Home Performance with ENERGY STAR® Impact Evaluation (PY2010-2013)

Final Report

Volume 5: Appendices

November 21, 2016

NOTICE

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ABSTRACT

Volume 5 includes six appendices to the final report. The first appendix is the glossary of terms and the following two appendices are the GJGNY audit-only survey instrument and the billing model details. The final three volumes include the GJGNY audit-only program influence survey and detailed information on the Analytic Hierarchy Process (AHP) and Barriers Approach methods of analyzing complex decisions.

ACKNOWLEDGMENTS

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APPENDIX A: GLOSSARY OF TERMS[1]

Attrition – Loss of participants in analysis; attrition in billing analysis can occur for a variety of reasons, such as length of tenure at residence.

Billing Analysis – Analysis of utility billing records; billing analyses may be conducted for a variety of reasons; in this evaluation, the billing analysis was used to determine annual consumption for calibrating heating and cooling savings estimates.

Building Shell/Envelope – The assembly of exterior components of a building which enclose conditioned spaces, through which thermal energy may be transferred to or from the exterior, unconditioned spaces, or the ground. The measures in HPwES in this category include insulation (attic and wall insulation), window and door replacement, and air sealing.

Collinearity – Collinearity refers to the situation where two or more independent variables in a model are highly correlated, such as when two measures tend to be installed together. Collinearity results in higher variances for both predicted and explanatory variables and creates difficulty in partitioning variance among the competing explanatory variables.

Contact rate – This is one of the final disposition and outcome rates for surveys defined by the American Association for Public Opinion Research (AAPOR).[2] The contact rate has all outcomes where an eligible respondent was reached and the interview attempted divided by these plus those not contacted. The three contact rate outcomes are: completes, refusals and break-offs (the numerator of the contact rate).

Cooperation rate – This is one of the final disposition and outcome rates for surveys defined by the American Association for Public Opinion Research (AAPOR).[3] The proportion of all cases interviewed of all eligible units ever contacted. Those contacted (the denominator) includes completes, refusals and break-offs.[4]

Coefficient of Determination (R^2, R-squared) – Proportion of variability in a regression data set that can be explained by the model.

Evaluated Gross Savings – The verified change in energy consumption and/or demand that results directly from program-related actions taken by participants in the program, regardless of why they participated.

Heteroskedacity – Heteroskedasticity occurs in a regression model when there are subpopulations within the model with unequal variances. Heteroskedasticity does not bias the regression coefficients but can bias the standard errors and standard statistical tests.

MW – A megawatt is one thousand kilowatts (1,000 kW). A megawatt or kilowatt is a measure of the amount of electricity delivered to users at a given point in time. It reflects the demand for power at that point in time.

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[1] NYSERDA generally follows and uses the terms as defined in the "Northeast Energy Efficiency Partnerships Glossary of Terms," found at http://www.neep.org/emv-forum-glossary-terms-and-acronyms. This glossary defines those terms absent from the NEEP report or provides more-specific definitions to generalized NEEP terms.

[2] American Association for Public Opinion Research (AAPOR) 2011. *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*, Revised 2011. Each of the rates presented here has multiple more specific categories and definitions provided by AAPOR. *Standard Definitions* is available on AAPOR website: www.aapor.org

[3] *Ibid.*

[4] *Ibid.*

MWh – A megawatt hour is one thousand kilowatt hours (kWh) and measures of the amount of electricity used over time. If a 60W light bulb is on for one hour, it uses 60 Watt hours or 0.060 kWh.

Nonparticipants/ Non-Participating - Any customer or contractor who was eligible but did not participate in the program under consideration. Non-participating contractors can include contractors that have never participated in the program and contractors that formerly participated, prior to the year(s) being evaluated and have not participated since then.

Program Year, PY – The calendar year when a HPwES project was completed.

Refusal Rate – This is one of the final disposition and outcome rates for surveys defined by the American Association for Public Opinion Research (AAPOR).[5] The proportion of all cases in which an eligible respondent refuses to be interviewed, or breaks-off an interview, of all potentially eligible cases.

Realization rate (RR) – The ratio of the evaluated gross savings to the Program's program-reported savings. The RR represents the percentage of program-estimated savings that the Impact Evaluation Team estimates as being actually achieved based on the results of the evaluation M&V analysis. The RR calculation for electric energy for a sampled project is shown below:

$$RR = \frac{kWh_{evaluation}}{kWh_{program}}$$

where,

RR is the realization rate

$kWh_{evaluation}$ is the evaluation M&V kWh savings (by evaluation M&V contractor)

$kWh_{program}$ is the kWh savings claimed by program

Response Rate – This is one of the final disposition and outcome rates for surveys defined by the American Association for Public Opinion Research (AAPOR).[6] The response rate estimates the fraction of all eligible working numbers where a request for an interview was made. The denominator of this ratio is inclusion of all possible components where a request for an interview could be attempted. More specifically the response rate is the number of completed interviews divided by the sum of: completes, refusals, break-offs, not contacted and the figure estimated for unknown eligibility. Response rate = (Completes)/(Completes+refusals+break-offs+not contacted+(e*(unknown eligibility)).

t-value – The t-value of a regression coefficient measures whether the value of the coefficient is statistically different from zero. The statistic is the coefficient over its standard error.

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[5] *Ibid.*

[6] *Ibid.*

APPENDIX B: GJGNY SCREENER SURVEY INSTRUMENT

Section	Question Numbers	Asked of…
Screener	SCR1 – SCR2, PR1-PR8 (10 questions)	All respondents
Detailed Screener	DS1-DS10 (10 questions)	Respondents who pass initial screener questions; must respond correctly to all detailed screener questions to be eligible for the billing analysis; BAFLAG set to 1 if meet criteria
Measures	M1a – M4 (~12 questions) (SM1 to SM9 no longer asked	Respondents who installed any measure regardless of whether passed all detailed screener questions
No installations	NA1 (1 question)	Respondents with no installations
Contractor information	CON1- CON8 (8 questions)	Installed any measure SM1 to SM4, regardless of whether passed the detailed screener questions
Measure details	MD1 to MD8 (8 questions)	Based on responses to measures SM1, SM2, SM3, and SM6 and only respondents who pass detailed screener questions
Early replacement	ER1 to ER 4 (4 questions)	Installed measure SM4, SM6 and/or SM8 and only respondents who pass detailed screener questions
Appliances	AP1 to AP4 (asks about purchase of 12 appliances, then 3-question loop for each of those purchased)	Respondents who pass detailed screener questions
Heating system	HS1 to HS8 (10 questions)	Respondents who pass detailed screener questions
Supplemental heating	SUP1 to SUP5 (5 questions)	Respondents who pass detailed screener questions
Process Questions	Q1 to Q59	Asked of 68 short completes 1 and 2

CBO questions	Q61 to Q91	Ask of 68 short completes 1 and 2
Demographics	D1 – D6 (D7 dropped) (6 questions)	Respondents who pass initial screener questions
Closing	C1-C3 (3 questions)	Respondents who pass screener questions

Survey Instrument

May I speak to **[NAME]**?

Hello my name is _____ and I'm calling on behalf of the New York State Energy Research and Development Authority or NYSERDA.

We're calling households that received a home energy audit through NYSERDA's Home Performance with ENERGY STAR® Program. We're calling today with a survey about your experience with this Program and your answers will help us evaluate how NYSERDA might serve people better. We sent you a letter recently telling you that we would be calling and explaining the research we are doing.

[IF ASKED] Your responses to this survey will be kept confidential to the extent permitted by law.

[IF NECESSARY:] As you may recall, the Home Performance with ENERGY STAR home energy audit involves a contractor coming to your home and inspecting the living space, attic, and basement or crawl space. The contractor also performs a number of tests using special equipment, possibly including a blower door. The assessment typically takes one to three hours. At the end of the assessment, the contractor makes recommendations about things that you could do to improve the energy efficiency, comfort, and safety of your home.

Our records show that you received a Home Performance with ENERGY STAR home audit sometime in **[AUDITYEAR]**. **[IF NECESSARY:]** You were selected as part of a random sample of participants and your feedback about how this audit influenced your decisions is very important to future planning for energy efficiency programs in the State.

SCREENER FOR CONTACT

SCR1. I have your name down as the contact for the home audit. Do you recall receiving a Home Performance with ENERGY STAR home energy audit?

    1. YES **[GO TO PR1]**

    2. NO

    96   REFUSED **[THANK AND TERMINATE]**

    97   DON'T KNOW

SCR2. Is there someone else in your household who may be able to help me?

    1. YES **[ASK TO SPEAK TO NEW CONTACT, RESTART AT INTRO]**

    2. NO **[THANK AND TERMINATE]**

    96 REFUSED **[THANK AND TERMINATE]**

    97 DON'T KNOW **[THANK AND TERMINATE]**

[SCHEDULE ANOTHER TIME FOR INTERVIEW IF NECESSARY]

The first questions I have will take less than 5 minutes to complete, depending upon your responses.

GENERAL INSTRUCTIONS

Your opinions about NYSERDA's Home Performance with ENERGY STAR home energy audit program are important to this research effort. If we ask you a question you aren't sure you can answer, your best guess or even a rough judgment is fine. If you have no idea whatsoever, that's OK too: just indicate that you don't know and we will move on.

PROGRAM RECALL

First, I would like to confirm the accuracy of our records.

PR1.   Was the home energy audit conducted in [AUDITMONTH] of [AUDITYEAR]?

    1. YES **[GO TO PR3]**

    2. NO

    96   REFUSED [**GO TO PR3**]

97   DON'T KNOW [**GO TO PR3**] PR2Y. (IF PR1 = 2) What year was the audit done?

    10 - 2010
    11 - 2011
    12 - 2012
    13 - 2013
    14 - 2014
    96 - REFUSED
    97 - DON'T KNOW

    [IF PR1 = 2]
    PR2S. What season was the audit done?

    01 - Winter
    02 - Spring
    03 - Summer

04 - Fall
05 - Other, Please specify: _____
96 - REFUSED
97 - DON'T KNOW

PR3. According to our records, **[AUDITCONTRACTOR]** conducted the audit. Is this correct?

1. YES, IS CORRECT **[GO TO PR5]**

2. NO, IS NOT CORRECT

96   REFUSED **[GO TO PR5]**

97   DON'T KNOW **[GO TO PR5]**

PR4.   Who was the contractor who conducted the audit?

