NYSERDA 2007-2008 EMPOWER NEW YORK[SM] Program Impact Evaluation Report

Final

Prepared for

The New York State
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ABSTRACT

To reduce the energy burden on income-qualified households within New York, NYSERDA offers the EmPower New York[SM] (EmPower) program, a retrofit program that provides cost-effective electric reduction measures (*i.e.*, primarily lighting and refrigerator replacements), and cost-effective home performance measures (*i.e.,* insulation, air-sealing, heating system repair and replacement, and health and safety measures) to income qualified homeowners and renters. The purpose of this impact evaluation of the EmPower program is to establish first year energy savings for program years 2007 and 2008.

The primary vehicle for estimating savings was an analysis of utility consumption and billing data covering the pre- and post-installation periods. The rigorous analysis had multiple components with both internal and external validation to ensure that the results of the billing analysis were within a reasonable range. All of the supplemental activities support the use of the results from the full billing model.

In addition, a pilot effort to assess free ridership (FR) and spillover (SO) in the low income market was conducted using self reports obtained through a telephone survey of EmPower participants, as is consistent with the approach used in other NYSERDA evaluations. Since this was a pilot effort and the result was so close to 1.00, the evaluated gross savings are reported for this program without any adjustments for net effects; however it is possible that the magnitude of the net effects may change in the future.

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GLOSSARY OF ACRONYMS AND DEFINITIONS[1]

AAPOR - American Association for Public Opinion Research – A leading association of public opinion and survey research professionals.

ANCOVA (Analysis of Covariance) - A type of regression model also referred to as a "fixed effects" model. This model allows each individual to act as its own control. The unique effects of the stable but unmeasured characteristics of each customer are their "fixed effects" from which this method takes its name. These fixed effects are held constant.

Autocorrelation - Autocorrelation occurs when observations in a regression model are not independent; the consequence of uncorrected autocorrelation is typically higher calculated statistical precision than is actually the case

Billing Analysis - Estimation of program savings through the analysis of utility billing records comparing consumption prior to program participants and following program participation. This term encompasses a variety of types of analysis, from simple pre/post to complex regressions.

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.

Construct Validity - The extent to which an operating variable/instrument accurately taps an underlying concept/hypothesis, properly measuring an abstract quality or idea.

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) - Proportion of variability in a regression data set that can be explained by the model

Correlation Coefficient (R) - A measure of the linear association between two variables; in linear regression, it is the square root of the coefficient of determine and measures the linear relationship

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[1] Much of this report's Glossary is taken from the *2004 California Evaluation Framework*, which was prepared for the California Public Utilities Commission and the Project Advisory Group in September 2004 by a Team led by TecMarket Works and included a lead role by one of the authors of this report from Megdal & Associates.

[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.*

between the response (dependent) and predictor (independent) variables; the sign indicates whether the relationship is positive or negative.

DHW - domestic hot water

FR - Free Riders, Free Ridership - A program participant who would have implemented the eligible measure or practice in the absence of the program.

Heteroskedasticity - Heteroskedasticity occurs in a regression model when there are subpopulations with the model with unequal variances; heteroskedasticity tends to increase the reported variance from the model and may be a sign of model misspecification.

Model Misspecification - This covers large areas of regression misapplication in which the model chosen omits relevant explanatory variables, includes irrelevant explanatory variables, ignores qualitative changes in explanatory variables, or accepts regression equations with incorrect mathematical form.

NTG, NTGR – Net-to-Gross, Net-to-Gross Ratio – The relationship between net energy and/or demand savings, where net is measured as what would have without the program, what would have occurred naturally, and gross savings (often evaluated savings). The NTGR is the ratio of net savings to gross savings. For NYSERDA programs the NTGR is defined as one minus free ridership plus spillover (1 – FR + SO).

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.

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)).

SO – Spillover: Includes **Participant Inside Spillover (ISO)** and **Participant Outside Spillover (OSO)** and **Non-Participant Spillover -** Reductions in energy consumption and/or demand caused by the presence of the energy efficiency program, beyond program related gross savings of participants.

- "Inside" spillover occurs when, due to the project, additional actions are taken by the participant to reduce energy use at the same home, but these actions are not included as program savings.
- "Outside" spillover occurs when an actor participating in the program initiates additional actions that reduce energy use at other sites that are not participating in the program.
- "Non-participant spillover" is the reductions in energy consumption and/or demand from measures installed and actions taken or encouraged by non-participating vendors or contractors because of the influence of the program

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[5] *Ibid.*

[6] *Ibid.*

EXECUTIVE SUMMARY

This report provides a detailed description of the impact evaluation of the NYSERDA EmPower Program conducted for program years (PY) 2007 and 2008. The Executive Summary provides a brief overview of the evaluated savings, followed by a description of the Program, the evaluation approach, context and issues, and a discussion of the evaluation components.

OVERVIEW OF EVALUATED SAVINGS

The evaluated program savings were estimated from the full billing models; the final results are shown in Table ES- 1. The EmPower Program saved 11,295,798 annual kWh of electricity and 64,095 annual MMBtu of non-electric (fossil) fuels from projects completed during program years 2007 and 2008. The realization rates are 54% and 70% for the electric and natural gas and other fossil fuel savings, respectively.[7] These results are based on all homes with sufficient and reliable utility billing records. Consequently, the 90% confidence intervals of 7.2 and 12.5 presented in Table ES- 1 reflect the variability within the models, not the sampling precision.

Table ES- 1. Summary of EmPower Program Reported and Evaluated Savings

	Annual Electric Savings (kWh/Yr)	Summer Peak Demand Savings (kW)	Annual Non-Electric Savings (MMBtu/Yr)
Evaluated Savings	11,295,798	1,203	64,095
Lower 90% Confidence Limit	10,482,145	1,110	56,054
Upper 90% Confidence Limit	12,109,450	1,295	72,136
NYSERDA Program Reported Savings	20,819,574	2,123	91,602
Realization Rate	54%	57%	70%
90% Confidence Interval on Realization Rate[1]	±7.2%	±7.7%	±12.5%

[1] The confidence band on the realization rate reflects variability in the models, not sampling precision, as no sampling was conducted for this analysis. All homes with sufficient billing records were included in the models.

Average program savings per household were compared to the average annual residential use and pre-installation average annual use of homes in the billing model, as shown in Table ES- 2. As a group, EmPower participants use more energy than the average residential customer and saved approximately 9% of their total energy use.

[7] It was not possible to conduct a billing analysis for the heating-related measures for homes with an oil or propane primary heating system due to the complexity of obtaining and interpreting the billing and delivery records. Given the similarity in the analysis of heating-related loads, the realization rates for the heat-related measures from the natural gas analysis were be applied to the savings estimates for oil and propane heated homes. This strategy is based on the assumption that the accuracy (level of bias) of the algorithms used by the Program for estimating oil and propane savings is the same as those applied by the Program for natural gas heated homes.

Table ES- 2. Comparison of Residential Annual Consumption and EmPower Program Savings

	New York State Residential Average Consumption per Home (2005)[1]	Participant Average Consumption per Home Prior to EmPower Services (Billing Model)	EmPower Evaluated Annual Savings per Home	Evaluated Savings as % of Annual Consumption
Annual Electric Consumption and Savings (kWh)	6,882	7,792	694	9%
Annual Natural Gas Consumption and Savings (MMBtu)	71	109	10	9%

[1] Patterns and Trends: New York State Energy Profiles: 1995 to 2009, NYSERDA, January, 2011, Appendix B

For EmPower, as is the case for many low income efficiency retrofit programs, the assumption has been that the net-to-gross ratio (NTGR) is 1.0, that is, that the program does not have free riders or spillover. A pilot net-to-gross (NTG) study was conducted to assess the validity of this assumption. The pilot effort indicates that both free ridership and spillover occur within the low income population. The NTG approach was consistent with the methods used in the evaluation of other NYSERDA programs, and the results indicate a free rider rate of 17% and spillover of 14%, for a combined NTG of 0.97. The program savings were not adjusted by the NTG ratio since this initial study was designed as a pilot. In addition, the NTG ratio of 0.97 is extremely close to the value of 1.00 currently in use.

The evaluation results (both net and gross savings) were developed through a rigorous analysis involving many components. Following the program description, each of the major components of the study is discussed below in context of its contribution to the final savings estimate.

PROGRAM DESCRIPTION

To reduce the energy burden on income-qualified households within New York, NYSERDA offers the EmPower New York^{SM} (EmPower) Program, a retrofit program that provides cost-effective electric reduction measures (*i.e.*, primarily lighting and refrigerator replacements) and home performance measures (*i.e.,* insulation, air-sealing, heating system repair and replacement, and health and safety measures) to income qualified homeowners and renters. Expanding on the implementation of energy reduction measures, the Program delivers in-home energy use education which provides customers with additional strategies for managing their energy costs. The Program installs cost-effective efficiency measures for low-income households at no cost to the participant.

Electric customers who live in single family or multifamily buildings with 100 units or fewer, and either participate in a utility payment assistance program or have a household income below 60% of State median, are eligible.

EVALUATION APPROACH

The purpose of this impact evaluation was to establish first year energy savings for projects completed in program years 2007 and 2008. The primary vehicle for estimating savings is an analysis of utility billing records covering the pre- and post-installation periods. In addition, the evaluators estimated savings by major measure group and assessed the realization rates for each measure group to provide feedback to program implementers for identifying and addressing specific issues in the field.

A pilot effort to assess free ridership and spillover in this market was conducted. In other jurisdictions, low income programs are assumed to have a net-to-gross (NTG) factor of 1.0. This assumption has been

brought into question by a prior NYSERDA study[8] and also an evaluation of the Low Income Energy Efficiency program in California.[9] Consequently, a participant telephone survey was conducted to assess net impacts through self reports, as is consistent with the approach used in other NYSERDA evaluations.

EVALUATION CONTEXT AND ISSUES

Billing analysis was selected for EmPower due to the characteristics of the Program. Billing analysis is appropriate for retrofit programs where energy-intensive equipment is removed and replaced with high efficiency alternatives and also when the program savings are expected to be 8% or more of the total consumption. EmPower meets both of these criteria.[10]

Bias and sampling precision are two critical factors that affect the underlying reliability of evaluation results. For a large scale regression model, as was conducted for the EmPower Program, there is no sampling as all participants with sufficient billing history are included in the models. Thus, the primary concern for this evaluation was the possibility of bias.

Two primary types of bias were considered by the evaluation. The degree of each of these sources of bias was considered and investigated in the evaluation. The first potential source of bias is that participants without available or sufficient consumption history were excluded from the model.

Due to a variety of issues, many homes had to be removed from the billing models. One major source of attrition was created by the inability of the utilities to locate many EmPower participants in their respective billing systems; this type of error is random and would not be expected to introduce bias into the results. The potential impact of this source of attrition was considered through comparing the model participants to total participants by a few key parameters, which indicated that distribution of homes in the billing models was similar to program participants as a whole.

The other major source of attrition occurs when participants move from one location to another. Since the billing models require about two years of uninterrupted billing records before and after treatment through the program, participants who move often were eliminated from the billing models. While specific participants may no longer be located at the residence, it is likely that the EmPower measures continue to save energy, either as the previous participants took portable devices with them to the new residence or as the current residents have the advantage of living in a more efficient home. There is no way to assess the impact of this effect, or modify the billing models to address it.

Another possible source of bias is that external influences, such as economic factors or changes in household composition, could drive changes in energy consumption. Modeling results, from restricted and full billing models as described below, suggested that external influences did not exert a clear upward or downward bias on the savings estimates.

The final electric and natural gas billing models included 38% and 23% of EmPower participants, respectively. While the attrition was high, the billing models included many homes (more than 4,500

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[8] 2005 New York Energy Smart Annual Program Evaluation and Status Report, Report to the System Benefits Charge Advisory Group Final Report, March 2006. Section 6, Table 6-2.

[9] "Impact Evaluation of the 2005 California Low Income Energy Efficiency (LIEE) Program," prepared for SCE, PG&E, SDG&E and Southern California Gas by West Hill Energy and Computing, Inc, August, 2008. See Chapter 8, Section 8.6.6.

[10] TecMarket Works. *2004 California Evaluation Framework*, prepared for the California Public Utilities Commission and the Project Advisory Group, September 2004, page 101.

homes for the electric model and 1,100 for natural gas). Thus, the models were sufficiently large to ensure that a wide range of Empower participants were reflected and that program savings could be estimated. This evaluation did not include participant households that moved within one year of treatment; consequently, it is not possible to determine if savings associated with these participants differs from savings measured in the model.

EVALUATION COMPONENTS

The impact evaluation has three major components:

1. a full billing analysis of all participants with sufficient billing history (full regression model)
2. a restricted billing analysis including only participants who responded to the telephone survey
3. a pilot study of free ridership and spillover

Two telephone surveys of participants were conducted: one to support the restricted billing model and a second survey to obtain information for the NTG analysis. Each of the components is described briefly below.

Full Billing Analysis

The full billing analysis was the primary method of estimating the evaluated gross savings. All participants with sufficient and reliable billing records were included in a fixed effects regression model, which was selected to address house-to-house differences in use. A variety of modeling configurations were tried, beginning with the simplest configuration to estimate savings by household and moving to the inclusion of additional variables to model the installation of specific measure groups. The models were evaluated according to the statistical methods specified by the information-theoretic approach and also the ability to improve the estimation of savings. The evaluated gross savings by measure group, household and for the Program as a whole were based on the results from this model.

The full model was also run with both participants and non-participants to compare results. Non-participants were defined as EmPower 2009 participants prior to their participation, *i.e.*, only billing data during the pre-installation period were used. These "future" participants are expected to match closely to the PY07/08 participants, and consequently, are a reasonable comparison group. With the understanding that the results from the combined model may include net effects, the model estimators were compared for illustrative purposes.

In addition, trend lines were added to the full billing analysis to reflect the change in unemployment rate and gasoline prices over the period. The monthly unemployment rate and gasoline price were obtained from the Department of Labor and the U.S. Energy Information Administration (EIA) web sites, respectively.[11]

Energy Change Participant Survey and Restricted Billing Analysis

A telephone survey of participants was conducted to assess non-program related changes made during the analysis period to include in the restricted model. The purposes of the survey are listed below:

1. to assess non-program-related changes that occurred within the home during the analysis period that may have affected energy consumption

[11] Links are at Department of Labor and US Energy Information Administration.

2. to confirm or determine the presence and use of major energy-using appliances
3. to assess whether the measures installed through the EmPower Program are still in place

The individual responses were used to populate the restricted regression model. Efforts were made to minimize non-response by attempting to contact participants multiple times at different times of day.

A total of 659 surveys were completed, including 400 respondents with complete natural gas billing data and 600 with electric billing data.[12] The initial intention was to achieve 600 completed surveys for each model; however implementation of the survey was more difficult than anticipated. Many of the phone numbers were not in service, making it impossible to reach a high proportion of the sample frame. For the natural gas model, the entire sample frame of approximately 1,300 participants was contacted to achieve the 400 completes. The results of the survey are summarized and presented in Appendix C.

The restricted billing analysis was conducted only using the 659 participants who completed the energy change telephone survey (400 homes for the natural gas model and 600 homes for the electric model). The purpose of the restricted billing analysis was to determine whether more information about the within home variations allowed us to identify potential sources of bias in the estimated savings.

Through the participant telephone survey, it was possible to associate certain types of changes with specific homes over the analysis period. The restricted billing analysis was conducted by modeling the changes and comparing the energy savings per household for each scenario. All model results were compared against the base case, which included only the variables available from the program tracking data and the NOAA weather files, *i.e.*, only the variables that could be included in the full regression model.

NTG Pilot

Low-income programs are often assumed to have no free riders or spillover based on the belief that occupants cannot afford to take any of these actions without the program, and free ridership and spillover are set to zero. This evaluation included a pilot project to test this assumption. A participant survey was designed to follow prior NYSERDA free ridership and spillover inquiries and measurement used in evaluating NYSERDA's other residential energy efficiency retrofit program serving existing homes, Home Performance with ENERGY STAR®. Using questions and an algorithm already tested with known free ridership findings from another NYSERDA residential population ensured that the results from the EmPower free ridership and spillover test could be compared to evaluated NTGR's from NYSERDA's other residential program impact evaluations.

RESULTS

The restricted model demonstrated that the within home variations do not introduce a bias into final estimated savings. In addition, the results from the full billing model were tested for the effects of external influences by incorporating a comparison group of non-participants in the model and also by adding trend lines to the participant model. These analyses did not indicate a clear directional bias. Thus, the results of the full billing model are a reliable estimate of program savings.

[12] A total of 314 respondents had both complete natural gas and electric consumption data and were used in both billing models.

Savings by Measure Group

Both the electric and natural gas models were run twice, once with all of the measure groups from the final model and once to estimate total household savings. The total savings from the household models were slightly higher than the savings as calculated by adding the measure groups. This result may be due to additional savings from behavioral changes or simply savings that are occurring in the homes but cannot be properly assigned to a specific measure. Given that EmPower is a comprehensive audit program and many measures are installed in each home, attempting to separate the savings into each measure group through billing analysis is complex and some uncertainty remains in the measure-level estimates of savings. The measure groups included in the final models are described in Table ES- 3 below.

Table ES- 3. Measure Group Definitions

Measure Group	Description	Fuel Saved	Fuel with Extra Use
Clothes Dryer Fuel Switch	Replacement of an electric clothes dryer with a natural gas clothes dryer	Electricity	Natural gas
Water Heating Conservation	Pipe wrap, low flow showerheads, tank wraps	Electricity or natural gas, depending on the water heater fuel in the home	None
Water Heating Fuel Switch	Replacement of an electric water heater with a fossil fuel water heater (most common) or replacement of a fossil fuel water heater with an electric water heater	Electricity or natural gas, depending on the existing water heater fuel in the home at the time of the audit	Electricity or natural gas, depending on the fuel type of the new water heater installed through the Program
Water Heater Repair	Repairs to the existing water heater	Electricity or natural gas, depending on the water heater fuel in the home	None
Envelope	Installation of additional insulation and blower-door assisted air sealing	Electricity or natural gas, depending on the fuel used for space heating	None
Heating System Fuel Switch	Replacement of an electric space heating system with a fossil fuel heating system	Electricity	Natural gas
Heating System Repair or Replacement	Repair or replacement of the space heating system	Electricity or natural gas, depending on the fuel used for space heating	None
Lighting	CFL and hardwired fixtures	Electricity	None
Refrigeration	Refrigerator replacement and freezer replacement	Electricity	None
Thermostat	Replacement of a manual thermostat with a programmable thermostat	Natural Gas	None
Other	Miscellaneous small measures that do not fit into the categories listed above	Electricity or Natural Gas	None

Electric Model Results

Table ES- 4 shows the savings by measure group and by household for the homes included in the electric model. The savings per household from measure groups was 47% compared to 57% for the savings from the household only model. The two measures that comprise the majority of the total program reported electricity savings, lighting and refrigerator replacement had realization rates for electricity savings of 31% and 55%, respectively. Since there was no sampling and all participants with sufficient and reliable billing data were included in the model, the confidence intervals reflect the variability in the model, not the sampling precision.

Table ES- 4. Electric Savings by Measure Group from the Electric Billing Model

Measure Group	Program Savings per Home (kWh/Year)	Evaluated Savings per Home (kWh/Year)	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Realization Rate
Lighting	419	130	124	136	31%
Refrigerator Replacement	1,040	569	511	628	55%
Water Heating Conservation	323	153	0	306	47%
Water Heater Repair	195	727	369	1,085	373%
Water Heating Fuel Switch	3,803	3,663	3,189	4,136	96%
Clothes Dryer Fuel Switch	2,451	1,739	1,483	1,995	71%
Other Electric Measure	840	407	-101	916	48%
Heating System Fuel Switch	6,236	8,557	8,184	8,929	137%
Savings per Household from Measure Groups	1,197	566	523	610	47%
Savings from Household Only Model	1,197	685	610	759	57%

Natural Gas Model Results

Table ES-5 contains the measure group savings for the natural gas model. The savings per household from measure groups was 64% and for the savings from the household only model it was 68%. While the overall savings in the model are reasonably consistent across the modeling options, the split of the savings between water heating and space heating measures tended to vary. Consequently, the household savings are reliable, but the savings associated with specific measure groups are somewhat variable. The water heating measures tend to show high variability (wide confidence intervals); however, since these measures are a small proportion of the total program reported savings (5%) and the total program reported savings reflect savings from the household model, this result is unlikely to introduce a bias to the evaluated savings.

Table ES- 5. Natural Gas Savings by Measure Group from the Natural Gas Billing Model

		Regression Results			
Measure Group	**Program Savings per Home (MMBtu/Yr)**	**Evaluated Savings per Home (MMBtu/Yr)**	**Lower 90% Confidence Limit**	**Upper 90% Confidence Limit**	**Realization Rate**
Water Heating Conservation	1.8	2.8	8	48	156%
Water Heater Repair	1.9	5.9	16	103	311%
Water Heating Fuel Switch Extra Use[1]	(18.1)	(4.1)	(241)	160	23%
Heating System Repair	10.3	11.0	92	127	107%
Envelope Measures	26.1	14.8	135	160	57%
Programmable Thermostats	8.3	2.4	1	47	29%
Savings per Household from Measure Groups	21.6	13.8	124	152	64%
Savings from Household Only Model	21.6	14.6	133	159	68%

[1] Fuel switching extra natural gas use occurs when an electric water heater is switched to a natural gas water heater; in these situations, there are substantial electric savings and additional natural gas use.

Evaluated Program Savings

Total evaluated program savings are based on the results from the billing analysis model. Evaluated program savings were augmented to include the extra savings found in the household models that could not be assigned to specific measures. The process of calculating total evaluated program savings was conducted in two steps:

1. the realization rates for each measure group were applied to the evaluated program savings by measure group
2. the unassigned savings per household were added for all households with savings

Measures that were excluded from the model because none of the participants in the model had installed the measure (such as waterbed measures) were assumed to have a realization rate of 1.0. These measures account for less than 1% of the total program reported savings. The realization rates from the natural gas model were applied to all measures with MMBtu savings, regardless of the fuel type. Since this evaluation is for SBC-funded measures, the total program reported savings include only those measures, *i.e.*, measures funded through other programs such as the National Grid natural gas program, were removed from the analysis.

NTG Pilot Study Results

The pilot study of net effects clearly demonstrated that there are net effects associated with the EmPower Program. With an estimated FR rate of 17% and spillover of 14%, the overall NTGR is 0.97, which is very close to the current estimate of 1.00. Since this was a pilot effort and the result was so close to 1.00, the evaluated gross savings are reported for the Program without any adjustments for net effects. However, this study reflects the results for program years 2007 and 2008, and it is possible that the magnitude of the net effects may change in the future.

Additional Research Components

Three other research components were also included as part of this evaluation. The NTG survey included questions to assess whether the economic upheaval of the last four years may have had an impact on self-reports of free ridership. The survey responses do not demonstrate that the recent economic uncertainty affected the self-reports of free ridership.

This evaluation also investigated the relationship between program activities, net effects and the growing awareness of energy efficiency. This analysis found that increased knowledge of energy efficiency due to the Program was related to higher spillover among participants, which further strengthens the ties between the Program and the additional measures installed in homes with spillover.

The Energy Change Survey included a series of questions regarding the ability of participants to pay utility bills. This survey was fielded to improve the billing models, and thus was administered to participants with eighteen months or more of utility bills at the same address. This approach suggests that the respondents may be more stable than EmPower participants as a whole and thus not necessarily representative of the EmPower population.

Even with this caveat, the results are worthy of note. Sixty-seven percent of the 629 survey respondents with responsibility for the bill reported that it was difficult to pay their natural gas bills prior to participation in the EmPower Program, and almost half of these participants responded that the EmPower Program has improved their ability to make payments. Among participants with difficulties in making natural gas bill payments prior to EmPower participation, there was a marked increase in the number of respondents able to pay their bills in full and on time (from 51% to 64%), and a dramatic decrease in the number who are no longer struggling to make the payment each month (from 16% to 5%). These results suggest that the EmPower Program is making a valuable contribution to low income participants that goes beyond the energy savings alone.

Section 1:

INTRODUCTION

The **New York Energy $mart**[SM] programs are funded by an electric distribution System Benefits Charge (SBC) paid by customers of Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., New York State Electric and Gas Corporation, National Grid, Orange and Rockland Utilities, and Rochester Gas and Electric Corporation. The programs are available to all electric distribution customers that pay into the SBC. The New York State Energy Research and Development Authority (NYSERDA), a public benefit corporation established in 1975, began administering the SBC funds in 1998 through NYSERDA's **New York Energy $mart**[SM] Program.

This report provides a detailed description of the impact evaluation conducted for NYSERDA's New York[SM] Program (EmPower) for program years 2007 and 2008. There are four sections to this report. The introduction provides a brief description of the main objectives of the impact evaluation, the evaluation approach, and a discussion of the context for the evaluation. Section 2 contains a description of the EmPower Program, a summary of EmPower accomplishments during that timeframe, a discussion of the characteristics of the population and details about the development of the homes included in the billing analysis models. Section 4 details the methods, followed by the results and conclusions in Section 5.

1.1 EVALUATION OBJECTIVES

The purpose of the impact evaluation is to establish per household first year energy savings for PY2007 and 2008 participants and to develop initial estimates of free riders and participant spill over. Savings by major measure group were estimated, providing some insight into whether specific measures groups are more or less likely to achieve the expected savings. In addition, a pilot study of attribution was conducted based on self-reports from program participants.

In comparison to the last Measurement and Verification analysis conducted on the Program in 2007, the sample size has increased dramatically from 20 site visits to a billing analysis of all participants, as well as incorporating a more focused billing analysis of a sample of approximately 600 households and a pilot study of attribution (which had not been addressed by prior evaluations).

1.2 EVALUATION APPROACH

The impact evaluation has three major components:

1. a full billing analysis of all participants with sufficient billing history (full regression model)
2. a restricted billing analysis including only participants who responded to the telephone survey
3. a pilot study of free ridership and spillover

Two telephone surveys of participants were conducted, one to support the restricted billing model and a second to obtain information for the NTG analysis.

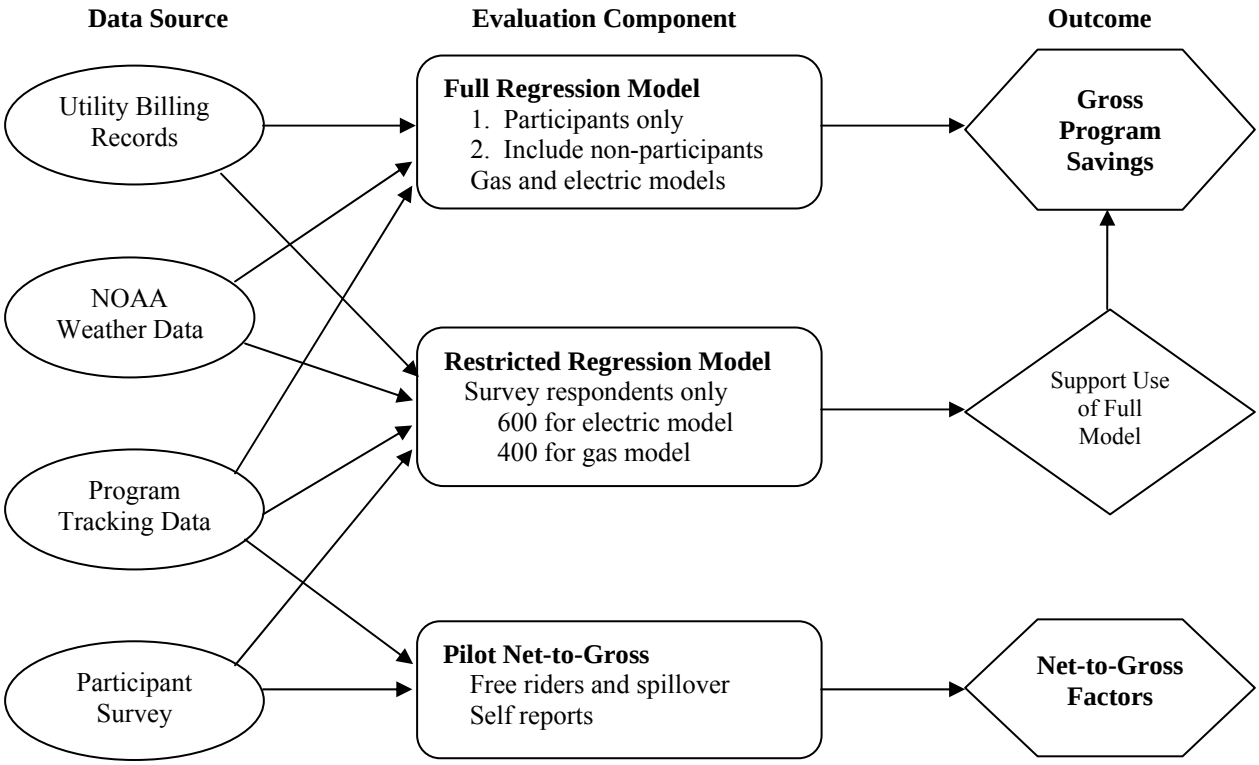
The primary method of estimating program impacts was the full billing analysis. The Energy Change Survey and restricted billing analysis support the validity of this approach. The NTG pilot was designed to assess whether EmPower, as a low income program, has non-zero free ridership and spillover.

The evaluation required data from four primary sources:

1. program data on measures installed in each home and characteristics of the homes
2. billing records from the utilities
3. weather data
4. participant surveys

The contribution of each data source to the final results is shown in Figure 1-1.

Figure 1-1: Evaluation Components, Data Sources and Outcomes



1.3 EVALUATION CONTEXT AND ISSUES

Billing analysis was selected for EmPower due to the characteristics of the Program. Billing analysis is appropriate for retrofit programs that meet two criteria: 1) energy-intensive equipment is removed and replaced with high efficiency alternatives and 2) the program savings are expected to be 8% or more of the total consumption[13]. EmPower meets both of these criteria.

[13] TecMarket Works. *2004 California Evaluation Framework*, prepared for the California Public Utilities Commission and the Project Advisory Group, September 2004, page 101.

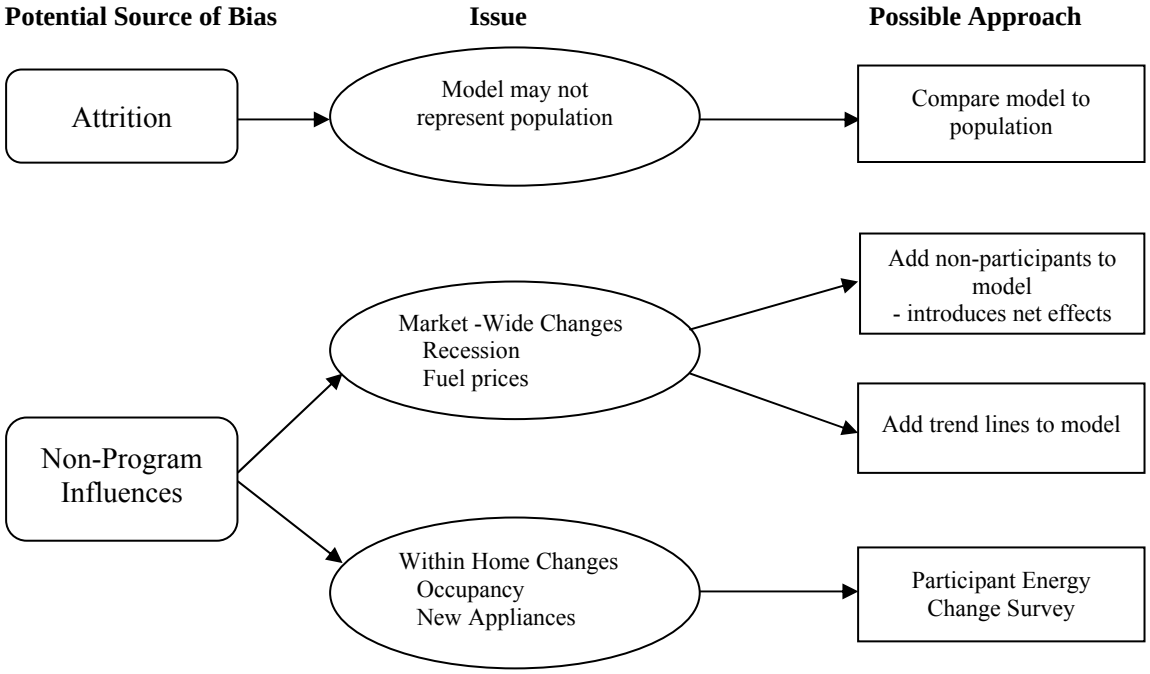
Bias and sampling precision are two critical factors that affect the underlying reliability of evaluation results. For a large scale regression model, as was conducted for the EmPower Program, there is no sampling as all participants with sufficient billing history are included in the models. Thus, the primary concern for this evaluation was the possibility of bias.

The primary sources of potential bias are as follows:

- the final list of participants who have sufficient billing history and are included in the model may not be representative of the entire program population
- some external (non-program) influences may affect energy use but cannot be directly included in the regression models

The potential sources of bias and strategies for identifying the degree of bias are described in Figure 1-2 below and discussed in more detail in the following paragraphs.

