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Verification of Vermont Gas Systems 2021 Annual Savings Claims

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ES Executive Summary

This report covers savings verification for Vermont Gas Systems (VGS) energy efficiency programs for program year (PY) 2021. The 3-year verification cycle covers PY2021 through PY2023. The Vermont Department of Public Service (PSD) contracted with West Hill Energy and Computing (West Hill Energy) to provide independent verification of VGS's energy efficiency portfolio. The West Hill Energy team, consisting of West Hill Energy and Cx Associates, implemented this evaluation, which covers VGS's residential and commercial energy efficiency programs.

The primary objective of this evaluation was to estimate the program and portfolio annual and peak day Mcf realization rates (RRs) associated with VGS reported savings. The West Hill Energy team also reviewed VGS's progress in meeting the quantifiable performance indicators (QPIs) established by the Vermont Public Utilities Commission (PUC) and provided recommendations to address ongoing issues with project documentation and analyses in order to streamline verification efforts.

ES.1 Methods

This evaluation verified the annual incremental Mcf saving, peak day savings, and lifetime natural gas savings for PY2021. The West Hill Energy team also determined VGS's progress toward several QPIs, as described in the Vermont PUC order.

The main savings verification method was to conduct engineering desk reviews for a sample of sites. Where applicable, billing analysis was conducted to estimate actual savings or to inform the results of the desk review. Sample sizes were designed to meet 80/10 confidence and precision for the gross annual Mcf savings at the portfolio level. Error ratios were informed by prior PY2020 savings verification results. Table ES-1 provides a summary of the sampling and evaluation approach by program.

TABLE ES-1: SUMMARY OF VGS PY2021 SAMPLING AND EVALUATION APPROACH

Program	Sampling Approach	Evaluation Approach
Commercial and Industrial (C&I) Programs	Stratified random sample by unique site to capture interactive effects	Engineering desk review and billing analysis for select projects, where appropriate
Residential Multifamily Programs	Stratified projects by program and project size	
Residential Equipment Replacement (RER) Single Family	Stratified random sample	The West Hill Energy team conducted sampling and the PSD conducted desk reviews for this program.
Residential Single-Family Retrofit	Census	VGS applied RRs from the previous impact evaluation were applied.[1]
Residential Single Family New Construction	Census	RR for the RNC program from EVT's 2020 Annual Savings Verification was applied.[2]

[1] Impact Evaluation of Vermont Gas System's Residential Retrofit Program. Prepared by West Hill Energy and Computing. September 2018. Page 7.
[2] Report to Verify Efficiency Vermont 2020 Savings Claim. Prepared by Cadmus Group. June 2021. Page 21.

The West Hill Energy team completed desk reviews for each project in the sample. The steps in evaluating each project across all programs were similar and included multiple steps of initial project file review, data requests, analysis, and review. The evaluation process is shown in Figure ES-1.

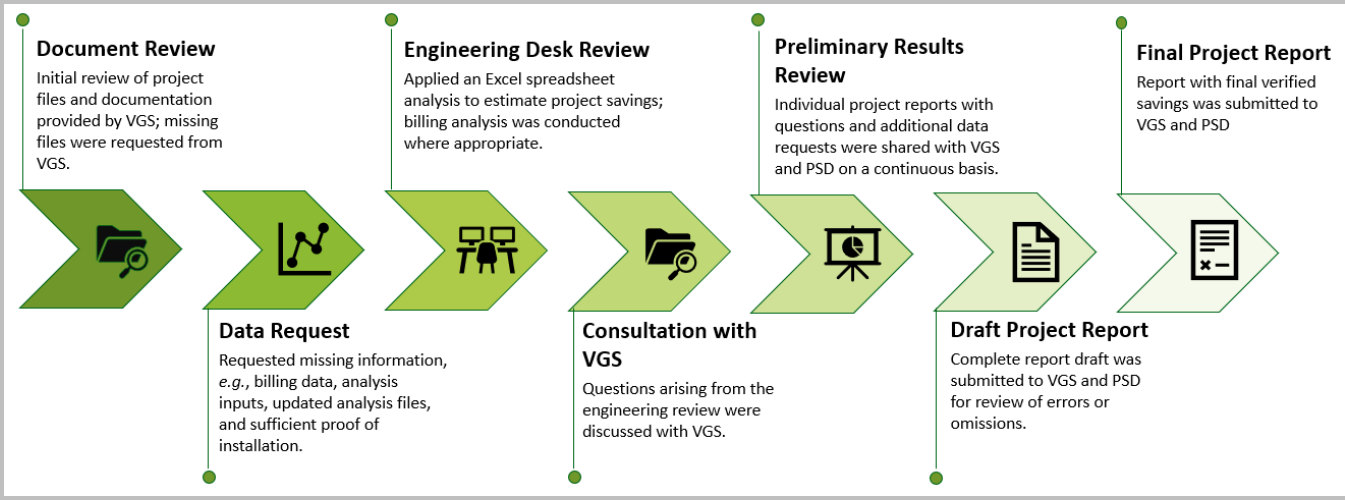

FIGURE ES-1: EVALUATION DESK REVIEW APPROACH

The West Hill Energy team was in regular communication with VGS and the Vermont PSD staff to ensure verified savings were based on a complete understanding of what happened with each project.

ES.2 Results

The West Hill Energy team developed verified savings estimates for each project in the sample. The ratio of these verified results to the program reported savings is the RR, which was then applied to the total population to determine the 2021 verified savings.

ES.2.1 Annual Mcf Savings

The RRs and relative precision for VGS's annual Mcf savings are provided in Table ES-2. The portfolio RR is 86% with a relative precision of 1.0% at the 80% confidence level.

