



Verification of Vermont Gas Systems 2018 Savings Claims

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SUBMITTED TO:
Vermont Department of Public Service
Vermont Gas Systems, Inc.

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Section 1 Executive Summary

This evaluation report documents the evaluation activities undertaken by NMR Group, Inc. (NMR) and BrightLine Group, collectively referred to as the NMR team, to verify the reported savings for Vermont Gas Systems' (VGS) energy efficiency programs in 2018. The NMR team was retained by the Vermont Department of Public Service (PSD) and completed this evaluation with their oversight. This evaluation project includes the following six VGS programs:

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

A variety of measures were installed through these programs including boiler and hot water heater replacements, heat recovery equipment installation, building shell improvements, and heating system control improvements. VGS reported a total of 2,233 projects with a claimed annual savings of 59,471 MCF (thousand cubic feet of natural gas) for its entire portfolio in 2018. However, after discussion with VGS and DPS, only one RER project and 17 RNC projects were considered in the scope of this evaluation. As a result, a total of 53,885 MCF reported savings from 1,781 projects were considered in the sample frame. The remainder of the projects were reviewed by PSD staff.

The primary objective of this evaluation was to calculate the annual and peak day realization rates (RRs) associated with the VGS reported savings at the program and sector levels, while suggesting process improvements to streamline program implementation and savings verification efforts.

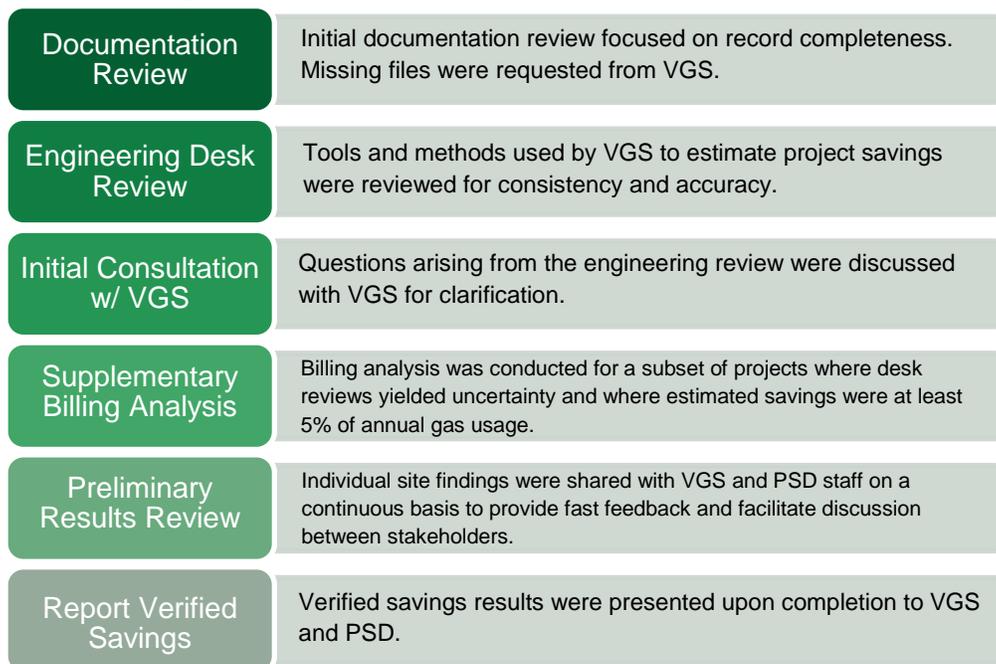
1.1 SAMPLING

The NMR team developed a sampling plan based on VGS reported savings and designed to achieve 80/10 confidence and precision for gross savings at the program level, in accordance with PSD guidelines. The sample design (included in Appendix B) was approved by the PSD in the initial phase of the evaluation project. Stratified ratio estimation (SRE) was employed to appropriately weight the impacts of different sizes of projects and reduce relative precision of results. Error ratios used to inform sample sizes were selected for each program based on prior evaluation results. Within each program, the largest projects were designated into a census stratum to ensure their inclusion in the evaluation sample. The NMR team formed the remainder of the 2018 evaluation sample by randomly selecting projects to satisfy each stratum in the sampling plan.

1.2 METHODOLOGY

The NMR team completed desk reviews for each project in the evaluation sample. These desk reviews followed the same general methodology across all programs, incorporating multiple phases of analysis and review, as described in [Figure 1](#).

Figure 1. 2018 Evaluation Desk Review Process



1.3 RESULTS

The NMR team developed verified savings estimates for each project in the evaluation sample. The ratio of these verified results to the initial reported savings claimed by VGS is the realization rate. Realization rates were then applied to the total population reported savings to determine the 2018 verified savings values. [Table 1](#) and [Table 2](#) summarize the realization rates and verified savings for each program, sector, and the overall portfolio for annual savings and peak day savings, respectively.