Figure 1-2: Sources of Bias and Strategies for Mitigation



1.3.1 Attrition

To conduct a billing analysis, the preferred approach is to include one year of pre- and one year of post-installation billing records for each participant. While this rule of thumb is not immutable, it is important to ensure that critical periods (such as the deep winter for the natural gas model) are included in both the pre- and post-periods. For EmPower and other low income programs, a segment of the population is often quite mobile and obtaining sufficient billing history is simply not possible. In addition, the models work best when the housing units are similar, and thus master-metered multifamily buildings or mobile

home parks cannot be included in the analysis.[14] Other similar evaluations have found that about 40% to 60% of the program participants may be eliminated for these reasons.[15]

The EmPower attrition results were similar to other low income evaluations in one major respect, *i.e.*, about 50% of the participants with billing data provided by the utilities could not be included in the model. However, EmPower is different from utility programs in that program services are delivered to EmPower participants by NYSERDA rather than directly through the electric or natural gas utilities. This arrangement had the unanticipated consequence of adding a layer to the process of obtaining the billing records, which resulted in additional attrition due to the fact that some EmPower participants could not be identified in the utility billing systems. This added layer of attrition was substantial and resulted in two utilities (representing 2% of program participants) being removed from the billing analysis in their entirety.

When the modeling was underway, it also became clear that the billing data from an additional two utilities contained many unidentified estimated reads and reconciliations, thus breaking the direct relationship between consumption and the weather impacts during the specific billing periods. The final models were run both with and without these two utilities and the final savings are based on the model without the two utilities.

Since EmPower had a total of more than 17,000 participants during program years 2007 and 2008, the final models were well populated, with over 4,500 participants in the electric model and over 1,100 in the natural gas model. The potential ramifications, and methods for addressing, the potential sources of bias are discussed below.

- EmPower staff has been very clear that the delivery of EmPower services is consistent across utilities. Thus, we would not expect savings to vary by utility territory, other than the natural variations due to housing stock and weather, and weather variables are directly incorporated into the model. The exclusion of specific utilities accounting for 2% of the population would not be expected to bias the model.
- The attrition caused by the inability to identify EmPower participants in the utility billing systems would not be expected to bias the results. The mismatch of account information would be expected to be random and should not be associated with any specific characteristic of the home or participant.
- The participants in the billing models were compared to the population of participants on a few key variables to assess whether there were substantial differences. The homes in the billing models were found to compare reasonably closely to all homes in the Program by house type and percent of owners and renters, as discussed in more detail in Section 2.5.

As is common with the billing analysis of low income programs, there are some potential sources of bias that cannot be readily addressed or quantified. Master-metered units, generally apartments and mobile home parks, could not be included in the model. This omission could introduce bias to the extent that there are systematic differences between the individually- and master-metered units and these differences

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[14] While master-metered units were excluded from the billing analysis, individually metered mobile homes and apartment units with complete billing data were included in the billing models. As discussed below, the distribution of housing types in the billing models was similar to all EmPower participants.

[15] *Impact Evaluation of the 2005 California Low Income Energy Efficiency Program*, Final Report, prepared for Southern California Edison Company by West Hill Energy & Computing, Inc., August 2008

result in lower or higher savings. In the absence of sufficient master-metered facilities that were treated by EmPower and also have complete billing history, it was not possible to test whether there is any bias associated with the removal of master-metered units. However, almost 70% of EmPower participants live in single family homes, and apartments and mobile homes were represented in the billings models at a similar proportion as found among all program participants. In addition, large apartment buildings of 100 or more units are not eligible for services through EmPower. These program characteristics suggest that the differences between master- and individually-metered units would have be quite substantial to introduce bias into the final results.

Another major source of attrition occurs when participants move from one location to another. Since the billing models require about two years of uninterrupted billing records before and after treatment through the Program, participants who move often were eliminated from the billing models. While specific participants may no longer be located at the residence, it is likely that the EmPower measures continue to save energy, either as the previous participants took portable devices with them to the new residence or as the current residents have the advantage of living in a more efficient home. There is no way to assess the impact of this effect, or modify the billing models to address it.

1.3.2 External Influences

External factors often have as much, or more, impact on energy use than efficiency programs. When savings are estimated from a billing analysis, these external impacts may introduce either an upward or downward bias to the results. Given that the national economy was moving into a period of contraction during the 2007 and 2008 program years, one would expect that energy consumption may be reduced across the board, making it likely that program reported savings may be under- or over-estimated, depending upon the timing of the pre- and post-installation periods.

The fixed effects model controls for the characteristics of the home that are stable over time and also for seasonal changes in energy use that can be directly incorporated into the model, such as weather and monthly or annual variations. However, it is possible that the estimation of program impacts can be affected by other factors that change over time. These types of changes can be conceptualized in two broad categories:

1. changes in the overall economy that affect the residential market in a global way, such as volatile gasoline prices, unemployment rates, or an increase in home heating costs.
2. individual changes that affect specific homes, such as acquiring new household members, taking a longer vacation, or having a change in one's work schedule

These issues were considered and addressed separately. Strategies for assessing the impacts of these external factors have been tested in previous billing analyses and were used in this evaluation, as discussed further in the following sections.

<u>Global External Influences</u>

There are three common approaches to address the global factors within the statistical billing analysis:

1. include a non-participant comparison group directly in the billing analysis
2. incorporate trend lines based on consumption of the non-participant comparison group
3. incorporate trend lines from third party data on critical market trends, such as the unemployment rate, into the analysis.

The first strategy can introduce net effects into the models. In the end, a billing analysis that includes both participants and a non-participant comparison group will likely produce savings estimates that are somewhere in between gross and net effects and, thus, difficult to interpret with any degree of accuracy.

However, this comparison was conducted as a test to determine whether non-participants were experiencing a reduction or increase in use over the same period.

For EmPower, it was not possible to develop trend lines using a non-participant comparison group due to issues with identifying non-participants who would be considered to be similar to the EmPower participants and obtaining non-participant billing data. However, trend lines reflecting changes in gasoline prices and the unemployment rate were incorporated into the model.

Within Home Influences

Many changes occur over time that are completely outside the influence of the Program and yet have an impact on energy use within homes. Making changes to heating equipment or the addition of a new member to the household are likely to change the patterns of energy use. When conducting a billing analysis, information about these types of changes is not available.

The approach of including all homes with sufficient billing history in the model is intended to provide a sufficient number of homes in the sample to allow the within home variations to balance out. For the EmPower evaluation, the Impact Evaluation Team also fielded a participant survey to inform the billing analysis and assess whether this assumption is correct. This survey was designed to obtain additional information regarding typical changes occurring with the residence during the pre- and post-installation periods (such as adding major appliances and changes in schedules and occupancy).

Section 2:

PROGRAM DESCRIPTION AND HOUSEHOLD CHARACTERISTICS

2.1 EMPOWER PROGRAM DESCRIPTION

The EmPower Program (including the prior SBC-funded Weatherization Network Initiative) has served over 32,000 low-income households through September 30, 2008. Energy savings from participating households between July 1, 2006 and March 31, 2009 (SBC 3 time period) total 26.1 GWh Statewide, with 4.6 GWh (18%) occurring downstate in the Con Edison service territory.[16]

The focus of EmPower is on cost-effective electric reduction measures, particularly lighting and refrigerator replacements, as well as other cost-effective home performance measures (insulation, air-sealing, heating system repair and replacement, and health and safety measures). In-home energy use education provides customers with additional strategies for managing their energy costs. Participants are also invited to energy-use management and financial management workshops held in communities across the state.

Electric customers are eligible if they live in single family homes or small multifamily buildings with 100 units or fewer, and either participate in a utility payment assistance program, or have a household income below 60% of State median. There is no cost to the customer. In rental situations, measures that directly benefit the eligible tenant do not require a landlord contribution. Additional measures generally require a 25% landlord contribution. The energy efficiency services are delivered by a group of nearly 100 private contractors and Weatherization Agencies accredited by the Building Performance Institute (BPI).

The Program prioritizes cost-effective efficiency measures for low-income households with high energy costs. The average annual energy savings for customers receiving electric reduction are estimated by the Program at 1,306 kWh and 28 MMBtu for those customers receiving home performance services. The Program supplements the efficiency services with energy use management and financial management education. It also provides a referral mechanism to target services to households with high energy burdens and improve coordination of complementary low income energy programs.

In addition, the Program also provides health and safety installations, and repairs that are necessary for the installation of the energy efficient measures. In all, the EmPower Program covers a wide range of services designed to increase the energy efficiency, and also to improve the health, safety and comfort, of participating households.

Table 2-1 displays the MWh savings projected for both EEPS- and SBC-funded portions of the EmPower Program.

[16] NYSERDA, **New York Energy $mart**[SM] Program Evaluation and Status Report, Quarter Ending March 31, 2009, Report to the Public Service Commission, May 2009, Table 4-1.

Table 2-1. Projected MWh Savings for EmPower Program (2008-2011)

	2008 (4th quarter)	2009	2010	2011	Total
EEPS MWh	0	8,015	10,686	10,686	**29,387**
SBC MWh	3,985	5,725	2,482	2,482	**14,674**
TOTAL	**3,985**	**13,740**	**13,168**	**13,168**	**44,061**

2.2 EMPOWER PROGRAM ACCOMPLISHMENTS IN PY 2007 AND 2008

The primary share of electric energy savings from the EmPower Program can be attributed to refrigerator replacement and lighting efficiency. Together these two end uses account for 87% of program-reported electric savings. Fifty percent of program reported savings are attributable to the replacement of inefficient refrigerators and another 37% of savings as estimated by the Program are from lighting upgrades.

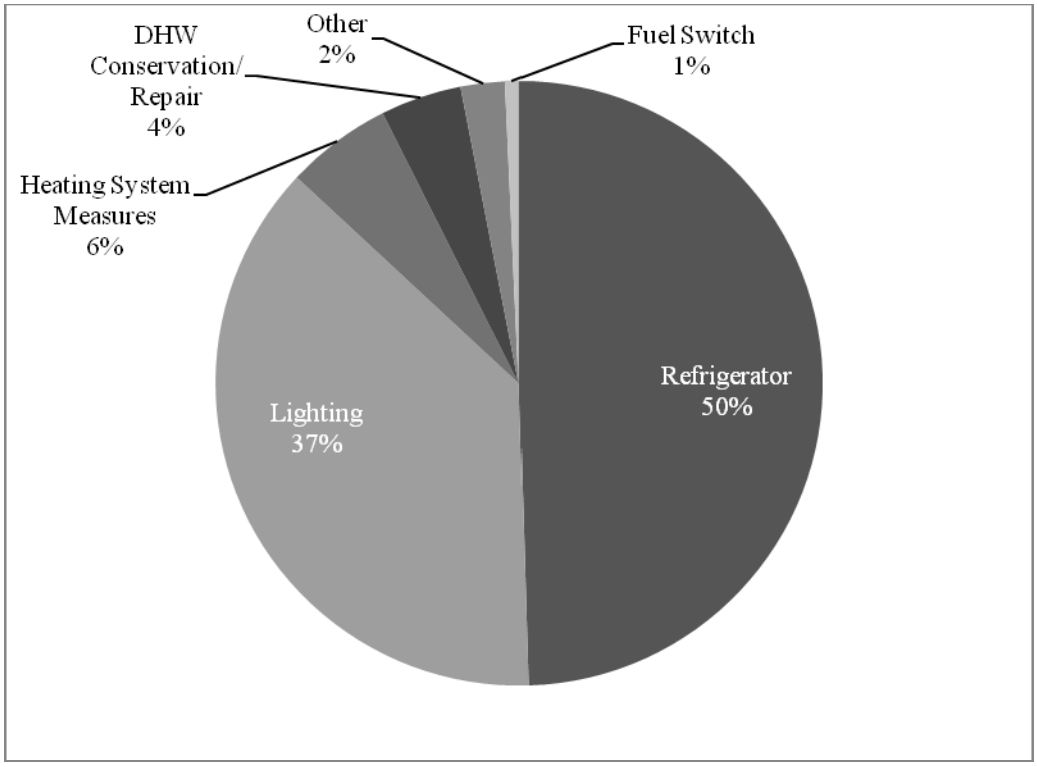
Improvements in residential refrigerator efficiency in the past 20 years coupled with the initial purchase cost of a new unit often make replacing refrigerators a cost-effective option in the low income sector. The expected lifetime of a residential refrigerator often approaches 20 or more years and there is an active market for "used" refrigerators in most parts of the country. The initial lower cost of second hand units can make them an attractive option for families that have few financial resources. The opportunity provided by EmPower to obtain a new, efficient unit is a valuable service to the low-income community.

Lighting efficiency continues to be an important component of residential programs in general and this is also true of EmPower. The ubiquitous nature of lighting opportunities allows the Program to serve a wider spectrum of the low income community than would otherwise be possible, with 97% of the homes served through the Program receiving lighting measures. Half of the program reported electricity savings are replacing refrigerators with new ENERGY STAR® refrigerators. The number of homes receiving the various electric measures and their program reported savings can be seen in Table 2-2 below and Figure 2-1 provides a pie chart describing the distribution of program reported electric savings by measure type.

Table 2-2. Program Reported Electric Savings by Measure Type

Measure	Number of Homes	Annual kWh Savings by Home	Total Annual kWh Savings	% of Total Program Savings
Refrigerator	10,012	1,030	10,311,477	50%
Lighting	15,843	491	7,783,622	37%
Heating System Measures	4,921	240	1,180,648	6%
Water Heating Conservation/Repair	5,693	159	903,447	4%
Other	1,149	427	490,789	2%
Water Heater Fuel Switch	56	2,102	117,689	1%
Heating System Fuel Switch	6	5,317	31,902	0%
Total Homes	**16,286**	**9,766**	**20,819,574**	**100%**

Figure 2-1: Program Reported Electric Savings by Measure Type



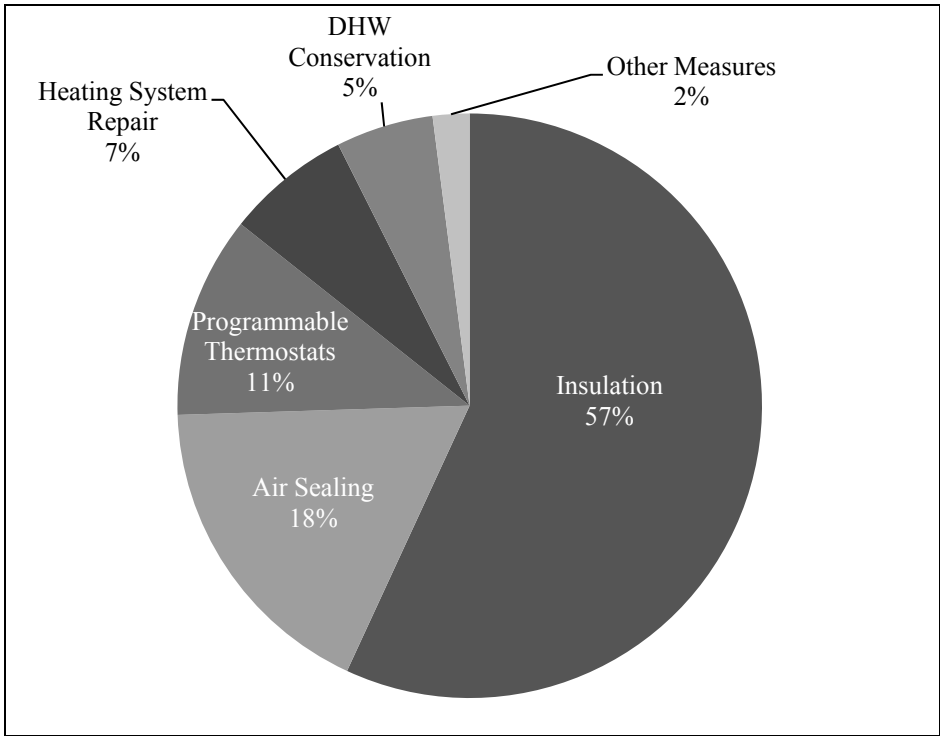
As with refrigerators and lighting for electric savings, a large portion of the savings from natural gas is driven by two measure types, insulation and air sealing. As can be seen in Table 2-3 and Figure 2-2 below, at 57% and 18% respectively these two measures account for 75% of program reported natural gas savings. The remaining 25% of program savings are from programmable thermostats, heating system repair, water heating conservation and miscellaneous measures.

Table 2-3. Program Reported Natural Gas Savings by Measure Type

Measure	Homes with Natural Gas Savings	Annual MMBtu Saved per Home	Total Annual MMBtu Saved	% of Positive Program Savings
Insulation	2,175	24.5	53,387	57%
Air Sealing	1,192	8.3	16,519	18%
Programmable Thermostat	1,515	6.9	10,496	11%
Heating System Repair	903	7.2	6,475	7%
Water Heating Conservation	3,697	1.4	5,058	5%
Water Heater Repair	382	2.5	965	1%
Other Measures	146	4.8	696	1%
Water Heater Fuel Switch (Fossil Fuel to Electric)	18	13.6	245	0%
Fuel Switching Extra Use	134	(16.7)	(2,238)	
Total	**6,550**	**32.6**	**91,602**[a]	**100%**

a The total in this column is not exact due to rounding.

Figure 2-2: Program Reported Natural Gas Savings by Measure Type



2.3 EMPOWER PARTICPANTS

There were 17,050 homes served by EmPower in PY 2007 and 2008. Some characteristics of this population are described below.

- 13,362 (about 78%) were reported as owning their own homes and 3,688 as renters.
- 11,724 (69%) participants live in single family homes, 2,887 (17%) live in mobile homes and 2,365 (14%) live in apartments.
- 3,422 (20%) participants have a secondary electric or kerosene space heater.

2.4 ANALYSIS OF ENERGY CONSUMPTION

Consumption patterns are central to assessing potential savings. For example, if the furnace was not operating correctly prior to receiving EmPower services, repairing the furnace may result in an increase in use, rather than the expected savings. While the benefit to the participant is clear, the energy savings are not achieved in these situations.

The relationship between the level of consumption and the magnitude of the program savings, *i.e.*, higher users tends to have higher savings, has been shown in other evaluations.[17] To identify high and low users, an analysis of consumptions patterned during the pre-installation period was conducted. This analysis provides insights into the potential savings in EmPower homes. The analysis is summarized in Table 2-4, Table 2-5 and Table 2-6 and some of the findings are listed below.

- EmPower households use more energy (both natural gas and electricity) than the average residential customer.
- The saturation of electric space heat is slightly lower (5%) than NYS residential homes (8%).
- The saturation of electric water heating is substantially higher in EmPower homes, with 30% of Program homes having electric water heating as compared to 8% of residential homes in the state.
- The prevalence of both natural gas space and water heating devices is higher among EmPower participants.
- Average natural gas consumption for EmPower participants is over 50% higher than the average residential use.

These results suggest that EmPower participants have electric and natural gas end uses that can be treated and may have substantial potential for achieving energy savings.

[17] Examples can be found in the following two documents:

- *Impact Evaluation of the 2005 California Low Income Energy Efficiency Program*, Final Report, prepared for Southern California Edison Company by West Hill Energy & Computing, Inc., August 2008
- Blasnik, Michael. 2004. *Ohio Electric Partnership Program Impact Evaluation*, final report prepared for the Ohio Office of Energy Efficiency.

Table 2-4. Comparison of Residential Annual Consumption to EmPower Participants

	New York State Residential Average Consumption per Home (2005)[1]	Participant Average Consumption per Home Prior to EmPower Services[2]
Annual Electric Consumption (kWh)	6,882	7,792
Annual Natural Gas Consumption (MMBtu)	71	109

[1] Patterns and Trends: New York State Energy Profiles: 1995 to 2009, NYSERDA, January, 2011, Appendix B

2 Estimated from all EmPower participants with sufficient pre-installation billing records.

Table 2-5. Comparison of the Saturation of Electric Heating for EmPower Participants and NYS Residential Customers

	All New York State Residential Customers (2005)[1]		EmPower Participants with Savings	
	Number of Households	% of Households	Number of Households	% of Households
Total	7,100,000	100%	16,600	100%
Space Heating	600,000	8%	760	5%
Water Heating	800,000	11%	5,007	30%

[1] Patterns and Trends: New York State Energy Profiles: 1995 to 2009, NYSERDA, January, 2011, Appendix B

Table 2-6. Comparison of the Saturation of Natural Gas Heating for EmPower Participants and NYS Residential Customers

	All New York State Residential Customers (2005)[1]		EmPower Participants with Savings	
	Number of Households	% of Households	Number of Households	% of Households
Total	5,300,000	100%	6,024	100%
Space Heating	3,800,000	72%	5.891	98%
Water Heating	3,800,000	72%	5,371	89%

[1] Patterns and Trends: New York State Energy Profiles: 1995 to 2009, NYSERDA, January, 2011, Appendix B

2.5 ATTRITION IN THE BILLING ANALYSIS

The billing model requires participants with sufficient billing records throughout the pre- and post-installation periods to be able to estimate savings. Data cleaning was conducted to identify homes that could be included in the billing analyses. The first step was to review the billing data provided by the utilities and determine the participants with sufficient billing data to be included in the models. This process involved a number of distinct activities, as described below.

- Since the account numbers in the NYSERDA data were not completely reliable (as would be expected for long strings of unrelated numbers), it was necessary to verify that the billing data was associated with a specific EmPower participant. Utility account numbers, names and addresses were matched between the EmPower Program data set and the utility billing records.

- The billing data was assessed for each participant to ascertain whether there were sufficient pre- and post-installation records for the model. Each participant was required to have at least nine months of billing records before and after the installation of measures.
- The billing data was reviewed for anomalies, such as many estimated reads, zero reads and missing data.
- The program and billing data were merged to ensure that the participants in the sample frame had natural gas and electric measures with associated savings. Participants with less than 1.0 MMBtu of natural gas savings and 50 kWh of electric savings were eliminated, since savings of this small magnitude would be difficult to detect in a billing analysis.

The results of this process are summarized in Table 2-7 below. About 30% and 55% of the total program participants with savings were eliminated from the electric and gas models, respectively, because no billing data at all was obtained from the utilities. This may be due to issues related to matching the program participants to utility records and identifying the correct utilities associated with each participant.

Comparing the number of participants with billing data to the participants determined to be eligible for inclusion in the billing analysis indicates an attrition rate in the range of 45% to 55%. This result is similar or higher than other impact evaluations based on billing analysis in the low income sector, including the recent impact evaluation completed by Energy and Resource Solutions (ERS) for NYSERDA on the Con Edison and National Grid natural gas efficiency programs (June, 2010).[18]

[18] Also see "Impact Evaluation of the 2005 California Low Income Energy Efficiency (LIEE) Program," prepared for SCE, PG&E, SDG&E and Southern California Gas by West Hill Energy and Computing, Inc, August, 2008. See Chapter 4.

Table 2-7. Summary of Attrition in the Billing Models

	Participants with Electric Service	Participants with Gas Service
2007/2008 Participants (Completed Projects)[1]	17,051	17,042
Participants with Savings	16,598	7,325
Participants with Savings but no Billing Data	5,116	3,958
Participants with Savings and Billing Data	11,482	3,367
% of Participants with No Billing Data	31%	54%
Reasons for Removal from Billing Analysis		
Insufficient Billing Data	4,529	1,512
Erratic Billing Data	815	323
Total Participants Removed	5,344	1,835
Total Participants in Billing Analysis	6,138	1,532
% of Participants with Billing Data	55%	51%
% of All Participants with Savings	38%	23%

[1] There was 1 project completed in December 2006 with sufficient billing history to include in the sample frame and the billing analysis. This project is included in the totals.

Homes in the model were compared to the total population by house type and percent of renters, as shown in Table 2-8. In both cases, the percentage of homes in each category is reasonably close for all participants and for participant including in the model. This analysis indicates that the billings models are reasonably representative of the population in terms of the housing types and distribution of owners and renters.

Table 2-8. Summary of Attrition by Renters versus Owners and by House Type

	Percent of All Participants with Electric Service and Savings	Percent of Participants Included in Electric Model		Percent of All Participants with Natural Gas Service and Savings	Percent of Participants Included in Natural Gas Model
Rent	22%	20%		16%	19%
Own	78%	80%		84%	81%
Apartment	15%	13%		15%	17%
House	68%	73%		78%	78%
Mobile Home	17%	13%		11%	5%

Section 3:

METHODS

This section describes the methods used to estimate gross and net savings. The evaluation consisted of a rigorous analysis with multiple components. The foundation of the evaluation was a full billing analysis, initially including all participants with complete and reliable billing data. The billing analysis compared the energy consumption prior to participation in the Program with energy use after the energy efficiency measures were installed to determine program savings.

Two surveys were conducted, as described below.

- To support the full billing analysis, a telephone survey of a sample of participants, the Energy Change Survey, was conducted to discover whether household changes outside of the Program, such as a change in the occupancy, may affect the magnitude of the evaluated gross savings. A secondary billing analysis was performed on this subset of surveyed participants to incorporate the additional household information and the results compared to the full billing analysis.
- A pilot study of net effects was conducted based on self-reports through a separate telephone survey of EmPower participants.

The subsections cover each major component of the evaluation, *i.e.*, the energy change survey, the NTG survey, the restricted billing analysis, the full billing analysis and the pilot NTG study.

3.1 ENERGY CHANGE SURVEY

Telephone surveys were completed for a total of 659 participants, with 400 completions for the natural gas measures and 600 for the electric model. The purposes of the survey are listed below:

- to assess non-program-related changes that occurred within the home during the analysis period that may have affected the energy consumption
- to confirm or determine the presence and use of major energy-using appliances
- to assess whether the measures installed through EmPower are still in place and operational

Although this survey is primarily designed to support the billing analysis, it is possible that some responses may assist in understanding participant behavior and may be useful to NYSERDA staff for program delivery purposes. Thus, some of the key results of the survey are summarized and presented in Appendix C. The individual responses were used to populate the restricted regression model.

Some of the topics covered in the survey include the following:

- changes in occupancy, schedule and possibly employment status
- length and timing of periods of vacancy of the home (vacations, etc.)
- presence and use of heating and cooling equipment and other energy-intensive appliances
- presence and use of measures installed through EmPower
- ability to pay utility bills and EmPower impacts on the ability to pay

The survey instrument was approved by NYSERDA and the DPS prior to fielding the survey. The survey was implemented by APPRISE, NYSERDA's survey contractor. Advance letters to introduce the survey were sent to all potential participant contacts before they were contacted. The survey instrument is attached as Appendix A.

3.1.1 Sampling

Sampling was conducted for the telephone survey following the data cleaning process. The sample frame consisted of all participants to be included in the billing analysis model. Thus the sample frame was developed using the Program and billing data.

No stratification was conducted for the telephone survey. The initial sample frame provided to APPRISE included all participants who could be included in the both the natural gas and electric billing models. However, there was a high non-response rate, largely due to the inability to reach many of the participants on the list. Consequently, it was necessary to supplement the sample frame with participants who could be included only in the natural gas model or only in the electric model. All participants who could be included in the natural gas model were contacted. The supplemental sample frame for the electric model was the remaining participants eligible for inclusion in the electric billing model and a random sample of these participants was contacted.

3.1.2 Timing

In the process of developing the survey instrument, considerable discussion and thought was given to the challenges of fielding a survey to obtain information about energy use changes made three to four years ago. The concern was that participants would not be able to answer the questions at all or would not provide reliable answers. Reliability is a common concern with self-reports, and the lag time may exacerbate the situation. For this reason, the wording of the questions was carefully considered and many questions were benchmarked to current practices.

3.1.3 Sample Disposition

The fielding of the Energy Change Survey was more complicated than anticipated and required more time than planned. The survey was fielded from June 7, 2011 through July 25, 2011 and the final data was provided to the Impact Evaluation Team on August 24, 2011. The major issue was the contact rate of 57% as shown in Table 3-1. Many participants could not be reached or were found to be ineligible for the survey. APPRISE provided a report with the details of the survey implementation described in this section.[19]

[19] All of the disposition codes and rate formulae provided by APPRISE are consistent with the standards of the American Association for Public Opinion Research (AAPOR).The contact, cooperation, and response rates are the AAPOR #3 rates.

Table 3-1. Sample Disposition for the Energy Change Survey

		Number of Participating Homeowners In Sample Frame	Percent of Participating Homeonwers
Total Sample Used		2,580	100.00%
Unusable Sample	Not working/Unusable number	534	20.70%
Not Contacted (a minimum of eight calls were made)	Respondent never available	23	0.89%
	Answer Machine	137	5.31%
	Call back/Left 800#	425	16.47%
Unknown Eligibility	No Answer/Busy	212	8.22%
	Records not yet called/Scr. Not complete	161	6.24%
Not Eligible	Respondent Not Eligible1	298	11.55%
Refused/ Break-off	Refused Break-off	131	5.08%
Completed interview		659	26%
Contact rate = ((659+131)/(659+131+23+137+425)) = (790/1,375) = 0.5745			57%
Cooperation rate = 659/(659+131) = 0.8342			83%
Response rate = 659/(659+131+23+137+425) = (659/1,375)*(1,375/2,207) = 0.479			41%

[1] It was not possible to reach the household member who could answer questions about participating in EmPower.

See the Glossary for definitions of Contact Rate, Cooperation rate and Response rate as defined by AAPOR.

The interviews were conducted using a computer-assisted telephone interview (CATI) survey instrument. Comprehensive checks were conducted by APPRISE prior to fielding to ensure that all skip patterns were correct and all question wording was comprehensible to respondents. Three participating home owner surveys were conducted as a pretest to assess the wording of the survey instrument and minor adjustments to the questions and response options were made as a result of the pretests. Interviewers called potential respondents during daytime weekday hours and calls were rotated between the morning and afternoon on different days of the week to minimize non-response bias. A total of 659 surveys were completed and included in the data set provided to the Impact Evaluation Team.

3.2 NTG SURVEY

The NTG survey was designed for participating homeowners and included four primary areas of interest:

1. free ridership
2. spillover
3. energy efficiency environment
4. economic environment

Data was also collected on participant demographics. The survey instrument was approved by NYSERDA and the DPS prior to fielding the survey. The survey was implemented by APPRISE as NYSERDA's survey contractor. Advance letters to introduce the survey were sent to all potential primary participant contacts before they were contacted. The survey instrument is attached as Appendix B.

3.2.1 Sampling

Initially, the energy change and NTG questions were intended to be combined into one survey. Due to the length of the survey, the Impact Evaluation Team subsequently decided to field the NTG component of the survey separately. All participants with sufficient billing data for both the natural gas and electric models were contacted or found to be unreachable in the process of completing the Energy Change Survey. The subset of the program participants without any billing data were used as the sample frame for the NTG survey since there does not appear to be any systematic reason for the inability to match participants to specific utility accounts and consequently this group should be representative of the Program as a whole. This approach would not be expected to introduce bias into the final results. The sample size for the NTG survey was 70 homes to allow us to meet the 90/10 confidence/precision target for a yes/no question.[20]

3.2.2 Timing, Economic Effects and Increasing Public Awareness of Energy Efficiency

The program years 2007 and 2008 covered in this evaluation were a period of economic upheaval for many. The National Bureau of Economic Research stated (in December 2008) that the "Great Recession" began in December 2007 (the beginning of the post-retrofit period for the earliest 2007 participants). The trough of the recession occurred around July 2009 and the economic recovery is recognized as being slow.

The timing of the survey raised three issues:

1. the accuracy of recall given the long lag between program participation and the survey
2. the impact of a change in economic status on a participant's ability to recall decisions that were made or would have been made
3. the increase in attention to energy efficiency in the media throughout this period

These issues were addressed by adding a question at the beginning of the telephone survey about economic changes occurring in the household and then using this subject to introduce an aid to recall by asking respondents to answer as they would have without allowing the economic change to influence their responses. Then the free ridership questions and spillover inquiries were made. Towards the end of the survey, additional questions on household economics and knowledge of energy efficiency were included. This approach was designed to minimize potential bias associated with self-reports during a period of economic stress and changing perceptions of energy efficiency.

[20] The sample size depends on the type of statistical analysis being conducted and the type and variability of the specific parameters to be estimated. For example, a simple random sample required to achieve 90% confidence and 10% sampling precision for a yes/no question is about 67 for a large population. However, if the variable of interest is the realization rate and the coefficient of variation is 0.75, a simple random sample would require a sample size of 152 to achieve the same precision and confidence level.

3.2.3 Sample Disposition

As with the Energy Change Survey, comprehensive checks were conducted by APPRISE prior to fielding to ensure that all skip patterns were correct and all question wording was comprehensible to respondents. Four participating home owner surveys were conducted as a pretest to assess the wording of the survey instrument and the aid to recall items, as well as to train interviewers at the call center; minor adjustments to the questions and response options were made as a result of the pretests.

The interviews were conducted using a computer-assisted telephone interview (CATI) survey instrument. Five specially trained interviewers were used due to the complexity of the questionnaire and the need for the interviewer to exercise judgment in selecting questions and coding responses. These five interviewers conducted all of the surveys for this evaluation. Extensive training and quality control checks were conducted by APPRISE to ensure that the survey house had the necessary support to field the surveys.

The NTG survey of participating home owners was in the field from July 13, 2011 to July 26, 2011. Interviewers called potential respondents during daytime weekday hours and calls were rotated between the morning and afternoon on different days of the week.

