Clean Energy Fund New Construction Program

Commercial and Multifamily Direct Impact Evaluation

Final Report

Prepared for:

New York State Energy Research and Development Authority
Albany, NY

Althea Koburger
Project Manager, NYSERDA

Prepared by:

DNV

Katy, TX

Corporate Headquarters: Katy, TX

Mersiha McClaren, Principal, DNV

Sue Haselhorst, Sr. Principal, DNV

Tom Ledyard, Sr. Principal, DNV

Vijay Gopalkrishnan, Senior Engineer, DNV

Shruti Rose James, Energy Engineer, DNV

NYSERDA Contract 165541A

March 2025

Record of revision

Report Title
Clean Energy Fund New Construction Program Commercial and Multifamily Direct Impact Evaluation – Phase Two March 2025

Revision Date	Description of Changes	Revision on Page(s)
March 12, 2025	Original issue	N/A

Notice

This report was prepared by the DNV Evaluation Contractor Team in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority (hereafter "NYSERDA"). The opinions expressed in this report do not necessarily reflect those of NYSERDA or the state of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, NYSERDA, the state of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service or the usefulness, completeness, or accuracy of any processes, methods, or other information contained, described, disclosed, or referred to in this report. NYSERDA, the state of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe on privately owned rights and will assume no liability for any loss, injury, or damage resulting from or occurring in connection with the use of information contained, described, disclosed, or referred to in this report.

NYSERDA makes every effort to provide accurate information about copyright owners and related matters in the reports we publish. Contractors are responsible for determining and satisfying copyright or other use restrictions regarding the content of reports that they write, in compliance with NYSERDA's policies and federal law. If you are the copyright owner and believe a NYSERDA report has not properly attributed your work to you or has used it without permission, please email print@nyserda.ny.gov.

Information contained in this document, such as web page addresses, are current at the time of publication.

Table of contents

List of figures

List of tables

1 Introduction

This section presents a program description, the study goals, and a summary of the evaluation approach.

1.1 Program description

NYSERDA's New Construction Program (NCP) provides funding for commercial, low-rise residential (single-family, multi-unit, and multifamily), high-rise multifamily, and institutional customers that pay into the System Benefits Charge Program (SBC). Past and current programs in the market include:

- The Low-Rise Residential New Construction Program (PONs 2309 and 3717)
- The Multifamily New Construction Program (PONs 3319 and 3716)
- The New Construction – Housing Program (PON 4337)
- The Commercial New Construction Program (PON 1601)
- The New Construction – Commercial Program (PON 3609)
- The Buildings of Excellence (BOE) Competition (RFP 3928)
- The Building Cleaner Communities Competition (previously known as the Carbon Neutral Community Economic Development Program)
- Building Better Homes Program (PON 5765)
- The Net Zero Portfolio Support Program (PON 3943)

These PONs are summarized in Appendix B.

The New Construction Program also engages in other services that provide market support (i.e., PON 3771). All these efforts aim to accelerate the market adoption of efficiency, electrification, energy storage, renewables, and electric vehicle charging infrastructure in new construction, gut renovation, and adaptive reuse buildings. The overall goal of these programs is to move the market to pursue and ultimately achieve carbon-neutral or net zero energy performance one to three code cycles before such code requirements are required. At the time of scoping, it was noted that the New Construction Program was shifting priorities, with future programmatic efforts aimed at incentivizing project planning and early design stages in all-electric projects.

In the housing programs, owners or developers and their design teams can apply to NYSERDA for whole-building incentives in addition to targeted financial and technical support. The applicants are generally expected to include a NYSERDA-approved Primary Energy Consultant in their project team to act as the primary technical resource for their participation. However, participants may use a consultant of their choice, subject to NYSERDA review and approval. The applicants in the New Construction Housing programs are also expected to select and comply with the third-party performance standard they intend to rely on to guide their project's design and construction. NYSERDA accepts multiple third-party

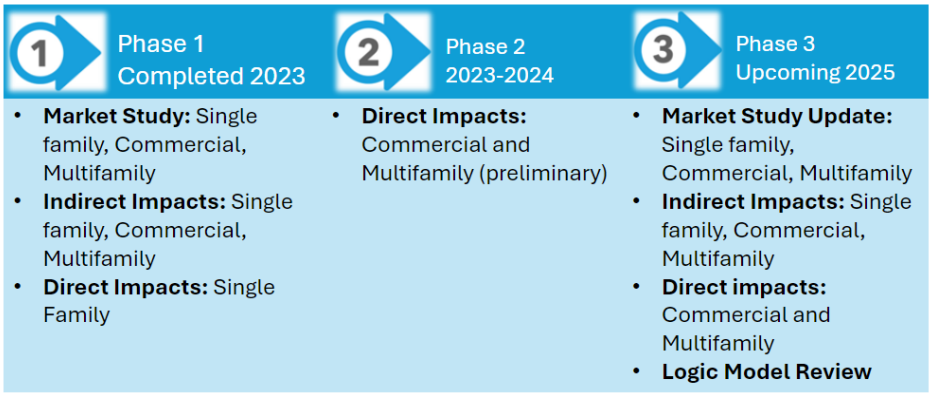
performance standards for housing projects, including ENERGY STAR® programs and the Phius (Passive House Institute US) and Passive House Institute (PHI) standards. Applicants identify their projects as either Low to Moderate Income, which is eligible for additional incentives, or Market Rate as part of the application process.

The Commercial New Construction Program offers technical and financial support to building owners to effect a permanent transformation in the way new and substantially renovated buildings are designed and constructed in New York. This support includes cost-shared technical support to help applicants, and their design teams assess and determine the most applicable energy efficiency opportunities for the building. Applicants can use a NYSERDA-approved Primary Energy Consultant or their own (with NYSERDA approval) to produce an energy model following the ASHRAE 90.1 Appendix G standard to verify that the project will meet the program's source energy savings threshold. Supplemental technical support is available for applicants pursuing a deep energy savings or zero net site energy project.

1.2 Overall evaluation plan and impact methodology summary

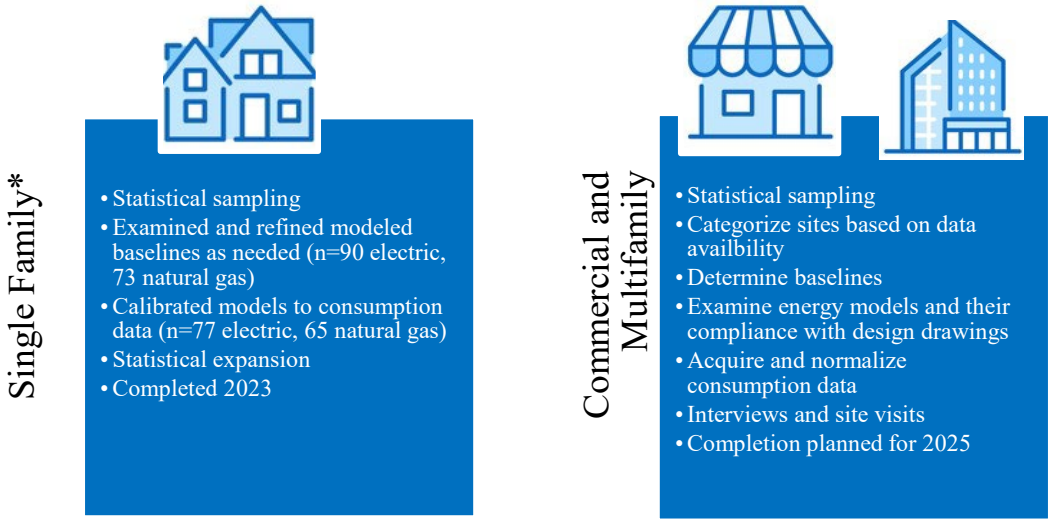
This report covers Phase Two of three total phases of evaluation, as illustrated in Figure 1-1. The three phases were designed to cover program activity in the PONs cited above from 2016 to 2023. The phased approach allowed for a shift in evaluation focus between sectors as participant numbers fluctuated. This staged approach also provided an intervening program period between a market baseline assessment in Phase One and the update to baseline in Phase Three. In Phase One, the evaluation covered direct impacts around single-family activity as well as an indirect impact assessment among single-family, commercial, and multifamily and the market baseline study. This second phase provides a preliminary assessment of direct impacts for commercial and multifamily sectors. Finally, Phase Three will provide the baseline update mentioned earlier, final commercial and multifamily direct impact estimates, and updated indirect impacts for all sectors. A logic model review will also be performed, with a focus on whether paths and metrics to indirect savings are clear.

Figure 1-1. Overall evaluation plan phases



Direct impacts for multifamily and commercial sectors are the focus of the Phase Two report. Figure 1-2 shows the methods used here as well as those used for single-family in Phase One. Although single-family is not included in this report, it is included in the graphic to capture the methods and status of all direct impact work together. Phase Two methods include a statistical sample and selection of participants, assessment of baseline appropriateness and application, energy model accuracy and adherence to drawings, acquisition and analysis of consumption data, and participant interviews with a subset of site visits. Details on each method used can be found in Section 3, Methods.

Figure 1-2. Direct impact methods summary by sector



**Single-family impact results were provided in June 2022 as part of Phase One work with a follow-up single-family baseline review with updated VGS RRs completed on May 25, 2023.*

1.3 Impact evaluation objectives

The commercial and multifamily sectors are the focus of the impact effort in this phase of study. Table 1-1 is excerpted from the evaluation plan and provides the objectives, evaluation questions, and overview of data and methods completed.

Table 1-1. NCP evaluation objectives, research questions, and data sources

Objective	Evaluation questions	Data sources and analytic methods
Evaluate verified gross energy impacts	What is the annualized evaluated gross energy savings based on electric (kWh) and fuel savings (MMBtu) at customer sites?	Energy modeling (IPMVP Option A or D) with inputs from survey data, secondary data, billing data, and operational data supplied by building control systems (Impact Contractor)
Verified gross savings realization rate (VGS RR)	What is the ratio of the sum of evaluated savings divided by the sum of the program-reported savings?	Statistical expansion of sample results to final population of program activity (Impact Contractor)

Note that the verified gross savings realization rate (VGS RR) provided in this report is relative to the official scorecard savings submitted by NYSERDA for the projects in the population used in this study. Also note that the VGS and VGS RR are expected to be interim results pending completion of the third (final) phase of this study.

2 Results, key findings, and recommendations

While all three sectors in the NCP will be evaluated over the three-year contract period, the commercial and multifamily sectors are the focus of this report.

2.1 Multifamily and commercial program tracking activity

This section provides the scorecard annual electric and natural gas savings by program type (commercial, multifamily) including the status of project activity at the time of sampling. One multifamily site had a significant change to its claimed savings partway through Phase Two, which resulted in its gross natural gas savings being revised from 21,635 MMBtu to 892 MMBtu. This revision appeared to be a transcription error that was observed in the evaluation sample. Following this finding, NYSERDA reviewed all other sites in the population for each sector for similar errors and revised the gross and scorecard savings as appropriate. Only one multifamily site (the site that prompted the review) within the sample frame was affected due to this review.

The sample frame, at the time of selecting the statistically significant study sample from 2016–2022 in the multifamily or commercial sector, included 228 projects that account for 35,039 MWh of electric savings and 227,194 MMBtu of natural gas savings, as indicated in Table 2-1.

