Verification of Vermont Gas Systems 2019 Savings Claims

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SUBMITTED TO:
Vermont Department of Public Service

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Section 1 Executive Summary

This evaluation report documents the year 2 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 2019. 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)
- Residential Equipment Replacement (RER)
- Custom Residential New Construction (RNC)
- Custom Residential Retrofit (RIR)

A variety of measures were installed through these programs including boiler and hot water heater replacements, space heating, heat recovery equipment installation, building shell improvements, heating system control improvements, faucet aerators, and pipe wrap. VGS reported a total of 1,696 projects with a claimed annual savings of 57,643 MCF (thousand cubic feet of natural gas) for its entire portfolio in 2019.

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 placed in a census stratum to ensure their inclusion in the evaluation sample. The NMR team formed the remainder of the 2019 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. 2019 Evaluation Desk Review Process

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.

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 which were then applied to the total population to determine the 2019 verified savings values. Table 1 and Table 2 summarized the realization rates and verified savings for each program, sector, and the overall portfolio for annual savings and peak day savings, respectively.

Table 1: PY2019 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	45	7	4,265	4,046	94.9%	4.4%
Commercial New Construction	21	4	10,282	9,199	89.5%	4.3%
Commercial Retrofit	38	7	13,216	12,997	98.3%	3.6%
Commercial Sector	**104**	**18**	**27,763**	**26,241**	**94.5%**	**2.5%**
Residential Equipment Replacement	1,567	12	18,825	17,336	92.1%	8.0%
Residential New Construction	23	6	10,904	10,892	99.9%	4.1%
Residential Retrofit*	2	2	150	149	99.0%	0.0%
Residential Sector	**1,592**	**20**	**29,880**	**28,377**	**95.0%**	**5.2%**
Portfolio Level	**1,696**	**38**	**57,643**	**54,618**	**94.8%**	**3.0%**

[1]At 80% confidence
*Custom multifamily residential retrofit projects only. Other residential retrofit subprograms were verified by PSD staff in coordination with the NMR evaluation team and are not included here

Table 2: PY2019 Verified Peak Day Savings Summary

Program	Total Projects	Sampled Projects	Peak Day Mcf		
			Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate
Commercial Equipment Replacement	45	7	42.9	39.7	92.6%
Commercial New Construction	21	4	104.3	91.9	88.1%
Commercial Retrofit	38	7	52.4	51.5	98.4%
Commercial Sector	**104**	**18**	**199.6**	**183.1**	**91.8%**
Residential Equipment Replacement	1,567	12	163.5	146.7	89.7%
Residential New Construction	23	6	121.5	121.8	100.2%
Residential Retrofit	2	2	1.9	1.8	99.3%
Residential Sector	**1,592**	**20**	**286.8**	**270.3**	**94.3%**
Portfolio Level	**1,696**	**38**	**486.4**	**453.5**	**93.2%**

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 94.5%. Project-level realization rates varied based on individual project findings, with findings from one large project significantly driving the sector realization rate. Key observations for the commercial sector are:

- **Issue with vendor-provided savings calculation.** One vendor-provided savings estimation was determined to be overly aggressive. The NMR team and VGS recalculated savings for this project using VGS's standard internal calculations for variable-flow hood exhaust, resulting in a significant reduction in verified savings.
- **Incorporating billing gas usage data into TRM-based algorithms.** VGS used billing gas usage data as a 'heating load' input into TRM algorithms for equipment replacements. To estimate 'heating load', billing data should typically be adjusted to account for the efficiency of the boiler in place during the billing periods used.
- **Adherence to the TRM and general consistency.** VGS employed a number of TRM-based and other calculators in a consistent manner, with noted improvements over prior years.

1.3.3 Key Drivers - Residential Annual Savings Realization Rates

The Residential Equipment Replacement (RER) program which accounts for 63% of the sector savings and a realization rate of about 92% was the primary driver of the overall sector level realization rate of 95%. Project-level realization rates varied based on individual project findings but were primarily in a 6% band between 97% and 103%. The RER program realization rate was

largely driven by one project that had a low realization rate of 32%. Key observations driving the realization rates for the residential sector are:

- **Documentation adjustments.** Documentation error was identified for two measures, where the calculated savings using custom analysis were slightly different than the claimed savings. However, correcting this issue did not significantly alter the realization rates for those measures.
- **In-eligible measures.** Two RER projects were found to have installed in-eligible equipment by virtue of installed equipment efficiency below program requirements. One of the two projects resulted in a low realization rate of 32% after accounting for the correct efficiency. The program staff indicated that in such cases, as a corrective action, the vendors undergo trainings to reacquaint themselves with the program requirements.
- **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.

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 is in the process of taking a deeper look at (and revamping) their analytical tools and overall processes in preparation for expansion of their programs. We recommend that VGS consider increasing the amount of information documented for each type of project. The NMR team had a similar recommendation last year and has seen VGS starting to implement it. However, by deciding to revamp the analytical tools, VGS will be able to consistently gather and document additional information such as:

  - 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.

- **Expand Internal QC Processes**

  VGS should consider adding or expanding internal QC process to include the following:

  - Add internal QC review for high impact measure savings calculations and include scrutiny of vendor-submitted savings calculation.
  - Develop process to ensure that final savings calculations are stored, and final savings values are entered in tracking database.

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 second in the series and will address the evaluation activities for program year 2019 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, budget expenditures and evaluation strategies.

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 were verified are as follows:

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

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 conducted regular scheduled project update/review meetings with the PSD and VGS teams.

2.3 Summary of Program Reported Savings

VGS staff provided PY2019 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 PY2019 Reported Savings Summary*

Program	Projects	Reported Annual Savings (MCF)	Reported Peak Day Savings (MCF)
Commercial Equipment Replacement	45	4,265	42.9
Commercial New Construction	21	10,282	104.3
Commercial Retrofit	38	13,216	52.4
Commercial Sector	**104**	**27,763**	**199.6**
Residential Equipment Replacement	1,567	18,825	163.5
Residential New Construction	23	10,904	121.5
Residential Retrofit	2	150	1.9
Residential Sector	**1,592**	**29,880**	**286.8**
Total	**1,696**	**57,643**	**486.4**

* 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 PY2018 evaluation.

Figure 2. Sampling Plan Approach

Sample Frame	All projects completed 1/1/2019 through 12/31/2019	Smallest projects (bottom 4% of savings) excluded
Method	Stratified Ratio Estimation (SRE)	Consistent with approach employed in 2016, 2017, and 2018
Primary Sampling Unit	Project	Project may contain multiple measures
Confidence/Precision	80/10	Targeted at the program level
Error Ratio	Program-specific values ranging from 0.20 to 0.35	Customized based on results from prior evaluations
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 and the anticipated precision for all the programs and stratum.

