (low and medium temperature). It might be better to use the lower of the two to encourage participants to properly ID the unit type and temperature range. • There should be no summer kW savings for this (savings only occur during off peak temperatures, as noted in the load shape table), but this does allow kW to be calculated by dividing energy savings by annual operating hours. Disregard this if the implementers must use the load shape table when calculating summer kW. • Review savings for self-contained units to verify the calculated values are correct and should not be significantly lower. Other TRMs (NY, IL) appear to use values that are ~20-40% of the values used for VT TRM. • The current version of the RTF calculator is 3.0, dated 2022, but the TRM is based on version 1.5, dated 2016 (4 revisions behind current). Consider updating the TRM based on the most recent version.

ID	Measure	Comments

I-E-8e	Evaporator Fan Motors	• The hours of use is represented by a duty factor, set to 97.8%. This duty factor is equivalent to 8573 hours of use.
		  o It is unclear how this number was derived. The footnote states it is based on 8550 hours due to defrost cycles on freezer.
		  o The independent auditor believes this value may be (slightly) high and should be set for future review. The NY TRM uses that value for no cooler control, but also has hours of use for On/Off control and Multistep control of 5,571 and 6,062 hours, respectively (based on a 2015 Cadmus Commercial Refrigeration load shape study). Wisconsin Focus on Energy uses 4,500 hours, although that may be overly conservative and simply based on compressor runtime. The Arkansas TRM uses 8,273 hours to account for four 20-minute defrost cycles per day for a freezer unit.
		• Consider including efficiency values for Q-Sync motors in subsequent TRM updates.
		• It is not clear how the bonus factors of 1.4 for coolers and 1.8 for freezers are derived.
		  o These appear to be high from an energy-saving perspective, while likely more acceptable from a demand perspective. They appear to assume a cooler refrigeration COP of 2.5 and freezer COP of 1.25, which are likely based on design conditions. As energy savings is calculated as demand savings multiplied by 8760, this value should be derated to better reflect the average COP over the year. Because VT has a relatively mild/cold climate, the average efficiency of its refrigeration systems will typically be much higher than the design conditions.
		  o Rather than using fixed values, these bonus factors may be more accurately calculated using the actual peak and average COP values from the refrigeration system (BF = 1 + 1/COP) with default values where applicable.
		•

CI-RFG-DOOR b	Add Doors to Open Display Cases	• Consider adding default values for the heat gain change with horizontal casing like the IL TRM. The default value for this measure appears to be comparable to the IL vertical case, but the IL horizontal case value is ~17% of the value, so savings claimed on horizontal cases will be substantially overestimated. • Consider adding different default values for high efficiency vs standard efficiency doors, as well as differentiating based on freezers and coolers.

ID	Measure	Comments
CI-RFG-DHC e	Door Heater Controls	• The bonus factor (BF) is calculated based on design conditions, which is properly applied to demand savings. However, this bonus factor likely needs to be derated when applied to energy savings throughout the year as the average typical efficiency levels of the refrigeration system will increase as outside temperatures decrease from design conditions. • The energy savings factor (EF) is set to 45.1%, which according to footnotes is based on a NEEP study from 2015. However, the NEEP TRM references the same study, but breaks out the savings based on the type of controller (on/off vs micropulse). It's not clear how the 45.1% was determined, but it appears to be more heavily weighted towards the higher end of savings (micropulse controllers). This should be reviewed to ensure it is an accurate weighted average.
CI-RFG-EVPMC e	Evaporator Fan Moto Controls	• The bonus factor (BF) is calculated based on design conditions, which is properly applied to demand savings. However, this bonus factor likely needs to be derated when applied to energy savings throughout the year as the average typical efficiency levels of the refrigeration system will increase as outside temperatures decrease from design conditions. • The description of the efficient equipment refers to a "smaller wattage circulating fan", but this description requires more detail. What does smaller refer to? Smaller than a certain size? Smaller than the baseline? • It is not clear to the independent auditor why summer and winter peak kW load shapes are the same (83.1%). Presumably summer operation would have higher loads if operated the same way, which would reduce the summer peak kW savings relative to the winter. We recommend reevaluating this calculation.
CI-RFG-LKPR b	Refrigerant Leak Repair	• The savings for this measure depend on a spreadsheet-based calculation done to approximate the impact on efficiency, using assumed inputs that don't appear to be sourced based on measured data. While the overall assumptions appear to be reasonable, the actual impact on system efficiency is highly dependent on average baseline case refrigerant charge levels.[3] The independent auditor recommends further research or study to identify more accurate average refrigerant loss or efficiency degradation data.
CI-RFG-RIREFR h	Commercial Reach-In Refrigerators and Freezers	• This measure is based on the ENERGY STAR specification v4.0, but the Independent Auditor recommends updating the measure values to reflect the current version of the specification which was released March 2022 (v5.0[4]).
I-E-14 d	High Efficiency Condensing Units	• The Independent Auditor recommends verifying the accuracy of the demand and energy savings calculations, particularly for smaller medium-temperature equipment. The claimed values appear to be potentially high relative to their baseline use. • This measure appears to be based on engineering calculations alone and there are very few studies or other references available to corroborate savings values. The Independent Auditor recommends confirming savings estimates with metered data studies if funding permits.