1. RECORD CONTRACTOR NAME: _____

96   REFUSED

97   DON'T KNOW

PR5.   Do you recall receiving an audit report with recommendations?

1. YES, DO RECALL

2. NO, DON'T RECALL

96   REFUSED

97   DON'T KNOW

((PR1 = 96 or 97) and (PR3 = 96 or 97) and PR5 = 96 or 97)) THEN THANK AND
      TERMINATE.

PR6. Our records show that the home audit was conducted at [ADDRESS]. Is this correct?

1. YES **[GO TO PR8]**

2. NO

96   REFUSED **[THANK AND TERMINATE]**

97   DON'T KNOW **[THANK AND TERMINATE]**

PR7.   Where was the audit conducted?

RECORD ADDRESS: _____

96   REFUSED **[THANK AND TERMINATE]**

97   DON'T KNOW **[THANK AND TERMINATE]**

PR8.   Are you still living at this address?

1. YES

2. NO **[THANK AND TERMINATE]**

96   REFUSED **[THANK AND TERMINATE]**

97   DON'T KNOW **[THANK AND TERMINATE]**

[IF PR1, PR3 AND PR5 = DK OR REF, OR IF PR8 <> YES, THANK AND TERMINATE.]
DETAILED SCREENING QUESTIONS
[SET BILLING ANALYSIS FLAG (BAFLAG) TO 1.]

DS1.   Since the audit, have you installed any energy efficiency upgrades?

1. YES

2. NO   **[SET BAFLAG TO ZERO; GO TO DS10]**

96   REFUSED **[THANK AND TERMINATE]**

97   DON'T KNOW **[THANK AND TERMINATE]**

We are mainly interested in four upgrades: insulation, air sealing, window or door replacement and heating system replacement.

DS2. Did you install one or more of these four upgrades?

1. YES

2. NO   **[SET BAFLAG TO ZERO; GO TO DS10]**

96   REFUSED **[THANK AND TERMINATE]**

97   DON'T KNOW **[THANK AND TERMINATE]**

DS3. Did the total cost of this work come to more than $ $2,000?

1. YES

2. NO **[SET BAFLAG TO ZERO; GO TO DS10]**

96   REFUSED **[SET BAFLAG TO ZERO; GO TO DS10]**

97   DON'T KNOW **[SET BAFLAG TO ZERO; GO TO DS10]**

DS3a. (IF DS3=1) Did you spend more than $3,000 on this work?

1. YES

2. NO

96. REFUSED

97. DON'T KNOW

DS4. Thinking about these major efficiency upgrades, did you live in your home for at least one year before the work on the first efficiency upgrade began?

1. YES

2. NO **[SET BAFLAG TO ZERO; GO TO DS10]**

96   REFUSED **[SET BAFLAG TO ZERO; GO TO DS10]**

97   DON'T KNOW **[SET BAFLAG TO ZERO; GO TO DS10]**

DS5. Was work on the last efficiency upgrade completed before February of 2014

1. YES

2. NO **[SET BAFLAG TO ZERO; GO TO DS10]**

96   REFUSED **[SET BAFLAG TO ZERO; GO TO DS10]**

97   DON'T KNOW **[SET BAFLAG TO ZERO; GO TO DS10]**

DS6.   Do you heat your home with natural gas? **[IF NECESSARY, CLARIFY THAT WE ARE ASKING ABOUT NATURAL GAS, NOT PROPANE.** "Natural gas is provided by the gas utility and you receive monthly bills. Propane is delivered by a fuel dealer on a set schedule or on request."]

1. YES

2. NO **[SET BAFLAG TO ZERO; GO TO DS10]**

96   REFUSED **[SET BAFLAG TO ZERO; GO TO DS10]**

97   DON'T KNOW **[SET BAFLAG TO ZERO; GO TO DS10]**

DS7.   Did you heat your home with natural gas before you installed the energy efficiency upgrades?

1. YES

2. NO **[SET BAFLAG TO ZERO; GO TO DS10**]

96   REFUSED **[SET BAFLAG TO ZERO; GO TO DS10]**

97   DON'T KNOW **[SET BAFLAG TO ZERO; GO TO DS10]**

DS8. Did you receive rebates or obtain a loan for these energy efficiency upgrades through NYSERDA's Home Performance with Energy Star program?

1. YES [SET BAFLAG TO ZERO; THANK AND TERMINATE]

2. NO

96 REFUSED

97   DON'T KNOW

[IF BILLING ANALYSIS BAFLAG=1, THEN ASK DS9; OTW, GO TO DS10.]

DS9.   Congratulations. You have qualified to participate in our study. We have some additional questions that may take up to 15 minutes, depending on your answers. We will also need written permission to request usage history from your natural gas and electric utilities. Are you willing to participate by signing and returning the permission form?

[IF NEEDED: Your usage information will be kept confidential. It will be used only to estimate the savings from Home Performance efficiency upgrades. IF MORE IS NEEDED: Only the aggregated results of the analysis will be available to the public.]

1. YES **[GO TO MEASURES SECTION]**

2. NO **[SET BILLING BAFLAG TO ZERO, GO TO MEASURES SECTION]**

96 REFUSED **[SET BILLING BAFLAG TO ZERO, GO TO MEASURES SECTION]**

97 DON'T KNOW **[SET BILLING BAFLAG TO ZERO, GO TO MEASURES SECTION]**

DS10. OK. I have a few additional questions for you. It should not take more than five minutes.

MEASURES

[IF DS1=YES] I'm going to read you a list of possible energy efficiency upgrades and ask a few questions about each one.

Survey Measures [MEAS]	Description [SMDESC]
SM1. [INSULATION]	SMDESC1. Insulation
SM2. [AIR SEALING]	SMDESC2. air sealing
SM3. [REPLACEMENT WINDOWS OR DOORS]	SMDESC3. high efficiency windows or doors
SM4. [HEATING SYSTEM]	SMDESC4. a high efficiency heating system
SM5. [PROGRAMMABLE THERMOSTAT]	SMDESC5. a programmable thermostat
SM6. [WATER HEATER]	SMDESC6. a high efficiency water heater
SM7. [CFLs OR HIGH EFFICIENCY LIGHTING FIXTURES]	SMDESC7. CFL's or high efficiency lighting fixtures
SM8. [CENTRAL AIR CONDITIONING SYSTEM]	SMDESC8. high efficiency central air conditioning system
SM9. [HOT WATER CONSERVATION MEASURES] (e.g., low flow showerhead, tank wrap, or pipe insulation)	SMDESC9. hot water conservation measures

M1a. Did you install any of the following energy efficiency upgrades after you received the home energy audit? **[IF DS3=NO, START READING AT NUMBER 5. RECORD AS MANY AS APPLY.]**

    1. Insulation **[SM1=1]**

    2. Air sealing to reduce drafts **[SM2=1]**

    3. Energy-efficient windows or doors **[SM3=1]**

    4. High efficiency heating system or heat pump **[SM4=1]**

    5. Programmable thermostat **[SM5=1]**

    6. High efficiency water heater **[SM6=1]**

    7. Energy-efficient lighting **[SM7=1]**

    8.   New central air conditioner **[SM8=1]**

    9. Hot water conservation measures such as low flow showerheads **[SM9=1]**

    96   REFUSED

    97   DON'T KNOW

[LOOP FOR EACH MEASURES IDENTIFIED IN M1a. X=1 TO 9 FOR SM[X]=1.]

M1b. Was SMDESC[X] recommended by the Home Performance with ENERGY STAR auditor?

    1. YES

    2. NO

    96   REFUSED

    97   DON'T KNOW

M1c. Were you planning to install this high efficiency upgrade before receiving the audit?

    1. YES

    2. NO

    96   REFUSED

    97   DON'T KNOW

[END LOOP]

M2a. [IF BAFLAG=1] Thinking about all of the efficiency upgrades you did, when did the work on the first efficiency project begin?

    RECORD YEAR: _____

    RECORD MONTH OR SEASON: _____ **[PROMPT FOR SEASON IF RESPONDENT DOESN'T REMEMBER THE MONTH; RESPONSE IS NEEDED FOR THE BILLING ANALYSIS, BUT IT DOESN'T HAVE TO BE 100% ACCURATE – ROUGHLY ACCURATE IS SUFFICIENT. TRY TO PROMPT THEM IF THE INSTALLATION WAS DONE EARLY OR LATE IN THE YEAR AND WORK FROM THERE. IF THEY CAN'T PROVIDE A MONTH OR SEASON AT ALL, WE WILL ASSUME THE INSTALLATION STARTED THE FIRST DAY OF THE YEAR.]**

    96   REFUSED MONTH/SEASON

    97   DON'T KNOW **MONTH/SEASON**

M2b. [IF BAFLAG=1] When was work on the last efficiency upgrade completed?

    RECORD YEAR: _____

RECORD MONTH OR SEASON: _____ **RESPONSE IS NEEDED FOR THE BILLING ANALYSIS, BUT IT DOESN'T HAVE TO BE 100% ACCURATE – ROUGHLY ACCURATE IS SUFFICIENT. TRY TO PROMPT THEM IF THE INSTALLATION WAS DONE EARLY OR LATE IN THE YEAR AND WORK FROM THERE. IF THEY CAN'T PROVIDE A MONTH OR SEASON AT ALL, WE WILL ASSUME THE INSTALLATION WAS COMPLETED ON THE LAST DAY OF THE YEAR. HOWEVER, THIS COULD BE A PROBLEM IF THE INSTALLATION WAS DONE IN 2014.]**

M3a. Did you receive any rebates, tax credits or other incentives to help pay for any of the efficiency upgrades?

  1. YES

  2. NO **[GO TO M4]**

  96   REFUSED **[GO TO M4]**

  97   DON'T KNOW **[GO TO M4]**

M3b. **[IF QM3a = 1]** Who provided the rebate, tax credit or other incentive? **[READ IF NECESSARY; MULTIPLE RESPONSES ALLOWED]**

  1. NYSERDA

  2. UTILITY COMPANY

  3. STATE GOVERNMENT

  4. FEDERAL GOVERNMENT

  5. OTHER (SPECIFY): _____

  96   REFUSED

  97   DON'T KNOW

M4.   Did you install any other energy efficiency upgrades recommended in the home audit?