TABLE ES-2: SUMMARY OF PROGRAM REPORTED AND VERIFIED PY2021 ANNUAL MCF SAVINGS

Program	Total Sites	Sampled Sites	Reported Annual Savings (Mcf)	PSD Verified Annual Savings (Mcf)	Realization Rate	Related Precision
Commercial Sector						
Equipment Replacement	47	3	7,777	6,740	87%	3.3%
New Construction	15	3	3,167	3,150	99%	4.5%
Retrofit	26	9	12,980	9,918	76%	3.0%
Total Commercial Sector	88	15	23,923	19,808	83%	1.0%
Residential Sector						
Equipment Replacement	1,440	15	16,159	12,848	80%	0.0%
New Construction	70	65	5,667	6,017	106%	0.9%
Retrofit	439	436	5,270	5,098	97%	1.7%
Total Residential Sector	1,949	516	27,096	23,963	88%	1.9%
Portfolio Total	**2,037**	**531**	**51,019**	**43,771**	**86%**	**1.0%**

The most common reasons for differences in realized savings for the commercial and industrial (C&I) sector are listed below.

- **Incorrect inputs -** Using inputs such as boiler efficiency and annual hours that did not match the project documentation
- **Baseline usage -** The West Hill Energy team used billing data to as part of the verification, where possible, and found that baseline use was overstated at two of the sampled C&I sites. The use of pre-installation billing data would have made a more accurate estimate possible.
- **Pipe insulation documentation -** Savings for pipe insulation was based on steam temperatures when both the steam and domestic hot water pipes were insulated. This approach overstates heat loss for the hot water pipes, as they are limited to under 140°F.

The most common reasons for differences in realized savings for the residential sector are below.

- **Incorrect inputs -** For RER heating system replacements, VGS used the disaggregated consumption data as the heating load input to the Technical Reference Manual (TRM) algorithm without adjusting for the efficiency of the heating system. For multifamily projects, inputs such as boiler efficiency, annual hours, and air sealing CFM50 did not match the project documentation.

- **Interactive Effects -** For a multifamily site with multiple measures, the boiler measure did not account for the reduction in heating load from shell and energy recovery ventilation (ERV) measures. This omission greatly overstated savings of the boiler measures.
- **Pipe insulation documentation -** For a multifamily project, savings for pipe insulation based on steam temperatures when both the steam and domestic hot water pipes were insulated.

ES.2.2 Peak Day Mcf Savings

The RRs and relative precision for VGS's peak day Mcf savings are provided in Table ES-3. The portfolio RR is 91% with a relative precision of 1.5% at the 80% confidence level.

TABLE ES-3: SUMMARY OF PROGRAM REPORTED AND VERIFIED PY2021 PEAK DAY MCF SAVINGS

Program	Total Sites	Sampled Sites	Reported Peak Day Savings (Mcf)	PSD Verified Peak Day Savings (Mcf)	Realization Rate	Related Precision
Commercial Sector						
Equipment Replacement	47	3	59.2	42.7	72%	5.1%
New Construction	15	3	35.2	35.1	100%	9.2%
Retrofit	26	9	58.7	55.3	94%	3.2%
Total Commercial Sector	88	15	153.1	133.1	87%	1.3%
Residential Sector						
Equipment Replacement	1,440	15	116.8	100.9	86%	1.9%
New Construction	70	65	63.4	71.5	113%	3.1%
Retrofit	439	436	68.6	58.8	86%	2.5%
Total Residential Sector	1,949	516	248.8	231.2	93%	4.4%
Portfolio Total	**2,037**	**532**	**401.9**	**364.4**	**91%**	**1.5%**

To determine verified peak savings, the West Hill Energy team multiplied the verified annual MCF savings by the end-use multiplier for each measure; therefore, findings that affect annual MCF savings carry over to peak day MCF savings proportionally for the mix of non-interruptible projects in the sample.

For a few commercial and several residential measures, West Hill Energy team found discrepancies with VGS's application of peak day multipliers; for example, the heating multiplier was applied to shell measures.

ES.3 Recommendations

The West Hill Energy team offers the following recommendations to improve future VGS programs RRs and streamline future verification processes. Addressing ongoing issues will reduce the amount of time spent on each project review and provide transparency into VGS calculations and assumptions.

TABLE ES-4: SUMMARY OF PROGRAM RECOMMENDATIONS

Recommendation	Description
Improve Project-level Documentation[1]	Provide more detailed description of the project in the project files and include a project overview, sources of analysis inputs and measure-level proof of installation
Review Heating Load and Input v Output Capacity in All Calculations and Analysis Tools[1]	Review tools and other calculations to ensure that the heat load and capacity are correctly defined and used in VGS's analysis tools for RER heating system replacements, the commercial heating system tool, the commercial tool for shell measures and all other places where this type of error may occur.
Establish Criteria for Selecting Methods, Inputs and/or Use of the TRM	Establish criteria for using the VGS TRM, site-specific inputs and/or custom approaches or alternative TRM approaches and establish protocols for clear documentation in the project files.
VGS TRM Measure Review	All VGS TRM measures should be reviewed to check for potential confusion or errors and ensure consistency with the Vermont TRM where applicable. The peak day multipliers should be added to the TRM.
Update Normalization to Use Average Weather Values rather than TMY3	Update weather normalization to use the most recent 6-to-10 years for the nearest NOAA weather station to estimate the future heating loads more accurately. The average heating degree days for the selected period could be calculated at the beginning of the program year and used throughout the year.
Improve Internal Savings Calculation Quality Control (QC)	Internal QC process should be improved to include a comprehensive review of project documentation, savings calculations, and application of the correct peak day multiplier.
Whole Building Analysis	Assign all measures at a specific site to a single program to facilitate the verification review process and reduce the likelihood of missing interactive effects. At a minimum, the QC process should include a whole building review of the measures and savings.

[1]These recommendations were also made in whole or in part in the PY2020 savings verification report prepared by NMR.

[1]Verification of Vermont Gas Systems 2020 Savings Claims. Page 14. Prepared by NMR Group, Inc and BrightLine Group. July 28, 2021.

1 Introduction

This report documents the savings verification of VGS energy efficiency programs during PY2021. Vermont PSD contracted with West Hill Energy to provide independent verification of VGS's energy efficiency portfolio. The West Hill Energy team, consisting of West Hill Energy and Cx Associates, conducted the evaluation. The evaluation included the following VGS programs:

- Commercial Equipment Replacement (CER)
- Commercial Retrofit (CSR)
- Commercial New Construction (CNC)
- Residential Equipment Replacement (RER)
- Residential New Construction (RNC)
- Residential Retrofit (RIR)

VGS offers incentives for a variety of measures including space heating (boilers, furnaces) and heating systems controls, hot water replacement, building shell improvements, pipe insulation, cooking equipment, faucet, and shower aerators.

