

NYSERDA Residential Retrofit Impact Evaluation

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Final Report

Prepared for:

New York State Research and Development Authority

Albany, NY

Elizabeth Boulton
Project Manager

Prepared by:

NMR Group, Inc.

Somerville, MA

Shirley Pon
Senior Project Manager

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1 Introduction

This report presents the methods and interim impact findings for NYSERDA’s home retrofit programs: Home Performance with ENERGY STAR® (HPwES) and EmPower New York (EmPower), which also administers National Fuel Gas Distribution Corporation’s (NFGDC) Low-Income Usage Reduction Program (LIURP). The interim report focuses on EmPower and HPwES projects funded by the Clean Energy Fund (CEF) and LIURP projects funded by the Energy Efficiency Transition Implementation Plan (ETIP) from 2017 through the first quarter of 2019. The analysis incorporates residential electricity and natural gas consumption data and NYSERDA and NFGDC program tracking data of participating program homes to estimate first year energy savings using a billing analysis. The following sections of this report provide program descriptions, summary of evaluation objectives and methods, results, findings, and recommendations, and ending with a detailed discussion of the methods.

1.2 Program and Participant Description

Table 1 provides program descriptions including income eligibility, building type, incentives and financing options, and eligible measures. The datasets provided by NYSERDA to the Impact Evaluation Contractor for this study characterize the programs as EmPower and HPwES. Many participants in Assisted HPwES appear in both the EmPower and HPwES datasets, as they received some measures from each program. These participants were classified as the Assisted HPwES and are analyzed separately from EmPower and HPwES. Under CEF, programs previously classified as EmPower, Assisted HPwES, and HPwES were reclassified as low-income, moderate-income, and market-rate, respectively.

Table 1: Program Description

	EmPower and LIURP	Assisted HPwES	HPwES
Income eligibility	Low-income - household income 60% or below state median income	Moderate income - household income 80% or below state median income	Market Rate
Building eligibility	Single-family, multifamily (less than 100 units)	Single-family, multifamily (2-4 units)	
Homeowner incentives	Discount covering 100% of the cost of eligible energy efficiency improvements	Discount covering up to 50% of the cost of eligible energy efficiency improvements.	N/A

	EmPower and LIURP	Assisted HPwES	HPwES
		Maximum incentive: single-family units \$5,000 2-4 family units \$8,000	
Contractor incentives	N/A	5% Advanced Modeling contractor incentive	10% of eligible work
Financing options	N/A	\$1,500 minimum, up to \$25,000	
Eligible measures	<ul style="list-style-type: none"> • Air sealing • Attic and wall insulation • Clothes dryer • Heating and cooling equipment • Heating repairs • High efficiency lighting • Pipe wrapping • Refrigerators and freezers • Showerheads • Thermostats • Water heating equipment • Water heating improvements 	<ul style="list-style-type: none"> • Air sealing • Attic and wall insulation • Dehumidifier • Heating and cooling equipment • High efficiency lighting • Pipe wrapping • Refrigerators and freezers • Room ACs • Showerheads and aerators • Thermostats • Water heating equipment • Windows and doors 	

Table 2 reports the average annual baseline usage per participant prior to program participation by program and fuel type, as estimated from homes modeled in the billing analysis. Market-rate participants tend to have the highest level of energy usage compared to moderate and low-income participants. The average pre-program energy usage for all programs in this study was lower compared to the 2012 – 2016 study, though most notably lower for market-rate participants. One potential explanation is that the housing stock currently participating in the program is already more energy efficient than the housing stock that participated in prior years. Average annual usage excludes homes with fuel switching.

Table 2: Average Annual Baseline Usage by Fuel Type and Program

Fuel Type	Program Year	CEF			LIURP
		Low-Income	Moderate	Market	
Electric (kWh)	2012-2016	8,280	8,497	11,412	--
	2017-Q1 2019	7,663	8,079	9,651	--

Natural Gas (MMBtu)	2012-2016	109	100	108	146
	2017-Q1 2019	104	97	98	118

1.3 Summary of Objectives and Methods

This impact evaluation focused on estimating the per-household, first-year energy savings for NYSERDA projects installed between 2017 through the first quarter of 2019. The evaluation does not go beyond the first quarter of 2019 due to the agreed scope of the study and desire to avoid complications from COVID-19 pandemic shutdowns (which began mid-March 2020) that may have impacted the post period usage.

The evaluation utilized a billing analysis of all completed projects with at least 12 months of utility billing records before and after installation for homes that completed their projects in 2017 and 2018 and at least nine months of billing records for homes that completed their projects in 2019. Households that exclusively installed an electric reduction measure¹ through the EmPower program were also excluded from the natural gas analysis. The purpose of this study, as described in **Table 3**, was to provide robust and reliable estimates of electric and natural gas savings. This study provided savings by fuel type, program, year, measure, engineering model type, utility, and contractor.

Table 3: Evaluation Objectives and Methods

Objective	Purpose	Method
Review of literature	Provide insight on the drivers of the differences between engineering models versus billing analyses as compared to similar jurisdictions	Limited literature review of relevant studies
Evaluate energy impacts	Establish energy savings based on the electric (kWh) and natural gas (MMBtu) savings at the customer site.	Billing analysis
Develop realization rates (RRs)	Determine the ratio of estimated verified savings to program-reported savings	Calculations using NYSERDA Program data and modeled billing data

1.3.1 Study Limitations

A billing analysis utilizes billing records to estimate the verified (actual or ex post) savings attributable to a program. Essentially, a billing analysis captures a snapshot of electric and/or natural gas consumption

¹ Electric reduction (ER) measures are a separate type of retrofit from the home performance retrofits offered through the EmPower program. ER projects often consist of one or more of the following measures: LEDs, refrigerators, CO detectors, smoke detectors, pipe wrap, and weatherstripping. The ER measures are flagged in the program tracking database based on criteria such as whether NYSERDA had an existing landlord agreement for the project or the residence had extremely low electricity usage.

before (pre-period) and after (post-period) a program measure installation, over a specified period. The verified savings is the net of the pre- and post-period consumption estimated from the billing analysis. Program reported savings are the ex ante savings calculated from engineering models and are provided with the program tracking data. The ratio of verified savings to reported savings is the RR.

One drawback of a billing analysis using monthly billing data is that it is unable to tease apart the complexities of the programs or provide explanations for the drivers of high or low RRs.² The limited literature review in **Section 2.1** discusses potential drivers that may affect RRs. Additionally, a billing analysis relies on consumption data from which to draw inferences. Such consumption data are not readily available for homes served by delivered fuels, and this study's scope did not include efforts to collect such data. Therefore, savings for delivered fuel participants are not captured in the billing analysis presented in this study. Furthermore, the measures covered in the billing analysis may not be fully representative of all the measures installed through the program. The billing analysis results in this study should be interpreted with these limitations in mind.

1.3.1.1 Fuel Switching

Fuel switching in the program occurs when a household installs program equipment (e.g., space heating or water heating) that uses a different type of fuel than the one used by the pre-existing equipment and that results in an overall net reduction in energy usage. For example, when a household with a propane furnace switches to a more efficient natural gas furnace, their propane usage naturally would decrease, and their natural gas usage would increase. All other factors being equal (e.g., number of occupants, temperature settings, etc.), the households overall energy consumption would also decrease due to the improved net efficiency of the home's new natural gas heating system.

The most common fuel switching scenario that occurred in the program during the period of study involved fuel oil, propane, or other delivered fuel users switching to natural gas. This situation differs from current program and state goals of converting fossil fuel systems to electric heat pumps. Heat pump conversions did not start at any significant level until after this evaluation period. A billing analysis that relies on electric or natural gas consumption records would not account for changes in consumption from delivered fuels. Billing analyses of delivered fuels would require collection of fuel delivery records which

² A prior 2010-2011 NYSERDA evaluation included a billing analysis and a follow-up study to determine the main drivers to the low natural gas RRs. To identify the drivers, the study included on-site data collection at participant sites, customer surveys, project file reviews, and review of the EmPCalc modeling software. Source: NYSERDA EmPower Program and National Fuel Gas Distribution Corporations' Low Income Usage Reduction Program Impact Evaluation (2010-2011). Prepared by ERS. May 2015.

are time consuming and costly due to the large number of delivered fuel companies. Obtaining accurate delivered fuel consumption data is also difficult due to the delivery at irregular intervals and/or fuel tanks may not be fully empty at the time of delivery.³

The results in the main body of this report excludes households that installed measure that resulted in fuel switching.⁴ Results with fuel switchers with available natural gas and electric billing records are presented in **Appendix A: Detailed Results**.

1.3.1.2 Attrition

Table 4 shows the attrition rates, the percentage of participants that the contractor had to remove from the analysis due to data issues relating to program tracking data and/or billing data. The attrition rates are broken out by fuel type for participants that installed projects with expected savings, which include projects with positive (reductions in usage) and negative (increases in usage) savings. Of the participants in the program with expected savings, the rate of attrition is approximately 50%. This level of attrition is not uncommon for billing analyses in energy efficiency evaluation. The inability to match program and billing records, inadequate billing data, and challenges with the program tracking data (e.g., missing or errors in account or address information) were the most common reasons for attrition. The attrition rate was lower (33% to 36%) when accounting for participants with matching billing data. Detailed information on attrition is provided in **Section 3.1.2.1**.

Table 4: Summary of Attrition Rates

Program	Attrition Rate	
	Participants with Savings	Participants with Savings and Billing Data
CEF Electric	48%	36%
CEF Natural Gas	50%	33%
LIURP Natural Gas	41%	37%

³ A prior 2011-2013 NYSERDA study estimated the evaluated energy savings for the HPwES Program using a billing analysis of unregulated fuels.

Source: Home Performance with Energy Star: Unregulated Fuels Impact Evaluation (2011-2013). Prepared by ERS. November 2016.

⁴ Fuel switching occurs when a household installs a program equipment (e.g., space heating or water heating) that uses a different type of fuel than the one used by the pre-existing equipment, and which usually results in an overall net reduction in energy usage. For example, when a household with a propane furnace switches to a more efficient natural gas boiler, their propane usage would decrease and their natural gas usage would increase but their overall energy consumption would decrease due to the improved net efficiency of the home's heating system.

2 Results, Findings, and Recommendations

The Impact Evaluation Team conducted a literature review to understand drivers of realization rates (RRs), or the differences between reported and verified energy savings. The team also generated estimates of achieved program savings, or verified savings, for the CEF single-family initiatives. The analysis includes separate assessments of electric and natural gas billing data. The subsections that follow present the results. The results section for each fuel-type focus on presenting the verified savings and RRs, while the program-level findings and recommendations sections provide context and implications of the results.

For the program analysis portion of the study, the Impact Evaluation Contractor provided RRs using two types of reported savings values:

- Model-based program savings are the reported savings submitted by contractors in the program tracking data set and are restricted to the homes in the billing analysis
- NYSERDA-reported program savings are the reported savings from Scorecards

NYSERDA-reported programs savings were not available at more granular levels. This memo presents measure, engineering, utility, and contractor-level analysis RRs using model-based program savings only.