[3] https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2121&context=iracc
[4] https://www.energystar.gov/products/spec/commercial_refrigerators_and_freezers_specification_version_5_0_pd

ID	Measure	Comments
CI-RFG-COVE d	Refrigerated Case Covers	• This measure does not contain fossil fuel impacts, but there are likely savings associated with space heating. In some cases, there may be unaccounted for demand impacts as well if cooling loads are shifted from the refrigeration system to the space conditioning systems. • This measure may be made more accurate by calculating the display area rather than its length and using a heat gain estimate per square foot of display area rather than linear foot of case. • It is not clear why continuous curtains would have a lower efficiency factor than strip curtains. These values appear to be derived from very different sources and may not accurately represent the efficiency gains for both products. We recommend trying to validate this value based on studies using consistent methodologies as well as using data that is more location specific.
CI-RFG-EVAP b	High Efficiency Evaporators	• This measure combines several measures into a single measure: High Efficiency Evaporator Fan Motor Controls (Tier 1), Evaporator Fan Motors (Tier 1), Defrost Controls (Tier 2), and Electronic Expansion Valves (Tier 2). Tier 1 requires both Tier 1 measures, and Tier 2 includes all Tier 1 and Tier 2 measures. • For comments on Evaporator Fan Motor Controls and Evaporator Fan Motors (Tier 1 measures), please see their comments in their respective sections in this report. • For Tier 2, some medium temperature refrigeration will not require defrost, and should be ineligible for Tier 2 savings. • The Electronic Expansion Valves (EEV) measure uses a rule of thumb value of 1.5% savings per degree increase in suction pressure, as well as an assumed average 3°F increase in suction pressure. While these values are based on industry rules of thumb, the Independent Auditor recommends sourcing more location-specific data.
CI-HWE-PRSVa	High Efficiency Pre-Rinse Spray Valve	• In a case where not all of the water used by pre-rinse valves is heated, including a percentage of water provided by water heaters may yield a more accurate result.
I-K-2 b	Heat Recovery Units for Dairy Farms	• It is unclear how the Btu and kW savings per unit were calculated/obtained before being inputted into the spreadsheet. (The file reviewed by the independent auditor: "dairy-hru-analysis-v3-xls.xls") • The measure is based on an engineering analysis, specific to Vermont. Since it is based on custom data inputs, the measure appears to fit Vermont TRM best. A similar measure from a Wisconsin TRM was found (Heat Recovery Tank, No Heating Element, Electric or Natural Gas in the Agriculture section). However, it did not yield comparable savings results. The calculations are based on custom user inputs, such as tank size, number of cows, how many times they are milked per day, etc.