  1. YES (SPECIFY) _____

  2. NO

  96   REFUSED

97   DON'T KNOW

NO INSTALLATIONS

NA1.   **[IF NO MEASURES SM1 THROUGH SM4 INSTALLED, SET BAFLAG TO ZERO] [ASK IF (SM1 THROUGH SM9=0 AND M4=NO, DK OR Ref) OR DS1=NO]** Why did you decide not to install the recommended upgrades? Was it because …**[READ OPTIONS, SELECT ALL THAT APPLY, RANDOMIZE OPTIONS 1 THROUGH 7]**

1. The recommended upgrades were too expensive

2. You were waiting for existing equipment to need replacement

3. The energy savings were not worth the cost

4. You were concerned about the comfort of your home

5. You are planning to install them, just haven't gotten to it

6. You had other priorities for home improvement dollars

7. You wanted to do the work yourself

8. SOMETHING ELSE [SPECIFY]: _____

     96   REFUSED [GO TO DEMOGRAPHICS]

     97   DON'T KNOW [GO TO DEMOGRAPHICS]

[IF NA1 IS ASKED, GO TO DEMOGRAPHICS.]

CONTRACTOR INFORMATION

[IF NO MEASURES SM1 THROUGH SM4 INSTALLED, SET BAFLAG TO ZERO. ONLY ASK THE CONTRACTOR SERIES FOR MEASURES SM1 THROUGH SM4. IF ONLY MEASURES > SM4 WERE INSTALLED, GO TO THE EARLY REPLACEMENT SECTION.]
CON1. Did you hire one or more contractors to perform the work?

1. YES

2. NO **[IF BAFLAG=1, GO TO MD1; IF BAFLAG=0, GO TO DEMOGRAPHICS]**

96   REFUSED **[IF BAFLAG=1, GO TO MD1; IF BAFLAG=0, GO TO DEMOGRAPHICS]**

97   DON'T KNOW **[IF BAFLAG=1, GO TO MD1; IF BAFLAG=0, GO TO DEMOGRAPHICS]**

CON2. Do you recall the name of the company that did all or most of the work?

ENTER NAME: _____

96   REFUSED

97   DON'T KNOW

CON3. Did you hire a second contractor?

1. YES

2. NO **[GO TO CON6]**

96   REFUSED **[GO TO CON6]**

97   DON'T KNOW **[GO TO CON6]**

CON4. Do you recall the name of the second company?

ENTER NAME: _____

96   REFUSED

97   DON'T KNOW

CON5. Which efficiency upgrades did the second contractor install?

ENTER RESPONSE: _____

96   REFUSED

97   DON'T KNOW

CON6. Have you heard of Building Performance Institute?

1. YES

2. NO **[IF BAFLAG=1, GO TO MD1; IF BAFLAG=0, GO TO DEMOGRAPHICS]**

96   REFUSED **[IF BAFLAG=1, GO TO MD1; IF BAFLAG=0, GO TO DEMOGRAPHICS]**

97   DON'T KNOW **[IF BAFLAG=1, GO TO MD1; IF BAFLAG=0, GO TO DEMOGRAPHICS]**

CON7. In selecting the contractor, did you look for a BPI contractor?

1. YES

2. NO

96   REFUSED

97   DON'T KNOW

CON8. Did you use a BPI contractor for this work?

1. YES

2. NO

96   REFUSED

97   DON'T KNOW

MEASURE DETAILS

[IF BA_FLAG=0, GO TO DEMOGRAPHICS; OTW, CONTINUE.]

[NOTE: THIS SERIES ONLY INCLUDES SM1, SM2, SM3 AND SM4. NO QUESTIONS ARE NEEDED FOR THE OTHER MEASURES.]

IF MEAS = SM1 INSTALLED, ASK MD1, ELSE GO TO MD2.]

MD1. [IF SM1 = 1] Where in your home was the insulation installed? [SELECT ALL THAT APPLY]

     1. **ATTIC**

     2. **BASEMENT/CRAWLSPACE**

     3. **WALLS**

     4. **FLOORS**

     5. **OTHER [RECORD]**

     96   **REFUSED**

     97   **DON'T KNOW**

MD2. **[IF SM2 = 1]** Do you recall whether a blower door test was conducted before the air sealing was done, after the air sealing or both before and after? **[IF NEEDED:** A blower door is a large fan that fits into the doorway of your home and is used to depressurize the house to see where air leaks are occurring.**]**

     1. YES, BEFORE THE AIR SEALING WAS DONE

2. YES, AFTER THE AIR SEALING WAS DONE

3. YES, BOTH BEFORE AND AFTER THE AIR SEALING WAS DONE

4. NO, NO BLOWER DOOR TEST

96   REFUSED

97   DON'T KNOW

MD3.   **[IF SM3 = 1]** How many windows did you replace with energy efficient windows?

RECORD WINDOWS QUANTITY:_____Range: 0 to 60, 60 = 60 or more

96   REFUSED

97   DON'T KNOW

MD4.   **[IF SM3 = 1]** How many doors did you replace with energy efficient doors?

RECORD DOORS QUANTITY:_____ Range = 0 to 10, 10 = 10 or more

96   REFUSED

97   DON'T KNOW

MD5.   [IF SM4 = 1] What type of high efficiency heating system did you install? [RECORD ONE]

1. **Furnace, with hot air distribution [MEAS4 = "furnace"]**

2. **Boiler, with hot water baseboard, radiant heat or steam radiators [MEAS4 = "boiler"]**

3. **Heat pump with electric back up [MEAS4 = "heat pump"]**

4. **Heat pump with natural gas back up [MEAS4 = "heat pump"]**

5. **Heat pump with other fuel back up (not electricity or natural gas) [MEAS4 = "heat pump"]**

6. **OR SOMETHING ELSE? (SPECIFY: _____)**

96   REFUSED

97   DON'T KNOW

MD6. [IF SM4 = 1] What type of heating system did you have before the high efficiency system was installed? [RECORD AS MANY AS APPLY]

1. **Hot air furnace**

2. **Water or steam boiler, with baseboard, radiant heat or radiators**

3. **Heat pump with electric back up**

4. **Heat pump with natural gas back up**

5. **Heat pump with other fuel back up (not electricity or natural gas)**

6. **OR SOMETHING ELSE? (SPECIFY: _____)**

96   REFUSED

97   DON'T KNOW

EARLY REPLACEMENT

The next series of questions is about the condition of the equipment you replaced.

[ONLY FOR MEASURES SM4, SM6 AND SM8; LOOP THROUGH EACH INSTALLED]
ER1. Did the new [MEAS[X]] replace your previous [MEAS[X]]?

1. YES

2. NO [IF LAST ITEM IN LOOP, GO TO AP1]

96   REFUSED [IF LAST ITEM IN LOOP, GO TO AP1]

97   DON'T KNOW [IF LAST ITEM IN LOOP, GO TO AP1]

ER2.   To the best of your recollection, how old was the original [MEAS[X]] prior to the installation of your new [MEAS[X]]? [RECORD AGE IN YEARS]

RECORD AGE IN YEARS: _____

96 REFUSED

97   DON'T KNOW

ER3.   Which of the following best describes the condition of the original equipment that was replaced? [RECORD ONE, RANDOMIZE OPTIONS 1 THROUGH 5]

1. It was in good working condition.

2. It worked well, but was old and inefficient.

3. It required frequent maintenance.

4. It had serious defects and would probably have been replaced within the next couple of years.

5. It had failed or was about to fail.

6. OR SOMETHING ELSE? (SPECIFY: _____)

96   REFUSED

97   DON'T KNOW

ER4.   How does the size of your new **[MEAS[X]]** compare to your old **[MEAS[X]]**? Is it …

1. About the same size

2. Smaller

3. Larger

96   REFUSED

97   DON'T KNOW

[END LOOP; IF BAFLAG=0 GO TO DEMOGRAPHICS.]

HPwES PARTICIPATION

HP1. (ASK IF BAFLAG =1) Why did you decide not to access NYSERDA's Home Performance program incentives and services when you completed this work in your home?

RECORD OPEN-ENDED RESPONSE: _____

96 REFUSED

97   DON'T KNOW

APPLIANCES

AP1.   I'm going to read you a list of appliances and electronic devices. For each one, please tell me whether the item was installed following your audit. Please do not include any equipment that was recommended by your auditor and discussed in the earlier questions. **[READ LIST, RECORD AS MANY AS APPLY]**

1. Central air conditioner

2. Room or wall air conditioner

3. Dishwasher

4. Clothes washer

5. Refrigerator/freezer

6. Heat pump with electric back up

7. Heat pump with natural gas back up

8. Electric space heater

9. Natural gas space heater, not propane

10. Television

11. Computer and/or computer peripherals, such as printers or routers

12. Other personal electronics

13. ANY OTHER DEVICES? (SPECIFY): _____

14. NONE – NO APPLIANCES/DEVICES LISTED INSTALLED AFTER AUDIT

96   REFUSED

97   DON'T KNOW

[IF NO APPLIANCES ARE IDENTIFIED, GO TO THE NEXT SECTION. OTW, LOOP THROUGH EACH APPLIANCE IDENTIFIED IN AP1, LABELED AS APP[X], ASK AP2-AP7]

AP2. Can you recall the year and season that you installed the **[APP[X]]**?

        RECORD YEAR: _____

        RECORD SEASON: _____

        96   REFUSED

        97   DON'T KNOW

AP3. Is the new [APP[X]] an Energy Star model?

        1. **YES**

        2. **NO**

        96   **REFUSED**

        97   **DON'T KNOW**

AP4.   **Did the new [APP[X]] replace your previous [APP[X]]?**

        1. **YES**

        2. **NO [GO TO TOP OF LOOP]**

        96   **REFUSED [GO TO TOP OF LOOP]**

        97   **DON'T KNOW [GO TO TOP OF LOOP]**

SPACE AND WATER HEATING SYSTEMS

HS1.   Is your primary heating system controlled by a programmable thermostat?

