State of New Hampshire
Public Utilities Commission

Unitil Energy Systems, Inc.
DG 09-053
Responses to Staff Record Requests Set 1

Record Request 5: (Reserved Hearing Exhibit No. 8):

Please explain why the Total Resource Cost ("TRC") Test results for the Residential Home Performance with Energy Star is 1.1, while the TRC Test for the Low Income Program is 1.8.

Response:

The TRC analysis for the Low Income Program assumed that participating customers receive WAP assistance in addition to Company rebates. This leveraging helps to reduce the Company's $/kWh-saved, making projects more cost-effective. The Residential Home Performance with ENERGY STAR® does not include the benefit of WAP funding, resulting in higher $/kWh-saved for comparable projects.

Person Responsible: Deborah Jarvis **Date:** May 7, 2009

D.G. 09-053
RR 1-3 Attachment 1

GasNetworks®
Promoting Natural Gas Efficiency

Measuring the Impact of Programmable Thermostats

Final Report

December 2006

Prepared by

RLW ANALYTICS

179 Main Street, 3rd Floor
Middletown, CT 06457

Acknowledgments

The authors wish to thank all of the people at the participating utilities who took the time to support and help with this study. Regrettably, we cannot thank everyone individually, but we do want to acknowledge the contributions made by Jim Carey, New England Gas Company, David Weber and Lisa Shea, NSTAR Gas, Subid Wagley, KeySpan Energy Delivery, Lisa Glover, Unitil, Ken Sadlowski, Berkshire Gas, and Marjorie Izzo, Bay State Gas and Northern Utilities, Inc.. The data, insight, and support provided by these individuals helped to establish the foundation for this report. *RLW* assumes sole responsibility for any errors or omissions in this report.

Measuring the Impact of Programmable Thermostats
Final Report

Table of Contents

GasNetworks®
Promoting Natural Gas Efficiency

Measuring the Impact of Programmable Thermostats
Final Report

List of Tables

List of Figures

List of Equations

GasNetworks
Promoting Natural Gas Efficiency

Measuring the Impact of Programmable Thermostats

Executive Summary

ENERGY STAR® Programmable Thermostats Save Significant Natural Gas Energy for Consumers

Manufacturers often market programmable or set back thermostats as a tool to help consumers save energy. The energy savings are derived from the decrease in temperature a residence is required to maintain during specific hours, such as unoccupied or night hours. The current literature is mixed regarding the energy savings associated with programmable thermostats. EPA has proposed to discontinue the EnergyStar® labeling for programmable thermostats citing various field studies which showed that programmable thermostat installation achieved no significant savings over non-programmable thermostats. However, these studies were electric fuel focused and were criticized for the relatively small sample sizes employed.

To help provide meaningful input into this issue, GasNetworks authorized *RLW* to conduct a survey supported billing analysis on a large sample of participants in the GasNetworks EnergyStar® Qualified Thermostat Rebate Program. The project used a test-control experimental design to help control for extraneous variables yielding net program impacts from the analysis. The primary objective was to calculate the net annual gas energy savings for programmable thermostat program participants.

The basic equation used to estimate savings is presented as Equation 1.

$$\text{PostVariableUse/SF} = \beta_0 + \beta_1 * \text{PreVariableUse/SF} + \beta_2 * \text{EstSaving} + \beta_3 * \text{ProgTherm}$$

Equation 1: Estimation Equation

Where,

PostVariableUse/SF= Post Normalized Variable Use per Square Foot,
PreVariableUse/SF = Pre Normalized Variable Use per Square Foot,
EstSaving = Estimated Savings based on 5% of PreVariableUse/SF
ProgTherm = Programmable Thermostat Indicator Variable

Using this equation, the project team developed an estimated savings of 70ccf, or 5.4% of total household annual natural gas consumption. This estimate is normalized to a 2,000 square foot home with a pre-program normalized annual consumption (pre-NAC) of 1,287ccf. The estimate was derived using a weighted least squares model on a usage per square foot, an estimated savings of 5% of the variable household load, and an indicator variable for programmable thermostats. The relative precision associated with this estimate is calculated to be ±23.7%. This yields a 90% confidence interval from 53.2ccf to 86.2ccf or a percent savings range from a low of 4.1% to a high of 6.7% of normalized annual total household consumption.