Table 4: Overall Sample Design PY2019

Program	Strata	Annual Mcf	# Projects	% Savings	Error Ratio	Sample Size	Relative Precision
Commercial Equipment Replacement	Census	1,500	3	35%	0.35	3	0%
	1	1,314	8	31%	0.35	2	27%
	2	1,299	24	30%	0.35	2	30%
	3	152	10	4%	n/a	0	n/a
CER Total		**4,265**	**45**			**7**	**13.0%**
Commercial New Construction	Census	5,377	2	52%	0.20	2	0%
	1	4,498	12	44%	0.20	2	17%
	2	407	7	4%	n/a	0	n/a
CNC Total		**10,282**	**21**			**4**	**7.5%**
Commercial Retrofit	Census	5,120	3	39%	0.30	3	0%
	1	3,797	4	29%	0.30	2	19%
	2	3,824	16	29%	0.30	2	25%
	3	475	15	4%	n/a	0	n/a
CSR Total		**13,216**	**38**			**7**	**9.5%**
Commercial Sector		**27,763**	**104**			**18**	**5.7%**
Residential Equipment Replacement	Census	272	2	1%	0.30	2	0%
	1	8,986	318	48%	0.30	5	17%
	2	8,999	944	48%	0.30	5	17%
	3	568	303	3%	n/a	0	n/a
RER Total		**18,825**	**1,567**			**12**	**11.9%**
Residential New Construction	Census	5,818	4	53%	0.20	4	0%
	1	4,651	10	43%	0.20	2	16%
	2	436	9	4%	0.20	0	n/a
RNC Total		**10,904**	**23**			**6**	**7.2%**
Residential Retrofit	Census	150	2	100%	n/a	2	0%
RIR Total		**150**	**2**			**2**	**0.0%**
Residential Sector		**29,880**	**1,592**			**20**	**8.0%**
Overall Portfolio		**57,643**	**1,696**			**38**	**5.0%**

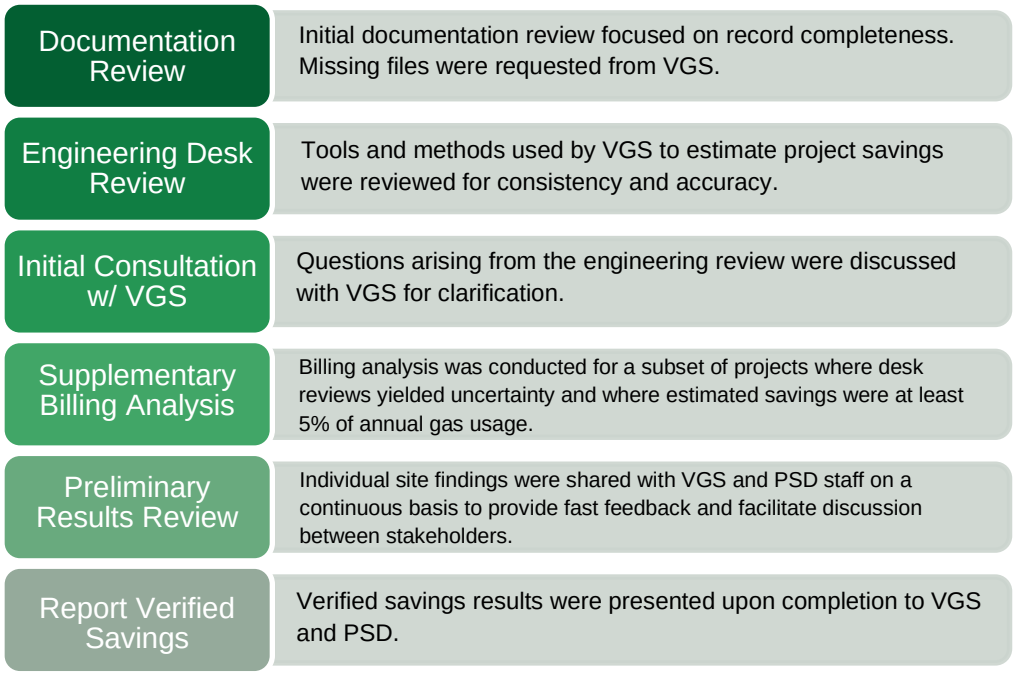
Section 4 Methodology

Following approval of the sampling plan, the NMR team formed the 2019 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



4.1.1 Documentation Reviews

Documentation reviews were completed for all projects in the evaluation sample as a critical pre-cursor 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 re-calculated 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.

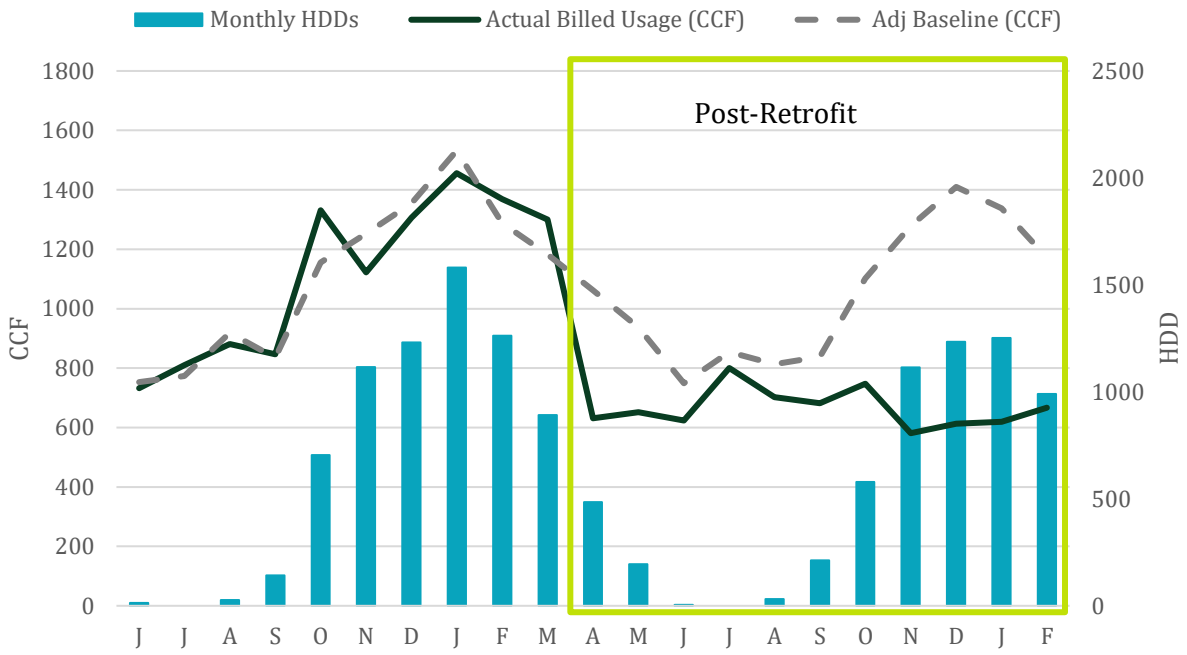
4.1.3 Billing Analysis

In 2019, billing analysis was incorporated for a subset of three projects in the evaluation sample 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. 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:

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

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 2019 programs and presents a comparison with findings from the evaluations of VGS's 2018 programs. Detailed results for the projects included in the evaluation sample are provided in Appendix A.

5.1 OBSERVATIONS

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

- The NMR team's review of verified savings for all programs found that, overall, the verified savings estimations were aligned with the evaluation framework, followed proper custom site-specific activities, applied TRM protocols correctly, and that the verified savings are generally accurate.
- VGS program staff members displayed in-depth technical understanding of natural gas equipment operation and engineering principles surrounding energy efficiency savings calculations.
- VGS has incorporated recommendations from the PY2018 evaluation into practice and has showed increased attention to detail in PY2019.
- VGS's consistency in Mcf/MMBtu conversion factors has greatly improved for PY2019 compared to PY2018.
- VGS program staff members also expressed an ongoing commitment to maintaining positive customer relationships and improving program offerings.
- 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.
- The NMR team found two measures that were not eligible due to lower than required installed equipment efficiencies. However, VGS went ahead with the project to maintain positive customer relationships. When such instances occur, VGS conducts trainings for their vendors to raise awareness of these issues.