Table 2-1. Preliminary Phase Two population

Sector	Projects	Electric savings (MWh)	Natural gas savings (MMBtu)
Multifamily	170	15,821	148,515
Commercial	58	19,218	57,936
Total	228	35,039	227,194

After selecting the study sample, three sites were determined to be Level 1 Support sites, which represent projects supported by NYSERDA through its design phase, but not thereafter. As they require a different evaluation methodology, all level 1 Support projects were removed from the Phase Two sample and will be included in the Phase Three scope of work pending further discussion with NYSERDA as part of that scoping effort. This resulted in the removal of 18 commercial sites with 781 MWh of electric savings and 400 MMBtu in natural gas savings. As shown in Table 2-2, removing those sites provides a final population of 210 projects with 34,258 MWh and 206,051 MMBtu of gross savings. This is the population to which the sample was ultimately expanded in order to estimate gross savings.

Table 2-2. Final Phase Two population

Sector	Projects	Electric savings (MWh)	Natural gas savings (MMBtu)
Multifamily	170	15,821	148,515
Commercial	40	18,437	57,536
Total	210	34,258	206,051

Figure 2-1 shows the status[1] of multifamily and commercial projects at the time of sampling for Phase Two, including Level 1 Support project sites. The top bar shows the number of completed projects in the population for the Phase Two sample frame. The following two bars show the number of projects either approved or pending approval. The NYSERDA tracking system shows a strong backlog of program activity for both sectors, with 284 commercial projects and 139 multifamily projects approved or pending approval. Phase Three will sample from activity from these status groups that have been completed through 2023. Note that one commercial project had a status of submitted and one multifamily site had a status of closed, neither of which are included in this figure or the Phase Two sample frame.

Figure 2-1. Status of projects in Phase Two data

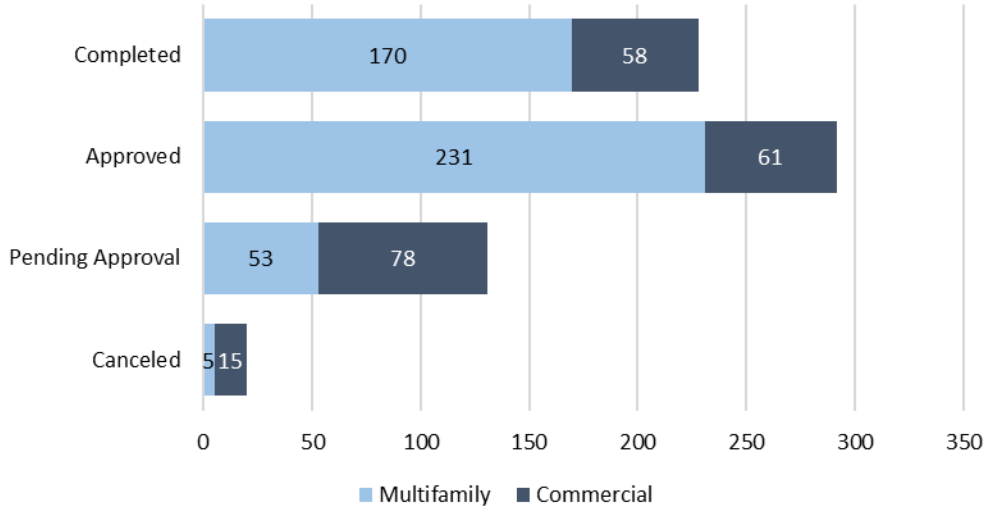
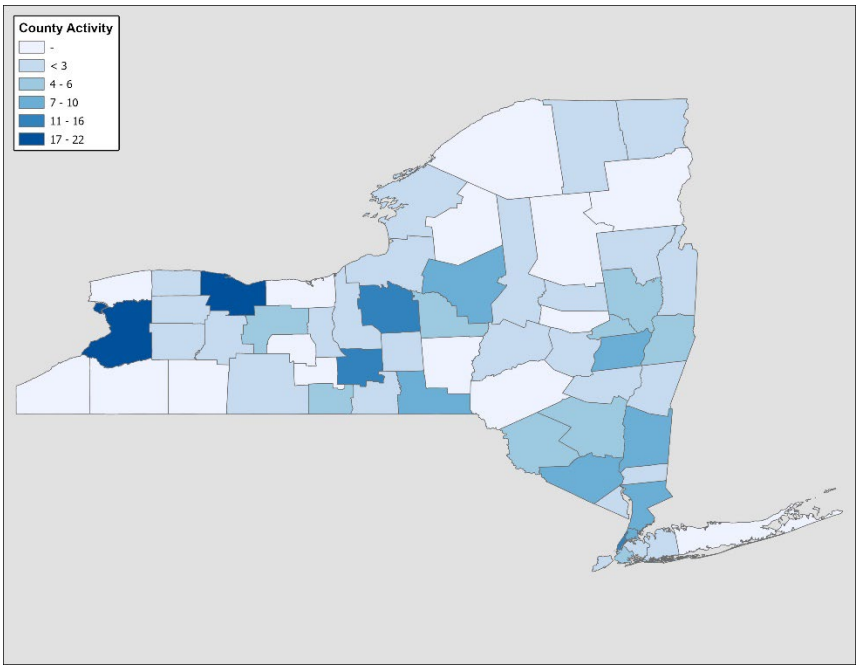


Figure 2-2 shows program activity (number of projects) by county. Participation is spread across 46 counties (out of 62 in NYS), ranging from 15 counties with one project each to up to 22 in Monroe County around Rochester. This program interfaces with the market through builders that construct commercial and multifamily facilities to efficiencies beyond standard code requirements. The heaviest

[1] Pending Approval means the project has been approved by program staff, but a contract hasn't been executed yet. Canceled means the project was canceled before it could be completed.

program activity is in counties with high populations and economic activity, including Onondaga (Syracuse), Monroe (Rochester), Erie (Buffalo), and New York (Manhattan).

Figure 2-2. 2016–2022 completed multifamily and commercial projects by county



2.2 Site-level savings adjustments

This section of the report provides the results around each stage of determining the verified gross savings for sampled sites. An overview of the methods used and more details on the actions performed in each step is included in Section 3.2, Methodology overview. The first stage of determining impacts was categorizing sampled sites based on information availability (Table 2-3). Out of the 63 sampled sites, most projects (43) had functioning simulation models and backup documentation, but roughly a third of sites (15) did not. Two sites used a spreadsheet analysis method to determine gross savings, and three sites were determined to be Level 1 support projects. As previously noted, it was decided that these three sites were not ready to be evaluated, and they were removed from the Phase Two sample and are planned for inclusion in Phase Three. A list of the building simulation software programs used in Phase Two can be found in Appendix D, Sample savings model types and other gross savings methods.

Table 2-3. Categorization of sampled sites

Project categorization	Count of projects
a. Projects with functional building simulation models and backup documentation	43
b. Projects with backup documentation with no or non-functional building simulation models	15
c. Projects with no documentation or models, with only tracking savings [a]	0
d. Projects that did not use a building simulation model to calculate savings	2
e. Level 1 support projects (not addressed in this phase)	3
Total	**63**

a. Projects initially categorized as a 'c' were eventually reallocated as data became available. The Evaluation Contractor Team left this category in the table to accommodate any Phase 3 sites that fall in it in the next round of reporting.

2.2.1 Baselines and code compliance results

An analysis of correct New York State Energy Conservation Code (ECC) application was performed for sites in the sample. Code was determined to be correctly applied for all commercial sites and all but three of the multifamily sites.[2] Two of these multifamily sites used 2016 NYS ECC code but should have used 2020 NYS ECC, and one used 2010 NYS ECC but should have used 2016 NYS ECC. Table 2-4 shows these sites and the impact of the code used to revise the verified gross savings estimates. They are all low-rise multifamily sites.

Appropriate energy codes were applied in the gross savings estimates in nearly all cases.

Table 2-4. Impacts of revised code on selected sites

Sector	Code used	Correct code	Impact
Multifamily Low-Rise	2016 NYS ECC	2020 NYS ECC	1.7% site energy adjustment
Multifamily Low-Rise	2016 NYS ECC	2020 NYS ECC	1.7% site energy adjustment
Multifamily Low-Rise	2010 NYS ECC	2016 NYS ECC	24% site energy adjustment

2.2.2 Energy model compliance with project documentation results

For sites with functional energy models, the Evaluation Contractor Team ran the baseline and proposed energy models and compared the model results to the values reported in the project documentation. Some

[2] The Evaluation Contractor Team was unable to determine the correct application of code for three projects because the application/installation dates were too close to the code switchover point to estimate the appropriate codes. These sites are assumed to have the correct code applied.

sites used PHPP and WUFI, which finds the project's performance (and not a baseline). For these sites, the team verified the appropriate baseline code was applied using a locked spreadsheet-based tool. A spreadsheet based whole building performance calculator provided in project documentation from Salesforce was used to review the proposed design.

This documentation included a combination of reporting files, including Technical Assistance (TA) reports, ENERGY STAR spreadsheets, and model output files. The ratio between the modeled and reported electric and natural gas consumption is called the modeled-to-reported ratio. Overall, the Evaluation Contractor Team found that the modeled-to-reported ratios were close to 100%. Only one commercial site showed a notable discrepancy between the model and the reported data. The modeled-to-reported ratio was applied as an adjustment to projects that had project documentation but no functional models (Category B defined in Table 2-3). The Evaluation Contractor Team opted to not apply the commercial ratios to the remaining commercial projects because they were based on a single outlier project. The remaining commercial projects were found to have a modeled-to-reported ratio close to 100%.

Nearly all energy models were consistent with supporting program documentation.

Table 2-5. Baseline vs. proposed modeled-to-reported ratios

Program	Baseline modeled-to-reported ratios		Proposed modeled-to-reported ratios	
	MWh	MMBtu	MWh	MMBtu
Commercial New Construction	110%	93%	101%	78%
High-Rise New Construction	100%	100%	100%	100%
Low-Rise New Construction	99%	100%	99%	100%

2.2.3 On-site and technical interview results

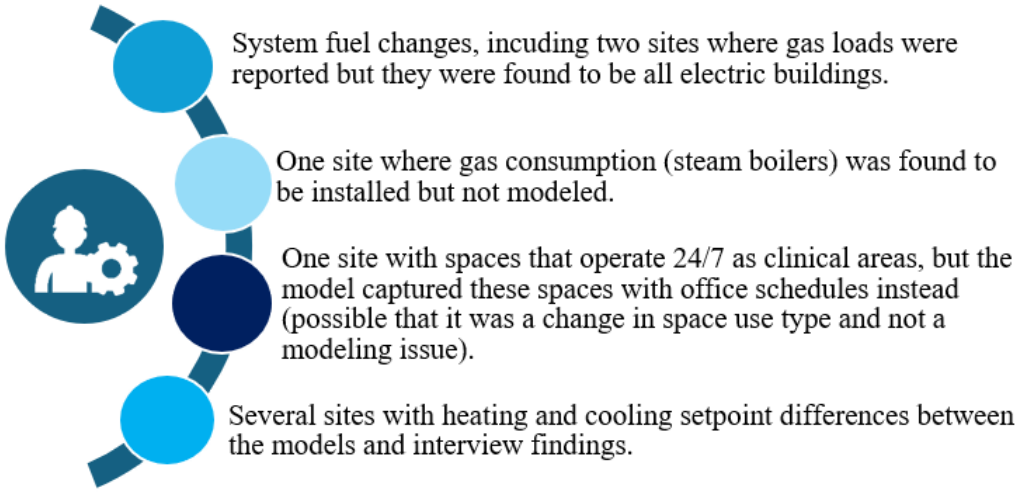
Eighteen multifamily and 11 commercial sites had technical interviews performed; a subset of five sites also received an on-site visit. These activities are further discussed in Section 3.4.6, Customer technical interviews and -site visits. These activities were used to gather information to understand and refine discrepancies between modeled and weather-normalized consumption data. Information gathered and reviewed included nameplate details for key equipment, operating schedules for lighting and mechanical equipment, operating setpoints, as-built construction documents, and, when available, field verification or commissioning reports. Most systems

Most systems and operations were installed as reported. Discrepancies observed included fuels used, equipment differences, setpoints, and space use.

and operations reviewed in the interviews and on-sites were found to be installed as reported in project files.

