NYSERDA Residential Retrofit Impact Evaluation Report (PY2012—2016)

Final Report

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Table of Contents

List of Tables

1 Introduction

This study is a final evaluation of EEPS2-funded residential programs. The report presents the methods and gross energy savings from the evaluation of 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 analysis incorporates residential electricity and natural gas consumption data and NYSERDA and NFGDC Program tracking data of participating program homes to estimate first year gross energy savings using a billing analysis. This evaluation of projects installed from 2012 through 2016 with EEPS2 funding and focuses on NYSERDA's residential programs funded by the Energy Efficiency Portfolio Standard (EEPS2) and supplemented by Regional Green House Gas Initiative (RGGI).[1]

The following section of this report provides program descriptions, summary of evaluation objectives and methods, results, findings, and recommendations, and ends with a detailed discussion of the methods.

1.1 Program Description

1.1.1 EmPower New York

During the EEPS2-funding period EmPower provided income-eligible participants[2] with home energy assessments conducted by qualified Building Performance Institute (BPI)-Gold Star (accredited) contractors. Along with the home energy assessments, participants were provided with in-home energy education on ways to manage their energy use and costs. EmPower also provided at no-cost electric and natural gas energy efficient measures such as high-efficiency lighting and showerheads, air sealing, attic and wall insulation, and replacement of old inefficient

[1] Measures that did not qualify for funding under EEPS2 Electric or Gas were funded by RGGI. More information on RGGI can be found https://www.nyserda.ny.gov/Researchers-and-Policymakers/Regional-Greenhouse-Gas-Initiative

[2] NYSERDA defines low-income households as those that are income-eligible for the NYS HEAP (Heating Energy Assistance Program); households with incomes at or below 60 percent of state median income (SMI). NYSERDA defines moderate-income households as those with incomes above the HEAP threshold, but less than or equal to 80 percent of the greater of state median income and area median income for the household's geographic area. Moderate-income households are not eligible for HEAP, but are often income-eligible for housing programs.

refrigerators, freezers, and conversion of electric dryers and domestic hot water systems to natural gas.

Eligible participants had to live in one- to four-unit family homes or multifamily buildings with 100 units or fewer (although this study primarily focused on the single-family participants), and either have a household income below 60 percent of the state median income or participate in a utility payment assistance program. Participants also had to be either a customer of a participating utility or heat their homes with unregulated fuels (e.g. fuel oil, propane, and/or kerosene). Both homeowners and renters were eligible.

For electric measures, EmPower focused on lighting, refrigerator and freezer replacements, and energy education. Other measures included building envelope and domestic hot water. For natural gas measures, EmPower focused on building envelope measures such as air sealing and insulation, heating measures such as heating equipment replacements and repairs, and conversion to natural gas clothes dryers. Measures associated with unregulated fuels that did not qualify for EEPS2 Electric or Gas funding were supplemented with RGGI funding. RGGI provides funding for measures aimed to reduce energy consumption and greenhouse gas emissions by shifting away from fuel oil, propane, and kerosene consumption towards electricity and natural gas.

The program tracking data identified EmPower reported savings for each fuel type, as listed in **Table 1**. Note that these savings are not fuel neutral[3] and do exclude ancillary savings[4] in the measure-specific program tracking database. In addition, summing savings in the program tracking database for each of the fuels yields different estimates of total savings than those listed in a separate spreadsheet provided by NYSERDA.[5] Appendix A provides the program-reported measure specific savings by fuel type.

While the program overall reduces usage, in some situations, measure installation may increase usage. This was most apparent for EmPower natural gas in which fuel switching from domestic

[3] Fuel neutral does not differentiate electric or gas savings by fuel-specific funding.

[4] Ancillary savings are secondary savings resulting from a fuel-specific funded project. Natural gas savings resulting from EEPS funded projects intended to result in electricity savings are considered ancillary savings.

[5] The Impact Evaluation Contractor did not report the annual savings as provided in the NYSERDA spreadsheet because the program staff applied a retroactive correction for 2012 to 2015 all within the 2015 estimates of savings and participation for the HPwES program. While this correction produces accurate savings for the entire 2012 to 2016 period, it does not accurately represent the savings for each year. Instead we reported annual savings summed from the Program Tracking Data.

hot water increased natural gas use by 937 MMBtu. When combined with the savings from other measures, the total EmPower natural gas savings decreases to 638,436 MMBtu.

Table 1: EmPower Program Reported Annual Savings and Increased Use for EEPS2 Funded Measures [a, b]

Fuel Type	2012	2013	2014	2015	2016	Total
Electric (MWh) Savings	7,748	11,691	9,582	7,847	3,898	40,765
Electric Total	**7,748**	**11,691**	**9,582**	**7,847**	**3,898**	**40,765**
Natural Gas (MMBtu) Savings[c]	58,361	136,482	167,760	194,304	82,466	639,373
Natural Gas (MMBtu) Increased Use[d]	0	-5	-346	-487	-100	-937
Natural Gas Total	**58,361**	**136,477**	**167,415**	**193,817**	**82,366**	**638,436**

[a] Program savings does not include savings from sources other than EEPS2. Refer to Appendix C for savings from RGGI funded measures.
[b] Savings may not sum to total due to errors in rounding.
[c] Program savings for homes that use natural gas for space and domestic hot water heating. Savings from homes that use other fuels for primary heating such as fuel oil, propane, or kerosene are excluded.
[d] Note that some measures, such as fuel switched domestic hot water, were expected to increase usage.

1.1.2 Low-Income Usage Reduction Program (LIURP)

LIURP was consistent with and administered through NYSERDA's EmPower program. Like EmPower, LIURP aimed to reduce natural gas consumption of high-use customers by providing customers with home energy assessments, education on reducing energy use, and installation of energy efficient equipment such as heating systems and large appliances. To be eligible, customers must have had a household income that is 150% or below the Federal poverty income level. Customers must also have had high gas usage, a considerable past due balance, and resided in the current residence longer than one year.[6] **Table 2** lists the LIURP program-reported natural gas savings by project completion year. The study examines LIURP projects completed with EEPS2 funding between 2012 and 2016. Because LIURP shifted from EEPS2 to the Energy Efficiency Transition Implementation Plan (ETIP) funds early in 2016, only 39 projects with EEPS2 funding were completed in 2016 (excluded from **Table 2**).

[6] For more information on the LIURP, please refer to http://www.rhls.org/utilities/pulp/pa-low-income-utility-assistance-programs/national-fuel-gas-nfg-corporations-universal-service-programs/#liurp

Table 2: LIURP Program Reported Annual Savings for NFGDC Funded Measures [a, b]

Fuel Type	2012	2013	2014	2015	Total
Natural Gas (MMBtu)	33,801	33,866	51,617	37,010	156,294

[a] Program savings does not include savings from sources other than NFGDC (e.g. EEPS2, RGGI), which are captured by other analyses presented in this report.
[b] Program savings for homes that use natural gas for space and domestic hot water heating.

1.1.3 Home Performance with ENERGY STAR® (HPwES)

The Home Performance with ENERGY STAR (HPwES) Program under EEPS2 provided homeowners with home energy assessments to identify ways to improve the energy efficiency of homes. Qualified BPI-Gold Star contractors used a whole-house approach to identify opportunities for energy efficiency improvement in the home. The HPwES Program also offered low-interest loans (not addressed in this evaluation) and a 10 percent discount on eligible measures. Eligible measures included building envelope such as air sealing and insulation, primary heating and cooling such as furnaces, boilers, and water heating, appliances such as refrigerators, ENERGY STAR qualified freezers, dishwashers, clothes washers, and lighting which includes CFLs and LEDs. To be eligible to participate in the HPwES Program, New York State residents must have owned a one- to four-unit family home. Renters participated by having their landlords submit applications.

Moderate-income residents received through their contractor a 50 percent reduction in the cost of qualified energy efficiency improvements through the Assisted HPwES (AHPwES), a component of the HPwES Program.[7] To be eligible, residents must have a household income that was less than 80 percent of the median county income. Measures installed via AHPwES were funded by either HPwES or the EmPower programs. For this reason, some households received funding from both HPwES and EmPower, depending on the mix of measures ultimately installed. A common example of this occurred when HPwES funded the installation of high efficiency heating equipment and EmPower paid for some or all of the insulation in the same home.

The HPwES program in evaluation differs from previous evaluations because of increased prevalence of fuel switching measures. Fuel switching measures such as water and space heating switch households away from a dirtier type of fuel, such as fuel oil or propane, to a more efficient fuel, such as natural gas. The treatment of program savings from fuel switching measures differs

[7] Up to $4,000 per project for single-family homes and $8,000 per project for two- to four- unit homes.

by fuel type. The program claims natural gas savings but not electric savings resulting from fuel switching measures (the latter are considered ancillary savings).

Table 3 and **Table 4** list the HPwES and AHPwES program-reported savings, respectively, by fuel and project completion year. Note that these savings are not fuel neutral and exclude ancillary savings for both natural gas and electric measures and fuel switching savings for electric measures. In addition, summing savings in the program tracking database for each of the fuels yields different estimates of total savings than those listed in a separate spreadsheet provided by NYSERDA.[8] The HPwES and AHPwES programs provide RGGI funding for measures associated with unregulated fuels that do not qualify for EEPS2 Electric or Gas funding. Appendix C provides additional details on program savings and measures funded by RGGI.

While the program overall reduces usage, in some situations, measure installation may increase usage. This was most apparent for HPwES natural gas in which substantial fuel switching from electricity or oil to natural gas – not considered ancillary savings by the program or this analysis - for primary heating and domestic hot water increased usage. Likewise, natural gas use increased due to the waste heat factor[9] applied for the installation of efficient lighting. The overall increased usage amounted to 146,123 MMBtu. When combined with the savings from other measures, the total HPwES natural gas savings decreases to 94,035 MMBtu.[10] Similarly, AHPwES resulted in 71,103 MMBtu in increased usage, bringing total savings to 142,879 MMBtu.

[8] The Impact Evaluation Contractor did not use the savings as provided in the NYSERDA spreadsheet because the program staff applied a retroactive correction for 2012 to 2015 all within the 2015 estimates of savings and participation. While this correction produces accurate savings for the entire 2012 to 2016 period, it does not accurately represent the savings for each year.

[9] Incandescent and halogen light bulbs emit a great deal of waste heat. Swapping inefficient bulbs for efficient CFLs and LEDs reduces energy use for lighting but causes a small increase in heating usage to make up for the reduction in waste heat.

[10] Heating system fuel switching is not considered ancillary for natural gas, so such savings – and increased use – are included in these tables.