Table 1. PY2018 Verified Annual Savings Summary

Program	Total Projects	Sampled Projects	Annual MCF			
			Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision ¹
Commercial Equipment Replacement	34	8	7,372	8,068	109%	10.0%
Commercial New Construction	27	4	7,489	8,962	120%	8.8%
Commercial Retrofit	30	11	14,959	15,468	103%	4.1%
Commercial Sector	91	23	29,819	32,498	109%	3.9%
Residential Equipment Replacement	1,672	41	13,207	13,092	99%	3.9%
Custom Residential New Construction	17	8	9,750	10,257	105%	3.9%
Custom Residential Retrofit	1	1	1,110	1,076	97%	0.0%
Residential Sector	1,690	50	24,067	24,425	101%	2.7%
Portfolio Level	1,781	73	53,885	56,923	106%	2.5%

¹At 80% confidence

Table 2. PY2018 Verified Peak Day Savings Summary

Program	Total Projects	Sampled Projects	Peak Day MCF			
			Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision ¹
Commercial Equipment Replacement	34	8	34.7	34.3	99%	1.8%
Commercial New Construction	27	4	60.3	63.8	106%	9.0%
Commercial Retrofit	30	11	29.2	38.8	133%	22.5%
Commercial Sector	91	23	124.1	136.9	110%	6.9%
Residential Equipment Replacement	1,672	41	113.6	112.7	99%	0.4%
Custom Residential New Construction	17	8	105.2	110.7	105%	1.9%
Custom Residential Retrofit	1	1	0.0	0.0	n/a	0.0%
Residential Sector	1,690	50	218.7	223.4	102%	0.9%
Portfolio Level	1,781	73	342.8	360.3	105%	2.6%

¹At 80% confidence

1.3.1 Key Drivers – Relative Precision

The sampling plan developed for this project successfully exceeded the targeted 80/10 program-level confidence and precision for the annual MCF savings. Most programs, both residential and commercial, are dominated by a few large projects. Including all such large projects in the evaluation sample through stratified sampling ensured low overall relative precisions.

1.3.2 Key Drivers – Commercial Annual Savings Realization Rates

The overall realization rate for the commercial sector was 109%. Project-level realization rates varied based on individual project findings, but the commercial sector results are largely driven by the six largest projects that account for 47% of the sector's reported savings. Key observations driving the realization rates for the commercial sector are:

- **New construction heat recovery projects.** VGS's calculation for heat recovery projects in new construction was determined to be deducting more than required for code-required baselines. Correcting this error resulted in high realization rates (>130%) for three different measures.
- **Adherence to the TRM and general consistency.** VGS employed a number of TRM-based and other calculators in a consistent manner such that many projects achieved realization rates near 100%.
- **Involuntary Omissions.** The NMR team determined significant omissions causing savings to be underreported for two projects. Correcting these omissions resulted in high project realization rates for PY2018.

1.3.3 Key Drivers – Residential Annual Savings Realization Rates

The overall realization rate for the residential sector was 101%. Project-level realization rates varied based on individual project findings, but the residential sector results are largely driven by the four largest Custom Residential New Construction (RNC) projects that account for 23% of the sector's reported savings. The RNC program, with a realization rate of 105%, was the key driver for the sector-level realization rate. Key observations driving the realization rates for the residential sector are:

- **New construction boiler projects.** VGS's calculation for boiler projects in new construction was determined to be deducting more savings than required for code-required baselines. Correcting this error resulted in high realization rates (>112%) for two large projects.
- **Quantity adjustments.** Two new construction projects underreported the savings by 50% by not accounting for the correct equipment quantities. Correcting this error resulted in high realization rates (119% and 107%) for these two projects.
- **Adherence to the TRM and general consistency.** VGS employed a number of TRM-based and other calculators in a consistent manner such that many projects achieved realization rates close to 100%.

1.3.4 Key Drivers – Peak Day Savings Realization Rates

VGS calculates peak day savings by applying a set of end-use multipliers to estimated annual savings. Therefore, findings that affect annual MCF savings carry over to peak day MCF savings proportionally.

In the commercial sector, VGS does not claim peak day savings for customers enrolled in interruptible service rates, so the projects that make up the reported peak day savings are only a subset of the total population. Therefore, the mix of interruptible and non-interruptible customers also affects the realization rates for commercial programs. The NMR team also corrected the end-use multiplier for two projects in the Commercial Retrofit program, resulting a high realization rate (133%).

1.4 RECOMMENDATIONS

The NMR team offers the following recommendations to Vermont Gas to improve future programs, bring realization rates closer to 100%, and streamline future evaluation activities. Additional recommendations and details are included in [Section 6](#) of this report.

➤ **Expand Project Documentation Practices**

VGS's energy efficiency projects sometimes stretch across multiple program years and therefore may also involve one or more handoffs between VGS personnel. VGS should consider increasing the level of detail and organization of project documentation. Inadequate documentation can result in accuracy losses over time. Three specific recommendations for increased documentation are:

- Include a project summary document in text form that describes the installed energy efficiency measure, the relevant baseline condition, equipment operating conditions, project timeline, and project invoices.
- Note the source(s) behind all key parameters driving energy savings estimates in the calculation spreadsheets.
- For prescriptive measures, VGS should include inspection reports and invoices that will help streamline the evaluation activities.

These expanded documentation practices will streamline future evaluations by providing a more organized view of each project and transparency into VGS's assumptions.

➤ **Additional Internal QC Process**

VGS should consider adding an internal QC process or expanding existing processes to include a comprehensive final review of project documentation and savings calculations at the time of project closeout, particularly for medium and large projects. This QC step could be accompanied by a checklist to help ensure consistency across projects.

➤ **Onsite Data Collection for High Impact Measures**

VGS's commercial portfolio was dominated by a few large projects in PY2018. VGS should consider incorporating onsite data collection for key energy usage drivers for projects where savings estimates exceed 1,500 MCF per year. Incorporating site-specific data collection would reduce the uncertainty associated with using estimates and rules of thumb for these high impact measures.