2.1 Literature Review

The Impact Evaluation Team conducted a limited literature review of relevant studies to provide insights on the drivers of the differences in the ex ante savings derived from engineering/simulation models and ex post savings from evaluation studies that typically rely on billing analyses. The review identified four studies completed between 2015 and 2020 from the Northeast and Mid-Atlantic region. The literature review identified the following potential drivers influencing ex ante savings:

- Accuracy of the engineering models
- Quality of program equipment installation
- End user behavior and changes in occupancy

Findings from the literature review suggest that engineering models may not accurately reflect real world situations. A Massachusetts study compared the modeled energy consumption of two engineering/simulation models with consumption from billing records and found that both engineering/simulation models overstated ex ante savings. CLEAResult's Demand Side Management Tracker model

overpredicted pre-program consumption and post-program consumption by 29% and 20%, respectively.⁵ Energy Savvy's Optix model accurately predicted the pre-program consumption but under-estimated post-program consumption.

Another factor affecting accuracy of engineering models is that the inputs used by contractors in the modeling software may not match the actual conditions of the home.⁶ In the same Massachusetts study, interviews with assessors found that assessors often have limited time to perform energy modeling in the program participant's homes and rely on default values rather than follow the industry best practice of populating the fields using observed values specific to the home (e.g., thermostat set points).⁷ In a Connecticut study, quality control auditors found that many vendors (i.e., contractors completing the work) treated finished basements as unconditioned spaces and incorrectly sealed them off from the space included in blower door tests, a practice that may inflate verified savings by under-predicting actual post-improvement air exchange rates.⁸

Program equipment installation may be of lower quality than what is assumed in the engineering model assumptions, the program specifications, or even industry best practice.⁹ In the Connecticut study, the independent evaluator conducting on-site quality inspections found gaps and penetrations in the building shell or duct work in essentially every home they visited.¹⁰ During in-depth interviews, vendors explained that they often assigned this work to assistant technicians rather than the BPI-certified lead technicians, which may explain the lapse in installation quality. Engineering models assuming program equipment was correctly installed will overestimate savings if contractor installations fall short of expected values.

Lastly, changes in end user behavior or occupancy of the house not captured in engineering models may also affect the accuracy of energy consumption.¹¹ Changes that could affect the accuracy of energy estimates include increased usage of program-installed equipment because they are more efficient

⁵ Home Energy Services Realization Rate Assessment (RES39). Prepared by Navigant. March 2020. https://ma-eeac.org/wp-content/uploads/MA-RES-39-HES-RR-Assessment-Executive-Summary_FINALwES_19MAR2020.pdf

⁶ NYSERDA Home Performance with Energy Star Realization Rate Attribution Study. Prepared by Performance Systems Development. January 21, 2015. <http://psdconsulting.com/wp-content/uploads/2015/04/NYSERDA-HPwES-RR-Study-Rev1-012115.pdf>

⁷ See also Review of Impact Evaluation Best Practices Final Report (R91). Prepared by Cadmus Group, Inc. March 30, 2016. https://energizect.com/sites/default/files/2019-06/R91-ReviewofImpactEvaluationBestPractices_FinalReport_3.30.16.pdf

⁸ Connecticut HES Air Sealing, Duct Sealing, and Insulation Practices Report (R151). Prepared by NMR Group, Inc. March 24, 2016. https://energizect.com/sites/default/files/R151%20-%20CT%20HES%20Air%20Sealing,%20Duct%20Sealing,%20and%20Insulation%20Practices%20-%20Final%20Report_3.24.16.pdf

⁹ Ibid., R91

¹⁰ Ibid., R151

¹¹ Ibid., R91

(snapback), changes in the number of occupants, and changes in the number of non-program energy-using devices in the home. Other changes could decrease use, such as fewer occupants or extended vacations. Additionally, if program-installed equipment resulted in fuel switching from a delivered fuel source to a metered fuel or if the home relies on supplemental heating, any changes in energy consumption resulting from changes to end user behavior may not be accurately reflected in the engineering models.

Behavioral changes such as snapback could also affect the accuracy of the ex post savings. Billing analyses rely on consistent tracking of billing records to measure energy consumption. When changes in energy consumption related to supplemental heating or fuel switching are not accounted for in the billing records, then the change may not be accurately captured in the ex post savings by billing analyses.¹²

2.2 Program Analysis

This section presents the high-level billing analysis results by program, year, and fuel type. **Table 1** provides program descriptions and the list of measures that were incentivized by the program. The following section, **Section 2.3**, shows which measures may be driving the savings for the different programs.

2.2.1 Electric Analysis Results

Table 5 presents a summary of electric direct impacts including income level, realization rate, evaluated savings as a percent of evaluated consumption baseline, sample size, and population size.

¹² Ibid., R91

Table 5: Direct Impacts Reporting Tables - Electric

Parameter	Realization Rate Analysis Type - Weighted/ Unweighted	Realization Rate	Evaluated savings as a percent of evaluated consumption baseline (%)	Confidence Interval/ Relative Precision	Sample Size (n) ^a	Population Size (N)
Low-income	Unweighted ^b	0.62	4.66%	N/A ^c	5,400	11,073
Moderate Income		0.53	2.94%		1,407	2,925
Market Rate		0.82	3.06%		2,827	5,127

^a This is not a random sample drawn from the population. Sample size represents all participants with usable elements from the population are included in the study.

^b Population data is unweighted.

^c No confidence intervals/relative precision when using population data.

Table 6 shows the verified energy savings and RRs by program type for the 9,634 program homes verified in the analysis. The annual verified gross savings are 357 kWh for low-income, 238 kWh for moderate-income, and 295 kWh for market rate participants. **Table 7** reports the average verified gross savings values as a percent of consumption baseline for low-income, moderate-income, and market rate participants at 4.7%, 2.9%, and 3.1%, respectively. The RRs using NYSERDA-reported savings varied from a low of 0.62 for low-income participants to a high of 0.82 for market rate participants. The RRs using model-based savings ranged from 0.60 to 1.40. **Table 47** in **Appendix A.1.1** provides results including fuel switching participants.

Table 6: Electric Verified Gross Savings^a

Program Type	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Model-based		NYSERDA-reported	
			Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	Reported Savings per Home (kWh/Yr) (C)	RR ^b (A/C)
Low-Income	5,400	357	591	0.60* (0.53, 0.68)	572	0.62* (0.55, 0.70)
Moderate-Income	1,407	238	378	0.63* (0.42, 0.84)	445	0.53* (0.36, 0.71)
Market	2,827	295	212	1.40* (1.12, 1.67)	360	0.82* (0.66, 0.98)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

Table 7: Electric Verified Gross as a Percent of Baseline Usage

Program Type	Verified Gross Savings per Home (kWh/Yr) (A)	Evaluated baseline usage (kWh/Yr)	Verified gross savings as a percent of evaluated consumption baseline
Low-Income	357	7,663	4.66%
Moderate-Income	238	8,079	2.94%
Market	295	9,651	3.06%

Table 8 presents the verified energy savings and RRs by year for the 5,400 low-income participants used in the analysis. The annual verified gross savings were 406 kWh in 2017, 339 kWh in 2018, to 187 kWh in Q1 of 2019, averaging to 357 kWh. The NYSERDA-reported RRs were 0.69 in 2017 and declined slightly in 2018 to 0.60. The NYSERDA-reported RR for Q1 of 2019 was not statistically significant. The program electric RR averaged over all the years in the study to 0.62 with NYSERDA-reported savings. The results imply that NYSERDA overreported low-income participant savings by about 37%. The model-based RRs showed a similar trend in RRs and had an overall electric RR of 0.60. See **Table 48** in **Appendix A.1.1** for results including fuel switching.

Table 8: Low-Income Electric Verified Gross Savings^a

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Model-based		NYSERDA-reported	
			Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	Reported Savings per Home (kWh/Yr) (C)	RR ^b (A/C)
2017	2,440	406	614	0.66* (0.55, 0.77)	586	0.69* (0.57, 0.81)
2018	2,854	339	564	0.60* (0.50, 0.70)	559	0.60* (0.51, 0.71)
Q1 2019	106	187	769	0.24 (-0.27, 2.39)	572	0.33 (-0.36, 3.21)
Overall ^c	5,400	357	591	0.60* (0.53, 0.68)	572	0.62* (0.55, 0.70)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

^c Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 9 reports the verified energy savings and RRs by year for the 1,407 moderate-income program homes used in the analysis. The annual verified gross savings were 270 kWh in 2017 and 217 kWh in 2018. Savings were not statistically significant for Q1 of 2019, likely due to the small sample size. The NYSERDA-reported RRs were 0.50 in 2017 and increased to 0.53 in 2018. The overall NYSERDA-reported program RR averaged to 0.53. The results indicate that NYSERDA overreported moderate-income program savings by about 45%. The model-based RRs were 0.58 in 2017 and 0.68 in 2018, averaging to 0.63. See **Table 49** in **Appendix A.1.1** for results with fuel switching included.

Table 9: Moderate-Income Electric Verified Gross Savings^a

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Model-based		NYSERDA-reported	
			Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	Reported Savings per Home (kWh/Yr) (C)	RR ^b (A/C)
2017	577	270	466	0.58* (0.33, 0.83)	538	0.50* (0.29, 0.72)
2018	793	217	321	0.68* (0.34, 1.02)	412	0.53* (0.26, 0.79)
Q1 2019	37	-37	229	0.12 (-2.12, 2.37)	234	0.16 (-2.67, 2.98)
Overall ^c	1,407	238	378	0.63* (0.42, 0.84)	445	0.53* (0.36, 0.71)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

^c Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 10 shows the verified energy savings and RRs by year for the 2,827 market rate participants used in the analysis. The annual verified savings were 317 kWh in 2017 and 293 kWh in 2018. Like the moderate-income program, savings were not statistically significant for Q1 of 2019. The NYSERDA-reported RRs were 0.81 in 2017 and increased to 0.85 in 2018. The overall program RR averaged to 0.82 with NYSERDA-reported savings. The results imply that NYSERDA overreported its savings for market rate by almost 20%. The model-based RRs were 1.21 in 2017 and 1.65 in 2018, with an overall program RR averaged of 1.40. See **Table 50** in **Appendix A.1.1** for results with fuel switching included.

Table 10: Market Rate Electric Verified Gross Savings^a

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Model-based		NYSERDA-reported	
			Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	Reported Savings per Home (kWh/Yr) (C)	RR ^b (A/C)
2017	1,142	317	262	1.21* (0.90, 1.60)	393	0.81* (0.60, 1.07)
2018	1,646	293	177	1.65* (1.38, 2.28)	346	0.85* (0.71, 1.17)
Q1 2019	39	-47	181	-0.26 (-13.06, 22.92)	301	-0.16 (-7.87, 13.82)
Overall ^c	2,827	295	212	1.40* (1.12, 1.67)	360	0.82* (0.66, 0.98)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

^c Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

2.2.2 Natural Gas Analysis Results

Table 11 presents a summary of natural gas direct impacts from the CEF and LIURP programs including income level, realization rate, evaluated savings as a percent of evaluated consumption baseline, sample size, and population size.

Table 11: Direct Impacts Reporting Tables – Natural Gas

Parameter	Realization Rate Analysis Type - Weighted/ Unweighted	Realization Rate	Evaluated savings as a percent of evaluated consumption baseline (%)	Confidence Interval/ Relative Precision	Sample Size (n) ^a	Population Size (N)
Low-income	Unweighted ^b	0.73	8.98%	N/A ^c	2,543	6,260
Moderate Income		0.66	11.73%		1,789	3,658
Market Rate		0.45	5.54%		2,178	4,131
LIURP		0.52	10.17%		1,100	1,935

^aThis is not a random sample drawn from the population. Sample size represents all participants with usable elements from the population are included in the study.

^b Population data is unweighted.