The average number of programmable thermostats in the test group was 1.63, whereas there were 0.76 programmable thermostats in the control group. This yields a difference of 0.87 thermostats. Using this difference to calculate the savings per thermostat yields an estimate of 80ccf per thermostat or 6.2% of pre-NAC consumption. The 90% confidence interval for this estimate is 61ccf to 99ccf.

There was concern expressed by the project team that the above analysis was picking up residual savings associated with the promotion and installation of new heating systems through the various utility sponsored programs. To isolate these effects a supplemental analysis was completed that examined customers who indicated that they had participated in a utility heating program and had installed a new heating system during the participation window. This analysis yielded the results[1] presented in Table Ex 1.

Parts (Count)	Control (Count)	Age of Heating System	Square Feet (sqft)	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)	Net Change in Program Thermos	Savings Per Thermostat
415	838	Programmable Thermostats	1,932	64	945	6.8%	0.86	75
38	30	Heating Pgm w/ New System	1,999	112	1,118	10.1%	0.49	232
453	868	Total	1,937	68	960	7.1%	0.84	81

Table Ex 1 – Isolating Programmable Thermostat Savings

Customers participating in utility sponsored program and installing a new heating system saved 112ccf or 10.1% of the pre-NAC consumption. The remaining customers, i.e., those installing just programmable thermostats, were estimated to save 64ccf or 6.8% of the pre-NAC consumption. On a per thermostat basis this estimate is calculated to be 75ccf. This is the recommended estimate for use in quantifying the net annual gas savings impacts associated with programmable thermostats. The estimated relative precision is calculated to be ±28% yielding a 90% confidence interval from 54ccf to 96ccf per thermostat.

Additional insights were gained from the survey supported billing analysis including that the energy savings were greater for the following subgroups of customers:

- ? Customers with newer (<5years) and older(>49year) homes;
- ? Customers without gas fireplaces;
- ? Customers with boiler heating systems;

[1] The results in Table Ex 1 will differ slightly from the aforementioned results due to differences in sample size used in the analysis.

? Customers with heating systems rated poor or average; and
? Customers in two-story homes with basements.

A final analysis was conducted to examine customers in the control group with manual thermostats that indicated they invoked some form of manual control[2]. The results of this analysis are interesting in that the customers that indicated they manually controlled their thermostats actually increased their usage by 25ccf in the post period compared to other control group customers with manual thermostats. The combined sample size for this analysis was over 800 with 36% indicating some form of manual control. This provides compelling evidence to indicate that in spite of the customer's good intentions they are actually doing a poor job of reducing their overall natural gas consumption.

Supported by the results obtained in this project, we believe that the ***EPA should NOT suspend the Energy Star Label for Programmable Thermostats in the Northeast.*** Other equally valid reasons include:

? We are in the midst of a global energy crisis and this is not the time to confuse consumers and the overall marketplace with "suspensions" of a well known and entrenched energy-saving product.
? The newer, more user-friendly programmable thermostats are undeniably more likely to change consumer behavior than those used in the studies referenced by EPA, making these studies inapplicable by today's standards.
? Energy efficiency programs combining ENERGY STAR-labeled products with consumer education have realized significant fossil fuel savings, particularly in the Northeast.
? Maintaining the ENERGY STAR label is more important than ever for marketing energy- saving products such as programmable thermostats.
? Rising energy costs provide further incentive for consumers to yield significant energy savings through setback programming.
? Suspension of the ENERGY STAR label handicaps the utilities ability to promote and incentivize a known energy-saving devise that can help our consumers, including our most vulnerable and low-income customers, save energy and money on what are their highest fuel costs they have ever seen.
? The option of suspending the program is counter-productive given all of the recent gains realized here in New England regarding programmable thermostats (i.e., consumer education, retailer partnerships, demonstrated product improvements, and much greater consumer acceptance, etc.)
? The rationale for EPA's recommendation to suspend or "sunset" the program is based on outdated studies consisting of small sample sizes. The current study clearly shows significant savings, i.e., 75ccf, in natural gas energy.