While minor observations were made in the technical interviews and on-site visits (such as HVAC efficiencies, HVAC setpoints, lighting power densities, and envelope U-values), Figure 2-3 shares some of the more substantial high-level findings. These findings include two sites where modeled natural gas loads were found to be electric instead of natural gas, a site where a change in space use was observed, and five sites with system and equipment setpoint changes.

Figure 2-3. High-level technical interview and on-site findings



2.2.4 Billing data weather normalization results

For sites with billing data, the Evaluation Contractor Team calculated as-built weather-normalized electric and natural gas consumption. The team calculated the ratio between the weather-normalized consumption data and the proposed model consumption data (or reported proposed model output consumption, if models were not available). This ratio is referred to as the billed-to-modeled ratio. The billed-to-modeled ratio was calculated separately for each of the three project sectors, i.e., low-rise multifamily, high-rise multifamily, and commercial. As shown in Table 2-6, the electric billed data was found to consistently be higher than the modeled data in all three sectors. The natural gas usage was found to be higher than modeled for commercial sites, and slightly lower for the two multifamily sectors.

> Electric billed data was found to consistently be higher than the modelled data in all sectors. Natural gas usage was found to be higher for commercial sites and slightly lower for multifamily.

Table 2-6. Billed-to-modeled ratio results

Sectors	Proposed billed-to-modeled ratio	
	MWh	MMBtu
Commercial New Construction	114%	117%
High-Rise New Construction	117%	91%
Low-Rise New Construction	102%	92%

2.2.5 Calculation of overall interim realization rates and VGS RR

Figure 2-4 shows a scatterplot of the NYSERDA gross electric savings versus evaluated savings for each site in the sample. The heavy, dark solid diagonal line shows where all points would fall if the verified gross savings for each sample point were the same as the gross savings estimated by NYSERDA (i.e., a 100% realization rate). The blue dashed line shows the electric realization rate developed by expanding the sample to reflect total program electric impacts. Although there is some scatter along the 1:1 reference line, this did not have a significant impact on the interim electric realization rate, with an estimate of 100.8% ±5.8% relative precision at the 90% confidence interval.

> The interim electric realization rate is 100.8% ±5.8% relative precision at the 90% confidence interval.

Three sites are notable in the scatterplot, though their impacts largely offset one another (highlighted in Figure 2-4 in light blue). The site well above the reference line with a verified gross savings of 2,618 MWh versus gross savings of 1,723 MWh was the result of a discrepancy between the gross savings and modeled/reported savings. The rightmost site below the reference line, with a verified gross savings of 2,259 MWh versus gross savings of 3,371 MWh, is due to a discrepancy in the engineering analysis associated with an error in the spreadsheet-based analysis of lighting measures. The third site with verified gross savings of 1,527 MWh versus gross savings of 2,124 MWh was due to updated baseline chiller efficiencies and roof and wall insulation U values in the energy model due to discrepancies that were identified during the energy model review for this site.

Figure 2-4. Electric gross vs verified gross savings scatterplot

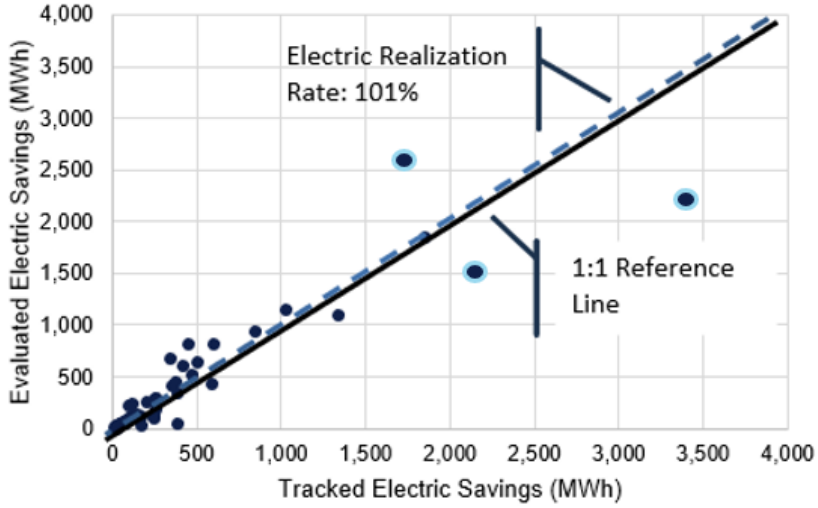


Figure 2-5 shows a scatterplot of the NYSERDA gross natural gas savings versus verified gross savings for each site in the sample. As with the electric savings figure, the heavy dark solid diagonal line shows where all points would fall if the verified gross savings for each were the same as that estimated by NYSERDA (i.e., a 100% realization rate). The blue dashed line shows the natural gas realization rate developed by expanding the sample to reflect total program electric impacts. The natural gas realization rate is 112.3% ±8.1% relative precision at the 90% confidence interval.

> The interim gas realization rate is 112% ±8.1% relative precision at the 90% confidence interval.

Several sites with blue highlights are of particular interest on this scatterplot. Two natural gas sites, well above the reference line with verified gross savings of 17,018 MMBtu versus gross savings of 8,790 MMBtu and verified gross savings of 8,760 MMBtu versus gross savings of 3,069 MMBtu, were the result of significantly higher natural gas usage than modeled or reported. Facility staff from both facilities indicated that the natural gas-fired boilers run significantly more than modeled to serve humidification and reheat loads. Since the billing data analysis for these sites was conducted after the site technical interviews, these two sites will be revisited in Phase Three and, through additional site visits and interviews, the savings calculations and estimates will be reviewed and updated as needed to ensure that the final estimate of verified gross savings are being captured appropriately for them. Other site-specific items of note include:

- *One project with verified gross savings of 7,200 MMBtu versus gross savings of 545 MMBtu.* At this site, neither the deemed savings estimates nor model run results matched the gross savings. Project documentation supported a gross savings estimate of 5,822 MMBtu, which is about 10 times higher than the found gross value. Using the project documentation and energy model as the basis for evaluated savings drove the increase in savings for this site.

- *One project with verified gross savings of 8,641 MMBtu versus gross savings of 4,621 MMBtu.* At this site, the deemed savings estimate results matched the gross savings. The energy model savings was also similar in magnitude to the deemed savings estimates, and the model was found to be accurate based on the project files provided. This site could not be reached for an interview. Since no other factors explained the increased natural gas usage, the increased usage was attributed to increased operation of natural gas equipment, which also increased the baseline natural gas usage. This is the reason for the increased savings for this project.
- *One project with verified gross savings of 5,237 MMBtu versus gross savings of 7,278 MMBtu.* At this site, no functional energy models were provided, but the project documentation was reviewed and found to be reasonable. The billed natural gas usage is less than the reported usage, and since no other factors explain the reduced usage, it was attributed to decreased operation of natural gas equipment. This reduction was applied to the baseline natural gas usage, and consequently, the savings for this project reduced.
- *One project with verified gross savings of 1,132 MMBtu versus gross savings of 3,540 MMBtu.* At this site, the deemed savings estimate results matched the gross savings, however, the energy model savings were significantly lower than the gross savings. The energy model was reviewed and found to be accurate based on the project files reviewed. Hence, the energy model savings were used as the basis for the evaluated savings, thereby reducing the verified gross energy savings for this project.
- *One project with verified gross savings of 3,090 MMBtu versus gross savings of 6,871 MMBtu.* This project did not have functional model files, and so, the project documentation was reviewed. The primary driver for reduced savings for this project was primarily attributed to the incorrect application of baseline energy code. The applicant used a 2010 code baseline; however, a review of the project documentation identified the 2016 code baseline should have been used for this project. Adjusting the baseline for this project to the correct code reduced the energy savings for this project. This site was discussed earlier in Section 2.2.1, Baselines and code compliance results.

Figure 2-5. Natural gas gross vs verified gross savings scatterplot

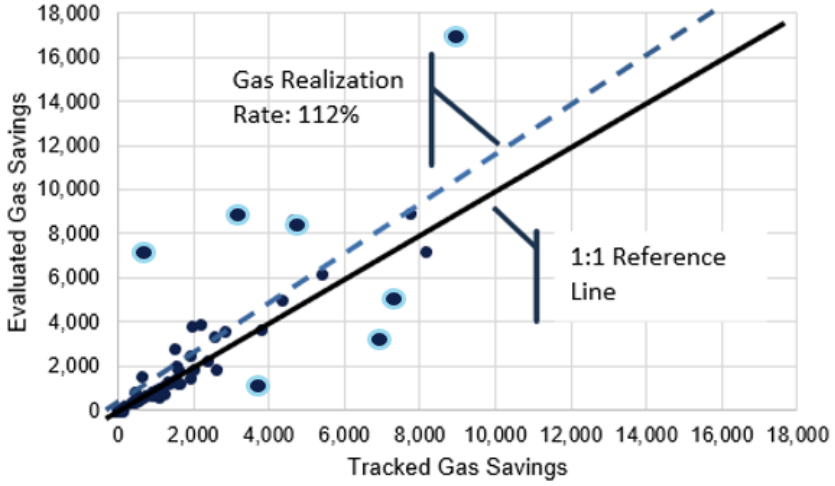


Table 2-7 provides the gross savings, interim verified gross savings, realization rates, and accompanying relative precisions for both electric and natural gas fuels for all three building sectors (commercial sites

overall and breaking out high-rise and low-rise sites). This information is provided to show performance by multifamily sector (low-rise vs high-rise) with interim overall multifamily versus commercial impacts provided in Table 2-8. Overall performance across segments was very good and supported program savings claims. High-rise multifamily sites showed better performance with a poorer precision than low-rise multifamily sites.

Table 2-7. Interim savings and realization rates by fuel and sector

Fuel	Sector	Gross savings	Interim verified gross savings	Realization rate	Relative precision at 90% confidence
Electric (MWh)	Commercial	18,437	18,221	98.8%	±7.9%
	High-Rise	6,081	7,205	118.5%	±16.3%
	Low-Rise	9,740	8,954	91.9%	±6.3%
Natural gas (MMBtu)	Commercial	57,536	70,297	122.2%	±10.3%
	High-Rise	53,066	76,426	144.0%	±16.6%
	Low-Rise	95,449	84,578	88.6%	±8.5%

Table 2-8 provides results for commercial and multifamily sites, and overall results. As suggested above, the interim results shown here indicate performance of these programs has been very good, with realization rates of just under 101% for electric savings and just over 112% for natural gas supporting savings estimates of 34,380 MWh and 231,301 MMBtu.