Table 3: HPwES Program Reported Annual Savings and Increased Use for EEPS2 Funded Measures [a, b, c]

Fuel Type	2012	2013	2014	2015	2016	Total
Electric Savings (MWh)	672	482	507	638	247	2,547
Electric Increased Use (MWh)[d]	0	-1	0	0	0	-1
Total Electric (MWh)	**672**	**481**	**507**	**638**	**247**	**2,546**
Natural Gas (MMBtu)[e]	55,832	44,826	49,692	65,367	24,440	240,158
Natural Gas Increased Use (MMBtu)[f]	-657	-28,014	-45,062	-60,372	-12,017	-146,123
Total Natural Gas (MMBtu)	**55,176**	**16,812**	**4,630**	**4,995**	**12,423**	**94,035**

[a] Program savings does not include savings from sources other than EEPS2. Refer to Appendix C for savings from RGGI funded measures.
[b] Program savings excludes savings from AHPwES projects.
[c] Savings may not sum to total due to errors in rounding.
[d] Certain measures (e.g., primary heating and cooling measures installed as new load) were expected to increase electric usage.
[e] Program savings for homes that use natural gas for space and domestic hot water heating. Savings from homes that use other fuels for primary heating such as fuel oil, propane, or kerosene are excluded.
[f] The numerous instances of fuel switching for primary heating and domestic hot water, among a few other measures, increased usage.

Table 4: AHPwES Program Reported Annual Savings and Increased Use for EEPS2 Funded Measures [a, b]

Fuel Type	2012	2013	2014	2015	2016	Total
Electric Savings (MWh)	296	217	785	600	395	2,292
Total Electric (MWh)	**296**	**217**	**785**	**600**	**395**	**2,292**
Natural Gas (MMBtu)[c]	32,063	31,070	45,869	74,164	30,815	213,981
Natural Gas Increased Use (MMBtu)[d]	-445	-14,250	-25,065	-25,325	-6,017	-71,103
Total Natural Gas (MMBtu)	**31,619**	**16,820**	**20,803**	**48,839**	**24,798**	**142,879**

[a] Program savings does not include savings from sources other than EEPS2. Refer to Appendix C for savings from RGGI funded measures.
[b] Savings may not sum to total due to errors in rounding.
[c] Program savings for homes that use natural gas for space and domestic hot water heating. Savings from homes that use other fuels for primary heating such as fuel oil, propane, or kerosene are excluded.
[d] The numerous instances of fuel switching for primary heating and domestic hot water, among a few other measures, increased usage.

1.2 Summary of Evaluation Objectives, Methods, and Data Cleaning

1.2.1 Summary of Objectives and Methods

This impact evaluation estimates the first-year gross energy savings for EEPS-funded projects installed from 2012 through 2016 through HPwES (including AHPwES), EmPower, and the NFGDC LIURP projects administered through Empower. The evaluation also presents results of NYSERDA EmPower and HPwES (including AHPwES) measures funded through RGGI. The evaluation relies on a billing analysis of all completed projects with adequate utility usage and program data.[11] The purpose of this study, as described in **Table 5**, is to provide robust and reliable evaluated estimates of achieved (as opposed to reported) electric and natural gas savings by funding source, program, measure, contractor, and year of installation.

Table 5: Evaluation Objectives and Methods

Objective	Purpose	Method
Evaluate energy impacts	Establish first-year energy savings based on the electric (kWh) and natural gas (MMBtus) savings at the customer site.	Billing analysis
Develop realization rates (RRs)	Determine the ratio of evaluated savings to Program-reported savings	Calculations using NYSERDA and NFGDC Program tracking data and modeled billing data for the households included in the billing analysis
Assess contractor performance	Determine how contractor-evaluated savings compare to evaluated savings for large, medium, and small contractors	Billing analysis, including realization rates

1.2.2 Summary of Data Cleaning and Attrition Analysis

The Impact Evaluation Contractor cleaned both the program tracking received from NYSERDA and billing data received from the utilities through NYSERDA. The analysis requires that certain criteria be met in both the program tracking and billing data. Failure to meet these criteria results in a participant being dropped from the analysis, a situation known as attrition. For more detail on attrition (including results by year and utility), see Section 3.1.2.1 and Section 3.1.2.2.

[11] Attrition occurs when participants are removed from the analysis during data cleaning due to not having sufficient observed utility usage data before and after program implementation, missing program tracking information, etc. Refer to Section 1.2.2 for detailed information on attrition.

Table 6 summarizes the steps in the data cleaning process as well as explanations for the causes of participant removal from the analysis. While the items marked *primary source* are those responsible for the greatest attrition, the majority of attrition stem from the inability to merge program tracking data with utility billing data and adequacy of the utility billing data. Two situations contributed to the primary source of attrition, 1) homes without matching billing account numbers: a) the installation or home energy assessment contractor input the wrong account number, failed to collect it, or it was not provided and b) the tracking system created errors in the account number (especially for Con Edison), see Section 3.1.2.1 for details information. The second and third primary sources of attrition rest with utility billing data: 2) the customer did not have 12 months of usable pre- and post-participation billing data or, 3) the billing data included more than 50% estimated reads, which renders them unreliable (this was most common for natural gas).

Table 6: Summary of Data Cleaning

Reason for Removal	Explanation
Projects with zero savings	Households had health and safety, non-energy repair measures
Program data cleaning	Missing measure-level information (program-level data did not have matching measure-level data using Project ID variable; mainly impacts 2012)
	Incomplete, incorrect, missing account information
	Inconsistent site addresses; multiple sites with the same account number
Utility did not provide billing data	Remove accounts where utilities were unable to provide billing records. Notable utilities that did not provide billing data include Central Hudson and Orange and Rockland.
Homes without matching billing account numbers	Match billing records with cleaned program data using the utility account number, utility name, and zip code. *(Primary source)*
Homes with multiple project counts	Households with more than one (1) project completed during the 2012-2016 period
Homes without adequate 12 months of pre/post billing data	Accounts with less than 12 months of billing records before and after project installation *(Primary source)*
	Accounts where billing records fall outside the period of project installation (e.g. project installation occurred in 2013 but available billing records begin in 2015)
Homes eliminated after billing data cleaning	Too many estimated reads to actual reads where over 50% of observations are estimated reads *(Primary source)*
	Gaps in billing data occur when billing start date does not align with the previous monthly record end date
	Overlapping or duplicate reads occur when billing start and/or end dates overlap
	Negative records indicating negative consumption
	Too many zeros suggesting absence

Application of these criteria led to very high attrition rates. **Table 7** reports the percentage of participating homes with reported savings that were retained or excluded from the analysis by program and fuel. The attrition rate is the same as the percentage of households excluded from the analysis. The analysis applies to the full 2012 to 2016 program period, with annual rates and rates by utility and fuel presented in Section 3.1.2.1.

Table 7: Summary of Program Attrition

	Number of Homes with Savings	% of Homes Retained	% of Homes Excluded
EmPower Electric	36,931	32%	68%
EmPower Natural Gas	19,335	29%	71%
LIURP	3,484	60%	40%
HPwES Electric[a]	5,539	26%	74%
HPwES Natural Gas[a]	18,396	28%	72%

[a] Includes AHPwES.

2 Results, Findings, and Recommendations

The Impact Evaluation Team generated three sets of analyses results as a part of this study: 1) estimates of achieved program savings (as opposed to program reported savings) for the EmPower, LIURP, and HPwES programs; and separate assessments of 2) electric and 3) natural gas billing data for EmPower and for HPwES. The Impact Evaluation Team also estimated savings resulting from RGGI funding and for unregulated fuels. The subsections that follow present those three sets of results. The results section for each program and fuel-type focus on presenting the evaluated savings and realization rates (RRs), while the program-level findings and recommendations sections delve more deeply into the context and implications of the results. All realization rates are based on a comparison of evaluated savings and program-reported savings as listed in the program tracking databases for the households included the billing analysis.

2.1 EmPower Gross Energy Savings Results

Table 8 presents a summary of results from EmPower program-reported savings from program-tracking data, RRs (with 90% confidence intervals) calculated as the evaluated savings over the program-reported savings for households included in the billing analysis, and the resulting evaluated gross savings.

Table 8: Summary of Reported and Evaluated Electricity and Natural Gas Annual Gross Savings for EmPower Projects Installed in Years 2012 through 2016

	Annual Electric Savings (MWh)[a]	Annual Natural Gas Savings (MMBtu)[b]
Funding	EEPS2 Electric	EEPS2 Gas
Program-reported savings	40,765	638,436
Realization Rate	0.58	0.44
Realization Rate 90/10 confidence interval	0.49 – 0.68	0.42 – 0.47
Evaluated gross savings	23,644	280,912

[a] NYSERDA program-reported savings to the DPS were 43,392 MWh. Applying the realization rate resulted in evaluated gross savings of 25,167 MWh.
[b] NYSERDA program-reported savings to the DPS were 700,030 MMBtu. Applying the realization rate resulted in evaluated gross savings of 308,013 MMBtu.

Table 9 compares the current RRs to those found in the two most recent evaluations of the EmPower programs. The Impact Evaluation Contractor presents these for informational purposes only, as the scope of the current evaluation did not include the types of activities that help to explain the variation in RRs over time. Potential explanations could include programmatic differences (e.g., the measures offered or assumed savings for those measures) or participant differences (e.g., demographic and housing characteristics). For example, under EEPS2, EmPower used RGGI funds to provide heating measures to oil-heated homes; this may have changed the demographic and housing characteristics in such a manner that the resulting *electricity* savings also changed.

Table 9: Comparison of EmPower Realization Rates across Evaluations

	2007 to 2008[a]	2010 to 2011[b]	2012 to 2016
Electricity	0.54	0.97	0.58
Natural Gas	0.70	0.49	0.44

[a] NYSERDA 2007-2008 EmPower New York[SM] Program Impact Evaluation Report. Prepared by Megdal & Associates and West Hill Energy & Computing. April 2012. Table 4-4. https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2012ContractorReports/2012-EmPower-New-York-Impact-Report.pdf
[b] NYSERDA EmPower Program and National Fuel Gas Distribution Corporation's Low Income Usage Reduction Program Impact Evaluation (2010–2011). Prepared by ERS, Itron, and West Hill Energy and Computing. May 2015. Table 2-2. https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2015ContractorReports/2015-EmPower-National-Fuel-Gas-Evaluation-Report.pdf

2.1.1 EmPower Electric Results

This section summarizes the electric savings resulting from the installation of measures in EmPower funded by EEPS2 Electric. The billing analysis regression results (see Section 3.3 and Appendix A for more detailed discussions of the regression models) yields per household evaluated program savings for the sample of 11,734 program homes used in the analysis (**Table 10**). The table also presents the program evaluated savings and RRs for the same 11,734 homes in the analysis. The results suggest that evaluated savings for these households fall below their program evaluated savings. Section 2.1.4 includes a discussion of potential reasons for this.