5.2 COMMERCIAL PROGRAM RESULTS

5.2.1 2019 Commercial Program Annual MCF Savings Results

The verified annual savings for VGS's commercial programs was 26,241 MCF, with an overall sector realization rate of 94.5%. 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 ±2.5% precision band. This low relative precision was achieved by employing census sampling for large project strata.

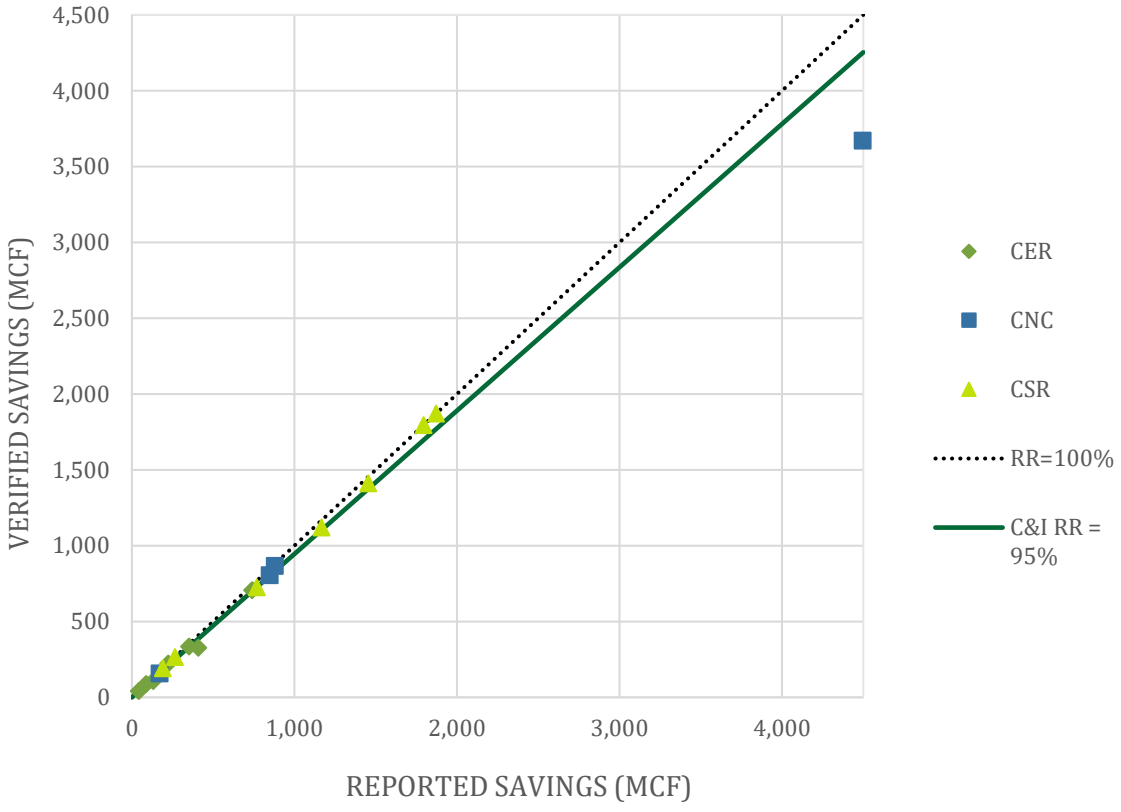
Table 5: PY2019 Commercial Sector Verified Annual Savings Summary

Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision[1]
Commercial Equipment Replacement	45	4,265	4,046	94.9%	4.4%
Commercial New Construction	21	10,282	9,199	89.5%	4.3%
Commercial Retrofit	38	13,216	12,997	98.3%	3.6%
Commercial Sector	**104**	**27,763**	**26,241**	**94.5%**	**2.5%**

[1]At 80% confidence level

Figure 5 is a graphical representation of the project-level results for each project in the evaluation sample. While many projects were found to have a near-100% realization rate, findings for VGS's largest project are a significant contributor to the sector-level 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:

- **Incorporating billing gas usage data into TRM-based algorithms.** VGS used billing gas usage data as a 'heating load' input into TRM algorithms for equipment replacements. To estimate 'heating load', billing data should typically be adjusted to account for the efficiency of the boiler in place during the billing periods used.
- **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 13 of 18 projects in the commercial sample achieving realization rates between 95% and 100%.
- **Issue with vendor-provided savings calculation.** VGS claimed savings for one variable-flow hood exhaust system using a vendor-provided calculator. The NMR team determined that the vendor's calculation was overestimating savings, potentially due to some residual hard-coded values left over from a prior analysis. The NMR team and VGS recalculated savings for this project using VGS's standard internal calculations for variable-flow hood exhaust, resulting in a significant reduction in verified savings.
- **Minor discrepancies between savings calculations and tracked savings.** The NMR team observed several projects where minor differences were noted between the savings values in the tracking database and the final calculations.

5.2.2 2019 Commercial Program Peak Day MCF Savings Results

The verified peak day savings for VGS's commercial programs was 183.1 MCF, with an overall sector realization rate of 91.8%. Table 6 provides the program-level results and associated relative precision.

Table 6: PY2019 Commercial Sector Verified Peak Day Savings Summary

Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate
Commercial Equipment Replacement	45	42.9	39.7	92.6%
Commercial New Construction	21	104.3	91.9	88.1%
Commercial Retrofit	38	52.4	51.5	98.4%
Commercial Sector	**104**	**199.6**	**183.1**	**91.8%**

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.

For 2019, the NMR team did not find any discrepancies with VGS's application of peak day multipliers.

5.2.3 Commercial Algorithm Findings

The NMR team observed that in 2019, VGS improved upon several minor inconsistencies noted in prior evaluations. Although these are relatively minor drivers of overall evaluation realization rates, the NMR team recommends updates to VGS's algorithms to improve consistency.

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 algorithm should be applied.

Use of Billing Data to Estimate Heating Load: Algorithms in the TRM Commercial Space Heating Measure call for a 'heating load' input. When using billing data to estimate a building's heating load, the billing data should be adjusted in several ways: to account for any non-weather dependent usage, to account for any other unaffected heating systems, and to account for the efficiency of the pre-retrofit system in place during the period of billing data analysis.

5.3 Residential Program Results

5.3.1 2019 Residential Program Annual MCF Savings Results

The verified annual savings for VGS's residential programs was 28,377 MCF, with an overall sector realization rate of 95%. 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 ±5.2% precision band. This low relative precision was achieved by employing census sampling for large strata.