^c No confidence intervals/relative precision when using population data.

2.2.2.1 CEF Natural Gas Results

Table 12 shows the verified energy savings and RRs by program type for the 6,510 program homes used in the analysis. The annual verified gross savings varied from 9.3 MMBtu for low-income, 11.4 MMBtu for moderate-income, and 5.4 MMBtu for market rate participants. These verified gross savings values correspond to 9.0%, 11.7%, and 5.5% of the consumption baseline, respectively, as shown in **Table 13**. The RRs using NYSERDA-reported savings varied from a low of 0.45 for market rate participants to a high of 0.73 for low-income participants. The model-based RRs varied from a low of 0.33 for market rate participants to a high of 0.51 for moderate-income participants. See **Table 51** in **Appendix A.1.2** for results with fuel switching included.

Table 12: Natural Gas Verified Gross Savings^a

Program Type	Number of Homes in Analysis	Verified Savings per Home (MMBtu/Yr) (A)	Model-based		NYSERDA-reported	
			Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	Reported Savings per Home (MMBtu/Yr) (C)	RR ^b (A/C)
Low-Income	2,543	9.3	26.4	0.35* (0.33, 0.37)	12.9	0.73* (0.67, 0.77)
Moderate-Income	1,789	11.4	22.1	0.51* (0.46, 0.53)	17.2	0.66* (0.60, 0.69)
Market	2,178	5.4	16.2	0.33* (0.30, 0.37)	12.0	0.45* (0.41, 0.50)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

Table 13: Natural Gas Verified Gross Savings as a Percent of Baseline Usage

Program Type	Verified Gross Savings per Home (MMBtu/Yr) (A)	Evaluated baseline usage (MMBtu/Yr) (B)	Verified gross savings as a percent of evaluated consumption baseline (A/B)
Low-Income	9.3	103.7	8.98%
Moderate-Income	11.4	97.1	11.73%
Market	5.4	97.9	5.54%

Table 14 presents the verified energy savings and RRs by year for the 2,543 low-income participants used in the analysis. The annual verified gross savings were 9.2 MMBtu in 2017, 9.4 MMBtu in 2018, and 16.9 MMBtu in Q1 of 2019, averaging to 9.3 MMBtu. The RRs with NYSERDA-reported savings were 0.83 in 2017, 0.65 in 2018, and 1.35 in Q1 of 2019. The overall program RR averaged to 0.73 with NYSERDA-reported savings. The results imply that NYSERDA overreported low-income participant natural gas savings by about 27%.

The model-based RRs were lower than RRs based on NYSERDA reported savings for all program years at 0.38 in 2017, 0.32 in 2018, and 0.59 in Q1 of 2019. The overall program RR averaged to 0.35 with model-based savings. See **Table 52** in **Appendix A.1.2** for results with fuel switching included.

Table 14: Low-Income Natural Gas Verified Gross Savings by Year^a

Program Type	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Model-based		NYSERDA-reported ^b	
			Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	Reported Savings per Home (MMBtu/Yr) (C)	RR (A/C)
2017	1,395	9.2	24.1	0.38* (0.35, 0.42)	11.1	0.83* (0.76, 0.91)
2018	1,100	9.4	29.2	0.32* (0.29, 0.35)	14.5	0.65* (0.59, 0.71)
Q1 2019	48	16.9	28.7	0.59* (0.33, 0.84)	12.5	1.35* (0.77, 1.94)
Overall ^c	2,543	9.3	26.4	0.35* (0.33, 0.37)	12.9	0.73* (0.67, 0.77)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

^c Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 15 reports the verified energy savings and RRs by year for the 1,789 moderate-income program homes used in the analysis. The annual verified savings averaged 11.4 MMBtu and varied from 10.0

MMBtu in 2017 to 11.3 MMBtu in 2018 and 21.1 MMBtu in Q1 of 2019. The NYSERDA-reported RRs were 0.49 in 2017 and increased to 0.78 in 2018 and 1.36 in Q1 of 2019. The overall program RR averaged to 0.66 with NYSERDA-reported savings. The results mean that NYSERDA overreported moderate-income program savings by about 35%.

The model-based RRs were 0.42 in 2017 and increased to 0.55 in 2018. Savings estimates for Q1 of 2019 were not statistically significant at the 90/10 confidence level. The overall program RR averaged to 0.51. See **Table 53** in **Appendix A.1.2** for results with fuel switching included.

Table 15: Moderate-Income Natural Gas Verified Gross Savings by Year^a

Program Type	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Model-based		NYSERDA-reported	
			Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	Reported Savings per Home (MMBtu/Yr) (C)	RR ^b (A/C)
2017	834	10.0	23.6	0.42* (0.33, 0.83)	20.5	0.49* (0.44, 0.54)
2018	876	11.3	20.5	0.55* (0.34, 1.02)	14.5	0.78* (0.70, 0.85)
Q1 2019	79	21.1	25.4	0.83 (-13.02, 12.67)	15.5	1.36* (1.08, 1.63)
Overall ^b	1,789	11.4	22.1	0.51* (0.46, 0.53)	17.2	0.66* (0.60, 0.69)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

^c Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not equal the sum of the individual program year savings.

Table 16 shows the verified energy savings and RRs by year for the 2,178 market rate program homes used in the analysis. The annual verified gross savings ranged from 6.0 MMBtu in 2017 up to 8.6 MMBtu in Q1 of 2019. The NYSERDA-reported RRs in 2017 and 2018 were 0.43 and 0.49, respectively, before increasing to 0.71 in Q1 of 2019. The overall program RR averaged to 0.45. The results mean that NYSERDA overreported market rate program savings by about 55%. The overall model-based program RR averaged to 0.33 when using model-based savings. See **Table 54** in **Appendix A.1.2** for results with fuel switching included.

Table 16: Market Rate Natural Gas Verified Gross Savings by Year^a

Program Type	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Model-based		NYSERDA-reported	
			Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	Reported Savings per Home (MMBtu/Yr) (C)	RR ^b (A/C)
2017	960	6.0	18.4	0.33* (0.28, 0.37)	13.8	0.43* (0.38, 0.49)
2018	1,158	5.1	14.4	0.35* (0.30, 0.41)	10.4	0.49* (0.42, 0.56)
Q1 2019	60	8.6	17.6	0.49* (0.31, 0.68)	12.2	0.71* (0.44, 0.98)
Overall ^c	2,178	5.4	16.2	0.33* (0.30, 0.37)	12.0	0.45* (0.41, 0.50)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b RRs to be reported to DPS.

^c Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not equal the sum of the individual program year savings.

2.2.2.2 LIURP Natural Gas Results

Table 17 presents the energy savings estimates and realization rates for the 1,100 LIURP program homes used in the analysis by year. The annual evaluated savings ranged from 13.9 MMBtu in 2017 down to 10.8 MMBtu in 2018 and up to 14.2 MMBtu in Q1 of 2019. The average verified gross savings for the LIURP for all years in the study was 12.0 MMBtu, which corresponds to 10.2% of the evaluated baseline usage (**Table 18**). The NFGDC-reported RRs in 2017 and 2018 were 0.52 and 0.50, respectively, before increasing to 0.73 in Q1 of 2019. The overall program RR averaged to 0.52 using NFGDC-reported savings. The results mean that NFGDC overreported market rate program savings by about 50%. The model-based RRs averaged to 0.38 for the overall program. See **Table 55** in **Appendix A.1.2** for results with fuel switching included.

Table 17: LIURP Natural Gas Verified Gross Savings by Year^a

Program Type	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Model-based		NFGDC-reported	
			Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	Reported Savings per Home (MMBtu/Yr) (C)	RR (A/C)
2017	359	13.9	33.6	0.41* (0.35, 0.48)	26.9	0.52* (0.43, 0.6)
2018	579	10.8	30.5	0.35* (0.30, 0.41)	21.5	0.50* (0.43, 0.58)
Q1 2019	162	14.2	28.5	0.50* (0.40, 0.59)	19.5	0.73* (0.59, 0.87)
Overall ^b	1,100	12.0	10.8	0.38* (0.35, 0.42)	22.9	0.52* (0.47, 0.57)

^a RR 90/10 confidence intervals provided in parentheses. Statistical significance at the 90/10 confidence level indicated with (*).

^b Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 18: LIURP Natural Gas Verified Gross Savings as a Percent of Baseline Usage

Program Type	Verified Gross Savings per Home (MMBtu/Yr) (A)	Evaluated baseline usage (MMBtu/Yr) (B)	Verified gross savings as a percent of evaluated consumption baseline (A/B)
LIURP	12.0	117.9	10.17%

2.2.3 Program Year Comparison

First quarter 2019 verified gross savings were not found to be statistically significant for the moderate-income and market rate electric analyses. For the natural gas analysis, the Q1 2019 verified gross savings were statistically significant and they showed higher savings for all programs. Potential reasons for these could be due to the following:

- There is a smaller sample size for Q1 2019 than for other years due to the shorter study period and limited availability of billing data. A small sample size results in large estimation errors (wider confidence intervals) and low statistical power, which in turn, makes it less likely for the regression model to be able to detect a statistically significant impact even when an impact exists.
- The homes in the Q1 2019 sample only required nine months of pre- and post-billing data. Homes that participated in 2017 and 2018 required 12 months of pre- and post-billing data (see [Section 3.1.2](#) for additional information). Having only nine months of pre- and post-billing data means there are fewer observations available to estimate the heating and cooling degree day slopes in the model and may result in less precise estimates.

The overall program model is a weighted average of the effect of the three years. A sensitivity analysis restricting the billing analyses to only projects completed in 2017 and 2018 did not show a significant difference in results that suggested that Q1 2019 should be excluded from the analysis. Q1 2019 makes up a small proportion of the overall sample and does not have a big impact on the overall program savings and RRs, which is an average of all program years.

2.3 Measure Analysis – For Informational Purposes Only

NYSERDA also requested information about RRs by measure group using 2017, 2018, and Q1 2019 participant data. The report presents these results for informational purposes only due to small sample sizes for many measures and the challenges of isolating savings for a single measure group when multiple measures are installed at the same time. Several measures were not found to be statistically significant at the 90/10 confidence level, as indicated in the report tables. This section presents results by fuel type and program. To increase sample sizes for smaller measures, the Impact Evaluation Contractor combined the HPwES and Assisted HPwES analysis. Consistent with the rest of the analyses, the measure-specific results exclude participants with fuel switching. Additional measure-specific results with fuel switching participants included can be found in [Appendix A.2](#). This and all following analyses produced results that

are for informational purposes only due to small sample sizes, and some of the following results are not statistically significant.

2.3.1 Electric Results by Measure

Table 19 shows the EmPower verified and program-reported savings by measure group in the electric model. Lighting consisted of 71% of the program-reported savings and had a RR of 0.61. Refrigeration and envelope measures together make up of 25% of the program savings and had RRs of 0.77 and 0.35, respectively. DHW conservation, DHW and heating system replacement/repair, and thermostat measures did not have statistically significant savings estimates. **Table 56** in **Appendix A.2.1** provides results with fuel switching participants included.

