

Home Performance with ENERGY STAR[®] Program Impact Evaluation Report (PY2010-2013)

Final Report

Volume 4: Green Jobs-Green New York Audit-Only Impact Evaluation

November 21, 2016

Prepared for

**The New York State
Energy Research and Development Authority**

Carley Murray
Project Manager

Prepared by

ERS
120 Water Street, Suite 350
North Andover, MA 01845
Phone: 978-521-2550

Principal Investigator:
West Hill Energy and Computing

NOTICE

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

ABSTRACT

Volume 4 presents the evaluation component designed to investigate whether Green Jobs--Green New York (GJGNY) audit-only recipients were generating savings outside of the HPwES Program and to estimate the savings from these installations.

The first component of the evaluation included an initial screening survey to identify GJGNY audit-only participants who had installed major energy efficiency measures and to create the sampling frame for billing analysis.

The second stage involved using a billing analysis to estimate energy savings from the measures that were recommended in the audit report but installed outside the Program.

The final component involved use of cognitive interviews to gain insights into decision making, assess program influence and test an alternative approach to quantifying program influence through the use of pairwise comparisons.

ACKNOWLEDGMENTS

The ERS Impact Evaluation Team would like to thank Carley Murray and Judeen Byrne for the assistance they provided throughout the process of implementing the HPwES impact evaluation. The ERS Team would also like to thank NYSERDA's HPwES program staff, including Karen Hamilton, Laura Geel and Kim Lenihan who provided critical support and information to help us to understand program procedures and policies. In addition, the ERS team appreciated the valuable feedback provided by William Saxonis of the Department of Public Service and, Rick Ridge and Ralph Prah from the DPS contractor team, through the review of our planned work. Finally, the ERS Team would like to acknowledge the efforts of the utility staff members who provided the electric consumption information and records requested for participant projects.

TABLE OF CONTENTS

NOTICE I

ABSTRACT II

ACKNOWLEDGMENTSIII

LIST OF TABLES V

LIST OF FIGURES V

SECTION 1: INTRODUCTION 1

SECTION 2: PROGRAM DESCRIPTION..... 2

SECTION 3: METHODS 3

 3.1 GJGNY Audit-Only Survey..... 3

 3.2 GJGNY Billing Analysis 7

 3.3 GJGNY Cognitive Interviews 12

SECTION 4: RESULTS 19

 4.1 GJGNY Audit-Only Survey..... 19

 4.2 GJGNY Billing Analysis 35

 4.3 Cognitive Interviews..... 38

SECTION 5: CONCLUSIONS 41

 5.1 GJGNY Audit-only survey 41

 5.2 GJGNY Billing Analysis 41

 5.3 Cognitive Interviews..... 42

SECTION 6: RECOMMENDATIONS 44

SECTION 7: REFERENCES 45

LIST OF TABLES

Table 1: Survey Disposition 4

Table 2: Eligibility for the Billing Analysis 6

Table 3: Attrition by Utility 10

Table 4: Steps in the Barriers Approach 14

Table 5: Number of Barriers v. Number of Pairwise Questions 16

Table 6: Source of Incentives for Efficiency Measure Installation 28

Table 7: Reasons for Not Accessing HPwES Incentives or Services 29

Table 8: Reasons for Not Installing Energy Efficient Upgrades 30

Table 9: Installation of Recommended and Nonrecommended Measures 32

Table 10: Measure Overlap for Respondents with Energy Efficient Windows and Doors 34

Table 11: Comparison of Savings from HPwES Billing Analyses 35

Table 12: Recommended Measure Installation Compared to All Measure Installation 37

Table 13: Estimated Annual Savings from the GJGNY Audit 37

Table 14: Findings from the Survey Fielding 38

LIST OF FIGURES

Figure 1: Summary of Survey Components 5

Figure 2: Program Influence for GJGNY Audit-Only Recipients 13

Figure 4: Measures Installed 20

Figure 5: Measures Installed, Recommended and Planned 21

Figure 6: Location of Insulation 22

Figure 7: Blower Door Testing 22

Figure 8: Windows and Doors Replaced 23

Figure 9: Types of Heating Systems 23

Figure 10: Condition of Equipment before Replacement 24

Figure 11: Other Appliances Installed after the Home Energy Audit 25

Figure 12: Changes in Thermostat Settings among Respondents with Lower Heating Bills 26

Figure 13: Major Measures Installed, Recommended and Planned 33

SECTION 1: INTRODUCTION

Volume 4 presents the methods and findings of the evaluation component designed to assess whether GJGNY audit-only recipients were generating savings outside of the HPwES Program and to estimate the savings from these installations. The GJGNY program was started in 2010 to provide homeowners in New York free or reduced cost energy audits and encourage installation of energy efficiency measures through the Home Performance with ENERGY STAR® (HPwES) Program. In addition to audit incentives available through the HPwES program, GJGNY provides low cost financing to homeowners for installation of eligible energy efficiency measures. The GJGNY program also offers funding for training and green collar careers in targeted communities with the support of Constituency Based Organization (CBOs).

A home energy audit is the first step in participation in the HPwES Program. Audit recipients who decide to continue with the program choose a HPwES contractor to install measures that were recommended in the audit. These homeowners are eligible for incentives, and the savings for these projects are tracked and reported under the HPwES Program. However, GJGNY audit recipients who do not complete a project through HPwES may also install efficiency measures on their own. The recent Market Characterization Assessment (MCA) report on the GJGNY Program indicated that 38% of participants approved for a GJGNY audit went on to install energy efficiency measures outside the HPwES Program.

The GJGNY component of the HPwES Phase 2 impact evaluation was designed to investigate whether these GJGNY “audit-only” recipients are generating savings outside of the HPwES Program and to estimate the energy-related savings from these installations. This component of the evaluation had three parts:

1. Initial screening survey to identify GJGNY audit-only recipients who had installed major measures and create the sampling frame for the billing analysis
2. Billing analysis to estimate energy savings from the measures that were recommended in the audit report but installed outside of the Program
3. Cognitive interviews to gain insights into decision making, assess program influence and test an alternative approach to quantifying program influence through the use of pairwise comparisons

The remainder of this report presents an overview of the HPwES Program, and describes evaluation methods, results, and conclusions.

SECTION 2: PROGRAM DESCRIPTION

HPwES encourages home and building owners and tenants of existing one- to four-family homes and small low rise buildings to implement comprehensive energy efficiency-related improvements. Improvements and technologies are installed by participating contractors accredited by the Building Performance Institute (BPI). Eligible measures include building shell measures, such as air sealing and insulation; efficient appliances, such as ENERGY STAR refrigerators; heating measures, such as boilers and furnaces; cooling measures, such as ENERGY STAR room or central air conditioners; water conservation measures; domestic hot water improvements; efficient lighting; and certain renewable energy technologies.

Starting in 2010, participating in the HPwES program involved the following steps:

- An interested household can request a home energy audit through the GJGNY audit program
- A participating HPwES contractor carries out the home energy audit
- Based on the audit, the participating contractor creates a building model in TREAT or HomeCheck and uses the model to quantify the energy impacts of a package of recommended efficiency measures; this model is uploaded to the program portal as “audit”
- The participating contractor provides an audit report and recommendations to the participant household
- The participant household decides which efficiency measures, if any, they are interested in having installed and contracts with either the contractor who completed the audit or another HPwES participating contractor to complete the work
- The selected contractor uploads an updated model of the home that includes the selected package of efficiency measures as “contract”

GJGNY audit recipients who installed HPwES eligible measures but decided not to apply for HPwES incentives were the subject of this evaluation.

SECTION 3: METHODS

This section describes the methods for each component of the GJGNY evaluation: 1) the GJGNY audit-only screener survey, 2) the billing analysis and 3) cognitive interviews and alternative method of quantifying of program influence.

3.1 GJGNY AUDIT-ONLY SURVEY

The foundation of this component of the Phase 2 impact evaluation was a survey to determine the frequency of installations outside of the HPwES Program. In addition, the survey was designed to collect detailed information necessary for a billing analysis of GJGNY audit recipients who had natural gas space heating.¹

3.1.1 Sample frame

A total of 48,432 GJGNY audits were completed between December 2010 and August 2013. As part of the audit, information was collected on primary space heating fuel. The sample frame was restricted to audit recipients who use natural gas as their primary space heating fuel and were not recorded in the HPwES Program tracking database. Almost two-fifths of the total audit recipients (39%) met these two criteria. The sample frame consisted of the 18,823 audit recipients for whom contact information (phone or e-mail) was available.

3.1.2 Fielding of survey

The GJGNY audit-only survey was fielded by Abt/SBRI between September 19 and December 16 2014. The initial survey was Web-based and respondents received a letter that provided a Web access link. Reminders were sent by e-mail and USPS. Follow up telephone surveys were conducted with those who did not respond to the Web survey. Survey respondents were requested to mail a utility data release form to NYSERDA. No incentives were offered for completing the survey or returning the release form.

A summary of the GJGNY survey disposition is provided in Table 1 below. The response rate was 21%, mostly due to the large percent of the sample frame that could not be reached (42%).

¹ The survey was restricted to GJGNY audit-only recipient who heat with natural gas as complete billing records are easier to obtain and analyze for homes with natural gas.

Table 1: Survey Disposition

Description		Number of GJGNY Audit Recipients	Percent of GJGNY Audit Recipients
Total Sample ¹		18,823	100%
Excluding Sample	Not working/Unusable number	1,947	10%
Not Contacted	Respondent never available/call back	7,910	42%
Unknown Eligibility	No Answer/Busy	1,774	9%
Not Eligible	Not Eligible/Not Qualified	394	2%
Refused/Break Off		2,666	14%
MCA module ²		202	1%
Completed interview		3,930	21%

¹ Abt only did follow up telephone surveys for audit recipients who did not respond to the web survey. Respondents completed the interview either through the web or telephone survey.

² These homeowners were in the MCA module but did not complete the impact evaluation questions in the survey.