➤ **Specific Algorithm Updates**

The NMR team proposes several specific updates to VGS's algorithms for energy savings to improve consistency. These suggestions have been passed to VGS throughout the evaluation and some or all of them have already been incorporated.

Section 2 Project Background

The NMR team was retained by the Vermont PSD to provide technical assistance with Verification of Vermont Gas Systems (VGS) Annual Savings Claims. This evaluation project includes primarily impact evaluation activities for program years 2018 and 2019. This report is the first in the series and will address the evaluation activities for program year 2018 only.

2.1 GOALS AND OBJECTIVES

The primary goal of this evaluation is to provide assurance that programs cost-effectively address customer barriers to implementing energy-efficiency measures in their homes or businesses. The primary findings from these evaluation efforts will help the Vermont PSD and VGS plan for future program offerings and budget expenditures.

The objective of this evaluation is to calculate the annual and peak day realization rates (RRs) at the program and sector levels while suggesting process improvements to streamline program implementation and savings verification efforts.

The programs for which the gas savings will be verified are as follows:

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

The PSD has outlined the following specific objectives for the evaluation of VGS' energy-efficiency program annual savings claims for program years 2018 and 2019:

- Determine VGS' progress toward several quantifiable performance indicators (QPIs) for the program years 2018 and 2019, as described in the Vermont Public Utilities Commission (PUC) order from October 2017, including:
 - QPI #1: Annual Incremental MCF Savings
 - QPI #2: Total Resource Benefits (Costs)¹
 - QPI #3: Peak Day MCF Savings
- Develop best in class, transparent, and thoroughly documented evaluations.

2.2 SUMMARY OF EVALUATION ACTIVITIES

The NMR team has divided the overall evaluation effort into six key tasks.

¹ This QPI is not addressed in the report. The NMR team will provide support to DPS to address this QPI outside the scope of this report.

- **Task 1: Kick-off meeting and work plan development.** Develop an evaluation work plan to describe the processes that will be followed to complete the tasks outlined in this project for each program year.
- **Task 2: Tracking data review and analysis.** Review the VGS program participant tracking databases for accuracy and comprehensiveness. We will also include suggestions for potential improvements to the tracking system for streamlining future evaluations.
- **Task 3: Sampling plan development.** Develop a sampling plan designed to meet 80/10 confidence/precision for the MCF savings for each program based on the outcomes of Task 1 and Task 2.
- **Task 4: Engineering analysis and verification.** Perform technical engineering analysis to verify natural gas energy savings for each program and sector.
- **Task 5: Project reporting and deliverables.** Deliver a final report that meets the requirements and deadlines set by the Vermont PSD and PUC. The NMR team will also provide PSD and VGS staff with all project documentation in a mutually agreed upon and easy to use database.
- **Task 6: Project Management.** Yogesh Patil of NMR is the Principal-in-Charge and single point of contact with the PSD and VGS for this project. He will also oversee the work conducted by BrightLine Group, who will have key responsibilities within each task. He will conduct regular scheduled project update/review meetings with the PSD and VGS teams.

2.3 SUMMARY OF PROGRAM REPORTED SAVINGS

VGS staff provided PY2018 tracking data for all the programs encompassed by this evaluation. The NMR team reviewed and analyzed the tracking data to determine the actual program- and measure-level gas savings. [Table 3](#) presents the overall portfolio savings at the program level as reported by VGS. Measure-level summaries for each program were included in the workplan (Appendix C). Reported annual savings were relatively evenly split between the residential and commercial sectors.

Table 3. Overall PY2018 Reported Savings Summary*

Program	Projects	Reported Annual Savings (MCF)	Reported Peak Day Savings (MCF)
Commercial Equipment Replacement	34	7,372	34.7
Commercial New Construction	27	7,489	60.3
Commercial Retrofit	30	14,959	29.2
Commercial Sector	91	29,819	124.1
Residential Equipment Replacement	1,672	13,207	113.6
Custom Residential New Construction	17	9,750	105.2
Custom Residential Retrofit	1	1,110	0.0
Residential Sector	1,690	24,067	218.7
Total	1,781	53,885	343.0

* Includes only the projects evaluated by the NMR team under this verification effort, not the entire portfolio

Section 3 Sampling

The NMR team developed a sampling plan designed to achieve 80/10 confidence and precision for gross savings at the program level, in accordance with DPS guidelines. The sample design was detailed in a memo (included in Appendix B) delivered to and approved by the PSD in the initial phase of the evaluation project.

We are using stratified ratio estimation (SRE) to improve precision and minimize sample sizes. Each part of the sample design is described briefly in this section.

3.1 SAMPLING PLAN

The NMR team employed stratified ratio estimation (SRE) to improve precision and minimize sample sizes. Each component of the sample design is described briefly in [Figure 2](#). The projects accounting for the bottom 4% of reported savings were excluded from the sample frame. The largest projects within each program were allocated into a census stratum, ensuring their inclusion in the evaluation sample. Sample sizes were selected to meet the intended 80/10 confidence and precision target using assumed error ratios customized to each program based on results from the PY2017 evaluation.

Figure 2. Sampling Plan Approach

Sample Frame	All projects completed 1/1/2018 through 12/31/2018	Smallest projects (bottom 4% of savings) excluded
Method	Stratified Ratio Estimation (SRE)	Consistent with approach employed in 2016 and 2017
Primary Sampling Unit	Project	
Confidence/Precision	80/10	Targeted at the program level
Error Ratio	Program-specific values ranging from 0.30 to 0.70	Customized based on results from prior evaluation
Stratification Variables	Program, Project Size	Largest projects separated into a census stratum

3.2 SUMMARY

[Table 4](#) presents the overall sample design indicating the sample sizes for each program and stratum.