ID	Measure	Comments
I-A-10 b	Maple Sap Vacuum Pump VFD	• The measure is based on an engineering analysis, specific to Vermont. Since it is based on custom data inputs, the measure appears to fit Vermont TRM best. No similar measures were found in other technical reference manuals, so no comparisons can be made. • The kWh/HP & kW/HP values seem to be based on an older version of the document and may need to be updated. (The file reviewed by the independent auditor: "evt-analysis-maple-sap-vfd-nov-2021-v3-xlsx") • The source of the annual MWh savings per year is unclear.
I-A-5 d	Milk Vacuum Pump VFD	• Most VFD measures in other jurisdictions and in Vermont assume a 15-year measure life. This measure uses a 10-year measure life, with no citation. Without a source, it is impossible to know where this value came from, but it is conservative and reasonable that the harsher operating environment of a dairy farm would result in a shorter lifetime for the VFD. • Wisconsin uses a deemed savings value that is based on the number of head of cattle in the facility. This methodology would better reward larger dairy facilities than the current Vermont analysis. However, if cattle head count data is unavailable for the previous custom rebate projects upon which the analysis is based, this becomes difficult to implement. The Independent Auditor mentions this potential issue because the standard deviation of kWh savings in the custom rebate data is 7,377 kWh, which is almost equal to the deemed savings value of 8,303 kWh. That means that the current deemed value is over- or under-estimating savings from many projects (statistically, if a population follows a normal distribution, 32% of points will fall outside one standard deviation from the mean). In this case, it will almost always be an under-estimate of savings due to the lower bound of 0 kWh savings being close already to the mean. In the data itself, only 23 out of 225, or 10% of projects fell outside this range, but that isn't necessarily predictive for future projects. This is merely an issue to be aware of and a limitation of this approach.
CI-KTN-GRID	ENERGY STAR Griddle	• Consider adding a preheating term to the energy calculations. The Focus on Energy TRM and the Illinois TRM include a preheating term which is based on a Food Service Equipment Workpaper and the Commercial Foodservice Equipment Life-cycle Cost Calculator. • The Focus on Energy TRM utilizes different operating hours and operating days based on the sector (Agriculture, Commercial, Industrial, and Schools & Government) to account for the reduced operating hours/days for schools.

ID	Measure	Comments
I-A-6 c	Commercial Brushless Permanent Magnet (BLPM) Fan Motor	• The Independent Auditor recommends reviewing the measure lifetime, which is listed as 15 years. This may be too high since this is an early replacement measure for existing equipment (heating and/or cooling). The Illinois TRM gives this measure a lifetime of 5.5 years and states this is "Early replacement only: For the remaining useful life of an existing furnace (Assumed 5.5 years)." They also stated that for remaining measure life of existing furnace (next 11 years) the savings is 0 kWh. • There is savings for heating equipment due to this motor improvement. Gas savings should/could be determined. • The Bonus Factor was part of a 2014 study by NREL. The independent auditor recommends reviewing this and updating it with more recent data, if available.
I-A-7 b	Brushless Permanent Magnet (BLPM) Circulator Pump	• The Control Factor was part of a 2010 and 2013 study by EPRI. The Independent Auditor recommends reviewing this and updating it with more recent data, if available. • The hours of operation are based on an assumed time when the average outdoor temperature is less than 55°F. This was taken from data between 2012 and 2015. This should be updated to more recent weather data. o The hours used in VT seem high compared to those used in the NY TRM. Updating to more current weather data may bring them closer if the 55°F cut off is still used. VT will likely have slightly higher hours of use since the average latitude is further north in this state.
I-D-1 b	Advanced Thermostats	• The Furnace fan / boiler pump energy consumption as a percentage of annual fuel consumption (Fe) seems a bit low, but it was calculated using a Lawrence Berkeley Labs algorithm. IL-TRM breaks it into different building types: "Fe is estimated using TRM models for the three most popular building types for programmable thermostats: low-rise office (10.2%), sit-down restaurant (8.6%), and retail – strip mall (4.4%). 7.7% reflects the average Fe of the three building types. See "Fan Energy Factor Example Calculation 2021-06-23.xlsx" for reference"
CI-CKE-CONOV a	Conveyor Oven	• There is a typo in the first footnote. This is referencing the PG&E workpapers. • The Independent Auditor recommends reviewing the measure lifetime. The NY TRM uses DEER and lists a 12 year EUL. The Illinois TRM measure references the Arkansas TRM that uses 17 years.
CI-KTN-ROVN a	Rack Oven	• The NY TRM gives inputs for the algorithm for both single and double rack ovens. That TRM uses the same reference, PG&E workpaper, but it uses the 2018 version. This measure could be expanded using those two sources to include single and double rack ovens rather than just double, as is now. WI TRM gives info on this too, sourced from ENERGY STAR.