3.1.3 Eligibility for the Billing Analysis

The purpose of the survey was to identify GJGNY audit-only recipients who installed major measures, collect detailed information for billing analysis and gather additional information that may be useful for program implementation. Survey respondents went through a detailed screener that involved questions about the audit and measures installed after the audit. Screener questions were used to determine eligibility for the billing analysis. To be eligible to be included in the billing analysis, respondents had to meet the following criteria:

- Received GJGNY audit but did not install measures through the HPwES Program
- Installed any one or more of four major measures (insulation, air sealing, energy efficient windows/doors or a new heating system)
- Spent more than \$2,000 on major energy efficiency upgrades
- Lived in home at least one year before and one year after the audit
- Use natural gas as their primary space heating fuel

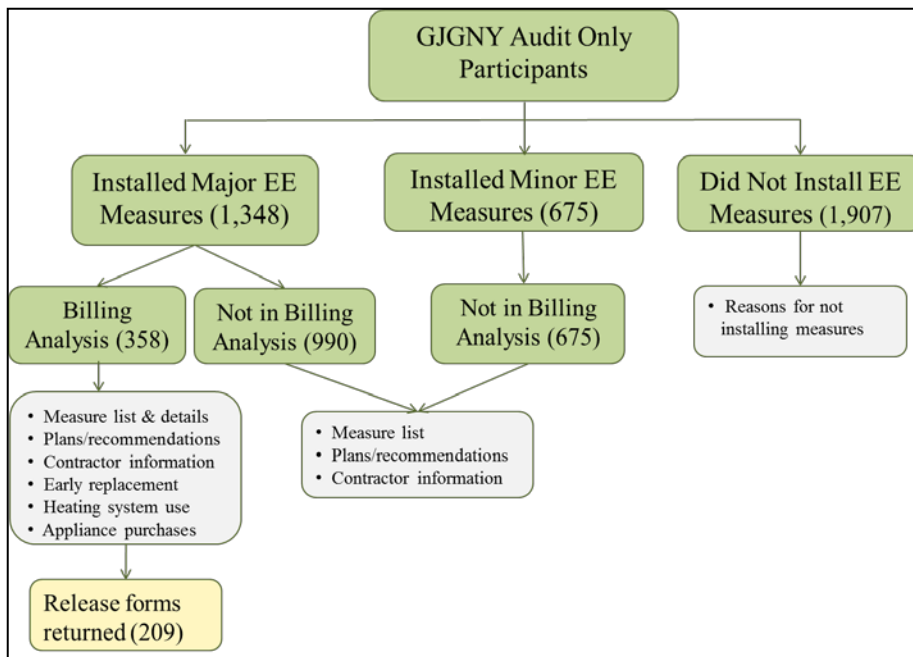
The rest of the survey involved measure-specific, contractor and demographic questions.

The Impact Evaluation Team divided survey respondents into the following three categories:

1. Installed Major Energy Efficiency (EE) Measures. Installed one or more major measure (insulation, air sealing, energy efficient windows/doors, or new heating system)
2. Installed Minor Energy Efficiency Measures. Installed one or more minor measure (thermostats, water heaters, lighting, air conditioners and domestic hot water conservation measures) and did not install any of the four major measures.
3. No Installation. Did not install any of the energy efficiency measures.

The major measure category was further divided into respondents who were eligible for inclusion in the billing analysis and those who were not. The survey components and the number of respondents in each category are shown in Figure 1 below.

Figure 1: Summary of Survey Components



During the survey, some of the respondents provided inconsistent answers about measure installations. In some cases, the respondents reported installing major measures and then failed to select one of these measures from the measure list. Other respondents indicated that they had not installed major measures in the initial question and later chose a major measure from the measure list or described a major measure in the “other” category. The vast majority of the inconsistent responses came from respondents who did not meet the dollar threshold for the billing analysis, i.e., who spent less than \$2,000 on the efficiency upgrades. The “Installed Major EE Measures” box in Figure 1 above includes those who identified major measures in the “other” category. Overall, these inconsistent responses had little impact on the size of the billing analysis pool as most of the additional respondents with major measures did not meet the other criteria.

The survey was designed to identify those respondents with major measures and then continue with more detailed questions about measures recommended and planned. Respondents who identified a major measure in the “other” category were not asked some of the measure details. Consequently, these respondents were included as major measure installations in the measure review section, but excluded from subsequent analyses where the information was not available. These results suggest that more flexibility may be needed in survey design to ensure that full information is available for all respondents with measures.

Out of the 3,930 respondents who completed the survey, only 358 respondents met the criteria for billing analysis, which is much lower than expected. Based on the results of the Market Characterization Assessment (MCA) report on the GJGNY Program², about 38% of GJGNY audit-only recipients were taking energy efficiency actions following the audit. With a population of about 20,000 homes who had natural gas heat and did not receive incentives through HPwES, the sample frame was substantial and, based on the MCA report findings, the Impact Evaluation Team initially estimated 1,000 homes would be eligible for the billing analysis. The reasons that respondents were dropped from the billing analysis pool are given in Table 2.

Table 2: Eligibility for the Billing Analysis

Reasons for Removal From Billing Analysis	Number of	Percent of Respondents
Did not install any of the major measures ¹	2,114	100%
Spent less than \$2,000 on upgrade ²	878	10%
Did not live in home during the entire period or did not have natural gas heat	474	42%
Not willing to return permission forms	93	9%
Did not mention major upgrade in measure list	13	2%
Included in the billing analysis pool	358	14%
Total survey respondents	3,930	1%

¹ This general screening question was asked at the beginning of the survey. The installation rates presented later in this memo are based on the responses to the more detailed measure level questions.

² Process Evaluation and Market Characterization and Assessment, Green Jobs – Green New York Residential Program. Final Report prepared for the New York State Energy Research and Development Authority by NMR Group, Inc., Somerville, MA. Project Numbers #9835 and #9875. September, 2012. Table 94.

3.1.4 Preliminary Analysis of Program Influence

The GJGNY program is intended to influence audit recipients to install measures by offering a comprehensive home audit, access to financing and education about energy efficiency. The influence of the program can thus be gauged by measuring the degree to which audit recipients took action on energy efficiency following the audit. The audit could influence homeowners to take the following actions:

1. Install more energy efficient measures than they had been planning
2. Increase the efficiency of the energy efficient measures over what they were originally planning
3. Install the energy efficient measures sooner than they would have without the audit

This survey was not intended to quantify program influence, however, a few open-ended questions were included to qualitatively assess whether there was any indication of program influence. Survey respondents were asked about their plans prior to the audit, measures recommended by the audit, and measures installed following the audit. The Impact Evaluation Team did not have access to audit reports so relied on information provided by the homeowner about audit recommendations. For this analysis, the focus was on the respondents in the billing analysis pool, and the installed, recommended and planned measures were analyzed as follows:

- Assess the frequency of respondents installing measures that were recommended
- Compare installation of recommended measures and planned measures
- Review measure installation patterns to assess overlap among installation of specific recommended and planned measures

In aggregate, these analyses provide insight into whether respondents are installing additional measures beyond those planned prior to the audit. It does not address the timing or efficiency of the installations.

3.2 GJGNY BILLING ANALYSIS

Billing analysis was selected for estimating gross savings as it is the most reliable and least costly approach to residential impact evaluation and it provides results that can be directly compared to

previous evaluations. Billing analysis is an effective tool for impact evaluation for programs such as HPwES when savings are estimated from the existing condition in the home prior to the installation and are of sufficient magnitude to be found in the billing records.

The HPwES Program encourages a whole house approach to energy efficiency. Given that space heat typically represents the largest residential energy load and the majority of New York homes are heated with some form of fossil fuel, the large majority of the savings in this Program are from fossil fuels rather than electricity. Consequently, the survey of GJGNY audit recipients focused primarily on gathering information about efficiency measures that would be expected to save space heating fuel (thermal shell measures, heating system replacement, etc.). The installation of major natural gas measures was a requirement for survey respondents selected for the billing analysis.

Out of the 3,930 respondents who completed the survey, only 358 respondents met the criteria for billing analysis, which was much lower than expected. Based on the results of the Market Characterization Assessment (MCA) evaluation of the GJGNY Program, the Impact Evaluation Team initially estimated 1,000 homes would be eligible for inclusion in the billing analysis. A total of 209 of the 358 eligible respondents returned permission forms permitting the release of their billing data. Billing data was provided for 186 of these homes.

The evaluation plan called for conducting a billing analysis for measures intended to save both natural gas and electricity. Given the size of the sample frame (over 28,000) and the percent of homes expected to have installed measures from the MCA evaluation (about 40%), the Impact Evaluation Team anticipated that there would be at least 600 homes in the final model. However, the percent of respondents eligible for the billing analysis was much lower than expected and the number of respondents with utility data was under 200. The natural gas model was still feasible due to the strong relationship between natural gas space heating consumption and weather conditions (heating degree days). However, the Impact Evaluation Team realized that the electric billing analysis was not feasible for the following reasons:

1. Due to the focus on the installation of heating measures, there were few respondents in the billing analysis pool with electric measures (92 of the 186 homes).
2. For most of the 92 homes, the primary electric measure was lighting, which tends to have small savings that are difficult to estimate in a billing analysis.

Consequently, the billing analysis was limited to natural gas savings. The remainder of the Methods section outlines the eligibility requirements for a home to be included in the natural gas

billing analysis, the sources of data used in the analysis, data cleaning that was carried out, the resulting attrition in billing model homes, the baseline used (retrofit), and presents an overview of the modelling approach.

3.2.1 Data Sources and Issues

This section describes the methods used to develop savings estimates for GJGNY audit recipients who have natural gas space heating and installed major efficiency measures outside of the HPwES Program. The discussion here is limited to methods particular to the estimation of gross savings for the relevant homes.

Four major data sources were used for the billing analysis:

- Program data on the location of each home
- Survey data on household characteristics, the efficiency measures installed, installation dates, and whether each measure was recommended as part of the GJGNY audit
- Billing records from natural gas utilities
- Weather data from the National Oceanic and Atmospheric Administration (NOAA)

Program data was used to associate each home with the nearest weather station. Heating and cooling degree days for each billing cycle were calculated from the NOAA data and connected to the billing data through the weather station. The survey data specified the efficiency measures installed and when installation took place. No significant issues were encountered with the data used in the billing model.

3.2.2 Data Cleaning

Data cleaning is a critical component of any billing analysis and is generally the most time consuming step in the process. The impact evaluation team carefully reviewed the billing data for the following issues:

- Sufficient pre- and post-installation billing records; nine months before and nine months after the installation of all measures, with at least three consecutive winter months for the natural gas model in both the pre- and post-installation periods
- Breaks in billing history indicating a possible lapse in service; typically, monthly reads with no energy use or missing reads

- Annual consumption within the range of residential use
- Consumption with high variability or a “see-saw” pattern which may indicate that alternating meter reads were estimated but not marked as such by the utility

Homes identified through this process were not necessarily eliminated from the model, but they were identified and reviewed for inclusion.

3.2.3 Attrition

Bias and sampling precision are two critical factors that affect the underlying reliability of evaluation results. For this analysis there was no sampling as all GJGNY audit-only respondents with sufficient billing history were included in the model and all utilities provided billing data. The primary concern for this evaluation was thus the possibility of bias.

Two potential types of bias were considered:

1. Exclusion of respondents without available or sufficient consumption history (attrition)
2. External influences that create change in energy usage and affect the results of the billing analyses

The concern regarding the first source of bias (attrition) is whether the removal of specific groups of homes with similar characteristics may introduce bias into the regression results. The key issue is whether there is any expectation that a specific group of excluded homes may behave differently than the general population.

Table 3 summarizes billing model attrition by utility. Six of the seven utilities were included in the final model. This makes bias due to selective geographic attrition unlikely.