Table 4. Overall Sample Design

Program	Strata	Annual MCF	# Projects	% Savings	Error Ratio	Sample Size
Commercial Equipment Replacement (CER)	Census	4,678	4	63%	0.50	4
	1	2,413	17	33%	0.50	4
	2	280	13	4%	n/a	0
CER Total		7,372	34	100%		8
Commercial New Construction (CNC)	Census	4,770	2	64%	0.30	2
	1	2,440	15	33%	0.30	2
	2	279	10	4%	n/a	0
CNC Total		7,489	27			4
Commercial Retrofit (CSR)	Census	9,739	6	65%	0.70	6
	1	4,634	12	31%	0.70	5
	2	586	12	4%	n/a	0
CSR Total		14,959	30			11
Commercial Sector		29,819	91			23
Residential Equipment Replacement (RER)	Census*	342	3	3%	0.50	3
	1	6,170	349	47%	0.50	19
	2	6,179	1,028	47%	0.50	19
	3	515	292	4%	n/a	0
RER Total		13,207	1,672			41
Custom Residential New Construction (RNC)	Census	5,447	4	56%	0.60	4
	1	3,962	10	41%	0.60	4
	2	341	3	4%	0.60	0
RNC Total		9,750	17			8
Custom Residential Retrofit (RIR)	Census	1,110	1	100%	0.30	1
RIR Total		1,110	1			1
Residential Sector		24,067	1,690			50
Overall Portfolio		53,885	1,781			73

* All custom projects

Section 4 Methodology

Following approval of the sampling plan, the NMR team formed the 2018 evaluation sample by randomly selecting projects to satisfy each sample stratum as outlined in the plan. All records and documents associated with the projects in the evaluation sample were then obtained from VGS. Desk reviews were completed for each project. Verified savings for these projects were then rolled up to the program- and sector-level.

4.1 DESK REVIEW PROCESS

The NMR team applied the same general method to evaluate savings for all programs, incorporating the steps described in [Figure 3](#). More detail into the specifics of these steps are provided in subsequent sections.

Figure 3. Evaluation Desk Review Activities

Documentation Review	Initial documentation review focused on record completeness. Missing files were requested from VGS.
Engineering Desk Review	Tools and methods used by VGS to estimate project savings were reviewed for consistency and accuracy.
Initial Consultation w/ VGS	Questions arising from the engineering review were discussed with VGS for clarification.
Supplementary Billing Analysis	Billing analysis was conducted for a subset of projects where desk reviews yielded uncertainty and where estimated savings were at least 5% of annual gas usage.
Preliminary Results Review	Individual site findings were shared with VGS and PSD staff on a continuous basis to provide fast feedback and facilitate discussion between stakeholders.
Report Verified Savings	Verified savings results were presented upon completion to VGS and PSD.

4.1.1 Documentation Reviews

Documentation reviews were completed for all projects in the evaluation sample as a critical precursor to completing further savings analysis activities. The documentation review sought to determine whether the provided project files were complete, well documented, and adequate for calculation of energy savings.

Projects with missing documentation were flagged to VGS, and VGS was able to locate and transfer the missing documentation in all cases.

4.1.2 Engineering Desk Reviews

Engineering Desk Reviews were also completed for all projects in the evaluation sample. This review focused on verifying the energy savings for each measure within each sampled project. Key questions answered through this review process are:

1. Do the calculation methods rely on deemed or prescribed technical reference manual (TRM) algorithms, program tools, or custom savings calculations performed by participants or third-party contractors (if applicable)?
2. Are the calculation methods correctly applied, appropriate, and accurate?
3. What reliable documentation is available on the baseline conditions, including information in the program database, such as applications, savings calculations performed by participants or third-party contractors (if applicable), audits, construction energy codes (new construction only), invoices for equipment or contracting services, and any other documentation available to VGS?
4. What data sources were used as the basis of savings calculations (e.g. manufacturer spec sheets, site-specific data, or rules of thumb)?

For measures incentivized using prescribed TRM algorithms, the NMR team independently recalculated savings using parameters verified through inspection of equipment documentation like spec sheets or AHRI certificates. For measures based on custom savings calculations, the NMR team assessed both the incorporated algorithms and the associated input parameters. Algorithms were evaluated for alignment with industry best practices, including consideration of other publicly available TRMs, DOE UMPs, and ASHRAE publications.

Findings from engineering desk reviews were discussed at multiple points with VGS and PSD staff to allow for additional consideration into project context and background. Finalized savings calculations for each project become the evaluation verified savings.