Table 19: Informational Purposes Only – EmPower Electric Measure-Specific Program Savings

Measure Group	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Program Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Lighting	5,255	260	429	0.61	(0.50, 0.71)	Yes
Refrigeration	772	430	557	0.77	(0.55, 1.00)	Yes
DHW conservation	251	212	143	1.48	(-0.15, 3.12)	No
Envelope	126	985	2,841	0.35	(0.18, 0.52)	Yes
Heating system replace/repair	106	224	223	1.00	(-0.81, 2.81)	No
DHW replace/repair	24	664	97	6.82	(-0.03, 13.66)	No
Thermostat	19	387	167	2.32	(-1.69, 6.32)	No
Other	70	1,200	1,151	1.04	(0.68, 1.40)	Yes

Table 20 shows the HPwES (including Assisted HPwES) verified gross and program-reported savings by measure group in the electric model. Air conditioning (33%), building envelope (25%), lighting (14%), and heating system replacement and repair (14%) made up most of the program reported savings in the analysis. Of those four, air conditioning and envelope measures had the high RRs of 1.06 and 1.01, respectively. Lighting had the lowest RR of 0.43.

Thermostats, domestic hot water replacement and repair, and refrigeration measures consisted of 6% of program-reported savings in the analysis but had the highest RRs ranging from 1.46 to 3.13. The negative DHW verified savings likely resulted from the small sample size, and the DHW savings are not statistically significant. This shows that DHW conservation measures did not significantly impact electricity consumption. Heating system conservation, heat pumps, and heating system replacement and

repair savings estimates were also not found to be statistically significant. See **Table 57** in **Appendix A.2.1** for results with fuel switching participants included.

Table 20: Informational Purposes Only – HPwES and Assisted HPWES Electric Measure-Specific Program Savings

Measure Group	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Program Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Air conditioning	1,806	218	205	1.06	(0.67, 1.45)	Yes
Heating system replace/repair	1,421	73	113	0.64	(-0.14, 1.43)	No
Envelope	1,389	209	207	1.01	(0.59, 1.43)	Yes
Thermostat	476	226	72	3.13	(1.11, 5.15)	Yes
DHW replace/repair	417	150	53	2.82	(0.23, 5.42)	Yes
Lighting	338	195	453	0.43	(0.031, 0.83)	Yes
Heating system conservation	75	228	91	2.50	(1.70, 6.70)	No
Heat pump	25	243	1,499	0.16	(0.33, 0.65)	No
Refrigeration	15	601	412	1.46	(0.17, 2.75)	Yes
DHW conservation	9	-800	114	-6.99	(-15.27, 1.29)	No
Other	86	404	598	0.68	(0.11, 1.24)	Yes

2.3.2 Natural Gas Results by Measure

2.3.2.1 CEF Natural Gas Results by Measure

Table 21 shows the EmPower verified and program-reported savings by measure group in the natural gas model. Envelope measures, with an RR of 0.37, made up 91% of the natural gas program-reported savings in the analysis. Heating system replacement and repair measures, with 4% of the program-reported savings, also had an RR of 0.37. Domestic hot water replacement/repair, with the highest RR (1.56), made up of less than 1% of the program-reported savings. Thermostat and DHW conservation measure savings estimates were not statistically significant. See **Table 58** in **Appendix A.2.2** for results with fuel switching participants included.

Table 21: Informational Purposes Only – EmPower Natural Gas Measure-Specific Program Savings

Measure Group	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Program Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Envelope	2,451	9.2	24.9	0.37	(0.34, 0.40)	Yes
DHW conservation	567	-0.4	0.6	-0.60	(-3.07, 1.87)	No
Heating system replace/repair	378	2.6	7.0	0.37	(0.11, 0.63)	Yes
DHW replace/repair	56	5.4	3.5	1.56	(0.56, 2.56)	Yes
Other	89	-3.2	2.2	-1.47	(-2.74, -0.20)	Yes

Table 22 shows the HPwES (including Assisted HPwES) verified and program-reported savings by measure group in the natural gas model. Heating system replacement and repair (54%) and envelope (36%) measures made up the majority of the program-reported natural gas savings with RRs of 0.34 and 0.44, respectively. Heating system conservation and DHW replacement and repair measures had the highest RRs of 1.33 and 1.04, respectively. Verified savings from DHW conservation, lighting, and other measures were not found to be statistically significant. **Table 59** in **Appendix A.2.2** reports results with fuel switching participants included.

Table 22: Informational Purposes Only – HPwES Natural Gas Measure-Specific Program Savings

Measure Group	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Program Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Heating system replace/repair	2,828	4.9	14.3	0.34	(0.30, 0.39)	Yes
Envelope	1,547	7.6	17.4	0.44	(0.39, 0.49)	Yes
DHW replace/repair	858	4.2	4.1	1.04	(0.78, 1.30)	Yes
Thermostat	706	3.1	5.7	0.54	(0.30, 0.79)	Yes
Lighting	75	0.7	-0.8	-0.83	(-3.30, 1.63)	No
Heating system conservation	73	4.3	3.2	1.33	(0.26, 2.39)	Yes
DHW conservation	24	-4.3	1.1	-3.89	(-9.03, 1.25)	No
Other	40	2.5	0.4	6.06	(-3.41, 15.54)	No

2.3.2.2 LIURP Natural Gas Results by Measure

Table 23 shows the LIUPR verified and program-reported savings by measure group. Envelope measures, with an RR of 0.42, made up 90% of the program-reported savings in the analysis.

Thermostats, with 6% of the program-reported savings, were not statistically significant. Domestic hot water replacement/repair and conservation measures had statistically significant RRs but have very small samples, making them sensitive to outliers. Heating system replacement/repair measures were also not statistically significant. See **Table 60** in **Appendix A.2.2** for results with fuel switching participants included.

Table 23: Informational Purposes Only – LIURP Natural Gas Measure-Specific Program Savings

Measure Group	Number of Homes in Analysis	Verified Savings per Home (MMBtu/Yr) (A)	Program Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Envelope	1,064	12.4	29.2	0.42	(0.37, 0.47)	Yes
DHW conservation	353	1.5	6.5	0.22	(-0.15, 0.59)	No
Heating system replace/repair	133	-1.8	6.4	-0.28	(-0.81, 0.26)	No
DHW replace/repair	25	6.7	3.3	2.06	(0.41, 3.72)	Yes
Other ^a	21	-8.7	0.5	-18.57	(-32.53, -4.61)	Yes

^a Other measures include one heating system conservation installation.

2.4 Engineering Model Analysis – For Informational Purposes Only

The analysis compared RRs by engineering model under HPwES and Assisted HPwES. The sample of homes in the HPwES analysis primarily used Snugg Pro and TREAT modeling software.¹³ The low-income Empower program uses a single modeling software, EmPCalc, for the entire program. The scope did not support a deeper dive into why results varied by engineering models between HPwES and Assisted HPwES.

2.4.1 Electric Results by Engineering Model

Table 24 shows the verified and program-reported savings and associated RRs by program. The main takeaways were the following:

- The EmpCalc model is used to estimate reported savings for all low-income participant savings and has a RR 0.60.
- For both moderate-income and market rate participants, the TREAT model had higher verified savings (345 kWh and 457 kWh, respectively) compared to homes modeled using Snugg Pro. TREAT also had higher RRs of 0.75 and 1.50.
- For moderate-income participants, the Snugg Pro model verified savings was not statistically significant at the 90/10 confidence level.

¹³ The HPwES uses one of eight different software programs to model program-reported savings: AUDITOR, CakeSystems, EmPCalc, HOMECHECK, OptiMiser, Snugg Pro, and TREAT.

Table 24: Electric Verified Gross Program Savings by Engineering Model

Engineering Model	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Program Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
Low-income						
EmpCalc	5,400	0.36	0.59	0.60	(0.53, 0.68)	Yes
Moderate-Income						
Snugg Pro	482	33	193	0.17	(-0.61, 0.97)	No
TREAT	764	345	461	0.75	(0.60, 1.07)	Yes
Market Rate						
Snugg Pro	1,866	216	158	1.37	(0.93, 1.81)	Yes
TREAT	926	457	305	1.50	(1.14, 1.83)	Yes

2.4.2 Natural Gas Results by Engineering Model

Table 25 provides verified and program-reported natural gas savings and associated RRs by engineering model for the three program groups. The primary takeaways were the following:

- EmpCalc, the program used by the low-income program, had an RR of 0.35.
- For moderate-income participants, the TREAT model had higher verified savings at 11.9 MMBtu compared to Snugg Pro at 9.6 MMBtu. Both programs had similar RRs of 0.51 and 0.53, respectively.
- For market-rate participants, TREAT had a higher RR (0.35) than Snugg Pro (0.30).

Table 25: Natural Gas Verified Gross Program Savings by Engineering Model

Engineering Model	Number of Homes in Analysis	Verified Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu /Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
Low-income						
EmpCalc	2,543	9.3	26.4	0.35	(0.33, 0.37)	Yes
Moderate-Income						
Snugg Pro	537	9.6	18.1	0.53	(0.46, 0.60)	Yes
TREAT	1,162	11.9	23.4	0.51	(0.47, 0.55)	Yes
Market Rate						
Snugg Pro	1,143	4.4	14.4	0.30	(0.26, 0.35)	Yes
TREAT	524	6.4	18.1	0.35	(0.31, 0.40)	Yes

2.5 Utility-level Analysis – For Informational Purposes Only

The analysis compared RRs by program and fuel type for each utility. Consolidated Edison (ConEd), National Grid (NGRID), New York State Electric & Gas (NYSEG), National Fuel Gas Distribution Corporation (NFGDC), and Rochester Gas and Electric (RG&E) had sufficient data for inclusion in the analysis.

2.5.1 Electric Results by Utility

Table 26, **Table 27**, and **Table 28** present verified energy savings and RRs for the following utilities: Consolidated Edison (ConEd), National Grid (NGRID), New York State Energy and Gas Corporation (NYSEG), and Rochester Gas and Electric (RG&E). While NYSERDA provides residential retrofit programs to participants that live in Central Hudson and Orange and Rockland utility territories, these two utilities could not provide data needed for this analysis. **Table 26** presents the verified energy savings and RRs for low-income participants by utility. The annual verified savings varied from 277 kWh/year for ConEd up to 523 kWh/year for NGRID. NYSEG and ConEd had the lowest model-based RRs of 0.47 and 0.48, respectively. NGRID had the highest RR of 0.88 followed by RG&E at 0.66. Results were very similar, with 93 fuel switching participants included (see **Table 61** in **Appendix A.3.1**).

Table 26: Low-Income Electric Verified Gross Program Savings by Utility

Utility	Number of Homes in Analysis	Verified Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
ConEd	1,144	277	579	0.48	(0.35, 0.61)	Yes
NGRID	2,129	523	595	0.88	(0.75, 1.00)	Yes
NYSEG	1,052	295	630	0.47	(0.29, 0.64)	Yes
RG&E	995	354	537	0.66	(0.46, 0.86)	Yes

Table 27 reports the verified energy savings and RRs for moderate-income participants by utility. The annual verified savings were 162 kWh for RG&E, 240 kWh for NYSEG, and 264 kWh for NGRID. ConEd, with only nine homes in the analysis, did not have a statistically significant savings estimate. NGRID and NYSEG had the higher model-based RRs of 0.64 and 0.63, respectively. RG&E had the lowest RR of 0.51. Utility RRs with 156 fuel switching participants included showed NYSEG and RG&E to have closer RRs of 0.55 and 0.57, respectively (see **Table 62** in **Appendix A.3.1**).