Table 10: EmPower Electric Model Annual Savings for Analysis Homes

Year	Number of Homes in Analysis	Average Evaluated Savings per Home (kWh)[a] (A)	Average Program Reported Savings per Home (kWh) (B)	RR (A/B)
2012	1,910	619	1,047	0.59
2013	2,613	586	1,091	0.54
2014	3,394	557	974	0.57
2015	1,846	360	793	0.45
2016	1,971	490	706	0.69
Aggregated[b]	11,734	547	939	0.58

[a] Adjusted for program savings attributed to RGGI funded programs; approximately 0.05% of aggregated reported savings.
[b] Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not sum to the total of the individual year savings.

Table 11 breaks out the reported program savings for homes in the analysis by EEPS2 and RGGI funding. Measures funded by RGGI had a very small ancillary impact on electric consumption with an aggregated savings of 0.05% of total reported savings or 5,000 kWh. Further investigation showed the variation in the RGGI reported program savings, particularly the comparatively high savings in 2016, are driven by a few households installing measures with large reported savings (or increase use).

Table 11: Summary of RGGI Annual Electric Annual Savings for Analysis Homes

Year	EEPS2 Reported Program Savings (kWh)	RGGI Reported Program Savings (kWh)	Total Reported Savings (kWh)	Percent of EEPS2 Savings	Percent of RGGI Savings	RGGI Evaluated Savings per Home (kWh)
2012	1,999,711	-3,102	1,996,609	100.2%	-0.2%	-1
2013	2,851,073	-7,344	2,843,729	100.3%	-0.3%	-2
2014	3,305,946	-504	3,305,442	100.0%	<0.1%	<-1
2015	1,463,957	3,733	1,467,690	99.7%	0.3%	1
2016	1,391,778	12,217	1,403,995	99.1%	0.9%	4
Aggregated	11,012,465	5,000	11,017,465	100.0%	<0.1%	<1

2.1.2 EmPower Natural Gas Results

This section summarizes the natural gas savings resulting from the installation of measures in EmPower funded by EEPS2 Gas. The billing analysis regression results (see Section 3.3 and Appendix A for more detailed discussions of the regression models) yield per household evaluated program savings for the sample of 5,606 program homes used in the analysis (**Table 12**). The table also presents the program evaluated savings and RRs for the same 5,606 homes in the analysis. The results suggest that evaluated savings for these households fall considerably below their program evaluated savings. Section 2.1.4 includes a discussion of potential reasons for this. Measures funded by RGGI (**Table 13**) had a very small impact on natural gas consumption as their purpose is to reduce delivered fuel use with an aggregated savings of 0.05% of total reported savings or 285 MMBtu.

Table 12: EmPower Natural Gas Model Annual Savings for Analysis Homes

Year	Number of Homes in Analysis	Evaluated Total Annual Savings per Home (MMBtu)[a] (A)	Program Reported Annual Savings per Home (MMBtu) (B)	RR (A/B)
2012	441	13	30	0.42
2013	973	14	28	0.50
2014	1,533	11	27	0.43
2015	1,848	11	29	0.37
2016	811	14	25	0.57
Aggregated[b]	5,606	12	28	0.44

[a] Adjusted for program savings attributed to RGGI funded programs; approximately 0.18% of aggregated reported savings.

[b] Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not sum to the total of the individual year savings.

Table 13: Summary of RGGI Natural Gas Annual Savings for Analysis Homes

Year	EEPS2 Reported Program Savings (MMBtu)	RGGI Reported Program Savings (MMBtu)	Total Annual Reported Savings (MMBtu)	Percent of EEPS2 Savings	Percent of RGGI Savings	RGGI Evaluated Savings per Home (MMBtu)
2012	13,386	0	13,386	100%	0%	0
2013	27,298	0	27,298	100%	0%	0
2014	40,662	0	40,662	100%	0%	0
2015	53,994	0	53,994	100%	0%	0
2016	20,201	285	20,486	99%	1%	<1
Aggregated	155,541	285	155,826	100%	<1%	<1

2.1.3 EmPower Contractor Analysis

The Impact Evaluation Team examined savings for contractors grouped by the number of EmPower projects they completed from 2012 to 2016. The analysis groups the Top 10 contractors and splits the remaining contractors into those who completed a medium or small number of jobs (Appendix A provides the detailed regression models). The small sample sizes for some contractors coupled with the high attrition rates raise enough concerns about the results to advise against interpreting the RRs as a definitive summary of contractor performance. Moreover, the study scope did not include the types of tasks that would allow the Impact Evaluation Contractor to delve into the reasons for differences among individual contractors, contractor groups, or fuels.

Table 14 shows the savings results for EmPower Electric. The Top 10 contractors accounted for 39% of reported savings and had an aggregate RR of 0.62. The aggregate RR for the Top 10 contractors is higher than the RRs for the medium (0.53) and small (0.59) category contractors. The Top 10 contractors for EmPower gas accounted for 51% of the reported savings and had an aggregate RR of 0.40 (**Table 15**). The aggregate RR for the largest contractors falls below the RRs for the medium (0.45) and small (0.51) category contractors.

Table 14: EmPower Electric Realization Rates by Contractor

Contractor Size Category	Number of Projects Completed	Number of contractors in Analysis	Percent of Total Program Reported Savings	RR	Significant at 90/10
Top 10 aggregated (295 to 809 projects)	4,467	10	39%	0.62	Yes
Medium (130 to 266 projects)	3,634	20	31%	0.53	Yes
Small (less than 130 projects)	3,632	131	30%	0.59	Yes

Table 15: EmPower Gas Realization Rates by Contractor

Contractor Size Category	Number of Projects Completed	Number of contractors in Analysis	Percent of Total Program Reported Savings	RR	Significant at 90/10
Top 10 aggregated (140 to 583 projects)	2,774	10	51%	0.40	Yes
Medium (80 to 139 projects)	1,215	11	24%	0.45	Yes
Small (less than 80 projects)	1,617	96	25%	0.51	Yes

2.1.4 EmPower Findings

The results indicate that the EmPower program achieved energy savings for participants during the EEP2 funding period. On average, customers reduced their annual electricity consumption by 547 kWh and natural gas by 12 MMBtu,. However, the electric and natural gas savings fall short of the deemed savings[12] estimated and filed with the DPS for the program. For the 2012 to 2016 time period, electricity savings achieved 58% and natural gas savings 44% of the reported savings as listed in the program tracking databases for the households in the analysis.

NYSERDA asked the Impact Evaluation Contractor to consider possible reasons for the lower than anticipated realization rates. Some of the potential explanations included the following:

- Bias created by high attrition rates (see Section 1.2.2 and Section 3.1.2.1)
- Evaluator practice in preparing and conducting the billing analysis
- Inaccurate assumptions guiding deemed savings estimates
- Installations not of sufficient quality to achieve evaluated savings
- Customer behavior such as snapback (using efficient equipment more than estimates assume)[13] or removal of items from service

The focused scope of the billing-analysis based impact evaluation of measures installed between two and seven years in the past limited the depth of exploration of realization rates. In particular, the study did not directly query contractors about installation practices or participants about

[12] Deemed savings are pre-determined savings of energy efficiency measures, typically developed from data sources (e.g., previous studies) and engineering estimates.

[13] Snapback captures a behavior in which, since the efficient measures saves energy and money, the user decides to use it more than they would an inefficient measure. For example, they may turn the thermostat up a couple degrees more or leave a light on overnight that they would not have done with less efficient equipment.

behavior or conduct onsite visits to verify the presence and quality of installations. Yet, the study was able to yield the following insights.

Bias in Attrition: The Impact Evaluation Contractor compared the average program-reported energy savings as listed in the program tracking data for the households included in the analysis and those excluded from the analysis. **Table 39** and **Table 40** in Section 3.1.2.2 show the overall results by year for EmPower Electric and Natural Gas. The results suggest no systematic differences in program-reported savings for the EmPower participants that were retained or removed from the analysis for the full time period.

Evaluator Practice: The Impact Evaluation Contractor may have made decisions in data cleaning and preparation that negatively affected the RRs. To guard against this possibility, NYSERDA evaluation and program staff had numerous conversations about the structure, content, and assumptions in the NYSERDA program tracking data. For example, the Impact Evaluation Contractor made adjustments to their estimation techniques for early replacement scenarios to align with NYSERDA's practices when preparing savings estimates for filing with the DPS. Likewise, the Impact Evaluation Contractor followed evaluation best practices in data and model preparation and diagnostics. Therefore, the Impact Evaluation Contractor staff believes that the models are accurate representations of the change in energy use among EmPower participants before and after taking part in the program.

Inaccurate Assumptions. The assumptions about measure use, customer behavior, and household characteristics that are used to estimate savings are vitally important to developing accurate estimates of actual energy use post-installation. This study did not explore whether engineering model or other savings assumptions reflected to actual use or conditions in the participating homes.

This study did examine one critical aspect of the models: the impact of *assumptions about the weather* on predicted energy savings (See Appendix B for details). Following evaluation best practice, the billing analysis relied on weather data that corresponds to the time period addressed in the study. The engineering models used by home performance contractors rely on the Typical Meteorological Three (TMY3) dataset, which reflects temperatures from 1991 to 2005.[14]

[14] For more information on TMY3, refer to https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

NYSERDA has developed an internal updated weather dataset (2011 to 2017) to serve as an alternative to TMY3. The Impact Evaluation Contractor reran some of the models produced for this study using TMY3 data, NYSERDA's weather dataset, and the actual weather for the time period under consideration. **Table 16** presents a summary of these results for EmPower. The analysis suggests that the weather data had little impact on the RRs for EmPower, but, as shown in Appendix B, the weather data used does have a larger impact on the HPwES and AHPwES electric results (and a similar impact on natural gas results). The reason for this different conclusion across programs is that EmPower electric participants received a much smaller proportion of weather-related measures (i.e., heating, cooling, envelope) compared to HPwES electric participants.

Table 16: Summary of EmPower RRs by Source of Weather Data

	Electric			Natural Gas		
Program	Actual	NYSERDA Weather Data	TMY3	Actual	NYSERDA Weather Data	TMY3
EmPower	0.58	0.57	0.58	0.44	0.44	0.46

Installation Quality and Customer Behavior: This study did not directly address whether the installation quality of program-supported measures fell below those assumed for energy savings. The Impact Evaluation Contractor examined RRs by groups of contractors and did not find any systematic variation to explain low RRs. Prior work conducted in Connecticut suggests that installation quality may contribute to low realization rates, at least in some cases.[15] Likewise, the study did not examine customer behaviors, such as snapback, occupancy changes, or physical changes to the home, that may have contributed to lower-than-expected RRs.