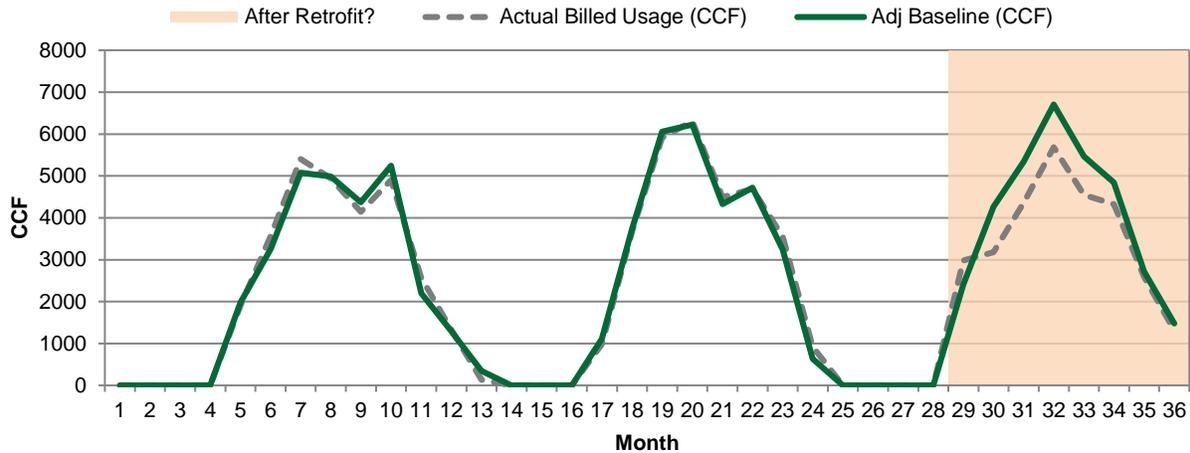
4.1.3 Billing Analysis

For a subset of projects in the evaluation sample, additional billing analysis was conducted to supplement the engineering desk review. Two primary criteria were used to determine when billing analysis should be utilized to assess verified energy savings. The first criterion is when the outcome of the engineering desk review yielded uncertainty in determining verified savings. For example, when the algorithms behind the tool used for advanced burner control measures were not readily available for review. The second is when the project's reported savings represented at least 5% of premise-level natural gas energy consumption. Additional consideration was given to the amount of available billing data and the appropriate baseline condition.

The billing analyses incorporated 12 to 24 months of pre-retrofit data and as much post-retrofit data as was available as well as weather observations for the same period. The analysis method incorporated weather normalization such that the resultant verified savings outputs were calculated a typical year (TMY3).

Figure 4 is an example of an output from billing analysis in graphical format.

Figure 4. Example Billing Analysis Result



4.1.4 Continuous Feedback

The VGS team incorporated multiple points of communication with VGS and PSD throughout the evaluation to ensure that verified savings estimates for each project incorporated a complete understanding of project conditions. Requests for clarification and additional documentation were provided to VGS on a rolling basis through the desk review process. Verified savings were also provided in batches upon completion for review and comment.

4.2 REPORT VERIFIED SAVINGS

The evaluation desk review activities result in adjustment factors, or realization rates (RR), calculated for each stratum in the sample using the following relationship:

$$RR = \frac{\sum \text{Sample Verified Savings}}{\sum \text{Sample Reported Savings}}$$

Verified savings for each stratum are obtained by multiplying strata realization rates against the total reported savings for that stratum. Results from each stratum were rolled up to the program-, sector-, and portfolio-level using project weights and stratification tiers as appropriate.

Section 5 Observations and Results

VGS's programs were determined to be providing significant annual energy and peak day energy savings. This section describes findings and results from the evaluation of VGS's 2018 programs and presents a comparison with findings from the evaluations of VGS's 2016 and 2017 programs. Detailed results for the projects included in the evaluation sample are included in [Appendix A](#).

5.1 OBSERVATIONS

During the course of the evaluation, the NMR team made the following high-level observations.

- VGS program staff members displayed in-depth technical understanding of natural gas equipment operation and engineering principles surrounding energy efficiency savings calculations.
- VGS program staff members also expressed an ongoing commitment to maintaining positive customer relationships and improving program offerings.
- VGS has incorporated recommendations from the PY2016 and PY2017 evaluations into practice. VGS is employing TRM-based calculation approaches for several measures including boiler, furnace, and hot water heater replacements. VGS is also incorporating billing data analysis into savings calculations.
- VGS's project documentation can be challenging for an outside observer to piece together. Assumptions included in savings estimates are frequently undocumented. These factors pose challenges to evaluators but can also pose internal hurdles during project handoffs between VGS staff.

5.2 COMMERCIAL PROGRAM RESULTS

5.2.1 2018 Commercial Program Annual MCF Savings Results

The verified annual savings for VGS's commercial programs was 32,498 MCF, with an overall sector realization rate of 109%. [Table 5](#) provides the program-level results and associated relative precision. At the 80% confidence level designated at the outset of this study, these results have a $\pm 3.9\%$ precision band. This low relative precision was achieved by employing census sampling for large project strata.