Table 3: Attrition by Utility

Utility	GJGNY Survey Respondents with Utility Bills	Homes Removed From the Model	Homes Included in Final Model	Percent of Homes in the Final Model
Central Hudson Gas and Electric	5	5	0	0%
Consolidated Edison	12	11	1	8%
National Fuel	17	5	12	71%
National Grid	51	12	39	76%

New York State Gas and Electric	35	6	29	83%
Orange and Rockland	2	0	2	100%
Rochester Gas and Electric	64	9	55	86%
Total	186	53	133	72%

The modeling approach, a fixed effects regression with household-specific heating slopes, was chosen to minimize the impacts of attrition. The fixed effects model compares each home to itself, which means that house specific differences consistent across the analysis period are addressed in the regression analysis. Some of the critical factors that are unlikely to be affected by attrition in the context of a fixed effects billing analysis are weather effects (directly included in the model), the fixed characteristics of the homes (housing stock, appliance holdings, etc.), and the mix of measures installed.

3.2.4 Baseline

Since HPwES is primarily a retrofit program, the baseline is the pre-installation condition of the home. An exception to the retrofit scenario occurs when participants replace an aging or nonfunctional heating or cooling system. In this case, the decision is to replace equipment that has failed or is expected to fail in the near future. The baseline for these natural (market opportunity) replacements should be the state or federal standard rather than the consumption of the previously-existing equipment.

The analysis of GJGNY audit-only gross savings was conducted using the pre-existing conditions as the baseline. While other strategies for estimating savings for market opportunity replacements have been developed, the available data were limited and did not allow for this additional analysis.³

³ An example of an impact evaluation of market opportunity heating system replacements is “New York Statewide Residential Gas High-Efficiency Heating Equipment Programs Evaluation of 2009-2011 Programs,” prepared by Opinion Dynamics Corporation for Consolidated Edison (April, 2014).

3.2.5 Billing Analysis

The billing analysis was conducted using a cross-sectional, time-series regression model, the same approach used to evaluate savings for HPwES program participants. A fixed effects model was chosen to address the energy-related characteristics of the home that do not change over time, such as the size of the home, and the presence of major natural gas appliances and heating equipment. The regression model included weather and efficiency installations through the program as predictor (independent) variables. The response (dependent) variable was the average daily energy consumption, and the regression coefficients for measure installation variables were used to estimate the savings.

One component of the modeling process was to compare alternative models to determine the model that best fits the data and to assess the relative importance of specific variables or groups of variables. The information-theoretic approach to model selection was employed, and the outputs were reviewed to assess whether the model was effective at estimating the parameters of interest. This approach ensured that the selection of the final model was based on objective statistical standards and provided reliable estimates of the parameters of interest.

The Impact Evaluation Team reviewed the final model results to ensure that all savings estimates are statistically sound. The model was tested for autocorrelation, multicollinearity, outliers, high-leverage data points, and unequal variances across homes (heteroskedasticity).

It was not possible to incorporate a comparison group into this model due to the extensive effort and expense required to identify GJGNY audit-only recipients who installed measures. However, in the fixed effects model, the home is essentially its own control as the savings are estimated in comparison to previous consumption patterns. Details about the model are provided in Appendix C.

3.3 GJGNY COGNITIVE INTERVIEWS

The Impact Evaluation Team designed an alternative approach to estimating program influence, the Barriers Approach, and tested this new method through cognitive interviews. The Barriers Approach is based on identifying the barriers to measure installation and measuring the relative importance of these barriers and the extent to which the program helped the participants overcome the barriers. This section provides an overview of the Barriers Approach, a discussion of the objectives of the cognitive interviews, an explanation of how the survey was fielded, and a description of the review process.

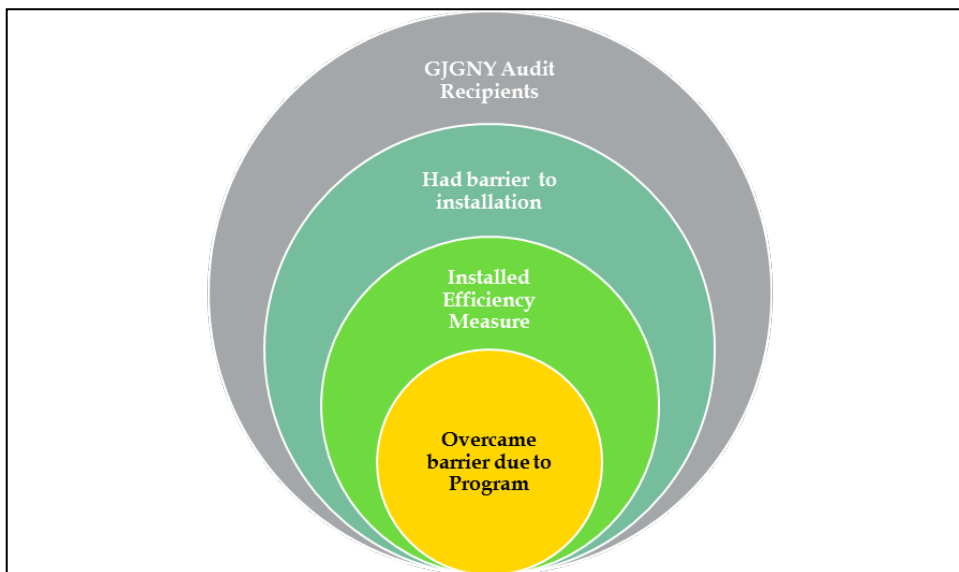
3.3.1 Overview of the Barriers Approach

Energy efficiency programs are designed to help customers overcome barriers to installation. For the installation of energy efficiency measures to be influenced by the GJGNY energy audit, the homeowner has to meet two criteria:

- They had one or more barriers to measure installation that could be addressed by the program.
- The GJGNY energy audit helped the homeowner to overcome the barrier(s).

This framework is illustrated in Figure 2 below. The yellow circle reflects the GJGNY audit recipients who installed measures as a result of the Program.

Figure 2: Program Influence for GJGNY Audit-Only Recipients



Understanding the decision making process is critical to determining whether and how much influence was exerted by the Program. An alternative approach to quantifying program influence needs to account for the range of possible influential factors, both program- and nonprogram-related, that affect the decision to install energy efficiency measures.

The conceptual framework for investigating the decision-making process and quantifying program influence is as follows:

1. **identify the barriers** to installing the efficiency measure(s)

2. assess the **relative importance of the barriers** from the homeowner’s perspective (Barrier Score)
3. identify the **influential factors** that were instrumental in overcoming the barriers
4. quantify **the relative importance of the program- and nonprogram-related factors** in overcoming the barriers (Program Contribution Score for each barrier)
5. calculate the **Pairwise Program Influence Score** by combining the Barrier Scores and the Program Contribution scores within each home

This approach directly measures how the program is working and can provide valuable feedback to program staff.

Table 4: Steps in the Barriers Approach

Step	Description	Comments
1	Identify the barriers	Necessary research to define options
2	Quantify the relative importance of the barriers	Calculate Barrier Scores (percent of the decision associated with each barrier)
3	Identify the influential factors	Necessary research to define options
4	Quantify the relative importance of program and nonprogram influences	Calculate the Program Contribution Scores for each barrier (the percent of the barrier overcome by the program)
5	Calculate the Pairwise Program Influence Score	Integrate the Barrier and Program Contribution Scores to calculate the overall program influence within each home

Each of these steps is discussed in more detail below.

Identifying the Barriers

Extensive research has been conducted to document the common barriers that prevent residential customers from taking action to improve the energy efficiency of their homes. A previous study was conducted on the GJGNY residential audit program used for this research and it documented

the following key barriers: (1) high cost of measures; (2) finding a contractor; (3) waiting for old equipment to break; and (4) ineligible for financing.⁴

Based on findings from other research and a review of responses to open-ended questions in the GJGNY audit-only screener survey, we identified four barriers to installing energy efficiency measures:

1. concerns about **money** (up-front costs)
2. lack of **information**
3. **time** constraints
4. finding a **contractor**

Of these four, the lack of information is the broadest, as it could range from information about costs, benefits and payback to health and safety issues and the specifics of the installation.

The GJGNY audit program is designed to overcome two of these barriers: lack of information and finding a contractor. Theoretically, it could also help those homeowners with time constraints by saving them time in researching the measures and/or selecting a contractor. The GJGNY audit program does not provide monetary assistance, although money is a driving factor in the decision-making process for many homeowners.

Assess Relative Importance of the Barriers and Develop the Barrier Score

Pairwise comparisons are a powerful tool for breaking down the decision making process. This approach is the cornerstone of the Analytic Hierarchy Process (AHP), which was designed to provide a structure for complex decision making. It is intended to assist in making decisions involving many factors and often many stakeholders. More information on the AHP process can be found in Appendix E and examples (with calculations) of the AHP and Barriers Approach can be found in Appendix F.

The Barrier Score is the first step in quantifying program influence. The strategy was to define the barriers first, and then conduct a series of pairwise comparisons to identify the relative importance of each barrier. Due to the wide range of viewpoints among residential homeowners, defining the barriers required four steps:

1. Respondents identified as many concerns that applied to them from a comprehensive list; they were asked to **rank the concerns** on a 0 to 10 scale and add concerns, as needed.

⁴ *Op. cit.*, NMR, 2012.

2. Each of the concerns ranked above 5 was then **mapped to one of the four main barriers** (time, money, information, finding a contractor).
3. The assignment to the four main barriers was **verified with the respondent**.
4. The responses on the 0 to 10 scale were used to **rank the four main barriers in order of importance** and this ranking was also verified with the respondent.

Respondents were asked to compare the barriers two at a time and rank them on a scale where 1 meant that they were of the equal importance and 5 meant that the first (more important) barrier was extremely more important than the other. A mathematical process using matrix algebra was then used to rank each barrier, resulting in a Barrier Score that reflects the percent contribution of each barrier to the lack of action. The scores for all of the barriers add to 100% for each respondent.⁵

Table 5: Number of Barriers v. Number of Pairwise Questions

Number of Barriers	Number of Pairwise Questions	Comments
1	0	Only one barrier; barrier score is 100% for that barrier, zero for all other barriers.
2	1	Comparing two factors requires only one question and a simple calculation to calculate the barrier score.
3	3	Matrix algebra is needed to calculate the barrier score.
4	6	Six questions are likely to become too burdensome to the respondent.

Due to the potential rapid increase in the number of questions with each additional barrier, the Impact Evaluation team intended to inquire only about the three most highly ranked barriers. However, this restriction was unnecessary as none of the respondents had four barriers with a ranking greater than 5.

Identifying Influential Factors

⁵ The details of the calculations are provided in Volume 5: Appendices, Appendices E and F.

For each barrier, there are numerous influences that assist homeowners with overcoming it and installing the efficiency measure. For example, there are numerous sources of information about energy efficiency measures: the HPwES audit, other (non-HPwES) contractors, friends and family, advertisements for specific products, Internet research, etc.