Table 7: PY2019 Residential Sector Verified Annual Savings Summary

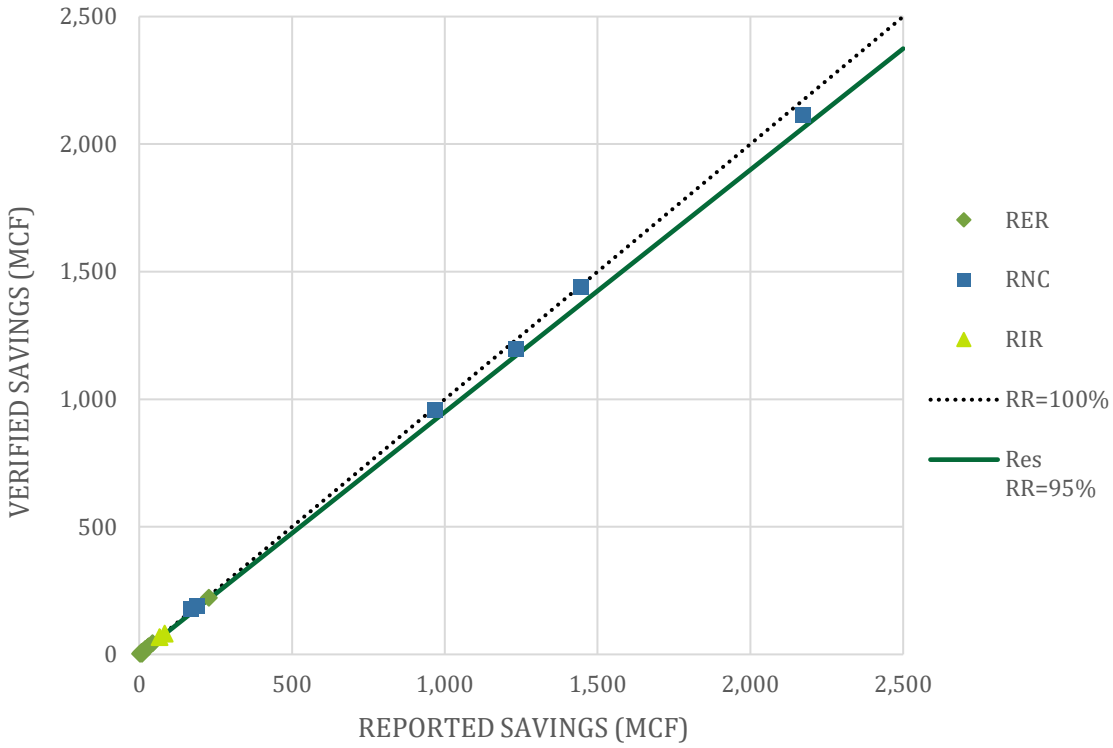
Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate	Relative Precision[1]
Residential Equipment Replacement	1,567	18,825	17,336	92.1%	8.0%
Residential New Construction	23	10,904	10,892	99.9%	4.1%
Residential Retrofit	2	150	149	99.0%	0.0%
Residential Sector	**1,592**	**29,880**	**28,377**	**95.0%**	**5.2%**

[1]At 80% confidence level

Note that only two custom projects for RIR program were evaluated. The remainder of the non-custom 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 2019 Residential Program Peak Day MCF Savings Results

The verified peak day savings for VGS's residential programs was 270.3 MCF, with an overall sector realization rate of 94.3%. Table 8 provides the program-level results and associated relative precision.

Table 8: PY2019 Residential Sector Verified Peak Day Savings Summary

Program	Projects	Reported Savings (MCF)	Verified Savings (MCF)	Realization Rate
Residential Equipment Replacement	1,567	163.5	146.7	89.7%
Residential New Construction	23	121.5	121.8	100.2%
Residential Retrofit	2	1.9	1.8	99.3%
Residential Sector	**1,592**	**286.8**	**270.3**	**94.3%**

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 PY2019 as compared to PY2018 are shown in Table 9 for the commercial sector and Table 10 for the residential sector. For the commercial sector, the reported savings in PY2019

were similar to those reported in PY2018. For the residential sector, the reported savings in PY2019 were about 20% more than those reported in PY2018. PY2019 was the first year in the four-year history shown that the residential sector savings exceeded the commercial sector savings.

Table 9: PY2019 Commercial Sector Verified Annual Savings Summary

Commercial Sector	2018	2019
Total Qty of Projects	91	104
Sampled Projects	23	18
Annual Savings		
Reported Annual Savings (MCF)	29,819	27,763
Verified Annual Savings (MCF)	32,498	26,241
Realization Rate	109%	94.5%
Relative Precision	4%	2.5%
Peak Day Savings		
Reported Peak Day Savings (MCF)	124.1	199.6
Verified Peak Day Savings (MCF)	136.9	183.1
Realization Rate	110%	91.8%

Table 10: PY2019 Residential Sector Verified Annual Savings Summary

Program Year	2018	2019
Total Qty of Projects	1,690	1,592
Sampled Projects	50	20
Annual Savings		
Reported Annual Savings (MCF)	24,067	29,880
Verified Annual Savings (MCF)	24,425	28,377
Realization Rate	101%	95.0%
Relative Precision	3%	5.2%
Peak Day Savings		
Reported Peak Day Savings (MCF)	218.7	286.8
Verified Peak Day Savings (MCF)	223.4	270.3
Realization Rate	102%	94.3%

5.5 Error Ratios

Observed error ratios in the 2019 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 2019 since only one project was evaluated.

Table 11: 2019 Program Level Error Ratios

Program	Error Ratio	
	2019 Design	2019 Evaluated
Commercial Equipment Replacement (CER)	0.35	0.08
Commercial New Construction (CNC)	0.20	0.08
Commercial Retrofit (CSR)	0.30	0.02
Residential Equipment Replacement (RER)	0.30	0.22
Residential New Construction (RNC)	0.20	0.02
Residential Retrofit (RIR)	n/a	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 is in the process of taking a deeper look at their analytical tools and overall processes in preparation for expansion of their programs. We recommend that VGS consider increasing the amount of information documented for each type of project. The NMR team recommended something similar last year and has seen VGS starting to implement it. However, by deciding to revamp the analytical tools, VGS will be able to consistently gather and document additional information such as:

- 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 Processes**

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 especially for large-sized projects. Items that could be relevant for inclusion in the final QC step and/or checklist are: QC review of savings calculation, 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.

Specific processes that could improve realization rates include:

- Add internal QC review for high impact measure savings calculations and include scrutiny of vendor-submitted savings calculation.
- Develop process to ensure that final savings calculations are stored, and final savings values are entered in tracking database.

- **Specific Algorithm Updates**

The NMR team proposes two 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.