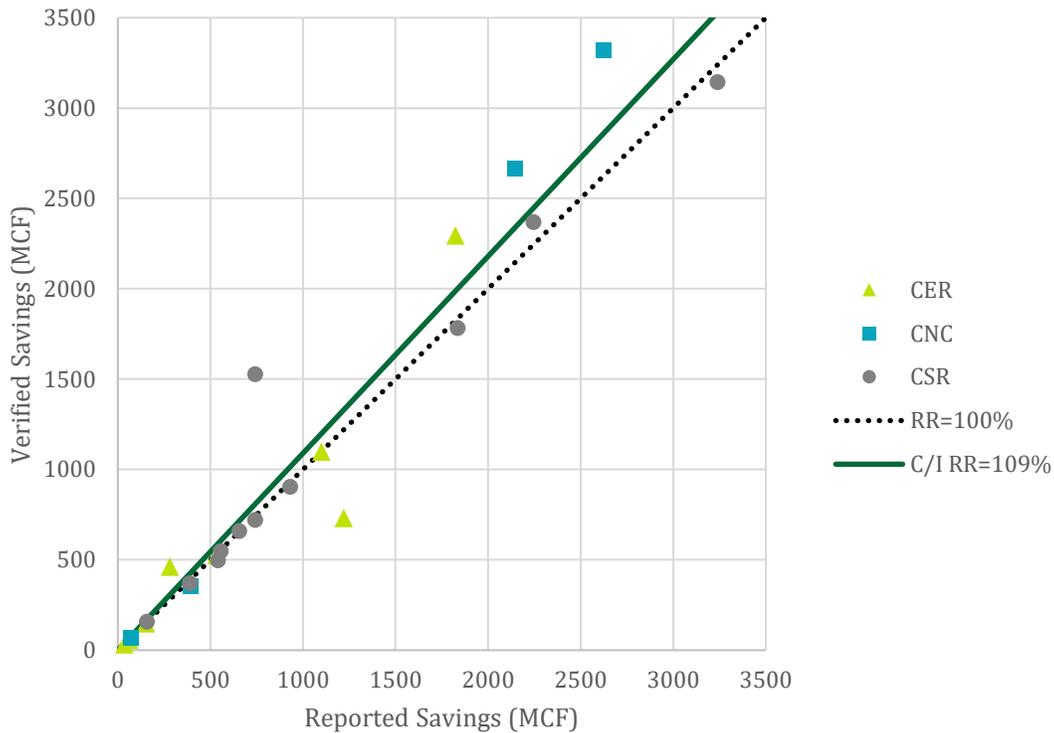
Table 5. PY2018 Commercial Sector Verified Annual Savings Summary

Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision ¹
Commercial Equipment Replacement	34	7,372	8,068	110%	10.0%
Commercial New Construction	27	7,489	8,962	120%	8.8%
Commercial Retrofit	30	14,959	15,458	103%	4.1%
Commercial Sector	91	29,819	32,498	109%	3.9%

¹At 80% confidence level

Figure 5 is a graphical representation of the project-level results for each project in the evaluation sample. Six projects account for 47% of the commercial portfolio, and because of this large contribution, the results from these projects have similarly large impact on the portfolio realization rate.

Figure 5. Commercial Project-Level Results



Project-level realization rates varied based on individual project findings. Key observations influencing the realization rates for the commercial sector are:

- **New construction heat recovery projects.** VGS's calculation for heat recovery project in new construction was determined to be deducting more than required for code-required baselines. Correcting this error resulted in high realization rates for three large projects.
- **Adherence to the TRM and general consistency.** VGS employed a number of TRM-based and other calculators in a consistent manner. This consistency resulted in 11 of 23 projects in the commercial sample achieving realization rates between 97% and 103%.

- Involuntary Omissions.** The NMR team determined significant omissions causing savings to be underreported for two projects. Correcting these omissions resulted in high project realization rates for both projects. In one case, energy savings estimates for a controls measure were only claimed for a portion of the day. The NMR team determined that the measure savings should be extended to the entire day. This oversight stemmed from project handoff following a VGS staffing change.

In a second case, one measure of a multi-measure project was not completely finalized in VGS's tracking system and the associated savings were inadvertently omitted from VGS's 2018 reported savings. The NMR team added this measure back into the verified savings.

5.2.2 2018 Commercial Program Peak Day MCF Savings Results

The verified peak day savings for VGS's commercial programs was 136.9 MCF, with an overall sector realization rate of 110%. Table 6 provides the program-level results and associated relative precision.

Table 6. PY2018 Commercial Sector Verified Peak Day Savings Summary

Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision ¹
Commercial Equipment Replacement	34	34.7	34.3	99%	1.8%
Commercial New Construction	27	60.3	63.8	106%	9.0%
Commercial Retrofit	30	29.2	38.8	133%	22.5%
Commercial Sector	91	124.1	136.9	110%	6.9%

¹At 80% confidence level

VGS does not claim peak day savings for customers enrolled in interruptible service rates. Thus, the projects that make up the reported peak day savings are a subset of the total population. VGS calculates peak day savings by applying a set of end-use-specific multipliers to estimated annual savings at the measure level. The NMR team verified peak day savings by first determining the appropriate end-use multiplier for each measure and then multiplying by the verified annual MCF savings for each measure. Therefore, findings that affect annual MCF savings as outlined in Section 5.2.1 carry over to peak day MCF savings proportionally for the mix of non-interruptible projects in the sample.

The VGS team noted two measures within the Commercial Retrofit program where VGS has applied the wrong multiplier. These two corrections result in the variation between peak day and annual savings realization rates (133% for peak day vs 103% for annual savings) as well as the higher relative precision for that program.

5.2.3 Commercial Algorithm Findings

The NMR team observed several minor but frequent inconsistencies in VGS's energy savings estimates, as described in the following paragraphs. Although these are relatively minor drivers of overall evaluation realization rates, the NMR team recommends updates to VGS's algorithms to improve consistency.

Consistent Conversion to Natural Gas Volume Units: VGS was observed to be inconsistently converting from natural gas energy units (e.g. MMBtus) to volume units (MCF). The NMR team recommends that VGS consistently apply the same conversion factor so that all reported savings are in uniform units.