The purpose of this survey component was to determine the relative importance of influential factors in overcoming the barriers. For each barrier, a list of influential factors was constructed and respondents were asked to identify the factors that affected their decision to move ahead with the installation.

These influential factors were grouped into three categories:

1. Direct influence from the HPwES audit
2. Indirect HPwES influence (such as the HPwES Web site)
3. Nonprogram influence (such as friends and family or non-HPwES contractors)

The respondent was then asked to confirm these types of influence.

As we were particularly unsure about how to handle the time barrier, we included an open ended question about how the GJGNY audit help to save time and then the pairwise questions were incorporated into the interview, if needed.

Quantify Relative Importance of Program and Nonprogram Influences

Pairwise questions were developed to compare the direct, indirect and external influences for each barrier. The strategy mirrored the approach used to identify the barriers, as follows:

1. Respondents were asked to **rank the influences** on a 0 to 10 scale and add to the list.
2. Each of the factors ranked above 5 was **mapped to one of three main types of influence**.
3. The selection of the influence(s) from the three categories was **verified with the respondent**.
4. The responses on the 0 to 10 scale were used to **rank the influences in order of importance**.
5. **Pairwise comparisons** were used to quantify the relative importance of the influences for each barrier.

The Program Contribution Scores for each barrier were calculated using matrix algebra as described in Appendix F. If the homeowner attributed all of the influence to only one influential factor, the pairwise comparison step was unnecessary.

Calculate the Pairwise Program Influence Score

Consistent with the calculation of the overall AHP rank, the Pairwise Program Influence Score combines the Barrier Scores and the Program Contribution Scores for each respondent, as shown below.

$$PPI = \sum_{i=1}^n (BS_i \times PC_i)$$

where BS = Barrier Score for barrier i

PC = Program Contribution score for barrier i

n = the total number of barriers identified by the survey respondent

To take this analysis one step further, net program savings could be calculated as follows:

$$NPI = PPIS \times GPI$$

where

NPI is the net program impacts

PPIS is the average Pairwise Program Influence Score for all respondents

GPI is the gross program impacts

The gross program impacts could be energy or demand savings, reductions in greenhouse gas emissions or other metrics. In addition, the PPIS could be weighted to reflect the mix of measures in each home or other considerations.

3.3.2 Objectives of the Cognitive Interviews

The purpose of the cognitive interviews was to determine the relative importance of influential factors in overcoming barriers to installation and consider feasibility of using the Barriers Approach and pairwise comparisons to quantify program influence. Before embarking on this new approach, evaluators needed to ascertain whether it was likely to produce reliable results. The cognitive interviews were designed to provide insight into the following areas:

- Do the four barriers cover the full range experienced by homeowners?
- Are we using terminology that homeowners understand?
- Do the pairwise comparisons make sense to the survey respondents?
- Are the pairwise responses consistent?

- Does the approach to quantifying program influence provide numerical scores that seem reasonable in the context of the story told by the survey respondent?

These interviews provided important feedback for testing the Barriers Approach to estimating program influence.

3.3.3 Fielding of the Interviews

The sample frame for the GJGNY cognitive interviews consisted of the respondents to the screener survey who had installed at least one major efficiency measure outside of the HPwES program and had agreed to participate in a second survey. The sample frame was randomly ordered.

The first round consisted of 10 interviews that were fielded from April 28 to May 12, 2015. The initial survey instrument was largely open ended, and many of the respondents simply stated money was a barrier without giving the question any further reflection. Consequently, the Impact Evaluation (IE) Team modified the survey instrument to provide more structure and detailed probing to obtain a more complete picture of the decision-making process.

A second round of 13 interviews was carried out from June 25 to July 21, 2015 and surveys averaged 30 minutes a piece.

3.3.4 Cognitive Interview Review Process

All interviews were audio recorded and recordings were provided to four reviewers. Each reviewer came to an independent assessment of the Pairwise Program Influence Score. The analysis from these interviews provided a better understanding of the respondents' decision making process and the PPIS was compared to the story told by the respondent. A conference call was held to assess the validity of responses and whether the scores matched the responses.

SECTION 4: RESULTS

The section presents the results and findings from the GJGNY evaluation components.

4.1 GJGNY AUDIT-ONLY SURVEY

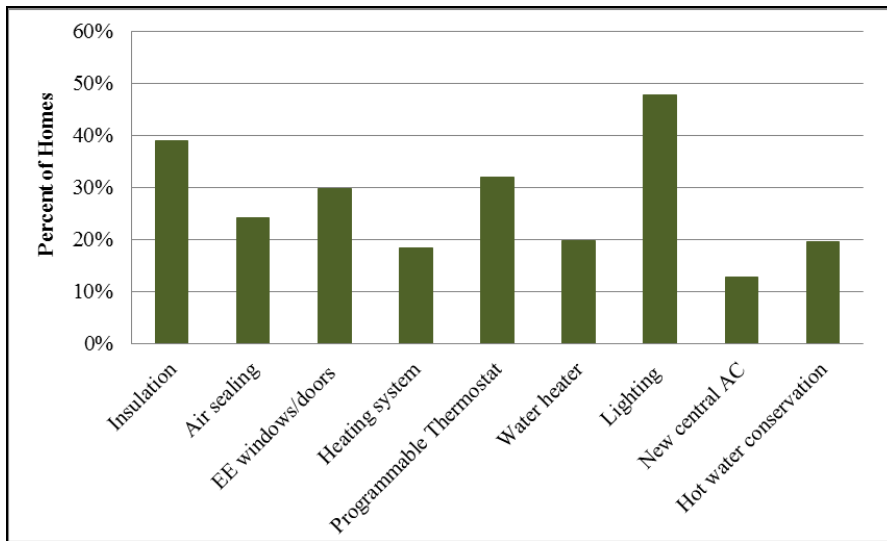
The GJGNY audit-only survey provided detailed information on the measures installed by respondents who passed through the screening questions. The discussion of survey results is divided into two major sections. The first presents findings on the measures installed after the

audit. The second provides additional information collected during the survey that may be useful for program implementation.

4.1.1 Measure Installations

Survey respondents were asked an initial set of questions about all measures installed, whether or not the measure was recommended in the audit report. These results indicate that a high proportion of audit recipients took some type of energy savings action following the audit. Figure 4 provides a summary of the measures installed following the home energy audit. All respondents who reported installing one or more measures are included in the graph below; however, not all of these measures were recommended in the GJGNY audit report.

Figure 3: Measures Installed



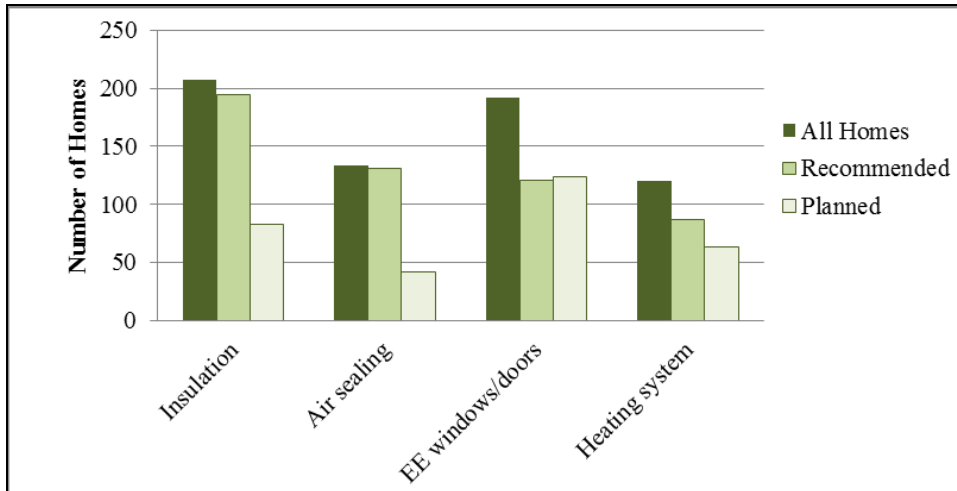
4.1.2 Measures Recommended

As part of the survey, respondents were asked which measures were recommended in the GJGNY audit report and whether they had been planning to make the recommended upgrade before receiving the audit. The Impact Evaluation Team did not have access to audit reports and had to rely on the respondents’ recollection.

The results below reflect the responses from the billing analysis pool only. Over four-fifths of the respondents (84%) reported that one or more major measures were recommended and about 71%

of the respondents installed all major measures that were recommended in the audit report. As can be seen in Figure 5 below, insulation and air sealing were the two most frequently recommended and installed measures. These numbers are likely to be an upper bound on recommendations and lower bound on planned measures due to the way that the invalid responses were treated.⁶

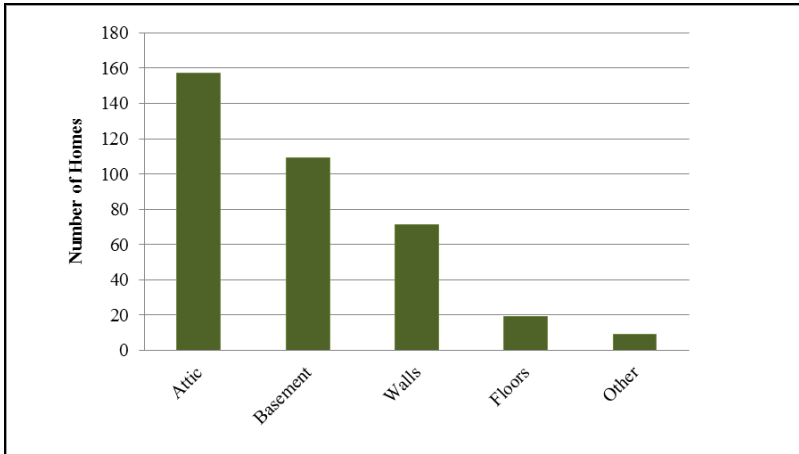
Figure 4: Measures Installed, Recommended and Planned



A total of 207 out of 358 survey respondents installed insulation. One-fifth of billing analysis respondents (20%) installed insulation in more than one location. Overall, most of the respondents installed attic and basement insulation. Figure 6 provides a summary of the location of the insulation.