Appendix A Site Results

ID	Program	Annual Mcf			Peak Mcf		
		Claimed	Verified	RR	Claimed	Verified	RR
PY19CER01	Commercial Equipment Replacement	739.4	705.5	95.4%	8.7	8.3	95.4%
PY19CER02	Commercial Equipment Replacement	409.0	327.2	80.0%	4.8	3.8	80.0%
PY19CER03	Commercial Equipment Replacement	351.4	334.7	95.2%	4.1	3.9	95.2%
PY19CER04	Commercial Equipment Replacement	131.2	107.3	81.8%	1.5	1.3	81.8%
PY19CER05	Commercial Equipment Replacement	223.4	223.4	100.0%	0.6	0.6	99.5%
PY19CER06	Commercial Equipment Replacement	42.3	42.3	100.0%	0.1	0.1	100.0%
PY19CER07	Commercial Equipment Replacement	87.2	87.4	100.2%	0.3	0.3	100.2%
PY19CNC01	Commercial New Construction	4,497.4	3,671.2	81.6%	52.6	42.9	81.6%
PY19CNC02	Commercial New Construction	879.2	866.3	98.5%	10.1	10.0	98.6%
PY19CNC03	Commercial New Construction	847.3	805.0	95.0%	7.2	6.7	93.2%
PY19CNC04	Commercial New Construction	170.8	157.8	92.4%	1.8	1.6	91.4%
PY19CSR01	Commercial Retrofit	1,795.0	1,795.0	100.0%	4.8	4.8	100.0%
PY19CSR02	Commercial Retrofit	1,454.0	1,411.6	97.1%	0.0	0.0	0.0%
PY19CSR03	Commercial Retrofit	1,871.4	1,871.4	100.0%	0.0	0.0	0.0%
PY19CSR04	Commercial Retrofit	1,167.3	1,120.7	96.0%	13.7	13.1	96.0%
PY19CSR05	Commercial Retrofit	769.3	725.6	94.3%	0.0	0.0	0.0%
PY19CSR06	Commercial Retrofit	266.0	266.0	100.0%	0.7	0.7	100.3%
PY19CSR07	Commercial Retrofit	190.4	190.4	100.0%	2.2	2.2	100.1%
PY19RER01	Residential Equipment Replacement	228.3	221.5	97.0%	1.8	1.7	97.0%
PY19RER02	Residential Equipment Replacement	44.0	43.9	99.7%	0.4	0.4	99.8%
PY19RER03	Residential Equipment Replacement	31.1	31.1	100.0%	0.2	0.2	100.0%
PY19RER04	Residential Equipment Replacement	29.8	29.8	100.0%	0.2	0.2	100.0%
PY19RER05	Residential Equipment Replacement	26.9	26.9	100.0%	0.2	0.2	100.0%
PY19RER06	Residential Equipment Replacement	21.3	21.3	100.0%	0.1	0.1	100.0%
PY19RER07	Residential Equipment Replacement	20.5	20.5	100.0%	0.1	0.1	100.0%
PY19RER08	Residential Equipment Replacement	11.0	11.0	100.4%	0.1	0.1	100.2%
PY19RER09	Residential Equipment Replacement	9.7	3.1	32.2%	0.1	0.0	32.2%
PY19RER10	Residential Equipment Replacement	8.3	8.3	100.0%	0.1	0.1	100.0%
PY19RER11	Residential Equipment Replacement	7.5	7.5	100.0%	0.1	0.1	100.0%
PY19RER12	Residential Equipment Replacement	3.1	3.1	100.0%	0.0	0.0	100.0%
PY19RNC01	Residential New Construction	1,232.0	1,196.0	97.1%	13.8	13.4	97.1%
PY19RNC02	Residential New Construction	2,171.6	2,115.4	97.4%	22.5	21.8	96.7%
PY19RNC03	Residential New Construction	1,445.6	1,439.3	99.6%	18.6	18.6	99.7%
PY19RNC04	Residential New Construction	968.3	957.9	98.9%	10.6	10.5	99.1%
PY19RNC05	Residential New Construction	170.9	177.0	103.6%	1.9	2.0	104.0%
PY19RNC06	Residential New Construction	188.7	190.1	100.7%	1.7	1.7	102.1%
PY19RIR01	Residential Retrofit	66.9	67.6	101.0%	0.8	0.8	102.2%
PY19RIR02	Residential Retrofit	83.3	81.1	97.4%	1.1	1.0	97.3%

Appendix B Workplan

Workplan for Technical Assistance with Verification of Vermont Gas Systems Annual Savings Claims – PY2019

March 18, 2020

SUBMITTED TO:
Vermont Department of Public Service

SUBMITTED BY:
NMR Group, Inc.
BrightLine Group

Table of Contents

Section 1 Introduction and Key Issues

NMR Group, Inc. (NMR) and BrightLine Group, collectively referred to as the NMR team, have been retained by the Vermont Department of Public Service (PSD) to provide Technical Assistance with Verification of Vermont Gas Systems (VGS) Annual Savings Claims. This evaluation project includes impact evaluation activities for program year 2019 (PY2019). Final evaluation results for PY2019 will be delivered by August 2020.

In addition to the work plan, attached in Appendix A of this document is the desk review sample plan of all the natural gas programs in the VGS portfolio for PY2019.

1.1 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 PY2019:

- Determine VGS' progress toward several quantifiable performance indicators (QPIs) for the PY2019, 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)
    - QPI #3: Peak Day Mcf Savings
- Develop best in class, transparent, and thoroughly documented evaluations.

1.2 Summary of Evaluation Activities

The NMR team has divided the overall effort into six key tasks for successful completion of the evaluation.

- **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 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 will be 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.

1.3 Summary of Program Data

The VGS staff provided PY2019 tracking data for all the six programs. We reviewed and analyzed the tracking data to determine the program level and measure level gas savings.

Table 1 presents the overall portfolio savings.

Table 1: Overall PY2019 Portfolio Level Savings Summary

Program	Projects	Measures	Annual Mcf	Peak Mcf	Avg Mcf/ Project
Commercial Equipment Replacement	45	47	4,265	43	94.8
Commercial New Construction	21	69	10,282	104	489.6
Commercial Retrofit	38	47	13,216	52	347.8
Commercial Sector	**104**	**163**	**27,763**	**200**	**266.9**
Residential Equipment Replacement	1,567	2,296	18,825	163.5	12.0
Residential New Construction	23	80	10,904	121.5	474.1
Residential Retrofit	2	5	150	1.9	75.1
Residential Sector	**1,592**	**2,381**	**29,880**	**286.8**	**18.8**
Total	**1,696**	**2,544**	**57,643**	**486.4**	**34.0**

We analyzed the measure level savings for each program. As a part of data cleanup, we reviewed the measure end-use and measure description for each project to make necessary modifications. This allowed us to consolidate/standardize some of the measures. For example, the insulation measures were categorized as roof insulation and wall insulation; we combined them to be represented as "insulation" measures. The following tables present the measure-level savings for each program.

Table 2 presents the summary of measure-level savings for the CER program.

Table 2: PY2019 Measure Level Savings – Commercial Equipment Replacement

Measure Type	Counts	Annual Mcf	Peak Mcf	% of Total	Avg Mcf/ Project
Boiler	15	2,629	30.8	62%	175
DHW	6	179	0.6	4%	30
Furnace	18	842	9.9	20%	47
Low Flow Shower Heads	1	9	0.0	0%	9
Oven	3	118	0.3	3%	39
Process	4	487	1.3	11%	122
Total	**47**	**4,265**	**42.9**		

Table 3 presents the summary of measure-level savings for the CNC program.

Table 3: PY2019 Measure Level Savings – Commercial New Construction

Measure Type	Counts	Annual Mcf	Peak Mcf	% of Total	Avg Mcf/ Project
Air Sealing	3	214	2.5	2%	71
Boiler	9	3,362	39.3	33%	374
Controls	4	1,044	12.2	10%	261
DHW	7	516	1.7	5%	74
Fryer	3	366	1.0	4%	122

Furnace	14	715	8.4	7%	51
Heat Recovery	9	2,557	21.6	25%	284
Humidifier	1	309	3.6	3%	309
Insulation	12	901	11.4	9%	75
IR Heater	1	155	1.8	2%	155
Process	5	98	0.3	1%	20
Unit Heaters	1	43	0.5	0%	43
Total	**69**	**10,282**	**104.3**		

Table 4 presents the summary of measure-level savings for the CSR program.