The primary goal of this evaluation was to verify the Mcf annual and peak day savings for PY2021. The West Hill Energy team also determined VGS's progress toward several QPIs as described in the Vermont PUC order of October 22, 2020. The West Hill Energy team also provides recommendations to address ongoing issues with project documentation and analyses in order to streamline future verification efforts.

One complication in evaluating VGS PY2021 program was the Covid-19 pandemic that started in March 2020. As a result of the pandemic, some facilities had limited staff and restricted site access making it difficult for VGS to implement their programs and document all installations.

The following sections provide details on VGS PY2021 program activity and previous evaluation history.

1.1 Program Activity

The West Hill Energy team reviewed VGS PY2021 program tracking database to determine program and sector level savings. Table 1-1 provides a summary of the overall portfolio savings at the program level as reported by VGS. As shown in Table 1-1, the commercial and residential annual Mcf savings are evenly distributed between the two sectors.

TABLE 1-1: SUMMARY OF PROGRAM REPORTED PY2021 SAVINGS

Program	Number of Projects	Reported Annual Savings (Mcf)	Reported Peak Day Savings (Mcf)
Commercial Sector			
Equipment Replacement (CER)	47	7,777	59.2
New Construction (CNC)	15	3,167	35.2
Retrofit (CSR)	26	12,980	58.7
Total Commercial Sector	88	23,923	153.1
Residential Sector			
Equipment Replacement (RER)	1,440	16,159	116.8
New Construction (RNC)	70	5,667	63.4
Retrofit (RIR)	439	5,270	68.6
Total Residential Sector	1,949	27,096	248.8

1.2 Evaluation History

The PSD has conducted annual savings verification for VGS for the past several years. From PY2018 through PY2020, the NMR Group was the evaluator. The West Hill Energy team was contracted to conduct savings verification for PY2021 through PY2023. This report is the first savings verification report for the 3-year cycle.

VGS operates the single family residential new construction (RNC) in conjunction with Efficiency Vermont (EVT). The PSD has conducted annual savings verification for EVT from its inception in 2000. Cadmus conducted the most recent verification cycle.[2]

The PSD also oversaw impact evaluations of the components of VGS's residential portfolio for PY2014 to 2016.[3]

[2] Impact Evaluation of Vermont Gas System's Residential Retrofit Program. Prepared by West Hill Energy and Computing. September 2018.
[3] Report to Verify Efficiency Vermont 2020 Savings Claim. Prepared by Cadmus Group. June 2021.

2 Methods

The primary goal of this evaluation was to estimate annual incremental Mcf savings, peak day savings, and lifetime natural gas savings for PY2021. The main verification method was to conduct desk reviews on a sample of sites. Where applicable, billing analysis was conducted to estimate actual savings or to inform the results of the desk review. Table 2-1 provides a summary of the evaluation approach by program.

TABLE 2-1: SUMMARY OF VGS PY2021 EVALUATION APPROACH BY PROGRAM

Program	Evaluation Approach
Commercial & Industrial Programs	Engineering desk review and billing analysis for select projects, where appropriate
Residential Multifamily Programs (MER, MNC, MIR/MLI)	
RER Single Family	The West Hill Energy team conducted the sampling and the PSD conducted desk reviews.
RIR Single Family	VGS applied RR from the previous impact evaluation was applied.[1]
RNC Single Family	The RR for the RNC program from the EVT's 2020 Annual Savings Verification was applied.[2]

[1] Impact Evaluation of Vermont Gas System's Residential Retrofit Program. Page 7. Prepared by West Hill Energy and Computing. September 2018.
[2] Report to Verify Efficiency Vermont 2020 Savings Claim. Page 21. Prepared by Cadmus Group. June 2021.

The following sections describe the sampling and analysis.

2.1 Sampling

VGS programs were divided into three groups of programs for sampling purposes: C&I, residential multifamily (including the MER, MIR/MLI, and MNC), and the RER single family. The sampling plans were designed to address program specifics.

TABLE 2-2: SAMPLING OVERVIEW

VGS Program	Number of Sites/ Projects	Sample Size	Sampling Group	Notes
Commercial				
CER	47	12	C&I	Sampling was done by site. *Post hoc* stratification was conducted to determine RRs by program.
CNC	15			
CSR	26			
Residential Multifamily				
RER	3	1	MF RER	Sampling was done by site and by program.
RIR	4	1	MF RIR	
RNC	8	3	MF RNC	
Residential Single Family				
RER	1,437	14	SF RER	The West Hill Energy team conducted the sampling. The PSD conducted the reviews for this program.
RIR	448	0	SF RIR	VGS applied RR from the previous impact evaluation were applied.
RNC[1]	62	0	SF RNC	The RR for the RNC program from the EVT's 2020 Annual Savings Verification was applied.

[1]VGS operates this program in conjunction with Efficiency Vermont.

The following sections provides the sampling plan for each of the three programs.

2.1.1 Commercial and Industrial

C&I programs account for 53% of VGS's PY2021 portfolio. The projects in this category include equipment replacement, new construction, and retrofit projects completed at C&I facilities. The West Hill Energy team employed stratified ratio estimation and sample sizes were calculated to meet or exceed 80/10 confidence/precision level. A summary of the sampling approach is provided in Table 2-3.

TABLE 2-3: COMMERCIAL AND INDUSTRIAL SAMPLING APPROACH

Sampling Component	Description	Comments
Population Size[1]	81 sites	All C&I sites were included in the population. VGS's database had some sites under more than one program. The unique site was used for sampling.
Sample Frame	49 sites	Projects accounting for 5% or less of the program reported annual Mcf savings were excluded from the sample frame.
Stratification	Annual Mcf reported savings	Projects were divided into three strata based on the size of the annual Mcf savings and sample sizes were calculated using an error ratio of 0.60.
Primary Sampling Unit	Site	The unique site was the sampling unit to account for interactive effects.
Target Sample Size[1]	15	Random selection was applied to small projects (stratum 1) and a census of the largest projects (stratum 2) was reviewed.