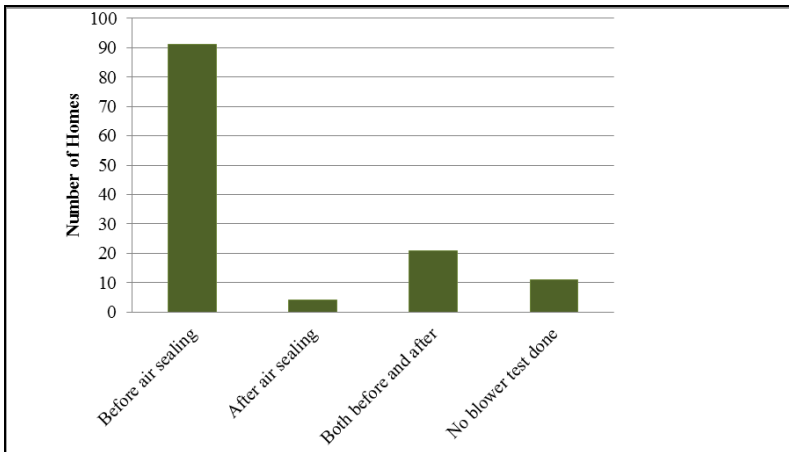
⁶ Invalid responses (“don’t know” or refused) for the recommendation question were assumed to be recommended.

Figure 5: Location of Insulation



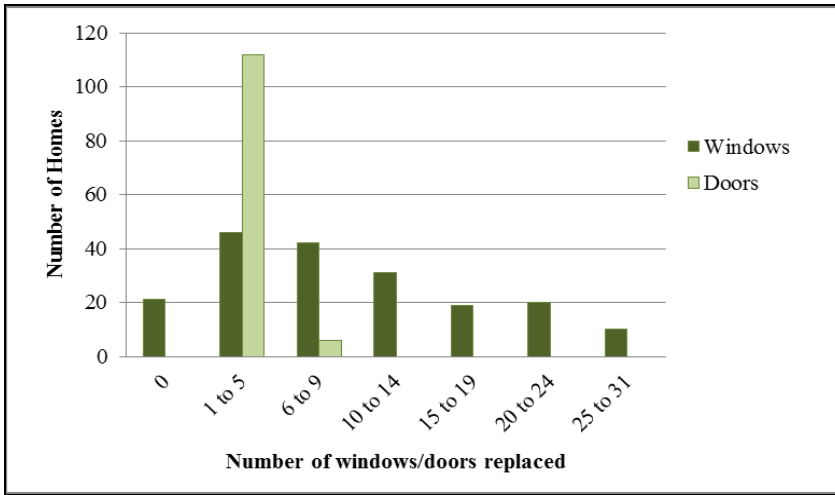
As part of the GJGNY energy audit, the contractor conducted a blower door test to measure air leaks. GJGNY audit recipients were asked when the blower door test was conducted. Out of 133 respondents who installed air sealing, 68% reported that the blower door test was done before the air sealing was installed and only 16% had the blower door test performed both before and after installation. Figure 7 provides a summary of the responses.

Figure 6: Blower Door Testing



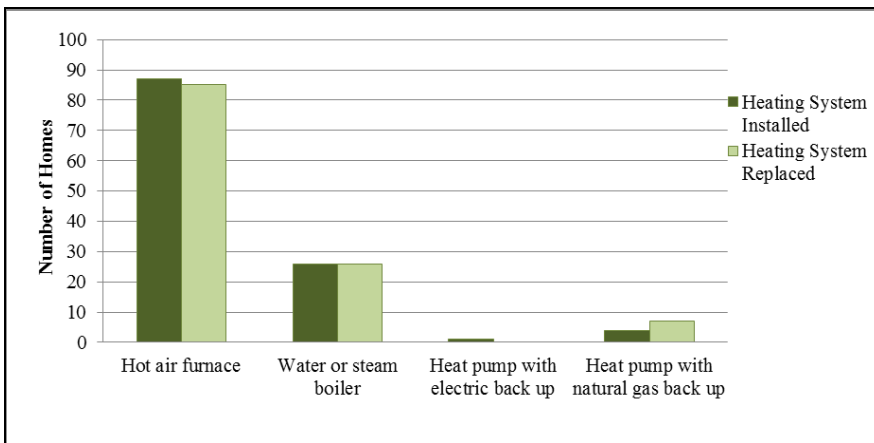
Over one-half (54%) of the respondents in the billing analysis pool reported having installed energy efficient windows and doors. Less than half of these respondents (43%) replaced windows with ten or more energy efficient windows. Figure 8 provides a summary of the number of homes that installed energy efficient windows and doors.

Figure 7: Windows and Doors Replaced⁷



Survey respondents were also asked the type of heating system that they installed following the audit and the type of heating system that was replaced. A summary of the respondents’ responses is provided in Figure 9 below. Of the 118 respondents in the billing analysis pool who installed a new heating system, 74% replaced a hot air furnace and installed a new one following the audit. Over one-fifth (22%) of respondents replaced water or steam boilers and a much smaller percentage installed heat pumps with electric or natural gas back up.

Figure 8: Types of Heating Systems



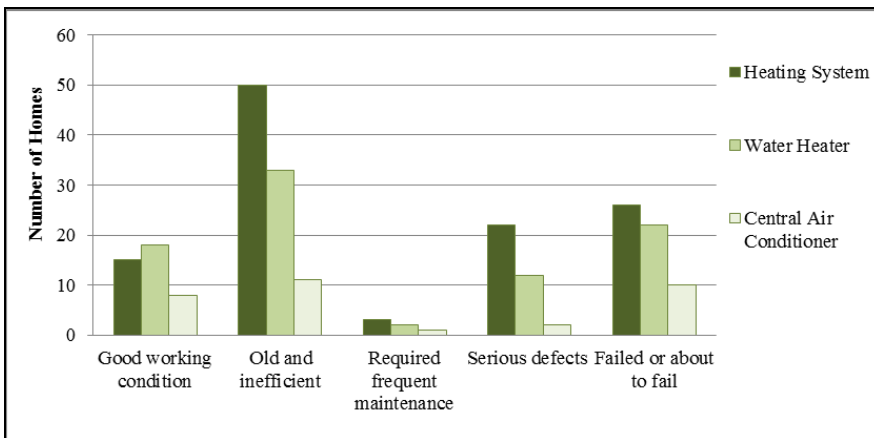
⁷ The survey asked how many windows or doors were replaced with energy efficient windows or doors. Twenty-one respondents said none of the windows were replaced.

4.1.3 Early Replacement

Early replacement of inefficient equipment involves removal of equipment before the end of its effective useful life and replacement with a new high efficiency unit. In this case, the baseline is the pre-existing heating system until the old heating system would be expected to fail. In contrast, the baseline for replacement at time of failure is a standard heating system currently on the market. According to the 2012 Market Characterization Study⁸, 28% of the homeowners who completed the audit frequently mentioned wanting to replace broken equipment as the reason to install energy efficient measures.

GJGNY survey respondents in the billing analysis pool were asked the condition of their heating system, water heater and air conditioning system before replacement. On average, 38% respondents reported that the equipment replaced was old and inefficient and 26% reported that the old equipment had failed or was about to fail. Figure 10 provides a summary of the number of responses.

Figure 9: Condition of Equipment before Replacement



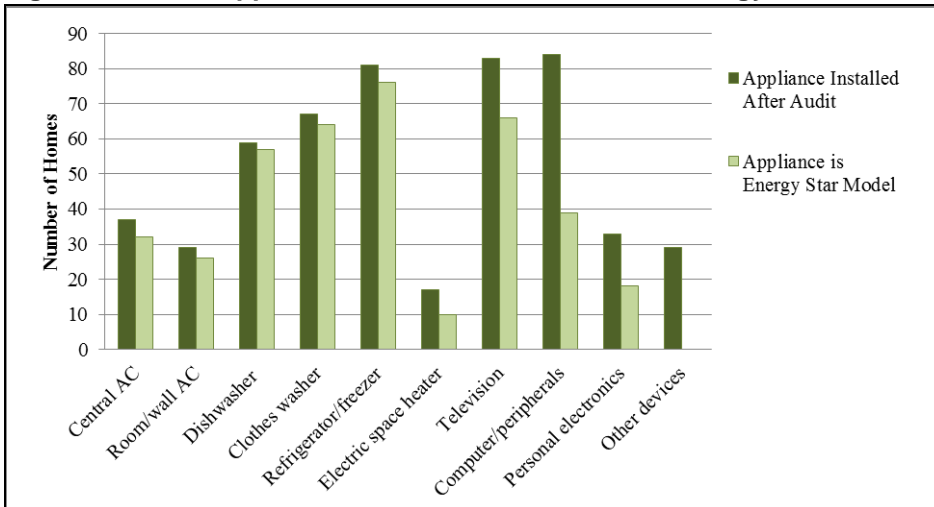
These results suggest that a combination of early replacement and replacement on failure is occurring, with at least a quarter of the units falling into the “replace on failure” category.

⁸ Process Evaluation and Market Characterization and Assessment, Green Jobs – Green New York Residential Program. Final Report prepared for the New York State Energy Research and Development Authority by NMR Group, Inc., Somerville, MA. Page ES-13

4.1.4 Other Appliances

Survey respondents who qualified for billing analysis were also asked if they installed other appliances and whether the appliances were ENERGY STAR models. Figure 11 provides a summary of the number of respondents who installed each appliance. Over half of the respondents in each appliance category installed ENERGY STAR models following the audit.

Figure 10: Other Appliances Installed after the Home Energy Audit



4.1.5 Heating System Use

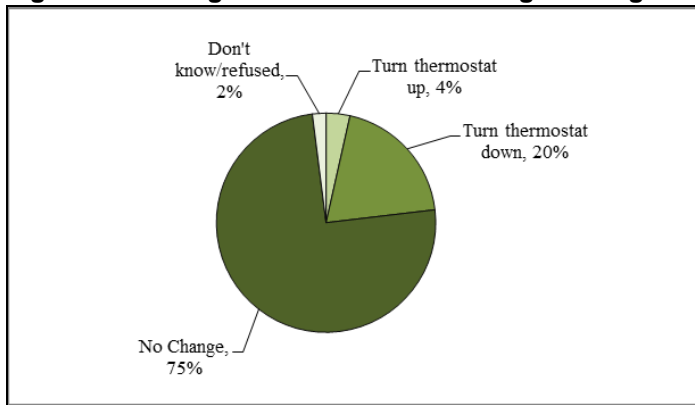
Snap back occurs if the homeowner decides to “take back” some of the savings in increased comfort, *i.e.*, if they notice a reduction in their heating bills and decide to turn up the thermostat to keep their homes warmer. To investigate snapback, survey respondents were asked a series of questions as described below:

- Did you notice a change in their heating fuel bills after the upgrades?
- Did you notice that your house was more comfortable?
- If answered the first question affirmatively, respondents were asked whether they changed their thermostat setting and whether the change was 5°F or more.

These questions were only asked of the respondents who were eligible for the billing analysis. About 55% (199) of the respondents stated that they noticed a change in their heating bills after the installation of the efficiency measures. As shown in Figure 12, 75% of the 199 respondents reported not changing the thermostat settings, 20% turned the thermostat down and 4% turned the thermostat up. About 10% reported changing their thermostat setting by 5°F or more during the

winter after installation. These percentages were consistent between those who noticed that their homes were more comfortable and those who did not.