A total of 70 interviews of participating homeowners were completed and included in the final data file for these respondents. Table 3-2 shows the disposition of all sampled telephone numbers dialed for the participating homeowner survey and provides the contact, cooperation, and overall response rates. APPRISE provided a report with the details of the survey implementation described in this section.[21] The response rate estimates the fraction of all eligible working numbers where a request for an interview was made. The cooperation rate is the percentage of contact numbers where consent for an interview was not refused. The NTG Participating Homeowner Survey achieved a contact rate of 56.96%, the cooperation rate was 77.78%, and the overall response rate was 43.12%. These rates and the detail counts are provided in Table 3-2.

[21] All of the disposition codes and rate formulae provided by APPRISE are consistent with the standards of the American Association for Public Opinion Research (AAPOR).The contact, cooperation, and response rates are the AAPOR #3 rates.

Table 3-2. Sample Disposition for the EmPower NTG Survey of Participating Homeowners

		Number of Participating Homeowners (NTG)	Percent of Participating Homeonwers (NTG)
Total Sample Used		300	100.00%
Unusable Sample	Not working/Unusable number	80	26.67%
Not Contacted (a minimum of eight calls were made)	Respondent never available	21	7.00%
	Answer Machine	30	10.00%
	Call back/Left 800#	17	5.67%
Unknown Eligibility	No Answer/Busy	8	2.67%
	Records not yet called/Scr. Not complete	0	0%
Not Eligible	Respondent Not Eligible[1]	54	18.00%
Refused/	Refused	19	6.33%
Break-off	Break-off	1	0.33%
Completed interview		70	23.33%
Contact rate = ((70+1+19)/(70+1+19+21+30+17)) = 90/158 = .5696			56.96%
Cooperation rate = (70/(70+1+19)) = (70/90) = .7778			77.78%
Response rate = (70/158 + ((158/292)*8) = (70/158 + ((0.541*8) = .4312			43.12%

[1] It was not possible to reach the household member who could answer questions about participating in EmPower.

See the Glossary for definitions of Contact Rate, Cooperation rate and Response rate as defined by AAPOR.

3.3 THE BILLING ANALYSIS

The basic regression model was a fixed effects model including weather and efficiency measures installed through the Program. The type of modeling used in the restricted and full regression models is often referred to as cross-sectional, time series (CSTS) analysis, in which the program-level data provided at the household level comprise the "cross-sectional" component and the monthly billing records are the "time series" data. These two sources of data are merged with the weather data to create a CSTS data set. The regression models also have customer-specific intercepts to take into account the characteristics of the home that do not vary over time.

3.3.1 Data Sources

The evaluation required data from four primary sources:

1. program data on measures installed in each home and characteristics of the homes
2. billing records from the utilities

3. weather data
4. participant surveys

A description of the data sources is provided below.

Program Data

NYSERDA provided the full program database, which included both project-level and measure-level data. All measures were identified by the funding source. There was a substantial amount of information available about each home, including the fuel source of the space and water heating systems. Some information that would have been useful to the billing analysis was not included in the program tracking data, such as the number of occupants in the home and whether a home has a working central or room air conditioner.

Utility Billing Data

The data request to the utilities included numerous fields. Some utilities provided most or all of the fields and other utilities provided just a subset. An example of a missing field is whether the meter read was estimated. This information can be useful for interpreting the utility data.

Weather Data

Weather data was obtained from the National Oceanographic and Atmospheric Administration (NOAA) for the weather stations in New York State to calculate the heating and cooling degree days. The base temperature was 65°F for heating degree days and 75°F for cooling degree days. Specific homes were mapped to the weather station by zip code, using the file provided by NYSERDA for this purpose.

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 period of pre- and post-installation billing records, generally nine months pre and nine months after the installation of all measures; for the natural gas model, both the pre and post periods where checked to ensure that winter months were included
- breaks in billing history indicating a possible lapse in service - typically monthly reads with no energy use or missing reads
- overall use is within the range of residential use; homes with electric space heating tend to have higher use; above 50 MWh per year suggests some other type of use; sometimes the consumption level is lower than would be used to run a refrigerator and a few lights, suggesting that the home may be unoccupied for some periods
- assess billing records for high variability or a see-saw pattern which may indicate estimated reads that were not labeled as such

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

When the modeling was underway, it also became clear that the billing data from two utilities contained many unidentified estimated reads and reconciliations, thus breaking the direct relationship between consumption and the weather impacts during the specific billing periods. For this reason, the models were run twice, 1) with all participants and 2) then with the billing data from these two utilities removed.

The program data was reviewed for internal consistency. A number of issues were identified and largely resolved with program staff. For example, about 30% of the homes did not have the water heating fuel

identified, which is critical for assessing savings from water heating measures. However, review of the data and discussion with program staff indicated that homes with electric water heating were correctly identified and the homes with missing data used natural gas for both space and water heating.

3.3.2 The Regression Model

Weather effects and EmPower measure installations were included as predictor (independent) variables and the response (dependent) variable was the daily energy consumption. The regression coefficients for program variables were used to estimate the program savings. For the restricted model including only respondents to the telephone survey, the variables were expanded to include specific changes in the household over the analysis period, such as changes in occupancy. Separate natural gas and electric models were developed.

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

$$C_{it} = \alpha_i + \tau_t + \sum_{j=1}^{p} x_{ijt}\beta_j + \sum_{k=1}^{q} z_{ikt}\gamma_k + \varepsilon_{it}, \quad (1)$$

where

C_{it} is the monthly consumption for the household *i* in period *t*, expressed in monthly kWh 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,

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,

z_{it} are the predictor variables reflecting non-program related effect *k* (such as weather impacts) for household *i* in period *t,*

γ_k represents the slope coefficients that quantify the average influence of modeled non-program related effect *k* on monthly consumption,

q is the total number of non-program related effects 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. The use of SAE modeling was considered. This approach replaces the *x's* with the program-estimated energy savings for the measure or household and the coefficients represent the realization rate. The SAE model works well when the savings estimates are site-specific and calibrated to pre-installation use, as is done in the EmPower Program. However, if there is random error in the *x's*, the coefficients may be biased downward.

3.3.3 Model Selection Process

A component of the modeling process is 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. Standard statistics, such as the coefficient of determination (R^2) and T-values for specific parameters were compared. In addition, the information-theoretic approach to model selection was employed to ensure that the selection of the final model is based on objective statistical standards.[22] This approach was used in conjunction with a review of the modeling results to ensure that the "best model" in terms of the statistical properties also allowed for improved estimation of the variables of interest.

The information-theoretic approach is designed to allow a group of candidate models to be compared and ranked by use of Akaike's Information Criterion (AIC). The model with the lowest value of the AIC is the one that best fits the data set, *i.e.*, the model that minimizes the information loss.

The AIC is calculated from the log likelihood function with an added penalty reflecting the number of parameters in the model, as shown below:

$$AIC = -2\log(\mathrm{L}(\hat{\theta}|y)) + 2K, \quad (2)$$

where $\log(\mathrm{L}(\hat{\theta}|y))$ is the value of the log likelihood function at its maximum point for the vector of parameters designated by θ, given the data *y*, and K is the number of estimable parameters, including the intercept and the residual variance.[23]

If the candidate models are fit by least squares regression and the outcomes are not transformed, the maximum likelihood estimate (MLE) of the residual variance can be calculated directly from the residual sum of squares (RSS/n) (Burnham and Anderson 2002).[24]

The AIC's of all models in the set of candidates can be rescaled to simplify the comparison and ranking process:

$$\Delta_i = \mathrm{AIC}_i - \min(\mathrm{AIC}), \quad (3)$$

where index *i* indicates the number of the model and min(AIC) is the smallest AIC value.

The relative values of Δ_i indicate the level of support for the given model. A rule of thumb is that models varying by only 1 or 2 from the best model have strong support; models with Δ_i's between 3 and 7 show less support and a value of 10 or more indicates little to no support (Burnham and Anderson 2002). However, these ground rules presume that all of the basic assumptions of linear regression are met.

There are some limitations to applying the information-theoretic approach. The candidate models must have the same number of observations and a similar structure. Models in which the dependent variable is

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[22] In billing analysis, the analyst makes many decisions regarding the statistical characteristics of the model and the specific parameters to be included. Thus, there are typically a number of possible models that could be used to estimate savings. The information-theoretic approach provides an objective framework for selecting the best model among a series of competing candidate models. Please refer to *Model Selection and Multimodel Inference* by Kenneth Burnham and David Anderson, Springer-Verlag, NY, 2002.

[23] Maximum likelihood methods allow for the estimation of the parameters of interest, given a set of data and an assumed model. A brief introduction to maximum likely theory is provided in the Burham and Anderson text.

[24] The maximum likelihood estimator (MLE) is the value of the parameter for which the log likelihood function is at its maximum.

transformed or that assume a lognormal distribution of errors (for example) cannot be compared with untransformed models.[25]

3.4 RESTRICTED BILLING ANALYSIS

The purpose of the restricted model was to determine whether non-program, within-home changes in energy consumption introduce a bias into the savings estimates. To achieve this objective, regression variables were constructed from the Energy Change Survey, included in the model, and the savings were compared. This comparison assessed whether adding the change variables made a significant difference in the resulting savings estimates.

The Energy Change Survey provided detailed information regarding changes made within the participating households during the analysis period. Two strategies were employed to obtain information about energy changes:

1. Questions about changes in the use of energy-intensive equipment and schedule were constructed by comparing the pre-installation period to the post-installation period.
2. Additions or replacements of appliances and changes in occupancy were recorded by inquiring about the timing of the change, *i.e.*, the change could occur at any point throughout the analysis period.

The variables included in the restricted model were designed to compare changes between the pre- and post-installation periods. However, the timing of the change also affects the magnitude of the impact on the regression estimates. For example, a home with a change made early in the pre-installation period and then remaining in place throughout the rest of the analysis period is not particularly different from a home with no change at all. For these questions, the variables for the regression model were constructed by developing an average value for the pre-installation period and for the post-installation period.

Combining all of the information from the survey data, variables were constructed to model the difference in appliance holdings, occupancy, schedules, and energy use patterns between the pre-installation and post-installation periods. Participants were also asked if they participated in "the Weatherization Assistance Program or programs other than EmPower." Since installation of measures through another program could create an upward or downward bias in the saving estimates (depending on the timing), the responses to this question were also included among the candidate models.

All model results were compared against the base case, which included only the variables available from the program tracking data and the NOAA weather files, *i.e.*, only the variables that could be included in the full regression model. Survey-based variables reflecting the major potential sources of variation in energy use were then added to the base model to assess whether there was any change in the savings. The candidate models are described in Table 3-3 and Table 3-4. Variables expected to result in a change in heating or cooling use were interacted with heating or cooling degree days for those homes with self-reported electric space heating or cooling use, respectively.

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[25] Please refer to *Model Selection and Multimodel Inference* by Kenneth Burnham and David Anderson, Springer-Verlag, NY, 2002.

Table 3-3. Candidate Models for the Restricted Electric Model

Model Number	Description	Variables
1	Base model	Base model, household savings, heating degree days and cooling degree days (these variables are included in all candidate models)
2	Other program	Whether the participant reported receiving services through another energy efficiency program (this variable was included in the remaining models)
3	Change in occupancy and cooling use	Increase in occupancy, decrease in occupancy, increase in A/C use (new A/C added), decrease in A/C use (old A/C replaced)
4	Changes that would increase base, space heating or cooling use	Composite variable that includes any change expected to increase use, such as adding electric appliances, self-reported increase in use of A/C or space heating, scheduling changes or an increase in occupancy
5	Changes that would decrease base, space heating or cooling use	Composite variable that includes any change expected to decrease use, such as replacing old electric appliances, self-reported decrease in use of A/C or space heating, scheduling changes or a decrease in occupancy
6	Both increase or decrease base, space heating or cooling use	Both composite variables as described for models 4 and 5 above
7	Any change that would affect energy use	Composite variable that reflects any change at all in the household that would affect energy use
8	Schedule changes	Self-reports of changes in vacation schedule or time at home

Table 3-4. Candidate Models for the Restricted Natural Gas Model

Model Number	Description	Variables
1	Base model	Base model, household savings, heating degree days (these variables are included in all candidate models)
2	Thermostat control	Heating savings separately for participants who set the thermostat at one temperature and those who setback either manually or with a programmable thermostat
3	Use of supplemental heat	Heating savings separately for participants who use a supplemental (non-natural gas) heat source and those who do not
4	Other program	Whether the participant reported receiving services through another energy efficiency program
5	Changes that would increase base or space heating use	Composite variable that includes any change expected to increase use, such as adding natural gas appliances, self-reported increase in use of space heating, scheduling changes or an increase in occupancy
6	Changes that would decrease base or space heating use	Composite variable that includes any change expected to decrease use, such as replacing old natural gas appliances, self-reported decrease in use of space heating, scheduling changes or a decrease in occupancy
7	Both increase or decrease base or space heating use	Both composite variables as described for models 5 and 6 above
8	Change in occupancy	Increase in occupancy, decrease in occupancy
9	Any change that would affect energy use	Composite variable that reflects any change at all in the household that would affect energy use
10	Schedule changes	Self reported changes in vacation schedule or time at home

3.5 FULL BILLING ANALYSIS

The savings estimates were developed using two regression models: one for electric measures and one for natural gas. Customer intercepts are incorporated into both models.[26] These intercepts are established for each home in the model and account for the fixed characteristics of the home, such as house size and presence of major appliances. The customer intercepts explain a large part of the fluctuations in usage, and consequently the R-squared statistic for these models tends to be high.

3.5.1 Common Model Specifications

Time Period Effects and Definition of the Pre and Post Periods

To estimate measure savings, the measure variables are interacted with a dummy variable (dpost), which defines the pre and post periods. All measure variables interacted with this dummy variable are set to zero during the pre period and one (or a specific value, such as the number of lighting products installed)

[26] By using customer-specific intercepts, changes in used are estimated for each home in comparison to the average use in the home. This approach allows the model to account for house-to-house differences in size, housing stock, occupancy and life style.

for the post period. The pre-installation period is defined as all activity prior to the initial energy assessment, and the post-installation period begins following the installation of the last efficiency measure. Since energy consumption during the period between the date of the initial energy assessment and the date of the installation of the last measure tends to be volatile due to the measure installation process, these records were eliminated from the analysis on a house-by-house basis.

The electric model includes monthly variables to account for the time effects to allow us to account for the monthly variation in usage that is not related to the Program or other known factors. In the natural gas model, a dummy variable for each year was incorporated into the model to pick up changes in use over time. The terms for space heating and cooling effects in the models were interacted with average daily heating or cooling degree days to reflect weather-dependent use.

Measure Groups

Measures were grouped into categories to simplify the modeling process and improve the ability of the model to estimate savings by measure group. These groups are defined below.

Table 3-5. Measure Group Definitions

Measure Group	Variable Name	Model (G=Gas, E=Electric, B=Both)	EmPower Measures Included
Clothes Dryer Fuel Switch	cdfs	B	Clothes dryer replacement with positive kWh savings and extra MMBtu use
Water Heating Conservation	dhwcons	B	Pipe wrap, low flow showerheads, tank wraps
Water Heating Fuel Switch	dhwfs	B	Domestic hot water improvement with positive kWh savings and extra MMBtu use (or reverse for the natural gas model)
Water Heater Repair	dhwrep	B	Domestic hot water improvement with kWh or MMBtu savings but no extra fuel use of either type
Envelope	Env	B	Insulation and air sealing
Heating System Fuel Switch	hsfs	B	Heating replacement with positive kWh savings and extra MMBtu use
Heating System Repair or Replacement	hsrr	B	Heating repair, or heating replacement with kWh or MMBtu savings but no extra fuel use of either type
Lighting	ltgqty	E	CFL and hardwired fixtures
Refrigeration	ref	E	Refrigerator replacement and/or freezer replacement
Thermostat	tstat	B	Thermostat
Other	other	B	Other

Weather Effects

The heating and cooling degree day variables in the regression model were calculated based on the daily temperatures for each billing cycle. Temperature data was obtained from NOAA, and these data were averaged and summed to obtain the heating and cooling degree days for each billing cycle. The weather station associated with each participant's home was assigned by zip code. The program and weather data were merged with the billing history for use in the regression model. All regression models included terms to control for temperature (heating and cooling degree days).

Calculation of Savings from Estimators

Savings for the non-temperature-dependent measures were estimated by the direct inclusion of the dpost variable in the model. The resulting estimators were in units of kWh or therms per day, and must be multiplied by 365 days to calculate energy savings per year.

All measures designed to save space heating energy use were modeled by estimating the heating slope for the post-installation period and the heating slope over the entire period; the post-installation variable reflects the difference in heating slopes, and thus the savings. The resulting estimators were in units of therms savings per degree day, and must be multiplied by the annual heating degree days for the participants with the measure to calculate energy savings per year. Both variables were specific to the homes that received the measure, as this approach tends to improve the ability to estimate savings.

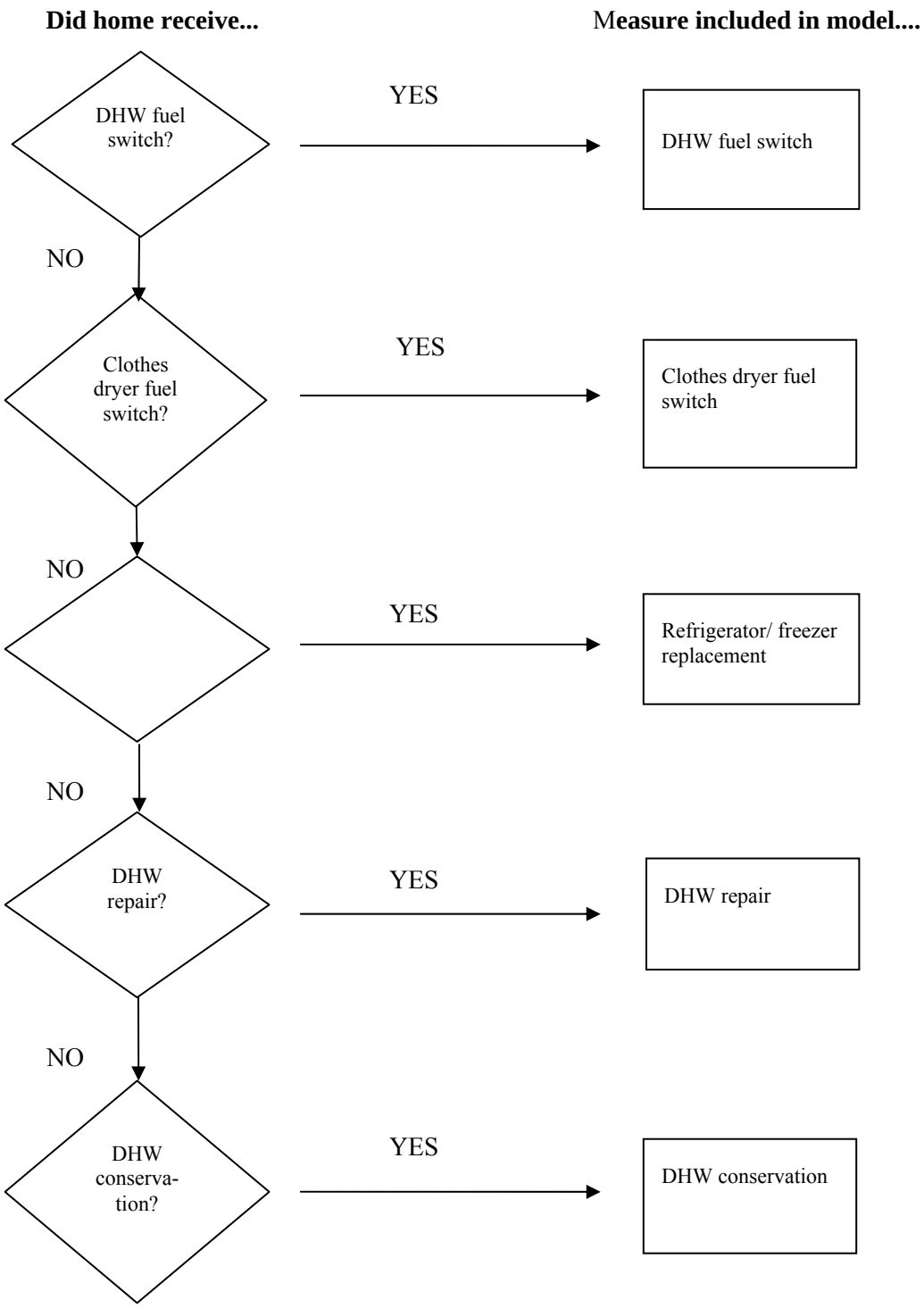
3.5.2 Electric Model Variables

The electric model was used to estimate the savings from refrigerator and freezer replacement, lighting, hot water conservation, water and space heating fuel switches and clothes dryer fuel switches. Homes tended to receive multiple measures, which may introduce collinearity into the model and makes it more complicated to separate savings by measure group. 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 tends to result in instability in the model estimators, *i.e.*, large swings in the magnitude of the estimators depending upon the variables included in the model, and may result in estimators of the wrong sign, *i.e.*, estimators indicating that a measure results in an increase in use rather than savings.

With the exception of lighting and "other" measures, which were included for all homes with the measure, a hierarchical structure was developed for assigning the specific measure to be estimated from the several options in each home to avoid collinearity.[27] For example, if the water heating fuel was switched from electric to fossil fuel, no other measures (except lighting and "other" measures) were estimated from that home. The larger, less frequently installed measures were placed at the top of the hierarchical structure and the smaller, frequently installed measures at the bottom. This approach also prevents the savings from smaller measures, such as those for DHW conservation, to be artificially inflated by the savings from other measures. Figure 3-1 illustrates the method of identifying the measures to be estimated in each home.

[27] Heating system fuel switches were excluded from this structure, since the savings were interacted with heating degree days and would not affect the estimation of savings from the other measures.

Figure 3-1: Measure Assignments by Home in Electric Model



The outcome of this process is shown in Table 3-6. This table provides the total number of homes with the measure group included in the model, and the number of homes used to estimate the savings after the allocation of measures was completed as described above. As can be seen, the water heating conservation measures, which tend to be low savings measures installed in many homes and was consequently on the bottom of the hierarchy, had a large drop between the total number of homes with the measure group and the number of homes allocated to estimating savings, as did the water heater repair. This result is largely due to the fact that refrigerator replacements were installed in so many homes.

Table 3-6. Summary of Homes in the Electric Model by Measure Group

Measure Group	Total Number of Homes in Model	Number of Homes in Model Allocated to Estimate Savings	Measure Group Savings Estimated from Model
Lighting	4,600	4,600	Yes
Refrigeration	2,916	2,888	Yes
Water Heating Conservation	562	181	Yes
Water Heater Repair	164	31	Yes
Water Heating Fuel Switch	17	17	Yes
Clothes Dryer Fuel Switch	63	60	Yes
Other	15	15	Yes
Heating System Fuel Switch	2	2	Yes
Envelope	14	14	No
Thermostat	583	583	No
Heating System Repair or Replacement	0	0	No
Total Number of Homes in the Model	4,695	4,695	

3.5.3 Electric Model Selection

The candidate models for the electric model are described below. All measures intended to estimate savings for heating- or cooling-related measures were interacted with heating or cooling degree days, respectively. The candidate models reflect different strategies to modeling the savings, starting with the simplest approach of estimating savings by household, and moving to more complicated models with all measure groups estimated separately.

Table 3-7. Candidate Electric Models

Model Number	Description	Explanation
1	Household model	Includes only a single variable for all measures installed to estimate savings by household, plus heating and cooling degree days
2	Measures divided into base and heating measures	Measures were divided into two groups, *i.e.*, homes with any base measure and homes with any heating-related measure
3	Base measure groups separated and heating measure combined	Savings for base (non-heating) measure groups (refrigerators, lighting, water heating-related measures, etc.) were estimated individually; all heating-related measures were grouped together
4	Base and heating measure groups estimated individually	Savings were estimated for all measure groups
5	Broader definition of heating and cooling variables	Heating and cooling savings were included for all homes with envelope and thermostat measures, regardless of whether the program estimated electric savings for the measures

Through this process, the two highest ranked models according to the information-theoretic model were model numbers four and five. None of the models were successful at estimating savings from heating- and cooling-related measures (such as envelope measures and thermostats). While model number five was technically the highest ranked model, it did not improve our ability to determine the savings from heating and cooling measures, as intended. Thus, model four with all measures groups included was selected as the final model.

3.5.4 Specifications of the Final Electric Model

The final model as determined by the model selection process included variables for all of the measure groups as defined above in Section 3.5.1, as shown in Table 3-8.

Table 3-8. Variables in the Final Electric Model

Measure Group Estimated	Variable Name	Interaction	Description
None	amonth	None	Accounts for time effects not related to the program or other known factors
Lighting	ltgqty	None	Quantity of lighting products installed in each home
Refrigerator and/or Freezer Replacement	ref	None	Dummy variable, 1 if the home had the replacement, 0 if no replacement
Water Heating Conservation Measures	dhwcons	None	Dummy variable, set to 1 if any water heating conservation measures was installed (low flow showerhead, pipe wrap or tank wrap)
Water Heating Fuel Switch	dhwfs	None	Dummy variable, set to 1 if the home received a water heating fuel switch
Water Heater repair	dhwrep	None	Dummy variable, set to 1 if the home received a water heater repair
Clothes Dryer Fuel Switch	cdfs	None	Dummy variable, set to 1 if the home received a clothes dryer fuel switch
Other Measures	other	None	Dummy variable, set to 1 if the home received an unclassified measure
Heating System Fuel Switch	hsfs	Heating degree days	Dummy variable, set to 1 if the home received a heating system fuel switch; a second variable was also defined to estimate the heating slope throughout the analysis period for homes with heating system fuel switches
Insulation and/or Air Sealing	env	Heating and cooling degree days	Dummy variable, set to 1 if the home received insulation or air sealing; a second variable was also defined to estimate the heating and cooling slopes throughout the analysis period
Thermostat	tstat	Heating and cooling degree days	Dummy variable, set to 1 if the home received a thermostat; a second variable was also defined to estimate the heating and cooling slopes throughout the analysis period
None	nhdd	Daily heating degree days	Accounts for weather-related changes in use
None	ncdd	Daily cooling degree days	Accounts for weather-related changes in use

3.5.5 Natural Gas Model Variables

Measure Definitions

As with electric measures, participants often received more than one measure and a hierarchical structure was established to determine which measure among many should be used for estimating savings in specific homes to avoid collinearity in the model. Only one heating-related measure was identified for each home. The hierarchy was established as follows:

- heating system repair or replacement
- insulation and air sealing (envelope measures)
- programmable thermostats

Thus, savings from programmable thermostats were estimated only for homes with this measure that did not receive heating system or envelope measures. This approach also prevents the savings from smaller measures, such as programmable thermostats, to be artificially inflated by the savings from other measures. The same approach was used for the water heating measures, *i.e.*, the water heating conservation measures were estimated only from homes that did not receive a water heater repair measure.

Table 3-9. Summary of Homes in the Natural Gas Model

Measure Group	Total Number of Homes in Model	Number of Homes in Model Allocated to Estimate Savings	Measure Group Savings Estimated from Model
Water Heating Conservation	508	485	Yes
Water Heater Repair	68	68	Yes
Water Heating Fuel Switch	3	3	Yes
Heating System Repair/Replace	245	245	Yes
Envelope	710	519	Yes
Thermostat	322	166	Yes
Total Homes in Model	1,141	1,141	

3.5.6 Natural Gas Model Selection

The natural gas model selection was similar to the process used for the electric model. The base model started with the simplest form, estimating savings by household, and the candidate models increased in complexity by adding measure groups. Except where otherwise noted, each model built upon the previous one.

Table 3-10. Candidate Natural Gas Models

Model Number	Description	Explanation
1	Household model	Includes only a single variable for all measures installed to estimate savings by household, plus heating degree days
2	Household model with timing variable	Added dummy variable for each calendar year to account for non-program effects
3	Household model with fuel switching extra natural gas use	Added variables to account for extra natural gas use associated with switching electric water heater and clothes dryers to natural gas
4	Separated heating measures (combined, not by house type)	Estimated savings separately for envelope measures, heating system replace/repair and thermostats
5	Separated DHW measures	Estimated savings separately for water heating conservation and water heater repair
6	Estimated heating measure groups and by presence of secondary space heat	Each of the three measure groups had two variables, one for homes without secondary heat and one for homes with secondary heat

Using the information-theoretic approach, model number 6 was the top contender. However, further review indicated that this model did not change the estimated savings over model 5. Since model 5 was the simpler option, it was used to estimate the program savings.

3.5.7 Specifications of the Final Natural Gas Model

The final model as determined by the model selection process included variables for all of the measure groups as defined above in Section 3.5.1, as shown in Table 3-11. Savings for heating-related measures were calculated using heating degree days normalized for years 2003 through 2009.

Table 3-11. Variables in the Final Natural Gas Model

Measure Group Estimated	Variable Name	Interaction	Description
None	year1 - year3	None	Accounts for time effects not related to the Program or other known factors
Water Heating Conservation Measures	dhwcons	None	Dummy variable, set to 1 if any water heating conservation measures was installed (low flow showerhead, pipe wrap or tank wrap)
Water Heater Fuel Switch	negdhwfs	None	Dummy variable, set to 1 if the home switched water heater fuel from electric to natural gas, variable accounts for extra use
Water Heater Repair	dhwrep	None	Dummy variable, set to 1 if the home received a water heater repair
Heating System Replace/Repair	hsrr	Heating Degree Days	Dummy variable, set to 1 if the home received a heating system replace/repair measure; a second variable was also defined to estimate the heating slope throughout the analysis period for homes with heating system replace/repair measures
Insulation and/or Air Sealing	env	Heating Degree Days	Dummy variable, set to 1 if the home received insulation or air sealing; a second variable was also defined to estimate the heating throughout the analysis period
Thermostat	tstat	Heating Degree Days	Dummy variable, set to 1 if the home received a thermostat; a second variable was also defined to estimate the heating throughout the analysis period
None	nhdd	Daily Heating Degree Days	Accounts for weather-related changes in use

The final models were tested for violations of assumptions.

3.5.8 Final Comparisons

The final models were run using the all participants with sufficient billing history, omitting participants from the two utilities with billing data that seemed to include many unidentified estimated reads. (See Section 3.3.1, Data Sources.) After the final models had been selected, the models were run in a number of different ways, as specified below:

- the two utilities with problematic billing records were added
- a comparison group of non-participants were added to assess impacts from external factors
- trend lines to take into account economic factors were added, also to assess impacts from external factors
- variables were added to estimate savings separately for participants who were also served by the federal Weatherization Assistance Program

The results were then compared, as discussed in the following section.

3.5.9 Estimating Summer Peak Demand Savings

The electric billing analysis provided estimates of the average energy (kWh) savings per household. To estimate the summer peak demand savings, these values were converted to kW by using a conversion

factor developed by major measure group from NYSERDA's Deemed Savings Database (DSD). The conversion factor was calculated as follows:

kW/kWh conversion factor = summer peak kW savings / annual kWh savings

The values are presented below.

Table 3-12: kW/kWh Conversion Factor

Measure Group	Summer Peak Conversion Factor (kW/annual kWh)
Lighting	0.00008
Refrigerator Replacement	0.00014
Water Heating Conservation	0.00005
Water Heater Repair	0.00005
Water Heating Fuel Switch	0.00005
Clothes Dryer Fuel Switch[1]	0.00023
Other Electric Measure[2]	0.00011
Heating System Fuel Switch	0.00000

[1] The conversion factor for clothes dryer fuel switch was calculated from the most similar measure in NYSERDA's DSD, which was efficient clotheswashers.

[2] The conversion factor for the "other" measures was calculated as a savings-based weighted average of the other measure groups.

3.6 NET-TO-GROSS MODELING

Low-income programs are often assumed to have no free riders or spillover based on the belief that occupants cannot afford to take any of these actions without the program, and free ridership and spillover are set to zero. This evaluation included a pilot project to test this assumption. A participant survey was designed to follow prior NYSERDA free ridership and spillover inquiries and measurement used in evaluating NYSERDA's other residential existing homes program, Home Performance with ENERGY STAR®. Modifications to the questions were made as necessary to reflect the differences between the two programs, in particular that EmPower participants do not contribute to the costs of the installed measures. Using questions and an algorithm already tested with known free ridership findings from another NYSERDA residential population ensured that the results from the EmPower free ridership and spillover test could be compared to evaluated NTGR's from NYSERDA's other residential program impact evaluations.

3.6.1 Overview of the NTG Methods

For an impact evaluation to construct solid and defensible estimates of all impacts that are program-induced (rather than naturally occurring) requires the estimation of impacts from three distinct groups of participants and non-participants:

1. participants who would have taken program actions within the same time frame in the absence of the program (free riders)
2. participants who took non-program actions due to the program (inside spillover)

3. impacts from non-participants due to the program (outside spillover)

Impacts are often estimated by assessing the proportion of program reported savings associated with free riders (FR) and the proportion of program reported savings due to spillover (SO). These factors are then compared to develop the net-to-gross ratio (NTGR), which becomes the adjustment factor to derive net impacts. Given the nature of this program, interviews were conducted only with participating homeowners. Therefore, this evaluation did not incorporate outside spillover.

The reliability for attribution relies more on construct validity than on sampling precision. Construct validity, or the lack thereof, is the major driver of uncertainty in the assessment of FR and SO estimates. The alternative of what would have occurred cannot be known with certainty. Survey inquiry is complicated as we are asking interviewees to conjecture about their response to a theoretical alternative. The Impact Evaluation Team relied on prior survey experience from similar residential (non-low-income) programs for specific question wording.