[1] One site sampled under the residential multifamily program also had a commercial project completed at the same site. The commercial project completed at this site was included in the final C&I sample savings calculation.

The Table 2-4 provides a summary of the C&I savings by stratum and the sample sizes.

TABLE 2-4: C&I SAMPLE SIZES FOR PY2021

Strata	% Annual Mcf Commercial Savings	% Peak Day Mcf Commercial Savings	Total Number of Sites	Sampled Sites
0	3%	5%	32	0
1	36%	47%	41	7
2	61%	47%	7	7
Total			80	14

2.1.1 Residential Multifamily

The residential multifamily projects account for approximately 13% of VGS's PY2021 portfolio. The projects in this category include retrofit, equipment replacement, and new construction projects completed in multifamily facilities.

The West Hill Energy team stratified projects by program and project size. Sample sizes were calculated to meet or exceed 80/10 confidence/precision level for the portfolio. Due to the small population, the strata for these programs were defined by reviewing the data.

For the multifamily new construction (RNC/MNC) program, 3 projects out of 8 were sampled. The two projects accounting for 66% of the program savings were reviewed and one project was randomly selected from four projects with substantial savings. The two smallest projects that contributed only 2% of the savings were dropped from the sample frame.

For the RIR and RER multifamily programs, the smallest project was removed and one project was randomly selected from the remaining projects. Table 2-5 provides a summary of the residential multifamily savings by program.

TABLE 2-5: RESIDENTIAL MULTIFAMILY SAMPLE SIZES FOR PY2021

Program/Subprogram	% of Total Annual Mcf Residential MF Savings	% of Total Peak Day Residential MF Savings	Total Number of Sites	Sampled Sites
RER/MER	9%	7%	3	1
RIR/MLI & MRR	18%	20%	4	1
RNC/MNC	73%	73%	8	3
Total			15	5

2.1.2 RER Single Family

RER single family projects account for 31% of VGS's PY2021 annual savings portfolio. VGS calculated savings for these measures using the VGS TRM. Sample sizes were calculated to meet or exceed 80/18 confidence/precision level. A summary of the sampling approach is provided in Table 2-6.

TABLE 2-6: RESIDENTIAL SINGLE-FAMILY SAMPLING APPROACH

Sampling Component	Description	Comment
Population Size	1,437 projects	All RER single family projects were included in the population.
Sample Frame	1,167 projects	Projects accounting for 5% or less of the program reported annual Mcf savings were excluded from the sample frame.
Stratification	Annual Mcf reported savings	Projects were divided into four strata based on the size of the annual Mcf savings. The five projects with the highest savings (85 Mcf or higher) were placed in the fifth stratum and a census of these projects were reviewed. Sample sizes were estimated using an error ratio of 0.30.
Primary Sampling Unit	Project	The project was the sampling unit.
Target Sample Size	14 projects	The original sample size was 11 projects, but none of the randomly selected projects had thermostats. Accordingly, one project in each stratum with a thermostat measure was randomly selected to increase the sample size to 14.

Table 2-7 provides a summary of the RER single family savings and sample sizes by stratum.

TABLE 2-7: RER SINGLE FAMILY SAMPLE SIZE

Strata	% Annual RER SF Mcf	% Peak Day RER SF Mcf	Total Number of Projects	Sampled Sites
0	19%	3%	270	0
1	48%	26%	692	3
2	21%	32%	303	3
3	12%	32%	167	3
4	0%	6%	5	5
Total			1,437	14

2.2 Review Process

The West Hill Energy team conducted desk reviews for all sampled commercial and residential multifamily projects and the Vermont PSD conducted desk reviews on the single-family RER projects. The verification process is shown in Figure 2-1.

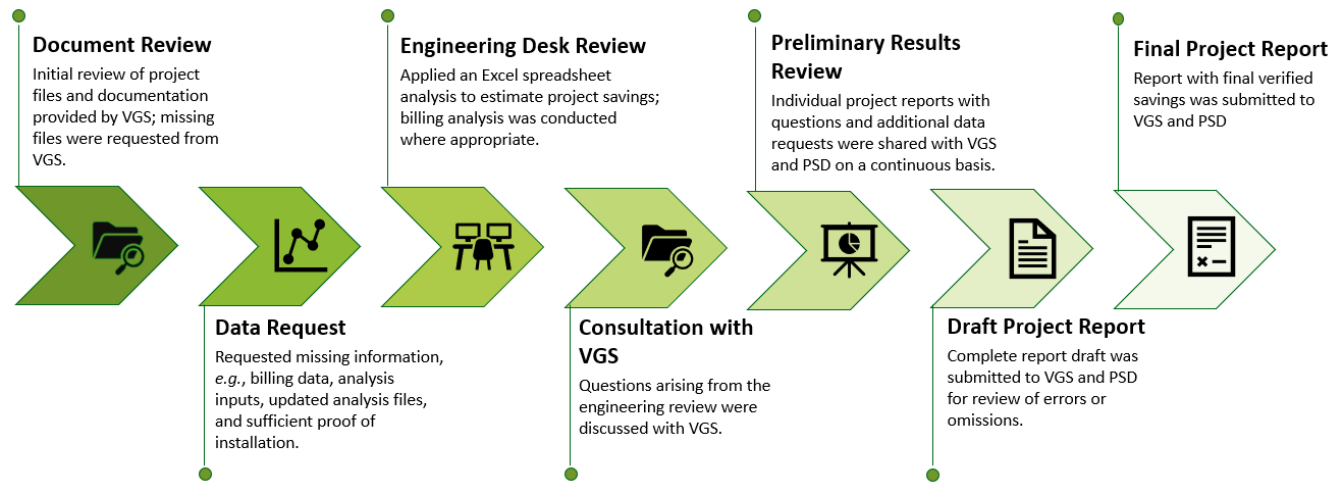

FIGURE 2-1: EVALUATION DESK REVIEW APPROACH

2.2.1 Documentation Review

Documentation review was the initial step in the evaluation process for all projects in the evaluation sample to determine if any project files were missing and if there was adequate information to calculate energy savings and verify proof of installation. The West Hill Energy team sent data requests to VGS for projects with missing or insufficient documentation.