Table 27: Moderate Electric Verified Gross Program Savings by Utility

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
ConEd	9	868	677	1.28	(-2.66, 5.23)	No
NGRID	614	264	421	0.63	(0.36, 0.90)	Yes
NYSEG	275	240	377	0.64	(0.15, 1.12)	Yes
RG&E	501	162	316	0.51	(0.13, 0.90)	Yes

Table 28 shows the verified energy savings and RRs for market-rate participants by utility. The annual verified savings varied from 334 kWh/year for NGRID up to 960 kWh/year for ConEd. NYSEG and RG&E had the lowest model-based RRs of 1.03 and 1.25, respectively. ConEd had the highest RR of 3.36. Results were very similar, with 87 fuel switching participants included (see **Table 63** in **Appendix A.3.1**).

Table 28: Market Rate Electric Verified Gross Program Savings by Utility

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
ConEd	79	960	286	3.36	(1.69, 5.03)	Yes
NGRID	768	334	190	1.76	(1.22, 2.30)	Yes
NYSEG	480	284	275	1.03	(0.45, 1.61)	Yes
RG&E	1,494	247	197	1.25	(0.85, 1.66)	Yes

2.5.2 Natural Gas Results by Utility

This section compares utilities with participants that participated in the CEF programs (EmPower NY, Assisted Home Performance with Energy Star, and Home Performance with Energy Star) and does not include LIURP participants. NFGDC customers can participate in the CEF programs through their electric utility provider. Participation in CEF programs as an electric customer can result in ancillary natural gas savings. Since CEF programs are a fuel blind, this analysis of the CEF program includes these NFGDC customers.

Table 29, **Table 30**, and **Table 31** show the verified energy estimates and RRs for the following utilities: ConEd, National Fuel Gas Distribution Corporation’s (NFGDC), NGRID, NYSEG, and RG&E. NYSERDA does provide residential retrofit programs to participants in Central Hudson and Orange and Rockland utility territories; however, these two utilities could not provide data for this study. **Table 29** shows the verified energy savings and RRs for low-income participants by utility. The annual verified savings varied from 7.8 MMBtu/year for RG&E 10.2 MMBtu/year for NGRID. NFGDC, with only 58 homes in the analysis, had the lowest estimated gas savings of 3.6 MMBtu/year. This is likely due to program participants being primarily those who received electric measures resulting in ancillary natural gas savings. ConEd, with only 44 homes in the analysis, did not have a statistically significant savings estimate. Of the utilities with larger sample sizes, NGRID had the highest model-based RR of 0.40 and NYSEG with the second highest at 0.34. RG&E had the lowest RR of 0.28. Results were very similar, with 61 fuel switching participants (see **Table 64** in **Appendix A.3.2**).

Table 29: Low-Income Gas Verified Gross Program Savings by Utility

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
ConEd	44	-4.4	29.8	-0.15	(-0.37, 0.07)	No
NFGDC	58	3.6	18.7	0.19	(0.01, 0.37)	Yes
NGRID	1,290	10.2	25.4	0.40	(0.37, 0.44)	Yes
NYSEG	431	9.4	27.7	0.34	(0.3, 0.39)	Yes
RG&E	682	7.8	27.9	0.28	(0.24, 0.32)	Yes

Table 30 reports the verified energy savings and RRs for moderate-income participants by utility. The annual verified savings varied from 9.0 MMBtu/year for RG&E to 14.7 MMBtu/year for NFGDC. NFGDC also had the highest model-based RR of 0.60. RGE, NYSEG, and NGRID all had RRS in the 0.40s, with NYSEG being the lowest (0.40). Results were very similar with 43 fuel switching participants included (see **Table 65** in **Appendix A.3.2**).

Table 30: Moderate Gas Model Program Savings by Utility

Utility	Number of Homes in Analysis	Verified Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
NFGDC	424	14.7	24.4	0.60	(0.52, 0.68)	Yes
NGRID	382	12.0	24.7	0.49	(0.43, 0.55)	Yes
NYSEG	238	8.3	20.9	0.40	(0.31, 0.48)	Yes
RG&E	734	9.0	19.7	0.46	(0.40, 0.51)	Yes

Table 31 reports the verified energy savings and RRs for market-rate participants by utility. The annual verified savings varied from 4.3 MMBtu/year for NYSEG to 8.4 MMBtu/year for NFGDC. ConEd did not have a statistically significant savings estimate with only 34 homes in the analysis. NFGDC also had the highest model-based RR of 0.50. NGRID and RG&E had RRs of 0.31 and 0.30, respectively. NYSEG had the lowest RR (0.26). Results were very similar, with 15 fuel switching participants included (see **Table 66** in **Appendix A.3.2**).

Table 31: Market Rate Gas Model Program Savings by Utility

Utility	Number of Homes in Analysis	Verified Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Statistically Significant at the 90/10 Confidence Level
ConEd	34	2.4	31.0	0.08	(-0.27, 0.43)	No
NFGDC	218	8.4	17.0	0.50	(0.39, 0.61)	Yes
NGRID	359	5.8	18.6	0.31	(0.26, 0.37)	Yes
NYSEG	260	4.3	16.8	0.26	(0.17, 0.35)	Yes
RG&E	1,301	4.5	14.9	0.30	(0.26, 0.35)	Yes

2.6 Findings

The results indicate that the CEF single-family retrofit program achieves energy savings for participants without fuels switching. Overall, low-income, moderate-income, and market rate participants reduced their electricity consumption by 357 kWh, 238 kWh, and 295 kWh, respectively. Low-income, moderate-income, and market rate participants reduced their natural gas consumption by 9 MMBtu, 11 MMBtu, and 5 MMBtu, respectively. However, the electric low-income program verified gross savings fell short of reported savings estimated for the program achieving 67% of the reported savings from the NYSERDA tracking database. The electric moderate-income and market rate programs verified savings achieved 92% and 91% of NYSERDA-reported savings, respectively. Natural gas savings also fell short of the reported savings estimated for the program. For the relevant study period, natural gas savings for low-income and market rate programs achieved 68% and 63% of the reported savings listed in the NYSERDA program tracking database, respectively. Market rate natural gas savings achieved 42% of the savings reported in the tracking database.

Table 36, **Table 37**, and **Table 38** compare the electric verified savings and RRs of this study with the results from prior year studies. Verified electric annual savings per home are generally decreasing for all programs despite the RRs showing a general increase. Natural gas shows a similar downward trend in verified savings, but the RRs do not show a clear upward or downward trend. One possible explanation for the declining savings is that compared to previous years studies, the homes in this study consumed less energy on average (as shown **Table 2**), perhaps because they were already more efficient or due to other characteristics (e.g., age, home size, etc.). In general, it is more difficult or costly to generate savings in homes that already use less energy.

Table 32: CEF Electric Verified Annual Savings per Participant (kWh) and Realization Rate Comparison with Prior Studies

Program Year	Low-income (EmPower)		Moderate-income (Assisted HPWES)		Market Rate (HPwES)	
	Verified Annual Savings per Home (kWh)	RR	Verified Annual Savings per Home (kWh)	RR	Verified Annual Savings per Home (kWh)	RR
2007-2008	694	0.54	--	--	315	0.35
2010-2011	1,275	0.97	--	--	154	0.19
2012-2016	547	0.58	387	0.43	724	0.51
2016-mid 2017 ^a	327	0.54	442	0.52	443	0.62
2017-Q1 2019	357	0.67	238	0.92	295	0.91

^a RR calculated using model-based savings instead of NYSERDA-reported savings.

Table 33: CEF Natural Gas Verified Annual Savings (MMBtu) per Participant and Realization Rate Comparison with Prior Studies

Program Year	Low-income (EmPower)		Moderate-income (Assisted HPWES)		Market Rate (HPwES)	
	Verified Annual Savings per Home (MMBtu)	RR	Verified Annual Savings per Home (MMBtu)	RR	Verified Annual Savings per Home (MMBtu)	RR
2007-2008	10	0.70	--	--	17	0.65
2010-2011	2	0.49	--	--	13	0.48
2012-2016	12	0.44	15	0.43	11	0.42
2016-mid 2017 ^a	8	0.30	7	0.33	11	0.37
2017-Q1 2019	9	0.68	11	0.63	5	0.42

^a RR calculated using model-based savings instead of NYSERDA-reported savings.

Table 34: LIURP Natural Gas Verified Annual Savings per Participant (MMBtu) and Realization Rate Comparison with Prior Studies

Program Year	Verified Annual Savings per Home (MMBtu)	Model-based RR	LIURP-reported RR
2010-2011	2	--	0.37
2012-2016	22	--	0.52
2016-mid 2017 ^a	13	0.40	--
2017-Q1 2019	12	0.38	0.52

^a RR calculated using model-based savings instead of LIURP-reported savings.

2.7 Recommendations

The following recommendation from the prior 2016 CEF interim study still stands:

Recommendation 1: NYSERDA should consider conducting a process study of CEF-funded projects to examine the on-the-ground conditions that could be limiting achieved savings. The literature review identified the accuracy of the engineering models and their inputs to reflect real world situations, quality of measure installation, and end user behavior and occupancy changes as the potential drivers affecting ex ante savings. The process study could address a range of factors, including the following:

- Customer surveys and on-site visits to compare engineering and other assumptions versus actual conditions of the home (e.g., number of household members, thermostat settings, etc.)
- Engineering model desk reviews to compare inputs used by contractors in the modeling software with the actual conditions of the home
- In-depth interviews and ride-alongs with home performance contractors to understand the factors that inform their recommendations to participants as well as their installation practices
- Pre- and post-metering and logging studies designed to update savings assumptions for specific measures

Such explorations seem most critical for households receiving natural gas measures.

NYSERDA’s Response to Recommendation 1: Pending. NYSERDA will release a mini-bid for the next residential retrofit program impact evaluation, including a statewide analysis encompassing the new EmPower+ Program, in Q3 2022. This evaluation study will include a process evaluation.

The study also yields three new recommendations.

Recommendation 2: NYSERDA should consider conducting a more thorough impact evaluation drawing on multiple approaches to verify gross savings and estimate RRs. The results of the various approaches could be combined into a single RR through triangulation and, if needed, reliance on Delphi panels or other similar structured expert consensus methods. Two suggested impact approaches include desktop verification of reported savings assumptions and their alignment with the TRM and program-specific VGS specifications, 2) independent third-party site visits that include visual inspections, metering, and testing to verify savings, and 3) the same surveys of customers mentioned above for the recommended process evaluation.

NYSERDA’s Response to Recommendation 2: Pending. The next evaluation is in the scoping process, and these suggestions are being considered for the methodology.

Recommendation 3: NYSERDA should consider conducting a delivered fuels impact evaluation.

This evaluation would require approaches to access delivered fuels consumption data, an approach that has proved challenging in the past. However, without such data, impact evaluations will continue to exclude a sizable portion of program participants and be unable to provide a full accounting of the energy savings associated with electrification.

NYSERDA’s Response to Recommendation 3: Pending. NYSERDA will include a delivered fuel analysis in the next impact evaluation, which is in the scoping process.

Recommendation 4: NYSERDA should consider working with the utilities to ensure utility data is received and has few estimated reads. Utility data was not received for two utilities for this evaluation. Additionally, the utility data that was received for this evaluation included data with excessive estimated reads (more than eight estimated reads out of twelve reads yearly). A much larger percentage of homes would be included in this analysis if the utility data was complete. This would present a more realistic view of the program and increase statistical significance in the results.

NYSERDA’s Response to Recommendation 4: Pending. NYSERDA is working with utilities to improve the utility data requesting process, which will increase the responses to utility requests. NYSERDA will discuss the number of estimated reads with utilities in preparation for the next residential retrofit evaluation.