Measuring NTGR in multiple ways can increase the construct validity of the estimate. While the NTG pilot is based on self-reports, the approach required measuring FR in more than one way and obtaining other comparatives to increase the reliability of the estimate of the NTGR.

The primary self-report inquiries and NTGR algorithm for this evaluation replicate the algorithm used in previous NYSERDA SBC evaluations. This method was validated through a recent study of NYSERDA's C&I programs, which constitutes one of the only free ridership validation studies conducted to date across the country.[28]

In recent years, the energy efficiency program offerings in New York have expanded significantly with the addition of utility efficiency programs. Self-report FR methods and other FR methods will likely need to change in future evaluations to account for the range of efficiency programs being offered. Since this net-to-gross pilot evaluation covers the 2007 to 2008 program period, and thus predates the field implementation of the utility programs, replicating the previous SBC evaluation methods provides a defensible FR estimate for this evaluation and will establish a benchmark for comparison to future EmPower (and potentially other low-income program) evaluations.

The remainder of this section covers a general description of the method used to estimate FR and participant SO, additional detail on the algorithms used to estimate FR and participant SO, and an explanation of the calculation of the combined NTGR.

3.6.2 Free Ridership Self-Report Method and Algorithm

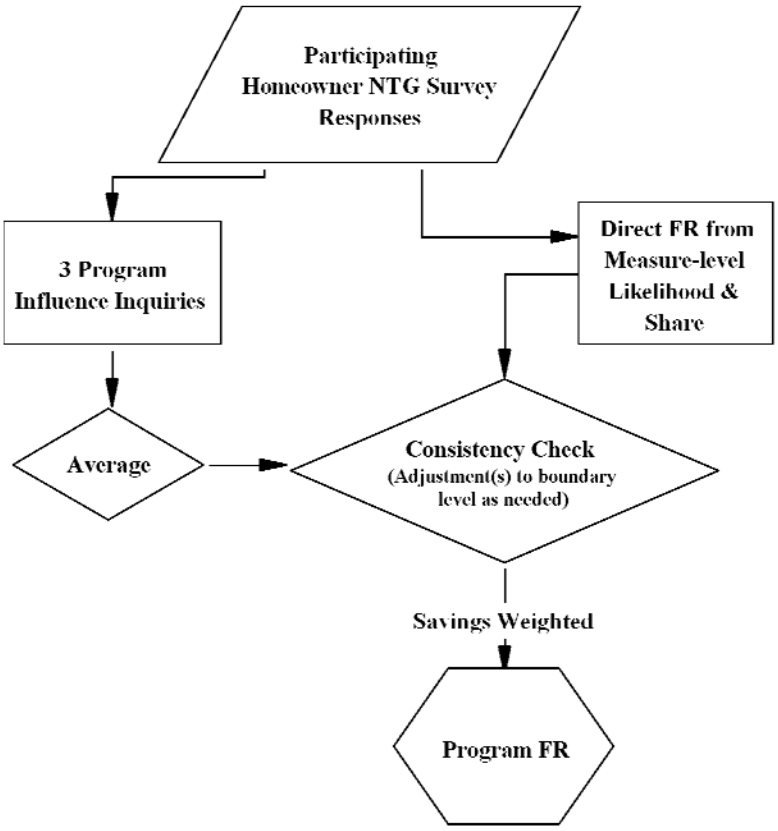
The process of estimating a participant's FR using NYSERDA's prior evaluation method has several components, as explained below.

- Direct FR is estimated by asking how the Program affected likelihood that each measure would be installed and the share of the measure that would have been installed. Then these are averaged and weighted by program estimates of savings for each of the participant's measures. This value is then adjusted to take into account the timing of installation.
- A consistency check is conducted by comparing this preliminary FR estimate against other measures of program influence.

[28] 2008. NYSERDA. *Impact Evaluation of the Largest Energy Saving Projects*, prepared for NYSERDA by the Megdal & Associates, LLC Impact Evaluation Team.

This process is illustrated in Figure 3-2 and described in the text below.

Figure 3-2. Self-Report Components for Estimating FR



To determine direct FR, participants are asked the likelihood of installation without the Program for each measure installed. Since the Program may be effective in increasing the quantity of efficient measures installed, participants are also asked to estimate the share (proportion) of the efficient measures that would have been installed without the Program, *e.g.*, the percentage of the light fixtures that would have been upgraded to efficient fixtures if the participant had not participated in the EmPower Program. The responses to these two questions (FR8 and FR9 in Table 3-13) are multiplied together to determine the FR rate by measure.

The third element of the direct FR analysis is timing. For the EmPower Program, the key issue is when the participant would have incorporated a similar measure or design. The NTG survey included a series of questions to determine whether the participant was planning to take similar actions prior to enrolling in the Program and these responses were used to establish the timing multiplier. This factor adjusts FR for participants who installed measures earlier due to participation in the Program, as described below.

- If the participant would have installed the measure within one year, the direct measurement of FR described above is left unadjusted.
- If the participant responds that they would have eventually installed the measure, but not for five years or more, direct FR is multiplied by zero, indicating that the participant is not a free rider.
- Proportional adjustments are made for responses between one and five years.

The preliminary participant FR is calculated as the savings weighted average of the measure level FR estimates multiplied by the timing factor. The survey questions on likelihood, share and timing are provided in Table 3-13 below as well as in the survey instrument included in the Appendices.

Table 3-13: FR Likelihood, Share and Timing Questions with Factor Calculations

Survey Question #	Survey Question	Factor, where applicable
FR7	Within how many months and years of when you participated in the EmPower Program would you have been likely to make these improvements if you had not participated in the Program? For example, if you would have installed the item at the same time as occurred through the Program, then your answer would be zero; if you would have installed it a year later and a half later, then your answer would be 1 year and 6 months.	Timing: Less than or equal to 1 = 1.0 More than 1 and less than 2 years = 0.75 More than 2 and less than 3 years = 0.5 More than 3 years and less than 5 years = 0.25 More than 5 years = 0
FR8	What is the likelihood that you would have [MEASURE] if you had not participated in the EmPower Program?	Likelihood by Measure
FR9	What share or percentage of the [MEASURE] would you have installed anyway without the EmPower Program?	Share by Measure
FR		FR7*FR8
Prelim FR		FR*Timing Factor

The consistency check was performed by comparing the preliminary FR estimate developed through the above process to the participant's responses regarding the influence of the Program. This verification process is facilitated by the use of another set of questions that asked about the influence of the Program on the installation of efficiency measures. The surveys contained three questions that are designed to measure the influence of the Program:

1. Prior plans. The participant was asked if they had any prior plans to install similar high efficiency measures as the measures received through EmPower. If so, they are asked to describe their plans for energy efficient installations made prior to participating in the Program. The interviewer then assigns a score for this level of planning that ranges from zero to four with '0' indicating no plans and '4' indicating the high efficiency equipment was selected and budgeted.
2. Program influence. Participants were asked if the EmPower Program influenced the type, number, or efficiency of measures installed. Those respondents who answered in the affirmative were asked to describe the Program's influence on the decision to install high efficiency measures. The interviewer then rated the response from zero to four with '0' indicating the Program had no influence and '4' indicating the Program was the primary reason that high efficiency equipment was installed.
3. Program importance. The participant was directly asked to rate the importance of the Program in their decision to install high efficiency measures on a scale from zero to four with '0' indicating the Program was not at all important in the decision to install high efficiency equipment and '4' indicating the Program was very important in that decision.

Through this process, a score between zero and four was assigned for each of the three questions and the three scores were averaged to determine the overall program influence score. This average was converted into an upper and lower bound range of plausible FR values and the range was compared to each participant's direct FR estimate discussed above. Table 3-14 below provides the survey questions, valid responses and factors.

Table 3-14. Planning and Influence Questions for FR Adjustments

Survey Question #	Survey Question	Valid Responses	Factor, where applicable
FR1c	What were you planning to do regarding energy efficiency before your participation in the EmPower Program?	Verbatim with Score recorded by Interviewer based upon the following guidelines:	Planning score is inverted prior to being used as 1st of 3 Influence Questions
		0 = No plans for high-efficiency equipment; respondent may have considered alternative technology options, but did not explicitly consider high efficiency.	
		1 = Initial steps toward consideration of high efficiency such as requesting information on or discussing, in general, high efficiency with vendors or contractors.	
		2 = In-depth discussion or consideration of specific types of high efficiency equipment (e.g., lighting, HVAC, appliances), including their positive or negative attributes and costs.	
		3 = Identification of specific equipment manufacturers and models, including assessment of their relative costs and performance characteristics.	
		4 = High efficiency equipment and designs fully specific and explicitly selected and plans to accommodate any increase in costs to obtain high efficiency.	
FR4	In what ways did NYSERDA's EmPower Program influence your having high efficiency measures or equipment in your home? (Be sure to identify specific measures/ equipment.)	Verbatim with Score recorded by Interviewer based upon the following guidelines:	2nd of 3 Influence Scores
		0 = No influence on the decision to install high-efficiency equipment. All equipment would have been installed at the same efficiencies even without the Program.	
		1 = Program helped in making final decision on equipment that had already been thoroughly considered.	
		2 = Program lent credibility to the decision to invest in high efficiency and/or it provided information that helped expand the quantity, scope or efficiency of the equipment.	
		3 = Program identified a significant number of specific high efficiency options that were installed but that had not previously been considered and/or Program was a major driver behind a significant increase in the quanitity, scope or efficiency of high-efficiency equipment.	
		4 = Program was the primary reason that high efficiency equipment was installed in the project.	
FR5	On a scale of 0 to 4, where 0 is "not at all important" and 4 is "very important," how important was your participation in the EmPower Program in having energy efficiency measures installed in your home? Was it…	0 Not at all important	3rd of 3 Influence Scores
		1 Slightly important	
		2 Somewhat important	
		3 Important	
		4 Very Important	

Table 3-15 below provides the conversion table for the average influence score and is modeled after the algorithm used in previous NYSERDA SBC evaluations. If the participant's direct FR estimate falls below the lower or above the upper bounds of FR based on the program influence questions, the final FR estimate for that participant is adjusted upward or downward to the edge of those bounds according to the influence score. For example, if the direct FR value for a specific participant were 10% and the average of the three influence scores were 2.00, the lower bound on the direct FR value from the table below would be used and the free ridership would be adjusted upward to 25%, as shown on the eighth row of Table 3-15. However, if the direct FR value were to fall between 25% and 75% and the average influence score was 2.00, then no change to the direct FR value would be made.

Table 3-15. Conversion Table for Average Influence Scores

Position #	Average Program Influence Score	Lower Bound Direct FR Value	Upper Bound Direct FR Value
0-1	0.00-0.33	75%	100%
2	0.50	70%	100%
3	0.67	65%	100%
4	1.00	60%	100%
5	1.33	55%	95%
6	1.50	35%	85%
7	1.67	30%	80%
8	2.00	25%	75%
9	2.33	20%	70%
10	2.50	5%	55%
11	2.67	3%	50%
12	3.00	0%	45%
13	3.33	0%	40%
14	3.50	0%	35%
15	3.67	0%	30%
16	4.00	0%	25%

3.6.3 Spillover Estimation Method

The participating homeowner NTG survey included questions to estimate participant inside SO, as summarized below.[29]

1. Were additional energy efficient measures installed in their home due to the influence of the Program that did not receive direct program support? This was asked by fuel type, *e.g.*, electricity and natural gas.
2. If so, were the savings from the added measures higher or lower than the energy savings from measures that were supported by the Program? This question was followed by a request to

[29] Please refer to the NTG survey instrument Appendix B for the exact wording of the NTG questions.

estimate the savings from the additional measures as a percentage of the savings achieved through participation in the Program.

3. What is the percentage of these extra savings that could be attributed to the respondent's experience with the Program?

The inside SO questions were asked by fuel source (electricity versus natural gas) in order to maximize the accuracy that could be obtained in a telephone survey. The SO rates were calculated by combining the responses by fuel type, converting all savings to source MMBtu for electricity and natural gas MMBtu, and then estimating an overall value for both fuels. This dual approach was designed to improve the accuracy of responses while maintaining larger sample sizes for greater sampling precision.

Developing specific estimates of savings from spillover from telephone respondents is recognized as a problematic process among evaluators. Asking end-users directly to estimate savings in kWh or therms is likely to result in very inaccurate answers. However, the evaluator does have the program estimate of savings for the participant, and an estimate of spillover can be derived by having respondents benchmark spillover savings against the savings they see from the measures installed through the Program.

The total SO rate was calculated by dividing the sum of the natural gas and electric SO savings by the sum of the Program natural gas and electric savings, as follows:

Total Participant Spillover = (Natural Gas SO Savings [MMBtu] + kWh SO Savings [MMBtu]) / (Natural Gas Program Savings [MMBtu] + kWh Program Savings [MMBtu])

3.6.4 Net-to-Gross Ratio

The above discussion describes two key components of constructing solid and defensible estimates of program induced impacts, FR and SO, and how these are estimated in this impact evaluation. The survey instrument is included as Appendix B.

The FR and SO rates are combined to produce a net-to-gross ratio that is applied to evaluation-estimated gross savings to produce net savings.

Net-to-Gross Ratio (NTGR) = 1 – Free Ridership Factor + Total Participant Spillover Factor

This method enables the Program to account for participant net savings incorporating both program savings that would have naturally occurred and savings undertaken by participants outside of the Program because of their prior participation in the Program. This ensures that the final net program savings estimate is all inclusive and credits the Program's impact in a balanced manner.

Section 4:

RESULTS

This section provides a summary of the results of the major components of the study and how these components contribute to the overall results. Context is provided for interpreting the results of the estimated savings by measure group. The summary of gross program savings is presented in Section 4.5.

4.1 RESTRICTED BILLING ANALYSIS

The survey was set up to identify additions or replacements of equipment and changes in occupancy as they occurred throughout the analysis period. Questions about changes in the use of energy-intensive equipment and schedule were constructed by comparing the pre-installation period to the post-installation period. From the survey data, variables were constructed to model the difference in appliance holdings, occupancy, schedules, and energy use patterns between the pre-installation and post-installation periods.

All model results were compared against the base case, which included only the variables available from the program tracking data and the NOAA weather files, *i.e.*, only the variables that could be included in the full regression model. Survey-based variables reflecting the major potential sources of variation in energy use were then added to the base model to assess whether there was any change in the savings.

This analysis indicated that the savings in the restricted models remained stable, regardless of the composition of the model variables. Since these types of changes are random, the variations in energy use do not introduce either an upward or downward bias to the final savings estimated as long as the number of homes in the model is sufficiently large.

In summary, the restricted model demonstrated that the within home variations do not introduce a bias into final estimated savings. Thus, the results from the full billing model are a reliable estimate of program savings.

4.2 FULL BILLING ANALYSIS

The full billing analysis was conducted first in its simplest form, which estimated the savings by household, and then with measure groups to estimate the savings by group. The final results were based on the participant-only model including the utilities with reliable billing data. Some of the characteristics of the final models are described below:

- The coefficient of determination (R^2), reflecting the proportion of the change in consumption explained by the model, are quite high at 0.82 for the natural gas model and 0.70 for the electric model.
- The results from the measure- and household-level models are close, indicating internal consistency.
- Most of the measure group savings were reasonably consistent under different definitions of the model variables, as discussed in more detail below in Section 4.4.
- For the most part, the measure group results are in the range of savings found for other, similar programs.

The regression output for the final measure group and household models are provided in Appendix F.

After completion of the model selection process, the final household model was run under a variety of scenarios to assess the impacts of potential influences on the results. Overall, this additional analysis

supported the use of the participants-only model using the utilities with reliable billing data. The results of these final comparisons are summarized below and additional detail is provided in Appendix G.

- All Utilities

  The two utilities with problematic billing records were added to include all utilities in the participant-only model. In both models, the R-squared statistic dropped substantially (from .818 to .375 for the natural gas model). Typically, the R^2 values are high for fixed effect models with customer-specific intercepts, since much of the variation in use is explained by explicitly modeling the house-to-house differences. Consequently, the low R^2 values for the all- utilities models raises serious questions about the validity of the results.

- Comparison Group

  The non-participant comparison group was added to the model, including only the utilities with reliable billing data, to provide some initial feedback on potential external factors affecting the larger low income residential population.[30] These models (both natural gas and electric) showed a reduction in savings, suggesting that there was an overall decrease in consumption over the analysis period. However, as this approach may introduce net effects into the results, it was used only for comparison purposes.

- Trend Lines

  Trend lines reflecting the changes in gasoline prices and unemployment rate were added to the models to address economic factors.[31] For the electric model, there was no change in the savings, indicating that external market factors may not be having major impact on program savings. The natural gas model showed the heating savings to be reasonably consistent, but the base measure savings (from water heating measures) dropped by about 20%. The savings from water heating measures tended to be unstable in general (as discussed in more detail in Section 4.4 below); however, these measures account for only a small percentage of the total program savings (about 5%) and thus the estimators from the final participant-only model without trend lines would not be expected to introduce bias to the program savings.

- WAP Participation

  Participation in other programs is a confounding factor for assessing the impacts from EmPower. Many EmPower participants also receive services through the federal Weatherization Assistance Program (WAP). The EmPower Program database identifies those participants who also receive WAP benefits, and variables were added to the household model to estimate the savings for WAP and non-WAP homes. Both models show that the WAP homes have higher savings than the non-WAP homes, although the electric model shows only a modest increase (4%) as compared to the natural gas model (13%). These results suggest that the EmPower Program savings estimates

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[30] The comparison group was drawn from "future" program participants, i.e., those who participated in 2009, including only the billing data in the period prior to program participation. Proxy "installation" dates were assigned to the comparison group to allow simulation of the "pre-installation" and "post-installation" periods. The proxy dates were assigned by taking the most recent available read prior to the EmPower audit and subtracting one year. This approach resulted in a distribution of the comparison group billing data that was similar to the participants'.

[31] The unemployment rates and gasoline prices were taken from the Bureau of Labor Statistics' and Department of Energy's Web sites. These sites provided monthly figures for the 2006 through 2010 time period. These figures were provided by month, but were translated to daily numbers (the same number for each day of the month). The daily values were then averaged over billing cycles of each participant.

include some WAP savings.[32] However, according to the program database, about 13% of the participants had services that were coordinated with WAP, so the effect on total program savings would be small.

This review indicates that the billing analysis provides reliable and reasonable savings for the EmPower Program during program years 2007 and 2008.

4.3 REGRESSION DIAGNOSTICS

The regression methods are based on the assumptions that the error term is independent, has a constant variance, and is normally distributed. Regression diagnostics were conducted for the final models (natural gas and electric) to determine whether there were any major deviations from these assumptions. The effects of heteroskedasticity (unequal variances), collinearity, autocorrelation (lack of independence among observations) and influential data points were assessed as part of the model diagnostics.

Only autocorrelation was found in the natural gas billing model, and both autocorrelation and heteroskedasticity were found in the final electric billing model. Autocorrelation is common with billing models as the consumption in one month within a home tends to be related to the consumption in the next month. Dependence among observations does not affect the reliability of the estimate, but does indicate that variability within the model estimates may be greater than represented by the confidence interval. Heteroskedasticity is often caused by the wide fluctuations between high use and lower use homes and results in estimates showing higher variability than actually exists. The models were also tested with and without outliers, and the savings results were found to be highly consistent. Additional information about model diagnostics is provided in Appendix E.

4.4 SAVINGS BY MEASURE GROUP

Both the electric and natural gas models were run twice, once with all of the measure groups from the final model and once to estimate total household savings. The total savings from the household models were slightly higher than the savings as calculated by adding the measure groups. This result may be due to additional savings from behavioral changes or simply savings that are occurring in the homes but cannot be properly assigned to a specific measure. Given that EmPower is a comprehensive audit program and many measures are installed in each home, attempting to separate the savings into each measure group is complex and some uncertainty remains in the measure-level estimates of savings. Thus, when the total program savings were estimated, the results were adjusted to include the full magnitude of the savings from the household models. The measure groups are defined in Table 4-1 below.

[32] In contrast to the model results, program savings suggest that homes with WAP coordination on average have lower savings than the non-WAP homes.

Table 4-1. Measure Group Definitions

Measure Group	Description	Fuel Saved	Fuel with Extra Use
Clothes Dryer Fuel Switch	Replacement of an electric clothes dryer with a natural gas clothes dryer	Electricity	Natural gas
Water Heating Conservation	Pipe wrap, low flow showerheads, tank wraps	Electricity or natural gas, depending on the water heater fuel in the home	None
Water Heating Fuel Switch	Replacement of an electric water heater with a fossil fuel water heater (most common) or replacement of a fossil fuel water heater with an electric water heater	Electricity or natural gas, depending on the existing water heater fuel in the home at the time of the audit	Electricity or natural gas, depending on the fuel type of the new water heater installed through the program
Water Heater Repair	Repairs to the existing water heater	Electricity or natural gas, depending on the water heater fuel in the home	None
Envelope	Installation of additional insulation and blower-door assisted air sealing	Electricity or natural gas, depending on the fuel used for space heating	None
Heating System Fuel Switch	Replacement of an electric space heating system with a fossil fuel heating system	Electricity	Natural gas
Heating System Repair or Replacement	Repair or replacement of the space heating system	Electricity or natural gas, depending on the fuel used for space heating	None
Lighting	CFL and hardwired fixtures	Electricity	None
Refrigeration	Refrigerator replacement and freezer replacement	Electricity	None
Thermostat	Replacement of a manual thermostat with a programmable thermostat	Natural Gas	None
Other	Miscellaneous small measures that do not fit into the categories listed above	Electricity or Natural Gas	None

4.4.1 Electric Model Results

Table 4-2 shows the savings by measure group and by household for the homes included in the electric model. Since there was no sampling and all participants with sufficient billing data were included in the model, the confidence intervals reflect the variability in the model, not the sampling precision.

Table 4-2. Electric Savings by Measure Group

Measure Group	Program Savings per Home (kWh/Year)	Evaluated Savings per Home (kWh/Year)	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Realization Rate
Lighting	419	130	124	136	31%
Refrigerator Replacement	1,040	569	511	628	55%
Water Heating Conservation	323	153	0	306	47%
Water Heater Repair	195	727	369	1,085	373%
Water Heating Fuel Switch	3,803	3,663	3,189	4,136	96%
Clothes Dryer Fuel Switch	2,451	1,739	1,483	1,995	71%
Other Electric Measure	840	407	-101	916	48%
Heating System Fuel Switch	6,236	8,557	8,184	8,929	137%
Savings per Household from Measure Groups	1,197	566	523	610	47%
Savings from Household Only Model	1,197	685	610	759	57%

Lighting

Lighting tends to be difficult to determine from a billing analysis due to the small magnitude of the savings and the high penetration of the measure among program participants. The model indicates that savings are in the range of 11 kWh per year per CFL bulb. Lighting savings tended to be unstable, *i.e.*, the magnitude of the savings varied according to the variables included in the model. If all of the unassigned savings from the household model are assumed to be associated with lighting (which is not an unreasonable assumption), the savings increase to 22 kWh per year, which is in the same range as found in previous impact evaluations of the Low Income Energy Efficiency (LIEE) Program and is consistent with the California Database for Energy Efficiency Resources (DEER) estimates for some CFL products. The most recent evaluation of the California LIEE Program found savings of 13 kWh per CFL in single family homes.[33]

In EmPower, an average of eight CFL bulbs are installed in each home and it could be that some of these bulbs are installed in low use locations. Program staff has modified the methods of estimating savings to take into account that the more CFL bulbs installed, the more likely some will be placed in low use locations.

Refrigerator and Freezer Replacement

In contrast to lighting, refrigerator and freezer replacements are estimated by the Program to achieve substantial savings (about 10% to 15% of average residential annual electric consumption). Since these measures are also commonly installed, the model included many households with these installations.

[33] Impact Evaluation of the 2009 California, Low-Income Energy Efficiency Program, Study ID: SCE0273.01 EcoNorthwest, Portland, OR. 2011 pg. 87
http://www.calmac.org/publications/LIEE_FINAL_2009_Impact_Eval_Report.pdf

The savings for these replacements are substantially lower than estimated by the program, at an average of 569 kWh per year per home as opposed to the program estimate of 1,040 kWh for homes in the model, giving a realization rate of 55% for this measure group.[34]

The recent evaluation of the California Low Income Energy Efficiency program found savings of 697 kWh per year per home for replacement refrigerators, indicating that the EmPower model results are within the same range as the California program.[35] These savings are also consistent with the expected reduction in the savings potential for refrigerator replacement due to increases in Federal Efficiency Standards adopted in 1997.

The Impact Evaluation Team understands that EmPower Program staff have reviewed and adjusted the method of calculating savings from these measures. The evaluation results emphasize the importance of this activity.

Water Heating Measures

Savings from water heating conservation measures tend to be difficult to estimate from billing models due to the relatively low penetration of the measure and high variability of consumption in these homes.[36] In this case, the savings from the model (153 kWh per year per home) are about half of the claimed program savings (323 kWh per year per home), but the model results are also highly variable, as indicated by the wide confidence interval of 0 to 306 kWh.

The impact evaluation of the California LIEE Program for program year 2005 included an analysis of showerhead savings. Flow rates were measured from a sample of existing showerheads removed from LIEE homes and compared to the new models installed through the program. This component of the evaluation led to the conclusion that the savings from low flow showerheads are about 170 kWh per year. LIEE impact evaluations prior to program year 2005 found the savings from the water heating conservation package (aerators, showerheads, pipe insulation and tank wraps) to be in the range of 30 to 240 kWh per year.[37] Thus, the findings from these external studies also suggest that the savings from the water heating conservation package may be lower than estimated by the EmPower Program.

Electric water heater repair measures, although infrequently installed, appear to save substantially more than estimated, as was shown in both the electric and gas models. This measure may include fixing the pressure relief valve, replacing controls, fixing the flue (for natural gas heaters) or replacing the tank. It must also be noted that there is a high degree of uncertainty in the estimated savings for this measure and there were only a few homes in the model with the measure. While this finding seems to be supported by similar results from the natural gas billing model, the Impact Evaluation Team recommends caution in assuming that this measure is widely applicable. Only 4% of EmPower participants received this measure, which may indicate that it is only appropriate for a small portion of the participants receiving services from EmPower.

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[34] The savings were estimated by home rather than by the number of appliance replaced. However, an alternate model was run to estimate savings by item and the results were similar.

[35] *Op. cit.*, EcoNorthwest, 2011.

[36] Examples: *Op. cit.*, Blasnik 2004 and West Hill Energy and Computing, 2008.

[37] *Op. cit.*, West Hill Energy and Computing, 2008.

Fuel Switching

Water heater, heating system and clothes dryer fuel switches are less frequently installed. These measures consist of completing removing the electric heater or dyer and replacing it, generally with a natural gas or other fossil fuel unit. Thus, the result is substantial electric savings and also increased consumption of natural gas or other fossil fuels. The additional natural gas use was included in the natural gas billing model, where appropriate.[38]

Although the number of installations was low, the savings are substantial in comparison to overall residential use. Consequently, the savings for these measures were stable and do not exhibit high variability. They are, however, based on a small number of homes (only two homes for space heat fuel switching).

Electric Space Heating Measures

No savings were found for measures designed to reduce electric space heating loads, possibly due to the small number of homes in the model with electric space heat and the high degree of variability in these homes. In terms of the impact on total program savings, envelope measures installed in electrically space heated homes account for about 5% of the total program electric savings, whereas programmable thermostats and heating system repairs in aggregate contribute less than 1% of the savings.

A separate analysis was conducted to assess whether savings could be estimated for these envelope measures in homes with electric space heat. The pre-installation heating consumption in these homes was calculated for the 14 homes in the model and compared to the claimed savings. The average heating consumption prior to program participation was about 10,200 kWh, but the average claimed savings for these homes exceeded that average heating use at approximately 14,00 kWh. In several cases, the claimed savings seem to be off by an order of magnitude, and the pre-installation billing data suggests that one home does not appear to have heating-related use. In any case, this secondary analysis also supports the conclusion that there are no savings in these homes.

4.4.2 Natural Gas Model Results

The challenge with the natural gas model is to distinguish between heating and base (non-temperature dependent) use. 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. In addition, the water inlet temperature drops during the winter, leading to higher water heating loads, which to some extent mimics the increase in natural gas use during the heating season.

While the overall savings in the billing model is reasonably consistent across the modeling options, the split of the savings between base and space heating measures tended to vary. Consequently, the household savings are reliable, but the savings associated with specific measure groups are somewhat variable.

[38] The natural gas billing model showed extra use for water heating fuel switching. There were no homes with electric space heat fuel switching (which was rarely) installed and the billing model did not show extra use for natural gas clothes dryers.

Table 4-3. Natural Gas Savings by Measure Group

		Regression Results			
Measure Group	**Program Savings per Home (MMBtu/Yr)**	**Evaluated Savings per Home (MMBtu/Yr)**	**Lower 90% Confidence Limit**	**Upper 90% Confidence Limit**	**Realization Rate**
Water Heating Conservation	1.8	2.8	1.1	4.5	159%
Water Heater Repair	1.9	5.9	2.3	9.6	311%
Water Heating Fuel Switch Extra Use[1]	(18.1)	(4.1)	(21.0)	12.9	23%
Heating System Repair	10.3	11.0	10.9	11.1	107%
Envelope Measures	26.1	14.8	14.7	14.8	57%
Programmable Thermostats	8.3	2.4	2.2	2.5	29%
Savings per Household from Measure Groups	21.6	13.8	13.7	13.9	64%
Savings from Household Only Model	21.6	14.6	13.0	16.2	68%

[1] Fuel switching extra natural gas use occurs when an electric water heater is switched to a natural gas water heater; for this measure, there are substantial electric savings and additional natural gas use.

Water Heating Conservation and Repair Measures

In the final model, the savings for the water heating conservation and repair measures were higher than expected. The water heating conservation measures consist of low flow showerheads, aerators and tank wrap. The water heater repair measure may include fixing the pressure relief valve, replacing controls, fixing the flue or replacing the tank. The savings for these measures show high variability (wide confidence intervals). However, since these measures contribute only 7% of the total program savings and the total program savings were adjusted to match the overall household savings, using the higher estimates of savings for these measures should not result in an upward bias on the total program savings.

The Impact Evaluation team cautions against concluding that the program reported savings from these water heating measures should be increased based on the results of this evaluation. For example, the Massachusetts TRM recommends that savings of 0.9 MMBtu be claimed for the water heating conservation package in homes with natural gas water heating based on an impact evaluation conducted.[39] There were very few homes with the model with water heater repairs, and the high savings for this measure may not be indicative of future savings if the measure were to be more widely installed.

Heating System Repair and Replacement

The savings for the heating system repair and replacement show the little variability, indicating that the modeling results are reliable for these measures. The program savings are highly consistent with the regression results.

Comparisons to impact evaluations in other states may not be as relevant to heating-related measures due to the wide fluctuations in housing stock and weather conditions. In the Northeast, the Massachusetts

[39] Massachusetts Technical Reference Manual, 2001 Program Year - Plan Version, October, 2010. pp. 122-123. The TRM cites the results of the following impact evaluation: Cadmus Group, Inc. (2009). *Impact Evaluation of the 2007 Appliance Management Program and Low Income Weatherization Program.* Prepared for National Grid.

TRM covers measures that are similar to those installed through the EmPower Program, and recommends claiming savings of 13.7 MMBtu per year for the replacement of oil heating systems with efficient models, which is in the range of both the program reported savings and the evaluated gross savings (10.3 to 11.0 MMBtu).

Insulation and Air Sealing

While the modeled savings from envelope and air sealing measures have low uncertainty and tight confidence intervals, the modeling results are substantially lower than the program estimates. This unexpected result suggests that it may be necessary to review the methods used to estimate savings for these measures. The Massachusetts TRM has savings estimates of 13.7 MMBtu per home per year for weatherization of homes with oil space heating, based on the impact evaluation of a low income program completed in 2009.[40] This value is very close to the evaluated savings of 14.8 MMBtu for EmPower.

Programmable Thermostats

The estimator for savings from programmable thermostats was highly variable and also showed substantially lower savings than anticipated. In this case, the savings value from the Massachusetts TRM of 7.7 MMBtu for oil space heating is more in line with the estimated program savings; however, the TRM value does not cite an impact evaluation.[41]

Other research suggests that the savings from programmable thermostats is related to setback behavior (manual or otherwise) prior to the installation, *i.e.*, homes which use the programmable setback features may have been manually controlling the thermostat prior to receiving program services.

Fuel Switching Extra Use

The expected additional natural gas use associated with fuel switches from electricity to natural gas was also included in the model. No additional use was found for homes with clothes dryer fuel switches and the increased use due to the water heating fuel switches was substantially lower than estimated, which may be partially due to the few number of homes in the model with this measure. No homes in the model switched from electricity to natural gas for space heating.

4.4.3 Evaluated Program Savings

Total evaluated program savings were based on the results from the billing model. Program savings were augmented to include the extra savings found in the household models that could not be assigned to specific measures. The process of calculating total program savings was conducted in two steps:

1. the realization rates for each measure group were applied to the program savings
2. the unassigned savings per household were added for all households with savings

Measures that were excluded from the model because none of the participants in the model had installed the measure (such as waterbed measures) were assumed to have a realization rate of 1.0. These measures account for less than 1% of the total program reported savings. The realization rates from the natural gas model were applied to all measures with MMBtu savings, regardless of the fuel type. Since this evaluation is for SBC-funded measures, the total evaluated program savings include only those measures,

[40] *Ibid.*, pp. 110 -111. The TRM cites the impact evaluation listed in the previous footnote.