ID	Measure	Comments
I-A-11 a	Notched V-Belts	• The Independent Auditor recommends considering adding additional inputs to this measure to customize the savings to each particular installation. Other TRMs offer more customization to different applications; they consider variables such as the hours of use for different building types and motor efficiencies. The VT TRM does state at the intro to this measure that these notched V belts are 2% more efficient than baseline cases so the Independent Auditor believes the energy savings factor and calculation method used is reasonable, just oversimplified for a wide range of use cases. o The independent auditor recommends using the NY and Illinois TRMs and their references for potential ways of adding additional customization to this approach. • The Independent Auditor did a set of validation calculations using the IL and NY TRMs, whose resultant values are in a similar savings range as the VT TRM. They fell between Type A and Type B belts in the deemed table.
CI-LTG-CONT b	Lighting Controls	• The Demand WHF is set at 1.102 for commercial buildings and 1.29 for refrigeration end uses. The Energy WHF is set at 1.036 for commercial buildings and 1.29 for refrigeration end uses. However, these values differ by climate, HVAC equipment type, and building/space type. o Consider adding a reference table of values organized by building/space type or climate and HVAC equipment type. • The Percent of Lighting in Heated Spaces (DFH) value is set at 95%. It is unclear how this value was derived. o Consider separating savings calculations between heated (office, classrooms, etc.) and unheated (freezer, exterior, etc.) areas to eliminate the use of an assumed DFH value.
CI-CKE-DISHW b	ENERGY STAR Commercial Dishwasher	• This measure is based on ENERGY STAR Commercial Dishwasher specification v2, which is not the latest version. o Consider updating to the latest specification v3. This will mainly impact energy rate values for ENERGY STAR dishwashers. • Electric and fuel heater efficiencies are set at 98% and 80%, respectively. It is unclear how these values were derived, although they seem reasonable and align with the assumptions in other TRMs. • Gross demand savings are calculated. o Consider accounting for a Coincidence Factor (CF) based on restaurant type to calculated summer peak demand savings.
CI-CKE-FRYER a	ENERGY STAR Fryer	• The electric and gas savings do not account for daily preheating. This means the savings calculated are slightly underestimated. o Consider adding in a term to account for daily preheating savings. • Gross demand savings are calculated. o Consider accounting for a Coincidence Factor (CF) based on restaurant type to calculated summer peak demand savings.

ID	Measure	Comments

CI-KTN-HFHC a	ENERGY STAR Hot Food Holding Cabinet	• Days of use and hours of operation are set at 312 days/year and 15 hours/day, respectively. However, these values differ by restaurant type or end use.
		  o Consider adding a reference table of values organized by restaurant type or end use.
		• Gross demand savings are calculated.
		  o Consider accounting for a Coincidence Factor (CF) based on restaurant type to calculated summer peak demand savings.
		• The measure incremental cost is set at $902. However, this cost would differ based on the interior holding volume.
		  o Since the savings calculations are categorized based on interior holding volume, consider updating the measure incremental cost to account for interior holding volume as well.

CI-CKE-STEAM a	Commercial Steam Cooker	• Percentage of time the steamer is in manual cooking mode (CMS%) is set to 40%, based on the ENERGY STAR CFS calculator default value. This is one of the few differing parameters between TRMs, with the Illinois TRM as high as 90% in manual cooking mode. While 40% seems to be a reasonable estimate for most commercial kitchens, consider researching equipment usage characteristics by kitchen type to establish an adjustable CMS% for different kitchen types and usage. • Operating hours/day and days/year should be user inputs from the application if known. Consider for subsequent TRM updates the inclusion of default value reference tables for operating hours/day and days/year based on kitchen types and usage (e.g., fast food restaurant, elementary school, hotel, etc.). • Load shape is noted as "Restaurant Indoor Lighting". Confirm if an acceptable commercial kitchen load shape is available.