Table 2-8. Interim savings and realization rates by fuel and program

Fuel	Sector	Gross savings	Interim verified gross savings	Realization rate	Relative precision at 90% confidence
Electric (MWh)	Commercial	18,437	18,221	98.8%	±7.9%
	Multifamily	15,821	16,159	103.2%	±8.8%
	Total	34,258	34,380	100.8%	±5.8%
Natural gas (MMBtu)	Commercial	57,536	70,297	122.2%	±10.3%
	Multifamily	148,515	161,004	108.4%	±10.5%
	Total	206,051	231,301	112.3%	±8.1%

2.3 Impact evaluation key findings and recommendations

Finding 1. The interim results largely support program savings claims with realization rates for commercial and multifamily between 99% and 122% of gross savings. These results provide an evaluated savings of 34,380 MWh and 231,301 MMBtu of natural gas savings for commercial and multifamily projects combined. Note that these interim results will be updated in final overall results, which will be

produced as part of Phase Three, which may include expanded review of some sites from this (Phase Two) sample.

Finding 2. Fifteen of 58 sampled sites did not have available energy models to support savings claims. The PONs for these programs required the submission of energy models as appropriate indicating that these were captured at the time the projects were completed. A transition between NYSERDA project data management platforms in 2023 may have affected the availability of this data and thus how many energy models were readily available to the Evaluation Team. Their presence in files provides the basis for verifying savings as part of impact evaluation work as well as general support for NYSERDA to ensure the accuracy of gross savings claims and performing internal QA/QC activities. The study also observed that gross savings were not always substantiated by project documentation. In two cases the discrepancies were significant. One project had gross savings that was more than 10 times higher than supported by project documentation. A second project was also found to have a discrepancy where gross savings were 20 times higher than supported by project documentation.

Recommendation 1: The study team recommends an audit of completed projects as part of closeout to ensure all required documents and models have been received, accurately transcribed into the tracking system, and properly filed for later access. Availability of key project documentation such as model files is critical for quality control and to verify gross savings estimates. These files are also an essential element in performing the impact evaluation work needed to support program claims.

- **NYSERDA Response to Recommendation 1: Pending.** NYSERDA New Construction Program will review this recommendation and discuss with staff to ensure that all of the required documents are collected and saved. The reinforcement of this and change in process may eliminate the need for a regular audit exercise.

Finding 3. Reviewed energy models were generally found to be representative of the treated buildings. Of the 43 models reviewed by the Evaluation Team, 37 accurately represented the completed project. Most discrepancies found in the models and project documentation were minor, with only six models showing significant discrepancies in system types, schedules, or setpoints.

Finding 4. Modeled codes used in energy savings baselines were correctly applied in most cases. Differences in energy performance of compliant buildings between building code cycles varies. While observed differences between more recent code changes has been estimated to have a smaller impact (estimated at approximately a 2% difference in energy performance), differences can be much more

notable between older code cycles; for example, the difference at one site with older code changes was significant (this mis-application of baseline reduced the claimable energy savings by 24%).

Finding 5. Several high-rise multifamily projects were modeled in eQuest, which did not utilize the energy model results in the gross savings, and instead used deemed savings estimates. These gross estimates were found to be highly variable compared to verified gross savings, introducing more uncertainty around site-level savings estimates.

Recommendation 2: The study team recommends using site-specific energy models where available as the basis for gross savings estimates and only using deemed savings estimates where energy models are not available.

- **NYSERDA Response to Recommendation 2: Pending.** NYSERDA New Construction Program will review this recommendation and discuss with staff to ensure that site-specific energy models are used whenever possible. The findings presented here indicate a need to rely on the energy modeling technique to gather more accurate saving information.

3 Methods

This section provides a description of the activities performed in evaluating the interim commercial and multifamily VGS and VGS RR. The following sections cover the context of this work, followed by a graphical overview of the methodology and each stage of the process used to produce site-level impacts.

3.1 Impact evaluation context

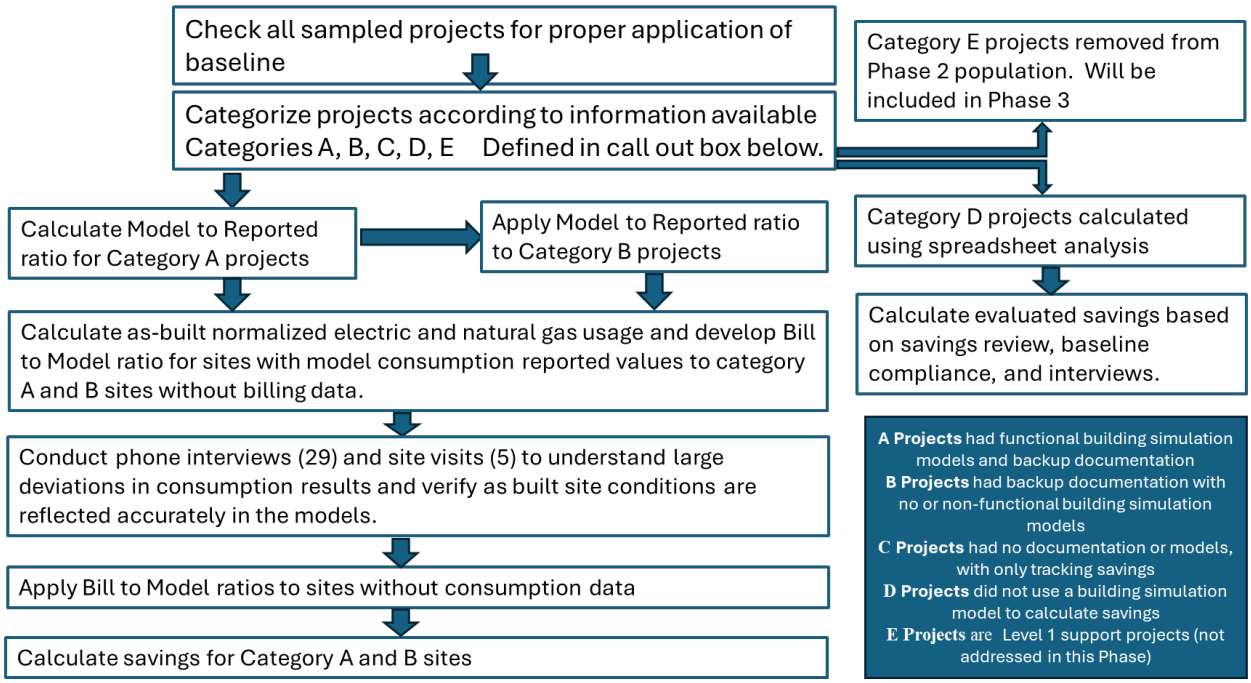
Section 1.2, Overall evaluation plan and impact methodology summary, notes that the evaluation contract for this study spans three phases in which the impact evaluation work was undertaken based on level of participant activity in each sector in each phase. At the time of sampling for Phase One impact work in 2021,[3] there were 1,837 completed single-family sub-projects, but only 86 multifamily and 39 commercial projects. At the time, it was decided that single-family activity was adequate for sampling and study, but that commercial and multifamily activity was going to ramp up substantially and would benefit from waiting for a fuller population, anticipated in Phases Two and Three. This report provides the findings of the Phase Two scope of work, covering interim findings on the commercial and multifamily sector program activity which will be continued in Phase Three.

3.2 Methodology overview

Figure 3-1 provides an overview of the savings methodology used to develop site level savings for the Phase Two sample. This sample was categorized according to available data (see Figure 3-1 inset with definitions). Each category had its own path for adjusting savings. Categories A and B are on the left side of the graphic, with Category D on the right. Category E projects (determined to be "Level 1" sites) were removed from the sample and population for this phase of study and will be included in Phase Three. Each step illustrated is described in more detail in the remainder of this section.

[3] Memo: New Construction and Survey Sampling Participating Buildings/Projects, from DNV to Kartik Pilar, June 14, 2021. This memo is attached as Appendix F.

Figure 3-1. Methodology overview



3.3 Acquiring program data and developing sample design

The Evaluation Contractor Team worked closely with NYSERDA program and evaluation staff to gather all commercial and multifamily program activity for each sector from Salesforce, which is the platform NYSERDA uses to track program activity and savings. This process was supported by meetings between the study team, NYSERDA IT staff, and the program management team. The final population of activity and the sample design was documented in a formal sample memo in April 2023, subsequently approved by NYSERDA.

The goal of the study sample design was to produce realization rates (RR) that meet ±10% precision at the 90% level of confidence across both Phase Two and Phase Three for multifamily and commercial sector projects. The estimated sample size for Phases Two and Three is shown in Table 3-1. As final participation numbers were not final, the Phase Three sample size was estimated to be 25% of the sample size in Phase Two for planning purposes. For the Phase Three study, evaluators will review the number of completed projects in 2023 and determine the optimal sample size needed to achieve the final overall desired confidence and precision. More details on the sample design, including the stratification of the sample frame and sample selection, are provided in Appendix C, Sample design details.

Table 3-1. Phases Two and Three sample overview

Sector	Phase Two (2016-2022)		Phase Three (estimated 2023)		Phases Two and Three (2016–2023)	
	Projects (N)	Sample (n)	Projects (N)	Sample (n)	Projects (N)	Sample (n)
Commercial	58	24	15	7	73	31
Multifamily	170	39	44	9	214	48
Total	228	63	59	16	287	79

3.4 Site-level savings determination

Sampled sites required a series of activities to derive a final verified gross savings value from the gross savings estimates provided in the population, as summarized in Section 3.2, Methodology overview. These steps included acquiring project-level data, categorizing sites based on data availability, determining baseline compliance, acquiring and weather-normalizing consumption data, checking model compliance against project documentation, performing interviews and site visits, and applying ratios to estimate performance for sites with inadequate information to otherwise determine them. Each of these steps is described further in the following sections.

3.4.1 Acquisition of project data

The study team began the data acquisition process by requesting project files for the sampled projects from the NYSERDA team. Upon receipt of available project files, the study team documented gaps in the data provided. These gaps included missing model files, drawings, and project reports. The study team worked with the NYSERDA program team and NYSERDA's data team to search for the documents across their Salesforce platform and archived files in an older data server. The study team then compiled a revised list of missing documents, reaching out to the Primary Energy Consultants (PEC) and facility staff where appropriate to acquire additional documentation to fill in the data gaps. Following this process, the study team compiled a final list of project files available for the evaluation.

3.4.2 Categorization of sites

To aid in the assessment of verified gross savings, the Evaluation Contractor Team categorized sampled sites based on availability of information (e.g., models, backup documentation, gross savings, non-modeled savings). NYSERDA transitioned program tracking systems during the period of activity evaluated, which contributed to the challenge of acquiring project files and supporting information. It was necessary to categorize each site based on what information was available to support developing a verified gross estimate of savings. Categorization was done following efforts to gather all available project data from PEC and NYSERDA. Section 2.2, Site-level savings adjustments, provides the findings from this activity.

3.4.3 Baseline compliance

Baselines are a key component of savings quantification for new construction projects. The baseline for the program is building code at the time of permitting. The study team requested information to determine the baseline appropriate for each sample site, and while permits or permit dates were not often available, application and construction completion dates were used as proxies to determine the permit date. Apart from two sites that had application/installation dates that were too close to the code switchover points to estimate the appropriate codes, the study team used this information to determine the appropriate application of code in the models and gross savings estimates.