[41] *Ibid.*, pp. 106 -107.

i.e., measures funded through other programs such as the National Grid natural gas program, were removed from the analysis.

4.5 SUMMARY OF GROSS PROGRAM SAVINGS

The program savings were estimated from the full billing models and the final results are shown in Table 4-4. EmPower achieved 11,295,798 kWh and 64,095 MMBtu of annual savings during program years 2007 and 2008. The realization rates are 54% and 70% for the electric and non-electric (fossil fuel) savings, respectively.[42] These results are based on all homes with sufficient billing records. Consequently, the 90% confidence intervals of 7.2 and 12.5 presented in Table 4-4 reflect the variability within the models, not the sampling precision.

Table 4-4. Summary of EmPower Program Reported and Evaluation Savings

	Annual Electric Savings (kWh/Yr)	Summer Peak Demand Savings (kW)	Annual Non-Electric Savings (MMBtu/Yr)
Evaluated Savings	11,295,798	1,203	64,095
Lower 90% Confidence Limit	10,482,145	1,110	56,054
Upper 90% Confidence Limit	12,109,450	1,295	72,136
NYSERDA Program Reported Savings	20,819,574	2,123	91,602
Realization Rate	54%	57%	70%
90% Confidence Interval on Realization Rate[1]	±7.2%	±7.7%	±12.5%

[1] The confidence band on the realization rate reflects variability in the models, not sampling precision, as no sampling was conducted for this analysis. All homes with sufficient billing records were included in the models.

Average household savings were compared to the pre-installation average annual use of homes in the billing model, as shown in Table 4-5. This analysis indicates that EmPower participants saved approximately 9% of their total energy use.

[42] It was not possible to conduct a billing analysis for the heating-related measures for homes with an oil or propane primary heating system due to the complexity of obtaining and interpreting the billing and delivery records. Given the similarity in the analysis of heating-related loads, the realization rates for the heat-related measures from the natural gas analysis were be applied to the savings estimates for oil and propane heated homes. This strategy is based on the assumption that the accuracy (level of bias) of the algorithms used by the program for estimating oil and propane savings is the same as those applied by the program for natural gas heated homes.

Table 4-5. Comparison of Annual Consumption and Program Savings for EmPower Participants

	Participant Average Consumption per Home Prior to EmPower Services (Billing Model)	EmPower Evaluated Annual Savings per Home	Evaluated Savings as % of Annual Consumption
Annual Electric Consumption and Savings (kWh)	7,792	694	9%
Annual Natural Gas Consumption and Savings (MMBtu)	109	10	9%

4.6 PILOT NTG STUDY

This section covers the results for the pilot net-to-gross effects of the EmPower Program, *i.e.*, free ridership (FR), spillover (SO) rates and net-to-gross (NTG) ratio. Low-income programs are often assumed to have no free riders or spillover based on the belief that occupants cannot afford to take any of these actions without the program, and free ridership and spillover were set to zero. This evaluation included a pilot project to test this assumption. A participant survey was designed to follow prior NYSERDA free ridership and spillover inquiries and measurement used in evaluating NYSERDA's other residential existing homes program, Home Performance with ENERGY STAR®. Using questions and an algorithm already tested with known free ridership findings from another NYSERDA residential population ensured that the EmPower free ridership and spillover test would be an objective assessment.

4.6.1 Free Ridership Pilot

As discussed in Section 3.6, construct validity is the area of greatest concern regarding estimating free ridership. This issue is addressed within the prior NYSERDA FR method used in similar evaluations through the use of multiple inquiries and consistency checks of a participant's responses. The series of "direct" self-report FR questions was designed to elicit explicit measure level estimates of FR from the respondents. A participant's preliminary FR is the savings weighted average for that participant of their measure level FR. A participant's preliminary FR estimate was adjusted when the estimate conflicts with questions regarding the level of program influence on their adoption decisions. This section follows this sequence by providing responses and results from the direct free ridership questions, survey results for the program influence group of three questions that make up the consistency check and then the free ridership estimate.

Direct Query

The direct free ridership estimate is based on the measure-specific questions. For each measure category received by the respondent, [43] the survey collected information on the following subjects:

1. the possible time frame for when, if ever, the equipment would likely have been installed without the EmPower Program.
2. the likelihood that the same high efficiency equipment would have been installed without the EmPower Program.

[43] A review of the Program data provided a list of measure categories which was used as refined and incorporated into the survey instrument. Measure categories are presented in Table 1 of the NTG Homeowner Survey Instrument.

3. the share of high-efficiency measures that would have been installed without the EmPower Program.[44]

It is not possible to make a direct comparison of these results to previous EmPower NTG studies since this is the first NTG analysis for this program. However, comparing the results to the nearly identical survey conducted for the Home Performance with ENERGY STAR (HPwES) in the same time frame allows us to assess the difference in FR rates for a low income and a non-low income program. Only 24% of EmPower participants responded that the Program caused them to install energy efficiency measures earlier than they otherwise would have, whereas 60% of HPwES participants responded affirmatively to this question.

The measure level questions on likelihood and share are the only questions asked at the measure group level and form the basis for the direct query FR estimates. However, the consistency checks are conducted at the project level, and thus, the responses to these questions as reported below are the direct responses, not the adjusted responses. Consequently, the final adjusted FR rate does not necessarily match the preliminary values developed from the responses to these questions. (Please refer to Section 3.6.2 for more information about the method of calculating the FR rate.)

The sample size was designed to achieve a sampling precision of 90 with a 10% error tolerance overall for the program. However, the number of respondents by measure is substantially smaller and only three measure groups, CFLs, refrigerators replacements and water heating conservation measures, have more than a couple of dozen respondents.[45]

Table 4-6. Direct Free Ridership Rates by Measure Category

Measure Category	Average FR Rate	Number of Respondents (n = 70)
CFL's or efficient lighting	14%	58
New Refrigerator	15%	37
Hot water conservation measures	5%	29

Program Influence

The program influence questions cover three areas:

1. the homeowner's plans to incorporate energy efficient measures prior to participating in the Program.

2. the program effect or influence on the amount, type, or efficiency level of the measures that were installed through the Program.

3. the importance of the Program (*i.e.*, financial and technical assistance) in their decision to install high efficiency measures.

[44] This question was only asked if insulation, air or duct sealing, CFL or efficient light fixtures, or hot water conservation measures was installed.

[45] These estimates of direct FR are not able to make use of the influence questions and, therefore, are more likely to be less accurate.

Almost three-quarters (73%) of participating homeowners indicated that they did not have plans to incorporate high efficiency measures prior to their participation the EmPower Program. Among those who did, less than 11% of the respondents did any planning for high efficiency beyond initial steps as detailed in Table 4-7.

Table 4-7. Participant Prior Plans for Installing High Efficiency Equipment without the EmPower Program

Prior planning	Number of Respondents (n = 70)	Percent of Respondents
No plans to install high-efficiency equipment[1]	54	77%
Initial steps taken toward consideration of high efficiency	8	11%
In-depth discussion or consideration of specific types of high efficiency	1	1%
Identification of specific equipment manufacturers and models	2	3%
High efficiency equipment and designs fully specified and explicitly selected	5	7%[a]

[1] This row combines the responses to two questions, the screener question and those who were asked about prior plans but indicated that they were not planning to install high efficiency equipment within the specified time frame.

a Total does not add to 100% due to rounding.

Respondents were first screened to see if they would have installed any of the new equipment without EmPower and then asked how the EmPower Program influenced the participant's decision to install high efficiency measures. Only 10% responded affirmatively to the screener question, as shown in Table 4-8.

Table 4-8. Participant Responses Regarding Program Influence

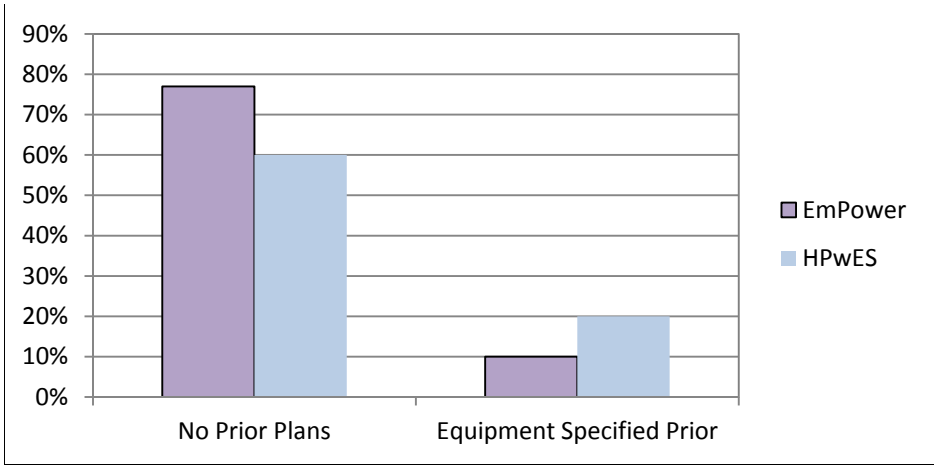
Extent of Program Influence on Decision to install	Number of Respondents (n = 70)	Percent of Respondents
Screener – Would *not* have installed *any* of the new equipment provided by EmPower without the Program	63	90%
No influence on the decision to install high-efficiency equipment	1	1%
Program helped in making final decision on equipment that had already been thoroughly considered	3	4%
Program lent credibility to the decision to invest in high efficiency	1	1%
Program was a major driver behind a significant increase in the quantity, scope, or efficiency of high-efficiency equipment	1	1%
Program was the primary reason that high efficiency equipment was installed in the project	1	1%[a]

[a] Total does not add to 100% due to rounding

Comparison to HPwES shows that the non-low-income program has higher potential for free ridership, as discussed below and illustrated in Figure 4-1.

- Over three-quarters (77%) of EmPower respondents stated they had no plans to install energy efficiency equipment prior to program participation, compared to 60% of HPwES respondents.
- Only 10% of EmPower respondents reported that they specified the equipment they planned to install prior to program participation. Twice as many (20%) HPwES respondents responded affirmatively to this question.

Figure 4-1. Comparison of EmPower and HPwES Plans for Efficiency Prior to Program Participation



Respondents were also asked to provide their own assessment of the Program's importance in the decision to install equipment at the same high level of efficiency that was provided by the Program. Table 4-9 shows that most (94%) respondents scored three or higher, indicating that the Program was a major factor in the measure installation.[46]

Table 4-9. Importance of Program on Decision to Install High Efficiency Equipment

Program Importance	N	Percent of Respondents
Not at All Important	0	0%
1	1	2%
2	3	4%
3	14	20%
Very Important	51	74%
Total	69[a]	100%

[a] One respondent did not respond.

Overall FR Estimate

The final, adjusted free ridership estimate is the savings weighted average of the individual respondent's estimates. The final free ridership rate for EmPower from this analysis is 17%.

The Economy and Self-Reported Free Ridership

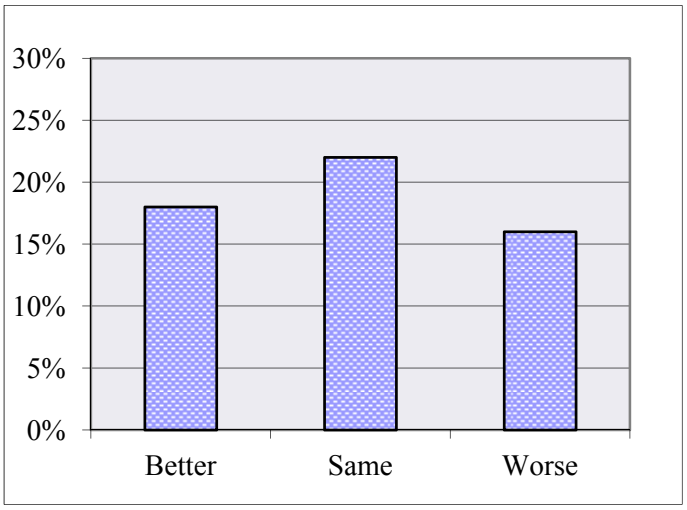
The initial question on economic conditions asked participants whether their household economic situation had improved (significantly better or somewhat better), not changed (the same), or diminished

[46] This question was worded to specify high efficiency "equipment" and it is possible that some participants did not consider some energy efficiency measures, such as insulation, air sealing or CFL's, to be equipment. Consequently, it is possible that the importance of the program may be overstated. This issue will be reviewed for future survey designs.

(somewhat worse or significantly worse) over the last couple of years as compared to the year prior to their program participation. Over half (55%) of the respondents reported an improved household economic condition, twice as many as reported their household's economic condition was worse (24%).

The free ridership rate is relatively stable across the three different categories reflecting the change in economic condition since the year prior to program participation, as illustrated in Figure 4-2. In this figure, the percentages on the y-axis are the FR rates and the three bars reflect the categories of economic changes within the household. For homes with an improvement in economic status, the FR was about 18%, as compared to 22% with no change and 16% who reported that their economic status had deteriorated. This result indicates that no relationship exists between a change in a household's economic condition and their self-reported free ridership.

Figure 4-2. Free Ridership Rates and Change in Household Economic Condition[1]



[1] Three of the participants responded with "Don't Know" for the change in economic condition question.

Participants were also asked if they had experienced a major drop in income any time between 2006 and 2009. Responses to this question were nearly evenly distributed. Households reporting a major drop in income also reported significantly higher free ridership, 21% as opposed to 12% for those that did not experience a drop in income.[47] The relationship between a drop in income and taking energy efficiency actions could be hypothesized to occur in either direction, a drop in income would mean there is even less money available to "invest" in energy efficiency but a drop in income might spur action to lower the utility bill.

In the final part of this series of questions, participants were asked to identify the number of adults in the household who were not employed and not looking for work, including individuals who were retired or not seeking work due to a disability. No relationship is seen between the FR and whether there are individuals in the home that are not seeking work as shown in Table 4-10. Most of the respondents, 71%,

[47] Three of the participants responded with "Don't Know" for this question.

reported having at least one household member who fell into this category. It is interesting to note that regardless of the response to this question, the free ridership rates were similar.

Table 4-10. Free Ridership Among Adults Not Employed or Looking for Work

Number of Adults Not Employed and Not Seeking Employment (# of Respondents, Percent of Households)	Free Ridership Rate
None (20, 29%)	18%
One (35, 50%)	17%
Two (15, 21%)	16%

This analysis indicates that there is no clear impact of the economic downturn in the self-reports of free ridership. The only potential correlation is between a major drop in income and an increase in free ridership, which is difficult to interpret and does not provide any clear insight into potential bias in the free rider results.

4.6.2 Participant Pilot Spillover

Spillover (SO) is defined as energy efficiency savings that are induced by a program, but are not directly included in program reported savings. The survey of participating home owners included questions to estimate participant SO inside the participant's home, *i.e.*, inside spillover.[48] The questions were those adopted from the prior and current evaluation of NYSERDA's other existing home program, HPwES.

Over one-third (36%) of the participants reported that the EmPower Program has led them to install measures to obtain additional electric savings. A smaller proportion, 13%, says their participation induced them to add measures that save natural gas. These results are shown in Table 4-11.

Table 4-11. Participant Spillover by Fuel Type

Fuel Type	Respondents Reporting Spillover %, n	Respondents Without Spillover %, n	"Don't Know" %, n
Electricity (n = 70)	36% 25	60% 42	4% 3
Natural Gas (n = 70)	13% 9	83% 58	4% 3

When asked whether the proportion of their SO savings was less than, similar to, or more than their program reported savings, responses for natural gas savings were evenly distributed, while more than half (54%) indicated that electric savings were the same. Table 4-12 highlights these findings.

[48] In general there are three potential types of spillover: participant inside spillover, participant outside spillover (spillover from participant actions outside the program home or building, such as in their parent's or child's home) and non-participant spillover (such as a neighbor taking energy efficiency actions from what they learned about energy savings from these actions from the program participant).

Table 4-12. Participant Spillover Savings Compared to Program Savings

SO savings compared to Project Savings	# of Respondents with Natural Gas SO	# of Respondents with kWh SO	% of Respondents with Natural Gas SO	% of Respondents with kWh SO
Less than program savings	2	5	22%	20%
Same as program savings	2	12	22%	48%
More than program savings	2	6	32%	24%
"Don't Know"	3	2	33%	8%
Total	**9**	**25**	**100%a**	**100%**

a Total does not add to 100% due to rounding.

Spillover is based on respondent estimates of the scope of the spillover installations and the share of the savings attributable to the Program. As discussed in Section Spillover Estimation Method3.6.3, the SO rates are calculated by combining the responses by fuel type, converting all savings to source MMBtu for electricity and natural gas MMBtu, and then estimating an overall value for both fuels.

Table 4-13 demonstrates that natural gas provides a greater spillover rate due to the higher potential MMBtu savings from natural gas measures; however, more respondents reported having electric spillover than natural gas spillover. Participating home owners reported an overall spillover value of 14%.

Table 4-13. Participant Spillover Estimate by Fuel Type and Overall Spillover Estimate

Type of Spillover	Spillover Rate	Number of Respondents (Used to Derive Spillover Rate)
Electric Spillover	10%	25
National Gas Spillover	19%	9
Overall Spillover	14%	34

4.6.3 Pilot Net-to-Gross Ratio

The FR rate and SO rate are combined to produce a net-to-gross (NTG) ratio that is applied to evaluation-estimated gross savings to produce net savings.

Net-to-Gross Ratio (NTGR) = 1 – Free ridership Factor + Participant Spillover Factor

The NTG pilot within this evaluation found free ridership and spillover to be close to one another. They essentially balance each other out. The pilot NTGR from this evaluation is calculated as follows:

EmPower Pilot NTGR= 1 – 0.17 + 0.14 = 0.97.

Sampling precision cannot be easily calculated using standard statistical methods due to the complexity of the NTG analysis. The reliability for free-ridership, however, relies more on construct validity than on sampling precision. The alternative of what would have occurred cannot be known with certainty. Survey inquiry can be difficult when asking about conjecture of a theoretical alternative. Prior survey experience for specific question wording, measuring free-ridership in more than one way, and obtaining market or other comparatives are several ways to increase the reliability of the attribution estimate. Measuring free-ridership in multiple ways and conducting consistency checks can increase the construct validity of the estimate. Even with multiple questions and consistency checks, there is still uncertainty in the estimates due to the nature of the inquiry. However, the free ridership rate of 17% and spillover of

14% using the same method as applied to other NYSERDA residential programs is indicative that there are net effects associated with the EmPower Program.

4.7 ABILITY TO PAY

Almost by definition, EmPower program participants have difficulty paying bills. The Energy Change Survey included a series of questions regarding the participant's ability to pay utility bills. Since the Energy Change Survey was intended to inform the billing analysis, the sample frame consisted only of participants with a minimum of eighteen months to two years of billing history at the same location. Many homes did not show consistent residency at one location over this period and were eliminated from the sample frame. Thus, this subset of EmPower participants may be more stable than participants as a whole and the results from this component of the survey may not reflect the entire population.

As seen in Table 4-14, 635 of the 659 survey respondents indicated that the electric bill is in their name, 228 responded that they receive outside assistance and 357 indicated having difficulty paying the bill. The numbers are a bit higher with the natural gas bills, with 629 claiming responsibility for the bill and 420 of those saying they receive outside assistance, with almost the same number having difficulty making payments.

Clearly, one goal of the EmPower Program is to lessen the burden for those who pay for the energy use. Sixty-seven percent of survey respondents with responsibility for the bill reported that it was difficult to pay their natural gas bills prior to participation in the Program, and almost half of these participants responded that the Program has improved their ability to make payments.

Table 4-14. Survey Responses to the Ability to Pay Questions

	Electric Utility Bills (n=659)			Natural Gas Utility Bills (n=659)		
	Yes	Don't Know/ Refused	Yes as % of Valid Responses[1]	Yes	Don't Know/ Refused	Yes as % of Valid Responses[1]
Responsible for paying utility bill	635	1	97%	629	3	96%
Receive outside assistance[2]	228	10	36%	420	7	68%
Difficulties in paying bill[2]	357	5	57%	417	6	67%
Change in ability to pay due to EmPower[3]	120	37	38%	114	39	30%

[1] The total number of valid responses is the total minus the number of respondents who said "don't know" or refused. For the first row (electric utility bills), the total number of valid responses is 659 (total number of surveys) - 1 DK/Refused=658. For the second row, the total number of valid responses is 635 (see footnote 2) - 10 DK/Refused = 625.

[2] The total for these responses is the number of participants who are responsible for paying the utility bill.

[3] The total for these responses is the number of participants who reporting having difficulties paying the utility bill.

Among participants with difficulties in making natural gas bill payments, there was a marked increase (13%) in the number of participants able to pay their bills in full and on time (51% to 64%), and a dramatic decrease (11%) in the number who are struggling to make the payment each month (from 16% to 5%). These results suggest that the EmPower program is making a valuable contribution to low income participants that go beyond the energy savings alone. These findings are summarized in Table 4-15 and Table 4-16.

Table 4-15. Program Impact on Ability to Pay Electric Bills

	Prior to EmPower Participation (n=120)		After EmPower Participation[1] (n=116)	
Homes Recording a Change in Ability to Pay	**Number of Respondents**	**% of Respondents**	**Number of Respondents[2]**	**% of Respondents[2]**
Generally paid bills in full and on time	66	55%	76	66%
Sometimes missed a payment or paid only part of the bill	39	33%	27	23%
Often missed payments or paid only part of the bill	11	9%	2	2%
Don't Know/Refused	4	3%	10	9%

[1]The total for these columns is 116 since 4 of the 120 survey respondents did not provide a valid answer to the timeliness of paying the utility bill prior to EmPower participation.

[2] One participant responded that the bills increased after participation in EmPower and it was harder to pay the bill. This response is not recorded in this table, and consequently the total number of respondents in this column adds to 115 rather than 116. The percentages add to 100% due to rounding.

Table 4-16. Program Impact on Ability to Pay Natural Gas Bills

	Prior to EmPower Participation (n=114)		After EmPower Participation[1] (n=111)	
Homes Recording a Change in Ability to Pay	**Number of Respondents**	**% of Respondents[2]**	**Number of Respondents[3]**	**% of Respondents[3]**
Generally paid bills in full and on time	58	51%	71	64%
Sometimes missed a payment or paid only part of the bill	35	31%	22	20%
Often missed payments or paid only part of the bill	18	16%	5	5%
Don't Know/Refused	3	3%	12	11%

[1]The total for these columns is 111 since 3 of the 114 survey respondents did not provide a valid answer to the timeliness of paying the utility bill prior to EmPower participation.

[2]Total does not add to 100% due to rounding.

[3] One participant responded that the bills increased after participation in EmPower and it was harder to pay the bill. This response is not recorded in this table, and consequently the total number of respondents in this column adds to 110 rather than 111. The percentages add to 100% due to rounding.

4.8 PROGRAM EFFECTS ON KNOWLEDGE OF EFFICIENCY

The EmPower Program offers print, in-home and classroom energy efficiency education. All customers referred to the Program receive a package of educational material, three compact fluorescent lights (CFLs), a water temperature thermometer and a nightlight at a minimum. Households that may benefit from full program participation receive an energy audit and in-home education. These participants also receive the installation of measures identified in the audit and possibly supplemental WAP services. The in-home energy use education provides customers with additional strategies for managing their energy costs. Participants are also invited to free workshops on energy-use management and financial management held in communities across the state.

The NTG telephone survey of participants asked whether the participant's knowledge of energy efficiency had been increasing or decreasing. More than three-quarters of those surveyed, 80%, reported that their familiarity with energy efficiency equipment and products had increased to some degree over the past few of years. These reported increases are evenly distributed between those who claimed that familiarity "increased somewhat" and those who indicated that it "increased significantly." Table 4-17 presents the responses to this question.

Table 4-17. Changes in Participant Familiarity with Energy Efficiency

Familiarity with Energy Efficient product and equipment has…?	Number of Respondents[1] (n = 68)	Percent of Respondents[2]
Increased Significantly	27	40%
Increased Somewhat	27	40%
The Same	12	18%
Decreased Somewhat	2	3%
Decreased Significantly	0	0%

[1] Two of the participants responded "Don't Know" to this question.

[2] Total does not add to 100% due to rounding.

Of the 80% with an increase in familiarity with energy efficiency, most attributed at least some of the increase to the EmPower Program. Almost one-quarter (23%) credited the Program with all of their increase in familiarity with energy efficiency, and another 46% stated that most of their increase in knowledge of energy efficiency was due to the Program. In summary, over two-third of the respondents stated that the Program was the source of most or all of their increased knowledge of energy efficiency. Table 4-18 highlights these results.

Table 4-18. Increase in Familiarity with Energy Efficient Measures Due to EmPower Program Participation

Proportion of Increase in Familiarity with Energy Efficiency Due to Program	Number of Respondents (n = 52)[a]	Percent of Respondents
All of it	12	23%
Most of it	24	46%
A small part	12	23%
None of it	4	8%

a This question was only asked if participants claimed an increase in their familiarity with energy efficiency. In addition, two respondents answered "Don't Know" to this question. (n = 70 - 16 = 54 with an increase in familiarity from Table 4-17 - 2 DK = 52.)

4.8.1 Increased Familiarity with Energy Efficiency due to EmPower and Spillover

The analysis of spillover in comparison to the increase familiarity with energy efficiency provided some interesting insights, as shown in Table 4-19 and discussed briefly below.

- Higher spillover rates were found among the 80% of participants who reported an increase in familiarity with energy efficiency.
- Spillover rates were higher for those who attributed their increase in familiarity to the Program.
- Spillover rates increased relative to the proportion of knowledge that was program induced.

This analysis suggests that spillover is related to the knowledge of energy efficiency obtained through the Program and that spillover is higher for homes where the Program was more successful in improving familiarity with energy efficiency.

Table 4-19. Spillover by Contribution of EmPower Program to Increase in Energy Efficiency Knowledge

Proportion of Increase in Familiarity with Energy Efficiency Due to Program	Spillover Rate	Number of Respondents (n = 26) [1]
None of it	5%	2
A small part	7%	2
Most of it	19%	15
All of it	29%	7

[1] To be included in this analysis, respondents had to have had an increase in familiarity with energy efficiency due to the Program and to have answered yes that they do have spillover, *i.e.*, additional measures installed or adopted due to the Program but not within the Program. A negative response to either of these questions caused the respondent to be excluded.

Section 5:

CONCLUSIONS AND RECOMMENDATIONS

This section covers the program recommendations, evaluation recommendations and conclusions.

5.1 PROGRAM RECOMMENDATIONS

5.1.1 Energy Savings

The billing analysis provided reliable savings estimates for the energy benefits associated with the EmPower Program, as discussed above. However, the low realization rates for some commonly installed measures, such as refrigerator replacements, insulation and air sealing, indicate the Program should review and update the process for calculating savings. In several homes with electric space heat and insulation and air sealing, the claimed savings seem to be off by an order of magnitude, and the pre-installation billing data suggests that one home does not appear to have heating-related use. The Impact Evaluation Team understands that program staff is in the process of reviewing and updating savings algorithms.

Recommendation: Methods for estimating savings for envelope measures (both natural gas and electric) and replacement refrigerators should be evaluated.

5.1.2 Installation of CFL's

The EmPower Program is also seeing lower savings than expected from the installation of CFL lamps. While estimating lighting savings from a billing model tends to be challenging, even the most favorable reading of the data suggests that the lighting savings are substantially lower than claimed for program years 2007 and 2008. Another potential factor is that eight CFL's on average per home were installed during these program years, and it is possible that not all of the bulbs could be installed in high use locations. The Impact Evaluation Team understands that EmPower program staff has taken proactive steps to adjust CFL savings depending on the number installed in the home for program years 2009 and 2010.

Recommendation: Review policies for CFL installation to assess how to assist participants and achieve cost-effective savings, and monitor change in CFL market to determine whether it is necessary to modify the approach to the installation of CFL's further as CFL's gain greater market acceptance.

5.1.3 Tracking System Validation

The Impact Evaluation Team conducted an initial review of the program tracking database and identified additional fields that would be useful for future impact evaluation activities, as well as some fields that could use improved error checking. One piece of highly useful information that was not recorded in the program tracking database for 2007/2008 participants was whether the home has a working air conditioner. Clear definition of fuel switching measures and differentiation of attic and wall insulation would also be helpful. This information will improve the modeling of electric and natural gas energy consumption.

There were also a number of internal data inconsistencies, particularly relating to the fuel use for water and space heating. One comment from program staff was that some of the characteristics of the home, such as the fuel used for water heating, was initially entered based on information provided by the participant, and it was not possible to correct the field following the site visit. Program staff was responsive to our questions and used the opportunity to make corrections to the tracking system.

Recommendation: Review the fields in the database and data collection processes to assess whether additional information, such as the presence of working air conditioning, could be added to the tracking system. Review the coding of measure descriptions to make it easier to identify fuel switching measures and differentiate attic and wall insulation. Improve error checking methods and frequency to correct tracking system errors in a timely manner.

5.2 EVALUATION RECOMMENDATIONS

5.2.1 Non-Energy Benefits

As indicated by the ability to pay analysis, the EmPower Program provides benefits in addition to energy savings. Improving participants' ability to make the monthly payments is an important non-energy benefit (NEB) monetarily as it reduces arrearages and disconnections but also leads to other important societal benefits. For low income customers saving money on their utility bills may allow expenditures on more necessary items than is the case for higher income households; items including an increase in food or healthier food, a healthier household environment and housing security.

A recent International Energy Agency (IEA) workshop on the evaluation of low-income efficiency program evaluation identified a wide range of co-benefits or non-energy benefits from low-income programs that not only accrue to the program participants but also governments, energy providers, property owners, local communities and society as a whole. These benefits include direct and indirect economic impacts, as well as improvements in social welfare and livelihood.

NYSERDA took a leading role in the nation in measuring non-energy impacts (NEI)[49] in studies conducted in 2003-2004. The studies incorporated a willingness-to-pay (WTP) approach using direct query with a benchmarking to monetize these benefits against the energy bill savings achieved and in asking the respondent for a total value, in order to adjust, as necessary, the sum of the monetized NEI's for their household or business.[50] NYSERDA also tested the use of conjoint analysis for NEIs in 2005-2006. Conjoint analysis involves creating multiple "packages" of attributes that interviewees are asked to rank according to their preference of the package.[51]

While this evaluation investigated one indicator of the impact of participation on the ability of participants to pay their electric bills, there are other indicators of important non-energy benefits that could be investigated through low cost participant surveys. Future surveys could be expanded to include questions just for indicators of the Program effects on health, property values and other potential NEB's/NEIs.

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[49] NYSERDA's use of the term non-energy impact rather than non-energy benefits was purposefully to ensure that studies and work associated with non-energy impacts was inclusion of benefits as well as costs to ensure a balanced unbiased perspective.

[50] See the *Program Evaluation and Status Reports* by NYSERDA 2004, 2005; Good summaries are also available in industry publications on the work conducted at NYSERDA: Bicknell, Charles and Lisa Skumatz. 2004. "Non-Energy Benefits (NEBs) in the Commercial Sector: Results from Hundreds of Buildings", *Proceedings from the 2004 ACEEE Summer Study*, American Council for an Energy-Efficient Economy, Asilomar: CA, pp. 4.10 – 4.22; and Fuchs, Leah, Lisa Skumatz, and Jennifer Ellefsen. 2004. "Non-Energy Benefits (NEBs) from ENERGY STAR®: Comprehensive Analysis of Appliance, Outreach, and Homes Programs", *Proceedings from the 2004 ACEEE Summer Study*, American Council for an Energy-Efficient Economy, Asilomar: CA, pp. 2.79 – 2.89.

[51] NYSERDA 2007. *Non-Energy Impacts (NEI) Evaluation*, prepared by Summit Blue Consulting, July 2007.

Another possible strategy is to monitor and reference, or to "piggyback" on, future efforts to quantify NEB's on a national effort. Oak Ridge National Laboratory (ORNL) is conducting a wide range of research into NEBs as part of the US WAP Program evaluation. Incorporation of these findings, where appropriate, into future evaluation effort can help to provide a balance to the impact evaluation so these perspectives are not lost to policymakers as they consider the investment choices for the EmPower Program.

Recommendation: Consider including indicators of NEBs into future evaluation efforts, a lower cost option than full monetization studies, to aid policy makers' ability to have a more complete viewpoint when decisions are being made regarding low income programs.

Monitor on-going efforts that seek to quantify NEBs so these may be referenced within impact evaluations. This type of referral and indicators of the importance of NEBs to NYSERDA's participants may offer a low cost approach to ensure a socially responsible perspective is not lost in the reporting of savings estimates from sophisticated quantitative impact evaluations.

5.2.2 Billing Data Issues

One impediment to conducting the billing analysis was the difficulty in obtaining billing data. This type of analysis relies on including as much of the population as possible in the regression models. No billing data was available for 31% of homes with electric savings and 54% of homes with natural gas savings. In addition, participants from two of the utilities were later removed from the models due to apparent unmarked estimated reads and other anomalies in the billing records. Increasing the percentage of participants with complete billing history would improve the confidence in the results from the modeling.