CI-KTN-COMB a	ENERGY STAR Combination Oven	• Calculation methodology is consistent with the current ENERGY STAR CFS calculator.
		• Reference Tables with Item Codes represent deemed savings based on the number of pans and whether the equipment is natural gas or electric. Consider for subsequent TRM updates providing more user-entered parameters to better fit equipment usage:
		  o Operating hours/day and days/year should be user inputs from the application if known. Consider for subsequent TRM updates the inclusion of default value reference tables for operating hours/day and days/year based on kitchen types and usage (e.g., fast food restaurant, elementary school, hotel, etc.).
		  o Consider including a duty/usage factor to adjust the equipment idle time vs. cooking time based on kitchen usage types instead of a 50/50 split as currently calculated.
		• Load shape is noted as "Restaurant Indoor Lighting". Confirm if an acceptable commercial kitchen load shape is available.

ID	Measure	Comments
CI-KTN-CONV a	ENERGY STAR Convection Oven	• Calculation methodology is consistent with the current ENERGY STAR CFS calculator. • Reference Tables with Item Codes represent deemed savings based on if the equipment is full-size or half-size and whether it is natural gas or electric. Consider for subsequent TRM updates providing more user-entered parameters to better fit equipment usage: o Operating hours/day and days/year should be user inputs from the application if known. Consider for subsequent TRM updates the inclusion of default value reference tables for operating hours/day and days/year based on kitchen types and usage (e.g., fast food restaurant, elementary school, hotel, etc.). o Consider including a duty/usage factor to adjust the equipment idle time vs. cooking time based on kitchen usage types instead of a 50/50 split as currently calculated. • Load shape is noted as "Restaurant Indoor Lighting". Confirm if an acceptable commercial kitchen load shape is available.

I-A-2 e	Variable Frequency Drives	• The listed baseline control method for cooling towers is discharge dampers. In the Independent Auditor's experience, most cooling towers, especially those below ten horsepower, use cycling control with no dampers. Cycling control is simple, inexpensive, and relatively efficient. VFD control is marginally more efficient than cycling control. A change to a cycling control baseline would significantly reduce the savings estimates for this application. We recommend investigating a change in baseline control for this application. • The WLHP application should also require automatic isolation valves (and the associated incremental cost) because the VFD will not save energy without them. The 2014 Cadmus study cited by this measure makes no mention of this issue and it does not appear they accounted for this in their analysis or data collection. Automatic isolation valves on individual heat pumps allow the water flow to bypass the heat pump when it is not in need of loop water. This reduces the pressure drop and pumping energy required for the loop. Automatic isolation valves are not common and most water-source heat pump systems do not use them and simply pump water through all heat pumps continuously. Thus, they are often installed in conjunction with a VFD installation on the loop pumps in order to extract the full impact of that VFD control. • The primary savings values for all applications other than the boiler fans and cooling tower fans come from a 2014 report by Cadmus. That study assumed 98% of baseline systems will be constant volume. This leads to savings values from this TRM being generally higher than other TRMs for most applications. The reasons for this assumption of high constant volume baseline operation are generally well-explained in the report. However, one issue with that report is that 65% of data points had an unknown method of baseline operation. This makes it difficult to draw generalizations about the overall population of baseline fan or pump controls from such a limited sample. The independent auditor does not have sufficient information to refute the high penetration of constant volume controls, but it does make this TRM's assumptions stand out from other jurisdictions and is a more aggressive assumption than in other locations. The auditor could not find more recent studies of VFD baseline controls to compare to. • Another issue with the Cadmus study is that it did not discuss the impact of triple duty valve positions on flow rates in pumping systems. That report focused on automated valve control (e.g., throttling valves). Triple duty valves and other balancing valves are often used during commissioning to adjust flow rates. However, if they are at any position other than 100% open, they introduce a flow reduction that impacts power consumption. Since this study did not meter the baseline control operation, the impacts of these valves may not have been properly accounted for. During VFD installations, contractors often fully open any balancing valves and allow the VFD to control flow rate and balance the system. Thus, using the post-retrofit metering with that flow restriction removed to determine the baseline power consumption and flow rate is inaccurate. The baseline power consumption would be lower than predicted by the study in these instances. • Given that VFDs have been particularly susceptible to supply chain and inflationary issues in the past year, the Independent Auditor recommends updating the incremental costs for inflation. The