        1. YES

        2. NO **[GO TO HS3]**

        96   REFUSED **[GO TO HS3]**

        97   DON'T KNOW **[GO TO HS3]**

HS2.   [IF HS3 = 1] How do you use your programmable thermostat? Do you… **[READ LIST, RECORD ONE RESPONSE]**

        1. Set and leave it at one temperature **[GO TO HS4]**

        2. Manually adjust the temperature as needed **[GO TO HS4]**

3. Use it to automatically adjust the temperature based on time of day, or **[GO TO HS4]**

4. DO SOMETHING ELSE (SPECIFY: _____) **[GO TO HS4]**

96   REFUSED **[GO TO HS4]**

97   DON'T KNOW **[GO TO HS4]**

HS3.   [If HS1 = 2, 96, or 97] How do you control your primary heating system? Do you…
        [READ LIST, RECORD ONE RESPONSE]

1. Set and leave it at one temperature

2. Manually adjust the temperature as needed

3. OTHER, SPECIFY: _____

96   REFUSED

97   DON'T KNOW

HS4a.   Comparing the winter before your efficiency upgrades were installed to the winter after,
        did you notice a change in your heating fuel bills?

1. YES

2. NO [GO TO **HS7**]

96   REFUSED **[GO TO HS7]**

97   DON'T KNOW **[GO TO HS7]**

HS4b.   During the winter after the installation, did you notice that your house was more
        comfortable?

1. YES

2. NO

96   REFUSED

97   DON'T KNOW

HS5a.   **[IF HS4a="YES" and HS4b <> "YES"]** What was your reaction to the change in your
        heating fuel bills – did you …   **[READ LIST, CHOOSE ONE, RANDOMIZE
        OPTIONS 1 and 2]**

1. Decide to turn up the thermostat

2. Decide to turn down the thermostat, or

3. Leave thermostat setting the same **[GO TO HS7]**

96   REFUSED **[GO TO HS7]**

97   DON'T KNOW **[GO TO HS7]**

HS5b.   **[IF HS4a="YES" and HS4b="YES"]** What was your reaction to the change in your heating fuel bills and comfort level – did you …   **[READ LIST, CHOOSE ONE, RANDOMIZE OPTIONS 1 and 2]**

1. Decide to turn up the thermostat

2. Decide to turn down the thermostat, or

3. Leave thermostat setting the same **[GO TO HS7]**

96   REFUSED **[GO TO HS7]**

97   DON'T KNOW **[GO TO HS7]**

HS6.   **[IF HS5a OR HS5b = 1 OR 2]** Did you change the thermostat setting by 5 degrees or more?

1. YES

2. NO

96   REFUSED

97   DON'T KNOW

HS7.   Does your water heater use natural gas?   **[DO NOT READ, CHOOSE ONE]**

1. YES

2. NO

3. OTHER, RECORD RESPONSE: _____
           [EXAMPLE: MAY HAVE SOLAR HOT WATER WITH BACK UP NATURAL GAS]

96   REFUSED

97   DON'T KNOW

HS8.   Did you use a natural gas water heater before you installed the efficiency upgrades?
[DO NOT READ, CHOOSE ONE]

1. YES

2. NO

3. OTHER, RECORD RESPONSE: _____

96   REFUSED

97   DON'T KNOW

SUPPLEMENTAL HEATING

SUP1. Do you have a supplemental heating source? **[IF NECESSARY:** Is your home equipped with an additional heating system, such as a woodstove, electric space-heater, wood fireplace, or gas fireplace?**]**

1. YES

2. NO **[GO TO DEMOGRAPHICS]**

96   REFUSED **[GO TO DEMOGRAPHICS]**

97   DON'T KNOW **[GO TO DEMOGRAPHICS]**

SUP2. [IF SUP1 = 1] Does your supplemental heating source use natural gas?

1. YES

2. NO

96   REFUSED **[GO TO DEMOGRAPHICS]**

97   DON'T KNOW **[GO TO DEMOGRAPHICS]**

SUP3.[IF SUP2 = 2]   Do you use your supplemental heating system ….

1. Rarely

2. Only on the coldest days

3. Only during the coldest months
        [IF NECESSARY: December through February**]**

4. Only in the spring and fall

5. Throughout the entire heating season

   [IF NECESSARY: September through May**]**

6. OTHER, SPECIFY: _____

96   REFUSED

97   DON'T KNOW

SUP4. Approximately what percentage of your living space is heated by the supplemental heat source? Would you say… **[READ LIST, RECORD ONE]**

1. Less than 20% **[GO TO DEMOGRAPHICS]**

2. 21 to 40%

3. 41 to 60%

4. 61 to 80%

5. More than 80%

96   REFUSED **[GO TO DEMOGRAPHICS]**

97   DON'T KNOW **[GO TO DEMOGRAPHICS]**

SUP5. **[IF SUP4 = 2, 3, 4, or 5]** Comparing the winter after your efficiency upgrades were installed to the winter before, did you use your supplemental heating system more during the winter after the upgrades were completed? **[READ LIST, RECORD ONE]**

1. I used the supplemental heat about the same during the winter before the work was done

2. I did not use the supplemental heat at all during the winter before the work was done

3. I used the supplemental heat a lot more during the winter after the work was done,

4. Somewhat more,

5. Somewhat less,

6. Or a lot less during the winter after the work was done

96   REFUSED

97   DON'T KNOW

DEMOGRAPHICS

Finally, I have a few general questions for statistical purposes. This information will be combined across all participants and will not be shared with anyone outside of the evaluation team in any way that identifies you or your household.

D1. What is your age? Is it…

  1. 18 TO 24

  2. 25 TO 34

  3. 35 TO 44

  4. 45 TO 54

  5. 55 TO 64

  6. 65 OR OVER

  96 REFUSED

D2.   Counting yourself, how many people normally live in this household on a full time basis? Please include everyone who lives in your home whether or not they are related to you and exclude anyone who is just visiting or children who may be away at college or in the military.

  RECORD NUMBER: _____ Range 1 to 10, where 10 = 10 or more

  96   REFUSED

D3.   Please stop me when I read the range that contains the total combined income of all members of your household over the past 12 months. **[READ LIST, RECORD ONE]**

  1. Less than $25,000

  2. $25,000 to less than $50,000

  3. $50,000 to less than $75,000

  4. $75,000 to less than $100,000

  5. $100,000 to less than $150,000

6. $150,000 to less than $200,000

7. $200,000 or more

96   REFUSED

97   DON'T KNOW

D4.   When was your home built? Please stop me when I get to the right category.

1. 1930's or earlier

2. 1940's or 1950's

3. 1960's or 1970's

4. 1980's or 1990's

5. 2000 or later

96   REFUSED

97   DON'T KNOW

D5. What is the highest grade of schooling you have completed so far? [DO NOT READ]

1. NO HIGH SCHOOL DIPLOMA OR GED

2. HIGH SCHOOL GRADUATE (INCLUDES GED)

3. ASSOCIATES DEGREE

4. BACHELORS DEGREE (4-YEAR DEGREE)

5. GRADUATE OR PROFESSIONAL DEGREE

96   REFUSED

97   DON'T KNOW

D6.   [DO NOT ASK. RESPONDENT IS ….]

1. MALE

2. FEMALE

CLOSING

[IF BILLING ANALYSISBA FLAG = 0, GO TO C3]

C1.   **[BAFLAG=1]** The next step is to sign and mail back the form giving us permission to request your usage information from your natural gas and electric utilities. We will send you the form in the mail, or you may download it from the Internet.

[IF NEEDED: Your usage information will be used to estimate the savings from Home Performance efficiency upgrades. Your usage information will be kept confidential. IF MORE IS NEEDED: Only the aggregated results of the analysis will be made available to the public.]

May I confirm your name, mailing address and e-mail? We have your name as …

[NAME]

RECORD NAME CORRECTIONS: _____

[ADDRESS]

RECORD MAILING ADDRESS CORRECTIONS: _____

[EMAIL]

RECORD EMAIL CORRECTIONS: _____

C2. **[BAFLAG=1]** If you would prefer to download the form, it is available at XXX. Would you like us to mail or e-mail you the permission form?

1. MAIL

2. E-MAIL

3. NEITHER, WILL DOWNLOAD

C3.   We are also conducting a phone survey of households that received a home energy audit through NYSERDA's Home Performance with ENERGY STAR Program that looks more generally at how households make decisions about energy. We will be starting that survey in September. Would you be willing to participate in that survey?

1. YES

2. NO **[THANK AND TERMINATE]**

THANK AND TERMINATE

Thank you for your time. The information you provided will be helpful in evaluating and improving the program.

APPENDIX C: GJGNY BILLING MODEL DETAILS

The model used was a generalized linear model with customer-specific intercept of the form shown in the equation below.

$$C_{it} = \alpha_i + \kappa_i + \tau_t + \sum_{j=1}^{p} x_{ijt}\beta_j + \varepsilon_{it}, \qquad (1)$$

where

C_{it} is the monthly consumption for the household i in period t, expressed in therms per day,

α_i is the "customer-specific" intercept (or error) for household i, accounting for unexplained difference in use between households associated with the number of occupants, appliance holdings and lifestyle,

κ_i is the customer-specific heating slope

τ_t is the "time-specific" error for period t, reflecting the unexplained difference in use between time periods,

x_{ijt} are the predictor variables reflecting the installation of energy efficiency measure j for household i in period t,

β_j are the slope coefficients that quantify the average influence of modeled efficiency measure j on monthly consumption,

p is the total number of energy efficiency measures included in the model, and

ε_{it} is the error term that accounts for the difference between the model estimate and actual consumption for household i in period t.

The model used dummy variables, in which the *x*'s for the installed measures are one or zero, to indicate the installation and the coefficients reflect the savings for the measures. Models with pooled and house-specific heating slopes were tested. The house-specific heating slope was found to better fit the data and used in the final model.

The regression output is presented in below. As natural gas use is primarily driven by heating, the modeling of heating efficiency measures in cold climates tends to be fairly straightforward. Heating use is closely related to outdoor temperature, but the characteristics of the relationship vary from one home to the next. For example, the thermostat settings, the outdoor temperature

that triggers the use of the heating system and the methods of controlling the thermostat are all highly individual to specific homes. Estimating savings from base measures such as hot water conservation tends to be more complicated and the results are often more variable.

All estimators were statistically significant at the 90% confidence interval, and the R^2 statistic was 0.93. The high R^2 statistic is due to the fixed effects model in which each home is compared to itself.