In addition, some utilities provided only a subset of the requested fields. Critical data, such as whether a reading was estimated, were missing. Consistent inclusion of all the data required for a billing analysis would improve the overall results.

In this study, the modeling results indicate the non-program related within-home changes did not affect estimates of evaluated program savings. This conclusion was supported by the Energy Change Survey that suggested there were few household that had changes affecting energy use. These complimentary findings increase the confidence in the overall results.

Recommendation: Work with utilities to ensure that billing data is complete, useful and properly interpreted.

5.2.3 Pilot NTG

The pilot NTG survey did not support the assumption that the EmPower Program has no net effects. Free ridership and participant spillover were estimated at 17% and 14% respectively. While the overall NTGR is 0.97 for the 2007 and 2008 program years, it is possible that future studies may find different results.

Recommendation: Continue to measure net effects for EmPower in future impact evaluations. The NTG component of the evaluation may not need to be conducted with every evaluation cycle, but the results of the pilot study indicate that periodic measurement of net effects is warranted.

5.2.4 Survey Responses

There were concerns raised during the planning phase of the evaluation as to the effectiveness of fielding participants' surveys due to the amount of time that had lapsed between program implementation and the evaluation. One concern was that participants would not be able to answer many of the questions. The survey results demonstrate that this concern was unfounded. Overall, the surveys provided valuable information that has helped in both the corroboration of the billing analysis, in that there were few changes in energy use, and provided insight into NEBs through the investigation of ability to pay utility bills.

Recommendation: Continue to use survey instruments to inform the billing analysis, assess non-energy benefits and NTG factors.

5.3 CONCLUSIONS

The evaluation consisted of a rigorous analysis with multiple components. The gross program savings were estimated through a billing analysis of all participants with complete and reliable billing data, and both internal and external validation was conducted to ensure that the results were within a reasonable range. The internal validations included implementation of an Energy Change Survey and the associated restricted billing analysis to inform the billing analysis, a review of alternative models to incorporate external influences into the billing regression and an assessment of the validity of the model. External validation consisted of comparing the results from the model to other similar programs.

All of these supplemental activities support the use of the results from the full billing model. The gross savings realization rates of 54% and 70% for electric and non-electric (fossil fuel) savings, respectively, were applied to estimate total program reported savings to obtain the evaluated gross savings.

In addition, a pilot study of net effects was conducted which clearly demonstrated that there are net effects associated with the EmPower Program. With an estimated FR rate of 17% and spillover of 14%, the overall NTGR is 0.97, which is very close to the current estimate of 1.00. Since this was a pilot effort and the result was so close to 1.00, the evaluated gross savings are reported for this program without any adjustments for net effects. However, this study reflects the results for program years 2007 and 2008, and it is possible that the magnitude of the net effects may change in the future.

Three other research components were also included as part of this evaluation. The NTG survey included questions to assess whether the economic upheaval of the last four years may have had an impact on self-reports of free ridership. The survey responses do not demonstrate that the recent economic uncertainty affected the self-reports of free ridership.

This evaluation also investigated the relationship between program activities, net effects and the growing awareness of energy efficiency. This analysis found that increased knowledge of energy efficiency due to the program was related to higher spillover among participants, which further strengthens the ties between the program and the additional measures installed in homes with spillover.

The Energy Change Survey included a series of questions regarding the ability of participants to pay utility bills. This survey was fielded to improve the billing models, and thus was administered to participants with eighteen months or more of utility bills at the same address. This approach suggests that the respondents may be more stable than EmPower participants as a whole and thus not necessarily representative of the EmPower population.

Even with this caveat, the results are worthy of note. Sixty-seven percent of survey respondents with responsibility for the bill reported that it was difficult to pay their natural gas bills prior to participation in the EmPower Program, and almost half of these participants responded that the Program has improved their ability to make payments. Among participants with difficulties in making natural gas bill payments, there was a marked increase (13%) in the number of participants able to pay their bills in full and on time (51% to 64%), and a dramatic decrease (11%) in the number who are no longer struggling to make the payment each month (from 16% to 5%). These results suggest that the EmPower Program is making a valuable contribution to low income participants that goes beyond the energy savings alone.

Appendices

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APPENDIX A.

ENERGY CHANGE SURVEY INSTRUMENT

EmPower Impact Evaluation 2010/2011 Participant Survey with Back Codes Added

FINAL VERSION

August 24, 2011

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 participated in NYSERDA's EmPower New York Program. Our records indicate that EmPower New York installed energy efficiency measures in your home on **[projend].** We're calling today to ask you some questions about your experience with this program to help us evaluate how the Program might serve people better. We sent you a letter recently telling you that we would be calling and explaining the research we are doing. Your responses to this survey will be kept confidential to the extent permitted by law.

[IF NECESSARY:] The EmPower Program helps people improve the energy efficiency of their homes. Our records show that you had an energy audit through Empower sometime in **[YEAR]**. The EmPower Program sent an auditor to your home to complete a visual inspection of the living space, attic, and basement or crawl space and to discuss ways to save energy with you. At the end of the assessment, the auditor recommended energy improvements that were installed in your home. Our records indicate that you received [**LIST MEASURES FROM SAMPLE FILE**].

[IF NECESSARY:] You were selected as part of a carefully designed sample and your feedback about this program is very important to future planning for energy efficiency programs in the State of New York.

[IF NECESSARY:] This survey will take about 15-20 minutes to complete, depending on your responses.

SCREENER FOR CONTACT

SCR1. Are you the person in your home we should speak to regarding participation in the EmPower Program and the energy efficiency actions taken?

1	YES	**[SKIP TO SCR3]**
2	NO	
96	REFUSED	**[THANK AND TERMINATE]**
97	DON'T KNOW	

SCR2. Is there someone else in your household that might 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]**

SCR3. According to our records, your address is **[ADDRESS]**. Is this correct?

1 YES

2 NO [**THANK AND TERMINATE**]

96 REFUSED [**THANK AND TERMINATE**]

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

SCR4. Were you living at the same address in **[YEAR1]**?

1 YES

2 NO [**THANK AND TERMINATE**]

96 REFUSED [**THANK AND TERMINATE**]

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

PROGRAM RECALL

GENERAL INSTRUCTIONS READ TO ALL:

Your opinions about the EmPower Program are very 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, you can just indicate that you don't know and we will move on.

In this survey, I will be asking you to remember any changes you may have made in your household that affects your energy use. I would also like to ask you to remember in what season and year you made a change.

As you may recall, the EmPower Program sent an auditor to your home to complete a visual inspection of the living space, attic, and basement or crawl space and to discuss ways to save energy with you. At the end of the assessment, the auditor recommended energy improvements that were installed in your home.

You may have also received some energy-saving devices at the time of the audit, such as compact fluorescent light bulbs and a low flow showerhead.

M1a. Do you recall receiving services through the EmPower Program?

1. YES

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

96. REFUSED **[THANK AND TERMINATE]**

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

M1b. According to our records, you received services through the EmPower Program in **[AUDITYEAR]**. Is that correct?

1. DEFINITE OR VAGUE YES **[GO TO M2]**
2. FIRM NO
96. REFUSED **[GO TO M2]**
97. DON'T KNOW **[GO TO M2]**

M1c. In what year did you receive services through the EmPower Program?

1. **[RECORD YEAR]**
96. REFUSED
97. DON'T KNOW

M2. I'm going to read you a list of measures that were installed through the EmPower Program according to our records. For each one, please tell me if that measure was actually installed or not. **[READ M1-M12 IF survey_measure1-12=1 IN SAMPLE FILE]**

Table A-1

M1. Insulation
M2. Air or duct sealing
M3. CFL's or efficient light fixtures
M4. New refrigerator
M5. New freezer
M6. New clothes dryer
M7. New heating system
M8. Heating repair
M9. New water tank or water tank repair
M10. Hot water conservation measures, such as installing low flow showerheads or aerators, or wrapping the water tank or pipes
M11. Programmable thermostat
M12. Switched fuel source for heating or water heating

1. YES
2. NO

96. REFUSED

97. DON'T KNOW

[IF SURVEY_MEASURE3=1 AND CFL>0, ASK M3, OTHERWISE SKIP TO M4]

M3. As part of the EmPower audit, how many compact fluorescent bulbs were installed in your home?

1. **[RECORD NUMBER]**

96. REFUSED

97. DON'T KNOW

[IF SURVEY_MEASURE3=1 AND CFL_FIX>0, ASK M4, OTHERWISE SKIP TO M5]

M4. As part of your EmPower Program participation, how many high efficiency compact fluorescent fixtures were installed in your home? These fixtures require special pin-based bulbs. I am only asking about hardwired fixtures that take CFL pin-based bulbs, **NOT** plug-in lamps or fixtures that take standard screw in bulbs.

1. **[RECORD NUMBER]**

96. REFUSED

97. DON'T KNOW

M5. Now I'd like to ask about any other energy efficiency improvement services you may have received in the past 5 years, from any OTHER program besides the EmPower Program. In the past 5 years, did you receive other energy efficiency improvements such as insulation or home repairs through the Weatherization Assistance Program or programs other than EmPower?

1. YES

2. NO

96. REFUSED

97. DON'T KNOW

READ FOR ALL:

For the rest of this survey, I'd like you to just think ONLY about the services you received through the EmPower Program. That would be the **[INSERT SERVICES RECEIVED THROUGH EMPOWER]**, Please just think about these services for the rest of the interview.

HEATING SYSTEM

[YEAR1=THE CALENDAR YEAR PRIOR TO THE PROGRAM; YEAR2=CALENDAR YEAR AFTER ALL MEASURES WERE INSTALLED. SUMMERYEAR1=CALENDAR YEAR THAT INCLUDES THE SUMMER MONTHS (JUNE TO AUGUST) OF THE YEAR PRIOR TO THE PROGRAM; WINTERYEAR1A & WINTERYEAR1B= CALENDAR YEARS THAT INCLUDES

THE WINTER MONTHS (NOVEMBER TO MARCH) OF THE YEAR PRIOR TO THE PROGRAM. SUMMERYEAR2 AND WINTERYEAR2A & WINTERYEAR2B ARE DEFINED IN THE SAME WAY.]

READ FOR ALL

The next set of questions is about your heating system and how you use it. We are particularly interested in changes between the year prior to your participation in the Program and the year following the installation of measures – that would be between **[INSERT YEAR1]** and **[INSERT YEAR2]**.

HS1a. What is the primary fuel you currently use to heat your home? **[READ LIST, MARK ALL THAT APPLY]**

1. Natural Gas, not Propane
2. Electricity
3. Oil
95. OTHER (Specify: _____)
96. REFUSED
97. DON'T KNOW

HS1b. Are you using the same heating fuel now as you were during the winter of **[WINTERYEAR1A/WINTERYEAR1B]**?

1. YES [**GO TO HS2**]
2. NO
96. REFUSED **[GO TO HS2]**
97. DON'T KNOW **[GO TO HS2]**

HS1c. What was the primary fuel used to heat your home in **[WINTERYEAR1A/WINTERYEAR1B]**? **[READ LIST, RECORD ONE]**

1. Natural Gas, not Propane
2. Electric
3. Oil
95. OTHER (Specify: _____)
96. REFUSED
97. DON'T KNOW

[SKIP TO HS2 IF HS1a = HS1c]

HS1d. In what season and year did you change your primary heating fuel? **[IF RESPONDENT PROVIDES A DATE THAT IS BEFORE YEAR1, PLEASE PROBE FOR ANY CHANGES**

WITHIN THE PERIOD OF INTEREST, THAT IS YEAR1 FORWARD. IF THE ONLY CHANGE IS BEFORE YEAR1, THEN CHOOSE OPTION 2 FOR THE YEAR BELOW.]

1. RECORD SEASON

[1=FALL; 2 =WINTER; 3=SPRING; 4 =SUMMER]

96. REFUSED

97. DON'T KNOW

1. RECORD YEAR

2. OUTSIDE OF PERIOD, BEFORE YEAR1 **[GO TO HS2]**

96. REFUSED

97. DON'T KNOW

HS1e. Did you make this change as a result of the EmPower Program?

1. YES

2. NO

96. REFUSED

97. DON'T KNOW

HS2. How do you control your primary heating system? Do you…**[READ LIST, RECORD ONE RESPONSE]**

1. Set it at one temperature and leave it

2. Manually adjust the temperature as needed

3. Set it back using a programmable thermostat

95. OTHER (Specify: _____)

96. REFUSED

97. DON'T KNOW

HS3a. Comparing the winter of **[WINTERYEAR2A/WINTERYEAR2B]** to the winter of **[WINTERYEAR1A/WINTERYEAR1B]**, did you change the way you use your primary heating system?

1. YES

2. NO **[GO TO HS4a]**

96. REFUSED **[GO TO HS4a]**

97. DON'T KNOW **[GO TO HS4a]**

HS3b. Would you say that you used the heating system a lot less, somewhat less, somewhat more, or a lot more in [**WINTERYEAR2A/WINTERYEAR2B**] than in [**WINTERYEAR1A/WINTERYEAR1B**]?

1. A LOT LESS
2. SOMEWHAT LESS
3. SOMEWHAT MORE
4. A LOT MORE
96. REFUSED
97. DON'T KNOW

HS4a. Did you use a supplemental heating system, such as a wood stove or portable heaters in **[WINTERYEAR2A/WINTERYEAR2B]**?

1. YES
2. NO **[GO TO HS5a]**
96. REFUSED **[GO TO HS5a]**
97. DON'T KNOW **[GO TO HS5a]**

HS4b. What type of supplementary heat did you use to heat your home during the winter of [**WINTERYEAR2A/WINTERYEAR2B**]? **[READ ALL AND RECORD ALL THAT APPLY]**

1. Natural gas, such as a gas space heater, fireplace, cooking stove or oven **[DISTINGUISH BETWEEN NATURAL GAS AND PROPANE]**
2. Electric portable heaters, electric baseboard, or other electric heaters
3. Wood, such as a wood stove or fireplace
95. OTHER (Specify: _____)
96. REFUSED
97. DON'T KNOW

HS4c. Which of the following best describes how you used the supplemental heat in **[WINTERYEAR2A/WINTERYEAR2B]**? **[READ LIST, RECORD ONE]**

1. 10 days or less
2. 11-30 days
3. 31-60 days
4. More than 60 days
96. REFUSED
97. DON'T KNOW

HS4d. Comparing the winter of **[WINTERYEAR2A/WINTERYEAR2B]** to the winter of **[WINTERYEAR1A/WINTERYEAR1B]**, did you change the way you use your supplemental heating system? **[READ LIST, RECORD ONE]**

1. No, I used the supplemental heat about the same **[GO TO HS5a]**
2. Yes, I did not use the supplemental heat at all in **[WINTERYEAR1A/WINTERYEAR1B] [GO TO HS5a]**
3. Yes, I used a different type of supplemental heat in **[WINTERYEAR1A/WINTERYEAR1B]**
4. Yes, I used the supplemental heat a lot less,**[GO TO HS5a]**
5. Somewhat less, **[GO TO HS5a]**
6. Somewhat more, **[GO TO HS5a]**
7. Or a lot more in **[WINTERYEAR2A/WINTERYEAR2B]** than in **[WINTERYEAR1A/WINTERYEAR1B] [GO TO HS5a]**

96. REFUSED **[GO TO HS5a]**

97. DON'T KNOW **[GO TO HS5a]**

HS4e. What type of supplementary heat did you use to heat your home during the winter of **[WINTERYEAR1A/WINTERYEAR1B]**? **[READ ALL, RECORD ALL THAT APPLY]**

1. Natural gas, such as a gas space heater, fireplace, cooking stove or oven **[DISTINGUISH BETWEEN NATURAL GAS AND PROPANE]**
2. Electric portable heaters, electric baseboard, or other electric heaters

95. OTHER (Specify :_____)

96. REFUSED

97. DON'T KNOW

HS5a. What fuel do you currently use to heat your water? **[READ LIST AND RECORD ONE]**

1. Natural Gas, not propane
2. Electric
3. Solar with electric back up
4. Solar with natural gas back up

95. OTHER (Specify: _____)

96. REFUSED

97. DON'T KNOW

HS6b. Are you using the same fuel to heat your water now as you were in **[YEAR1]**?

1. YES **[GO TO NEXT SECTION]**
2. NO

96. REFUSED **[GO TO NEXT SECTION]**

97. DON'T KNOW **[GO TO NEXT SECTION]**

HS6c. What fuel did you use to heat your water in **[YEAR1]**? **[READ LIST, RECORD ONE]**

1. Natural Gas, not propane
2. Electric
3. Solar with electric back up
4. Solar with natural gas back up
95. OTHER (Specify: _____)
96. REFUSED
97. DON'T KNOW

HS6d. In what season and year did you install the new water heater? **[IF RESPONDENT PROVIDES A DATE THAT IS BEFORE YEAR1, PLEASE PROBE FOR ANY CHANGES WITHIN THE PERIOD OF INTEREST, YEAR1 TO YEAR2. IF THE ONLY CHANGE IS BEFORE YEAR1, THEN CHOOSE OPTION 2 FOR THE YEAR BELOW.]**

1. RECORD SEASON

[1=FALL; 2 =WINTER; 3=SPRING; 4 =SUMMER]

96. REFUSED
97. DON'T KNOW

1. RECORD YEAR
2. OUTSIDE OF PERIOD, BEFORE YEAR1 **[GO TO NEXT SECTION]**
96. REFUSED
97. DON'T KNOW

HS6e. Did you make this change as a result of the EmPower Program?

1. YES
2. NO
96. REFUSED
97. DON'T KNOW

COOLING SYTEMS

CL1. Did you have a working central air conditioning system in **[SUMMERYEAR2]**?

1. YES

2. NO
96. REFUSED
97. DON'T KNOW

CL2. How many working room or window A/C units were in use in your home during the summer of **[SUMMERYEAR2]**?

1. **[RECORD NUMBER OF UNITS]**
94. NONE
96. REFUSED
97. DON'T KNOW

[IF CL1=2 AND CL2=94 SKIP TO CL4]

CL3. Which of the following best describes how you used the air conditioning in [**SUMMERYEAR2**]? **[READ LIST, RECORD ONE]**

1. Not at all
2. 10 days or less
3. 11-30 days
4. 31-60 days
5. More than 60 days
96. REFUSED
97. DON'T KNOW

CL4. Comparing **[SUMMERYEAR2]** to **[SUMMERYEAR1]**, did you change the way you use the air conditioning?

1. YES
2. NO **[GO TO NEXT SECTION]**
96. REFUSED **[GO TO NEXT SECTION]**
97. DON'T KNOW **[GO TO NEXT SECTION]**

CL5. Would you say that you ... **[READ LIST, RECORD ONE RESPONSE]**

1. Did not use air conditioning at all in **[SUMMERYEAR1]**?
2. Used the air conditioning a lot less,
3. Somewhat less,
4. Somewhat more,
5. Or a lot more in **[SUMMERYEAR2]** than in **[SUMMERYEAR1]**?
96. REFUSED

97. DON'T KNOW

APPLIANCES

AP1. I'm going to read you a list of appliances. For each one, please tell me, between **[YEAR1]** and **[YEAR2]**, did you add or replace this appliance on your own, ***not through the EmPower Program.*** We are only interested in appliances that use either natural gas or electricity and were not replaced through the Program.

a. Central air conditioner

b. Room or wall air conditioner

c. Electric clothes dryer

d. Gas clothes dryer, not propane

e. Refrigerator/Freezer

f. Heated waterbed

g. Electric heater

h. Gas heater, not propane

i. Jacuzzi or hot tub

j. Any other appliances I haven't mentioned? (SPECIFY: _____)

k. Stove

1. YES
2. NO
96. REFUSED
97. DON'T KNOW

[FOR EACH APPLIANCE IDENTIFIED IN AP1, ASK AP2 AND AP3 TOGETHER]

AP2. Was the **[APPLIANCE]** a new addition to your home or did it replace an existing one?

1. NEW ADDITION TO HOME
2. REPLACED AN EXISTING ONE
96. REFUSED
97. DON'T KNOW

AP3. In what season and year did you add or replace the **[APPLIANCE]**?

[IF RESPONDENT PROVIDES A DATE THAT IS BEFORE YEAR1 OR AFTER YEAR2, PLEASE PROBE FOR ANY CHANGES WITHIN THE PERIOD OF INTEREST, YEAR1 TO

YEAR2. IF THE ONLY CHANGE IS OUTSIDE OF THE PERIOD (EITHER BEFORE YEAR1 OR AFTER YEAR2), THEN CHOOSE OPTION 2 FOR THE YEAR BELOW.]

APPENDIX A. RECORD SEASON

[1=FALL; 2 =WINTER; 3=SPRING; 4 =SUMMER]

96. REFUSED

97. DON'T KNOW

1. [RECORD YEAR]

2. OUTSIDE OF PERIOD, BEFORE YEAR1

96. REFUSED

97. DON'T KNOW

OCCUPANCY AND SCHEDULE

READ FOR ALL

We would like to ask you some questions about any changes you might have had in the number of people living in your home and in your day to day schedule between [**YEAR1]** and **[YEAR2].**

SCH1a. The next question is about how many people are living in your home. Include all members of your household whether or not they are related to you. Do not include anyone who is just visiting or who may be away at college or deployed by the military for most of the year. How many people, including yourself, are currently living in your home?

1. **[RECORD NUMBER]**

96. REFUSED **[SKIP TO SCH2a]**

97. DON'T KNOW **[SKIP TO SCH2a]**

SCH1b. Thinking back to **[YEAR1]**, how many people including yourself were living in your home?

1. **[RECORD NUMBER]**

96. REFUSED **[SKIP TO SCH2a]**

97. DON'T KNOW **[SKIP TO SCH2a]**

[ASK SCH1c IF SCH1a NOT EQUAL TO SCH1b]

SCH1c. In what season and year did the size of your household change? Let's start in the beginning of **[YEAR1]** and go to **[YEAR2]**. Please tell me how the size of your household changed and when it happened each time there was a change.

[RECORD SEASON, YEAR, CHANGE FOR UP TO 5 CHANGES IN OCCUPANCY BETWEEN YEAR1 AND YEAR2.]

1. RECORD SEASON

[1=FALL; 2 =WINTER; 3=SPRING; 4 =SUMMER]

94. NO MORE CHANGES

96. REFUSED

97. DON'T KNOW

1. RECORD YEAR

2. OUTSIDE OF PERIOD, BEFORE YEAR1

96. REFUSED

97. DON'T KNOW

Change in number of occupants: _____ **[EX, -1 FOR ONE FEWER OCCUPANT IN COMPARISON TO THE NUMBER OF OCCUPANTS IN YEAR1.]**

96. REFUSED

97. DON'T KNOW

SCH2a. Thinking back to **[SUMMERYEAR1]**, approximately how many weeks were all household members away from the home for any reason during the summer months of June, July and August, for things such as hospital stays, visits to relatives or vacation? **[READ LIST]**

1. None

2. Less than a week.

3. 1-2 weeks

4. 3-4 weeks

5. 5-6 weeks

6. More than 6 weeks

96. REFUSED **[GO TO SCH3a]**

97. DON'T KNOW **[GO TO SCH3a]**

SCH2b. Was there a change in your vacation schedule or the number of weeks when no one was at home during the summer months in **[SUMMERYEAR2]**? **[READ LIST, RECORD ONE RESPONSE]**

1. No, no change in schedule. **[GO TO SCH3a]**

2. Yes, less time away in **[SUMMERYEAR2]**

3. Yes, more time away in **[SUMMERYEAR2] [GO TO SCH2d]**

96. REFUSED **[GO TO SCH3a]**

97. DON'T KNOW **[GO TO SCH3a]**

SCH2c. Was the time away during **[SUMMERYEAR2]** shorter by… [**READ LIST**]

1. Less than a week **[GO TO SCH3a]**
2. 1 to less than 2 weeks **[GO TO SCH3a]**
3. 2 to less than 3 weeks **[GO TO SCH3a]**
4. 3 weeks or more **[GO TO SCH3a]**
96. REFUSED **[GO TO SCH3a]**
97. DON'T KNOW **[GO TO SCH3a]**

SCH2d. Was the time away during **[SUMMERYEAR2]** longer by…**[READ LIST]**

1. Less than a week
2. 1 to less than 2 weeks
3. 2 to less than 3 weeks
4. 3 weeks or more
96. REFUSED
97. DON'T KNOW

SCH3a. During **[WINTERYEAR1A/WINTERYEAR1B]**, approximately how many weeks were all household members away from the home for any reason during the ***winter*** months of November through March, for things such as hospital stays, visits to relatives or vacation? **[READ LIST]**

1. None
2. Less than a week
3. 1-2 weeks
4. 3-4 weeks
5. 5-6 weeks
6. More than 6 weeks
96. REFUSED **[GO TO SCH4a]**
97. DON'T KNOW **[GO TO SCH4a]**

SCH3b. Was there a change in your vacation schedule or the number of weeks when no one was at home during the winter months of **[WINTERYEAR2A/WINTERYEAR2B]**? **[READ LIST]**

1. No, no change in schedule. **[GO TO SCH4a]**
2. Yes, less time away in **[WINTERYEAR2A/WINTERYEAR2B]**.
3. Yes, more time away in **[WINTERYEAR2A/WINTERYEAR2B]**. **[GO TO SCH3d]**
96. REFUSED **[GO TO SCH4a]**
97. DON'T KNOW **[GO TO SCH4a]**

SCH3c. Was the time away during **[WINTERYEAR2A/WINTERYEAR2B]** shorter by… **[READ LIST]**

1. Less than a week **[GO TO SCH4a]**
2. 1 to less than 2 weeks **[GO TO SCH4a]**
3. 2 to less than 3 weeks **[GO TO SCH4a]**
4. 3 weeks or more **[GO TO SCH4a]**
96. REFUSED **[GO TO SCH4a]**
97. DON'T KNOW **[GO TO SCH4a]**

SCH3d. Was the time away during **[WINTERYEAR2A/WINTERYEAR2B]** longer by…**[READ LIST]**

1. Less than a week
2. 1 to less than 2 weeks
3. 2 to less than 3 weeks
4. 3 weeks or more
96. REFUSED
97. DON'T KNOW

SCH4a. Did your household have a change in day-to-day schedule between **[YEAR1]** and **[YEAR2]**?

1. YES
2. NO **[GO TO SCH5a]**
96. REFUSED **[GO TO SCH5a]**
97. DON'T KNOW **[GO TO SCH5a]**

SCH4b. How did the schedule change? Were you… **[READ LIST]**

1. At home more in **[YEAR2]**
2. At home less in **[YEAR2]**
95. OTHER (Specify: _____)
96. REFUSED
97. DON'T KNOW

SCH5a Comparing **[YEAR1]** to **[YEAR2]**, were there any other major changes in your household that affected your natural gas use?

1. YES
2. NO **[GO TO SCH6a]**

96. REFUSED **[GO TO SCH6a]**

97. DON'T KNOW **[GO TO SCH6a]**

SCH5b. In **[YEAR1]**, did you use a lot more natural gas, somewhat more, somewhat less, or a lot less than in **[YEAR2]**?

1. A LOT MORE
2. SOMEWHAT MORE
3. SOMEWHAT LESS
4. A LOT LESS
96. REFUSED **[GO TO SCH6a]**
97. DON'T KNOW **[GO TO SCH6a]**

SCH5c. What was the reason for the change in natural gas use? **[RECORD ALL THAT APPLY]**

2. REMOVAL/ADDITION/CHANGE IN USE OF FURNACE
3. REMOVAL/ADDITION/CHANGE WINDOWS
4. REMOVAL/ADDITION/CHANGE IN USE OF DRYER
5. REMOVAL/ADDITION/CHANGE INSULATION
6. CHANGE IN SCHEDULE
95. **[RECORD VERBATIM]**
96. REFUSED
97. DON'T KNOW

SCH6a. Comparing **[YEAR1]** to **[YEAR2]**, were there any other major changes in your household that affected your electric use?

1. YES
2. NO **[GO TO NEXT SECTION]**
96. REFUSED **[GO TO NEXT SECTION]**
97. DON'T KNOW **[GO TO NEXT SECTION]**

SCH6b. In [**YEAR1**], did you use a lot more electricity, somewhat more, somewhat less, or a lot less than in **[YEAR2]**? **[READ LIST, RECORD ONE]**

1. A LOT MORE
2. SOMEWHAT MORE
3. SOMEWHAT LESS
4. A LOT LESS
96. REFUSED **[GO TO NEXT SECTION]**

97. DON'T KNOW **[GO TO NEXT SECTION]**

SCH6c. What was the reason for the change in electric use? **[RECORD ALL THAT APPLY]**

2. REMOVAL/ADDITION/CHANGE IN USE OF FURNACE
3. REMOVAL/ADDITION/CHANGE WINDOWS
4. REMOVAL/ADDITION/CHANGE IN USE OF DRYER
5. REMOVAL/ADDITION/CHANGE INSULATION
6. CHANGE IN SCHEDULE
7. REWIRING/ELECTRICAL UPGRADE
8. REMOVAL/ADDITION/CHANGE IN USE OF ELECTRONIC DEVICES
9. REMOVAL/ADDITION/CHANGE IN USE OF LIGHTS
95. **[RECORD VERBATIM]**
96. REFUSED
97. DON'T KNOW

PROGRAM EFFECTS ON ABILITY TO PAY BILLS

Now I would like to ask you a few questions regarding your electric and heating utility accounts

P1. Is the electric account for your home in your name or under the name of another member of your household?

1. YES, THE ELECTRIC ACCOUNT IS IN MY NAME OR IN ANOTHER HOUSEHOLD MEMBER'S NAME
2. NO, THE ELECTRIC ACCOUNT IS NOT IN MY NAME OR THE NAME OF ANOTHER MEMBER OF MY HOUSEHOLD **[GO TO P7]**
95. OTHER (Specify: _____)
96. REFUSED
97. DON'T KNOW

P2. Do you receive outside assistance from federal, state or local programs to help you pay your electric bill? Please do not include your participation in the EmPower Program.

1. YES
2. NO
96. REFUSED [**GO TO P7]**
97. DON'T KNOW [**GO TO P7]**

P3. Have you found it difficult to pay your electric bill in the past?

1. YES
2. NO **[GO TO P7]**
96. REFUSED **[GO TO P7]**
97. DON'T KNOW **[GO TO P7]**

P4. Has your ability to pay your electric bill been changed by participating in the EmPower Program? **[IF NECESSARY:]** I am asking about the EmPower Program only, **not** other programs that may provide financial assistance such as HEAP and WAP.

1. YES
2. NO [**GO TO P7**]
96. REFUSED [**GO TO P7**]
97. DON'T KNOW [**GO TO P7**]

P5. Before your participation in EmPower, did you…**[READ LIST]**

1. Generally pay your electric bills in full and on time?
2. Sometimes miss a payment or pay only part of the electric bill?
3. Often miss payments or only pay part of the electric bill?
96. REFUSED [**GO TO P7**]
97. DON'T KNOW [**GO TO P7**]

P6. Which of the following best describes how your ability to pay your electric bill has changed because of your participation in the EmPower Program? **[READ LIST]**

1. My electric bill is higher because of the services I received through EmPower and I find it harder to pay.
2. My electric bill is lower because of the services I received through EmPower and I am able to make all payments on time and in full.
3. My electric bill is lower because of the services I received through EmPower but I sometimes miss payments or pay only part of the bill.
4. My electric bill is lower because of the services I received through EmPower but I often miss payments or pay only part of the bill.
95. OTHER (Specify: _____)
96. REFUSED
97. DON'T KNOW

P7. Is the heating account for your home in your name or under the name of another member of your household?

1. YES, THE HEATING ACCOUNT IS MY NAME OR IN ANOTHER HOUSEHOLD MEMBER'S NAME

2. NO, THE HEATING ACCOUNT IS NOT IN MY NAME OR THE NAME OF ANOTHER MEMBER OF MY HOUSEHOLD **[GO TO NEXT SECTION]**

95. OTHER (Specify: _____)

96. REFUSED

97. DON'T KNOW

P8. Do you receive outside assistance from federal, state or local programs to help you pay your heating bill? Please do not include your participation in the EmPower Program.

1. YES

2. NO

96. REFUSED **[GO TO NEXT SECTION]**

97. DON'T KNOW **[GO TO NEXT SECTION]**

P9. Have you found it difficult to pay your heating bill in the past?

1. YES

2. NO **[GO TO NEXT SECTION]**

96. REFUSED **[GO TO NEXT SECTION]**

97. DON'T KNOW **[GO TO NEXT SECTION]**

P10. Has your ability to pay your heating bill been changed by participating in the EmPower Program? **[IF NECESSARY:]** I am asking about the EmPower Program only, **not** other programs that may provide financial assistance such as HEAP and WAP.

1. YES

2. NO [**GO TO NEXT SECTION**]

96. REFUSED [**GO TO NEXT SECTION**]

97. DON'T KNOW [**GO TO NEXT SECTION**]

P11. Before your participation in EmPower, did you…**[READ LIST]**

1. Generally pay your heating bills in full and on time?

2. Sometimes miss a payment or pay only part of the heating bill?

3. Often miss payments or only pay part of the heating bill?

96. REFUSED [**GO TO NEXT SECTION**]

97. DON'T KNOW [**GO TO NEXT SECTION**]

P12. Which of the following best describes how your ability to pay your heating bill has changed because of your participation in the EmPower Program? **[READ LIST]**

1. My heating bill is higher because of the services I received through EmPower and I find it harder to pay.

2. My heating bill is lower because of the services I received through EmPower and I am able to make all payments on time and in full.