[2] These customers indicated one or more of the following:

? We manually turn the thermostat down (winter time) or up (summer) when we are away
? We manually change the temperatures during sleeping periods in the winter
? We turn thermostat up and down throughout the day as needed to be comfortable

GasNetworks®
Promoting Natural Gas Efficiency

Measuring the Impact of Programmable Thermostats

Management Report

The EPA has Proposed to Discontinue the ENERGY STAR® Programmable Thermostat Label…

Introduction

Manufacturers often market programmable or set back thermostats as a tool to help consumers save energy. The energy savings are derived from the decrease in temperature a residence is required to maintain during specific hours, such as unoccupied or night hours. The current literature is mixed regarding the energy savings associated with programmable thermostats. To support their position the EPA shared five field studies which showed that programmable thermostat installation achieved no significant savings over non-programmable thermostats. However, these studies were electric fuel focused and were criticized for the relatively small sample sizes employed.

To help provide meaningful input into this issue, GasNetworks authorized *RLW* to conduct a survey supported billing analysis on a large sample of participants in the GasNetworks EnergyStar® Qualified Thermostat Rebate Program. The energy savings of programmable thermostats almost certainly varies by the thermal characteristics of the home; the home's heating system, the climate or region, the ease of programming the thermostat, and gas prices in the region. The project objective was to quantify the energy savings associated with programmable thermostats on gas heating consumption.

Approach and Methodology

This section outlines the general approach and methodology used in the evaluation.

Experimental Design

The analysis was conducted using a test/control observational study[3]. Under the test/control experimental design, utility tracking and billing information was used to

[3] More detail on the alternatives considered before deciding on the test/control observational study can be found in the *RLW* proposal dated and presented to the group on April 21, 2006.

construct a participant pool of customers with a high likelihood of having a programmable thermostat and a matched non-participant pool of residential consumers. The participant pool was comprised of customers receiving rebates from the GasNetworks EnergyStar® Qualified Thermostat Rebate Program, and customers receiving the installation of programmable thermostats through one of the utility based residential audit programs.

The participating utilities provided program tracking information and customer billing data based on the data request presented in Appendix A. A minimum of two years of billing consumption history was required with a preference given to the three years period from April 2003 through March 2006.

More than 7,000 participants were available for the study. Once these participants were identified and mapped to the utility billing information, a large 2:1 non-participant (i.e., control group) pool of approximately 14,000 was drawn to "match" the participant pool based on pre-participation period consumption. The pre-participation period was allowed to vary depending on when the thermostat was provided to the participating consumer. The specific methodology deployed in selecting the control group is outlined in Appendix B – Establishing a Control Group.

Sample Size Requirements

The number of "completed" surveys required for a meaningful study depends on the anticipated reduction in gas usage. Table 1 presents the anticipated relative precision given various sample size combinations. The table assumes a 1:1 experimental design. Three thousand (3,000) completed surveys are required to show a statistically significant reduction in usage if the reduction in gas usage is on the order of 6%. This means that we needed to complete about 1,500 participant and 1,500 non-participant surveys to be able to measure the difference. If the actual reduction is less then more "completed" surveys would be required and if the reduction is greater then less surveys are required.

Assumptions						
cv	1	1	1	1	1	1
z	1.645	1.645	1.645	1.645	1.645	1.645
n_test	750	1,000	1,500	2,000	2,500	3,000
n_control	750	1,000	1,500	2,000	2,500	3,000
rel prec	8.5%	7.4%	6.0%	5.2%	4.7%	4.2%

Table 1 – Sample Size Requirements

We assumed a 20% mail survey response rate requiring nearly 15,000 to be mailed. Therefore, the project team elected to include all participants falling within the participation window and a smaller number of matched non-participants. Please note additional questions were included in the survey to provide insight into program operations.