2.1.5 EmPower Recommendations

This study concludes that the EmPower program yielded energy savings for all fuel types during the EEPS2 funding period of 2012 to 2016. Although the savings fall short of those reported by NYSERDA in the program tracking database, low-income households throughout the state still saw reduced energy use which helped to lower their energy bills.

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

The study yielded the following recommendations:

Recommendation 1: NYSERDA should apply a 0.58 RR to EmPower electric and 0.44 to EmPower Gas for the 2012 to 2016 period.

Recommendation 2: NYSERDA should streamline Program Database Tracking for the EmPower and HPwES Programs as well as make certain project- and measure-level tracking align, a process that is already underway.

While the EmPower and HPwES Programs are evaluated as separate programs, streamlining the datasets using common field names and practices where feasible may result in evaluator efficiency gains for future interim and full impact billing analyses. This is especially important because households taking part in AHPwES often take part in both EmPower and HPwES. NYSERDA has informed the Impact Evaluation Contractor that this streamlining is already in progress. Program managers should coordinate and streamline their program tracking databases for EmPower and HPwES, tracking similar types of participant information (such as measure categories), and provide universal identifiers for homes that may qualify for and participate under both programs over the span of the program. Likewise, inability to link participants across the project- and measure-level databases served as one of the top three factors driving attrition.

More specific technical points to consider:

- Track reported MMBtu savings by fuel (e.g. natural gas, fuel oil, kerosene, propane, etc.).
- Track fuel switching for measures such as dryers and water heaters.
- Track early replacement vs. replace on failure vs. new equipment to the home.
- Improve the quality and record keeping of utility account information.
- Streamline measure categories (EmPower field name: *MeasureCategory*) to be consistent with HPwES measure categories. HPwES tracks details for each measure (HPwES field names: *DESCRIPTION1* and *DESCRIPTION2*) and higher-level measure categories (HPwES field names: *NYSERDA_SUB_CATEGORY* and *NYSERDA_CATEGORY*).

The study also yielded critical findings that fall short of recommendations but that the Impact Evaluation Contractor nevertheless believes should be called out.

Critical Finding 1: The DPS required NYSERDA to report ancillary EEPS2 savings separately, which fails to account for the entirety of savings achieved by the program. CEF is being administered and reported on a fuel neutral basis, which will provide a more complete accounting of its impacts.
EEPS2 required NYSERDA to divide the fund into EEP2 Electric and EEP2 Gas. EEP2 Electric could only claim electric savings, and EEP2 Gas could only claim natural gas savings. If electric or gas measures yielded savings for the other fuel, NYSERDA treated them as ancillary and filed them separately to the state.

Critical Finding 2: This study reinforces other research conducted by NYSERDA that documents that TMY3 may no longer represent the current weather conditions in New York. NYSERDA and NFGDC program staff and Home Performance Contractors may want to explore updating engineering models to include a vetted replacement to TMY3.
TMY3 remains the most commonly used weather data in such models across the nation. However, through this and other recent evaluations, NYSERDA has established that TMY3 no longer represents the current, warmer weather conditions in New York. Replacing TMY3 may produce more accurate estimates of savings, thereby increasing realization rates.

Critical Finding 3: NYSERDA has recognized the importance of conducting frequent interim billing analyses for early detection in identifying potential challenges and taking corrective action as soon as possible. The EEPS2 period ran from 2012 to mid-2016, but this impact evaluation did not get started until mid-2018, a full two-years later. This created challenges from an evaluation perspective, including the availability of billing data, staff recollections of programmatic and data tracking and reporting decisions made years earlier, etc. It also precluded NYSERDA from taking action to boost achieved savings, particularly for natural gas programs. More frequent evaluations will help to limit attrition and provide timely results to help improve program delivery.

Critical Finding 4: NYSERDA program staff should work with Home Performance Contractors to improve the frequency and accuracy of utility account number collection.

Many factors drove the high rates of attrition, with inaccurate utility account numbers contributing to one of the top three reasons. The Impact Evaluation Contractor noted missing account numbers and the assignment of the same account number to electric and natural gas utilities, even when the two utilities differed. Better collection and reduction of errors will reduce attrition rates, yielding more accurate assessments of savings in the future.

2.2 LIURP Gross Energy Savings Results

Table 17 presents a summary of results from LIURP projects completed in 2012-2015 (including 39 EEP2-funded projects started in 2015 but closed out in 2016). The table shows program-reported savings from the program-tracking data, realization rates (with 90% confidence intervals) calculated using the program-reported savings and evaluated savings for the households in the analysis, and the resulting evaluated gross savings.

Table 17: Summary of Reported and Evaluated Electricity and Natural Gas Annual Gross Savings for LIURP Projects Installed in Years 2012 Through 2015

	Annual Natural Gas Savings (MMBtu)[a]
Funding	NFGDC
Program-reported savings	156,294
Realization Rate	0.52
Realization Rate 90/10 confidence interval	0.49 – 0.55
Evaluated gross savings	81,273

[a] NYSERDA program-reported savings to the DPS were 170,882 MMBtu. Applying the realization rate resulted in evaluated gross savings of 88,953 MMBtu.

Table 18 compares the current RRs to those found in the most recent evaluation of the NFGDC LIURP program. The Impact Evaluation Contractor presents the comparison for informational purposes only, as the scope of the current evaluation did not include the types of activities that help to explain the variation in RRs between the two studies. Potential explanations could include programmatic differences (e.g., the measures offered or assumed savings for those measures) or participant differences (e.g., demographic and housing characteristics).

Table 18: Comparison of LIURP Realization Rates across Evaluations

Fuel	2010 to 2011[a]	2012 to 2016
Natural Gas	0.37	0.52

[a] NYSERDA EmPower Program and National Fuel Gas Distribution Corporation's Low Income Usage Reduction Program Impact Evaluation (2010–2011). Prepared by ERS, Itron, and West Hill Energy and Computing. May 2015. Table 2-2. https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2015ContractorReports/2015-EmPower-National-Fuel-Gas-Evaluation-Report.pdf

2.2.1 LIURP Program Natural Gas Results

The billing analysis regression results (see Section 3.3 and Appendix A for more detailed discussions of the regression models) yield total program savings for the sample of 2,105 homes used in the analysis (**Table 19**). The table also presents the program evaluated savings and RRs for the same 2,105 homes in the analysis. The results suggest that evaluated savings for these households fall below their program evaluated savings. Section 2.2.2. includes a discussion of potential reasons for this.

Table 19: LIURP Natural Gas Model Annual Savings for Analysis Homes

Year	Number of Homes in Analysis	Evaluated Total Annual Savings per Home (MMBtu) (A)	Program Reported Annual Savings per Home (MMBtu) (B)	RR (A/B)
2012	360	21	50	0.43
2013	407	23	42	0.53
2014	784	23	39	0.56
2015	515	23	39	0.51
2016[a]	39	16	33	0.47
Aggregated[b]	2,105	22	41	0.52

[a] Reflects projects funded by EEPS2 in 2015 but closed out in 2016.
[b] Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not equal to the sum of the individual year savings.

2.2.2 LIURP Findings

The results indicate that the LIURP achieved energy savings for participants between 2012 and 2015. On average, customers reduced their natural gas consumption by 22 MMBtu. This reduction, however, represents about one-half of the savings listed for the program in the tracking databases for the households included in the analysis.

NFGDC and NYSERDA asked the Impact Evaluation Contractor to consider possible reasons for the lower than anticipated realization rates. Some of the potential explanations included the following:

- Bias created by high attrition rates (see Section 1.2.2 and Section 3.1.2.1)
- Evaluator practice in preparing and conducting the billing analysis
- Inaccurate assumptions guiding deemed savings estimates
- Installations not of sufficient quality to achieve evaluated savings

- Customer behavior such as snapback (using efficient equipment more than estimates assume)[16] or removal of items from service

The focused scope of the billing-analysis based impact evaluation of measures installed between two and seven years in the past limited the depth of exploration of realization rates. In particular, the study did not directly query contractors about installation practices or participants about behavior or conduct onsite visits to verify the presence and quality of installations. Yet, the study was able to yield the following insights.

Bias in Attrition: The Impact Evaluation Contractor compared the average program-reported energy savings as listed in the program tracking data for the households included in the analysis and those excluded from the analysis. **Table 41** in Section 3.1.2.2 shows the overall results by year for LIURP. The results suggest no systematic differences in program-reported savings for the LIURP participants that were retained or removed from the analysis for the full time period. It is also the case that attrition was lower for LIURP than for EmPower and HPwES and for NFGDC customers regardless of which program they took part in.

Evaluator Practice: The Impact Evaluation Contractor may have made decisions in data cleaning and preparation that negatively affected the RRs. To guard against this possibility, NFGDC and NYSERDA evaluation and program staff had numerous conversations about the structure, content, and assumptions in the program tracking and billing data. Likewise, the Impact Evaluation Contractor followed evaluation best practices in data and model preparation and diagnostics. Therefore, the Impact Evaluation Contractor staff believes that the models are accurate representations of the change in energy use among LIURP participants before and after taking part in the program.

Inaccurate Assumptions. The assumptions about measure use, customer behavior, and household characteristics that are used to estimate savings are vitally important to developing accurate estimates of actual energy use post-installation. This study did not explore whether engineering model or other savings assumptions reflected to actual use or conditions in the participating homes.

[16] Snapback captures a behavior in which, since the efficient measures saves energy and money, the user decides to use it more than they would an inefficient measure. For example, they may turn the thermostat up a couple degrees more or leave a light on overnight that they would not have done with less efficient equipment.

This study did examine one critical aspect of the models: the impact of *assumptions about the weather* on predicted energy savings (See Appendix B for details). Following evaluation best practice, the billing analysis relied on weather data that corresponds to the time period addressed in the study. The engineering models used by home performance contractors rely on the Typical Meteorological Three (TMY3) dataset, which reflects temperatures from 1991 to 2005.[17] NYSERDA has developed an internal updated weather dataset (2011 to 2017) to serve as an alternative to TMY3. The Impact Evaluation Contractor reran some of the models produced for this study using TMY3 data, NYSERDA's weather dataset, and the actual weather for the time period under consideration. The analysis suggests that billing analyses that use TMY3 data yielded slightly higher RRs than the other weather datasets for programs that provided heating, cooling, and building envelope measures.