3. My heating bill is lower because of the services I received through EmPower but I sometimes miss payments or pay only part of the bill.

4. My heating bill is lower because of the services I received through EmPower but I often miss payments or pay only part of the bill.

95. OTHER (Specify: _____)

96. REFUSED

97. DON'T KNOW

DEMOGRAPHICS

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

D1. The first question is about how many **adults** live in your home. Include all members of your household whether or not they are related to you. Do not include anyone who is just visiting or who may be away at college or deployed by the military for most of the year. Including yourself, how many adults are currently living in your home?

1. **[RECORD NUMBER]**

96. REFUSED

97. DON'T KNOW

[READ D2-D6 AS 1 QUESTION. MAKE SURE SUM OF D2-D6=D1.]

D2. Including yourself, how many of these adults are employed or self-employed full-time?

1. **[RECORD NUMBER]**

96. REFUSED

97. DON'T KNOW

D3. How many of these adults are employed or self-employed part-time?

1. **[RECORD NUMBER]**

96. REFUSED

97. DON'T KNOW

D4. How many of these adults are temporarily unemployed?

1. **[RECORD NUMBER]**
96. REFUSED
97. DON'T KNOW

D5. How many of these adults are retired or disabled?

1. **[RECORD NUMBER]**
96. REFUSED
97. DON'T KNOW

D6. How many of these adults are not employed and not seeking work, retired or disabled?

1. **[RECORD NUMBER]**
96. REFUSED
97. DON'T KNOW

D7a. Would you say the total combined income of all members of your household over the past 12 months was under or over $50,000? **[READ LIST, RECORD ONE]**

1. UNDER $50,000
2. $50,000 OR MORE **[GO TO D7c]**
96. REFUSED **[GO TO CLOSING]**
97. DON'T KNOW **[GO TO CLOSING]**

D7b. 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 $15,000
2. $15,000 to less than $25,000
3. $25,000 to less than $35,000
4. $35,000 to less than $50,000
96. REFUSED **[GO TO CLOSING]**
97. DON'T KNOW **[GO TO CLOSING]**

[ASK D7c IF D7a = 2]

D7c. 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. $50,000 to less than $75,000

2. $75,000 to less than $100,000
3. $100,000 to less than $150,000
4. $150,000 to less than $200,000
5. $200,000 or more
96. REFUSED
97. DON'T KNOW

CLOSING:

Those are all the questions I have for you. Thank you so much for taking the time to go through this survey. The information you provided will be very helpful in evaluating and improving the Program.

APPENDIX B.

NET-TO-GROSS SURVEY INSTRUMENT

EmPower Impact Evaluation 2010/2011 Participant Net-to-Gross Pilot Survey

FINAL – July 13, 2011

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 participated in NYSERDA's EmPower New York Program. Our records indicate that EmPower New York installed energy efficiency measures in your home on **[SERVICE DATE]**. We're calling today to ask you some questions about your experience with this Program to help us evaluate how the Program might serve people better. We sent you a letter recently telling you that we would be calling and explaining the research we are doing. Your responses to this survey will be kept confidential to the extent permitted by law.

[IF NECESSARY:] The EmPower Program helps people improve the energy efficiency of their homes. Our records show that you had an energy audit through EmPower sometime in **[AUDITYEAR]**. The EmPower Program sent an auditor to your home to complete a visual inspection of the living space, attic, and basement or crawl space and to discuss ways to save energy with you. At the end of the assessment, the auditor recommended energy improvements that were installed in your home. Our records indicate that you received **[LIST MEASURES FROM SAMPLE FILE]**.

[IF NECESSARY:] You were selected as part of a carefully designed sample and your feedback about this program is very important to future planning for energy efficiency programs in the State of New York.

[IF NECESSARY:] This survey will take about 15 minutes to complete.

SCREENER FOR CONTACT

SCR1. Are you the person in your home we should speak to regarding participation in the EmPower Program and the energy efficiency actions taken?

1 YES **[SKIP TO SCR3]**

2 NO

96 REFUSED **[THANK AND TERMINATE]**

97 DON'T KNOW

SCR2. Is there someone else in your household that might 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]**

SCR3. According to our records, your address is **[ADDRESS]**. Is this correct?

1. YES

2. NO

96 REFUSED

97 DON'T KNOW

GENERAL INSTRUCTIONS

Your opinions about the EmPower Program are very 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, you can just indicate that you don't know and we will move on.

As you may recall, the EmPower Program sent an auditor to your home to complete a visual inspection of the living space, attic, and basement or crawl space and to discuss ways to save energy with you. At the end of the assessment, the auditor recommended energy improvements that were installed in your home. You may have also received some energy-saving devices at the time of the audit, such as compact fluorescent light bulbs and a low flow showerhead.

M1a. Do you recall receiving services through the EmPower Program?

1 YES

2 NO **[THANK AND TERMINATE]**

96 REFUSED **[THANK AND TERMINATE]**

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

M1b. According to our records, you received services through the EmPower Program in **[AUDITYEAR]**. Is that correct?

1 DEFINITE OR VAGUE YES **[GO TO M2]**

2 FIRM NO

92 DON'T REMEMBER **[GO TO M2]**

96 REFUSED **[GO TO M2]**

97 DON'T KNOW **[GO TO M2]**

M1c. In what year did you receive services through the EmPower Program?

1. [RECORD YEAR]

96 REFUSED

97 DON'T KNOW

M2. I'm going to read you a list of measures that were installed through the EmPower Program according to our records. For each one, please tell me if that measure was actually installed or not. **[READ M1-M12 IF M1-M12=1 IN SAMPLE FILE]**

Table B-1

M1. Insulation
M2. Air or duct sealing
M3. CFL's or efficient light fixtures
M4. New refrigerator
M5. New freezer
M6. New clothes dryer
M7. New heating system
M8. Heating repair
M9. New water tank or water tank repair
M10. Hot water conservation measures, such as installing low flow showerheads or aerators, or wrapping the water tank or pipes
M11. Programmable thermostat
M12. Switch in fuel source for heating or water heating

1 YES

2 NO

96 REFUSED

97 DON'T KNOW

AID TO ACCURATE RECALL

In this survey, I will be asking you to remember how you made decisions several years ago about improving the energy efficiency of your home.

It may help to think about major changes that occurred in the last four years. The events that would help most would be those that are important to you.

When answering these questions, I would like you to try to remember how you were actually thinking just prior to your participation in the EmPower Program in [AUDITYEAR].

A1. Is your household's economic situation significantly better, somewhat better, the same, somewhat worse, or significantly worse today than it was in [YEAR1]?

1 SIGNIFICANTLY BETTER
2 SOMEWHAT BETTER
3 THE SAME
4 SOMEWHAT WORSE
5 SIGNIFICANTLY WORSE
96 REFUSED
97 DON'T KNOW

[IF 'THE SAME' TODAY (A1=3) GO TO FR1a, OTHERWISE READ: Please try to answer the next few questions thinking back to [YEAR1].].

FREE RIDERSHIP

FR1a. Did you have specific plans to install or add the energy efficiency improvements provided by EmPower prior to the EmPower audit?

1 YES
2 NO **[GO TO FR2]**
96 REFUSED
97 DON'T KNOW

FR1b. What were you planning to do regarding energy efficiency before your participation in the EmPower Program? **[PROBE FOR TIMING, QUANTITY, AND EFFICIENCY, AS WELL AS PRIOR BUDGETING.]**

1 [RECORD VERBATIM]
96 REFUSED
97 DON'T KNOW

FR1c. **[BASED ON RESPONSES TO FR1b, FILL IN A "0 TO 4"SCORE INDICATING THE EXTENT TO WHICH RESPONDENT WAS ALREADY PLANNING TO INSTALL THE ENERGY EFFICIENCY MEASURES. DO NOT ASK RESPONDENT DIRECTLY.]**

[GUIDELINES FOR ASSIGNING HIGH-EFFICIENCY PROJECT PLANNING SCORE]

SCORE	EXTENT OF PLANNING
0	NO PLANS FOR HIGH-EFFICIENCY EQUIPMENT; RESPONDENT MAY HAVE CONSIDERED ALTERNATIVE TECHNOLOGY OPTIONS, BUT DID NOT EXPLICITLY CONSIDER HIGH EFFICIENCY.
1	INITIAL STEPS TOWARD CONSIDERATION OF HIGH EFFICIENCY SUCH AS REQUESTING INFORMATION ON OR DISCUSSING, IN GENERAL, HIGH EFFICIENCY OPTIONS WITH VENDORS OR CONTRACTORS.
2	IN-DEPTH DISCUSSION OR CONSIDERATION OF SPECIFIC TYPES OF HIGH EFFICIENCY EQUIPMENT (E.G., LIGHTING, HVAC, APPLIANCES), INCLUDING THEIR POSITIVE AND NEGATIVE ATTRIBUTES AND COSTS.
3	IDENTIFICATION OF SPECIFIC EQUIPMENT MANUFACTURERS AND MODELS, INCLUDING ASSESSMENT OF THEIR RELATIVE COSTS AND PERFORMANCE CHARACTERISTICS.
4	HIGH EFFICIENCY EQUIPMENT AND DESIGNS FULLY SPECIFIED AND EXPLICITLY SELECTED AND PLANS TO ACCOMMODATE ANY INCREASE IN COSTS TO OBTAIN HIGH EFFICIENCY.

96 REFUSED

97 DON'T KNOW

FR1d. Now I would like you to think about your plans for improving the efficiency of your home, and please consider the costs of the changes you made through the EmPower Program. Which of the following statements best describes your plans to install high efficiency equipment or improvements to your home? **[READ LIST]**

0. I had not considered the efficiency level of my home and had no plans for improving the efficiency of my home.

1 I had gathered some information on high efficiency or discussed it with friends or family.

2 I had one or more in-depth discussions with knowledgeable people or had received an analysis about specific high efficiency equipment or improvements.

3 I had considered specific high efficiency equipment and improvement options, including a comparison of costs and performance for these items.

4 I had already picked out the specific high efficiency equipment or improvements we wanted, and we were prepared to pay the full cost of these items.

96 REFUSED

97 DON'T KNOW

FR2. Did your participation in the EmPower Program in any way influence the type or efficiency level of the equipment that is now in your home?

1 Yes

2 No, all the same equipment would have been installed at the same high efficiencies.

[GO TO FR5]

96 REFUSED **[GO TO FR5]**

97 DON'T KNOW **[GO TO FR5]**

FR3. Would you have installed any of the new equipment provided by EmPower without the Program?

1 YES

2 NO **[GO TO FR5]**

96 REFUSED

97 DON'T KNOW

FR4a. In what ways did NYSERDA's EmPower Program influence your having high efficiency measures or equipment in your home? (Be sure to identify specific measures/equipment.)

1 [RECORD VERBATIM]

96 REFUSED

97 DON'T KNOW

FR4b. **[BASED ON RESPONSE TO FR4a, FILL IN A "0 TO 4"SCORE INDICATING THE EXTENT TO WHICH THE PROGRAM INFLUENCED THE DECISION TO INSTALL HIGH EFFICIENCY MEASURES OR EQUIPMENT. DO NOT ASK RESPONDENT DIRECTLY.]**

[GUIDELINES FOR ASSIGNING PROGRAM INFLUENCE SCORE]

SCORE	CHARACTERIZATION OF PROGRAM INFLUENCE
0	NO INFLUENCE ON THE DECISION TO INSTALL HIGH-EFFICIENCY EQUIPMENT. ALL EQUIPMENT WOULD HAVE BEEN INSTALLED AT THE SAME EFFICIENCIES EVEN WITHOUT THE PROGRAM.
1	PROGRAM HELPED IN MAKING FINAL DECISION ON EQUIPMENT THAT HAD ALREADY BEEN THOROUGHLY CONSIDERED.
2	PROGRAM LENT CREDIBILITY TO THE DECISION TO INVEST IN HIGH EFFICIENCY AND/OR IT PROVIDED INFORMATION THAT HELPED EXPAND THE QUANTITY, SCOPE, OR EFFICIENCY OF THE EQUIPMENT.
3	PROGRAM IDENTIFIED A SIGNIFICANT NUMBER OF SPECIFIC HIGH EFFICIENCY OPTIONS THAT WERE INSTALLED BUT THAT HAD NOT PREVIOUSLY BEEN CONSIDERED AND/OR PROGRAM WAS A MAJOR DRIVER BEHIND A SIGNIFICANT INCREASE IN THE QUANTITY, SCOPE, OR EFFICIENCY OF HIGH-EFFICIENCY EQUIPMENT.
4	PROGRAM WAS THE PRIMARY REASON THAT HIGH EFFICIENCY EQUIPMENT WAS INSTALLED IN THE PROJECT.

96 REFUSED

97 DON'T KNOW

FR5. On a scale of 0 to 4, where 0 is "not at all important" and 4 is "very important," how important was your participation in the EmPower Program in having energy efficiency measures installed in your home? Was it…

0 NOT AT ALL IMPORTANT

1

2

3

4 VERY IMPORTANT

96 REFUSED

97 DON'T KNOW

[FOR EACH SURVEY_MEASURE SM1-SM12 ASK FR6 – FR9 IN SEQUENCE THEN GO TO NEXT MEASURE AND ASK FR6 – FR9]

Now I'd like to talk specifically about the **[SURVEY_MEASURE FROM TABLE 1]** that you received through the EmPower Program.

FR6. If you had not participated in the EmPower Program, would you have **[SURVEY_MEASURE IN TABLE 2]**?**[IF NECESSARY FOR CFLs: IF THEY ALREADY BUY CFLs THEN WOULD THEY HAVE THE SAME NUMBER OF CFLs AS THEY DO WITH THE PROGRAM.]**

1 YES **[GO TO FR7]**

2 NO **[ENTER 0% FOR THE CATEGORY IN THE FREE RIDERSHIP VALUE COLUMN IN TABLE 2 BELOW (FR6) AND MOVE ON TO THE NEXT SURVEY_MEASURE]**

96 REFUSED **[MOVE ON TO THE NEXT SURVEY_MEASURE]**

97 DON'T KNOW **[MOVE ON TO THE NEXT SURVEY_MEASURE]**

FR7. Within how many months and years of when you participated in the EmPower Program would you have been likely to make these improvements if you had not participated in the Program? For example, if you would have installed the item at the same time as occurred through the Program, then your answer would be zero; if you would have installed it a year later and a half later, then your answer would be 1 year and 6 months.

1 [RECORD YEARS LATER, RECORD MONTHS LATER]

93 DO NOT UNDERSTAND THE QUESTION

96 REFUSED

97 DON'T KNOW

FR8. What is the likelihood that you would have **[SURVEY_MEASURE FROM TABLE 2]** if you had not participated in the EmPower Program?

1 Definitely would **not** have installed **[FR8a = 0 AND SKIP TO FR9]**

2 Definitely **would** have installed **[FR8a = 100 AND SKIP TO FR9]**

3 **May have** installed

96 REFUSED **[SKIP TO FR9]**

97 DON'T KNOW **[SKIP TO FR9]**

[FR8a = 0 IF FR8 = 1] [FR8a = 100 IF FR8 = 2] [ASK FR8a IF FR8 = 3]

FR8a. With what percent likelihood would you have **[SURVEY_MEASURE FROM TABLE 2]** if you had not participated in the EmPower Program?

1 [RECORD PERCENTAGE]

93 DO NOT UNDERSTAND THE QUESTION

96 REFUSED

97 DON'T KNOW

[ASK FR9 IF SURVEY_MEASURE = SM1, SM2, SM3, SM10]

FR9. What share or percentage of the **[SURVEY_MEASURE FROM TABLE 2]** would you have installed anyway without the EmPower Program?

1 [RECORD NUMBER]

96 REFUSED

97 DON'T KNOW

Table B-2

[FILL IN EITHER THE "LIKELIHOOD" VALUE OR THE "SHARE OF MEASURES" VALUE OR BOTH VALUES FOR EACH RELEVANT MEASURE CATEGORY.

IF RESPONDENTS ASK FOR THE TIMEFRAME, USE THE TIMEFRAME SPECIFIED ABOVE IN QUESTION FR7 .

THEN ENTER THE APPROPRIATE FREE RIDERSHIP VALUE (FR), WHICH WILL BE ONE OF THE FOLLOWING, DEPENDING ON THE NATURE OF THE PROJECT AND THE RESPONSES:

1) THE SINGLE VALUE FOR "LIKELIHOOD" OR "SHARE OF MEASURES" IF ONLY ONE IS ENTERED;

2) THE PRODUCT OF THE TWO, IF APPROPRIATE (E.G., IF THERE IS A 50% LIKELIHOOD THAT 75% OF THE MEASURES WOULD HAVE BEEN INSTALLED THEN THE FINAL IS 25%)

SURVEY_MEASURE	**FR6. WOULD HAVE INSTALLED IN FORESEEABLE FUTURE [YES = 1, NO = 2, REFUSED = -96, DON'T KNOW = -97]**	**FR7. WITHIN ____ YEARS OF PARTICIPATION [ENTER # OF YEARS REFUSED = -96, DON'T KNOW = -97]**	**FR8. LIKELIHOOD THAT EQUIPMENT…**	**FR9. SHARE OF MEASURES THAT…**		**FR. [ENTERED BY CALCULATION OF FR8*FR9 WHERE FR8=1 IF NOT ASKED AND FR9=1 IF NOT ASKED]**
	NO FR=0%		**…WOULD HAVE BEEN INSTALLED (AT HIGH EFFICIENCY) WITHOUT YOUR PARTICIPATIO IN THE EMPOWER PROGRAM**			**FREE RIDERSHIP VALUE**
SM1. Added Insulation	FR6a	FR7a	FR8a	and/or	FR9a	FR_a
SM2. Air sealed or Duct Sealed	FR6b	FR7b	FR8b	and/or	FR9b	FR_b
SM3. Installed CFL's or Efficient Light Fixtures	FR6c	FR7c	FR8c	and/or	FR9c	FR_c
SM4. Installed an Efficient Refrigerator	FR6d	FR7d	FR8d	and/or	FR9d	FR_d
SM5. Installed an Efficient Freezer	FR6f	FR7f	FR8f	and/or	FR9f	FR_f
SM6. Replaced the Clothes Dryer	FR6g	FR7g	FR8g	and/or	FR9g	FR_g
SM7. Replaced the heating system	FR6h	FR7h	FR8h	and/or	FR9h	FR_h

[FILL IN EITHER THE "LIKELIHOOD" VALUE OR THE "SHARE OF MEASURES" VALUE OR BOTH VALUES FOR EACH RELEVANT MEASURE CATEGORY.

IF RESPONDENTS ASK FOR THE TIMEFRAME, USE THE TIMEFRAME SPECIFIED ABOVE IN QUESTION FR7 .

THEN ENTER THE APPROPRIATE FREE RIDERSHIP VALUE (FR), WHICH WILL BE ONE OF THE FOLLOWING, DEPENDING ON THE NATURE OF THE PROJECT AND THE RESPONSES:

1) THE SINGLE VALUE FOR "LIKELIHOOD" OR "SHARE OF MEASURES" IF ONLY ONE IS ENTERED;

2) THE PRODUCT OF THE TWO, IF APPROPRIATE (E.G., IF THERE IS A 50% LIKELIHOOD THAT 75%

OF THE MEASURES WOULD HAVE BEEN INSTALLED THEN THE FINAL IS 25%)

SURVEY_MEASURE	**FR6. WOULD HAVE INSTALLED IN FORESEEABLE FUTURE** **[YES = 1, NO = 2, REFUSED = -96, DON'T KNOW = -97]**	**FR7. WITHIN ____ YEARS** **OF PARTICIPATION** **[ENTER # OF YEARS REFUSED = -96, DON'T KNOW = -97]**	**FR8.** **LIKELIHOOD THAT EQUIPMENT…**		**FR9.** **SHARE OF MEASURES THAT…**	**FR.** **[ENTERED BY CALCULATION OF FR8*FR9** **WHERE FR8=1 IF NOT ASKED AND FR9=1 IF NOT ASKED]**
	NO **FR=0%**		**…WOULD HAVE BEEN INSTALLED (AT HIGH EFFICIENCY) WITHOUT YOUR PARTICIPATIO IN THE EMPOWER PROGRAM**			**FREE RIDERSHIP VALUE**
SM8. Repaired the Heating System	FR6i	FR7i	FR8i	and/or	FR9i	FR_i
SM9. Replaced or repaired the water heater	FR6j	FR7j	FR8j	and/or	FR9j	FR_j
SM10. Installed Hot water conservation measures such as low flow showerhead, wrapped the tank, or insulated the pipes	FR6k	FR7k	FR8k	and/or	FR9k	FR_k
SM11. Installed a Programmable Thermostat	FR6l	FR7l	FR8l	and/or	FR9l	FR_l
SM12. Switched fuel source of heating or water heating	FR6m	FR7m	FR8m	and/or	FR9m	FR_m

SPILLOVER

SO1. Did your experience with the Empower Program cause you to install any additional energy efficient products to save **gas**?

1 NO **[GO TO SO4]**

2 YES

96 REFUSED **[GO TO SO4]**

97 DON'T KNOW **[GO TO SO4]**

SO2. Would you estimate the energy savings from these extra **gas** efficiency measures to be less than, similar to, or more than the savings from the energy efficiency **gas** measures installed through the Empower Program?

1 Less than the savings from the energy efficiency gas measures installed through the Program.

2 Similar to the savings from the energy efficiency gas measures installed through the Program **[SKIP TO SO3]**

3 More than the savings from the energy efficiency gas measures installed through the Program.

96 REFUSED **[SKIP TO SO3]**

97 DON'T KNOW **[SKIP TO SO3]**

SO2a. The energy savings from these extra gas measures are about what percent of the gas savings from the Program measures? [**READ IF NECESSARY**: If the savings from the additional measures are about a quarter of the savings you are achieving from the Program measures, then the percentage would be 25%.]

1 [RECORD PERCENTAGE > 100 IF SO2=3, PERCENTAGE <100 IF SO2=1]

93 DO NOT UNDERSTAND THE QUESTION

96 REFUSED

97 DON'T KNOW

SO3. What share of the **gas** savings from these extra measures can reasonably be attributed to the influence of the Empower Program?

1 [RECORD PERCENT, ACCEPT 100% OR LESS]

93 DO NOT UNDERSTAND THE QUESTION

96 REFUSED

97 DON'T KNOW

SO4. Did your experience with the Empower Program cause you to install any additional energy efficient products to save **electricity**?

1 NO [**GO TO EE1]**

2 YES

96 REFUSED **[GO TO EE1]**

97 DON'T KNOW **[GO TO EE1]**

SO5. Would you estimate the energy savings from these extra **electric** measures to be less than, similar to, or more than the **electric** savings from the energy efficient electric measures installed through the Program?

1 Less than the savings from the energy efficiency electric measures installed through the program.

2 Similar to the savings from the energy efficiency electric measures installed through the Program. **[SKIP TO SO6]**

3 More than the savings from the energy efficiency electric measures installed through the Program.

96 REFUSED **[SKIP TO SO6]**

97 DON'T KNOW **[SKIP TO SO6]**

SO5a. The energy savings from these extra electric measures are about what percent of the electric savings from the Program measures? [**READ IF NECESSARY**: If the savings from the additional measures are about a quarter of the savings you are achieving from the Program measures, then the percentage would be 25%.]

1 [RECORD PERCENTAGE > 100 IF SO5=3, PERCENTAGE < 100 IF SO5=1]

93 DO NOT UNDERSTAND THE QUESTION

96 REFUSED

97 DON'T KNOW

SO6. What share of the **electric** savings from these extra measures can reasonably be attributed to the influence of the Program?

1 [RECORD PERCENTAGE, ACCEPT 100% OR LESS]

93 DO NOT UNDERSTAND THE QUESTION

96 REFUSED

97 DON'T KNOW

ENERGY EFFICIENCY ENVIRONMENT

EE1. On a scale of 0 to 4, where 0 is "Not at all" and 4 is "Very often," in the past 6 months, how often have you heard or read about things that you could do to reduce energy use in your home? This could include purchasing energy efficient appliances, light bulbs, or changing behaviors.

0 NOT AT ALL
1
2
3
4 VERY OFTEN
96 REFUSED
97 DON'T KNOW

EE2. In the last couple of years, would you that say your familiarity with energy efficient products and equipment has …? **[READ LIST AND RECORD ONE RESPONSE]**

5 Increased significantly
4 Increased somewhat
3 Stayed the same
2 Decreased somewhat
1 Decreased significantly
96 REFUSED
97 DON'T KNOW

[ASK EE3 IF EE2 >3, OTHERWISE GO TO NEXT SECTION]

EE3. How much of your increased familiarity with energy efficiency is due to your participation in the EmPower Program?

4 All of it
3 Most of it
2 A small part, or
1 None of it
96 REFUSED
97 DON'T KNOW

[ASK EE4 IF EE3<3, OTHERWISE GO TO NEXT SECTION]

EE4. To what do you attribute your increased familiarity with energy efficiency?

1 [RECORD VERBATIM]

RECESSION EFFECTS

R1. Did anyone in your household experience a major drop in income anytime between 2006 and 2009?

1 YES

2 NO **[GO TO D1a]**

96 REFUSED **[GO TO D1a]**

97 DON'T KNOW **[GO TO D1a]**

R2. Was there more than one person in your household who experienced this type of income loss during this period?

1 YES

2 NO

96 REFUSED

97 DON'T KNOW

R3. In what year and season between 2006 and 2009 did the [first] loss of income begin?

1 [RECORD YEAR, RECORD SEASON]

96 REFUSED

97 DON'T KNOW

[ASK R4 IF R2 = 1]

R4. In what year and season between 2006 and 2009 did your household experience the second drop in income?

1 [RECORD YEAR, RECORD SEASON]

96 REFUSED

97 DON'T KNOW

DEMOGRAPHICS

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

D1a. Next we want to know many people live in your home most of the year. Do not include anyone who just visits or who may be away at college or deployed by the military for most of the year. Include all members of your household whether or not they are related to you. How many people, including yourself, currently live in your home year-round?

1 [RECORD NUMBER]

96 REFUSED

97 DON'T KNOW

D1b. How many adults, persons over 21, live in your home most of the year?

1 [RECORD NUMBER]

96 REFUSED

97 DON'T KNOW

[READ D2-D6 AS 1 QUESTION. MAKE SURE SUM OF D2-D6=D1.]

D2. Including yourself, how many of these adults are employed or self-employed full-time?

1 [RECORD NUMBER]

96 REFUSED

97 DON'T KNOW

D3. How many of these adults are employed or self-employed part-time?

1 [RECORD NUMBER]

96 REFUSED

97 DON'T KNOW

D4. How many of these adults are temporarily unemployed?

1 [RECORD NUMBER]

96 REFUSED

97 DON'T KNOW

D6. How many of these adults are not employed and not seeking work, including those not seeking work because they are retired or disabled?

1 [RECORD NUMBER]

96 REFUSED

97 DON'T KNOW

D7a. Would you say the total combined income of all members of your household over the past 12 months was under or over $50,000? **[READ LIST, RECORD ONE]**

1 Under $50,000, or

2 $50,000 or more **[GO TO D7c]**

96 REFUSED **[THANK RESPONDENT FOR THEIR TIME AND END INTERVIEW]**

97 DON'T KNOW **[THANK RESPONDENT FOR THEIR TIME AND END INTERVIEW]**

D7b. 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 $15,000

2 $15,000 to less than $25,000

3 $25,000 to less than $35,000

4 $35,000 to less than $50,000

96 REFUSED **[THANK RESPONDENT FOR THEIR TIME AND END INTERVIEW]**

97 DON'T KNOW **[THANK RESPONDENT FOR THEIR TIME AND END INTERVIEW]**

[ASK D7c IF D7a = 2]

D7c. 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 $50,000 to less than $75,000

2 $75,000 to less than $100,000

3 $100,000 to less than $150,000

4 $150,000 to less than $200,000

5 $200,000 or more

96 REFUSED

97 DON'T KNOW

Thank you so much for your time

APPENDIX C.

SUMMARY OF ENERGY CHANGE SURVEY RESPONSES

The following tables reflect the responses for various sections of the Energy Change survey. Respondents were asked to recall the measures which were installed. They were also asked about the use of primary and supplemental heating systems and cooling systems, whether they added or replaced various appliances and about changes in schedule or occupancy during the Program years 2007 and 2008. Then they were asked about their ability to pay the gas and/or electric bills and whether or not the EmPower Program had an effect on that ability.

Table C-1. Respondent Recollection of Measures Installed

Measure	Measure Installed (Program)	Measure Installed (Respondent)	Measure Not Installed (Respondent)	Don't Know/ Refused
Insulation	249	226	14	9
Air Sealing	252	117	77	58
CFL/ Fixtures	628	589	31	8
New Refrigerator	382	377	4	1
New Freezer	129	126	2	1
New Clothes Dryer	6	6	0	0
New Heating System	15	14	1	0
Heating System Repair	101	53	37	11
DHW Repair	68	58	9	1
Pipe Insul/ Showerhead/ Tank Wrap	363	271	74	18
Prog Thermostat	132	122	8	2
DHW Fuel Switch/ Heat Sys Fuel Switch	3	2	1	0
Total	**2,328**	**1,961**	**258**	**109**

Table C-2: Respondent Recollection of CFLs and Fixtures Installed

	Number of Homes (Program)	Number Installed (Program)	Number Installed (Respondent)	Number of Homes (Respondent)	Don't Know/ Refused
CFLs	626	5,162	3,901	491	96
Fixtures	45	100	92	38	5
Total	**671**	**5,262**	**3,993**	**529**	**101**

Table C-3: Primary Heating Fuel

Heating Fuel	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=650)
Natural Gas	545	82.70%	83.84%
Electric	18	2.73%	2.77%
Other	87	13.20%	13.38%
Don't Know/Refused	9	1.36%	.

Note: No survey respondents indicated switching to natural gas or electric fuel.

Table C-4: Control of Primary Heating System

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=647)
Set at one temperature	207	31.41%	31.99%
Manually adjust	247	37.48%	38.17%
Program thermostat	193	29.28%	29.83%
Don't Know/Refused	12	1.82%	.

Table C-5: Difference in Use of Primary Heating System

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=624)
No Change	542	82.24%	86.85%
Use a lot less	23	3.49%	3.69%
Use somewhat less	48	7.28%	7.69%
Use somewhat more	7	1.06%	1.12%
Use a lot more	4	0.60%	0.64%
Don't Know/Refused	35	5.31%	.

Table C-6: Supplemental Heating System

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=651)
None	491	74.50%	75.42%
Natural Gas	32	4.85%	4.91%
Electric	89	13.50%	13.67%
Other Fuel	39	5.91%	5.99%
Don't Know/Refused	8	1.21%	.

Note: No survey respondents indicated switching to natural gas or electric fuel.

Table C-7: Use of Supplemental Heating System

	Number of Homes	Percent of Homes (n=160)	Adjusted Percent of Homes (n=152)
Minimal (10 days or less)	32	20.00%	21.05%
Low (11 to 30 days)	35	21.87%	23.03%
Moderate (31 to 60 days)	21	13.12%	13.82%
High (more than 60 days)	64	40.00%	42.10%
Don't Know/Refused	8	5.00%	.

Table C-8: Change in Use of Supplemental Heating System

	Number of Homes	Percent of Homes (n=160)	Adjusted Percent of Homes (n=151)
No Change	98	61.25%	64.89%
Did not use supplemental heat at all in Season 1	12	7.50%	7.95%
A lot less in Season 2 than in Season 1	12	7.50%	7.95%
Somewhat less	12	7.50%	7.95%
Somewhat more	6	3.75%	3.97%
A lot more in Season 2 than in Season 1	11	6.87%	7.28%
Don't Know/Refused	9	5.62%	.

Table C-9: Fuel to Heat Water

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=634)
Natural Gas, not Propane	485	73.59%	76.49%
Electric	116	17.60%	18.30%
Solar with Electric Backup	1	0.15%	0.16%
Other	32	4.85%	5.05%
Don't Know/Refused	25	3.79%	.

Note: 2 respondents indicated changing fuel to heat water.

Table C-10: Fuel Switch

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=634)
Electric to Gas	1	50.00%	50.00%
Other to Gas	1	50.00%	50.00%

Note: One out of two respondents indicated that the change was a result of the EmPower Program.

Table C-11: Working Central Air Conditioning

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=657)
Yes	102	15.47%	15.52%
No	555	84.21%	84.47%
Don't Know/Refused	2	0.30%	.

Table C-12: Room Air Conditioning

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=647)
Yes	391	59.33%	60.42%
No	256	38.84%	39.56%
Don't Know/Refused	12	1.82%	.

Table C-13: Current Air Conditioning

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=659)
None	195	29.59%	29.59%
Either Central or Room A/C	435	66.00%	66.00%
Both Central and Room A/C	29	4.40%	4.40%

Table C-14: Use of Air Conditioning

	Number of Homes	Percent of Homes (n=473)	Adjusted Percent of Homes (n=413)
Not at all	13	1.97%	3.15%
10 days or less	58	8.80%	14.04%
11-30 days	136	20.63%	32.93%
31-60 days	121	18.36%	29.30%
More than 60 days	85	12.89%	20.58%
Don't Know/Refused	60	9.10%	.
Not Applicable	186	28.22%	.