2.2.2 Engineering Desk Reviews

Engineering desk reviews were completed for all projects in the evaluation sample. The review included verifying annual energy and peak day savings for each measure installed at the sampled site. The engineering desk review included a review of the inputs, calculations, and proof of installation as show in Figure 2-2.

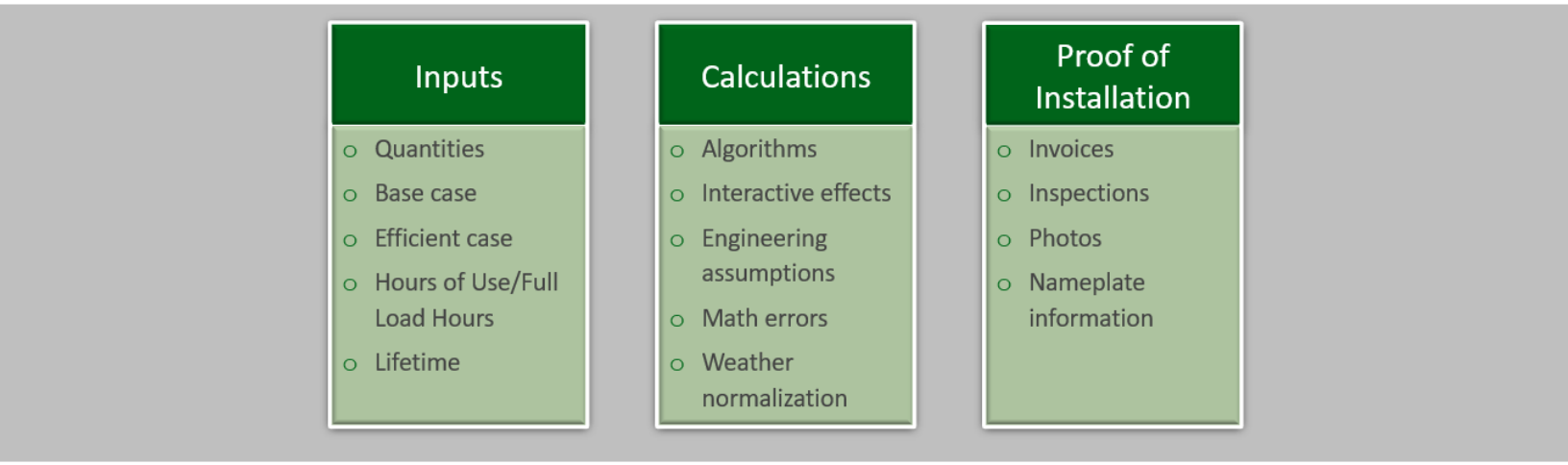

FIGURE 2-2:ENGINEERING REVIEW DETAIL

The desk reviews focused on verifying energy savings for each measure within the sampled project. The reviews focused on the following:

- **Calculation methods -** Identify if methods rely on deemed or custom analysis approach and if the methods are accurate and applied correctly.
- **Data sources -** Identify basis for savings calculations (*e.g.*, manufacturer specification sheets, site-specific data, billing data, energy code, audits).
- **Baseline and efficient case -** Identify project type (new construction, retrofit, equipment replacement) and analysis inputs for baseline and efficient conditions.
- **Proof of installation -** Check if each project has itemized invoices, inspection forms, photos, or nameplate information.

The VGS analyses generally used TRM methods and/or VGS standardized tools, which the West Hill Energy team reviewed to determine whether the inputs matched the best available information and that the appropriate TRM algorithm was used. For projects using custom analysis approaches, the PSD team reviewed the analysis approach and algorithm to determine if they met industry standards and used the best available information. The West Hill Energy team also reviewed billing data when available and, if appropriate, used billing analysis to calculate the savings, inputs into the savings algorithms, or to inform the desk review.

2.2.3 Continuous Feedback

The evaluation timeline for this project was constrained; therefore, the West Hill Energy team had biweekly check-in calls and regular email communication with VGS and the PSD throughout the

evaluation. These calls provided the opportunity to discuss project-specific details and to ensure that the West Hill Energy team had a complete understanding of each project.

The West Hill Energy team sent data requests to VGS for clarification and additional documentation on a rolling basis. Preliminary and draft project reports were sent upon completion to provide enough time for VGS to review the analyses for errors and omissions.

2.3 Realization Rate

The RR is the ratio of verified energy savings to the program's reported savings. The RR represents the percentage of program reported savings that is achieved based on the results of the savings verification. The RR was calculated as follows:

$$RR = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i x_i}$$

Where,

RR is the realization rate (ratio estimator)

i represents the site

n is the total number of verified sites in the sample

w_i is the expansion weight (the total number of sites in the stratum divided by the number of verified sites in the stratum)

y_i is the verified savings for site *i*

x_i is the original claimed savings for site *i*

Results from each stratum were rolled up to program-, sector-, and portfolio-level using expansion weights as appropriate.

2.3.1 C&I *Post Hoc* Stratification

C&I projects were sampled by site to verify all measures associated with each site. This approach allowed the West Hill Energy team to account for possible interactive effects. A few sites in the sample had projects in more than one program.

As the savings verification goal was to estimate the savings and provide RRs by program, the West Hill Energy team conducted *post hoc* stratification by program to meet the verification goals. Table 2-8 shows the distribution of projects across the strata for the population and the sample.

TABLE 2-8: C&I DISTRIBUTION AMONG PROGRAMS (POPULATION AND SAMPLE)

	Sites in Population				Sites in Sample			
Strata	CSR	CER	CNC	Total	CSR	CER	CNC	Total
1	12	21	11	44	4	2	2	8
2	5	1	1	7	5	1	1	7
Totals	17	22	12	51	9	3	3	15

2.4 Single Family RER Adjustment

VGS calculated savings for prescriptive measures in the RER program based on the pre-period consumption and the TRM equation; however, VGS used the pre-period consumption as the heat load without adjusting for the efficiency of the pre-existing space or water heating system. The West Hill Energy evaluation team addressed this systematic error by recalculating the savings using an estimated efficiency of the pre-existing heating system. The equation in VGS's TRM is shown in Equation 1.