Installation Quality: This study did not directly address whether the installation quality of program-supported measures fell below those assumed for energy savings. The Impact Evaluation Contractor examined RRs for NYSERDA's EmPower and HPwES programs by groups of contractors and did not find any systematic variation to explain low RRs. Prior work conducted in Connecticut suggests that installation quality may contribute to low realization rates, at least in some cases.[18] Likewise, the study did not examine customer behaviors, such as snapback, occupancy changes, or physical changes to the home, that may have contributed to lower-than-expected RRs.

2.2.3 LIURP Recommendations

Note that, because NYSERDA administers the LIURP program for NFGDC, the study makes few recommendations specific to NFGDC. However, the database tracking recommendation and critical findings named in Section 2.1.5 for EmPower may also apply to NYSERDA's administration of LIURP.

The study yielded the following recommendation: **Recommendation 1: NFGDC should apply a 0.52 RR to LIURP in the 2012 to 2015 period.**

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[17] For more information on TMY3, refer to https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

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

The study also yielded critical findings that fall short of recommendations but that the Impact Evaluation Contractor nevertheless believes should be called out.

Critical Finding 1: To the extent that NFGDC funds its own program evaluations or influences when NYSERDA evaluates LIURP, NFGCD should advocate for continued interim billing analyses, such as the two studies currently underway for ETIP-funded projects in coordination with NYSERDAs CEF interim billing analyses for 2016 (nearly complete) and 2017 to 2018 (in progress).

The EEPS2 period ran from 2012 to mid-2016, but this impact evaluation did not get started until mid-2018, a full two-years later. This created challenges from an evaluation perspective, including the availability of billing data, staff recollections of programmatic and data tracking and reporting decisions made years earlier, etc. It also precluded NYSERDA and NFGDC from taking action to boost achieved savings for LIURP. More frequent evaluations will help to limit attrition and provide timely results to help improve program delivery.

2.3 HPwES Gross Energy Savings Results

Table 20 presents a summary of results from HPwES projects completed in 2012-2016. The table shows HPwES and AHPwES program-reported savings from program-tracking data, RRs (along with 90% confidence intervals), and the resulting evaluated gross savings.

Table 20: Summary of Reported and Evaluated Electricity and Natural Gas Annual Gross Savings for HPwES and AHPwES Projects Installed in Years 2012 Through 2016

	Annual Electric Savings (MWh)[a]		Annual Natural Gas Savings (MMBtu)[b]	
Funding	HPwES – EEPSE	AHPwES – EEPSE	HPwES – EEPSG	AHPwES – EEPSG
Program-reported savings	2,546	2,292	94,035	142,879
RR	0.51	0.43	0.42	0.43
Realization Rate 90/10 confidence interval	0.42 – 0.68	0.18 – 0.51	0.40 – 0.45	0.40 – 0.46
Evaluated gross savings	1,298	986	39,495	61,438

[a] NYSERDA program-reported savings to the DPS were 5,250 MWh for HPwES and 2,200 for AHPWES. Applying the realization rate resulted in evaluated gross savings of 2,678 MWh for HPWES and 946 MWh for AHPWES.
[b] NYSERDA program-reported savings to the DPS were 354,409 MMBtu for HPwES and 192,995 MMBtu for AHPwES. Applying the realization rate resulted in evaluated gross savings of 148,852 MMBtu for HPWES and 82,988 MMBtu for AHPwES.

Table 21 compares the current RRs for HPwES to those found in the two most recent evaluations of the HPwES program. The prior evaluations did not provide separate results for AHPwES, a program that began during the EEPS2 funding period. The Impact Evaluation Contractor presents these for informational purposes only, as the scope of the current evaluation did not include the types of activities that help to explain the variation in RRs over time. Potential explanations could include programmatic differences (e.g., the measures offered or assumed savings for those measures) or participant differences (e.g., demographic and housing characteristics). For example, under EEPS2, HPwES funded fuel switching measures that switched homes from a less efficient heating fuel such as fuel oil to a more efficient fuel such as natural gas; this may have changed the demographic and housing characteristics in such a manner that the resulting *electricity* savings also changed.

Table 21: Comparison of HPwES / AHPwES Realization Rates across Evaluations

Fuel	2007 to 2008[a]	2010 to 2011[b]	2012 to 2016
Electricity	0.35	0.19	0.51
Natural Gas	0.65	0.48	0.42

[a] NYSERDA 2007-2008 Home Performance with ENERGY STAR® Program Impact Evaluation Report. Prepared by Megdal & Associates and West Hill & Energy Computing. September 2012. Table ES-4. https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2012ContractorReports/2012-HPwES-Impact-Report-with-Appendices.pdf

[b] Home Performance with ENERGY STAR Program Impact Evaluation Report (2010-2013) Final Report Volume 2: Phase 1 Billing Analysis, the New York State Energy Research and Development Authority. Prepared by ERS and West Hill Energy and Computing. November 2016. Table 6. https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2016ContractorReports/HPwES-IE-Report-Vol2.pdf

2.3.1 HPwES Electric Results

This section summarizes the electric savings resulting from the installation of measures in HPwES funded by EEPS2 Electric. It is important to note that NYSERDA filed ancillary electric savings – that is, electric savings resulting from the installation of gas measures – separately from program savings to the DPS. This includes electric savings resulting from fuel switching from electric to natural gas or other fuels. Ancillary electric savings are substantial for HPwES, so the billing analysis excluded households for which EEPS2 Gas paid for all electric saving measures. See Section 3.3 and Appendix A for more detailed discussions of the regression models.

Table 22 and **Table 23** present the per household evaluated program, program evaluated savings, and RRs for HPwES and AHPwES projects from 2012 to 2016 that were included in the billing analysis. The results suggest that evaluated savings for these households fall below their program evaluated savings. Section 2.3.4 includes a discussion of potential reasons for this.

Table 22: HPwES Electric Model Analysis Annual Savings for Analysis Homes [a, b]

Year	Number of Homes in Analysis	Evaluated Total Annual Savings per Home (kWh)[c] (A)	Program Reported Annual Savings per Home (kWh) (B)	RR (A/B)
2012	192	527	1,040	0.51
2013	115	605	1,162	0.52
2014	164	349	1,253	0.28
2015	232	1,333	1,890	0.71
2016	110	958	1,610	0.60
Aggregated[d]	813	724	1,420	0.51

[a] Excludes AHPwES participants.

[b] Excludes fuel switching and ancillary savings.

[c] Adjusted for program savings attributed to RGGI funded programs; approximately 7.1% of aggregated reported savings.

[d] Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not sum to the total of the individual year savings.

Table 23: AHPwES Electric Model Annual Savings for Analysis Homes [a]

Year	Number of Homes in Analysis	Evaluated Total Savings per Home (kWh)[c] (A)	Program Reported Savings per Home (kWh) (B)	RR (A/B)
2012	103	624	1,051	0.59
2013	92	233	1,301	0.18
2014	158	566	1,213	0.47
2015	224	342	1,118	0.31
2016	58	553	1,084	0.51
Aggregated[c]	635	387	1,154	0.34

[a] Excludes fuel switching and ancillary savings

[b] Adjusted for program savings attributed to RGGI funded programs; approximately 3.2% of aggregated reported savings.

[c] Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not sum to the total of the individual year savings.

Table 24 and **Table 25** provide an accounting of electric savings funded by RGGI in homes served by HPwES and AHPwES between 2012 and 2016. Annual RGGI savings percentages varied based on the types of electric savings measures installed in homes over time.

Table 24: Summary of RGGI Electric Annual Savings for Analysis Homes - HPwES

Year	EEPS2 Reported Program Savings (kWh)	RGGI Reported Program Savings (kWh)	Total Reported Savings (kWh)	Percent of EEPS2 Savings	Percent of RGGI Savings	RGGI Evaluated Savings per Home (kWh)
2012	199,589	2,870	202,459	98.6%	1.4%	8
2013	133,651	2,273	135,924	98.3%	1.7%	10
2014	205,457	36,325	241,782	85.0%	15.0%	62
2015	438,550	38,307	476,857	92.0%	8.0%	116
2016	177,149	8,288	185,437	95.5%	4.5%	45
Aggregated	1,154,395	88,063	1,242,458	92.9%	7.1%	55

Table 25: Summary of RGGI Electric Annual Savings for Analysis Homes – AHPwES

Year	EEPS2 Reported Program Savings (kWh)	RGGI Reported Program Savings (kWh)	Total Reported Savings (kWh)	Percent of EEPS2 Savings	Percent of RGGI Savings	RGGI Evaluated Savings per Home (kWh)
2012	108,235	546	108,782	99.5%	0.5%	3
2013	119,728	5,015	124,743	96.0%	4.0%	10
2014	191,608	4,750	196,358	97.6%	2.4%	14
2015	250,544	5,254	255,798	97.9%	2.1%	7
2016	62,876	8,771	71,647	87.8%	12.2%	77
Aggregated	732,991	24,336	757,327	96.8%	3.2%	13

2.3.2 HPwES Natural Gas Results

This section summarizes the natural savings resulting from the installation of measures in HPwES funded mainly by EEPS2 Gas but also by EEPS2 Electric. Although the DPS required NYSERDA to file ancillary (gas savings resulting from the installation of electric measures) separately from program savings, the participants included in the natural gas regression analysis had negligible ancillary savings. This contrasts with electric in which gas results in substantial ancillary electric savings. As such, the Impact Evaluation Contractor, retained ancillary natural gas savings in the analysis. Gas savings resulting from fuel switching from natural gas to electric are included in program savings reported to the DPS and are likewise included in the analysis.

Table 26 and **Table 27** present the per household evaluated program, reported evaluated savings, and RRs for HPwES and AHPwES projects from 2012 to 2016. The results suggest that evaluated savings for these households fall below their program evaluated savings. Section 2.3.4 includes a discussion of potential reasons for this.

Table 28 provide aggregated accounting of natural gas savings funded by RGGI in homes served by HPwES and AHPwES between 2012 and 2016. In EEPS2, RGGI most frequently funded measures in homes that heat with unregulated fuels. For this reason, the natural gas savings attributed to RGGI are very small, usually less than one MMBtu per home.

Table 26: HPwES Natural Gas Model Annual Savings for Analysis Homes [a, b]

Year	Number of Homes in Analysis	Evaluated Total Savings per Home (MMBtu)[a] (A)	Program Reported Savings per Home (MMBtu) (B)	RR (A/B)
2012	610	15	34	0.44
2013	556	13	26	0.50
2014	739	13	31	0.42
2015	923	11	32	0.34
2016	419	11	33	0.33
Aggregated[d]	3,247	13	31	0.42

[a] Excludes AHPwES participants

[b] Includes fuel switching participants

[c] Adjusted for program savings attributed to RGGI funded programs; approximately 0.05% of aggregated reported savings.

[d] Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not sum to the total of the individual year savings.