3 Methods

3.1 Data Preparation

3.1.1 Data Sources

The billing analysis utilized three sources of data. First was program tracking data at the project and measure-level. The project-level data provided by NYSERDA included information on the housing characteristics (e.g., address, heating fuel use, age, and square footage of home) and project details (e.g., program-reported savings by project, project installation complete date). The program tracking dataset at the measure-level data included information on installation contractor, reported savings by measure, measure type, and funding source. The analysis also used monthly electric and natural gas billing consumption records from five utilities – ConEd, NGRID, RG&E, NYSEG, and NFGDC.

The analysis included daily weather data from National Oceanic and Atmospheric Administration (NOAA) for the major weather stations in the state. Lastly, the analysis used 15-year climate normals from NOAA to calculate normalized baseload, heating, and cooling consumption, shown in **Table 39**.

Table 35: Annual HDD and CDD Normals

Weather Station	HDDs	CDDs
Ithaca Cornell University	7,079	428
New York LaGuardia Airport	4,240	1,482
Buffalo	6,307	67
Albany Airport	6,177	775
Elmira Corning Regional Airport	6,446	546
Rochester Greater International Airport	6,161	698
Syracuse Hancock International Airport	6,479	652

3.1.2 Data Cleaning

Data cleaning in preparation for analysis occurred over several steps:

1. The first step involved cleaning program data such as removing accounts that were flagged by program staff as “incomplete,” and projects with inconsistent or partial billing account information (e.g., short, missing, and overlapping account numbers for multiple sites).
2. The second step merged EmPower (including LIURP) and HPwES (including Assisted HPwES) program data to identify and exclude any homes that participated in both programs at different times over the study period. For participants that completed more than one project, the Impact Evaluation Contractor did the following:
 - a. Project completion dates differed by more than one month but by less than one year: Excluded accounts with different completion dates. Accounts with multiple projection completion dates – especially those that are more than several months apart – limits the predictive capabilities of the model.
 - b. Project completion dates differed by one year or more: Retained the account and based the analysis on the most recently completed project for accounts that completed multiple projects with completion dates greater than one year apart.

- c. Multiple program participation: Assigned the account to the program with the most reported savings for accounts that participated in multiple programs.
3. The Impact Evaluation Contractor used CEF program-reported savings to identify gas and electric measures. Accounts that listed no program-reported savings use (kWh savings for the electric projects and MMBtu savings for natural gas projects) were removed.
4. After cleaning the program tracking data, the Impact Evaluation Contractor merged the program and utility accounts from ConEd, NGRID, RG&E, NYSEG, and NFGDC. Program accounts that did not have matching utility data were dropped.
5. The next step involved cleaning the billing data accounts by identifying common issues such as negative, missing, and duplicate reads. The Impact Evaluation Contractor also removed reads with consecutive zeros during heating months, overlapping periods and gaps, outliers, and billing durations over 100 days (approximately three months or one full season).
6. The Impact Evaluation Contractor aggregated estimated meter reads to obtain an accurate total consumption spanning multiple billing periods. The total consumption for the aggregated period was divided by duration to get average daily use. Accounts with over 67% estimated reads in their billing data were removed from the analysis as they may fail to capture seasonal variation.¹⁴
7. The final step removed homes that did not have at least 12 months of pre- and post- project installation billing data for 2017 and 2018 projects. The Impact Evaluation Contractors removed homes completed in 2019 that did not have at least nine months of pre- and post- billing data. Projects completed in 2019 would not have a full year of billing data for weather normalization. For natural gas, participants must also have at least two months of pre- and post-project billing data that occurred during the winter heating months (October through May).

3.1.2.1 Attrition Analysis

Attrition occurs when participants are removed from the analysis during the data cleaning due to having missing, inadequate, or otherwise problematic program tracking data or utility billing data. **Table 40** through **Table 43** provide an attrition analysis by fuel type for HPwES (including Assisted HPWES) and EmPower programs. Each table lists the reasons for attrition and their impact on the sample size included in the billing analysis. The tables begin with total number of projects completed and total number of homes that participated in the programs. Since the programs are fuel blind, the tables distinguished fuel

¹⁴ The prior NYSERDA Retrofit 2012-2016 evaluation used a cut off of 50% (allowing one half of the year of billing records to be estimated meter reads). The Impact Evaluation Team increased the cut off to 67% to reduce attrition. However, having too many estimated reads adds noise to the data and makes the model estimates less precise by introducing measurement error.

type by projects and homes with non-zero savings. The tables conclude with the number and percentage of remaining homes with non-zero savings that were ultimately included in the billing analysis.

The reasons for attrition were similar across programs but varied by fuel type. Of the program homes with non-zero savings identified, approximately 79% to 82% of program homes had matching billing data except for EmPower gas, which had a 54% match rate. For the electric program shown in **Table 40** and **Table 41**, the most common source of attrition was not having enough -pre and -post utility data (17% to 20%). This would include participants with utility accounts opened shortly before participating or relocated soon after participating in the program so that they lacked 12 months of pre- or post-participation data. The second most common source is having more than 67% of billing data being estimated reads (10% to 18%). Approximately 2% to 7% involved participants with that completed multiple projects more than 1.5 months but less than one year apart.

Table 36: EmPower Program Attrition by Utility- Electric

	ConEd	NGRID	NYSEG	RG&E	Total
A. Total projects (with non-zero savings)	3,860	7,049	3,184	2,850	16,943
B. Number of homes (with non-zero savings)	3,526	3,592	1,863	2,092	11,073
C. Number of homes with non-zero savings and billing data	2,659	2,948	1,549	1,647	8,803
D. Data Cleaning - Reasons for Attrition (Multiple reasons allowed; ordered highest to lowest)					
1. Not enough pre/post billing data	12%	22%	26%	24%	20%
2. Over 67% estimated reads	50%	<1%	3%	14%	18%
3. Multiple projects (greater than 1.5 month and less than 1 year apart)	1%	2%	2%	4%	2%
4. Overlapping reads	2%	1%	1%	1%	1%
5. Outliers	<1%	1%	2%	1%	1%
6. Missing more than 25% heating months	<1%	<1%	1%	<1%	<1%
7. Gaps in billing records (greater than 1 month apart)	1%	0%	<1%	0%	<1%
8. Duration over 100 days	<1%	<1%	<1%	0%	<1%
9. Multiple zip for same program ID	0%	<1%	<1%	0%	<1%
10. Negative usage	0%	0%	0%	<1%	<1%
E. Number of homes after program and billing data cleaning	1,129	2,206	1,058	1,004	5,397
F. Percentage of homes included in billing analysis (Rows E/C)	32%	61%	57%	48%	49%
G. Percentage of homes with billing data included in billing analysis (Rows E/D)	42%	75%	68%	61%	61%

Table 37: HPwES (Includes Assisted HPWES) Program Attrition by Utility- Electric

	ConEd	NGRID	NYSEG	RG&E	Total
A. Total projects (with non-zero savings)	557	2,469	1,395	3,770	8,191
B. Number of homes (with non-zero savings)	565	2,413	1,388	3,686	8,052
C. Number of homes with non-zero savings and billing data	424	2,080	1,095	2,982	6,581
D. Data Cleaning - Reasons for Attrition (Multiple reasons allowed; ordered highest to lowest)					
1. Not enough pre/post billing data	20%	19%	17%	14%	17%
2. Over 67% estimated reads	67%	0%	3%	12%	10%
3. Multiple projects (greater than 1.5 month and less than 1 year apart)	4%	8%	5%	7%	7%
4. Outliers	3%	1%	2%	1%	1%
5. Missing more than 25% heating months	2%	<1%	1%	<1%	1%
6. Overlapping reads	0%	<1%	0%	<1%	<1%
7. Duration over 100 days	<1%	<1%	0%	<1%	<1%
8. Gaps in billing records (greater than 1 month apart)	0%	<1%	0%	<1%	<1%
9. Multiple zip for same program ID	0%	0%	0%	<1%	<1%
10. Negative usage	0%	0%	0%	0%	0%
E. Number of homes after program and billing data cleaning	89	1,512	815	2,055	4,471
F. Percentage of homes included in billing analysis (Rows E/C)	16%	63%	59%	56%	56%
G. Percentage of homes with billing data included in billing analysis (Rows E/D)	21%	73%	74%	69%	68%

For the natural gas program shown in **Table 42** and **Table 43**, the most common sources of attrition for CEF were having too many estimated reads (16-18%) followed by not enough pre- and post- billing data (12-14%). Approximately 4% to 7% involved participants with that completed multiple projects more than 1.5 months but less than one year apart.

Across all utilities, ConEd consistently had higher attrition due to their billing data exceeding 67% of estimated reads. Utilities use past consumption to estimate reads when they cannot get an actual read for that monthly billing cycle, then adjust the monthly bill with an actual read. Having too many estimated reads adds noise to the data which introduces measurement error and makes the model estimates less precise. A sensitivity analysis conducted on electric program participants did not find evidence of biased results from excluding more homes from the analysis. However, the natural gas findings suggested including more estimated reads may result in more measurement error.

For LIURP, the most common sources of attrition were not enough pre- and post- billing data (26%) followed by having too many estimated reads (10%). In addition, NFGDC had the lowest rate of attrition of all utilities as they were able to provide billing records for 94% of homes with non-zero savings.

Table 38: EmPower Program and LIURP Attrition by Utility – Natural Gas

	CEF					LIURP
	ConEd	NGRID	NYSEG	RG&E	Total	NFGDC
A. Total projects (with non-zero savings)	671	4,812	1,325	2,556	9,364	2,081
B. Number of homes (with non-zero savings)	472	3,231	817	1,740	6,260	1,935
C. Number of homes with non-zero savings and billing data	281	1,694	664	1,358	3,997	1,814
D. Data Cleaning – Reasons for Attrition (Multiple reasons allowed; ordered highest to lowest)						
1. Over 67% estimated reads	74%	1%	9%	26%	16%	10%
2. Not enough pre/post billing data	8%	10%	17%	18%	14%	26%
3. Multiple projects (greater than 1.5 month and less than 1 year apart)	1%	2%	3%	6%	4%	3%
4. Outliers	1%	2%	1%	1%	1%	1%
5. Duration over 100 days	2%	1%	0%	0%	1%	<1%
6. Overlapping reads	2%	<1%	<1%	1%	1%	3%
7. Missing more than 25% heating months	1%	1%	1%	<1%	<1%	<1%
8. Gaps in billing records (greater than 1 month apart)	2%	<1%	0%	0%	<1%	<1%
9. Multiple zip for same program ID	0%	<1%	<1%	0%	<1%	<1%
E. Number of homes after program and billing data cleaning	57	1,444	476	774	2,751	1,146
F. Percentage of homes included in billing analysis (Rows E/C)	12%	45%	58%	44%	44%	59%
G. Percentage of homes with billing data included in billing analysis (Rows E/D)	20%	85%	72%	57%	69%	63%

Table 39: HPwES (Includes Assisted HPWES) Program Attrition by Utility – Natural Gas