Furnace/Boiler Replacement: Algorithms in the TRM Commercial Space Heating Measure, applicable for boiler and furnace replacements, are based around equipment ‘capacity’ only. The TRM should be updated to specify ‘output capacity’. Similarly, the calculator for this measure should be updated to call for boiler or furnace ‘output capacity’, rather than ‘input capacity’. If VGS prefers to use algorithms based on input capacity, a different treatment of equipment efficiency variables is more appropriate.

Heat Recovery: VGS’s algorithms for exhaust air heat recovery projects were incorrectly adjusting for baseline code-minimum heat exchangers (primarily a condition of new construction measures) in PY2018. Going forward, VGS should make this adjustment using a ratio of the installed equipment’s effectiveness, rather than a straight subtraction.

Air Heat Transfer Equation: A number of VGS measures incorporate a version of the heat transfer equation “ $1.08 \times \text{CFM} \times \Delta T$ ”. In some cases, VGS used 1.1 as a rounded form of the 1.08 constant. The NMR team recommends using 1.08 throughout all savings estimates for consistency with the TRM and industry common practice.

5.3 RESIDENTIAL PROGRAM RESULTS

5.3.1 2018 Residential Program Annual MCF Savings Results

The verified annual savings for VGS’s residential programs was 24,425 MCF, with an overall sector realization rate of 101%. Table 7 provides the program-level results and associated relative precision. At the 80% confidence level designated at the outset of this study, these results have a $\pm 2.7\%$ precision band. This low relative precision was achieved by employing census sampling for large strata.

Table 7. PY2018 Residential Sector Verified Annual Savings Summary

Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision ¹
Residential Equipment Replacement	1,672	13,207	13,092	99%	3.9%
Custom Residential New Construction	17	9,750	10,257	105%	3.9%
Custom Residential Retrofit	1	1,110	1,076	97%	0.0%
Residential Sector	1,690	24,067	24,425	101%	2.7%

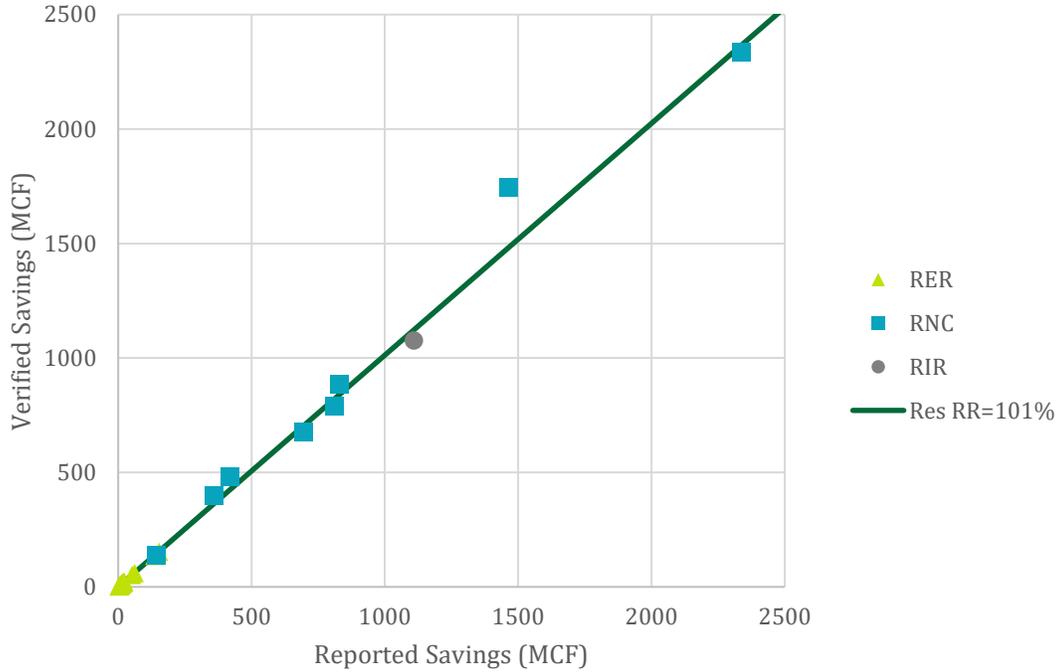
¹At 80% confidence level

Note that only one custom project for RIR program was evaluated. The remainder of the projects were evaluated in separate studies.

Figure 6 is a graphical representation of the project-level results for each project in the evaluation sample. Four RNC projects accounted for 56% of the program savings. For RER, the top three

projects only accounted for 3% of the program savings. For the sample frame overall, five projects accounted for 27% of the total portfolio savings.

Figure 6. Residential Project-Level Results



5.3.2 2018 Residential Program Peak Day MCF Savings Results

The verified peak day savings for VGS’s residential programs was 223.4 MCF, with an overall sector realization rate of 102%. Table 8 provides the program-level results and associated relative precision.

Table 8. PY2018 Residential Sector Verified Peak Day Savings Summary

Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision ¹
Residential Equipment Replacement	1,672	113.6	112.7	99%	0.4%
Custom Residential New Construction	17	105.2	110.7	105%	1.9%
Custom Residential Retrofit	1	0.0	0.0	n/a	0.0%
Residential Sector	1,690	218.7	223.4	102%	0.9%

¹At 80% confidence level

The peak day MCF savings verification was based on determining appropriate application of VGS’s peak savings factors used in the tracking database. Through interaction with VGS staff the NMR team was able to understand how those factors are developed and applied.