Figure 11: Changes in Thermostat Settings among Respondents with Lower Heating Bills



Overall, only one respondent reported that they noticed a change in their heating bill and comfort level and increased their thermostat setting by 5°F or more. These results suggest that snap back is a rare occurrence.

4.1.6 Other Program-Related Questions

The survey included questions on contractor choices, sources of incentives and reasons the respondents decided not to apply for HPwES incentives. These results are discussed below.

Contractor Choices and Awareness of the Building Performance Institute

Through the GJGNY Program, comprehensive energy audits are provided by HPwES contractors who have a Participation Agreement with NYSERDA.⁹ These contractors are accredited by the Building Performance Institute (BPI). The survey included questions to investigate the use of HPwES contractors and awareness of BPI. All respondents who installed one or more major measures, regardless of whether they were eligible for inclusion in the billing analysis, were asked this series of questions.

⁹ Process Evaluation and Market Characterization and Assessment, Green Jobs – Green New York Residential Program. Final Report prepared for the New York State Energy Research and Development Authority by NMR Group, Inc., Somerville, MA. Page 15

The first question was whether they hired a contractor to do the installation. Out of 897 respondents who installed major measures and provided contractor information, 85% hired a contractor and 14% hired the same contractor who did the audit to install the upgrades.

About 19% of the respondents who used a contractor reported that they had heard of BPI. A smaller percentage (6%) responded they looked for a BPI contractor to do the work and 6% said they used a BPI contractor to do the work. These responses suggest that many of the respondents are not familiar with BPI and do not realize that their HPwES auditor was BPI accredited. About 78% of the respondents who used the HPwES contractor to install the efficiency upgrades stated that they had not heard of BPI.

Sources of Incentives and Reasons for Not Participating in the HPwES

Through the HPwES Program, participating homeowners are able to receive the homeowner cash-back incentive or a utility rebate and finance the balance through a GJGNY loan. Income eligible households may receive a larger incentive for the installation of eligible energy efficient measures. The sample frame for this survey was pre-screened to remove GJGNY audit recipients who proceeded to install measures through HPwES. However, there are other sources of financial incentives for installing energy efficiency upgrades and the survey investigated the use of other sources of financial assistance.

Respondents were asked whether they received rebates, tax credits or other incentives to help pay for any of the efficiency upgrades. Table 6 provides a summary of the sources of incentive reported by each respondent group. All respondents who installed any of the major measures, regardless of whether they were eligible for inclusion in the billing analysis, were asked if they received incentives. The highest percentage of respondents received tax rebates from the federal government or incentives from their utility companies.

Table 6: Source of Incentives for Efficiency Measure Installation

Source of Incentives	Number of Respondents In Billing Analysis	Percent of Respondents in Billing Analysis	Number of Respondents with Major ¹ Measures	Percent of Respondents with Major Measures
NYSERDA	7	2%	45	8%
Utility Company	24	7%	56	10%
State Government	20	6%	41	8%
Federal Government	39	11%	50	9%
Other ²	3	1%	11	2%
Did not know source	9	3%	32	6%
Respondents with incentives	98	27%	187	35%
Respondents without incentives	260	73%	352	65%

¹ "Major installations" are respondents who installed any of the major measures and were asked HPwES participation question but were not eligible for the billing analysis.

² "Other" includes incentives provided by contractor, manufacturer, city or county. As some respondents obtained incentives from more than one source, the percentage by source does not add to the total percent of respondents with incentives.

Survey respondents in the billing analysis pool were asked why they did not access NYSERDA’s HPwES Program incentives and services when work was completed in their homes. About 11% of the respondents reported that they were dissatisfied with the audit and another 34% reported they did not know there were incentives available, while the rest mentioned reasons that were outside the Program’s control. A number of respondents gave multiple responses as to why they did not use HPwES incentive or loan programs. Table 7 provides a summary of the responses.

Table 7: Reasons for Not Accessing HPwES Incentives or Services

Reason for not accessing HPwES services ¹	Number of Responses	Percent of Respondents	Adjusted Percent ⁴
Did not know about incentives	89	25%	34%
Too expensive/used different contractor/DIY ²	60	17%	23%
Not eligible	55	15%	21%
Forgot/got other incentives/didn't need incentives	39	11%	15%
Dissatisfied with audit ³	30	8%	11%
Other	11	3%	4%
Did not answer (don't know or refused)	94	26%	
Total Respondents	357a		

¹As multiple responses were allowed, the percentages do not add to 100%.

²DIY stands for "do it yourself," *i.e.*, the respondents did the efficiency upgrade on their own.

³"Dissatisfied with audit" includes paperwork never received, contractor did not provide information and other negative comments.

⁴Adjusted percentages are based on the 260 respondents with valid responses to this question (excludes those who refused or didn't know).

a This question was not asked of one respondent in the billing analysis pool.

4.1.7 Preliminary Analysis of Program Influence

The GJGNY program is intended to help audit recipients to overcome the barriers to the installation of energy efficient measures by offering a comprehensive home audit, access to financing and educating homeowners about energy efficiency. While this survey was not designed to quantify program influence, some of the survey questions provided context for assessing whether the actions taken by GJGNY audit recipients were influenced by the program. These questions were open-ended and the responses were coded based on review of the verbatim answers.

The survey results below are divided out into two broad categories: barriers to installation and patterns of measure installations. This first part is based on the responses provided by audit recipients who did not install any energy efficient measures. Understanding these barriers is a key part of program design.

The patterns of installation compare installed, recommended, and planned measures for those in the billing analysis pool and respondents who installed major or minor measures. In the survey, respondents provided information about all measures installed, and subsequent questions covered whether the measure was recommended in the audit report and whether the respondent had

planned to do it prior to the installation. The Impact Evaluation Team did not have access to audit reports, so the team relied on information provided by the respondent.

In aggregate, these questions provide a more detailed picture of the decision making process. For example, if the measure was not recommended in the audit report, then it seems unlikely that the GJGNY audit influenced the decision. However, if the audit recipient initially planned to install new windows but ended up also adding insulation and having air sealing done, then the GJGNY audit influenced the homeowner to go substantially beyond their original plans. This analysis provides an initial investigation into this part of the decision making process.

Barriers to Installation

The HPwES Program is designed to address the barriers that prevent many homeowners from installing recommended measures. For survey respondents who indicated that they had not installed any measures, the GJGNY survey included an open-ended question to investigate the reasons why they did not take any action to install measures after the energy audit.

Out of 1,822 respondents who gave valid responses, 55% responded that measures were too expensive or energy savings were not worth the cost. About 20% of the respondents identified issues that were directly associated with the GJGNY audit, either indicating that they were dissatisfied with the audit (13%) or that they never received an audit report (7%). Table 8 provides a summary of the responses to this question.

Table 8: Reasons for Not Installing Energy Efficient Upgrades

Reason for not installing energy efficient upgrades	Number of Responses	Percent of Respondents ¹
Too expensive or energy savings not worth the cost	998	55%
Other priorities/ house already efficient	302	17%
Dissatisfied with audit or contractor	231	13%
Planning to install/ DIY	154	8%
Never received report or recommendations (and did not express dissatisfaction with audit)	135	7%
Other ²	123	7%
Total Respondents ³	1,822	

¹ As some respondents are counted in multiple categories, the percent does not add to 100%.

² “Other” includes not eligible, waiting for equipment to fail and concerned about comfort of home.

³ Eighty-five (85) invalid responses were removed from the total.

The GJGNY energy audit addresses some of the barriers to installation. The program provides easy access to contractors, thereby saving the homeowner time to look for a contractor by

themselves. The audit recommendation reports provide information to homeowners about specific energy efficient upgrades and give an estimate of the energy savings from the upgrade. The contractor also identifies and addresses health and safety issues. In addition, loans and incentives are offered to qualifying homeowners through the HPwES Program.

However, the single most commonly referenced barrier is cost: these GJGNY audit-only respondents either did not know about the HPwES incentives or concluded that the HPwES incentives or loans were not sufficient to overcome this hurdle. As shown in Table 6 above, 25% of the respondents in the billing analysis pool (34% when the invalid responses were removed) reported that they did not realize incentives were available.

Patterns of Measure Installation

These results are based on the responses to questions about all measures installed, whether the measure was recommended in the audit report and whether the respondent and planned to install it prior to the installation. The key topics of interest are listed below:

- How many respondents installed one or more measures that were recommended in the audit report?
- Of these measures that were recommended and installed, how many respondents planned to install the measure prior to the audit?
- Is there overlap between measures commonly selected by the respondents but not necessarily likely to achieve substantial savings (such as efficient windows and doors) and measures that are less likely to be selected but have more reliable savings (such as insulation and air sealing)?

The overlapping measures may suggest that homeowners initially requested the audit because they wanted new windows, but are motivated to install insulation or air sealing when they see the audit report.

Table 9 shows the number of respondents who installed at least one recommended measure and those who installed at least one major measure that was not planned prior to the audit. This analysis indicates that 84% of respondents in the billing analysis pool followed through with at least one recommended measure and 51% installed a major measure that was recommended and not planned.

Table 9: Installation of Recommended and Nonrecommended Measures

	Description	Number of Respondents in Billing Analysis	Percent of Respondents in Billing Analysis	Number of Respondents with Major/Minor Measures ¹	Percent of Respondents with Major/Minor Measures
Major Measures	Installed at least one recommended measure	299	84%	444	27%
	Installed at least one measure recommended but not planned ²	181	51%	230	14%
Minor Measures	Installed at least one recommended measure	183	51%	922	55%
	Installed at least measure recommended but not planned ²	109	30%	496	30%
Total homes		358		1,665	
<p>¹“Major/Minor installations” are respondents who installed any of the major or minor measures and were asked about measure recommendation and plans but were not eligible for the billing analysis.</p> <p>² Invalid responses (“don’t know” or refused) were excluded in determining the measures that were not planned prior to the audit.</p>					

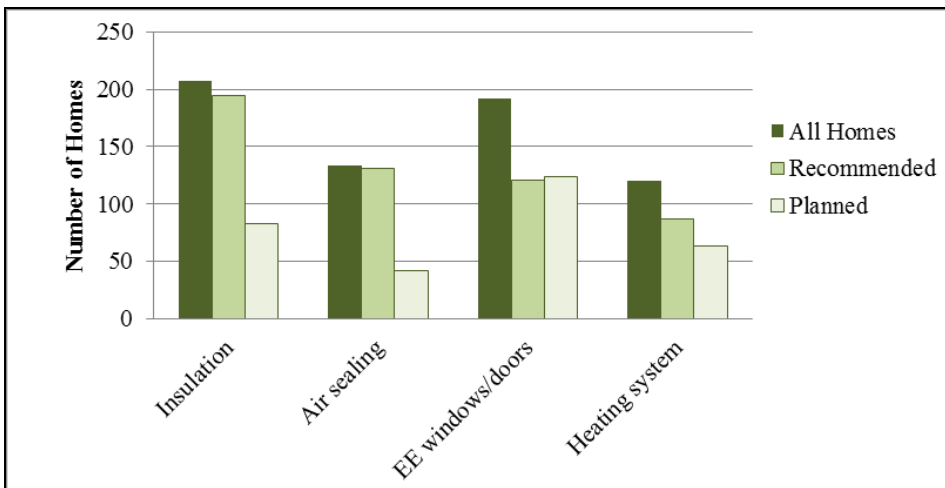
Figure 13 shows the total number of respondents in the billing analysis pool who installed each measure, as compared to the number who identified the measure as recommended in the audit report and the number who planned to install the measure prior to the audit. Some of the key findings from this analysis are discussed below.