Table 27: AHPwES Natural Gas Model Annual Savings for Analysis Homes [a]

Year	Number of Homes in Analysis	Evaluated Total Savings per Home (MMBtu)[b] (A)	Program Reported Savings per Home (MMBtu) (B)	RR (A/B)
2012	278	15	38	0.39
2013	345	20	33	0.61
2014	440	15	35	0.43
2015	551	10	34	0.29
2016	221	12	34	0.35
Aggregated[c]	1,835	15	35	0.43

[a] Includes fuel switching participants

[b] Adjusted for program savings attributed to RGGI funded programs; approximately -0.02% of aggregated reported savings.

[c] Row reflects results from a separate regression modeling the aggregate impact of the program and savings may not sum to the total of the individual year savings.

Table 28: Summary of RGGI Natural Gas Annual Savings for Analysis Homes

Program	EEPS2 Reported Program Savings (MMBtu)	RGGI Reported Program Savings (MMBtu)	Total Reported Savings (MMBtu)	Percent of EEPS2 Savings	Percent of RGGI Savings	RGGI Evaluated Savings per Home (MMBtu)
HPwES	101,232	48	101,280	100.0%	0.1%	0.01
AHPwES	63,642	-11	63,631	100.0%	<-0.1%	<0.01

2.3.3 HPwES Contractor Analysis

The Impact Evaluation Team examined savings for contractors grouped by the number of HPwES projects they completed from 2012 to 2016. The HPwES Electric analysis divides the group into the Top 10 contractors and everyone else, whereas for HPwES Gas, the analysis splits the contractors into the Top 10, those who completed a medium number of jobs, and those who completed a small number of jobs. The small sample sizes for some contractors coupled with the high attrition rates raise enough concerns about the results to advise against interpreting the RRs as a definitive summary of contractor performance. Moreover, the study scope did not include the types of tasks that would allow the Impact Evaluation Contractor to delve into the reasons for differences among individual contractors, contractor groups, or fuels.

Table 29 shows the savings for HPwES Electric. The Top Ten contractors accounted for 48% of reported savings and had an aggregate RR of 0.61. The small contractor category achieved an aggregate RR of 0.34, lower than the RR of the ten largest contractors combined.

Table 29: HPwES Electric Realization Rates by Contractor

Contractor Size Category	Number of Projects Completed	Number of contractors in Analysis	Percent of Total Program Reported Savings	RR	Significant at 90/10
Top 10 aggregated (33 to 146 projects)	779	10	48%	0.61	Yes
Small (less than 31 projects)	652	114	52%	0.34	Yes

Table 30 shows that the Top 10 HPwES Gas contractors accounted for 50% of reported savings and achieved an aggregated RR of 0.44. The RR was almost the same as for the medium and small contractors (0.41 and 0.40, respectively).

Table 30: HPwES Gas Realization Rates by Contractor

Contractor Size Category	Number of Projects Completed	Number of contractors in Analysis	Percent of Total Program Reported Savings	RR	Significant at 90/10
Top 10 aggregated (118 to 457 projects)	2,623	10	50%	0.44	Yes
Medium (50 to 116 projects)	1,279	15	26%	0.41	Yes
Small (less than 50 projects)	1,131	117	24%	0.40	Yes

2.3.4 HPwES Findings

The results indicate that the HPwES program achieved energy savings for participants during the EEPS2 funding period. On average, HPwES customers reduced their annual electricity consumption by 724 kWh and annual natural gas by 13 MMBtu. Assisted HPwES customers reduced their electricity consumption by 387 kWh and natural gas by 15 MMBtu. Evaluated electric savings results fell short of reported savings for the households included the analysis, yielding the following RRs: 0.51 for HPwES and 0.43 for AHPwES Electric, and 0.42 for HPwES and 0.43 for AHPwES Natural Gas.

NYSERDA asked the Impact Evaluation Contractor to consider possible reasons for the lower than anticipated realization rates. Some of the potential explanations included the following:

- Bias created by high attrition rates (see Section 1.2.2 and Section 3.1.2.1)
- Evaluator practice in preparing and conducting the billing analysis
- Inaccurate assumptions guiding deemed savings estimates
- Installations not of sufficient quality to achieve evaluated savings
- Customer behavior such as snapback (using efficient equipment more than estimates assume)[19] or removal of items from service

The focused scope of the billing-analysis based impact evaluation of measures installed between two and seven years in the past limited the depth of exploration of realization rates. In particular, the study did not directly query contractors about installation practices or participants about behavior or conduct onsite visits to verify the presence and quality of installations. Yet, the study was able to yield the following insights.

Bias in Attrition: The Impact Evaluation Contractor compared the average program-reported energy savings as listed in the program tracking data for the households included in the analysis and those excluded from the analysis. **Table 42** and **Table 43** in Section 3.1.2.2 show the overall results by year for HPwES (inclusive of AHPwES) electric and natural gas (exclusive of fuel switchers, who were disproportionately removed from the analysis due to a lack of pre-participation billing data). The results suggest no systematic differences in program-reported savings for the HPwES electric that were retained or removed from the analysis for the full time period. However, the results indicate that the program-reported savings for natural gas participants removed from the analysis were 2 MMBtu less than those included in this analysis. While statistically significant, the difference is relatively small (6% of savings per customer in the analysis), implying that any impact on the realization rate is also relatively small.

Evaluator Practice: The Impact Evaluation Contractor may have made decisions in data cleaning and preparation that negatively affected the RRs. To guard against this possibility, NYSERDA evaluation and program staff had numerous conversations about the structure, content, and assumptions in the NYSERDA program tracking data. For example, the Impact Evaluation Contractor made adjustments to their estimation techniques for early replacement

[19] Snapback captures a behavior in which, since the efficient measures saves energy and money, the user decides to use it more than they would an inefficient measure. For example, they may turn the thermostat up a couple degrees more or leave a light on overnight that they would not have done with less efficient equipment.

scenarios to align with NYSERDA's practices when preparing savings estimates for filing with the DPS. Likewise, the Impact Evaluation Contractor followed evaluation best practices in data and model preparation and diagnostics. Therefore, the Impact Evaluation Contractor staff believes that the models are accurate representations of the change in energy use among HPwES participants before and after taking part in the program.

Inaccurate Assumptions. The assumptions about measure use, customer behavior, and household characteristics that are used to estimate savings are vitally important to developing accurate estimates of actual energy use post-installation. This study did not explore whether engineering model or other savings assumptions reflected actual use or conditions in the participating homes.

This study did examine one critical aspect of the models: the impact of *assumptions about the weather* on predicted energy savings (See Appendix B for details). Following evaluation best practice, the billing analysis relied on weather data that corresponds to the time period addressed in the study. The engineering models used by home performance contractors rely on the Typical Meteorological Three (TMY3) dataset, which reflects temperatures from 1991 to 2005.[20] NYSERDA has developed an internal updated weather dataset (2011 to 2017) to serve as an alternative to TMY3. The Impact Evaluation Contractor reran some of the models produced for this study using TMY3 data, NYSERDA's weather dataset, and the actual weather for the time period under consideration. **Table 31** presents a summary of these results for HPwES and AHPwES. The analysis suggests that the weather data had a sizable impact on the electric RRs, and a smaller impact on the gas RRs. This likely reflects the fact that weather conditions have been warmer than those assumed in the TMY3 data and engineering models, which would lead to greater predicted and actual cooling use. Appendix B provides more details on this analysis.

Table 31: Summary of HPwES RRs by Source of Weather Data

	Electric			Natural Gas		
Program	Actual	NYSERDA Weather Data	TMY3	Actual	NYSERDA Weather Data	TMY3
HPwES	0.71	0.74	0.77	0.42	0.42	0.44
AHPwES	0.61	0.63	0.65	0.43	0.42	0.44

[20] For more information on TMY3, refer to https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

Installation Quality: This study did not directly address whether the installation quality of program-supported measures fell below those assumed for energy savings. The Impact Evaluation Contractor examined RRs by groups of contractors and did not find any systematic variation to explain low RRs. Prior work conducted in Connecticut suggests that installation quality may contribute to low realization rates, at least in some cases.[21] Likewise, the study did not examine customer behaviors, such as snapback, occupancy changes, or physical changes to the home, that may have contributed to lower-than-expected RRs.

2.3.5 HPwES Recommendations

This study concludes that the HPwES program (including AHPwES) yielded energy savings for all fuel types during the EEPS2 funding period of 2012 to 2016. Although the savings typically fall short of those reported by NYSERDA to the DPS, households throughout the state still saw reduced energy use which helped to lower their energy bills.

The study yielded the following recommendations:

Recommendation 1: NYSERDA should apply the following RRs to HPwES for the 2012-2016 time period:

Program	Electric RR	Gas RR
HPwES	0.51	0.42
AHPwES	0.43	0.43

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

Recommendation 2: NYSERDA should streamline Program Database Tracking for the EmPower and HPwES Programs as well as make certain project- and measure-level tracking align, a process that is already underway.

While the EmPower and HPwES Programs are evaluated as separate programs, streamlining the datasets using common field names and practices where feasible may result in evaluator efficiency gains for future interim and full impact billing analyses. This is especially important because households taking part in AHPwES often take part in both EmPower and HPwES. NYSERDA has informed the Impact Evaluation Contractor that this streamlining is already in progress. Program managers should coordinate and streamline their program tracking databases for EmPower and HPwES, tracking similar types of participant information (such as measure categories), and provide universal identifiers for homes that may qualify for and participate under both programs over the span of the program. Likewise, inability to link participants across the project- and measure-level databases served as one of the top three factors driving attrition.

More specific technical points to consider:

- Track reported MMBtu savings by fuel (e.g. natural gas, fuel oil, kerosene, propane, etc.).
- Track fuel switching for measures such as dryers and water heaters.
- Track early replacement vs. replace on failure vs. new equipment to the home.
- Improve the quality and record keeping of utility account information.
- Streamline measure categories (EmPower field name: *MeasureCategory*) to be consistent with HPwES measure categories. HPwES tracks details for each measure (HPwES field names: *DESCRIPTION1* and *DESCRIPTION2*) and higher level measure categories (HPwES field names: *NYSERDA_SUB_CATEGORY* and *NYSERDA_CATEGORY*).

The study also yielded critical findings that fall short of recommendations but that the Impact Evaluation Contractor nevertheless believes should be called out.

Critical Finding 1: The DPS required NYSERDA to report ancillary EEPS2 savings separately, which fails to account for the entirety of savings achieved by the program. CEF is being administered and reported on a fuel neutral basis, which will provide a more complete accounting of its impacts.