To adjust site savings to account for correct code for sites identified as having a misapplication, the study team identified a report[4] that provides the savings of consumption realized in the field from new construction compliance with each cycle of the IECC energy code. That document includes the cumulative and incremental impacts from previous code cycles. These cycles include between 2012 (2016 NYS ECC is the closest NYS code) and 2009 IECC (2010 NYS ECC) and 2015 (2016 NYS ECC) and 2018 IECC (2020 NYS ECC). While the consumption adjustments available from this source have limitations, including that they are not state-specific, they do provide a reasonable way to adjust program savings to reflect changes in code baseline when simulation models are not available for revision.

3.4.4 Billing/consumption data analysis

The study team conducted weather normalization on site-specific utility consumption data requested and received via the Electronic Data Interchange (EDI) system. The EDI data was in a typical billing series format, with columns that represented the EDI key, meter read start date, meter read end date, type of reading, unit of measurement, and total reading.

EDI data was requested for a total of 333 EDI keys for all NC projects. From the response data, 257 keys had usable data. The remaining 76 keys had no data on account of the meter being inaccessible, or inactive. The data included 202 electric meters and 55 gas meters.

Weather normalization is the process of measuring the impact of local weather on energy consumption, then using that relationship to calculate consumption for standard weather (TMY3). This allows comparison of energy consumption across different locations, without having to worry about the impact of local weather.

The study team employed the publicly available OpenEEmeter library developed by CALTRACK for the weather normalization of the EDI data. The OpenEEmeter Method specifies a set of empirically tested

[4] Impacts of Model Building Energy Codes, November 2023, US DOE (PNNL), p 6.

methods to standardize the way normalized meter-based changes in energy consumption are measured and reported. When the OpenEEmeter is implemented through open-source software, these methods can be used to support procurement of energy efficiency, electrification, and other distributed energy resources. Further details about the methods from this package can be found at https://docs.caltrack.org/en/latest/methods.html.

Weather normalization is done in accordance with standard industry protocol, where first, the consumption data is regressed against the actual weather data for the specific site location.

From this regression relation, the counterfactual consumption for a standard pre-specified weather file, which is TMY3 weather in this case, can be calculated. The team applied the weather-normalized regression to TMY3 to be able to compare it to the energy simulation models, which use TMY3 data.

3.4.5 Energy model compliance with project documentation

Proposed models are meant to be reflective of the actual building constructed or renovated regarding the envelope, internal loads, HVAC system, building management system settings, and other such factors. Proposed models are critical to determine the energy saving performance of the planned buildings. The study team reviewed the project documentation available for each site, including drawings, TA reports, performance validation reports, product submittals, ENERGY STAR compliance workbooks (for high-rise multifamily projects), and photo documentation where available. They compared the key model parameters (envelope, lighting, HVAC, domestic hot water, ventilation, etc.) against the project documentation to check the model representativeness and identify if any significant discrepancies existed. A comprehensive model review tool was used for this review.

> The models were generally found to be representative of the buildings. Most discrepancies identified were minor.

The energy models were generally found to be representative of the participating buildings. Most discrepancies identified were minor in nature, such as minor differences in HVAC efficiencies, lighting power densities, and envelope U-values. A small number of projects had more significant discrepancies, such as incorrect operating schedules, incorrect fuel types for certain end uses, and incorrect split up between electric and gas for heating systems. The discrepancies related to operating schedules are not linked to incorrect inputs. Rather, they stem from differences between the installed conditions (operating hours) and the proposed design.

For the two Category D sites, both of which had lighting measures, the spreadsheet models were reviewed and validated using project documentation and interviews with site staff.

3.4.6 Customer technical interviews and on-site visits

The study team attempted technical interviews for all multifamily and commercial sampled sites. Table 3-2 provides the final dispositions (outcomes) of these efforts. Twenty-nine interviews were conducted overall: 18 multifamily and 11 commercial. Contact was attempted up to seven times for each customer before ending recruitment efforts. The overall response rate for interviews was just over 48%. The study team also worked with NYSERDA to increase the interview recruitment completion rates. Despite these efforts, many viable contacts could not be interviewed, and many customers did not respond or refused to participate. The two scheduled commercial sites in Table 3-2 are instances where questions were sent to site contacts (after confirming they were the right contacts) but to the site contacts did not respond. All multifamily sites were completed (hence the zero in "scheduled"). "Viable technical contacts" refers to instances where the site contact was verified at the site but did not participate in interviews despite multiple efforts. "No response" means the site was entirely non-responsive, to the extent of being unable to confirm the contact was there.

Candidate sites were also selected for on-site visits. Criteria used to identify sites that would benefit from a site visit included sites that were particularly large and complex, sites with discrepancies observed between design documents and models, and sites where system fuel types were uncertain. These sites had similar recruitment issues in terms of getting customers to agree to and allow an inspection to occur on-site. Five total site visits were completed: four commercial and one multifamily.

Table 3-2. Technical interview disposition

Status	Counts
Multifamily (n=39)	
Completed	18
Scheduled	0
Viable technical contacts	7
No response	10
Refused	4
Commercial (n=21[a])	
Completed	11
Scheduled	2
Viable technical contacts	2
No response	6

a Excluding three Level 1 support sites.

3.5 Aggregation of results

All sampled sites had verified gross savings estimates developed, as described earlier in Section 3.2, Methodology overview. These verified gross site results and the program tracking estimates were compared through a ratio term to estimate savings at the program level. This term represents observed performance in the evaluation to the tracking system estimated performance (savings). Weights were applied as part of the statistical aggregation process that reflected the number of sites in the population that each sample site represents. One site was given a weight of one (to represent only itself) because a tracking error resulting in a significant discrepancy was not representative of other sites in the sample. Giving this site a weight of one ensures it remains in the sample without its impact being expanded to represent other sites. Appendix E, Technical note on stratified ratio estimation, provides the technical approach to this process, including formulas used and brief narrative.

This approach provides a standard error that recognizes the sample as drawn from a finite population by using a Finite Population Correction (FPC) factor. This factor is a reduction to the calculated variance that accounts for the fact that a relatively large fraction of the population of interest has been observed in the sample. This study applies precision statistics, such as confidence intervals, based on the standard error calculated as part of quantifying the results of the program during the study period only.

Appendix A Glossary of key terms

For purposes of this evaluation and the evaluated study period, key terms are defined as follows:

Billed-to-modeled ratio – the ratio between the weather-normalized consumption data and the proposed model consumption data (or reported proposed model output consumption, if models were not available).

Direct impacts – direct impacts are defined as the impacts expected from projects directly funded by NYSERDA, either immediate or lagged.

DOE-2 – DOE-2 is a widely used and accepted building energy analysis program that can predict the energy use and cost through hourly simulation for all types of buildings. DOE-2 modeling files are submitted to NYSERDA as part of the program energy modeling deliverables.

Dwelling unit – a single unit providing complete independent living facilities (sleeping, eating, cooking, and sanitation) for one or more persons.

EDI – Electronic Data Interchange.

Ekotrope– Ekotrope is an energy modeling platform used by home energy raters to perform home energy ratings and determine home-level impacts for program tracking purposes.

EnergyPlus –EnergyPlus is building energy analysis program that enables modelers to create detailed building energy models for simulating and analyzing energy consumption – for heating, cooling, ventilation, lighting and plug and process loads. EnergyPlus modeling files are submitted to NYSERDA as part of the program energy modeling deliverables.

eQuest – eQUEST (3D software) is designed to perform detailed comparative analyses of buildings using energy use simulation techniques and schematic and design development building creation wizards, measure wizards, and graphical display module. The eQuest files are submitted to NYSERDA as part of the program energy modeling deliverables.

Gross savings (GS) – also referred to as tracked savings or ex ante savings, the energy savings that result directly from program-related actions taken by participants in an energy efficiency program, regardless of why they participated and unadjusted by any significant factors. This may include some level of refinement, such as modeling or adjustments for QA/QC, to address sources of uncertainties in planned savings, including baseline assumptions or deemed values. Gross savings is determined prior to an independent evaluation. The term "gross" can be applied to annual savings as well as lifetime savings.

Home Energy Rater (Rater) – certified individual who provides modeling, verification, and testing to complete a Home Energy Rating on dwelling units. The Rater completes the Home Energy Rating in

accordance with industry standards, most notably "Mortgage Industry National Home Energy Rating System Standards" and EPA's ENERGY STAR Certified Homes Program technical standards and requirements.

Level 1 Support – Refers to commercial projects that applied and received funding for building design support; NYSERDA engagement with these projects was early design phase only.

Multifamily low-rise – Multifamily residential buildings of not more than three habitable stories in height.

Multifamily high-rise –multifamily buildings with four or more habitable stories, subject to special regulations in the building code.

NCP – New Construction Program – NYSERDA past and current new construction programs include: Low-Rise Residential New Construction Program, Multifamily New Construction Program, New Construction – Housing Program, Commercial New Constriction Program, , the Buildings of Excellence (BOE) Competition, Early Design Support Program, Building Cleaner Communities Competition (formerly the Carbon Neutral Community Economic Development Program), Building Better Homes (in the process of being reopened), and the Net Zero Portfolio Support.

Net Zero Energy (NZE) performance or building – an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy. Survey data was used to determine whether a property is NZE.

NYS – New York State.

NYS ECC – New York State Energy Conservation Code.

Non-participant – any owner/developer and their design teams who had not applied for funding or membership within one of the new construction subprograms included in the scope of this study. A stakeholder who applies for funding but whose application is canceled or rejected is considered a participant and not a non-participant.

Participant – any owner/developer and their design teams who had applied for funding or membership within one of the new construction subprograms included in the scope of this study.

Passive House Planning Package (PHPP) – PHPP is the energy modeling file required for projects seeking certification or meeting the standards set by the Passive House Institute (PHI). This comprehensive spreadsheet-based tool is used for planning energy efficiency and is submitted to NYSERDA as part of the energy modeling deliverables. The As-Designed PHPP modeling files are submitted to NYSERDA as part of the energy modeling deliverables.

Primary Energy Consultants (PEC) – firms or individuals who have successfully responded to NYSERDA's Request for Proposal (RFP) 3771 and have been qualified by NYSERDA to support Applicants who participate in NYSERDA's new construction programs and initiatives.

Property – refers to the sampling unit for the market assessment participant and non-participant surveys. It is a parcel of land owned by a single party and is typically a single-family home, or one or more similar buildings on a commercial or multifamily property.

REM/Rate – REM/Rate is a residential energy modeling software used for home energy ratings, code compliance and determine home-level impacts for program tracking purposes.

Scorecard – refers to quarterly reporting that provides program performance to date for each of the energy efficiency and building electrification programs run by a Program Administrator (PA). This data serves as the primary regulatory reporting and input to the information populated on the Clean Energy Dashboard.[5]

Single-family – a building with one to two dwelling units and townhomes.

Standard building – in the New Construction Program, defined as a construction project built to meet the applicable minimum code requirements.

TA report – Technical Assistance report.

Verified gross savings (VGS) – VGS is the value reported by an independent evaluator as energy efficiency program activities and gross savings analysis are complete. VGS is distinct from GS in two ways: 1) it is the product of a complete gross savings analysis using methods consistent with industry standard best practices, and 2) it is produced by an independent evaluator, not by NYSERDA.

Verified gross realization rate (VGS RR) – the ratio of VGS to GS, expressed as a decimal; indicates the performance of a program's reported GS relative to actual realized savings.

WUFI –a passive building energy modeling software used for projects meeting the standards set by Phius (Passive House Institute US). The As-Designed WUFI modeling files are submitted to NYSERDA as part of the energy modeling deliverables.