Mail Survey

An introductory letter and survey were mailed to more than 21,000 customers and included the 7,043 participants and a matched set of 14,866 non-participants. A copy of the introductory letter and survey are provided in Appendix C – Introductory Letter and Appendix D – Mail Survey. A customer incentive (i.e., a random prize drawing) was deployed to encourage customers to respond to the survey in a timely basis. A total of 4,061 completed surveys were returned by the deadline.

Billing Analysis Methodology

The billing analysis using the participant group and the control group employs a "time-series comparison/cross sectional experimental design". The time series/cross sectional design helps to reduce concerns about self-selection bias and free-ridership and helps the evaluation achieve internal and external validity. Internal validity means the evaluation is conducted in a manner that allows the results to isolate the impact of the activity being studied. When other factors are not recognized, the changes attributed to the program may be the result of other phenomena. For example, if the experiment does not recognize the dynamic nature of a participant's operational or end-use characteristics, their change in usage could be explained by changes in other participant characteristics. The mail survey helps to refine the analysis and account for the significant influence that equipment, building shell and operational characteristics has on the impact of the installation of programmable thermostats.

In addition, the research design can help achieve external validity by ensuring that the results are representative of a larger population of interest, allowing for the findings to be generalized. For example, for the programmable thermostat analysis, the information determined by a sample of participants, and the corresponding control group, permits the evaluation to represent the total program impacts.

Temperature Normalization

The temperature normalization procedure used in the analysis is the *Princeton Scorekeeping Model* (PRISM) algorithm. Through years of experience, *RLW* has taken the fundamental concept of the PRISM methodology and have refined it to produce more accurate estimates of normalized annual consumption (NAC).

The PRISM algorithm develops a mathematical model that represents the temperature to energy consumption relationship. This model is shown in Equation 2.

$$U_i = ? + ? * DD_i(?) + e_i$$

Where;

U_i = average daily consumption in interval i.
$DD_i(?)$ = average degree days in interval i, based on reference temperature ?.
? ?,? = parameters to be estimated to minimize e.
e = a random error term.

Equation 2: The PRISM Heating Only Model

The PRISM model reflects that a customer's energy usage is equal to some base level ?, and a linear function between a reference temperature ?, and the outside temperature. The constant proportionality, ?, represents a customer's effective heat-loss or heat-gain rate.

PRISM recognizes that each customer has unique space conditioning operating characteristics. To capture these unique space-conditioning characteristics, PRISM examines a range of heating and cooling reference temperatures. The model chosen to represent a customer's energy use is the model that best linearizes the relationship between usage and degree-days. For each customer, an optimal model based on a unique reference temperature (?? is identified by the minimum mean squared error (MSE) of the regression.

Once the optimal parameters have been established, normalized annual consumption is estimated using Equation 3. In the application for the GasNetworks project the NAC is calculated based on the number of days in the heating period.

$$NAC=365*?+?*DD_o(?)$$

Where:

DD_o is the number of degree days expected in a typical year.

Equation 3: Determination of Normalized Annual Consumption (NAC) [4]

When this model is applied to a residence's heating characteristics, it is referred to as the *heating only model* (HOM). When this model is applied to a residence's cooling characteristics, it is referred to as the *cooling only model* (COM).

For the analysis of gas consumption data we will use the *heating only model* (HOM). The standard PRISM approach to consider heating only loads is calculated using Equation 4.

$$U_i = ?_0 + ?_1 * HDD_i(?_1) + e_i$$

Where:

U_i	=	The gas usage during cycle i.
$HDD_i(?_1)$	=	The heating degree days based on reference temperature $?_1$, during cycle i.
$?_i$	=	The coefficients to be estimated to minimize the error term.
e_i	=	The error in predicting U.

Equation 4: The PRISM Heating Only Model

[4] For a more comprehensive technical discussion of PRISM, see Impact Evaluation of Demand-Side Management Programs, Volume 1: A Guide to Current Practice, EPRI Report CU-7178,V1, pages 5-6.

As with the standard PRISM procedure, the optimal heating model is determined by calculating the regression models assuming various reference temperature values ($?_1$). Expected annual degree-days are applied to the optimal model to calculate a normalized annual consumption (NAC). The results of the model can be interpreted as:

? $?_0$ is an estimate of the average base load for a cycle; and

? $?_1$ represents the heating slope, or the increase in electric usage for each incremental increase in heating degree days.