Table 1: Summary Statistics from the Natural Gas Regression Model

Measure Group	Estimator[1]	t-value[2]	Unit of Estimator	Number of Homes in Regression Model
Base Measure Savings[3]	(0.088)	(1.85)	Therms/Day	25
Heating System Savings[4]	(0.009)	(3.77)	Therms/Heating Degree Day	34
Envelope Measure Savings[4]	(0.014)	(9.14)	Therms/Heating Degree Day	101
Heating Degree Days	0.106	12.74	Therms/Heating Degree Day	133
R-Squared[5]		0.932		

[1] The "estimator" is the regression coefficient and reflects the impact on the change in average daily use.
[2] The t-value of a regression coefficient measures whether the value of the coefficient is statistically different from zero. The t-statistic is the regression coefficient over the its standard error. A t-value of magnitude 1.64 or greater indicates the coefficient is statistically different from zero at the 90% confidence level.
[3] "Base Measures" include measures that are not weather dependent, such as water heating conservation and replacement.
[4] Interacted with heating degree days (HDD), base 60°F.
[5] The R-squared (R^2) measures the proportion of variability in a regression data set that can be explained by the model. An R^2 of 1.0 indicates that the regression perfectly fits the data. Generally, an R^2 of 0.70 or higher reflects a strong relationship between the regression variables, from 0.30 to 0.70 reflects a moderate relationship and less than 0.30 indicates a weak relationship.   A fixed effects regression as used in this analysis tends to have a high R^2 as the model compares each home to itself.

The models were tested for autocorrelation, [7] multicollinearity,[8] outliers,[9] high-leverage data points,[10] and to assess the impacts of unequal variances across homes (heteroskedasticity).

---

[7] Autocorrelation of errors is most common in time-series due to the intrinsic relationship between the most recent prior period and the present measurement while unspecified variables are missing that would explain the underlying mechanisms for these changes. If the model exhibits autocorrelation, the estimators are unbiased but the variance in the model tends to be artificially low.
[8] Multicollinearity occurs when predictor variables are correlated with one another. This can happen if measures are installed as a group. If multicollinearity is present, the estimators are sometimes of the wrong sign or not statistically significant.

The natural gas model was relatively stable, with household savings reasonably consistent under different configurations of the model. The Goldfeld-Quandt test for heteroskedasticity was conducted, resulting in a GQ statistics of 1.5, indicating that the data set does not exhibit significant heteroskedascity.[11] Outliers and high-leverage data points were identified using standard statistical methods.[12] Through this process, five homes were removed from the analysis and the model was re-run. The results remained consistent. The pooled Durbin Watson test for autocorrelation resulted in a value of 1.63, indicating some autocorrelation exists (as is typical of utility billing data) but is not a cause for concern.[13]

---

[9] Outliers are observations with response variable values significantly different from the population that unduly influence results.

[10] High-leverage points are those that have predictor variable values significantly different from the population and may have an undue influence on the results.

[11] See Goldfeld in the Reference section.

[12] Outliers were identified through calculating the pooled DFFITS by household and setting a dispersion-adjusted cut off. See Belsley in the References section, chapter 2. High-leverage data points were identified using the DFBETA procedure.

[13] See Sayrs in the References section.

Program Influence Survey - Green Jobs - Green New York Audit Customers

3/13/15 Revised Version

INSTRUCTIONS TO INTERVIEWER

Procedure:

    (1) Read each question, record their answer and take notes

    (2) Do not speak other than asking "tell me what you're thinking" when the respondent pauses (during the pairwise questions).

****

Name	
Phone Number	
Address	
Measures Installed	Measure R1: Insulation
	Measure R2: Air Sealing
	Measure R3: Efficient Windows/Doors
	Measure R4: Efficient Heating System

INTRODUCTION AND FINDING CORRECT RESPONDENT

Q1. Hello, this is <INTERVIEWER NAME> calling from West Hill Energy & Computing on behalf of NYSERDA. This is not a sales call. May I please speak with PROGRAM_CONTACT?

    1. No, this person no longer lives here

    2. No, this person is not available right now

    3. Yes

    4. No, Other reason (specify)

SCREENER

Our records show that you recently responded to a survey about your participation in the Home Performance with Energy Star Program.

S1. Do you recall this survey?

    1. Yes [SKIP TO S3]

    2. No [CONTINUE]

S2. Is there someone else in your home may be more familiar with the Home Performance survey? IF YES: Can you tell me who that person might be?

1. Yes [RECORD NAME/PHONE FOR CALLBACK]
2. No [THANK AND TERMINATE]
3. DK/ REFUSED [THANK AND TERMINATE]

S3. In the previous survey, you indicated that you installed [MEASURES 1 TO 4]

Is that correct?

1. Yes [SKIP TO COGNITIVE SECTION]

2. No   [CONTINUE WITH S4]

S4. What measures do you remember installing, out of those recommended in the energy assessment conducted by the NYSERDA Home Performance contractor?

77 Record verbatim

[DEFINE NEW VARIABLE MAXMEAS AS THE TOTAL NUMBER OF MEASURES THEY INSTALLED CORRESPONDING TO THESE 4 CATEGORIES.]

[IF MEASURES DON'T MATCH AND RESPONDENT DOES NOT MENTION INSULATION, AIR SEALING, WINDOR OR DOOR REPLACEMENT AND/OR HEATING SYSTEM REPLACEMENT/HEAT PUMP, THANK AND TERMINATE. ELSE IF THEY MENTION A NEW MEASURE THAT CORRESPONDS, ADJUST MEASURE COUNT AND CONTINUE.]

COGNITIVE SECTION

In this survey, we are trying to understand how you made the decision to make energy efficiency upgrades to your home.

We are working on some new questions and we could really use your feedback. This survey should take less than 20 minutes, depending on your responses. Please let me know if you find any of the questions confusing or difficult to answer.

Is this a convenient time? [SET UP ANOTHER APPOINTMENT IF NEEDED.]

KEY DECISION INFLUENCES

KD1. First, please tell me in your own words why you requested a Home Performance energy audit from NYSERDA.
1. RECORD VERBATIM:
2. DK/refused

[IF THE NUMBER OF INSTALLED MEASURES CORRESPONDING TO THE 4 CATEGORIES IS GREATER THAN 1 AND S3 = 1 OR S4 CONFIRMS MEASURE MATCH, CONTINUE.

ELSE IF THEY ONLY INSTALLED ONE MEASURE CORRESPONDING TO THE 4 CATEGORIES AND S3 = 1 OR S4 CONFIRMS MEASURE MATCH SKIP TO THE PROJECT/ MEASURE/GROUP LOOP AND LOOP THROUGH ONCE.]

READ: The focus of this survey is the insulation and efficient heating system that you installed.

I'd like to understand whether you made one decision to install all of the measures or if you made separate decisions for each measure.

KD2. Was it a single decision making process that led you to install the [MEASURE1, MEASURE2, ETC]?
> 1. Yes
> 2. No

> [IF 2 MEASURES WERE INSTALLED AND KD6=NO, SET MAXMEAS TO 2; SET PROJECT[1] TO MEAS[1] AND PROJECT[2] TO MEAS[2] AND SKIP TO M1.]

> KD2a. Can you please describe how you made the decision for each of the measures I named? [IF NEEDED: which of the measures had a separate decision and, if relevant, which pair of measures had a joint decision] [DO NOT READ, RECORD RESPONSE FROM RESPONDENT. CLARIFY AS NEEDED.]
> > 1. I MADE SEPARATE DECISIONS FOR ALL MEASURES
> > 2. SEPARATE DECISION FOR MEASURE1, JOINT DECISION FOR MEASURES 2/3/4
> > 3. SEPARATE DECISION FOR MEASURE2, JOINT DECISION FOR MEASURES 1/3/4
> > 4. SEPARATE DECISION FOR MEASURE3, JOINT DECISION FOR MEASURES 1/2/4
> > 5. SEPARATE DECISION FOR MEASURE4, JOINT DECISION FOR MEASURES 1/2/3
> > 6. JOINT DECISION FOR MEASURE1/2, JOINT DECISION FOR MEASURE 3/4
> > 7. JOINT DECISION FOR MEASURE1/3, JOINT DECISION FOR MEASURE 2/4
> > 8. JOINT DECISION FOR MEASURE1/4, JOINT DECISION FOR MEASURE 2/3
> >   DK/REFUSED

IF KD2 = 1, THEN REFER TO THE 'PROJECT' FOR THE REMAINDER OF THE INTERVIEW.

IF KD2 = 2 AND KD2a = 1, THEN '<MEASURE x>' REFERS TO MEASURE1, MEASURE2, MEASURE3

IF KD2 = 2 AND KD2a = 2, 3, 4, THEN 'MEASURE x>' SHOULD BE CONSTRUCTED VARIABLES FOR THE MEASURE AND MEASURE GROUP BASED ON THE DECISIONS DESCRIBED, e.g. MEASURE 1, MEASURE 2/3

RECORD VARIABLES IN SPREADSHEET AND REFER TO AS YOU GO THROUGH THE PROJECT LOOP BELOW.

PROJECT1 LOOP

[LOOP THROUGH FOR EACH DECISION INDICATED. PROJECT1, PROJECT2, ETC., STARTING WITH n=1 TO MAXMEAS.]

READ: Thinking back before your Home Performance audit and how you made the decision to install the efficiency upgrades, we are interested in the factors that were important to your decision.

M1. In your own words, can you tell me why you decided to install [MEASURE x]?
    1. RECORD VERBATIM:
    2. DK/refused

M2. Using a scale from 0 to 10, where 0 means not at all important and 10 means very important, please rate the importance of the following factors in motivating you to move ahead with the installation of <MEASUREx>. [ROTATE.]

    1.   Wanted to reduce energy use/save energy.

    2.   Wanted to lower your energy bill.

    3.   Wanted to improve the comfort of your home.

    4.   Were concerned about health issues, such as mold or air quality.

    5.   Wanted to improve the environment, reduce carbon footprint

    6.   Recently purchased your new home or planned/started a remodeling project

    7.   Had more time available to oversee the work

    8.   Financial status changed/ and you were able to pay for the project

    9A.   Something else? [DESCRIPTION]

    9B.   SOMETHING ELSE SCORE

READ: It certainly sounds like you had good reasons for wanting to improve your home and were ready to take action. However, I also know trying to make home energy efficiency improvements can be challenging despite these good reasons. **[READ THIS ONLY ONCE FOR PROJECT 1]**

M3. Thinking back to before you installed <MEASUREx>, what kept you from taking action earlier?