- Insulation and air sealing were almost always recommended and about a large majority of the respondents with these measures indicated they had not been planning to install them prior to the audit. This suggests that the audit report made a difference in the decision making process for these measures.
- In contrast, about 63% of the respondents who installed efficient windows and doors reported that the measure was recommended, and almost two-thirds (65%) planned to install the measure prior to the audit, *i.e.*, slightly more respondents planned to install new windows or doors than received recommendations to install them.

- A total of 120 respondents reported that they installed a heating system following the audit. About 58%¹⁰ reported that the heating system had been recommended. This outcome indicates that many homeowners decided to install a new heating system even though it was not recommended in the audit report.

Overall, these results suggest that the GJGNY audit is influencing participants to install insulation, air sealing and, to a lesser extent, heating systems. Program influence could also occur even if the respondent reported that they planned to install the measure before the audit, as the respondent may have obtained additional information through the audit and decided to increase the efficiency level or scope of the installation.

Figure 12: Major Measures Installed, Recommended¹¹ and Planned



The next part of the analysis was to identify overlap between efficient windows and doors installations and other major measures to test the hypothesis that the initial audit request was motivated by the desire for new windows and doors but the audit recipient then added other recommended measures. More than one-third of the billing analysis respondents with efficient window and door installations installed more than one major measure that was recommended, as shown in Table 10 below.

¹⁰ This percentage excludes 17 respondents who said they didn't know if the heating system was recommended.

¹¹ Recommended measures include participants who said they didn't know if the measure was recommended. Heating system had the largest number of respondents (17) who reported that they didn't know if the measure was recommended.

Table 10: Measure Overlap for Respondents with Energy Efficient Windows and Doors

Number of Major Measures Installed and Recommended	Billing Analysis ¹		Major Measures ¹	
	Number of Respondents with Recommended EE Window or Door Installations	Percent of Respondents	Number of Respondents with Recommended EE Windows or Doors Installations	Percent of Respondents
Windows Only	35	29%	59	31%
One other measure	42	35%	80	42%
Two other measures	41	34%	46	24%
Three other measures	3	2%	7	4%
Total respondents ²	121		192	

¹ This analysis was based on the 358 respondents who qualified for billing analysis and respondents who installed major measures but did not meet all of the billing analysis requirements.

² These are total respondents who installed energy efficiency windows and doors that were recommended in the audit report.

Summary of Preliminary Analysis of Program Influence

The findings from these analyses are mixed. Key findings from the survey for the billing analysis pool that indicate positive program influence on the installation of measures are given below:

- 84% installed at least one major measure recommended in the audit report.
- 35% reported they did not plan to install any of the major measures prior to the audit.
- Insulation and air sealing were commonly recommended and less likely to be planned, suggesting higher program influence on these two major measures.
- About 71% of respondents installing the less commonly recommended efficient windows and doors also installed at least one other recommended major measure, most often insulation and air sealing.

These findings suggest that a substantial portion of the GJGNY audit-only recipients installed recommended major measures and expanded the scope of the measure they intended to install.

Findings that suggest areas where program influence is weaker are as follows:

- About 16% reported that none of the installed major measures were recommended in the audit report.
- 36% planned to install all major measures before the audit.
- Energy efficiency windows and doors were the measures most likely to be installed without a recommendation and most likely to be planned prior to the audit.

Clearly, there is no program influence on GJGNY audit recipients who did not install any of the recommended measures. Respondents who reported that they planned to install all of the

measures before the audit could still be influenced by the audit to increase the efficiency level. Efficient windows and doors are less commonly recommended as the costs are high and savings are variable. These measures may be seen as an opportunity to engage the homeowner in a discussion about energy efficiency and encourage the installation of other measures.

4.2 GJGNY BILLING ANALYSIS

Evaluated gross natural gas savings for GJGNY audit-only recipients are about 7.4 MMBtu per home. As the gross savings do not account for program influence, the actual savings attributable to the GJGNY audit are lower. Additional research is currently in progress to assess program influence.

In Table 11 below, the average household savings for the GJGNY audit-only recipients are compared to the evaluated savings from the recent HPwES billing analyses. This analysis indicates that the savings from the GJGNY audit is about half the evaluated savings realized in HPwES homes during program years 2010 to 2011.

Table 11: Comparison of Savings from HPwES Billing Analyses

	HPwES 2007-2008	HPwES 2009-2010	HPwES Phase 1 2010-2011	GJGNY Audit-Only Recipients 2010-2013
Evaluated average savings per household	17.3 ± 1.2 MMBtu	18.8 ± 2.1 MMBtu	13.3 ± 0.1 MMBtu	7.4 ± 1.3 MMBtu
Relative Precision	7%	11%	1%	18%
Percentage of pre-installation use saved ¹	16%	N/A	14%	8%
Number of homes in the model	1,462	2,156	5,009	133
Number of utilities in the model	3	3	7	6

¹ The annual consumption during the pre-installation period was averaged for all homes in the billing models. The “percent of pre-installation use saved” is the average annual evaluated savings divided by the annual average pre-installation consumptions.

As was expected given the limited number of homes, the desired precision of modeled results was not achieved due to the relatively low number of homes in the model. However, all estimators were statistically significant at the 90% confidence level, and the R² statistic was 0.93 for the final model.

The final model includes savings estimates for three measure groups: base measures (water heating and other non-weather dependent upgrades), heating system measures (thermostats and heating system repair/replacement), and envelope measures (insulation, air sealing, and efficient windows and doors). Attempts to model measure savings at a more granular level were unsuccessful, most likely due to the low number of homes in the model.

The final billing model was restricted to measures identified by the respondent as recommended in the GJGNY audit report. However, many respondents also installed major measures that were not recommended. Certain measures, notably the installation of high efficiency windows and doors, were installed more frequently than recommended (76 homes vs. 48).¹² Given the relatively small number of installations, efforts to separate the impact of window and door installations from other thermal shell measures were unsuccessful.

Table 12 compares the model results for all installed measures and only recommended measures. The key findings are discussed below.

- The household savings are not significantly different at the 90% confidence level; this result shows that the inclusion of the nonrecommended measures did not produce a significant increase in evaluated household savings.
- The average envelope savings for recommended measures were significantly greater than the savings achieved by all envelope measures, which could indicate either that the nonrecommended measures were smaller in scope or the quality of the installation was lower.
- Differences in modeled savings for base measures and heating systems, which more closely tracked GJGNY audit recommendations, were not statistically significant.
- The high variability in the savings for base measures reflects the relatively few homes in the model and the difficulty in estimating savings for nonheating measures in natural gas models.

¹² The Impact Evaluation Team was unable to determine exactly how many homeowners received recommendations for specific measures as the audit reports for the homes in the billing analysis were not available.

Table 12: Recommended Measure Installation Compared to All Measure Installation

Measure Group	All Installed Measures		Measures Recommended by GJGNY Audit	
	Homes	Modeled Savings per Home (MMBtu) ⁴	Homes	Modeled Savings per Home (MMBtu) ⁴
Base Measures ¹	37	4.2 ± 2.9	25	3.2 ± 2.9
Heating Systems	44	4.0 ± 1.7	34	4.5 ± 2.0
Envelope Measures ²	121	6.0 ± 1.3	101	7.4 ± 1.3
Total ³	133	7.9 ± 1.6	133	7.4 ± 1.3

¹ “Base Measures” includes water heating conservation and replacement.

² “Envelope Measures” includes insulation, air sealing, and the installation of high-efficiency windows and doors.

³ Total reflects the unique count of homes included in the model. Some homes installed multiple measures, so the sum of measure installations exceeds the total number of homes.

⁴ Household savings are reported at the 90% confidence interval.

Additional detail on the regression model is provided in Appendix C.

4.2.1 Estimated Savings

The Impact Evaluation Team has integrated the results from the screener survey and the billing analysis to develop an overall estimate of the savings associated with the GJGNY audit that are not currently included in the HPwES program savings. This analysis suggests that the additional gross savings from the GJGNY audits are about 14% of the annual HPwES evaluated MMBtu savings. These savings are not adjusted for program influence, i.e., all of the savings are assumed to be attributable to the program.

Table 13: Estimated Annual Savings from the GJGNY Audit

Description	Estimate
Average Number of GJGNY Audits per Year	10,300
Percent of GJGNY Audit Respondents who paid over \$2,000 for major measures	20%
Annual Number of GJGNY Audits with Savings	2,020
Billing Analysis Savings per Home (MMBtu/year)	7.4
Evaluated Gross GJGNY Audit-Only Savings (MMBtu/year)	15,000
Annual Evaluated HPwES Savings	105,000
GJGNY Audit-Only Gross Savings as Percent of HPwES Savings	14%

4.3 COGNITIVE INTERVIEWS

This section summarizes the findings from the cognitive interviews and it is divided into three sections: feedback from fielding the survey, interpretation issues and testing the Barriers Approach.

4.3.1 Feedback from Survey Fielding

Some of our findings and lessons learned from the survey are provided below.

Table 14: Findings from the Survey Fielding

Issue	Findings
Length	Respondents were engaged, interested, and wanted to tell their story, even though the average survey was 30 minutes. Starting with open ended questions helped to build rapport and gain their assistance.
Survey Structure	Structured questioning worked better as it generated more thoughtful responses.
Program Barriers	Four major barriers were confirmed; no additional barriers were mentioned.
Influential factors	Understanding of the wording and content of influential factors tended to vary from respondent to respondent. Time constraints as a barrier was a difficult concept for some respondents and intuitively obvious to others.
Comprehension Level	Responses were generally fluid and pairwise questions were understandable. Comparing lack of information to money constraints (for example) was easily comprehended by the respondents.
Flip Flops	In some cases, the respondents first gave one answer and on further reflection decided to change it. Survey design needs to allow for this.
Demographics	Respondents had already participated in the screener survey and were, on average, substantially more educated and in a higher income bracket than the population as a whole.
Complexity	Initially, we planned to conduct the questioning for each major measure group. It quickly became clear that this approach would make the survey too long and complex. Only one of the 13 respondents clearly stated that her decision process was different for the heating system than the insulation.