EEPS2 required NYSERDA to divide the fund into EEP2 Electric and EEP2 Gas. EEP2 Electric could only claim electric savings, and EEP2 Gas could only claim natural gas savings. If electric or gas measures yielded savings for the other fuel, NYSERDA treated them as ancillary and filed them separately to the state.

Critical Finding 2: This study reinforces other research conducted by NYSERDA that documents that TMY3 may no longer represent the current weather conditions in New York. NYSERDA and NFGDC program staff and Home Performance Contractors may want to explore updating engineering models to include a vetted replacement to TMY3.

TMY3 remains the most commonly used weather data in such models across the nation. However, through this and other recent evaluations, NYSERDA has established that TMY3 no longer represents the current, warmer weather conditions in New York. Replacing TMY3 may produce more accurate estimates of savings, thereby increasing realization rates.

Critical Finding 3: NYSERDA has recognized the importance of conducting frequent interim impact billing analyses for early detection in identifying potential challenges and take corrective action as soon as possible.

The EEPS2 period ran from 2012 to mid-2016, but this impact evaluation did not get started until mid-2018, a full two-years later. This created challenges from an evaluation perspective, including the availability of billing data, staff recollections of programmatic and data tracking and reporting decisions made years earlier, etc. It also precluded NYSERDA from taking action to boost achieved savings, particularly for natural gas programs. More frequent evaluations will help to limit attrition and provide timely results to help improve program delivery.

Critical Finding 4: NYSERDA program staff should work with Home Performance Contractors to improve the frequency and accuracy of utility account number collection.

Many factors drove the high rates of attrition, with inaccurate utility account numbers contributing to one of the top three reasons. The Impact Evaluation Contractor noted missing account numbers and the assignment of the same account number to electric and natural gas utilities, even when the two utilities differed. Better collection and reduction of errors will reduce attrition rates, yielding more accurate assessments of savings in the future.

3 Methods

3.1 Data Preparation

3.1.1 Data Sources

The billing analysis utilized three sources of data. The first source was EmPower and HPwES program tracking data for 2012 to 2016, provided by NYSERDA at both the project and measure-level. The project-level data included details on the projects completed through the program (e.g. program-reported savings by project, project installation complete date) and information on housing characteristics (e.g. address, heating fuel use, age and square footage of home. The measure-level data included information on installation contractor, reported savings by measure, measure type, and funding source. Monthly electric and natural gas billing consumption records from five utilities – Con-Edison, National Grid, RG&E, NYSEG, and NFG – served as the second data source. The full billing data set spanned January 2011 to December 2017, the data provided for individual households may have varied (e.g., if the customer moved into or out of

the house during that time period).[22] Lastly, the analysis included daily weather data from National Oceanic and Atmospheric Administration (NOAA) for the major weather stations in the state, also spanning the time period of January 2011 to December 2017.

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 and HPwES program data to identify and exclude homes that participated in both programs at different times over the study period. The Impact Evaluation Contractor excluded homes with more than one project number and for which the project completion dates differed by more than one month.[23]
3. The Impact Evaluation Contractor used EEPS2 Gas and Electric funding streams and 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 billing data from Con-Edison, National Grid, Rochester Gas and Electric, New York State Electric and Gas Corporation, and NFGDC using utility account numbers. Program accounts that did not have matching utility billing 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 50 percent estimated reads in their billing data were removed from the analysis as they may fail to capture seasonal variation.
7. The final step removed homes that did not have at least 12 months of pre- and 12 months post- project installation billing data.

[22] Several smaller utilities were not able to provide billing records by the requested deadline due to having limited personnel resources to access archived billing records.

[23] Different completion dates – especially those that are years apart – limits the predictive capabilities of the model.

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 32** through **Table 36** provide an attrition analysis by year and fuel type for the EmPower and HPwES Programs. Each table lists the reasons for attrition and their impact on the number of projects included in the billing analysis. The tables begin with total number of projects completed and total number of homes that participated in the programs (several homes completed multiple projects). The tables conclude with the number and percentage of remining homes with savings that were ultimately included in the billing analysis.

The reasons for attrition were fairly similar across the two programs:

- **No matching utility records -** Approximately 23% to 38% of attrition is attributed to participants without matching utility billing consumption records (Row G in **Table 32** through **Table 36**).
- **Insufficient number of months of billing data** - Another large contributor, 15% to 33% of attrition, are participants with insufficient billing records (Row I in **Table 32** through **Table 36**). This would include participants with utility accounts opened shortly before or closed soon after participating in the program so that they lacked 12 months pre- or post-participation data. Reasons for the lack of sufficient pre-post data include fuel switching to natural gas, having work done just after moving into a new home or just before moving out of one.
- **Poor quality utility data** - Lastly, participants with poor quality billing data, including too many estimated, overlapping, missing, duplicates, and gaps in records, make up 14% to 25% of attrition (Row J in **Table 32** through **Table 36**).

One additional source of attrition to note involved homes with missing program tracking information, including incomplete or missing account numbers, inconsistent site addresses, and missing measure-level data (Row E in **Table 32** through **Table 36**). For HPwES, the NYSERDA program staff provided explanations for most of the incomplete or missing account numbers:

- Low-rise projects in master-metered buildings lacking unit-specific meters (65% of the HPwES projects with missing account information)
- Fuel switchers (30%) who had not been assigned account numbers for the new fuel
- Municipal account information collected in a different field (4%)

Although NYSERDA provided these explanations, the Impact Evaluation Contractor did not revise the attrition analysis as these circumstances still arise in the data and prevent these participants from being included in the models due to the lack usable account numbers.

Natural gas billing consumption records tend to have more estimated reads and gaps in records than electric billing consumption records due to the seasonal nature of natural gas consumption.

Table 32: EmPower Program Attrition - Electric

	2012	2013	2014	2015	2016	Total
A. Total **projects**	6,224	9,235	8,953	10,803	6,438	41,653
B. Total projects with savings	5,954	8,579	8,304	9,390	5,126	37,353
C. Total number of **homes**	6,207	9,217	8,934	10,759	5,979	41,096
D. Number of homes with savings	5,939	8,562	8,286	9,357	4,787	36,931
E. Number of homes after program data cleaning	5,308	7,458	6,938	7,502	4,552	31,758
F. Number of homes with a utility that provided billing data	4,861	6,748	6,248	6,943	4,248	29,048
G. Number of homes with matching billing data accounts	4,422	6,071	5,575	3,789	3,282	23,139
H. Number of homes with single project counts	4,421	6,059	5,558	3,762	3,257	23,057
I. Number of homes with adequate pre/post billing data	2,001	2,899	4,531	3,072	2,679	15,182
J. Number of homes after billing data cleaning	1,910	2,613	3,394	1,846	1,971	11,734
K. Percentage of homes included in billing analysis (Rows D/J)	32%	31%	41%	20%	41%	32%
Attrition (100% – Row K)	68%	69%	59%	80%	59%	68%

Table 33: EmPower Program Attrition – Natural Gas

	2012	2013	2014	2015	2016	Total
A. Total **projects**	1,695	3,988	5,455	7,054	3,946	22,138
B. Total projects with savings	1,427	3,501	4,861	6,140	3,412	19,341
C. Total number of **homes**	1,695	3,984	5,455	7,053	3,945	22,132
D. Number of homes with savings	1,427	3,497	4,861	6,139	3,411	19,335
E. Number of homes after program data cleaning	1,352	3,202	4,402	4,888	2,854	16,698
F. Number of homes with a utility that provided billing data	1,287	2,877	4,047	4,595	2,652	15,458
G. Number of homes with matching billing data accounts	710	2,064	2,797	3,420	1,553	10,544
H. Number of homes with single project count	710	2,064	2,797	3,417	1,545	10,533
I. Number of homes with adequate pre/post billing data	514	1,269	2,395	2,908	1,407	8,493
J. Number of homes after billing data cleaning	441	973	1,533	1,848	811	5,606
K. Percentage of homes included in billing analysis (Rows D/J)	31%	28%	32%	30%	24%	29%
Attrition (100% – Row K)	69%	72%	68%	70%	76%	71%

Table 34: LIURP/NFG Program Attrition – Natural Gas

	2012	2013	2014	2015	2016	Total
A. Total **projects**	784	891	1,403	1,012	76	4,166
B. Total projects with savings	626	708	1,209	877	64	3,484
C. Total number of **homes**	784	891	1,403	1,012	76	4,166
D. Number of homes with savings	626	708	1,209	877	64	3,484
E. Number of homes after program data cleaning	622	698	1,205	877	64	3,466
F. Number of homes with a utility that provided billing data	622	698	1,205	877	64	3,466
G. Number of homes with matching billing data accounts	569	669	1,179	872	64	3,353
H. Number of homes with single project counts	569	653	1,169	843	64	3,298
I. Number of homes with adequate pre/post billing data	550	593	1,066	762	61	3,032
J. Number of homes after billing data cleaning	360	407	784	515	39	2,105
K. Percentage of homes included in billing analysis (Rows D/J)	58%	57%	65%	59%	61%	60%
Attrition (100% – Row K)	42%	43%	35%	41%	39%	40%

Table 35: HPwES (includes AHPwES) Program Attrition - Electric

	2012	2013	2014	2015	2016	Total
A. Total **projects**	1,954	2,263	2,576	2,888	1,670	11,351
B. Total projects with savings	997	1,125	1,250	1,667	683	5,722
C. Total number of **homes**	1,951	2,258	2,466	2,866	1,600	11,141
D. Number of homes with savings	996	1,122	1,142	1,659	620	5,539
E. Number of homes after program data cleaning	968	1,108	1,119	1,606	593	5,394
F. Number of homes with a utility that provided billing data	872	923	954	1,421	430	4,600
G. Number of homes with matching billing data accounts	720	753	675	862	392	3,402
H. Number of homes with single project counts	716	742	663	861	375	3,357
I. Number of homes with adequate pre/post billing data	333	317	592	860	350	2,452
J. Number of homes after billing data cleaning	295	207	322	456	168	1,448
K. Percentage of homes included in billing analysis (D/K)	30%	18%	28%	27%	27%	26%
Attrition (100% – Row K)	70%	82%	72%	73%	73%	74%

Table 36: HPwES (includes AHPwES) Program Attrition – Natural Gas

	2012	2013	2014	2015	2016	Total
A. Total **projects**	3,042	3,806	4,344	6,893	3,195	21,280
B. Total projects with savings	3,028	3,781	4,305	6,870	3,192	21,176
C. Total number of **homes**	3,019	3,734	4,174	5,210	2,383	18,520
D. Number of homes with savings	2,995	3,705	4,132	5,184	2,380	18,396
E. Number of homes after program data cleaning	2,694	3,233	3,336	4,039	1,924	15,226
F. Number of homes with a utility that provided billing data	2,625	3,143	3,207	3,861	1,864	14,700
G. Number of homes with matching billing data accounts	1,774	2,207	2,049	2,507	1,148	9,685
H. Number of homes with single project counts	1,760	2,175	1,996	2,424	1,096	9,451
I. Number of homes with adequate pre/post billing data	1,049	1,110	1,650	2,149	942	6,900
J. Number of homes after billing data cleaning	888	901	1,179	1,474	640	5,082
K. Percentage of homes included in billing analysis (Rows D/J)	30%	24%	29%	28%	27%	28%
Attrition (100% – Row K)	70%	76%	71%	72%	73%	72%

Table 37 and **Table 38** reports attrition by utility and fuel type. As noted earlier, Central Hudson and Orange and Rockland (O&R) did not provide billing data for the analysis. For electric customers, NGRID had the highest percentage of homes (57%) retained in the billing analysis. Con-Edison had the lowest (9%) percentage of homes due to having a large number of homes having incomplete utility account numbers in the program tracking data. For natural gas, over one-half (55%) of NFG homes were included in the billing analysis. Con-Edison and NYSEG had the least number of homes in the analysis at 15% and 17%.