    1. RECORD VERBATIM:

    2. DK/REFUSED

M4. I am going to list some factors that may have prevented you from taking action earlier to install the [MEASUREx]. Please rate their importance using the same 0 to 10 scale, where 0 means not at all important and 10 means extremely important. [ROTATE.]

    1. Needing more information about how to save energy or lower the costs of heating your house.

    2. Needing more information about how to address safety or health concerns in your household.

    3. Figuring out how to reduce your carbon footprint or greenhouse gas emissions.

    4. Finding a reliable source of information for energy savings and payback

    5. Finding the time to research the efficiency upgrades.

    6. Finding a contractor you could trust or finding the time to hire a contractor.

    7. Figuring out how to pay for the efficiency upgrades.

    8. Figuring out the details of what to install [ADDED FROM PRETEST]

    9. Finding a contractor you could trust or finding the time to hire a contractor or supervise the work.

    10. Recently purchase the home or other personal reasons

    11A.   Other 1 - description

    11B.   Other 1 - score

    12A.   Other 2 - description

    12B.   Other 2 – score

[WORDING FOR M5 AND PAIRWISE QUESTIONS:]

FACTOR	WORDING
INFO	Need for more information
TIME	Time limitations
CONTRACTOR	Finding a contractor
MONEY	Covering the installation costs

M5. OK. Let me rephrase. It sounds like you had [X] major considerations in the following order of importance [LIST BY HIGHEST SCORE IN M4]:

1. FACTOR1 _____

2. FACTOR2_____

3. FACTOR3_____

[Now I am going to ask you a series of questions that compare these factors two at a time.]

PAIRWISE RANKING – PRIORITIES

In the next set of questions, we are asking about your decision to install the [MEASUREX].

PR1. Comparing FACTOR1 to FACTOR2, was FACTOR1 equally as important, slightly more, moderately more, strongly more or extremely more important than FACTOR2?
    1. EQUALLY IMPORTANT
    2. SLIGHTLY MORE
    3. MODERATELY MORE
    4. STRONGLY MORE
    5. EXTREMELY MORE

[IF THERE ARE 3 FACTORS, MODIFY WORDING TO COMPARE FACTOR 1 AND FACTOR 2, FOLLOWED BY FACTOR 2 AND FACTOR3. ELSE SKIP TO NEXT SECTION.]

PROGRAM INFLUENCE

PI1. In your own words, how was the NYSERDA home energy assessment helpful to you?
    1. RECORD VERBATIM:
    2. DK/REFUSED

P12. On the same 0-to-10 point scale of importance, how important was the Home Performance energy assessment or the NYSERDA Web site in these ways:

1.   Figuring out what to install

2.   Addressing health or safety concerns

3.   Selecting a contractor

4.   Finding a source of financing

5.   Providing you with a reliable estimate of energy or dollar savings

6.   Saving you time by providing you with information or helping you find a contractor

7A.   Anything else? SPECIFY

7B.   SCORE FOR 6A

[RECORD MAXIMUM SCORES:]

        NYINFO _____

      NYMONEY _____

      NYTIME _____

      NYCONTRACTOR _____

[RANK PRIORITIES FROM MAXIMUM SCORES. MAX MUST BE 5 OR MORE]

PRIORITIES

      FIRST _____

      SECOND _____

      THIRD _____

[IF ALL NY VARIABLES ARE LESS THAN 5, GO TO FS1]

PAIRWISE – KNOWLEDGE

SV1. We are interested in the sources of information you used to make the decision to install [MEASUREx]. Please rate these sources of information by importance using the same 0 to 10 scale, where 0 means not at all important and 10 means extremely important. [ROTATE.]

1. The Energy Assessment by the Home Performance contractor [DIRECT=1]

2. A contractor not associated with NYSERDA's program [NONPROG=1]

3. Personal research or previous knowledge [NONPROG=1]

4. Assistance from family or friends who had a Home Performance energy audit [INDIRECT=1]

5. NYSERDA Web site or advertisements [INDIRECT=1]

6. Assistance from family or friends who did not have a Home Performance energy audit [NONPROG=1]

7. Other Web sites or advertisements [NONPROG=1]

8. Lumberyard or home improvement stores [NONPROG=1] [ONLY FOR DIY]

9A. Anything else? SPECIFY

9B. SCORE FOR 9A

[RECORD MAXIMUM SCORES]

      DIRECT_____

      INDIRECT_____

      NONPROGRAM_____

[IF ONLY ONE OF DIRECT, INDIRECT AND NONPROG IS >=5, THEN SKIP TO NEXT SECTION.]

READ: We have separated [DIRECT>=5: direct program information],[INDIRECT>=5: indirect program influence] and [NONPROG>=5: personal sources], and the next set of questions compares these types of influences.

[IF DIRECT>=5:] Direct program information is the Energy Assessment by the Home Performance contractor.

[IF INDIRECT>=5:] Indirect program influence is assistance from family or friends who had a Home Performance audit or using the NYSERDA Web site.

[IF NONPROG>=5:] Personal sources are personal research, home improvement stores, assistance from family or friends who did not have a Home Performance audit or visiting other Web sites.   [CUSTOMIZE TO THE ONES THE RESPONDENT MENTIONED]

[ORDER BY IMPORTANCE FROM DIRECT/INDIRECT/NONPROG RANKINGS ABOVE.]

ENERGY SAVINGS SOURCE 1 (MOST IMPORTANT): _____

ENERGY SAVINGS SOURCE 2:_____

ENERGY SAVINGS SOURCE 3: _____

SV4. It sounds like you relied on [DIRECT>=5: direct NYSERDA program information], [INDIRECT>=5: indirect NYSERDA influence] and [NONPROG>=5: personal sources].

1. EQUALLY IMPORTANT
2. SLIGHTLY MORE
3. MODERATELY MORE
4. STRONGLY MORE
5. EXTREMELY MORE

[IF THERE ARE 3 FACTORS, MODIFY WORDING TO COMPARE FACTOR 1 AND FACTOR 2, FOLLOWED BY FACTOR 2 AND FACTOR3. ELSE SKIP TO NEXT SECTION.]

PAIRWISE CONTRACTOR

[FIRST TIME ONLY] Finding contractor can be a challenge.

[SET DIRECT=0, INDIRECT=0 AND NONPROG=0.]
FC1.   Where did you look for information to help you choose a contractor for [MEASUREx]? Please rate these sources of information by importance using the same 0 to 10 scale, where 0 means not at all important and 10 means extremely important. [ROTATE.]
1. Selecting the HPwES Home Performance home energy auditor to do the work [DIRECT=1]

2. Using a non-Home Performance contractor I you knew from previous experience [NONPROG=1]

3. NYSERDA HPwES contractor list or Web site [INDIRECT=1]

4. Assistance from your fuel dealer [NONPROG=1]

5. Google, yellow pages or other advertisement [NONPROG=1]

6. Referral from other source [NONPROG=1]

7A. Anything else? SPECIFY

7B. SCORE FOR 7A

[RECORD MAXIMUM SCORES]

DIRECT_____

INDIRECT_____

NONPROGRAM_____

NOTE: [IF ONLY ONE OF DIRECT, INDIRECT AND NONPROG IS >=5, THEN SKIP TO NEXT SECTION.]

We have separated [DIRECT=1: direct program information],[INDIRECT=1: indirect program influence] and [NONPROG=1: personal sources], and the next set of questions compares these types of influences.

[IF DIRECT=1:] Direct program information is the Energy Assessment by the Home Performance contractor.

[IF INDIRECT=1:] Indirect program influence is assistance from family or friends who had a Home Performance audit or using the NYSERDA Web site.

[IF NONPROG=1:] Personal sources are personal research, home improvement stores, assistance from family or friends who did not have a Home Performance audit or visiting other Web sites. [CUSTOMIZE TO THE ONES THEY MENTIONED.]

[ORDER BY IMPORTANCE FROM DIRECT/INDIRECT/NONPROG RANKINGS ABOVE.]

CONTRACTOR SOURCE 1 (MOST IMPORTANT): _____

CONTRACTOR SOURCE 2:_____

CONTRACTOR SOURCE 3: _____

FC2. It sounds like you relied on [DIRECT=1: direct NYSERDA program information], [INDIRECT=1: indirect NYSERDA influence] and [NONPROG=1: personal sources].

FACTOR 1 V FACTOR 2 _____

FACTOR 1 V FACTOR 3_____

FACTOR 2 V FACTOR 3_____

[WORDING FOR "FACTOR1" ETC. GIVEN IN FC4}

FC3. Comparing FACTOR1 to FACTOR2, was FACTOR1 equally as important, slightly more, moderately more, strongly more or extremely more important than FACTOR2?

1.   EQUALLY IMPORTANT

2.   SLIGHTLY MORE

3.   MODERATELY MORE

4.   STRONGLY MORE

5.   EXTREMELY MORE

[IF THERE ARE 3 FACTORS, MODIFY WORDING TO COMPARE FACTOR 1 AND FACTOR 2, FOLLOWED BY FACTOR 2 AND FACTOR3. ELSE SKIP TO NEXT SECTION.]

PAIRWISE TIME

T1. What helped you to find the time to move ahead with [MEASUREx]?
   1. RECORD VERBATIM:
   2. DK/REFUSED

T2.   Anything else?
   1. RECORD VERBATIM:
   2. DK/REFUSED

[USE JUDGMENT TO CHARACTERIZE VERBATIMS AS DIRECT, INDIRECT AND NONPROGRAM. USE PAIRWISE IF IT MAKES SENSE.]

[IF TIME>=5 AND NYTIME>=5]

[IF ALREADY DISCUSSED IN PREVIOUS QUESTION, MODIFY AS NEEDED.]

We have separated [DIRECT>=5: direct program assistance],[INDIRECT>=5: indirect program influence] and [NONPROG>=5: personal sources].

[IF DIRECT>=5:] Direct program assistance is the Energy Assessment by the Home Performance contractor .

[IF INDIRECT>=5:] Indirect program influence is assistance from family or friends who had a Home Performance audit or using the NYSERDA Web site.

[IF NONPROG>=5:] Personal sources are personal research, home improvement stores, assistance from family or friends who did not have a Home Performance audit or visiting other Web sites.   [CUSTOMIZE TO THE ONES THEY MENTIONED.]