The standard PRISM approach uses usage and degree-day[5] data on a billing cycle basis. However, the data has an inherent variability associated with the varying lengths of billing cycles. For the estimation of the heating slopes ($?_1$) the effects of the varying lengths of the billing cycle are mitigated. This is a result of the number of degree-days being directly correlated to the number of days in the cycle. However, the estimates of base load ($?_0$) reflects the average base load per cycle and does not account for the days in the cycle. In effect, this estimate infers the base load will be $?_0$, regardless of the length of the cycle. Since base load usage is a function of time, this result may introduce a slight bias into the calculation. To eliminate this bias, the augmented PRISM approach uses usage per day as the dependent variable, and expresses the degree days on a per day basis.

The PRISM methodology assumes that there is a linear relationship between usage and temperature. However, if the assumption is not valid, it could lead to a violation of a basic regression assumption (i.e., the error terms are uncorrelated). To avoid any bias, an additional term is considered in developing individual customer gas load models. The term is heating degree-days squared. The incorporation of this variable is presented in Equation 5.

$$U_i = ?_0 + ?_1 * HDD_i(?_1) + ?_2 * (HDD_i(?_1))^2 + e_i$$

Equation 5: Gas PRISM Model, with Second Order Terms Incorporated

Since it is not known if the additional variable is significant, models featuring various variables are considered for each customer. Accordingly, the incorporation of these additional variables result in many additional models to consider. For example, for the gas consumption data, the permutations of four independent variables result in 15 different models to consider for each heating reference temperatures.

Alternative models, with different numbers of independent variables, introduce a challenge to choosing an optimal model. The standard PRISM approach relies on the maximization of R^2 to indicate the optimal model. However, in building mathematical regression models, the R^2 statistic has a tendency to increase as the number of independent variables increases. Therefore, when comparing models with different numbers of regressors, the maximum R^2

[5] We have elected to use Boston's Logan Airport as the Class A weather station for use in the analysis.

criteria may not lead to choosing the optimal model between alternative models. To avoid this possibility, an alternative method to determine the optimal model was used. The minimization of the mean squared error of the residuals (MS_E) is a good alternative. The MS_E accounts for the decrease in the degrees of freedom when an additional regressor is added to the equation. Therefore, the model that minimized the MS_E will be used to determine the optimal model to represent the temperature versus usage relationship.

Lastly, in an effort top obtain the most accurate models possible, a system of re-analyzing poor performing models is employed. A "poor performing model" is defined as one that produced a negative heating load.

The determination of the optimal model uses a four-step approach. These steps are:

1) The optimal models are determined using all available data.
2) If the optimal model produced in Step 1 has a negative heating load, the model is re-estimated omitting the heating slope variables.
3) From the first two steps, the customers with poor models are identified. For these customers, their predicted monthly usage is compared to the actual monthly usage. The monthly usage that was associated with the prediction with the greatest error will be omitted, and the model re-estimated.
4) Step 2 is repeated for the models estimated in Step 3.

The optimal models generated by this algorithm are then used to estimate the Normalized Annual Consumption (NAC), for each period.

Estimating the Energy Impacts

The energy impacts are determined through a multivariate regression (MVR) analysis. The MVR uses the temperature normalized annual consumption (NAC) for the participants and representative control group, tracking system data, and survey data. The proposed regression protocol is a comprehensive and systematic approach that has been applied with great success to the analysis of market based programs. The regression protocol consists of six steps that result in the selection of an optimal model that accurately quantifies the program impact. This sub-section describes the six steps of the regression protocol.

Step 1: The Simple Model

During this step an initial regression model is developed using ordinary least squares ("OLS"). This simple model determined the effect of one important variable (i.e., the participation indicator variable status, or the participant's engineering estimate of savings) on energy or demand savings while controlling for all other variables. The basic forms of this model are shown in Equation 6.