EQUATION 1: RER SAVINGS FROM THE VGS TRM

$$\Delta MMBtu = HL\ x \left(\frac{1}{AFUE_{BEE} - AFUE_{EE}}\right)$$

Where,

ΔMMBtu is the annual MMBtu savings

HL is the heat load of the home

$AFUE_{BEE}$ is the annual fuel utilization efficiency (AFUE) of the baseline replacement equipment

$AFUE_{EE}$ is the AFUE of the efficient replacement equipment

VGS used the pre-install consumption from the bill disaggregation as the heat load; however, the heat load should be estimated from the pre-install consumption as shown in Equation 2.

EQUATION 2: CALCULATING THE HEAT LOAD FROM THE PRE-INSTALL CONSUMPTION

$$HL = C\ x\ AFUE_{BEX}$$

Where,

C is the annual pre-install consumption from the bill disaggregation

$AFUE_{BEX}$ is the AFUE of the existing equipment

The West Hill Energy evaluation team corrected the VGS savings by multiplying by the estimated efficiency of the pre-existing equipment. The same issue arose for the water heater replacements. The savings were recalculated for all PY2021 installations. The specific

efficiencies and sources are provided in Table 2-9. The review of the sample of projects did not incorporate this correction to avoid double discounting the savings.

TABLE 2-9: RER EXISTING EQUIPMENT EFFICIENCIES

Measure	Existing Efficiency	Source	
Furnaces & Boilers	0.86	Vermont Single-Family Existing Homes Overall Report, Feb 2019 VT Public Service Department, Prepared by NMR Group, DNV GL, Dorothy Conant, Energy Futures Group, Figure 15	
Space heater	0.78	Professional judgment	Efficient models with incentives start at 0.80 AFUE.
WH integrated	0.86	Same as boilers	Used boiler efficiency
WH stand alone	0.65	2013 VT market characterization	0.60 in 2013 VT market characterization; more current information is not available; increased to 0.65 based on professional judgment that efficiencies have improved since 2013
WH on demand	0.65	Same as stand alone	Program assumption seems to be that on-demand water heater replace stand-alone water heater.

3 Results

This section provides the results from VGS PY2021 programs savings verification. Results are provided for annual, peak day, and lifetime savings. Site- or project-level results for the sample are summarized in Appendix A and site- or project-level reports are included as Appendix B.

3.1 C&I Annual Mcf Savings

The RRs and relative precision for VGS's annual Mcf savings are provided in Table 3-1. The portfolio RR is 83% with a relative precision of 1.0% at the 80% confidence level.

TABLE 3-1: SUMMARY OF C&I REPORTED AND VERIFIED PY2021 ANNUAL MCF SAVINGS

Program	Total Sites	Sampled Sites	Program Reported Annual Savings (Mcf)	PSD Verified Annual Savings (Mcf)	Realization Rate	Relative Precision
Commercial Equipment Replacement	47	3	7,777	6,740	87%	3.3%
Commercial New Construction	15	3	3,167	3,150	99%	4.5%
Commercial Retrofit	26	9	12,980	9,918	76%	3.0%
Commercial Total	88	15	23,923	19,808	83%	1.0%

Some of the key issues that influenced the RR are described below.

- **Incorrect inputs -** Using inputs such as boiler efficiency and annual hours that did not match the project documentation.
- **Baseline usage -** Baseline usage was greatly overestimated in two analyses. The West Hill team used billing data to verify the baseline consumption where possible.
- **Pipe insulation documentation -** Savings for pipe insulation were based on steam temperatures, although some pipes served domestic hot water tanks. This approach overstates heat loss for the hot water pipes, as they are limited to a maximum of 140°F.

Other issues are described in the project-level reports.

3.2 Commercial and Industrial Peak Day Mcf Savings Results

The RRs and relative precision for VGS's peak day Mcf savings are provided in Table 3-2. The C&I RR is 87% with a relative precision of 1.3% at the 80% confidence level.

TABLE 3-2: SUMMARY OF C&I REPORTED AND VERIFIED PY2021 PEAK DAY MCF SAVINGS

Program	Total Sites	Sampled Sites	Program Reported Peak Day Savings (Mcf)	PSD Verified Peak Day Savings (Mcf)	Realization Rate	Relative Precision
Commercial Equipment Replacement	47	3	59.2	42.7	72%	5.1%
Commercial New Construction	15	3	35.2	35.1	100%	9.2%
Commercial Retrofit	26	9	58.7	55.3	94%	3.2%
Commercial Total	88	16	153.1	133.1	87%	1.3%

To determine verified peak savings, the West Hill Energy team multiplied the verified annual MCF savings by the peak day factor for the end use; therefore, findings that affect annual MCF savings also affect peak day MCF savings. For a few commercial measures, the West Hill Energy team found discrepancies with VGS's application of peak day multipliers; for example, the heating system multiplier was applied to shell measures.

3.3 Residential Program Annual Mcf Savings

The RRs and relative precision for VGS's annual Mcf savings are provided in Table 3-3. The residential portfolio RR is 88% with a relative precision of 1.9% at the 80% confidence level.

TABLE 3-3: SUMMARY OF RESIDENTIAL PROGRAM REPORTED AND VERIFIED ANNUAL MCF SAVINGS

Program	Total Sites	Sampled Sites/ Projects	Program Reported Annual Savings (Mcf)	PSD Verified Annual Savings (Mcf)	Realization Rate	Related Precision
Residential Multifamily						
Equipment Replacement	3	1	538	538	100%	NA
New Construction	8	3	4,303	4,053	94%	5.5%
Retrofit	4	1	1,027	855	83%	NA
Residential Single Family						
Equipment Replacement	1,437	14	15,621	12,310	79%	0.0%
New Construction	62	62a	1,364	1,964	144%	0.0%
Retrofit	435	435b	4,243	4,243	100%	11.0%
Residential Total	1,949	516	27,096	23,963	88%	1.9%

a.RR for the RNC program from EVT's 2020 Annual Savings Verification was applied to all 62 projects.
b VGS applied RR from the 2018 impact evaluation of VGS residential were applied to all 435 projects

In the initial program tracking data, there were 17 RER measures with no savings and one project with unrealistically high savings due to a problem with the billing disaggregation. VGS revised the savings for these projects and the West Hill Energy team verified these revised savings. The correction was incorporated into the RER RR.