T3.   Please rate these time savers by importance using the same 0 to 10 scale, where 0 means not at all important and 10 means extremely important. [ROTATE.]

[DEVELOP WORDING AS NEEDED.]

DIRECT - SPECIFY

DIRECT SCORE [0 TO 10]

INDIRECT - SPECIFY

INDIRECT SCORE [0 TO 10]

NONPROG - SPECIFY

NONPROGRAM SCORE [0 TO 10]

[RECORD MAXIMUM SCORES]

DIRECT_____

INDIRECT_____

NONPROGRAM_____

 [IF ONLY ONE OF DIRECT, INDIRECT AND NONPROG IS >=5, THEN SKIP TO NEXT SECTION.]

[ORDER BY IMPORTANCE FROM DIRECT/INDIRECT/NONPROG RANKINGS ABOVE.]

ENERGY SAVINGS SOURCE 1 (MOST IMPORTANT): _____

ENERGY SAVINGS SOURCE 2: _____

ENERGY SAVINGS SOURCE 3: _____

T4. It sounds like you relied on [DIRECT=1: direct NYSERDA program information], [INDIRECT=1: indirect NYSERDA influence] and [NONPROG=1: personal sources].

FACTOR 1 V FACTOR 2 _____

FACTOR 1 V FACTOR 3_____

FACTOR 2 V FACTOR 3_____

[WORDING FOR "FACTOR1" ETC. GIVEN IN T4.]

T5. Comparing FACTOR1 to FACTOR2, was FACTOR1 equally as important, slightly more, moderately more, strongly more or extremely more important than FACTOR2?

1.   EQUALLY IMPORTANT

2.   SLIGHTLY MORE

3.   MODERATELY MORE

4.   STRONGLY MORE

5.   EXTREMELY MORE

[IF THERE ARE 3 FACTORS, MODIFY WORDING TO COMPARE FACTOR 1 AND FACTOR 2, FOLLOWED BY FACTOR 2 AND FACTOR3. ELSE SKIP TO NEXT SECTION.]

MONEY/FUNDING SOURCES

FS1.   What were the funding sources you used to finance the installation of [MEASUREx]? [DO NOT READ. RECORD AS MANY AS APPLY.]

1.   Incentives from HPwES Home Performance or another NYSERDA program

2.   Incentives or rebates from your natural gas or electric utility

3.   Incentives or grant from a municipal or federal program

4.   Federal or state tax credits

5.   Home equity line of credit

6.   Loan from your bank

7.   Personal savings

8.   Incentives from the contractor

9.   Credit card

10A. Anything else? Specify

FS2.Please rate funding sources from the most important to the least important.

[FILL IN AS MANY AN IDENTIFIED IN FS1.]

FUNDING SOURCE 1 (MOST IMPORTANT:_____

FUNDING SOURCE 2: _____

FUNDING SOURCE 3: _____

FUNDING SOURCE 4: _____

FUNDING SOURCE 5: _____

FS3. What was the total cost of installing [MEASUREx]? A rough estimate is fine.
    1. RECORD VERBATIM:
    2. DK/REFUSED

FS4. Approximately how much of the funding came from …. [KEEP ORDER SAME AS IN FS3.]

FUNDING SOURCE 1: _____

FUNDING SOURCE 2: _____

FUNDING SOURCE 3: _____

FUNDING SOURCE 4: _____

FUNDING SOURCE 5: _____

FS5. [IF FINANCING WAS USED; OTW, SKIP TO NEXT SECTION.] How important was the availability of financing in your decision to install [MEASUREx]?

1.   Not important at all

2.   Slightly important

3.   Moderately important

4.   Strongly important

5.   Extremely important

FS6. On the 0 to 10 scale of importance, how would you rate these loan features?

1.   Eligibility requirements

2.   Level of paperwork

3.   Interest rate

4.   Amount of the monthly payment

5.   Loan term

6.   Convenience of making payments

7A.   Anything else? [SPECIFY]

7B.   [0 to 10 SCORE]

[END PROJECT1 LOOP]

****

Additional Questions

A1. Have you noticed a reduction in your energy bills since you installed measures that were recommended in your Home Performance energy assessment?
   1. RECORD VERBATIM RESPONSE: _____
   2. DK/REFUSED

A2. If you wanted to have another energy audit in the future, what is the most you would be willing to pay for the audit? [DO NOT PROMPT]

    1. $500 or more
    2. $400
    3. $300
    4. $250
    5. $200
    6. $150
    7. $100
    8. Other: _____
    9. Nothing

A3. Would your answer change if the cost of the audit were refunded when you moved forward with the audit recommendations?

    1. YES
    2. NO [GO TO A5]

A4. What is the most you would be willing to pay for the audit if it were refunded when you made the recommended upgrades?

    1. $500 or more
    2. $400
    3. $300
    4. $250
    5. $200
    6. $150
    7. $100
    8. Other: _____
    9. Nothing

A5. If you were planning to install other efficiency upgrades in the future, how important would the availability of financing be?

    1. Not important at all
    2. Slightly important
    3. Moderately important
    4. Strongly important
    5. Extremely important

A6. [IF A5 > 1] Using the 0 to 10 scale, what are the most important features of the financing? [RECORD AS MANY AS APPLY.]

    1.   Reasonable eligibility requirements

2. Ease of completing the paperwork

3. Interest rate

4. Amount of the monthly payment

5. Loan term

6. Convenience of making payments

7. Other: _____

8. None of the above

A7. [IF A6=3] What would you consider to be a reasonable range for the interest rate?
1. RECORD VERBATIM RESPONSE: _____
2. DK/REFUSED

A8. Do you currently have access to a loan product that meets your criteria?
1. YES
2. NO

****

EXPLAIN ANSWERS
I have a few follow up questions. We want to be very sure that we are asking our questions the right way so we would appreciate some feedback about the questions I just asked you. We want to make sure the way we are phrasing our questions to be easy to understand.

NOTE TO INTERVIEWER: DEPENDING ON HOW THEY ANSWER THE ABOVE QUESTIONS, YOU SHOULD PLAN TO ASK FOLLOW-UP QUESTIONS, AS NEEDED, TO QUERY ON SPECIFIC PHRASING THEY OFFER. THIS IS THE LESS STRUCTURED PART OF THE INTERVIEW.

EA1. For example, when I asked you. . .

EA2. What was difficult about answering these questions?

EA4. Do you think our questions allowed you to tell us why you made this decision? If not, can you think of other questions we should have asked as to why you made this choice?

[RECORD VERBATIM]

EA5. Is there anything you would like to add about your experience with the GJNGY Home Performance audit?

EA6. On a scale from 1 to 5 where 1 is not at all confusing and 5 is very confusing, how would you rate these questions?

END OF SURVEY: That completes the survey. On behalf of NYSERDA, thank you very much for your time and thoughtful answers today.

APPENDIX E: ANALYTIC HIERARCHY PROCESS (AHP)

AHP was designed to provide a comprehensive structure for complex decision making. The overall strategy is to define the goal, alternatives and priorities, and then conduct a series of pairwise comparisons to identify the relative importance of each element. A relatively simple mathematical process is used to rank the elements. The outcome is a score for each alternative that quantifies its relative value in comparison to the other alternatives.

It allows diverse criteria to be quantified and combined in a consistent way. The framework is as follows:

1. develop a model of the decision making process that defines the goal, the alternatives and the criteria for selecting among them

2. prioritize the selection criteria using pairwise comparisons

3. rank the alternatives through pairwise comparisons within each selection criterion

4. integrate the priorities and the ranking of the alternatives to develop a score for each alternative reflecting the importance of each of the selection criteria and the relative value of the alternative within each selection criterion

5. check for consistency

Pairwise comparisons are the building blocks of AHP and are used at each stage in the model. At the first level, each selection criterion is compared to one other to assess the relative importance. AHP specifies the relationship between two decision making components using a numerical scale, as shown in Table 2. The even numbers can be used for responses that fall between the categories given below (Saaty, 2006). The number of pairwise questions increases with the number of options, with two options requiring one question, and four options requiring six questions.

Table 2: AHP Scale for Pairwise Comparisons

Numerical Scale	Description	Meaning
1	Equal importance	Both factors make the same contribution to the decision.
3	Moderate importance	The favored factor is moderately more important than the weaker factor.
5	Strong	The favored factor is strongly more important.
7	Very strong importance	The favored factor is very strongly more important.
9	Extreme importance	The favored factor is extremely more important.

These results are entered into a matrix and matrix algebra is used to calculate the eigenvector and the normalized score, with all of the scores for a specific priority adding to 1.0. The numerical ratings are entered into the lower right part of the matrix as follows:

1. If the rating is greater than 1 (indicating that the factor is the stronger of the two), the number is directly entered into the matrix.

2. If the rating is 1 (indicating that the factor is the weaker or that the two factors are equivalent), the reciprocal of the rating is entered.

In the corresponding upper left box, the reciprocal of the value entered into the lower right box is entered (Saaty, 2006). This process is unique to AHP. Different scaling mechanisms may be applied, as appropriate (Franek, 2014).

AHP also has a method to calculate the consistency ratio when three or more factors are compared. The consistency ratio compares the maximum of the eigenvalues for the matrix to the average eigenvalues of randomly generated reciprocal matrices.[14] Saaty recommends allowing a consistency ratio of 10% or less to account for variations in human judgment. (Saaty, 2006)

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[14] The method for calculating eigenvalues and the eigenvector can be found in textbooks on linear algebra (such as Anton, 1981), the AHP texts (such as Saaty, 2006) and numerous university Web sites. Saaty (2006) provides a description of exactly how to calculate the consistency ratio.

Estimating the impacts of efficiency interventions over and above the level of naturally occurring efficiency relies on assigning numerical values to subjective decision making. AHP has a number of advantages over previous approaches:

- It is based on a strong theoretical foundation to quantify decision making.

- It relies on questions that can be reliably understood and answered by the respondents.

- The resulting score can be directly applied to program impacts to estimate the "net" impacts of a program.

- It is highly versatile and has the potential to be applied to a wide range of types of energy efficiency interventions, including energy efficiency regulations, codes and labeling.

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.