ID	Measure	Comments
		costs here were developed for the Mid-Atlantic TRM in 2017, based on California data from 2014. That value included an adjustment for inflation and Maryland labor rates. • Reference 2, which pertains to the development of savings values for the boiler draft fan and cooling tower fan applications, is not fully cited and not attached as a document to the measure. The Independent Auditor was therefore unable to review or even locate the calculations and assumptions used for these two applications. We recommend a more precise citation so the document can be located and, ideally, the document would be attached to the measure for convenient review. • The deemed demand savings for several applications appear higher than other jurisdictions. o In particular, the New York TRM—which uses a similar kW/hp savings value—has kW/hp values 70% lower or more. That is a significant discrepancy, especially considering the proximity between New York and Vermont. Their values for supply and return fans, chilled water pumps, cooling tower fans, and water-source heat pumps reflect the fact that all of this equipment will reach its peak power consumption at about the same time as the grid peak and the fact that the VFD operation will still consume nearly as much or more than the baseline operation when operating during high cooling load periods when it is near 100% flow. o It appears that the Cadmus study from 2014 found many instances of over-sized equipment in their sample, such that even during very hot weather, the metered pumps and fans did not reach 100% flow with the VFD, based on the savings values. Oversizing was not explicitly mentioned in the report. o The independent auditor agrees that many pumps and fans are over-sized for their task, but air handling unit supply fans and cooling tower fans, in particular, are much more likely to operate at 100% flow at some point during the cooling season. In the case of the cooling tower fans, savings come from energy modeling results that must have included some significant over-sizing in order to reach the more than 20% demand savings assumption. New York recommends negative demand savings for cooling tower fan VFDs under the assumption that they will reach 100% flow during the summer and the VFD drive losses will result in an increase in demand over the baseline control. The auditor recommends re-evaluating demand savings factors for these applications and providing evidence to support the over-sizing assumptions inherent in the demand savings factors.

ID	Measure	Comments
I-B-6 b	Package Terminal Heat Pumps (Hotel Room)	• This measure is based on a custom engineering analysis, specific to Vermont. It appears to have comparable values for assumptions to other jurisdictions and values appear to be reasonable. Although savings here differ from other jurisdictions, we consider the assumptions and sources used by Efficiency Vermont to be superior to those other reference manuals in accuracy and they are appropriately conservative. Some of the other jurisdictions do not break out the heating EFLH between heat pump hours and electric resistance hours. Some still calculate cooling savings for this measure. The referenced New York research paper used for equipment size, temperature cut off, and measure cost is not cited by other jurisdictions, but should be. The fact that this measure uses a custom analysis means that it is very well tailored to the Vermont climate and the input assumptions, like hotel occupancy, balance temperature, oversizing, and heat pump cutout temperature can be easily seen and modified if needed. This is preferable to an approach that relies on simply modifying the results of energy modeling done in another location. • The Independent Auditor recommends adjusting the heat pump COP for outdoor air temperature. Heat pumps are rated at an outdoor air temperature of 47°F and their COP declines in an approximately linear fashion from there down to their minimum operating temperature. Thus, the COP of the heat pump does not stay constant during its operation, as the current analysis for this measure assumes. This is a relatively simple adjustment to the analysis that will certainly improve accuracy. It will reduce measure savings, however.
I-B-5 b	Commercial Ventilation Fan	• This measure is based on a custom engineering analysis, specific to Vermont. The values used for assumptions and inputs appear to be reasonable. No other jurisdiction could be found that has the same precise measure. Thus, no comparison was available. Because the assumptions for costs, efficient fan efficiency, and annual run hours all come from Vermont custom rebate data, the Independent Auditor believes they are very accurate and are excellent primary resources. • There is an internal inconsistency to address with this measure. Both the baseline and efficient CFM/watt average values do not match the latest 2021 data in the analysis spreadsheet. Instead, the TRM is still using values from 2017. The CFM/W values from 2021 differ by only 0.1 CFM/W compared to 2017, but they should be updated to match the 2021 data, regardless. The TRM uses 1.7 and 6.1 CFM/W, while the 2021 data shows 1.8 and 6.2 CFM/W. • The Independent Auditor also recommends reviewing the measure lifetime. The cited study (reference 4) lists 25 years and 19 years for two different residential ventilation fan types. The 15-year lifetime used for this measure is simply listed as coming from "several commercial measures." If those commercial measures for small-horsepower fans, 15 years is reasonable to use. Otherwise, an increase to the 19-year value may be more appropriate given that these ventilation fans are sized similarly to residential attic fans.