The most common reasons for differences in realized savings for the residential sector are discussed below.

- **Incorrect inputs -** For RER heating system replacements, VGS used the disaggregated consumption data as the heating load input to the TRM algorithm without adjusting for the efficiency of the heating system. In addition, two of the RER projects in the sample had input heating or domestic hot water (DHW) loads that varied substantially from the billing data. For multifamily projects, inputs such as boiler efficiency, annual hours, and air sealing CFM50 did not match the project documentation for some projects.
- **Interactive effects -** For two of the three new construction multifamily sites with comprehensive measures, the boiler measure did not account for the reduction in heating load from the shell and ERV measures at the same site. This omission greatly overstated the savings of the boiler measures. In addition, the interactive effects were not accounted for RER sites with heating system replacements and advanced thermostats. Correcting this oversight resulted in a small reduction in the thermostat savings for those sites.
- **Pipe insulation documentation -** For a multifamily project, savings for pipe insulation based on steam temperatures when both the steam and domestic hot water pipes were insulated. This overstates heat loss for the hot water pipes, as they are limited to under 140°F.
- **Incorrect algorithms -** The RER savings for the advanced thermostats did not match the TRM algorithm. VGS's applied a more conservative calculation whereas the PSD applied the TRM methodology resulting in higher PSD-verified savings for those measures.

Reasons for project-level adjustment and related issues are described in the project level reports.

3.4 Residential Peak Day Annual Mcf Savings

The RRs and relative precision for VGS's peak day Mcf savings are provided in Table 3-4. The residential RR is 93% with a relative precision of 4.4% at the 80% confidence level.

TABLE 3-4: SUMMARY OF PROGRAM REPORTED AND VERIFIED PY2021 PEAK DAY MCF SAVINGS

Program	Total Sites	Sample Sites	Reported Peak Day Savings (Mcf)	PSD Verified Peak Day Savings (Mcf)	Realization Rate	Relative Precision
Residential Multifamily						
Equipment Replacement	3	1	4.6	4.6	100%	NA
New Construction	8	3	46.2	46.8	101%	16.8%
Retrofit	4	1	12.8	3.0	23%	NA
Residential Single Family						
Equipment Replacement	1,437	14	112.2	96.3	86%	4.2%
New Construction	62	62a	17.2	24.7	144%	0.0%
Retrofit	435	435b	55.9	55.9	100%	11.0%
Residential Total	1,949	516	248.8	231.2	93%	4.4%

a RR for the RNC program from EVT's 2020 Annual Savings Verification was applied to all 62 projects.
b VGS applied RR from the 2018 impact evaluation of VGS residential were applied to all 435 projects

For several residential multifamily measures, the West Hill Energy team found discrepancies with VGS's application of peak day multipliers; for example, the heating system multiplier was applied to several shell measures. There were no adjustments to the RER peak day multipliers for the single-family projects.

3.5 Quantifiable Performance Indicators

The West Hill Energy team also reviewed VGS's progress toward selected QPIs for PY2021-PY2023, as described in the Vermont PUC order from October 22, 2020. These QPIs were designed to assess whether efficient energy utilities (EEUs) are meeting established goals on schedule and at levels set by the PUC. As verification of some of the QPIs were either part of the verification process or could be easily added, the West Hill Energy team reviewed VGS's progress toward meeting these selected QPIs.

Table 3-5 provides a summary of VGS's progress toward the portfolio-level savings and greenhouse gas emissions QPIs.

TABLE 3-5: SUMMARY OF PORTFOLIO-LEVEL QPIS

QPI	Sector	QPI Description	3-year Goal	PY2021 Verified Savings	Achieved vs 3-Year Goal
QPI1a.	Portfolio	Annual net Mcf savings	239,650	43,771	18%
QPI1b.	Portfolio	GHG metric tons emissions	13,214	2,414	18%
QPI2b.	Portfolio	Lifetime Mcf Savings	4,196,753	840,812	20%
QPI3.	Portfolio	Peak day Mcf savings	1,356	364	27%

Table 3-6 provides a summary of the selected residential QPIs.

TABLE 3-6: SUMMARY OF RESIDENTIAL AND RESIDENTIAL SINGLE FAMILY QPIS

QPI	Sector	QPI Description	3-year Goal	PY2021 Results	Progress Towards 3-Year Goal
QPI4a.	Residential Single Family[1]	Percent of home energy audits converted to a measure installation within 12 months (Existing)	30%	53%	On Track
		Percent of home energy audits converted to a measure installation within 12 months (Addison)	30%	50%	Unclear[2]
QPI5.	Residential	Energy Audits Completed	600 (Annually)	707	On Track

[1] VGS Note: Will be based on prior year's number of audits that had cost effective measures. For example, for calendar year (CY) 2018 results, the denominator will be single family audits completed in CY2017 that had cost effective measures and the numerator will be of those, how many became completions within 365 days of the audit.
[2] Unclear, only two audits in 2020, one completed and one stalled.

Table 3-7 provides a summary of the selected commercial retrofit (CSR) QPIs. As shown in Table 3-7, VGS is on track to meet the three-year requirements for diversity of measures implemented in the C&I retrofit program and lagging on meeting the requirements for controls and process-related measures for Addison County.

TABLE 3-7: SUMMARY OF C&I QPIS

QPI	Sector	QPI Description	3-year Goal	PY2021 Results	Progress Towards 3-Year Goal
QPI.7	C&I Retrofit	Diversity of measures implemented in CSR projects (Existing)			
		Controls	5%	12%	On Track
		Heating systems, heat recovery or domestic hot water system	20%	21%	On Track
		Process	5%	12%	On Track
		Shell or other-related	15%	55%	On Track
QPI.7	C&I Retrofit	Diversity of measures implemented in CSR projects (Addison)			
		Controls	5%	0%	In Progress
		Heating systems, heat recovery or domestic hot water system	20%	14%	In Progress
		Process	5%	0%	In Progress
		Shell or other-related	15%	86%	On Track

4 Recommendations

This section provides recommendations to improve future VGS programs' RRs and streamline future verification processes.