[5] https://dps.ny.gov/system/files/documents/2022/11/ce-10-data-dictionary-and-scorecard-guidance.pdf

Appendix B Program summary based on PONs

Table B-1 summarizes the PONs and RFPs issued by NYSERDA in support of its New Construction Program.

Table B-1. PONs/RFPs

PON/RFP	Name	Notes	Period
3319	Multifamily New Construction Program (MF NCP)	Offered support to developers serving multifamily high rise new construction and gut rehabilitation projects by providing technical support and guidance through Multifamily New Construction Partners.	Applications accepted from July 2016 through December 2018.
2309	Low-rise Residential New Construction	Offered support for constructing New York ENERGY STAR® Certified Homes as well as for certain gut rehabilitation projects that may be eligible to participate and receive the alternative New York Energy $mart designation. Implemented by CLEAResult.	Program incentives for qualified projects offered through December 29, 2017
3717	Low-rise Residential New Construction Program	Offered technical support and incentives to developers of single family, low-rise multi-unit, and low-rise multifamily new construction, as well as gut rehabilitation projects.	Applications accepted from January 2019 through December 31, 2020
3716	Multifamily New Construction Program (MF NCP)	Offered technical support and incentives to developers of multifamily high rise new construction and gut rehabilitation projects. Applicants were expected to hire a NYSERDA-approved Primary Energy Consultant to act as the primary resource for their participation.	Applications accepted from January 2019 through December 31, 2020 (or until funds expended)
4337	New Construction – Housing	Offered financial incentives and technical support for the new construction, gut rehabilitation or adaptive re-use of residential and mixed-use buildings, inclusive of single-family homes, multi-unit developments, multifamily buildings, residence halls, dormitories, and congregate living facilities, exclusive of nursing homes. Applicants were expected to hire a NYSERDA-approved Primary Energy Consultant to act as the primary resource for their participation.	Applications accepted through September 30, 2022 (or until funds expended)
1601	Commercial New Construction	Offered objective technical and financial support to building owners on a first-come, first-served basis, subject to funding availability. includes cost-shared technical support to help applicants and their design teams assess and determine the most applicable energy efficiency and green building opportunities for the building.	Applications accepted January 4, 2012, through December 29, 2017 (or until funds expended)

PON/RFP	Name	Notes	Period
		Applicants could use a NYSERDA-listed technical consultant or their own. Supplemental technical support was available for applicants pursuing a deep energy savings or zero net site energy project.	
3609	New Construction – Commercial	Offered technical support and financial incentives to Applicants and their design teams to identify and install energy efficiency, electrification, and carbon reduction opportunities to achieve Carbon Neutral-ready levels of performance in non-residential and mixed-use new construction, adaptive reuse, change of use, and substantial renovations to existing buildings. Applicants were able to select a Primary Energy Consultant from a list maintained by NYSERDA or a consultant of their selection.	Applications accepted February 1, 2022, through February 15, 2023 (or until funds expended)
3928	Buildings of Excellence Early Design Support Request for Proposal	Considers funding the early-stage design of projects that intend to serve all portions of the multifamily market sector, while primarily focusing on mid- to high-rise (8 stories or greater in height) multifamily buildings and for projects that involve the adaptive re-use of commercial office, institutional, or retail space to provide multifamily housing.	Applications accepted continuously through November 15, 2025 (or until funds expended)
3928	Buildings of Excellence Competition Demonstration Projects	Offers support for early-stage design and development for demonstration projects in all market sectors with a focus on mid-to high-rise multifamily buildings and for projects that involve the adaptive re-use of commercial office, institutional, or retail space to provide multifamily housing.	Applications accepted continuously. Round 5 ran through September 18 2024 (or until funds expended)
3943	Net Zero Portfolio Support	Offers support to develop performance standards and institutional mechanisms to enable the design, construction, or operation of Net Zero buildings. Applicants may include real estate developer-owners, colleges and universities, retailers, public sector entities, or other private, public, or non-profit entities. Services provided through a NYSERDA-approved Primary Energy Consultant (PEC).	Applications were accepted through December 31, 2019
3771	New Construction Initiatives Support Services	Sought firms capable of delivering support to clean and resilient buildings, energy modeling and analysis, testing and verification, third-party quality assurance, and measurement and verification services to support the design, development, and	Applications were accepted through June 27, 2024

PON/RFP	Name	Notes	Period
		construction of carbon neutral-ready buildings that provide healthy, safe, comfortable, and resilient living spaces for their occupants. Successful business were added to a list of Primary Energy Consultants to support NYSERDA offerings.	

Appendix C Sample design details

Table C-1 summarizes the VGS RR that will be produced for DPS reporting purposes along with these target precisions. Each sector (commercial and multifamily) will have each a single unique electric and gas VGS RR. Project ID and Market focus IDs are internal NYSERDA categories used to help manage and track the progress and performance of its new construction initiatives.

Table C-1. VGS RR realization rate precision targets across Phase Two and Phase Three

Project ID	Project Desc	Market Focus ID	Market Focus	RR with 90/10 target
C00017	Low-Rise New Construction	2525	Low-Moderate Income	Multifamily • Electric • Natural gas
C00017	Low-Rise New Construction	2025N	New Construction	
C00018	Multifam New Construction	2525	Low-Moderate Income	
C00018	Multifam New Construction	2025N	New Construction	
CNC003	New Construction Housing	2025	Low-Moderate Income	
CNC003	New Construction Housing	2025N	New Construction	
CNC001	New Construction Commercial	2025N	New Construction	Commercial • Electric • Natural gas
C00016	Commercial New Construction	2025N	New Construction	

In addition to the four VGS RR required for reporting program savings, the analysis will provide four additional informative realization rates as noted below. All-electric vs not-all-electric buildings target the electric and natural gas combined source MMBtu.[6] Each of these informative realization rates targets a 90/10 precision on source MMBtus.

1. Multifamily all-electric (source MMBtu)
2. Multifamily not-all-electric (source MMBtu)
3. Commercial all-electric (source MMBtu)
4. Commercial not-all-electric (source MMBtu)

Table C-2 presents the population, sample, and projected precision at 90% confidence for each of the eight realization rates where ±10% precision at the 90% confidence interval is targeted for Phases Two and Three combined. The table presents the expected precision at the end of Phase Two and for Phases

[6] Since all-electric buildings claim both electric savings and natural gas savings representing offset, the realization rate for all-electric and not-all-electric building segments will reported for total source MMBtu (electric and natural gas combined). Source energy was used for this equation as it is the most equitable unit of evaluation and enables a complete assessment of energy efficiency. Source energy traces the heat and electricity requirements of the building back to the raw fuel input, thereby accounting for any losses and enabling a complete thermodynamic assessment. The equation for source energy used to determine is below using factors from ENERGY STAR (https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf).

$$Source\ MMBtu\ = Electric\ MWH\ savings * 3.412 * 2.8 + Gas\ savings\ MMBtu * 1.05$$

Two and Three combined. Note that the same project can be in multiple groups, and therefore the total number of unique projects or sample points may not be equal to the sum of individual rows.

Table C-2. Phase Two and Three sample overview - by upper-level stratum

Sector	Fuel	Phase Two (2016-2022)			Phases Two & Three (2016-2023)		
		Projects (N)	Sample (n)	Projected precision at 90% confidence	Projects (N)	Sample (n)	Projected precision at 90% confidence
Commercial	Electric	34	20	±9.3%	43	25	±8.3%
	Gas	26	17	±10.1%	33	21	±9.0%
	Not-all-electric (source MMBtu)	29	17	±9.3%	36	21	±8.3%
	All-electric (source MMBtu)	10	7	±11.2%	13	9	±10.0%
Multifamily	Electric	137	39	±10.4%	171	49	±9.3%
	Gas	134	37	±10.4%	168	46	±9.3%
	Not-all-electric (source MMBtu)	134	36	±10.4%	168	45	±9.3%
	All-electric (source MMBtu)	3	3	±0.0%	4	4	±0.0%

The Phase Two sample was stratified by both project size and all-electric vs. not-all-electric. Stratification was performed based on size (savings) using Stratified Ratio Estimation and total MMBtu (not source) as a combined electric and natural gas metric. MMBtu (as opposed to source MMBtu) was used because more sites have electric savings than natural gas savings, and MMBtu leads to a higher number of sites with electric and natural gas savings being selected. The sample was stratified by all-electric vs. not-all-electric to ensure adequate representation of these sub populations of interest. To maximize the value of each evaluated site, the smallest sites, accounting for 3% of site MMBtu were dropped from the sample frame (stratum 0). To get the full verified gross savings, the combined realization rate of the remaining stratum will be applied to stratum zero. The estimated sample sizes assume a coefficient of variation (CV) of 0.5 based on previous programs of similar characteristics. Table C-3 provides an overview of the Phase Two sample size by stratum.

Table C-3. Phase Two sample by upper-level stratification and size

Sector	All-electric	Stratum	Minimum savings (MMBtu)	Maximum savings (MMBtu)	Phase Two		
					Projects	Sample	Weight (Projects/ sample)
Commercial	Not-all-electric	0	0	525	14	-	N/A
		1	586	3,509	16	6	2.7
		2	3,611	6,312	8	6	1.3
		3	9,311	11,597	5	5	1.0
	All-electric	0	2	83	5	-	N/A
		1	87	561	7	4	1.8
		2	573	1,950	3	3	1.0
Multifamily	Not-all-electric	0	4	374	33	-	N/A
		1	375	914	56	9	6.2
		2	920	1,622	42	9	4.7
		3	1,638	3,263	26	9	2.9
		4	3,382	21,758	10	9	1.1
	All-electric	1	69	224	3	3	1.0
Commercial total			**N/A**	**N/A**	**58**	**24**	**N/A**
Multifamily total			**N/A**	**N/A**	**170**	**39**	**N/A**
Grand total			**N/A**	**N/A**	**228**	**63**	**N/A**

Appendix D Sample savings model types and other gross savings methods

Table D-1 provides a detailed breakdown of the various building simulation tools utilized in the sample by the PEC in Phase Two. Multifamily projects utilized eQUEST, PHPP, REM/Rate, and Ekotrope software, while commercial projects used a mix of eQUEST, DOE-2, EnergyPlus, and WUFI software.[7] For two projects, the building simulation tools utilized were unknown. Level 1 support projects are not included in the table.

Table D-1. Phase Two sample by building simulation tool

Building simulation tool	Count of projects
eQuest	22
REM/Rate	14
Ekotrope	13
DOE-2	3
Lighting only (spreadsheet-based analysis)	2
PHPP (spreadsheet-based tool)	2
WUFI	1
EnergyPlus	1
Unknown - Energy Model	2
Grand Total	**60**

[7] One commercial site (cider production building) was built to Passive house standards-PHIUS certified and used WUFI software.

Appendix E Technical note on stratified ratio estimation

The independent savings estimates developed for this study relied upon a series of steps and savings adjustments, as described in Section 3, Methods. These included modeled-to-reported ratios, billed-to-modeled ratios, and other adjustments such as those needed to adjust for misapplication of baselines. Following development of these site-level estimates, a statistical analysis combines them for the sample with their tracking system counterparts in a stratified ratio estimation framework to produce the independent estimates of evaluate program impacts, i.e., annual electric and natural gas energy savings. Case weights developed at the time of the sample design are updated, if necessary, and used to develop the population-weighted estimates of the total gross savings and net savings. The case weights are defined for each sample point based on the number of participants in the population (N) represented by each sample point (n). Therefore, the case weights are defined as $(w_k)=N_h/n_h$.