Table 37: Program Attrition by Utility– Electric [a]

	Central Hudson	Con-Ed	LIPA	NGRID	NYSEG	O&R	RG&E
A. Total **projects**	2,322	7,285	4,270	19,311	11,598	1,536	5,983
B. Total projects with savings	1,954	6,512	189	17,075	9,816	1,435	5,707
C. Total number of **homes**	2,316	7,170	4,269	19,133	11,592	1,535	5,968
D. Number of homes with savings	1,949	6,413	189	16,900	9,813	1,434	5,692
E. Number of homes after program data cleaning	1,848	1,916	178	16,356	9,376	1,400	5,602
F. Number of homes with matching billing data accounts		1,501		12,133	8,103		4,804
G. Number of homes with single project counts		1,490		12,011	8,100		4,803
H. Number of homes with adequate pre/post billing data		904		10,318	3,775		2,643
I. Number of homes after billing data cleaning		555		9,662	1,742		1,223
J. Percentage of homes included in billing analysis (Rows D/I)		9%		57%	18%		21%
Attrition (100% – Row J)		91%		43%	82%		79%

[a] Includes EmPower and HPwES Program data

Table 38: Program Attrition by Utility– Natural Gas [a]

	Central Hudson	Con-Ed	NFG	NGRID	NYSEG	O&R	RG&E
A. Total **projects**	617	1,110	7,303	14,175	5,074	1,215	7,854
B. Total projects with savings	546	1,072	6,447	13,626	4,648	1,104	7,480
C. Total number of **homes**	613	1,105	7,268	11,829	5,070	1,197	7,535
D. Number of homes with savings	542	1,067	6,412	11,280	4,644	1,086	7,161
E. Number of homes after program data cleaning	532	943	6,276	10,962	4,546	1,072	6,998
F. Number of homes with matching billing data accounts		684	5,338	5,991	3,001		5,215
G. Number of homes with single project counts		669	5,251	5,855	2,998		5,211
H. Number of homes with adequate pre/post billing data		229	5,038	4,993	1,750		3,383
I. Number of homes after billing data cleaning		157	3,556	4,888	776		1,311
J. Percentage of homes included in billing analysis (Rows D/I)		15%	55%	43%	17%		18%
Attrition (100% – Row J)		85%	45%	57%	83%		82%

[a] Includes EmPower and HPwES Program data; LIURP Program data excluded and shown in **Table 34**.

3.1.2.2 Comparison of Analysis and Excluded Participant Savings

To explore whether attrition created bias by systematically excluding homes from the billing analysis that differed from those retained, the Impact Evaluation Contractor conducted two-sample t tests comparing the average reported savings per home of participants in the analysis against those excluded from the analysis. **Table 39** to **Table 42** show that the aggregated samples for EmPower (both fuels), LIURP, and HPwES Electric were generally not statistically different at the 90% confidence level. This provides evidence to refute the possibility that the attrition analysis introduced bias to the billing analysis.

Turning to natural gas, the billing analysis included only those fuel switchers who had sufficient natural gas consumption records prior to their participation in the program; the implication is that most households switching from another fuel to natural gas were excluded from the billing analysis due to inadequate billing records. To provide a more direct comparison, the analysis in **Table 43** excludes fuel switchers from the tests of equivalence between groups included and excluded from the models. **Table 43** shows that the average savings per home in the HPwES Natural Gas analysis was statistically higher (33) than excluded natural gas homes (31). Unlike electric, this implies that the average home removed the analysis differed from those included. The billing analysis includes a disproportionate number of participants with greater reported savings, which could lead to slightly overstate realization rates. Yet, the average difference in reported savings between those included and excluded from the model is only two MMBtus, so the Impact Evaluation Contractor concludes that the differences have minimal impact on realization rates.

Table 39: EmPower Testing for Statistical Difference in Means - Electric

Year	Reported kWh Savings per Home in Analysis	Reported kWh Savings per Home Excluded	t-value[a]	Significant at 90/10
2012	1,163	1,204	0.64	No
2013	1,212	1,277	0.93	No
2014	1,082	1,002	-1.70	Yes
2015	881	765	-2.66	Yes
2016	784	839	0.45	No
Aggregated	1,043	1,014	-1.00	No

[a] t-value greater than 1.645 indicates the means of the two independent groups are significantly different at the 90% confidence level.

Table 40: EmPower Testing for Statistical Difference in Means– Natural Gas

Year	Reported MMBtu Savings per Home in Analysis	Reported MMBtu Savings per Home Excluded	t-value[a]	Significant at 90/10
2012	34	29	-1.13	No
2013	31	34	0.82	No
2014	30	33	1.65	Yes
2015	33	31	-1.16	No
2016	28	27	-0.38	No
Aggregated	31	31	0.18	No

[a] t-value greater than 1.645 indicates the means of the two independent groups are significantly different at the 90% confidence level.

Table 41: LIURP Testing for Statistical Difference in Means – Natural Gas

Year	Reported MMBtu Savings per Home in Analysis	Reported MMBtu Savings per Home Excluded	t-value[a]	Significant at 90/10
2012	56	52	-0.43	No
2013	47	50	0.68	No
2014	43	43	-0.19	No
2015	44	41	-1.26	No
2016	35	34	-0.71	No
Aggregated	45	44	-0.49	No

[a] t-value greater than 1.645 indicates the means of the two independent groups are significantly different at the 90% confidence level.

Table 42: HPwES (Including AHPwES) Testing for Statistical Difference in Means – Electric

Year	Reported kWh Savings per Home in Analysis	Reported kWh Savings per Home Excluded	t-value[a]	Significant at 90/10
2012	753	781	0.41	No
2013	830	889	0.63	No
2014	928	1,251	3.05	Yes
2015	915	688	-2.54	Yes
2016	652	722	0.77	No
Aggregated	837	849	0.29	No

[a] t-value greater than 1.645 indicates the means of the two independent groups are significantly different at the 90% confidence level.

Table 43: HPwES (Including AHPwES) Testing for Statistical Difference in Means – Natural Gas[a]

Year	Reported MMBtu Savings per Home in Analysis	Reported MMBtu Savings per Home Excluded	t-value[b]	Significant at 90/10
2012	36	35	-0.22	No
2013	30	33	2.94	Yes
2014	33	35	2.14	Yes
2015	33	27	-6.93	Yes
2016	33	25	-6.59	Yes
Aggregated	33	31	-4.75	Yes

[a] Does not include homes that participated in fuel switching.

[b] A t-value greater than 1.645 indicates the means of the two independent groups are significantly different at the 90% confidence level.

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 includes an indicator variable for program treatment (completed installation) as the primary predictor. The model also includes 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. The model is run for the aggregated program and with year interactions to capture the impact for each analysis year. The main model is the following:

$$Average\ Daily\ Usage_{i,t} = \alpha_i + \beta_1 Completed\ Installation_{i,t} + \beta_2 Average\ Daily\ HDD_{i,t} + \beta_3 Average\ Daily\ CDD_{i,t} + \sigma_t + \epsilon_{i,t}$$

where,

$Average\ Daily\ Usage_{i,t}$ is the average daily electric or natural usage of household *i* in billing period *t* are predicted,

α_i is the customer-specific intercept for household *i*, this intercept controls for unobserved differences in daily usage

$Completed\ Installation_{i,t}$ is the binary variable indicating the installation of program equipment for household *i* in billing period *t*,

β_1 is the slope coefficient that representing the average savings from installation of program equipment,

$Average\ Daily\ HDD_{i,t}$ the continuous variable for the average daily heating degree days for household *i* in billing period *t*,

$Average\ Daily\ CDD_{i,t}$ the continuous variable for the average daily cooling degree days for household *i* in billing period *t*, excluded from natural gas billing analysis models,

β_2 and β_3 are the slope coefficients representing the impact of heating and cooling degree days, respectively,

σ_t is the month by year binary variables for billing period *t*, accounting for monthly variation in usage,

$\epsilon_{i,t}$ is the error term with mean zero for household *i* in billing period *t*.

Twelve months of pre-installation billing data capture the baseline or preexisting conditions of the participating households and is compared to twelve months 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.

3.3 Model Selection

The model specification process specifies two types of models. The first is the whole-home model aimed to estimate savings for each analysis year from 2012 to 2016. For the whole-home model, the team compared the results of individual regressions by year to a single regression with year interactions to obtain year-specific program savings. The single regression with year interactions allowed the model to have a larger sample size and longer panel which resulted in more stable and intuitive estimates.

The second model is a measure-specific model aimed to estimate savings by measure for each program and year. For comparative purposes, the measure categories were broken out to reflect measures identified in the prior 2010-2011 impact evaluation.

3.4 Accounting for RGGI Funds

Evaluated savings from the billing analysis included savings from RGGI funded measure as well as EEPS2 funded measures. RGGI savings consisted of a small proportion of overall reports savings of the sample of homes in the analysis. To assign electric and natural gas savings to the appropriate funding source (RGGI or EEPS2), the evaluation team adjusted the evaluated savings by the proportion of total reported program savings that can be attributed to each funding stream. The daily program savings parameter estimate, obtained from the billing analysis regression model (refer to Section 3.1.2.2 for model details), is multiplied by either the proportion of RGGI or EEPS2 reported program savings in the following equations:

For EEPS2:

$$Adjusted\ Average\ Daily\ Savings = \hat{\beta}_1 \times Percent\ of\ EEPS2\ Reported\ Savings$$

For RGGI:

$$Adjusted\ Average\ Daily\ Savings = \hat{\beta}_1 \times Percent\ of\ RGGI\ Reported\ Savings$$