Table 4: PY2019 Measure Level Savings – Commercial Retrofit

Measure Type	Counts	Annual Mcf	Peak Mcf	% of Total	Avg Mcf/ Project
Air Sealing	1	25	0.3	0%	25
Boiler	1	186	2.2	1%	186
Controls	8	651	5.9	5%	81
DHW	1	23	0.1	0%	23
Furnace	1	200	2.3	2%	200
Heat Recovery	3	1,270	14.9	10%	423
Insulation	11	474	5.9	4%	43
Pipe	12	4,067	8.1	31%	339
Process	5	2,518	5.6	19%	504
Steam Traps	4	3,802	7.1	29%	951
Total	**47**	**13,216**	**52.4**		

Table 5 presents the summary of measure-level savings for the RER program. Only the breakdown for custom projects is shown.

Table 5: PY2019 Measure Level Savings – Residential Equipment Replacement

Measure Type	Counts	Annual Mcf	Peak Mcf	% of Total	Avg Mcf/ Project
Boiler	1	34	0.4	12%	34
Controls	1	119	1.4	44%	119
DHW	2	119	0.4	44%	60
Total	**4**	**272**	**2.2**		

Table 6 presents the summary of measure-level savings for the RNC program.

Table 6: PY2019 Measure Level Savings – Residential New Construction

Measure Type	Counts	Annual Mcf	Peak Mcf	% of Total	Avg Mcf/ Project
Boiler	23	3,134	36.1	29%	136
Controls	1	88	1.0	1%	88
DHW	14	1,297	4.3	12%	93
Heat Recovery	13	2,503	29.3	23%	193
Insulation	9	3,482	49.4	32%	387
Low Flow Aerators	13	85	0.4	1%	7
Low Flow Shower Heads	5	240	0.8	2%	48
Oven	1	47	0.1	0%	47
Process	1	29	0.1	0%	29
Total	**80**	**10,904**	**121.5**		

Table 7 presents the summary of measure-level savings for the RIR program.

Table 7: PY2019 Measure Level Savings – Residential Retrofit

Measure Type	Counts	Annual Mcf	Peak Mcf	% of Total	Avg Mcf/ Project
Boiler	1	19	0.2	13%	19
DHW	1	6	0.0	4%	6
Insulation	3	125	1.6	83%	42
Total	**5**	**150**	**1.9**		

Section 2 Approach and Methods

This section defines the workplan for Tasks 2 through 5 in detail. Task 6 (Project Management) is discussed in Section 3.

2.1 Task 2 Participation Tracking Database Review

The first evaluation task will be to obtain and conduct a comprehensive review of VGS' participant data tracking systems. The purpose of the review is to assess data quality, assess the evaluability of each program, and identify potential issues and key measures for examination. We will assess data quality by reviewing which fields are being tracked and how well database fields are populated. This review will check for use of unique identifiers; labeled fields or variables; consistent documentation regarding program participation; household, building, and equipment characteristics and savings calculations; and a codebook to interpret fields and values. We will use this information for multiple evaluation tasks, including sample design for desk reviews and calculating savings.

2.2 Task 3 Sampling Plan Development

Sample design is an important part of the evaluation planning process that enables delivery of meaningful, defensible results. A sampling approach was developed for each of the programs to be evaluated for PY2019 to achieve 80/10 confidence/precision for program level Mcf. Details for the sampling design strategy are provided in the sampling plan memo, included in this workplan as Appendix A.

When sampling, the evaluation budget and rigor need to be balanced based on the value of information (VOI), which focuses budgets and rigor towards the programs/projects with high uncertainty and high impact. While the reported savings numbers on a program-by-program basis vary, it is advantageous to consider the VOI when evaluation efforts may be large.

The ideal magnitude of sample sizes varies as a function of:

- The population of interest
- The objective of sampling
- The inherent variability in the data
- Stratification and analysis techniques

We analyzed the program data and performed the sampling using stratified ratio estimation (SRE). Sampling was conducted using a project as the sampling unit. Error ratios were estimated for each program based on results from the prior evaluation study.

Table 8 summarizes the overall sampling plan.

Table 8: PY2019 Sampling Summary

Program	Projects	Measures	Annual Mcf	Peak Mcf	Sample Size	Relative Precision
Commercial Equipment Replacement	45	47	4,265	43	7	13.0%
Commercial New Construction	21	69	10,282	104	4	7.5%
Commercial Retrofit	38	47	13,216	52	7	9.5%
Commercial Sector	**104**	**163**	**27,763**	**200**	**18**	**5.7%**
Residential Equipment Replacement	1,567	2,296	18,825	163.5	12	11.9%
Residential New Construction	23	80	10,904	121.5	6	7.2%
Residential Retrofit	2	5	150	1.9	2	0.0%
Residential Sector	**1,592**	**2,381**	**29,880**	**286.8**	**20**	**8.0%**
Total	**1,696**	**2,544**	**57,643**	**486.4**	**38**	**5.0%**

2.3 TASK 4 ENGINEERING ANALYSIS, VERIFICATION, & TECHNICAL ASSISTANCE

Good research design begins with in-depth understanding of research objectives. What are the questions that absolutely must be answered and what are the nice to have questions? The best research options for a particular situation vary greatly as a function of the questions of interest, whether the analysis is being done for a new program or for a program that has been in place for a long time, the type of program being evaluated, the evaluation and program budget, the number of program participants, and other factors. These research objectives will be discussed in detail during the kick-off meeting.

As part of the evaluation planning, our team will tailor the specific analysis methods and activities for each program and measure type. In selecting the analysis method for the natural gas energy efficiency measure(s), we will consider prior evaluations for VGS and national-level resources such as the Department of Energy's (DOE) Uniform Measurement Protocols (UMP).

The NMR team will use the following steps to verify the savings:

Documentation Reviews

This step will involve a comprehensive review of VGS' participant tracking data to assess the data quality and evaluability of each program. In addition, this step will help identify any potential issues and potential key measures for focused examination.

Engineering Desk Reviews

Desk reviews will help determine the appropriateness and application of the engineering assumptions and baselines to the gas savings measures. This step will also help assess the accuracy of savings through comparison of project file data with tracking data.

Telephone Surveys

Standalone telephone surveys for a sample of program participants will be conducted to gather project specific operational information for a reliable verification of the energy savings. The surveys will be tailored for each program and will also include a program feedback component.

Billing Analysis

Where appropriate, for specific programs and/or measures, we will conduct billing analysis as a cross-check for reasonableness of the reported savings.

Continuous Review Process

Continuous reporting throughout the evaluation process, using well established procedures and systems, will allow all key stakeholders to understand the progress of the study and be aware of any concerns or observations that arise during the process. In addition, we will share individual site findings and results as they are completed with PSD and VGS staff for preliminary review.

The major activities that our team will include as part of the verification of energy savings are discussed in detail in the following sections.

2.3.1 Desk Reviews

As a first step in the analysis activity, the NMR team will conduct a desk review of sampled projects for which documentation exists. Desk reviews are a critical pre-cursor to conducting customer

surveys and completing further savings analysis activities. The desk review will seek to answer the following questions:

1. Are the data files of the sampled projects complete, well documented, and adequate for calculation and reporting of the savings?
2. Are the calculation methods correctly applied, appropriate, and accurate?
3. 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)?
4. 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?
5. Are all necessary fields properly populated?