The equations for the combined stratified ratio estimator are presented below:

$$\begin{aligned}
\hat{Y}_{ra} &= bX, \text{where} \\
b &= \frac{\bar{y}}{\bar{x}} \\
\bar{y} &= \frac{1}{\hat{N}}\sum_{k=1}^{n} w_k y_k \\
\bar{x} &= \frac{1}{\hat{N}}\sum_{k=1}^{n} w_k x_k \\
\hat{N} &= \sum_{k=1}^{n} w_k
\end{aligned}$$

This first set of equations present the population estimate of *y*, e.g., the evaluated annual savings as beta times the population tracking (gross) system estimate of savings, namely, *bX*. The beta coefficient (*b*) is the ratio of weighted mean *y* to weighted mean *x*, where y is the evaluated estimate of savings derived and *x* is the tracking (gross) system estimate of savings. Next, equations are presented for the weighted mean estimate of y, the weighted mean estimate of *x*, and the estimate of *N*, i.e., the number of projects in the population.

Equations for the confidence interval of the estimate, the estimated variance, the within-stratum variance of the sample residual, *e,* and the sample residual are presented below:

$$\hat{Y}_{ra} \pm 1.645\sqrt{V\left(\hat{Y}_{ra}\right)} \text{ where}$$

$$V\left(\hat{Y}_{ra}\right) = \sum_{h=1}^{H} N_h^2\left(1-\frac{n_h}{N_h}\right)\frac{s_h^2(e)}{n_h}$$

$$s_h^2(e) = \frac{1}{n_h-1}\sum_{k\in s_h}\left(e_k-\bar{e}_h\right)^2$$

$$e_k = y_k - bx_k$$

Next, the relative precision of the estimate $\hat{Y}_{ra}$ can be calculated using the equation:

$$rp = \frac{1.645\sqrt{V\left(\hat{Y}_{ra}\right)}}{\hat{Y}_{ra}}$$

Appendix F Methods to calculate savings as a percent of evaluated baseline consumption

The direct savings spreadsheet includes an entry for evaluated savings as a percent of evaluated baseline consumption. The methods used to develop these values are provided in the bullets below.

The savings as percent of baseline consumption was calculated as follows:

- Evaluated baseline consumption was calculated for sites with existing estimates for baseline consumption in program documentation by summing the product of site level billed-to-proposed modelled ratios and baseline modelled consumption for each direct impact savings spreadsheet result of interest (e.g., multifamily gas, multifamily electric, commercial gas and commercial electric).
- Evaluated savings were summed for all sites included in the baseline consumption calculation above for each direct impact savings spreadsheet result of interest (e.g., multifamily gas, multifamily electric, commercial gas and commercial electric).
- Evaluated savings as a percent of evaluated consumption baseline (%) was calculated as B/A.

Appendix G Memo: New Construction Impact and Survey Sampling Participating Projects

To: Kartik Pilar, NYSERDA

Date: June 14, 2021

Introduction

This memo describes the evaluation team's impact sampling of the new construction projects as well as sampling for the surveys targeting participating building owners/developers and architects, engineers, and modelers. We first define the sampling unit and the population and then proceed to describe the impact and survey sampling approaches.

The Sampling Unit and Population

The evaluation team's initial plan, as described in the draft statement of work (SOW), was to use project as the sampling unit for both the impact and participating building owner/develop survey sample. On reviewing the New Construction Program tracking database, the evaluation team noted that 493 of the 1,275 projects (39%) had multiple sites in different zip codes.[8] Further 5% of projects had multiple building types: specifically, 59 projects that had at least one single-family site also had at least one multifamily (44) or commercial (15) site.

The issue of project sites in different zip codes is of greater concern. These could suggest non-homogenous developments. For example, while the single-family dwellings built within a single zip code might vary in size, that variability may well be smaller than the variability in dwellings built across zip codes. To test this assumption, the evaluation team assessed the variability in median household income across single-family sites, comparing the variability across sites within a project, regardless of zip code, and across sites within a project *but* within the same zip code. The team refers to the latter – i.e., groupings of sites within a project that have the same zip code – as subprojects. There were 2,828 subprojects.

For each site, the team matched median household income from the U.S. Census to the specific Census tract for that site.[9] The team then calculated two sets of the standard deviations for the site-level median incomes:

[8] The team attempted to conduct a fine-grained analysis of patterns using Census tracts but was able to match Census tracts to the addresses of only about two-thirds of sites.

[9] Note that, only those sites the team was able to identify Census tracts for (about two-thirds of sites) were included in this analysis. It is possible that the results might vary somewhat if all sites were included, but the evaluation team believes it is unlikely they would vary enough to lead to a different conclusion.

- For each *project*, the team calculated the standard deviation of the site-level median incomes for that *project*. For example, for Project 1, the team calculated the standard deviation of the site-level median incomes for all sites associated with that project, and so forth for all other projects.
- The team did the same thing for each *subproject*. That is, for each subproject, or grouping of sites within a project that share the same zip code, the team calculated the standard deviation of the site-level median incomes for that *subproject*. For example, if Project 1 has two subprojects, the team calculated the standard deviation of the site-level median incomes for all sites associated with that project's first subproject and a separate standard deviation of the site-level median incomes for all sites associated with that project's second subproject, and so forth for all subprojects of other projects.

The team then calculated the mean of all the project-level standard deviations calculated as above and, separately, the mean of all the subproject-level standard deviations.

There was much greater variability at the project level than at the subproject level: the mean variability in site-level median household income across projects was $2,586, while the mean variability across subprojects was $565. The evaluation team thus chose the subproject as the sampling unit for both the impact and participating building owner/develop survey sample.

For the owner/developer survey, the team chose to sample by subproject (in lieu of selecting a unique applicant or developer as a sampling unit) for the following reasons:

- The survey has to collect project-related information for the impact analysis.
- Richer data can be collected at the subproject level on new construction practices and other information needed to estimate the indicators.
- The sampling for non-participants needs to be comparable to sampling for participants. The non-participant sampling will be based on tax lot or assessor data. The team will be able to use tax lot data to identify new construction properties within a single zip code outside of the program. For example, if many homes are built at the same time and within the same zip code, the team will treat those homes as one development with a single developer.

Also note that the team defined the participating building population as those subprojects that are complete. The timeframe considered is 2016 through the end of the evaluation period (2023). The team counted completed subprojects to date and projected completions to estimate the population of completed subprojects. The Impact Sampling section below describes how the team projected the number of completed subprojects between now (June 2021) and 2023.

Impact Sampling

This section describes the Contractor's plan for sampling completed single-family, multifamily, and commercial new construction subprojects to validate energy savings from NYSERDA's New Construction ("NC") program. As documented in the final statement of work (SOW), the Contractor will

use energy modeling (Option A or D) with a calibrated simulation developed for the as-built participant building and then modified to represent the built-precisely-to-code situation. Where possible, the Contractor will provide estimated savings by major measure group and assess whether specific measure groups are more or less likely to achieve estimated savings.

For the proposal, the Contractor developed an initial sample plan to achieve 90% confidence of 10% precision (90/10) at the program level as well as for all-electric buildings and buildings that use any non-electric fuel. That plan was based on information on the expected number of subproject completions by stratum that NYSERDA provided for proposal development. The Contractor has updated that plan based on more complete information provided since contract award. The additional information indicated that fewer subprojects are expected to be completed within the timeframe of this subproject than assumed for the proposal. As a result, it may be a challenge to achieve 90/10 confidence/precision for all primary strata, although the Contractor will treat this as the objective. The additional information also showed that the percentage of single-family and multifamily subprojects expected to be all-electric is much lower than originally expected; this has an impact on the sampling approach for that subgroup.

The estimated sample sizes assume a coefficient of variation (CV) of 0.5 for the single-family residential stratum but assume that a slightly lower CV of 0.45 will be achievable in the multifamily and commercial samples through stratification on program-reported energy savings. The top stratum of subprojects with the largest reported savings will be sampled with certainty, yielding a precision of ±0% for that stratum. The remaining subprojects will be put into three to four strata of similar-sized subprojects. Experience indicates that each of those strata will have a CV of 0.3 to 0.5, which will produce a lower pooled standard error and, thus, a lower CV, than would be achieved without this level of stratification.[10]

In all cases, the subproject populations are sufficiently small that the finite population correction (*fpc*) factor yields smaller sample sizes than would be required for an infinite population, particularly for all-electric subprojects, nonelectric subprojects (i.e., subprojects that have any non-electric savings), NZEED subprojects, and Buildings of Excellence, or BoE, subprojects).

As an initial indication of sampling needs, Table 1 shows the sample requirements for upper-level strata identified in the SOW as well as for NZEED and BoE subprojects, based on expected subproject completions by 2023. Expected completions are the sum of current completions and those expected to occur between now and 2023. The Contractor estimated the latter by calculating the percentage of completions that occurred one to five years after the subproject start year and then applying those

[10] During data collection and analysis, the evaluation will assess whether the desired level of precision will require larger samples and will attempt to increase sample sizes as needed.

percentages to subprojects currently in progress to forecast completions in 2022 and 2023.[11] As this table shows, 90/10 confidence/precision can be achieved by obtaining impacts data for 8% of completed subprojects in the single-family sector, 18% in the multifamily sector, and 29% in the commercial sector. It would require obtaining data from 59% of the mixed-use subprojects, however. Getting 80/20 confidence/precision for the multi-use subgroup could be achieved with data from 18% of those subprojects, which is an obtainable target. Alternatively, the Contractor will evaluate the feasibility of including some subprojects that have a mix of site types in the commercial stratum, including only the commercial buildings in the analysis.

Table 1: Impact Evaluation Sample Requirements for Upper-Level Strata, NZEED, and BoE

Stratum	Current Completed Sub-projects	Expected Completed Sub-projects by 2023	CV	Infinite Population Sample Size	Adjusted Sample Size (fpc)	% of Population
Total	1,962	2,640	n/a	n/a	n/a	n/a
Sector						
Single-family	1,837	2,153	0.5	68	66	3%
Multifamily	86	284	0.45	61	50	18%
Commercial	39	199	0.45	61	47	24%
Mixed use	0	4	0.5	Census[1]	Census	100%
Fuel						
All-electric	39	102	0.5	68	41	40%
Nonelectric	1,923	2,534	0.5	68	66	3%
NZEED and BoE						
NZEED	0	15	0.5	68	12	80%
BoE	0	7	0.5	68	6	86%

[1]The sample size for infinite populations exceeds the population size; therefore, 90/10 confidence/precision would have no meaning, and a census would be required.

Achieving 90/10 confidence/precision for NZEED, and BoE subprojects would require obtaining data from anywhere from 80% to 86% of the subprojects in those groups. While this is not a contract requirement, the evaluation team will make every effort to include as many of those subprojects as possible in the sample.

The SOW calls for obtaining 90/10 results for fuel type, across all initiatives. As seen in **Table 2**, the given the small population of all-electric subprojects, obtaining 90/10 for all-electric subprojects within

[11] Specifically, the Contractor calculated the percentage of all projects started one, two, three, four, and five years ago that are currently completed.

each sector would not be very feasible. However, the evaluation team will attempt to obtain 80/20 confidence/precision; this is more achievable, although it would still require getting data from about two-thirds of the all-electric multifamily subprojects.