APPENDIX F: AHP AND BARRIERS APPROACH EXAMPLES

This appendix contains two examples of the AHP:

1. A simple example to illustrate how the AHP works and the calculations are conducted

2. An example of how the Barriers Approach applies AHP to calculate the Pairwise Program Influence Score

Example 1: Analytic Hierarchy Process

A simple illustration of the AHP method is choosing a car. The purchasers are considering three electric vehicles and are planning to make the decision based on cost, reliability and distance per charge and overall fuel efficiency. The characteristics of the cars are described in the table below.

Table 3: Electric Car Characteristics

Criteria	Car A	Car B	Car C
Cost	30,000	45,000	70,000
Reliability	3-year warranty	8-year warranty	8-year warranty
Distance per charge	25 miles	50 miles	235 miles

The analysis has two stages: 1) determine the relative importance of the selection criteria and 2) determine the performance of each car according to the selection criteria. An integrated score for each car is constructed that accounts for the relative importance of each criterion and the performance of the car in comparison to the other alternatives.

The purchasers ranked the criteria in importance from most to least important: 1) cost, 2) distance per charge and 3) reliability. Pairwise questions are constructed to compare them two at a time, resulting in three questions. The results of these comparisons are shown in Table 4.

Table 4. Pairwise Responses for Selection Criteria for AHP Electric Car Example

Row	Criteria 1	Pairwise Rank 1	Criteria 2	Pairwise Rank 2	Response
1	Cost	5	Reliability	1	Cost is strongly more important than distance
2	Cost	3	Distance	1	Cost is moderately more important than reliability
3	Reliability	1	Distance	5	Distance per charge is

The results from this component are the priorities, i.e., the relative ranking of the selection criteria. Using the process described above, these values are entered in a matrix as described below and illustrated in Table 5.

1. Ones are entered on the diagonal.

2. In the first row of Table 4, the column Pairwise Rank 2 (PR 2) contains 1, so the reciprocal of PR 1 (1/5) is entered into the reliability/cost cell in the lower left corner of the matrix.

3. In the second row, PR 2 is 1, so the reciprocal of PR 1 (1/3) is entered into the cost/distance cell in the lower left corner of the matrix.

4. In the third row, PR 2 is 5, so PR 2 (5) is entered into the reliability/distance cell in the lower left corner of the matrix.

5. The top, right section of the matrix is filled in with the reciprocals of the corresponding cells in the bottom left.

The eigenvector is calculated and normalized by dividing each component of the eigenvector by the total of the eigenvector values, as shown in the table below. The priorities indicate that cost is the most important selection criteria, as the priority score is the highest.

Table 5. Priorities Matrix for AHP Electric Car Example

	Cost	Reliability	Distance per Charge	Eigenvector	Priorities (Normalized Eigenvector)
Cost	1	5	3	35.0	0.63
Reliability	1/5	1	1/5	4.5	0.08
Distance	1/3	5	1	16.3	0.29
Totals				55.8	1.000

The process is repeated for each of the three cars within each of the three criteria (for a total of nine pairwise comparisons). The responses are shown in Table 6.

Table 6. Alternatives Matrix for AHP Electric Car Example

Comparison	Criteria	PR 1/ PR 2	Criteria	PR 1/ PR 2	Criteria	PR 1/ PR 2
A/B	Cost	3/1	Reliability	1/5	Distance	1/3
A/C	Cost	7/1	Reliability	1/5	Distance	1/9
B/C	Cost	1/5	Reliability	1/1	Distance	1/7

The same process described above for the criteria is used to construct three matrices and calculate the ratings of each car. The final step is to integrate the results to calculate the overall AHP rank of the alternatives for each car, as shown in the equation and table below.

$$Overall\ AHP\ Rank = \sum_{i=1}^{n}(P_i \times A_i)$$

where   P = priority rank for selection criterion i

A = alternative rank for selection criterion i

n = the total number of selection criteria

Table 7. Summary of Results for AHP Electric Car Example

Car	Cost	Reliability	Distance	Overall AHP Rank	Calculations
A	0.65	0.09	0.06	0.44	(0.63 x 0.65) + (0.08 x 0.09) + (0.29 x 0.06)
B	0.28	0.46	0.15	0.25	(0.63 x 0.28) + (0.08 x 0.46) + (0.29 x 0.15)
C	0.07	0.45	0.79	0.31	(0.63 x 0.07) + (0.08 x 0.45) + (0.29 x 0.79)
Priority	0.63	0.08	0.29		

The outcome of this analysis indicates the purchasers should buy the car with the highest overall AHP rank (Car A at 0.44). This outcome is largely due to the importance of cost in the decision making process. Car C came in as the second choice, as distance per charge was substantially

more important than reliability. The consistency ratios for all of the matrices were under 10%, which is the limit recommended by Saaty.

Example 2: The Barriers Approach

The AHP method can be used to develop a more nuanced assessment of the savings to be attributed to an efficiency intervention. By applying the AHP approach to the process of deciding to install efficiency measures, we can deconstruct the decision making process and quantify program influence. This approach allows us to account for the wide range of elements that contribute to the decision to install measures. Table 8 shows how the AHP elements used in our example above relate to the Barriers Approach.

Table 8. Mapping AHP to the Barriers Approach

AHP Component	AHP Electric Car Example	Barriers Approach Example	Comments
Goal	Select best electric car	Quantify influence of the efficiency intervention	AHP: rank each car individually to select the best car based on the established criteria Barriers Approach: aggregates scores over many participants to quantify influence
Selection Criteria	Desired characteristics	Barriers to installing efficiency measures	AHP: cost, reliability, distance per charge Barriers Approach: money, information, time
Alternatives	Electric cars	Influential factors for overcoming the barriers	AHP: three types of electric cares Barriers Approach: direct influence of the intervention, indirect influence of other utility or regulatory efforts, external influences
Outcome	Overall AHP Rank	Program Pairwise Influence Score	AHP: combines relative importance of criteria with the qualities of each alternative Barriers Approach: combines relative importance of barriers with the intervention and external influences

The steps in the Barriers Approach to investigate the decision-making process and quantify program influence are 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.

An example of the barrier mapping process for one respondent is shown in Table 9. The ranking column shows the barriers in order of importance as identified by the respondent. The pairwise response columns show the respondent's ranking for the favored factor and the reciprocal for the less favored factor (as is entered into the matrix).

Table 9: Ranking Barriers for a Respondent

Highly Ranked Items	Barriers	Ranking	Pairwise Responses
1) Needing information about savings energy and what to install 2) Finding a reliable source of information	Information	#1	Information/Time:1 (roughly equal) Information/Money: 5 (information is strongly more important)
1) Finding time for research	Time	#2	Time/Money:3 (time is moderately more important) Time/Information:1 (equal)
No options were ranked above 5 on the 0-10 scale	Contractor	No ranking	Not included in pairwise comparisons
1) Figuring out how to pay for the efficiency upgrades	Money	#3	Money/Information: 1/5 (reciprocal of information/money) Money/Time: 1/3 (reciprocal of time/money)

The results from this component are the Barrier Scores, *i.e.*, the relative ranking of the barriers. Using the process described above, these values are entered in a matrix as described below and illustrated in Table 9.

1. Ones are entered on the diagonal.
2. In the first row of Table 6, the column Pairwise Rank 2 (PR 2) contains 1, so the reciprocal of PR 1 (1/5) is entered into the reliability/cost cell in the lower left corner of the matrix.
3. In the second row, PR 2 is 1, so the reciprocal of PR 1 (1/7) is entered into the reliability/cost cell in the lower left corner of the matrix.

4. In the third row, PR 2 is 3, so PR 2 (3) is entered into the reliability/distance cell in the lower left corner of the matrix.

5. The top, right section of the matrix is filled in with the reciprocals of the corresponding cells in the bottom left.

The eigenvector is calculated and normalized by dividing each component of the eigenvector by the total of the eigenvector values, as shown in the table below. The priorities indicate that cost is the most important selection criteria, as the priority score is the highest.

The barriers matrix and solution are presented in Table 10. The Barrier Scores are the normalized eigenvector and represent the relative importance of each barrier.[15] The consistency ratio is 2%.[16]

Table 10: Barriers Pairwise Matrix

	Information	Time	Money	Eigenvector	Barrier Scores
Information	1	1	5	1.71	48%
Time	1	1	3	1.44	41%
Money	1/5	1/3	1	0.41	11%

This example includes two options for program contribution: program and nonprogram influences. As the matrix algebra is simple, the responses and results are combined in Table 11. With only two options, there is no need for a consistency check.

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[15] In this example, the linear scale from the Saaty text was used, i.e., the values on the 1-9 scale were directly entered into the matrix. However, the final PPIS for the cognitive interviews were calculated using the balanced scale with values of {1:1; 2:1.22; 3:1.5; 4:1.86; 5:2.33; 6:4.5; 7:5.67; 9:9}, *e.g.*, if the respondent selected 5 on the 1-9 scale, 2.33 was entered into the matrix. (Franek, 2014) The balanced scale was selected as the weights from the linear scale are unequally dispersed. For a two by two matrix, selecting 5 (the midpoint) on the 1-9 linear scale gives the favored barrier a weight of 83%,; the same entry on the balanced scale gives the favored barrier a weight of 70% (halfway between equal weights [50%] and the top of the scale [90%]). The wording of the pairwise questions was modified to reflect the balanced scale.

[16] The consistency ratio compares the maximum of the eigenvalues for the matrix to the average eigenvalues of randomly generated reciprocal matrices. Saaty (2006) provides the details of how to calculate the consistency ratio.

Table 11: Program Contribution Matrix

Component	Influential Factors on Decision to Install	Program Ranking	Pairwise Responses	Program Contribution Score
Information	Energy audit (program) Nonprogram contractor	Program ranked #1 Nonprogram ranked #2	Program/NP: 7/1	88%
Time	Energy audit Personal time management	Program ranked #2 Nonprogram ranked #1	NP/Program: 3/1	25%
Money	No program influence	Nonprogram ranked #1	No pairwise	0%

For this example, the Pairwise Program Influence Score is 52%, as shown in the following equation.

$$\text{PPIS} = (\text{BS}_{info} \text{ x } \text{PC}_{info} + \text{BS}_{time} \text{ x } \text{PC}_{time} + \text{BS}_{money} \text{ x } \text{PC}_{money})$$
$$= (0.48 \text{ x } 0.88 + 0.41 \text{ x } 0.25 + 0.11 \text{ x } 0.00) = 0.52$$

The PPIS can be applied to the evaluated gross program impacts to estimate the net impacts.