2.3.2 Customer Surveys

The NMR team will conduct standalone telephone surveys for a sub-sample of program participants to gather additional project specific operational information for a reliable verification of the energy savings. The telephone surveys will be utilized to gather information on the energy-efficiency measure implemented, the key parameters needed to verify the assumptions to estimate verified energy savings, and any baseline data that may be available from the participant. We will coordinate this effort with the VGS staff.

The NMR team will develop surveys for each program utilizing this approach and will tailor questions to each measure within the program. As part of the survey development, the NMR team will identify the information that we need to perform the impact evaluation tasks and develop appropriate survey questions to gather this information during the telephone conversations. We will test the survey prior to implementation to ensure that the appropriate questions are being asked based on the program the participants participated in and the measure they implemented.

In addition, we will incorporate survey questions to gather limited information for the program feedback, such as satisfaction and awareness. The interviews will be conducted by experienced staff who will also be leading the desk review of their project.

These surveys will include questions to understand the customer's expectations and perceptions of the changes to their natural gas consumption based on the projects implemented and will also attempt to pinpoint adjustments that should be made to the project level analysis. Expected root causes to be explored and questions to help identify them are listed below.

- Issues with operation of rebated equipment
    - When was the equipment installed?
    - How long was the construction period?
    - When did the equipment become fully operational?
    - Were there any setbacks into the startup of the equipment once installed?

    - If so, how were setbacks rectified?
- Changes to customer load due to unrelated equipment
    - What equipment upgrades, if any, have been completed that are unrelated to the rebated equipment since its installation?
    - Have customers successfully phased out any unneeded equipment since the installation of the rebated equipment?
    - Have customers made any major changes to the sequencing of other equipment?
- Changes to operation of facility
    - Have there been any changes to the building footprint?
    - Have there been any significant changes to the number of employees or customers serviced?
    - Have there been any changes to the scheduled operating hours?

2.3.3 Billing Analysis

For some of the programs and/or measures where the changes to the improved technology represent more than a 10% improvement in the premise-level natural gas energy consumption, a comparison of the billing records, prior to and after the equipment retrofit, can be useful to verify the energy savings of the measure. We will utilize this approach as a reasonableness assessment of the reported energy savings. However, in some cases, this approach may produce the best estimate of the energy savings. In using this approach, special consideration needs to be made for:

- Completeness of billing data
- Weather normalization
- Non-routine events (NRE) or baseline adjustments in the baseline or retrofit periods
- Energy code or manufacturing standard correction
- Exogeneous influences

We will determine if and when this approach can be considered a method to verify savings as compared to a method for reasonableness assessment only, due to the constraints of this method. This will be possible after the actual sample is selected, and the measures included in the sample have been reviewed.

2.3.4 Engineering Analysis

Once information is collected regarding the premise characteristics, baseline conditions and operating characteristics of improved technology, our team will conduct an independent analysis of the energy savings as a verified outcome. These parameters would include, but not be limited to:

- Hours of operation; before and after
- Baseline equipment efficiency; before and after
- Presence of energy recovery systems
- Advanced operational controls and feedback
- Secondary parameters, such as insulation, water consumption, etc.
- Interactive factors with other end-uses and fuels

Algorithms will be established for each specific measure through consideration of nationally and industry recognized sources, such as technical reference manuals, DOE UMP, ASHRAE, etc.

Our team will roll-up the project level savings to an annual program level for regulatory verification purposes. The roll-ups will occur in accordance with the sampling plan, utilizing project weights and/or stratification tiers, as needed.

2.4 TASK 5 REPORTING AND DELIVERABLES

The reporting of the final evaluation results in a clear and concise manner is an integral part of the evaluation process and audit. Consistent reporting throughout the evaluation process will allow all key stakeholders to understand the progress of the study and be aware of any concerns or observations that arise during the process. We have systems in place that we will modify for effective project management, reporting, and maintaining frequent communications on project status, findings, and other relevant information with project stakeholders.

The draft and final Evaluation Report will be submitted by the July and August deadlines agreed upon during the development of this evaluation workplan and will satisfy all reporting requirements. The NMR team will report savings for each program and for all programs combined. Reports will include the following data for each program and combinations of programs so that information is reported by end-user market sector (residential and commercial):

- Annual Mcf savings
- Coincident Peak day Mcf reduction
- Total Resource Benefits (Costs)

Savings estimates will be reported both as a point and as a range with upper and lower bounds on the point estimate. The range will be reported at the 80% confidence interval, and the precision for each point estimate will also be reported.

The reports will contain a complete description of the evaluation plan, the evaluation activities, and the findings. They will contain all documentation reasonably needed to follow the analysis, starting with each measure and project in the sample, up to the final realization rates and their application to the final reported savings.

Finally, all project data collected in our project shall be entered into a mutually agreed on electronic MS-Access database and/or collection of Excel workbooks and provided to PSD to support additional analysis and future evaluations.

The NMR team will plan on meeting the PSD and VGS staff to discuss the findings and recommendations from the evaluation and to help implement the recommended changes.

Section 3 Project Management

This section presents our approach to managing the project and schedule, which will include all major data collection and analysis activities, milestones, and deliverable due-dates.

3.1 Project Management Framework

Through careful planning, hard work, and clear communication, the NMR team's goal is to produce findings that enhance the implementation and evaluation processes, support program innovations and continuous improvement, and facilitate regulatory reporting requirements. Yogesh Patil of NMR will be 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, sub-contractor to NMR, who will have key responsibilities within each task.

The NMR team has systems in place for effective project management, reporting, and maintaining frequent communications on project status, findings, and other relevant information with project stakeholders. We will proactively implement and promote a multi-pronged approach to ensure that the PSD, VGS, the NMR team, and other project stakeholders work together, are kept fully apprised of important developments, and are participants in the project through feedback. Specifically, our project manager will take the following steps:

- Set up and facilitate regularly scheduled bi-weekly meetings during the period from March 2020 through July 2020,
- Set up and facilitate ad hoc meetings as needed,
- Be responsible for ensuring that all communications are disseminated to all appropriate parties, and

The PSD and VGS staff will have the opportunity to review and provide feedback on the site results and findings on a continuous basis. Additionally, as part of the check-in meetings, the NMR team will keep the PSD and VGS apprised of all on-going activities as well as anticipated activities to be conducted during the upcoming month, and review the status of data requests, and any needed approvals or review from the PSD and/or VGS.

To ensure effective and on-time completion of tasks, and delivery of high-quality deliverables, our project management best practices to manage the project team includes:

- The clearly defined work plan and detailed schedule to guide the functional teams in effective planning towards deliverables.
- A dedicated project manager who will oversee and track progress of tasks against the schedule and budget. The project manager will pro-actively identify potential project management issues, such as a delay in a task, and develop strategies to prevent or mitigate the impact.
- Project management tools are used effectively to schedule resources and track project progress. The project manager will update the project management tools at least weekly

to plan, track, and allocate resources to tasks. The project manager will coordinate the allocation of resources with the total project team.