	ConEd	NFGDC	NGRID	NYSEG	RG&E	Total
A. Total projects (with non-zero savings)	369	1,171	1,305	970	4,257	8,072
B. Number of homes (with non-zero savings)	322	1,133	1,249	949	4,136	7,789
C. Number of homes with non-zero savings and billing data	267	1,029	1,024	758	3,343	6,421
D. Data Cleaning - Reasons for Attrition (Multiple reasons allowed; ordered highest to lowest)						
1. Over 67% estimated reads	85%	12%	0%	10%	21%	18%
2. Not enough pre/post billing data	10%	12%	14%	12%	11%	12%
3. Multiple projects (greater than 1.5 month and less than 1 year apart)	1%	10%	6%	8%	7%	7%
4. Outliers	10%	<1%	1%	1%	1%	1%
5. Missing more than 25% heating months	0%	<1%	<1%	1%	<1%	<1%
6. Overlapping reads	<1%	<1%	<1%	0%	<1%	<1%
7. Gaps in billing records (greater than 1 month apart)	1%	<1%	<1%	0%	0%	<1%
8. Duration over 100 days	0%	<1%	<1%	0%	<1%	<1%
9. Negative usage	0%	<1%	0%	0%	<1%	<1%
10. Multiple zip for same program ID	0%	0%	0%	0%	<1%	<1%
E. Number of homes after program and billing data cleaning	33	691	806	549	2,151	4,230
F. Percentage of homes included in billing analysis (Rows E/C)	10%	61%	65%	58%	52%	54%
G. Percentage of homes with billing data included in billing analysis (Rows E/D)	12%	67%	79%	72%	64%	66%

3.2 Billing Analysis

The model used a fixed-effects panel regression approach to predict the average daily consumption (kWh or MMBtu) of households over each billing cycle. This modeling setup included an indicator variable for program treatment (completed installation) as the primary predictor. The model also included controls for the average daily heating and cooling degree days (HDDs and CDDs) in that billing period (average daily HDDs only for gas models), based on the nearest weather station to the service site. Households with more than one observed program installation were excluded. The model was run for each program to capture the impact for each single-family initiative. The primary model was the following:

$$\begin{aligned} \text{AverageDailyUsage}_{i,t} = & \alpha_i + \beta_1 \text{Post}_{i,t} + \beta_2 \text{AverageDailyHDD}_{i,t} + \beta_3 \text{AverageDailyCDD}_{i,t} + \\ & \beta_4 \text{AverageDailyHDD}_{i,t} \cdot \text{Post}_{i,t} + \beta_5 \text{AverageDailyCDD}_{i,t} \cdot \text{Post}_{i,t} + \sigma_t + \varepsilon_{i,t} \end{aligned}$$

where the average daily usage of household i in billing period t are predicted using a model allowing for household-specific intercepts α_i , variables for average daily HDDs and CDDs for the household in the billing period with coefficients β_2 and β_3 , respectively, and a binary variable indicating the installation of program equipment in the household in that billing period with coefficient β_1 , and an error term with mean zero. The model also includes an interaction of the average daily HDDs and CDDs and the installation of program equipment variable with coefficients β_4 and β_5 .

Households that do not have at least 12 months (or nine months in 2019) of observations before and after the equipment installation date are excluded. The model also included month by year dummy variables to account for monthly variation in usage, denoted by σ_t .

Twelve months (or nine months in 2019) of pre-installation billing data capture the baseline or preexisting conditions of the participating households and is compared to 12 months (or nine months in 2019) of post-installation billing data. The fixed effects aspect of the model controls for characteristics of the homes that do not vary over time, which may otherwise bias the results.

In the post-estimation stage, the Impact Evaluation Contractor multiplies the coefficient estimates with the 15-year climate normal annual HDDs and CDDs to obtain the normalized annual baseload, heating, and cooling consumption in the pre- and post-installation periods.

3.3 Regression Coefficient Estimates

Table 44 and **Table 45** below show the regression coefficient estimates for the CEF whole-home models, as well as the standard error around that point estimate for each program and fuel. **Table 46** shows the corresponding regression estimates for the LIURP model.

Table 40: CEF Electric Fixed Effect Results without Fuel Switching ^{a,b}

(Dependent variable is kWh per day)

Independent Variable	Low-income Estimates	Moderate-income Estimates	Market-Rate Estimates	Overall Estimates
Post (Program Installations)	-1.2021* (-0.1092)	0.5633* (-0.2417)	-0.0074 (-0.1834)	-0.7911* (-0.0884)
Average Daily CDDs	0.5861* (0.0248)	1.2400* (0.0701)	1.2855* (0.0563)	0.7542* (0.0235)
Average Daily HDDs	0.1553* (-0.0093)	0.1723* (-0.0182)	0.0937* (-0.0121)	0.1137* (-0.0069)
Interaction: Average Daily CDDs*post	0.1655* (-0.0183)	-0.1911* (-0.0529)	-0.1974* (-0.0402)	0.0604* (-0.0167)
Interaction: Average Daily HDDs*Post	-0.0106* (0.0049)	-0.0540* (0.0097)	-0.0252 (0.0063)	-0.0143* (0.0036)
Constant	18.3401* (-0.2986)	17.9051* (-0.6282)	23.1444* (0.444)	20.6589* (-0.2311)
n observations	5,400	1,407	2,827	9,634
Adj. R-square	0.6798	0.6511	0.6846	0.6769

^a Robust standard errors in parentheses^b P-value < 0.10 indicated with (*)**Table 41: CEF Natural Gas Fixed Effect Results without Fuel Switching ^{a,b}**

(Dependent variable is MMBtu per day)

Variables	Low-income Estimates	Moderate-income Estimates	Market-Rate Estimates	Overall Estimates
Post (Program Installations)	-0.0015 (-0.0011)	0.0022* (-0.0011)	0.0017 (-0.0014)	0.0005 (-0.0007)
Average Daily HDDs	0.0096* (-0.0003)	0.0101* (-0.0002)	0.0096* (-0.0002)	0.0096* (-0.0001)
Interaction: Average Daily HDDs*Post	-0.0015* (-0.0001)	-0.0019* (-0.0001)	-0.0010* (-0.0001)	-0.0014* (0.00005)
Constant	0.2412* (-0.0097)	0.1585* (-0.007)	0.1733* (-0.0057)	0.1991* (-0.0050)
n observations	2,543	1,789	2,178	6,510
Adj. R-square	0.7771	0.7605	0.7667	0.7670

^a Robust standard errors in parentheses^b P-value < 0.10 indicated with (*)

Table 42: LIURP Natural Gas Fixed Effect Results without Fuel Switching ^{a,b}
 (Dependent variable is MMBtu per day)

Variables	LIURP Estimates
Post (Program Installations)	-0.0022 (0.0018)
Average Daily HDDs	0.0097* (0.0003)
Interaction: Average Daily HDDs*Post	-0.0018* (0.0001)
Constant	0.2979* (0.0094)
n observations	1,100
Adj. R-square	0.7412

^a Robust standard errors in parentheses

^b P-value < 0.10 indicated with (*)

3.4 Model Selection

The model specification process specifies two types of models. The first is the whole-home model aimed to estimate savings for each single-family initiative for 2016. A single regressor representing the average of the program allowed the model to have a larger sample size which resulted in more stable and intuitive estimates.

The second model is a measure-specific model aimed to estimate savings by measure. For comparative purposes, the measure categories were broken out to reflect measures identified in the NYSERDA 2012 – 2016 Impact Evaluation.

The Impact Evaluation Contractor made improvements to the whole-house and measure-specific models used in the 2012 – 2016 evaluation in two ways. First, the model uses month dummy variables instead of month by year dummy variables. A model should include month by year dummy variables if the evaluator believes energy usage varies by both month and year. Applying month dummy variables assumes that usage only varies by month. Given the shorter study period, the Impact Evaluation Contractor believes using month dummy variables is the more appropriate application. Second, the model added the addition of daily heating degree day and daily cooling degree day with post period interactions. Including these interactions allowed the Impact Evaluation Contractor to separate out baseline usage from cooling and heating usage and thus savings associated with baseline, cooling, and heating usage. The inclusion of these interactions provided similar results from the original model without the interactions.

Appendix A: Detailed Results

This appendix provides additional results, including fuel switching participants, to the models in the main body of this report. Specifically, it provides the following information by fuel type, program, year, measure, and utility.

A.1 Program-level Results by Year

A.1.1 Electric Results

Table 43: Electric Verified Gross Program Savings with Fuel Switching

Program Type	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals
Low-Income	5,492	383	633	0.60	(0.54, 0.67)
Moderate-Income	1,564	413	654	0.63	(0.49, 0.77)
Market	2,915	331	267	1.24	(1.01, 1.47)
Overall ^a	9,971	370	529	0.70	(0.64, 0.76)

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program savings.

Table 44: Low-Income Electric Verified Gross Program Savings by Year with Fuel Switching

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals
2017	634	449	686	0.65	(0.55, 0.76)
2018	887	349	581	0.60	(0.50, 0.70)
Q1 2019	43	215	776	0.28	(-0.03, 0.58)
Overall ^a	5,492	383	633	0.60	(0.54, 0.67)

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 45: Moderate Electric Verified Gross Program Savings by Year with Fuel Switching

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals
2017	634	419	776	0.54	(0.38, 0.70)
2018	887	409	572	0.71	(0.48, 0.95)
Q1 2019	43	-9	557	-0.02	(-1.23, 1.20)
Overall ^a	1,564	413	654	0.63	(0.49, 0.77)

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 46: Market Electric Verified Gross Program Savings by Year with Fuel Switching

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals
2017	1,174	349	316	1.10	(0.80, 1.41)
2018	1,699	325	233	1.39	(1.05, 1.73)
Q1 2019	42	206	260	0.79	(-2.09, 3.67)
Overall ^a	2,915	331	267	1.24	(1.01, 1.47)

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

A.1.2 Natural Gas Results

Table 47: Gas Verified Gross Program Savings with Fuel Switching

Program Type	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Low-Income	2,604	9.2	26.1	0.35	(0.33, 0.37)	Yes
Moderate-Income	1,832	11.4	21.9	0.52	(0.47, 0.54)	Yes
Market	2,193	5.4	16.1	0.33	(0.30, 0.37)	Yes
Overall ^a	6,629	8.6	21.6	0.40	(0.37, 0.41)	Yes

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program savings.

Table 48: Low-Income Gas Verified Gross Program Savings by Year with Fuel Switching

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
2017	1,434	9.1	23.7	0.38	(0.35, 0.42)	Yes
2018	1,121	9.4	29.0	0.32	(0.29, 0.35)	Yes
Q1 2019	49	17.2	28.8	0.60	(0.35, 0.84)	Yes
Overall ^a	2,604	9.2	26.1	0.35	(0.33, 0.37)	Yes

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 49: Moderate Gas Verified Gross Program Savings by Year with Fuel Switching

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
2017	852	9.9	23.3	0.43	(0.33, 0.83)	Yes
2018	900	11.4	20.3	0.56	(0.34, 1.02)	Yes
Q1 2019	80	21.5	25.8	0.83	(-13.02, 12.67)	No
Overall ^a	1,832	11.4	21.9	0.52	(0.47, 0.54)	Yes

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 50: Market Gas Verified Gross Program Savings by Year with Fuel Switching

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
2017	963	6.0	18.4	0.33	(0.28, 0.37)	Yes
2018	1,169	5.0	14.2	0.35	(0.30, 0.41)	Yes
Q1 2019	61	8.8	17.5	0.50	(0.32, 0.68)	Yes
Overall ^a	2,193	5.4	16.1	0.33	(0.30, 0.37)	Yes

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

Table 51: LIURP Gas Verified Gross Program Savings by Year with Fuel Switching

Program Year	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
2017	362	13.9	33.5	0.41	(0.35, 0.48)	Yes
2018	587	10.9	30.5	0.36	(0.31, 0.41)	Yes
Q1 2019	163	14.4	28.7	0.50	(0.41, 0.60)	Yes
Overall ^a	1,112	12.1	31.2	0.39	(0.35, 0.43)	Yes

^a Row reflects results from a separate regression modeling the overall impact of the program and savings may not equal the sum of the individual program year savings.