Table C-15: Change in Use of Air Conditioning

	Number of Homes	Percent of Homes (n=659)	Adjusted Percent of Homes (n=638)
No Change	578	87.70%	90.59%
Did not use at all in season 1	6	0.91%	0.94%
Use the air conditioning a lot less	14	2.12%	2.19%
Somewhat less	24	3.64%	3.76%
Somewhat more	9	1.36%	1.41%
A lot more in season 2 than season 1	7	1.06%	1.10%
Don't Know/Refused	21	3.18%	.

Table C-16: Added or Replaced Appliances

	Added	Replaced	Don't Know/ Refused
Central A/C	1	1	0
Room A/C	9	22	0
Electric Clothes Dryer	3	18	0
Gas Clothes Dryer	0	11	0
Refrigerator Freezer	5	24	0
Electric Heater	14	3	0
Gas Heater	0	3	0
Total Number of Homes with Change(s)	**32**	**82**	**0**

Table C-17: Change in Summer Vacation

	Less Time Away	More Time Away
Less than a week	5	3
1 to less than 2 weeks	8	4
2 to less than 3 weeks	2	.
3 weeks or more	2	8
Don't Know/Refused	3	.
Total	**20**	**15**

Table C-18: Change in Winter Vacation

	Less Time Away	More Time Away
Less than a week	7	2
1 to less than 2 weeks	3	5
2 to less than 3 weeks	.	2
3 weeks or more	.	5
Total	**10**	**14**

Table C-19: Other Changes in Schedule

	Number of Homes
At home more in 2008	24
At home less in 2008	13
Don't Know/Refused	7
Total	**44**

Table C-20: Program Effects on Ability to Pay Bills

	Electric	Don't Know/ Refused	Gas	Don't Know/ Refused
Responsible for Paying Bill	635	1	629	3
Outside Assistance	228	10	420	7
Difficulties in Paying Bill	357	5	417	6
Change in Ability to Pay	120	37	114	39

Table C-21: Timeliness of Bill Payment

	Electric	Gas
Generally pay in full and on time	66	58
Sometimes miss a payment or pay only part of the bill	39	35
Often miss payments or only pay part of the bill	11	18
Don't Know/Refused	4	3
Total	**120**	**114**

Table C-22: Program Impact on Ability to Pay Bills

	Electric	Gas
Harder to pay	1	1
Lower bill and am able to make payments on time and in full	76	71
Lower bill but sometimes miss payments or pay only part of the bill	27	22
Lower bill but often miss payments or pay only part of the bill	2	5
Don't Know/Refused	10	12
Not Applicable	4	3
Total	**120**	**114**

APPENDIX D.

MODELING RESULTS FROM THE ENERGY CHANGE SURVEY

The purpose of the restricted model was to determine whether non-program, within-home changes in energy consumption introduce a bias into the savings estimates. To achieve this objective, regression variables were constructed from the Energy Change Survey, included in the model, and the savings were compared. This comparison assessed whether adding the change variables made a significant difference in the resulting savings estimates. The candidate models are described in Section 3.4 of the main report.

Table D-1 shows the results of the restricted billing analysis for the electric model. The model with the lowest AIC would be the "best" model using the information-theoretic approach to model selection. Household savings varied by 3% or less, indicating that the additional information from the survey did not affect the magnitude of the savings from the billing models.

Model 3 includes only the survey responses indicating an increase in use in the post-installation period, and savings decrease by 2%. When the opposite approach is taken and only responses that indicate a (non-program related) increase in use in the post-installation period, savings increase by 2%. When both sets of variables were included (Model 5), there is no change in savings.

Table D-1: Energy Change Survey Results for the Restricted Electric Model

Model Description	Change in AIC	R^2	Estimated Household Savings (kWh/Year)	% Change in Savings from Base Model
Base Model - No Survey Variables	84.8	0.698	802	
1 Other Program	90.5	0.698	796	-1%
2 Occupancy/Cooling	80.1	0.699	806	1%
3 Increase in Use	64.5	0.699	790	-2%
4 Lower Use	27.7	0.699	817	2%
5 Both increases and decreases in use	19.8	0.701	802	0%
6 Schedules changes	66.9	0.700	822	3%
7 Any Change	0.00	0.701	784	-2%

Table D-2 shows the results of the restricted billing analysis for the natural gas model. Savings were slightly more variable in the natural gas model. In some cases, particularly with the schedule changes, the estimators did not have the expected sign. For example, respondents who reported that they were at home less in the post-installation period also showed an increase in use. As with the electric restricted model, Model 4 includes only the survey responses indicating an increase in use in the post-installation period, and savings decrease by 5%. However, including only variables suggesting a decrease in use did not have an effect on the household savings. Savings for respondents who reported that they also received services through another program were 6% higher than the base model.

Table D-2: Energy Change Survey Results for the Natural Gas Model

Model Description	Change in AIC	R^2	Estimated Household Savings (Therms/Year)	% Change in Savings from Base Model
Base Model - No Survey Variables	83.3	0.823	103	
1 Thermostat setting	0.0	0.826	105	1%
2 Supplemental Heat	62.7	0.824	101	-3%
3 Other Program	90.6	0.824	107	6%
4 Added gas use	58.2	0.824	102	-5%
5 Lower gas use	76.0	0.824	102	0%
6 Both added and lowered gas use	44.7	0.825	101	-1%
7 Occupancy Up/Down	90.7	0.823	103	1%
8 Any change - up or down	41.9	0.825	103	1%
9 Schedule changes	60.9	0.825	101	-3%

Although not directly related to the purpose of the restricted billing analysis, there were a couple of interesting findings from this process. The savings from heating measures are less variable and substantially higher (by 80%) for the 25% of respondents who reported that they set the thermostat at one temperature and leave it, in comparison to those who either reported some type of setback (manual or programmed) or did not provide a valid response to the question. The same result was found for secondary space heat; homes with secondary space heat saved half as much natural gas from heating-related measures and the savings exhibited a much higher degree of variability (p-value of 0.115 as compared to <.0001).

APPENDIX E.

REGRESSION DIAGNOSTICS

The regression methods are based on the assumptions that the error term is independent, has a constant variance, and is normally distributed. Combining CSTS data creates additional sources of variability. The underlying assumption behind pooling is that the cross-sectional units are homogenous. In real applications, this is rarely the case. Energy use in homes varies widely, as does the impact of the conservation treatments. Homes with electric space heat or unusually high use may well have different patterns of consumption than other homes.

For OLS, the assumption is that the error term is independent, has a constant variance and is normally distributed. In CSTS data sets, variation among the cross-sectional units may contribute to heteroskedasticity and the series of observations within each house may well be autocorrelated. Collinearity among the explanatory variables can also contribute to the uncertainty in the estimated intervention effects, sometimes resulting in estimators of the opposite sign.

Regression diagnostics were conducted for the final models (natural gas and electric) to determine whether there were any major deviations from these assumptions. The effects of heteroskedasticity (unequal variances), collinearity, autocorrelation (lack of independence among observations) and influential data points were assessed as part of the model diagnostics.

Autocorrelation was found to be the only issue in the final data set. This result is common with billing models as the consumption in one month within a home tends to be related to the consumption in the next month. Dependence among observations does not affect the reliability of the estimate, but does indicate that variability within the model estimates may be greater than represented by the confidence interval. The models were also tested with and without outliers, and the savings results were found to be highly consistent. The tests and results are described below.

Heteroskedasticity

Unequal variances result from the wide fluctuations in energy use from one home to the next due to appliance holdings, occupancy and lifestyle, and are exacerbated by anomalous variations in consumption, either due to estimated reads or other unusual circumstances. The inclusion of the customer-specific intercepts does not completely mitigate the unexplained month-to-month variations. Heteroskedasticity can also be a sign of model misspecification.

Heteroskedasticity can be detected through plots of the residuals v fits and tested by the Goldfeld-Quandt test or other specification. The Goldfeld-Quandt test is particularly useful for assessing heteroskedasticity in CSTS data sets. This process requires sorting the data set by a secondary variable that would be expected to be related to differences in variances by cross-section (house), in this case the pre-installation level of use. Separate regressions are then conducted for the top and bottom k cross-sectional units (homes), and the ratio of the residual sum of squares is calculated. This statistic has an F-distribution with $(N – R – 2K – 2)/2$, $(N – R – 2K – 2)/2$ degrees of freedom, where N is the total number of observations, R the number of central observations removed from the analysis and K is the total number of parameters to be estimated (Judge 1980: 148-149, Goldfeld and Quandt 1965).

The results of the Goldfeld-Quandt test were 1.02 for the electric model and 1.16 for the natural gas model, which is quite close to the F-value of 1.0 required to conclude that the data set does not exhibit heteroskedasticity at the 5% confidence level. These results indicate the data sets are not heteroskedastic.

Autocorrelation

Autocorrelation is commonly found in time series data, possibly resulting in biased variances. In this model, autocorrelation stems from the pattern of energy consumption during consecutive periods within each home, i.e., the amount of electricity used in one month is likely to be similar to consumption during the previous month. While the response variable in the fixed-effect model is the deviation from the expected use, this pattern will still hold to some extent.

While a positively autocorrelated data set should produce unbiased estimators, the variances of the coefficients are likely to be smaller than actually supported by the data. A number of strategies for mitigating first-order autocorrelation have been recommended, but even with these alternative strategies, errors are still likely to be understated in autocorrelated data sets, and care should be used in interpreting the results (Ostrom 1990:36).

The Durbin-Watson test is commonly used to assess the presence of first-order autoregression in least squares regression. The calculation is given below:

$$d = \frac{\sum_{j=1}^{n-1} (u_{j+1} - u_j)}{\sum_{j=1}^{n} u_j^2} \qquad \text{(E-1)}$$

Values of the test statistic of approximately 2.0 indicate there is no autocorrelation, and a specified threshold (given the sample size and number of explanatory variables) is designated as the "uncertainty zone" where autocorrelation may exist. Values below the threshold lead to the conclusion that the data set exhibits statistically significant positive autocorrelation (Sayrs 1989, Durbin and Watson 1951).

The pooled Durbin-Watson is the value of this test statistic as calculated for each home and averaged over all cross-sectional units (homes). This variation on the Durbin-Watson statistic is more appropriate for the CSTS structure and reflects the presence of autocorrelation on average among all homes in the analysis. As with the regular Durbin-Watson statistic, a value close to 2.0 indicates that the data set does not show signs of an autoregressive structure (Sayrs 1989:19).

The pooled Durbin-Watson statistic was 0.901 and 0.693 for the electric and natural gas models, respectively, indicating that the data set does exhibit autocorrelation. However, as mentioned earlier, autocorrelation does not introduce bias into the estimators.

Collinearity

Collinearity tends to be an issue whenever many variables are incorporated into the analysis reflecting measures installed at the same time or when other effects have a high correlation with the measure installations. For example, light bulb and fixture replacements as well as the installation of low flow devices, tank wraps and pipe insulation are often installed at the time of the initial energy assessment.

Collinearity results in higher variances for both response and explanatory variables, and sometimes produces estimators having the opposite sign than would be expected. Four approaches to detecting collinearity were pursued:

(1) assessing the correlation between pairs of independent variables in the model,

(2) identifying nonsignificant t tests for individual beta parameters where the F test for overall model is significant,

(3) reviewing estimators with opposite signs from what is expected,

(4) calculating the variance inflation factor for each parameter of interest.

The variance inflation factor is calculated as follows:

$$VIF_i = \frac{1}{1 - R_i^2}, \qquad \text{(E-2)}$$

where Ri2 is the multiple correlation coefficient of Xi regressed on the remaining explanatory variables and i is the index for the parameter to be estimated.

A variance inflation factor of 1.0 indicates no correlation, whereas a high value suggests collinearity among two or more of the explanatory variables (Belsley, Kuh and Welsch, 1980:92-93). If collinearity is found, possible mitigations include bundling measures into groups or trying to obtain additional information.

The VIF's were calculated and reviewed, and indicated that there is no collinearity among the measure variables. This result may be due to the method used to define the measure variables, which was designed to minimize the potential for collinearity.

Outliers and Influential Data Points

Outliers and influential data points can be an issue with regression models, particularly if only a small number of households receive a measure of interest. The DFFITS procedure was used to identify ouliters and influential data points. This process involves calculates a predicted value two ways, once with a potential influential observation and once without it. If there is a large difference between the two, the case is considered influential. Typically, observations with a value of DFFITS exceeding 2 are considered to be influential. Given the high number of observations, the cut off level was modified to reflect the number of variables and observations in the analysis, as recommended by Belsley, Kuh and Welsch (1980). This adjustment was set at 2 x square root(p/n), where p is the number of variables and n the number of observations. The DFFITS values were summed by household to identify homes that are outliers. Once detected, these households were removed and the regression analysis run to assess their impacts on the results.

For the natural gas model, only one home was identified as a potential influential data point and no further action was taken. For the electric model, 20 homes were identified and the final household model was run with and without these potential influential homes. When the influential homes were exlcuded, the household savings increased by about 3%. This change was so small that no further action was taken.

References

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

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

Judge, George G., William E. Griffiths, R. Carter Hill and Tsoung-Chao Lee. 1980. *The Theory and Practice of Econometrics*. New York: John Wiley and Sons.

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

APPENDIX F.

REGRESSION OUTPUT FOR FINAL MODELS

The SAS output for the final models is provided below in the following order:

1. Electric household model
2. Electric measure-level model
3. Natural gas household model
4. Natural gas measure-level model

Proc GLM Electric Household Model 1

The GLM Procedure

Class Level Information

Class	Levels	Values
amonth	46	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47

Number of Observations Read 109340
Number of Observations Used 109340

Dependent Variable: ConsPerDay Consumption per Day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4742	14939842.24	3150.54	49.29	<.0001
Error	104597	6685269.99	63.91		
Corrected Total	109339	21625112.23			

R-Square	Coeff Var	Root MSE	ConsPerDay Mean
0.690856	38.61160	7.994657	20.70533

Source	DF	Type I SS	Mean Square	F Value	Pr > F
empid	4694	14128619.05	3009.93	47.09	<.0001
amonth	45	487439.01	10831.98	169.48	<.0001
dpost	1	13032.38	13032.38	203.90	<.0001
nhdd	1	148637.32	148637.32	2325.56	<.0001
ncdd	1	162114.48	162114.48	2536.43	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F

amonth	45	131863.3421	2930.2965	45.85 <.0001
dpost	1	14604.6343	14604.6343	228.50 <.0001
nhdd	1	107219.4919	107219.4919	1677.54 <.0001
ncdd	1	162114.4807	162114.4807	2536.43 <.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
amonth	2	7.73317794 B	2.73363228	2.83	0.0047
amonth	3	6.86963043 B	2.21477645	3.10	0.0019
amonth	4	10.35124179 B	1.90432406	5.44	<.0001
amonth	5	10.01926962 B	1.56042065	6.42	<.0001
amonth	6	7.74775089 B	1.56181262	4.96	<.0001
amonth	7	9.07623097 B	1.54509230	5.87	<.0001
amonth	8	6.62069067 B	1.53346433	4.32	<.0001
amonth	9	5.73449936 B	1.52544181	3.76	0.0002
amonth	10	6.04133247 B	1.52103757	3.97	<.0001
amonth	11	5.46415826 B	1.51761663	3.60	0.0003
amonth	12	2.34069661 B	1.51765383	1.54	0.1230
amonth	13	2.89516173 B	1.51486040	1.91	0.0560
amonth	14	4.44068237 B	1.51579708	2.93	0.0034
amonth	15	5.50951396 B	1.52191383	3.62	0.0003
amonth	16	9.72124986 B	1.53117023	6.35	<.0001
amonth	17	10.02287168 B	1.53557017	6.53	<.0001
amonth	18	10.32073609 B	1.53735147	6.71	<.0001
amonth	19	9.51327140 B	1.53332226	6.20	<.0001
amonth	20	9.97704804 B	1.52546176	6.54	<.0001
amonth	21	6.35286236 B	1.51462910	4.19	<.0001
amonth	22	4.70875816 B	1.50782392	3.12	0.0018
amonth	23	4.63099252 B	1.50646625	3.07	0.0021
amonth	24	3.17450459 B	1.50637317	2.11	0.0351
amonth	25	3.12366678 B	1.50598526	2.07	0.0381
amonth	26	4.70469205 B	1.50828736	3.12	0.0018
amonth	27	6.07719242 B	1.51638128	4.01	<.0001
amonth	28	7.03066260 B	1.52417262	4.61	<.0001
amonth	29	11.06920431 B	1.53137485	7.23	<.0001

amonth	30	11.66371324 B	1.53093524	7.62	<.0001
amonth	31	10.70041794 B	1.52652740	7.01	<.0001
amonth	32	7.81949601 B	1.51768257	5.15	<.0001
amonth	33	6.13396020 B	1.51038288	4.06	<.0001
amonth	34	4.96470449 B	1.50408179	3.30	0.0010
amonth	35	4.02105592 B	1.50379816	2.67	0.0075
amonth	36	2.56326468 B	1.50424564	1.70	0.0884
amonth	37	3.37985750 B	1.50351485	2.25	0.0246
amonth	38	4.61778500 B	1.50745415	3.06	0.0022
amonth	39	6.52959159 B	1.51588374	4.31	<.0001
amonth	40	8.54532737 B	1.52366480	5.61	<.0001
amonth	41	11.05934725 B	1.53004663	7.23	<.0001
amonth	42	11.31227754 B	1.53560706	7.37	<.0001
amonth	43	9.71631140 B	1.53752726	6.32	<.0001
amonth	44	10.40169681 B	1.56084691	6.66	<.0001
amonth	45	5.86745392 B	1.67155749	3.51	0.0004
amonth	46	4.47261305 B	1.75827034	2.54	0.0110
amonth	47	0.00000000 B	.	.	.
dpost		-1.87594910	0.12410108	-15.12	<.0001
nhdd		0.30450708	0.00743465	40.96	<.0001
ncdd		4.71580877	0.09363649	50.36	<.0001

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

Proc GLM Electric Measure-Level Model 4

The GLM Procedure

Class Level Information

Class	Levels	Values
amonth	46	2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47

Number of Observations Read 109340
Number of Observations Used 109340

Proc GLM Electric Measure-Level Model 5

The GLM Procedure

Dependent Variable: ConsPerDay Consumption per Day

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4758	15190486.03	3192.62	51.89	<.0001
Error	104581	6434626.20	61.53		
Corrected Total	109339	21625112.23			

R-Square	Coeff Var	Root MSE	ConsPerDay Mean
0.702447	37.88377	7.843958	20.70533

Source	DF	Type I SS	Mean Square	F Value	Pr > F
empid	4694	14128619.05	3009.93	48.92	<.0001
amonth	45	487439.01	10831.98	176.05	<.0001
ltgqty*dpost	1	3275.14	3275.14	53.23	<.0001
dpost*dref	1	10448.21	10448.21	169.81	<.0001
dpost*dhwcons	1	3.82	3.82	0.06	0.8032
dpost*dhwrep	1	584.68	584.68	9.50	0.0021
dpost*dhwfs	1	9776.45	9776.45	158.90	<.0001
dpost*cdfs	1	7491.96	7491.96	121.77	<.0001
dpost*other	1	127.72	127.72	2.08	0.1497
dpost*env*nhdd	1	56649.42	56649.42	920.71	<.0001
dpost*env*ncdd	1	6750.48	6750.48	109.71	<.0001
dpost*nhdd*tstat	1	1564.87	1564.87	25.43	<.0001
dpost*ncdd*tstat	1	50674.37	50674.37	823.60	<.0001
dpost*nhdd*hsfs	1	5997.92	5997.92	97.48	<.0001
env*nhdd	1	79352.98	79352.98	1289.71	<.0001
nhdd*tstat	1	2034.90	2034.90	33.07	<.0001
nhdd*hsfs	1	73024.98	73024.98	1186.86	<.0001
env*ncdd	1	11.65	11.65	0.19	0.6635
ncdd*tstat	1	25801.69	25801.69	419.35	<.0001
nhdd	1	127277.97	127277.97	2068.63	<.0001
ncdd	1	113578.76	113578.76	1845.98	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
amonth	45	127760.3100	2839.1180	46.14	<.0001
ltgqty*dpost	1	614.0569	614.0569	9.98	0.0016
dpost*dref	1	15743.5904	15743.5904	255.88	<.0001
dpost*dhwcons	1	166.5059	166.5059	2.71	0.1000
dpost*dhwrep	1	687.1204	687.1204	11.17	0.0008
dpost*dhwfs	1	9953.7558	9953.7558	161.78	<.0001
dpost*cdfs	1	7687.8977	7687.8977	124.95	<.0001
dpost*other	1	106.9268	106.9268	1.74	0.1874
dpost*env*nhdd	1	1262.0758	1262.0758	20.51	<.0001
dpost*env*ncdd	1	4.0729	4.0729	0.07	0.7970
dpost*nhdd*tstat	1	332.7193	332.7193	5.41	0.0201
dpost*ncdd*tstat	1	595.0665	595.0665	9.67	0.0019
dpost*nhdd*hsfs	1	44156.2926	44156.2926	717.67	<.0001
env*nhdd	1	63813.9580	63813.9580	1037.16	<.0001
nhdd*tstat	1	1881.5397	1881.5397	30.58	<.0001
nhdd*hsfs	1	69866.5178	69866.5178	1135.53	<.0001
env*ncdd	1	16.2353	16.2353	0.26	0.6075
ncdd*tstat	1	4954.3764	4954.3764	80.52	<.0001
nhdd	1	98993.0438	98993.0438	1608.92	<.0001
ncdd	1	113578.7641	113578.7641	1845.98	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
amonth	2	8.28852133 B	2.67966808	3.09	0.0020
amonth	3	7.34902460 B	2.16947677	3.39	0.0007
amonth	4	10.76829595 B	1.86393171	5.78	<.0001
amonth	5	10.75204588 B	1.52518157	7.05	<.0001
amonth	6	8.70066105 B	1.52732461	5.70	<.0001
amonth	7	9.66386131 B	1.51033730	6.40	<.0001
amonth	8	7.23050362 B	1.49904794	4.82	<.0001
amonth	9	6.39689045 B	1.49136652	4.29	<.0001
amonth	10	6.74951624 B	1.48707669	4.54	<.0001
amonth	11	6.20345999 B	1.48395874	4.18	<.0001

amonth	12	3.19843080 B	1.48416981	2.16	0.0312
amonth	13	3.72121581 B	1.48159763	2.51	0.0120
amonth	14	5.09130712 B	1.48299626	3.43	0.0006
amonth	15	6.01159172 B	1.48948406	4.04	<.0001
amonth	16	10.11513854 B	1.49904602	6.75	<.0001
amonth	17	10.46346295 B	1.50388572	6.96	<.0001
amonth	18	10.79977737 B	1.50626843	7.17	<.0001
amonth	19	9.85976255 B	1.50238079	6.56	<.0001
amonth	20	10.20904442 B	1.49476532	6.83	<.0001
amonth	21	6.69253307 B	1.48424368	4.51	<.0001
amonth	22	5.18548637 B	1.47762193	3.51	0.0004
amonth	23	5.11922276 B	1.47651729	3.47	0.0005
amonth	24	3.64352085 B	1.47664160	2.47	0.0136
amonth	25	3.53120456 B	1.47644407	2.39	0.0168
amonth	26	4.93830116 B	1.47899546	3.34	0.0008
amonth	27	6.14883883 B	1.48719354	4.13	<.0001
amonth	28	7.07787920 B	1.49504369	4.73	<.0001
amonth	29	11.04832463 B	1.50224327	7.35	<.0001
amonth	30	11.54609259 B	1.50190165	7.69	<.0001
amonth	31	10.59145973 B	1.49763465	7.07	<.0001
amonth	32	7.73478546 B	1.48898405	5.19	<.0001
amonth	33	6.14550696 B	1.48182700	4.15	<.0001
amonth	34	5.07599082 B	1.47567126	3.44	0.0006
amonth	35	4.17311500 B	1.47543288	2.83	0.0047
amonth	36	2.73683064 B	1.47589207	1.85	0.0637
amonth	37	3.47573925 B	1.47517833	2.36	0.0185
amonth	38	4.60370367 B	1.47904920	3.11	0.0019
amonth	39	6.41132521 B	1.48733846	4.31	<.0001
amonth	40	8.33343651 B	1.49499635	5.57	<.0001
amonth	41	10.84134019 B	1.50126654	7.22	<.0001
amonth	42	11.14416931 B	1.50674217	7.40	<.0001
amonth	43	9.56041207 B	1.50861736	6.34	<.0001
amonth	44	10.22924095 B	1.53145101	6.68	<.0001
amonth	45	5.62586991 B	1.64007302	3.43	0.0006

amonth	46	4.37729384 B	1.72514171	2.54	0.0112
amonth	47	0.00000000 B	.	.	.
ltgqty*dpost		-0.03256524	0.01030826	-3.16	0.0016
dpost*dref		-1.55966453	0.09750223	-16.00	<.0001
dpost*dhwcons		-0.41860002	0.25446011	-1.65	0.1000
dpost*dhwrep		-1.99230812	0.59617720	-3.34	0.0008
dpost*dhwfs		-10.03453548	0.78893105	-12.72	<.0001
dpost*cdfs		-4.76543312	0.42631817	-11.18	<.0001
dpost*other		-1.11608656	0.84662271	-1.32	0.1874
dpost*env*nhdd		0.15777002	0.03483510	4.53	<.0001
dpost*env*ncdd		-0.79207652	3.07856246	-0.26	0.7970
dpost*nhdd*tstat		0.01462472	0.00628903	2.33	0.0201
dpost*ncdd*tstat		0.83512836	0.26853800	3.11	0.0019
dpost*nhdd*hsfs		-2.35041622	0.08773719	-26.79	<.0001
env*nhdd		1.13789624	0.03533297	32.20	<.0001
nhdd*tstat		-0.03513082	0.00635282	-5.53	<.0001
nhdd*hsfs		2.73669801	0.08121338	33.70	<.0001
env*ncdd		-0.82936327	1.61454544	-0.51	0.6075
ncdd*tstat		1.95470315	0.21783195	8.97	<.0001
nhdd		0.29320749	0.00730984	40.11	<.0001
ncdd		4.19995948	0.09775338	42.96	<.0001

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

Proc GLM Model A1 Natural Gas Household Model 12

The GLM Procedure

Number of Observations Read 26694
Number of Observations Used 26694

Dependent Variable: consperday

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1146	159372.3955	139.0684	100.08	<.0001
Error	25547	35498.6715	1.3895		
Corrected Total	26693	194871.0671			

R-Square	Coeff Var	Root MSE	consperday Mean
0.817835	40.19472	1.178789	2.932697

Source	DF	Type I SS	Mean Square	F Value	Pr > F
empid	1140	42021.23421	36.86073	26.53	<.0001
year1	1	2065.45950	2065.45950	1486.43	<.0001
year2	1	905.07981	905.07981	651.35	<.0001
year3	1	479.47134	479.47134	345.06	<.0001
dpost	1	14125.74828	14125.74828	10165.7	<.0001
dpost*nhdd	1	46114.27792	46114.27792	33186.6	<.0001
nhdd	1	53661.12448	53661.12448	38617.8	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year1	1	42.82843	42.82843	30.82	<.0001
year2	1	23.95286	23.95286	17.24	<.0001
year3	1	3.76429	3.76429	2.71	0.0998
dpost	1	26.73812	26.73812	19.24	<.0001
dpost*nhdd	1	265.08049	265.08049	190.77	<.0001
nhdd	1	53661.12448	53661.12448	38617.8	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
year1	-.2994656607	0.05394076	-5.55	<.0001
year2	-.1627481039	0.03919885	-4.15	<.0001
year3	-.0408917444	0.02484451	-1.65	0.0998
dpost	-.1586297415	0.03616224	-4.39	<.0001
dpost*nhdd	-.0139857876	0.00101259	-13.81	<.0001
nhdd	0.1486207930	0.00075629	196.51	<.0001

Proc GLM Model A1 Natural Gas Measure-Level Model 14

The GLM Procedure

Number of Observations Read 26694
Number of Observations Used 26694

Proc GLM Model A1 Natural Gas Measure-Level Model 15

Dependent Variable: consperday

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1153	160160.7415	138.9078	102.21	<.0001
Error	25540	34710.3256	1.3591		
Corrected Total	26693	194871.0671			

R-Square	Coeff Var	Root MSE	consperday Mean
0.821881	39.75134	1.165786	2.932697

Source	DF	Type I SS	Mean Square	F Value	Pr > F
empid	1140	42021.23421	36.86073	27.12	<.0001
year1	1	2065.45950	2065.45950	1519.77	<.0001
year2	1	905.07981	905.07981	665.96	<.0001
year3	1	479.47134	479.47134	352.80	<.0001
dhwcons*dpost	1	1861.79674	1861.79674	1369.92	<.0001
dpost*dhwrep	1	558.39384	558.39384	410.87	<.0001
dpost*negdhwfs	1	13.84843	13.84843	10.19	0.0014
dpost*nhdd*hsrr	1	5523.04846	5523.04846	4063.88	<.0001
dpost*nhdd*env	1	12262.61532	12262.61532	9022.88	<.0001
dpost*nhdd*tstat	1	4600.79622	4600.79622	3385.28	<.0001
nhdd*hsrr	1	20926.34794	20926.34794	15397.7	<.0001
nhdd*env	1	48169.80498	48169.80498	35443.5	<.0001
nhdd*tstat	1	6191.58351	6191.58351	4555.79	<.0001
nhdd	1	14581.26123	14581.26123	10729.0	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year1	1	29.39570	29.39570	21.63	<.0001
year2	1	11.07356	11.07356	8.15	0.0043
year3	1	4.98589	4.98589	3.67	0.0555
dhwcons*dpost	1	10.27092	10.27092	7.56	0.0060
dpost*dhwrep	1	9.71639	9.71639	7.15	0.0075
dpost*negdhwfs	1	0.21341	0.21341	0.16	0.6919
dpost*nhdd*hsrr	1	201.68766	201.68766	148.40	<.0001
dpost*nhdd*env	1	694.77192	694.77192	511.22	<.0001
dpost*nhdd*tstat	1	5.52679	5.52679	4.07	0.0437
nhdd*hsrr	1	201.63941	201.63941	148.37	<.0001
nhdd*env	1	326.36026	326.36026	240.14	<.0001
nhdd*tstat	1	70.53775	70.53775	51.90	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
nhdd	1	14581.26123	14581.26123	10729.0	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
year1	-.1882678433	0.04048118	-4.65	<.0001
year2	-.0820743340	0.02875297	-2.85	0.0043
year3	-.0443161303	0.02313713	-1.92	0.0555
dhwcons*dpost	-.0770243295	0.02801833	-2.75	0.0060
dpost*dhwrep	-.1627488592	0.06086735	-2.67	0.0075
dpost*negdhwfs	0.1117829001	0.28209263	0.40	0.6919
dpost*nhdd*hsrr	-.0168863842	0.00138617	-12.18	<.0001
dpost*nhdd*env	-.0228462971	0.00101045	-22.61	<.0001
dpost*nhdd*tstat	-.0040862323	0.00202631	-2.02	0.0437
nhdd*hsrr	0.0218231753	0.00179163	12.18	<.0001
nhdd*env	0.0241173008	0.00155632	15.50	<.0001
nhdd*tstat	-.0156824974	0.00217682	-7.20	<.0001
nhdd	0.1346373743	0.00129983	103.58	<.0001

APPENDIX G.

MODELING RESULTS FOR FINAL MODELS AND ALTERNATIVE RUNS

TablesTable G-1 and Table G-2 provide additional detail regarding the alternative models were tried, as discussed in Section 4.2 of the EmPower impact evaluation report. The final models were run using the all participants with sufficient billing history, omitting participants from the two utilities with billing data that seemed to include many unidentified estimated reads. After the final models had been selected, the models were run in a number of different ways, as specified below:

1. the two utilities with problematic billing records were added
2. a comparison group of non-participants were added to assess impacts from external factors
3. trend lines to take into account economic factors were added, also to assess impacts from external factors

The same set of alternative models was applied to the electric and natural gas billing models.

Table G-1: Alternative Runs for the Electric Model

Model	Model Description	# of Homes	R^2	Savings Estimator (kWh/Day)
Base	Household Model, Participants Only, Two Utilities Removed	4,695	0.691	-1.876
All Utilities	Household Model, Participants Only, All Utilities	6,138	0.585	-1.760
Non-Participants	Household Model, Participants and Non-Participants, Two Utilities Removed	6,422	0.659	-1.578
Trend Lines	Base Model: Household Model, Participants Only, Two Utilities Removed, Trend Lines Added	4,695	0.691	-1.885

Table G-2: Alternative Runs for the Electric Model

Model	Model Description	# of Homes	R^2	Non-Heating Savings Estimator (Therms/Day)	Heating Savings Estimator (Therms/ Heating Degree Day)
Base	Base Model: Household Model, Participants Only, Two Utilities Removed	1141	0.818	-0.159	-0.014
All Utilities	Household Model, Participants Only, All Utilities	1532	0.372	-0.249	-0.016
Non-Participants	Household Model, Participants and Non-Participants, Two Utilities Removed	1640	0.798	0.129	-0.021
Trend Lines	Base Model: Household Model, Participants Only, Two Utilities Removed, Trend Lines Added	1141	0.818	-0.096	-0.013