5.4 COMPARISON WITH PREVIOUS EVALUATIONS

Results from PY2018 as compared to prior years PY2016 and PY2017 are shown in [Table 9](#) for the commercial sector and [Table 10](#) for the residential sector. For the commercial sector, PY2018 included more projects but only about half of the reported annual savings. For the residential sector, the PY2018 evaluation covered significantly more energy savings. Prior evaluations did not include the RER program. However, RER was included in the scope of this evaluation. Both sectors' realization rates shifted upwards from PY2017, for both annual and peak day savings. The NMR team found that VGS had incorporated some of the recommendations from the prior evaluations, specifically the adoption of more TRM-based calculations, resulting in more consistent savings estimates.

Table 9. PY2018 Commercial Sector Verified Annual Savings Summary

Commercial Sector	2016	2017	2018
Total Qty of Projects	89	76	91
Sampled Projects	32	23	23
Annual Savings			
Reported Annual Savings (MCF)	48,485	58,569	29,819
Verified Annual Savings (MCF)	42,668	47,437	32,498
Realization Rate	89%	81%	109%
Relative Precision	4%	4%	4%
Peak Day Savings			
Reported Peak Day Savings (MCF)	232	140	124.1
Verified Peak Day Savings (MCF)	176	106	136.9
Realization Rate	76%	76%	110%
Relative Precision	5%	15%	7%

Table 10. PY2018 Residential Sector Verified Annual Savings Summary

Program Year	2016	2017	2018
Total Qty of Projects	17	11	1,690*
Sampled Projects	17	11	50
Annual Savings			
Reported Annual Savings (MCF)	6,274	5,704	24,067
Verified Annual Savings (MCF)	3,083	4,962	24,425
Realization Rate	49%	76%	101%
Relative Precision	n/a	n/a	3%
Peak Day Savings			
Reported Peak Day Savings (MCF)	67	64	218.7
Verified Peak Day Savings (MCF)	34	56	223.4
Realization Rate	50%	87%	102%
Relative Precision	n/a	n/a	1%

* Prior evaluations did not include the RER program

5.5 ERROR RATIOS

Observed error ratios in the 2018 evaluation sample are listed in [Table 11](#), alongside the assumed ratios used in sample design. For all programs, the observed error ratio was smaller than our sample design assumption. Error ratio is not applicable to RIR in 2018 since only one project was evaluated.

Table 11. 2018 Program Level Error Ratios

Program	Error Ratio	
	2018 Design	2018 Evaluated
Commercial Equipment Replacement (CER)	0.50	0.30
Commercial New Construction (CNC)	0.30	0.16
Commercial Retrofit (CSR)	0.70	0.22
Residential Equipment Replacement (RER)	0.50	0.07
Custom Residential New Construction (RNC)	0.60	0.08
Custom Residential Retrofit (RIR)	0.30	n/a

Section 6 Recommendations

The NMR team offers the following recommendations to Vermont Gas to improve future programs, bring realization rates closer to 100%, and streamline future evaluation activities.

➤ **Expand Project Documentation Practices**

VGS's energy efficiency projects sometimes stretch across multiple program years from initial project conceptualization to final incentive payment, due to extended construction timelines and other extraneous factors. VGS should consider increasing the level and organization of project documentation. Although VGS personnel apply sound understanding of system operations to their initial energy savings estimates, inadequate documentation can result in accuracy losses over time, especially as projects are handed off between personnel. Three specific recommendations for increased documentation are:

- Include a project summary document in text form that describes the installed energy efficiency measure(s), the relevant baseline condition, equipment operating conditions, project timeline, and project invoices.
- Note the source(s) behind all key parameters driving energy savings estimates in the calculation spreadsheets.
- For prescriptive measures, include inspection reports and invoices to more thoroughly document project scope.

In addition, these expanded documentation practices will streamline future evaluations by providing a more organized view of each project and transparency into VGS's assumptions.

➤ **Additional Internal QC Process**

VGS should consider adding an internal QC process or expanding existing processes to include a comprehensive final review of project documentation and savings calculations at the time of project closeout for medium- and large-sized projects. This QC step could be accompanied by a checklist to help ensure consistency across projects. Items that could be relevant for inclusion in the final QC step and/or checklist are: documentation of differences between contracted and finalized project scope, demarcation of final savings calculations, consistent unit conversions between natural gas volume and energy quantities, etc.

➤ **Onsite Data Collection for High Impact Measures**

VGS's commercial portfolio was dominated by a few large projects in PY2018. VGS should consider incorporating onsite data collection for key energy usage drivers for projects where savings estimates exceed 1,500 MCF per year. In PY2018, six projects met this criterion and accounted for 47% of annual energy savings. Incorporating site-specific data collection would reduce the uncertainty associated with using estimates and rules of thumb for these high impact measures. Potential data sources include EMS trend data and standalone data loggers. Gas measures are some of the most difficult measures to meter. However, wherever possible, we

recommend gathering any relevant information that will help support the key parameters used in the savings analysis.

➤ **Specific Algorithm Updates**

The NMR team proposes several specific updates to VGS's algorithms for energy savings to improve consistency, as outlined in [Section 5.2.3](#). These suggestions have been passed to VGS throughout the evaluation and some or all of them have already been incorporated.

A

Appendix A Site Results

This appendix includes the site results for the sampled projects.

Available upon request: keith.levenson@vermont.gov

Appendix B Sampling Plan Memo

Available upon request: keith.levenson@vermont.gov

Appendix C Workplan

Available upon request: keith.levenson@vermont.gov