- Internal project meetings with the project team, including sub-contractor Brightline, to ensure the project team is informed about resource allocation, potential project management issues are pro-actively identified, and mitigation strategies are developed and implemented.

3.2 PROJECT SCHEDULE

Table 9 provides a revised agreed upon schedule. This schedule is consistent with the requirements stated in the contract.

Table 9: Project Schedule

Description	2020						
	Feb	Mar	Apr	May	Jun	Jul	Aug
Kick-off meeting							
Work plan							
Tracking data review and analysis							
Sampling plan							
Desk reviews							
Telephone surveys							
Aggregate analysis							
Draft report							
Final report							
Results presentation							

Appendix A Sampling Plan

The purpose of this section is to present the desk review sample design for all the natural gas programs in the Vermont Gas Systems (VGS) portfolio.

For the verification of gas savings, the planned evaluation will include desk reviews for a representative sample of participants that have measures with natural gas savings the programs under the VGS umbrella. Measures installed through the following programs will be evaluated:

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

We are using stratified ratio estimation (SRE) to improve precision and minimize sample sizes. The Vermont Department of Public Service (PSD) guidelines require 80/10 confidence and relative precision for the gross saving at the program level.

Each part of the sample design is described briefly in this section.

A.1 Sample Frame

The sample frame for PY2019 sampling includes all VGS participants who have completed natural gas savings projects from January 1, 2019, through December 31, 2019. Similar to the previous evaluation, we filtered out the smallest projects accounting for the bottom 4% of savings for each segment for exclusion from the sampling frame.

For RNC program, only the custom projects (a total of 23 projects) were selected. The remaining projects were completed in partnership with Efficiency Vermont (EVT) and hence will be excluded.

Both the RER and RIR programs were recently evaluated and each had two custom projects. All the custom RER and RIR projects will be included in this evaluation.

A.2 Method

We used SRE since it allows for efficient sampling design and generally requires a lower sample size for a targeted level of precision if there is a strong correlation between the program reported savings and the verified gross savings. SRE generally works well for estimating realization rates (RR) because there usually is a strong correlation between these two variables and hence is commonly used in energy efficiency program evaluations. This is consistent with the sampling approach adopted during the previous evaluation.

A.3 PRIMARY SAMPLING UNIT

The sampling unit is a project. For example, if a single site hosts two projects, each is a different sampling unit. Conversely, if a single project application covers installation at two different sites, then both of those sites will be a single sampling unit. However, we did not observe such instances. A single project may contain multiple measures. All these measures will be evaluated.

A.4 ERROR RATIO

The error ratio expresses the level of variation between the RR for each verified project and the sample's mean RR. This factor is used to predict the anticipated variability of the RRs associated with a given program. For the 2019 program year sampling we referred to the error ratios from the previous efforts (2017 and 2018 studies). Table 10 below presents the error ratios obtained from the previous two studies and the ones used in the sample design.

Table 10: Sample Design Error Ratios and Error Ratios from Previous Reports

Program	PY 2017	PY 2018		PY 2019
	Evaluated Error Ratio	Design Error Ratio	Evaluated Error Ratio	Design Error Ratio
Commercial Equipment Replacement (CER)	0.54	0.50	0.30	0.50
Commercial New Construction (CNC)	0.15	0.30	0.16	0.30
Commercial Retrofit (CSR)	0.69	0.70	0.22	0.70
Residential Equipment Replacement (RER)	n/a	0.50	0.07	0.50
Residential New Construction (RNC)	0.57	0.60	0.08	0.60
Residential Retrofit (RIR)	0.11	0.30	n/a	0.30

For CER and CSR programs, the previous evaluation found higher error ratios for PY2017 and PY2018 than those used in the corresponding previous sample design. As a result, we chose the error ratio of 0.5 and 0.7 for CER and CSR respectively to account for the variability though a larger sample. For CNC, the error ratio achieved was found to be 0.15 for PY2017 and 0.16 for PY2018 which is low. Although we do not anticipate any major changes to the CNC program from PY2018 to PY2019, we chose to use a more conservative value, 0.3, as the error ratio in the sample design. Similar logic was applied in selecting error ratios for the residential programs.

A.5 STRATIFICATION VARIABLES

Two levels of stratification were used in the sample design. The upper-level stratification was conducted at the program level. As a result, the sample design had six upper level strata: 1) CER, 2) CNC, 3) CSR, 4) RER, 5) RNC, and 6) RIR.

Level of reported project savings (or size) was used as the lower-level stratification variable. Given the number of projects, we defined three size strata for the commercial programs and the RNC

program. The RIR program involved only one custom project which was chosen as the census stratum.

The strata cut-offs were established using the method described in the *2004 California Evaluation Framework*. First, for each program, the smallest projects accounting for 4% of the total savings were designated into a separate lower-level stratum. This is typically done to concentrate the sample on the (larger) projects with the greatest influence on program RRs and to decrease the project counts that go into the sample design.

Second, we separated the largest projects in each of the programs (except RER and RIR) into a certainty (census) stratum. All projects in these strata are automatically selected as the sample.

Third, the remaining strata were designated such that the sum of the annual gas savings for each lower-level stratum was approximately equal. The sample was then equally distributed across all strata. The sample size calculations consider the finite population correction factor.

For RER and RIR programs, we are only evaluating four custom projects (two RER and two RIR). All the custom projects were considered as a certainty stratum.

A.6 SUMMARY

Table 11 presents the overall sample design for the defined sample frame indicating the sample sizes and the anticipated precision for all the programs.

Table 11: Overall Sample Design PY2019

Program	Strata	Annual Mcf	# Projects	% Savings	Error Ratio	Sample Size	Relative Precision
Commercial Equipment Replacement	Census	1,500	3	35%	0.35	3	0%
	1	1,314	8	31%	0.35	2	27%
	2	1,299	24	30%	0.35	2	30%
	3	152	10	4%	n/a	0	n/a
CER Total		**4,265**	**45**			**7**	**13.0%**
Commercial New Construction	Census	5,377	2	52%	0.20	2	0%
	1	4,498	12	44%	0.20	2	17%
	2	407	7	4%	n/a	0	n/a
CNC Total		**10,282**	**21**			**4**	**7.5%**
Commercial Retrofit	Census	5,120	3	39%	0.30	3	0%
	1	3,797	4	29%	0.30	2	19%
	2	3,824	16	29%	0.30	2	25%
	3	475	15	4%	n/a	0	n/a
CSR Total		**13,216**	**38**			**7**	**9.5%**
Commercial Sector		**27,763**	**104**			**18**	**5.7%**
Residential Equipment Replacement	Census	272	2	1%	0.30	2	0%
	1	8,986	318	48%	0.30	5	17%
	2	8,999	944	48%	0.30	5	17%
	3	568	303	3%	n/a	0	n/a
RER Total		**18,825**	**1,567**			**12**	**11.9%**
Residential New Construction	Census	5,818	4	53%	0.20	4	0%
	1	4,651	10	43%	0.20	2	16%
	2	436	9	4%	0.20	0	n/a
RNC Total		**10,904**	**23**			**6**	**7.2%**
Residential Retrofit	Census	150	2	100%	n/a	2	0%
RIR Total		**150**	**2**			**2**	**0.0%**
Residential Sector		**29,880**	**1,592**			**20**	**8.0%**
Overall Portfolio		**57,643**	**1,696**			**38**	**5.0%**