In aggregate, our experience suggests that a Web-based survey is likely to work better than a telephone survey, and a couple of the respondents suggested this. Some of the reasons are listed below:

- Reading the question makes it easier to keep track of the predominant barrier in the pairwise questions; the pairwise questions can be confusing over the phone and the interviewer had to repeat the questions in some cases
- Programming could be added to ensure responses are consistent
- A Web survey will allow respondents to go back and modify responses if further reflection results in a change in ranking

4.3.2 Interpretation Issues

Some nonprogram factors, such as recently purchasing a home or changes in schedule or finances, were not included in the Barrier Scores. These were considered to be necessary pre-conditions to the installation of measures. While they were included in the list of barriers, they were excluded from the pairwise comparisons and calculation of the program influence.

There were some grey areas that arose. For example, a few respondents (3) mentioned having a pre-existing relationship with a HPwES contractor as a driver to their installation of measures.

The program influence could be argued both ways:

1. The respondent's contractor happens to be a HPwES contractor who did the audit, but the strength of the relationship is not program related
2. The contractor was motivated to promote the HPwES Program to current customers, thus generating additional work; as this is an intended part of the Program, it could be related to program influence.

We look forward to further discussion on how to characterize these types of issues.

4.3.3 Testing the Barriers Approach

Cognitive interviews were fielded for a small sample (13). All interviews were audio recorded and provided to four expert reviewers. Each reviewer came to an independent assessment of the Pairwise Program Influence Score (PPIS) and the PPIS was compared to the story told by the respondent. A conference call was held to assess the validity of responses and whether the scores matched the responses. The panel of reviewers agreed that the cognitive interviews supported the validity of this approach, *i.e.*, the interviews captured the concerns and issues of the respondents and the respondents' PPIS were consistent with the story that they told. These findings demonstrate the construct validity, *i.e.*, that the questions can be understood, reliably answered and provide the information needed to assess program influence.

The versatility of the AHP method provides a strong foundation for expanding the application of this approach to evaluating a wide variety of types of efficiency interventions. The structure of the analysis can accommodate a broad range of barriers and influential factors. The limiting issue may be the complexity of the decision making process, as the number of questions increases dramatically with the number of barriers.

SECTION 5: CONCLUSIONS

The section presents the conclusions from each component of the GJGNY impact evaluation.

5.1 GJGNY AUDIT-ONLY SURVEY

The primary purpose of this survey was to identify GJGNY audit recipients who could be included in a natural gas billing analysis with the goal of establishing whether there are quantifiable savings from the GJGNY audits. It represents an extensive effort to investigate the impacts of the GJGNY audit. With 3,930 completed surveys representing a census attempt to reach the GNGJY audit recipients who did not proceed with HPwES and heat with natural gas, it provides a rich data set to provide insights into the homeowners' decisions.

The results of this survey indicated that many audit recipients take actions to save energy, but a smaller percentage install major measures of a scope that would be likely result in a substantial reduction in energy bills. Of the 3,930 completed surveys, only 358 survey respondents reported installing major measures and met all criteria for billing analysis. After collecting the permission to request utility billing records and obtaining the billing history, it was unclear whether this pool of homes was large enough to obtain reliable results. However, preliminary results suggested that there were quantifiable savings in these homes.

The other component of quantifying savings is to establish program influence. Some preliminary questions were included in this survey to investigate this issue. The results were mixed, suggesting that program influence is stronger for some measures (such as air sealing) than others (efficient windows and doors). A substantial minority of respondents (16%) reported that they installed measures but none of the installed measures were recommended in the audit report, making it difficult to establish any program causality.¹³ However, 84% installed at least one major measure recommended in the audit report and 35% reported they did not plan to install any of the major measures prior to the audit, suggesting that the program motivated a substantial portion of these respondents to take action to improve the energy efficiency of their homes.

5.2 GJGNY BILLING ANALYSIS

The primary purpose of this analysis was to quantify gross savings for GJGNY audit recipients who took action to install efficiency measures. The analysis highlights several important findings:

¹³ As the audit reports were not available, it was not possible to verify these self-reports.

- Quantifiable savings are being realized for GJGNY audit-only recipients who installed major measures; evaluated household savings are 7.4 MMBtu per home.
- GJGNY audit-only household savings are a little over half (56%) of the magnitude of the HPwES savings from the Phase I impact evaluation.
- The lower magnitude of savings for GJGNY audit recipients in comparison to HPwES program participants suggests that the program is succeeding in promoting a more comprehensive “whole home” approach to energy efficiency and/or that the quality of the installations by HPwES contractors may be higher.
- Overall, savings from the GJGNY audit are 15% of the annual HPwES program savings and are not currently being claimed by the Program.
- These savings do not take program influence into account; the incidence of installed nonrecommended measures suggests that other factors influence installation decisions and not all installation savings are necessarily attributable to the Program

As this component of the HPwES Phase 2 Impact Evaluation was focused on natural gas billing analysis, homeowners with delivered fuels, such as oil and propane, were excluded. Due to the low price of natural gas in comparison to the delivered fuels in recent years, the economics of energy efficiency upgrades are different depending on the heating fuel. Thus, there may be differences between installation rates and other key survey outcomes between the natural gas homes included in this analysis and the overall population of GJGNY audit-only homes. The impact evaluation of the delivered fuels for HPwES should provide insight into differences between energy efficiency actions by homeowners with natural gas and delivered fuels.

5.3 COGNITIVE INTERVIEWS

Overall, the cognitive interviews indicate that the Barriers Approach is a promising method to quantify program influence. As programs are designed to overcome market barriers, the Pairwise Program Influence Score is an improvement over other methods as it measures the success of the Program in these terms.

The cognitive interviews provided a wealth of information about the decision making process, and, consequently, the Impact Evaluation Team was able to compare the Pairwise Program Influence Scores to the story told by the respondent to verifying the method produced reliable results. The cognitive interviews demonstrate the construct validity, i.e., that the questions can be understood, reliably answered and provide the information needed to assess Program influence.

The cognitive interviews also demonstrated the added value to investigating the decision making process. The information gained about the homeowners' motivations for requesting an audit and how they decided to move forward with efficiency upgrades is useful for considering how to modify program delivery.

Program influence is difficult to quantify and relies on assigning numerical values to subjective decision making. The Pairwise Program Influence Score approach has a number of advantages:

- It is internally consistent in that it is measuring the effectiveness of the program in overcoming market barriers.
- It is based on a strong theoretical foundation to quantify decision making.
- It relies on questions that can be reliably understood and answered.
- The resulting score can be directly applied to program savings to estimate the “net” impacts of a program.

The primary disadvantage may be the need to limit the number of barriers and influential factors to be able to keep the interviews at a reasonable length and level of complexity. The Impact Evaluation Team also recognizes that the GJGNY audit-only survey respondents may be more highly educated and higher income than participants in other programs or efficiency initiatives.

The sample size of 13 is clearly very small and additional research is needed to test this method on a larger scale.

SECTION 6: RECOMMENDATIONS

This research suggested that the Barriers Approach is potentially viable and worthy of additional research, as discussed below.

Recommendation #1: Consider Expanding Barriers Evaluation Approach to HPwES

This effort was preliminary and the sample size was small. The bulk of the development of the survey instrument for GJGNY and HPwES has been done and could be applied on a wider basis with little additional effort. The use of Web-based surveys would reduce costs.

Recommendation #2: Survey Modifications

While the initial cognitive interviews were conducted via the telephone to allow for direct feedback, comments from respondents and observations from the interviewer suggest that this survey would be much easier in a Web-based format. Reading the questions makes it easier to follow the flow and to keep track of the pairwise questions. Programming can be added to improve the flow and conduct consistency checks. Also, conducting the survey on the Web could reduce costs.

In addition, the cognitive surveys provided insight into how questions should be worded and how they are understood by the respondent. This information will be valuable for modifying the survey instrument for wider implementation.

Finally, this approach is predicated on a clear definition of program influence. These interviews indicate that there are some grey areas that should be considered prior to finalizing the next survey instrument.

Recommendation #3: Consider Other Applications

This survey suggests that the Pairwise Program Influence approach is a viable method and has some advantages over previous efforts. One of the advantages is that it can be easily applied to a wide range of program types and initiatives, including market-based programs and energy codes. The applicability of this approach will need to be balanced against the complexity of the decision making and the number of factors affecting the decision to install measures.

SECTION 7: REFERENCES

Process Evaluation and Market Characterization and Assessment, Green Jobs – Green New York Residential Program. Prepared for the New York State Energy Research and Development Authority. September 2012. NMR Group, Inc., Somerville, MA.

NYSERDA 2007-2008 New York Energy Star® Homes Program Impact Evaluation Report. Prepared for The New York State Energy and Research Development Authority. September 2012. Parlin, K., Lewis, L., Nelson J.

Belsley, D.A., Kuh, E., and Welsch, R.E. *Regression Diagnostics*, New York: John Wiley & Sons, Inc., 1980.

Burnham, Kenneth and David Anderson. 2002. *Model selection and multimodel inference*. New York: Springer-Verlag.

The California Evaluation Framework. TecMarket Works, et. al. Project Number: K2033910. Prepared for the California Public Utilities Commission and the Project Advisory Group. September, 2004.

California Energy Efficiency Evaluation Protocols: Technical, Methodological and Reporting Requirements for Evaluation Professionals. Prepared for the California Public Utilities Commission. April, 2006.

Dielman, Terry E. 1989. *Pooled cross-sectional and time series data analysis*. New York: Marcel Dekker.

Franek, Jiri, A. Kresta (2014). Judgement Scales and Consistency Measure in AHP. *Procedia Economics and Finance*, 12, 164-173.

Goldfeld, S.M. and R.E. Quandt. 1965. Some tests for homoscedasticity. *Journal of the American Statistical Association* 60 (2): 539-547.

NYSERDA 2007-2008 New York Energy Star® Homes Program Impact Evaluation Report. Prepared for The New York State Energy and Research Development Authority. September 2012. Parlin, K., Lewis, L., Nelson J.

Process Evaluation and Market Characterization and Assessment, Green Jobs – Green New York Residential Program. Prepared for the New York State Energy Research and Development Authority. September 2012. NMR Group, Inc., Somerville, MA.

“Results from Phase I of the 2013 Home Performance with ENERGY STAR Impact Evaluation, Program Years 2010 and 2011, Revised.” (Memorandum) from West Hill Energy and Consulting to NYSERDA. September, 2013 (NYSERDA).

“Results from the Survey of Green Jobs Green New York Audit Only Participants, Program Years 2010-2013.” (Memorandum) from West Hill Energy and Consulting to Carley Murray, Judeen Bryne, NYSERDA. July, 2015 (NYSERDA).

Says, Lois W. 1989. *Pooled time series analysis*. Newbury Park, California: Sage Publications.

Saaty, Thomas L. (1994). *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*. RWS Publications, Pittsburg, PA, Vol. VI of the AHP Series.