Table 2: Fuel Type by Sector Sample Requirements at 90/10 and 80/10 Confidence/Precision

Stratum	Current Completed Subprojects	Expected Completed Subprojects by 2023	At 90/10 Confidence/Precision		At 80/20 Confidence/Precision	
			Adjusted Sample Size (fpc)	% of Population	Adjusted Sample Size (fpc)	% of Population
All-electric subprojects[1]						
Single-family	29	49	29	59%	14	29%
Multifamily	1	11	9	82%	7	64%
Commercial	9	42	25	60%	12	29%
Nonelectric subprojects						
Single-family	1,808	2,104	66	3%	19	1%
Multifamily	85	273	50	18%	16	6%
Commercial	30	157	44	28%	15	10%

[1]All-electric subprojects are subprojects in which all buildings are all-electric. The evaluation team will evaluate the feasibility of including some subprojects that have a mix of all-electric buildings and buildings that use other fuels, including only the all-electric buildings in the analysis.

Table 3 shows the sample counts by sector that would allow 80/20 confidence/precision for all-electric strata within each sector and 90/10 confidence/precision for nonelectric strata. The all-electric subprojects would be oversampled relative to the other subprojects, but the level of oversampling would produce acceptable substratum weights.

The above plan would produce a total sample of 193 subprojects across the three sectors, plus four mixed-use subprojects, for a total of 197. However, as the non-proportional stratification would reduce the precision of the overall sector-level samples somewhat, the evaluation team will offset by increasing the number of nonelectric subprojects for each sector. The evaluation team anticipates a final sample of about 200 subprojects. As noted above, this may be increased to achieve needed precision levels.

Once a subproject is selected into the sample, the evaluation team will select a subsample of buildings for the subproject M&V. The team will select the subsample to ensure that the selected buildings are representative of the subproject as a whole.

The evaluation team also will attend to the distribution of subproject subtypes – e.g., high-rise versus low-rise multifamily and commercial building type/use – to ensure that the sample as a whole is representative

of the subprojects. If a particular subproject subtype is not well represented in the sample, the evaluation team will notify NYSERDA and propose an appropriate action.

Table 3: Weighting Scheme, Assuming Sampling All-Electric, NZEED, and BoE at 80/20

Group	Expected Completions by 2023	Target Confidence /Precision	Sample	% of Population	% of Sample	Weight
Single-family						
All-electric	49	80/20	14	2%	21%	0.11
Nonelectric	2,104	90/10	66	98%	79%	1.24
Sum			**80**			
Multifamily						
All-electric	11	80/20	7	4%	14%	0.28
Nonelectric	273	90/10	50	96%	86%	1.12
Sum			**57**			
Commercial						
All-electric	42	80/20	12	21%	26%	0.83
Nonelectric	157	90/10	44	79%	74%	1.06
Sum			**56**			
Total across sectors[1]			193			
NZEED and BoE[2]						
NZEED	15	80/20	9	8%	19%	0.39
Not NZEED	184	90/10	50	92%	81%	1.14
Sum			**59**			
BoE	7	80/20	5	4%	11%	0.33
Not BoE	192	90/10	50	96%	89%	1.08
Sum			**55**			

[1] Mixed use is not shown in this table, as it is too small to be divided between all-electric and nonelectric; therefore, no weighting will be involved.
[2] The large majority of NZEED and BoE subprojects are in the commercial sector. Therefore, the commercial sector total is used to calculate weights shown in this table for these groups. In the analysis, weights will be based on the actual sector of the sampled subproject.

Table 4 shows the complete sampling plan that is based on the above considerations. The total sample sizes for single-family, multifamily, and commercial are the sums of the sample sizes for all-electric (at 80/20) and nonelectric (at 90/10) for each of those strata.

The evaluation team will distribute the sample of completed subprojects across the three years of the research project roughly in proportion to the expected distribution of the completed subprojects, as shown in Table 4. However, the team will attempt to somewhat oversample in the current year and 2022 to ensure adequate sample in the event that the total number of completions is lower than expected.

Table 4: Complete Sample Plan

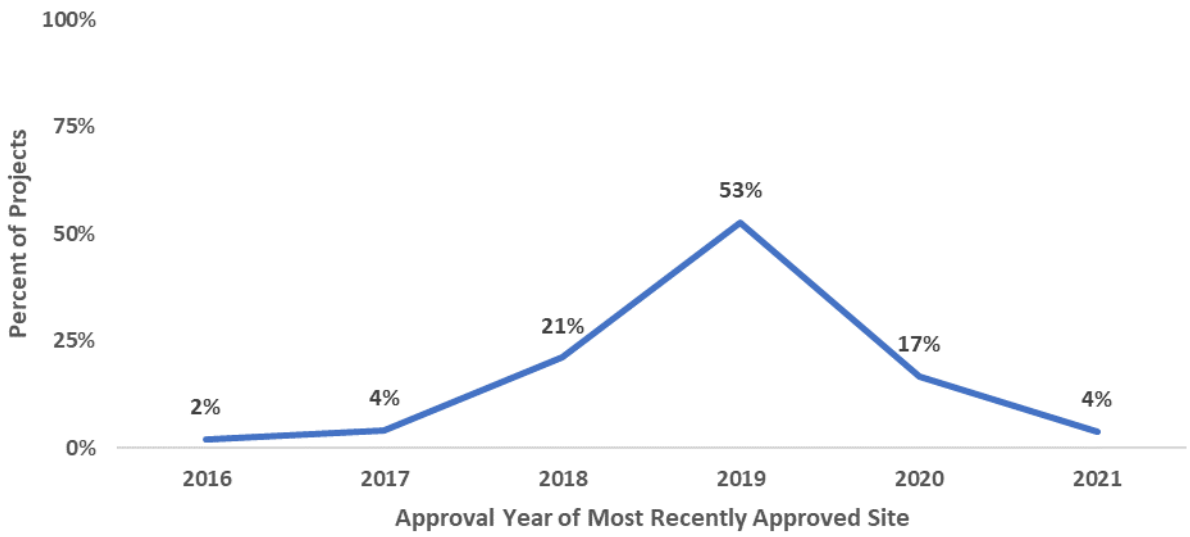
Stratum	Completed by 2023	2021 Sample[1]	2022 Sample	2023 Sample	Total Sample[2]	% of Completed
Single-family	2,153	65	14	1	80	4%
All-electric	49	8	5	0	14	29%
Nonelectric	2,104	57	9	1	66	3%
Multifamily	284	17	21	20	57	20%
Multifamily - By Fuel						
All-electric	11	1	3	3	7	64%
Nonelectric	273	16	18	17	50	18%
Multifamily - By Savings Size[3]						
Small	90	5	6	5	18	20%
Medium	124	7	8	7	25	20%
Large	67	4	4	4	13	19%
Largest	3	1	1	1	3	100%
Commercial	199	11	23	22	56	28%
Commercial - By Fuel						
All-electric	42	3	5	5	12	29%
Nonelectric	157	8	18	17	44	28%
Commercial - By Savings Size[3]						
Negative savings	13	1	1	1	3	23%
Small	66	3	6	6	16	24%
Medium	73	3	7	6	18	25%
Large	40	2	4	3	10	25%
Largest	7	1	3	3	7	100%
Mixed use	4	0	2	2	4	100%
Total sample	2,640	93	60	45	197	7%
All-electric total	102	13	13	7	33	32%
Nonelectric total	2,534	121	28	11	160	6%
NZEED[4]	15	0	5	4	9	60%
BoE[4]	7	0	3	2	5	71%

[1]The year-by-year samples are estimates, based on projected completions each year; therefore, in some cases, they do not sum exactly to the total sample size for a given row or column.
[2]The sample sizes shown for sector-level strata (single-family, multifamily, commercial, mixed-use) and nonelectric will provide 90/10 confidence/precision. Those shown for all other strata and substrata will provide 80/20 confidence/precision. The evaluation team will strive to include as many of the latter and of NZEED and BoE as possible to achieve 90/10 confidence/precision, which could add about 30 subprojects.
[3]The multifamily and commercial strata will be subdivided by project size, which includes a commercial substratum of subprojects with negative savings. In both multifamily and commercial, the "largest" substratum will be sampled at certainty (e.g., the evaluation team will attempt to achieve a census of these subprojects).
[4]A large majority of NZEED and BoE will come from the commercial sector.

Additional Sampling Considerations

The evaluation team and NYSERDA discussed whether it would be valuable to favor more recently completed subprojects in the sample. Respondents with more recently completed subprojects may be more likely to be able to provide useful information for both the impact and the market research. However, the team determined to not to incorporate subproject year explicitly into the sample scheme. The distribution of site approval dates shows that approvals increased sharply to 2019, peaking in that year (Figure 1). Therefore, a random sample will naturally be composed primarily of more recent subprojects. Making year of approval an explicit element of the sampling plan, on the other hand, may create challenges in meeting sample requirements by reducing the sample frame.

Figure 1: Distribution of Subproject Site Approval by Year



Participating Building Owner/Developer Survey Sample

The participating building owner/developer survey sample is also based on the expected number of subproject completions by strata referenced above in the Impact Sampling section. Unlike the impact sampling, the survey sample is not a rolling sample. The plan is to implement this survey only two times – in 2021 and when the market aspect of this study is repeated in 2023.

The goal of the survey is to capture a snapshot of the market. To do that, we will proportionally sample the number of completed subprojects by year, as discussed previously. The proportional sampling of completed subprojects by year will result in a sample that will collect more data on recent than past subprojects (see Figure 1, above).

Note that for the 2021 survey we can survey contacts only of completed subprojects to date (see Table 1 and Table 2). Also note that NYSERDA tracking data captures contact information of developers only. For the multifamily and commercial subprojects, most developers are also owners, per program staff. The survey instrument will capture whether the applicant is a developer or an owner to ensure this is indeed the case. For the residential survey, the team will target developer contacts. Developers rather than building owners will be able to provide data on the indicators around new construction practices (e.g., integrated design, incremental cost of building highly efficient or carbon neutral homes or buildings).

We will ensure that the number of contacts per firm are minimized since there could be instances of multiple contacts per firm.

None of the NZEED and BoE subprojects are complete to date. We anticipate in 2023, we will be able to survey contacts of those subprojects because a substantial proportion of those subprojects are estimated to be complete by 2023. However, for 2021 data collection, we suggest interviewing (not surveying) BoE and NZEED developer contacts of 5-7 of these subprojects to gather insights on existing challenges in the development process, including planning and construction and working with clients and the trades on clean energy advanced buildings.

Participating Architect, Engineer, and Modeler Survey Sample

We will leverage the sample of subprojects for the owner/developer survey to extract architect, engineer, and/or modeler contacts involved with the sampled subprojects. We understand that these market actors may not consistently be tracked by the program. Thus, when surveying owners/developers, we will ask them to provide contact information of the architects, engineers, and/or modelers they have worked with on the subproject.

At minimum, we will stratify this market actor group into two subgroups: architects and engineers/modelers. We anticipate that supplied contact information may not at times clearly indicate whether the contact is an architect or an engineer. Thus, we will rely on questions in the survey to identify whether contact and their firm offered architectural and/or engineering build or modeling services.

We will ensure that the number of contacts per firm are minimized since there could be instances of multiple contacts per firm.

Finally, we will monitor responses to ensure there is sufficient number of survey completions in each subgroup to meet 10% precision level at 90% confidence. Considering we are only sampling those trades who are associated with the completed subprojects (as referenced above), we should be able to inquire about all stages of construction (in design, in-construction, and completed).