A.2 Measure-level Results – For Informational Purposes Only

A.2.1 Electric Results

Table 56 shows the measure-level verified electric savings and RRs of the EmPower program with fuel switching participants included. Including fuel switching participants in the analysis only changed the RRs slightly (compared to the RRs in **Table 19**). Dryers and DHW systems included in this model switched fuel use away from electric and to natural gas. Dryers had an RR of 0.46. DHW systems, where a small sample of 32 participants switched their fuel used for water heating from electric to natural gas, had the second highest RR of 0.73.

Table 57 reports the measure-level verified savings and RRs for the HPwES (including assisted HPwES) program including fuel switching participants. Including fuel switching participants resulted in thermostats verified savings to decrease slightly from 226 kWh/year (see **Table 20**) down to 219 kWh/year. However, the corresponding RR decreased by almost 15% from 3.13 to 2.67. DHW, and heating system measures that switched fuel use away from electricity and to natural gas resulted in savings of 1,984 kWh/year and 1,832 kWh/year, respectively. Heat pump measures that switched to using electricity for space heading resulted in an increased use of 270 kWh/year with a realization rate of 0.53.

Table 52: EmPower Electric Measure-Specific Program Savings, with Fuel Switching

Measure Group	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Program Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Lighting	5,334	263	433	0.61	(0.50, 0.72)	Yes
Refrigeration	781	439	558	0.79	(0.56, 1.01)	Yes
DHW conservation	252	204	142	1.43	(-0.21, 3.07)	No
Envelope	129	924	2,870	0.32	(0.15, 0.49)	Yes
Heating system replace/repair	110	199	230	0.86	(-0.85, 2.58)	No
Dryer (fuel switch away)	60	858	1,862	0.46	(0.21, 0.71)	Yes
DHW (fuel switch away)	32	2,393	3,290	0.73	(0.51, 0.94)	Yes
DHW replace/repair	25	536	83	6.44	(-1.75, 14.64)	No
Thermostat	19	430	167	2.57	(-1.37, 6.52)	No
Other	81	1,100	1,561	0.70	(0.40, 1.01)	Yes

Table 53: HPwES and Assisted HPWES Electric Measure-Specific Program Savings, with Fuel Switching

Measure Group	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Program Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Air conditioning	1,854	215	206	1.04	(0.66, 1.43)	Yes
Envelope	1,447	251	219	1.15	(0.75, 1.55)	Yes
Heating system replace/repair	1,429	69	118	0.58	(-0.19, 1.35)	No
Thermostat	516	219	82	2.67	(0.74, 4.61)	Yes
DHW replace/repair	424	111	53	2.08	(-0.54, 4.70)	No
Lighting	375	206	451	0.46	(0.001, 0.91)	Yes
DHW (fuel switch away)	100	1984	2655	0.75	(0.53, 0.96)	Yes
Heating system (fuel switch away)	91	1,832	3,614	0.51	(0.32, 0.69)	Yes
Heating system conservation	77	193	90	2.14	(-2.03, 6.32)	No
Heating system (fuel switch to)	62	78	-80	-0.97	(-7.98, 6.03)	No
Heat pump	27	291	1479	0.20	(-0.25, 0.64)	No
Refrigeration	15	588	412	1.43	(0.12, 2.73)	Yes
Heat Pump (fuel switch to)	14	-270	-510	0.53	(0.25, 0.81)	Yes
DHW conservation	11	-334	164	-2.03	(-10.40, 6.33)	No
DHW (fuel switch to)	9	996	-27	-36.32	(-224.81, 152.18)	No
Other	90	394	589	0.67	(0.11, 1.23)	Yes

A.2.2 Natural Gas Results

Table 58 presents the measure-level verified gas savings and RRs of the EmPower program with fuel switching participants included. Including fuel switching participants in the analysis only affected the RRs slightly (compared to the RRs in **Table 21**). DHW system measures, with a small sample of 18 participants that switched their fuel used for water heating from electric and delivered fuels to natural gas, increased natural gas use by an average of 13.9 MMBtu/year.

Table 59 shows the measure-level verified gas savings and RRs for the HPwES (including Assisted HPWES) program including fuel switching participants. Measure RRs remained consistent with results in **Table 22**, despite including fuel switching participants. DHW measures that switched fuel use away from electricity and to natural gas resulted in increased usage of 7.9 MMBtu/year. Only three homes installed heat pump measures that switched to using electricity for space heating resulted in savings of 5.9 MMBtu/year with a realization rate of 0.60.

LUIRP measure RRs with fuel switching participants included, shown in **Table 60**, remained consistent with results in **Table 23**. Three homes installed DHW measures that switched to using natural gas but the increase in usage was not statistically significant.

Table 54: EmPower Natural Gas Measure-Specific Program Savings, with Fuel Switching

Measure Group	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Program Reported Savings per Home (MMBtu /Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Envelope	2,511	9.3	24.8	0.37	(0.34, 0.40)	Yes
DHW conservation	577	-0.4	0.6	-0.63	(-3.04, 1.78)	No
Thermostat	460	-0.2	5.7	-0.03	(-0.33, 0.26)	No
Heating system replace/repair	395	2.4	7.1	0.34	(0.08, 0.59)	Yes
DHW replace/repair	59	6.0	3.6	1.67	(0.72, 2.63)	Yes
Dryer	45	-2.4	-9.8	0.25	(-0.17, 0.67)	No
DHW (fuel switch to)	18	-13.9	-12.6	1.11	(1.59, 0.62)	Yes
Other	95	-3.1	2.0	-.53	(-2.99, -0.08)	Yes

Table 55: HPwES Natural Gas Measure-Specific Program Savings, with Fuel Switching

Measure Group	Number of Homes in Analysis	Verified Savings per Home (MMBtu/Yr) (A)	Program Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Heating system replace/repair	2,852	4.9	14.2	0.34	(0.30, 0.39)	Yes
Envelope	1,573	7.7	17.5	0.44	(0.39, 0.49)	Yes
DHW replace/repair	869	4.3	4.1	1.06	(0.80, 1.32)	Yes
Thermostat	721	3.2	5.7	0.55	(0.31, 0.80)	Yes
Lighting	79	0.2	-0.8	-0.24	(-2.72, 2.24)	No
Heating system conservation	74	4.0	3.2	1.23	(0.18, 2.29)	Yes
DHW conservation	24	-4.4	1.1	-3.94	(-9.05, 1.17)	No
DHW (fuel switch to)	21	-7.9	-11.1	0.71	(1.23, 0.18)	Yes
Heating system (fuel switch to)	20	-1.2	-11.6	0.11	(-0.55, 0.77)	No
DHW (fuel switch away)	4	15.2	4.6	3.33	(-0.02, 6.68)	No
Heat Pump (fuel switch away)	3	5.9	9.8	0.60	(0.04, 1.17)	Yes
Heating system (fuel switch away)	3	-0.004	10.3	-0.0004	(-0.72, 0.71)	No
Other ^a	40	2.7	0.4	7.32	(-3.14, 17.79)	No

^a Other measures include one heating system conservation installation.

Table 56: LIURP Natural Gas Measure-Specific Program Savings, with Fuel Switching

Measure Group	Number of Homes in Analysis	Verified Savings per Home (MMBtu/Yr) (A)	Program Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
Envelope	1,075	12.3	29.3	0.42	(0.37, 0.47)	Yes
Thermostat	357	1.3	6.5	0.20	(-0.17, 0.57)	No
Heating system replace/repair	139	-0.8	6.4	-0.13	(-0.69, 0.43)	No
DHW replace/repair	25	5.9	3.3	1.82	(0.21, 3.43)	Yes
DHW conservation	21	-8.6	0.5	-18.38	(-32.29, -4.48)	Yes
Dryer	9	17.0	4.4	3.88	(10.37, -2.60)	No
DHW (fuel switch to)	3	-9.8	-15.1	0.65	(1.30, -0.01)	No
Other ^a	15	-11.2	0.02	-687.71	(-178.34, -1,197.08)	Yes

^a Other measures include one heating system conservation installation.

A.3 Utility-level Results - Informational Purposes Only

A.3.1 Electric Results

Table 57: Low-income Electric Verified Gross Program Savings by Utility, with Fuel Switching

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
ConEd	1,144	278	579	0.48	(0.35, 0.61)	Yes
NGRID	2,207	566	680	0.83	(0.73, 0.94)	Yes
NYSEG	1,058	310	650	0.48	(0.31, 0.65)	Yes
RG&E	1,004	371	571	0.65	(0.46, 0.84)	Yes

Table 58: Moderate-income Electric Verified Gross Program Savings by Utility, with Fuel Switching

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
ConEd	9	869	677	1.28	(-2.66, 5.22)	No
NGRID	707	514	783	0.66	(0.48, 0.83)	Yes
NYSEG	306	325	590	0.55	(0.2, 0.9)	Yes
RG&E	533	288	503	0.57	(0.27, 0.88)	Yes

Table 59: Market Electric Verified Gross Program Savings by Utility, with Fuel Switching

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (kWh/Yr) (A)	Reported Savings per Home (kWh/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
ConEd	81	964	285	3.38	(1.74, 5.02)	Yes
NGRID	807	364	278	1.31	(0.91, 1.7)	Yes
NYSEG	503	347	330	1.05	(0.53, 1.57)	Yes
RG&E	1,517	268	235	1.14	(0.8, 1.48)	Yes

A.3.2 Natural Gas Results

Table 60: Low-income Gas Verified Gross Program Savings by Utility, with Fuel Switching

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
ConEd	44	-4.5	29.8	-0.15	(-0.37, 0.07)	No
NFGDC	59	3.7	18.6	0.20	(0.02, 0.38)	Yes
NGRID	1,334	10.0	24.9	0.40	(0.37, 0.43)	Yes
NYSEG	436	9.4	27.6	0.34	(0.3, 0.39)	Yes
RG&E	693	7.8	27.8	0.28	(0.24, 0.32)	Yes

Table 61: Moderate-income Gas Verified Gross Program Savings by Utility, with Fuel Switching

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
NFGDC	444	14.6	23.8	0.61	(0.53, 0.69)	Yes
NGRID	388	12.4	24.8	0.50	(0.44, 0.56)	Yes
NYSEG	244	8.2	20.5	0.40	(0.31, 0.49)	Yes
RG&E	745	8.6	19.6	0.44	(0.39, 0.5)	Yes

Table 62: Market Gas Verified Gross Program Savings by Utility, with Fuel Switching

Utility	Number of Homes in Analysis	Verified Gross Savings per Home (MMBtu/Yr) (A)	Reported Savings per Home (MMBtu/Yr) (B)	RR (A/B)	RR 90/10 Confidence Intervals	Significant at the 90/10 Confidence Level
ConEd	34	3.3	31.0	0.11	(-0.24, 0.45)	No
NFGDC	222	8.4	16.6	0.51	(0.4, 0.62)	Yes
NGRID	362	5.8	18.3	0.32	(0.26, 0.38)	Yes
NYSEG	263	4.4	16.9	0.26	(0.17, 0.35)	Yes
RG&E	1,306	4.3	14.8	0.29	(0.25, 0.34)	Yes