4.1 Improve Project-level Documentation

Issue: The verification process was hampered by missing project-level documentation. For 9 of the 19 sites selected for desk review, the West Hill Energy team had to request additional documentation to determine key inputs into the saving algorithms. Twelve (12) of the 19 sites were missing proof of installation for some measures; the West Hill Energy team recognizes that COVID-19 may be contributing factor to difficulties with collecting on-site photos or documentation.

Expanding project documentation was also a recommendation in the 2020 savings verification report prepared by NMR[4].

Recommendation: The West Hill Energy team recommends that VGS improves project-level documentation by providing more detailed description of the project files and analysis tools. Specific items to include in the project files include the following:

- A project overview that describes the installed energy efficiency measures, the baseline and efficient operating conditions, and project timeline. The applicable building energy code should be clearly stated, where appropriate.
- Clear reference to the VGS TRM measure or other source to identify the analysis method, as needed.
- Sources of all inputs to the savings algorithm in the analysis spreadsheet; this is especially important for any inputs that are different from the TRM defaults.
- Proof of installation such as itemized invoices, inspection reports, clear photos of nameplate information and installation photos.

Addressing these documentation issues will reduce the amount of time spent on each project review and provide transparency into VGS assumptions.

4.2 Heating Load and Input v Output Capacity

Issue: The West Hill Energy team identified several errors associated with the heating load and input and output capacity in VGS's calculations and analysis tools, as described in these examples:

1. For RER heating system replacements, VGS used the disaggregated consumption data as the heating load input to the TRM algorithm without adjusting for the efficiency of the heating system.

[4] Verification of Vermont Gas Systems 2020 Savings Claims. Page 14. Prepared by NMR Group, Inc and BrightLine Group. July 28, 2021.

2. The commercial tool for shell measures provides a space to enter the annual heating consumption if it is available and it appears that this input is also applied (when available) without adjusting for the efficiency. As with the RER, this input should be the heating load, not the heating consumption, to be consistent with the TRM algorithm.
3. The VGS commercial heating system tool lists output capacity when it should be input capacity.

These types of errors were also raised as part of the 2020 savings verification report prepared by NMR[5].

Recommendation: The West Hill Energy team recommends that VGS review all of its tools and other calculations to ensure that the heat load and capacity are correctly defined and used.

4.3 Establishing Methods, Inputs, and TRM Use

Issue: VGS appears to be using a combination of the VGS TRM, EVT TRM, TRMs from other jurisdictions, custom tools, and TRM algorithms with custom inputs. For example, for all three pipe measures in the sample, VGS uses heat loss values from the 3E Plus tool rather than the TRM R-values. This array of analysis strategies complicated the review process.

Recommendation: The West Hill Energy team fully supports using site-specific inputs and/or custom approaches where appropriate and when the sources of the inputs can be properly documented; however, a clear strategy for selecting among the alternative approaches is needed. An example is substituting the TRM measure characterization from another state when the measure is in the VGS TRM; in this case, the reason for the substitution should be documented in the analysis files for the project. In addition, identifying the VGS analysis tools in current use and when they should be applied would be helpful for the review process.

4.4 VGS TRM Measure Review

Issues: Some VGS TRM measure characterizations may be incorrect or open to alternative interpretations.

Recommendation: The West Hill Energy team recommends a complete review of the VGS TRM. All VGS TRM measures should be reviewed to check for potential confusion or errors and ensure consistency with the Vermont TRM where applicable.

The West Hill Energy team also recommends adding the peak day multiplier by end use to the TRM. In addition, assumptions or default values should be reviewed and updated for measures such as pipe insulation, where the current TRM is not being used. This review should help to reduce the differences between program reported and verified savings.

[5] Verification of Vermont Gas Systems 2020 Savings Claims. Page 14. Prepared by NMR Group, Inc and BrightLine Group. July 28, 2021.

4.5 Update Weather Normalization

Issue: Currently VGS uses typical meteorological year (TMY) 3 weather data to normalize all weather dependent calculations. Due to climate change, TMY3 30-year data (1976-2005) is not the best available information that represents future climate conditions for measures going forward.

Recommendation: The West Hill Energy team recommends using the most recent 6-to-10 years for the nearest National Oceanic Atmospheric Administration (NOAA) weather station to estimate the future heating loads more accurately. The average heating degree days for the selected period could be calculated at the beginning of the program year and used throughout the year.

4.6 Improve Internal Savings Calculation Quality Control

Issue: Some of the errors in the calculations appear to result from simple errors that could be prevented with additional quality control (QC).

Recommendation: The internal QC process should be improved to include a comprehensive review of project documentation and savings calculations. Topics to cover could include the following:

- Check that the analysis file savings match the program tracking database.
- Sanity checks on the magnitude of savings, using billing data if available.
- Check that the peak day factor matches the end use and/or standardize the approach to assigning the peak day multiplier to the end use.
- Check for interactive effects between measures.

Improving the internal QC is likely to improve RRs.

4.7 Whole Building Analysis

Issue: The West Hill Energy team conducted the sampling by site (building ID) to allow for whole building analysis. As multiple measures installed at the same site may have interactive effects, this approach ensures that these effects are correctly addressed. In some cases, measures installed at the same site were assigned to different programs. In the C&I sector, 7 of the 88 sites had measures in more than one program. In the desk review sample, one of the multifamily projects had a measure in a commercial program.

For VGS, this approach may be reasonable as participants enroll through different mechanisms; however, from an analysis perspective, it makes it more difficult to identify interactive effects and incorporate them into the analysis.

Recommendation: The West Hill Energy team recommends that all measures at a specific site be assigned to a single program to facilitate the verification review process and reduce the likelihood of missing interactive effects. At a minimum, the QC process should include a whole building review of the measures and savings.