$NAC_{post,i}$ = ? $_0$ + ? $_1$ $NAC_{Pre,i}$ + ? $_2$ P_i + ? $_i$

Where:
$NAC_{post,i}$ = Post Installation Normalized Annualized Consumption for customer i
$NAC_{pre,i}$ = Pre Installation Normalized Annualized Consumption for customer i
P_i = Participation Indicator Variable or Engineering Estimate of Savings
? $_i$ = Prediction error

Equation 6: Existing Homes Simple Regression Model

Step 2: Regression Diagnostics

As a result of the residual standard deviation being related to the size of the customer's gas usage or demand, one regression assumption most often violated is that the standard deviation of the error terms, (or "residuals") is not constant across the range of predicted values. When the standard deviation residuals are related to the predicted values, the model is said to be "heteroscedastic." Heteroscedasticity can often be detected in cross-sectional models used to analyze DSM program impact. During this step, verification that the regression assumptions are valid is performed. If the initial regression model is found to be "heteroscedastic," further multivariate regression analyses are performed under a weighted least squares ("WLS") approach.

Step 3: Weighted Least Squares

As discussed above, one of the fundamental regression assumptions is that the standard deviation of the error terms (or residuals) has a constant variance across the range of predicted values. When the residuals are related to the predicted values, the model is said to be heteroscedastic. Heteroscedasticity is a violation of one of the basic regression assumptions and could result in the mis-specification of mathematical relationships. As a result of the residual standard deviation being related to the size of the customer's gas usage, heteroscedasticity is often detected in cross sectional models used to analyze DSM program impact.

When heteroscedasticity is present, an ordinary least squares (OLS) approach to establishing the relationship between the dependent and independent variables may be inappropriate. An OLS approach that does not correct for the heteroscedastic relationship of its residuals will yield confidence intervals that are misleading. More specifically, when heteroscedasticity is present, the OLS regression coefficients are unbiased estimates of the true parameters, but they are subject to greater statistical variation than the appropriate estimates. Moreover, the standard errors produced by the OLS regression analysis are biased estimates of the true standard deviations of the regression coefficients.

Weighted least squares (WLS) is one approach to correct for heteroscedasticity in regression analysis. According to econometric theory, the advantages of WLS are:

a) Under a properly specified heteroscedastic model, WLS yields the best linear unbiased estimates of the true parameters and,

b) WLS gives an unbiased estimate of the variance of the estimators, providing appropriate confidence intervals and p-values.

In other words, WLS provides the most reliable estimate of savings and an accurate measure of the resulting reliability. The theory of WLS depends on a correct specification of the heteroscedasticity. The theory assumes that a positive-valued variable can be specified; say *z*, such that the residual standard deviation is proportional to *z*. Usually, *z* is taken to be some measure of size (for example, the pre-retrofit NAC consumption).

The benefits of WLS depend on the correct choice of *z*. Therefore, it is useful to have a way of comparing alternative candidates for *z*. If it can be confirmed that heteroscedasticity is present, the following procedure[6] is employed:

1. Postulate a family of possible candidates for *z*. In the following analysis, the regression has been estimated assuming that the residual standard deviation is proportional to pre-retrofit NAC dampened by raising this variable to some power between 0 and 1. This variable will be termed $(NAC_{Pre})^{?}$, where ? ? 0. Here the exponent, gamma, is an unknown parameter that creates a family of candidate choices of *z*.
2. For each candidate of *z*, geometrically standardize *z* by dividing each value of *z* by the geometric mean of the *n* sample values of *z*. The geometric mean is the n^{th} root of the product of the *n* values of *z*.
3. Fit the regression model using WLS with each geometrically standardized *z*, and calculate the root mean square error (RMSE) of each regression.
4. Minimize the RMSE to find the best choice of *z* and use this particular WLS regression to obtain the best estimate of savings.

During this step a residual analysis is performed. If heteroscedasticity is suspected, the models are estimated using WLS.

Step 4: The Unabridged Model

During this step an initial regression analysis (using OLS, or if more appropriate, a WLS approach) is performed. A multivariate regression full analysis model, the *unabridged model*, is developed. This model consists of any variable that may be significant in the determination of the program impacts. For example, during the analysis the model may consist of first degree, second degree and interaction terms using a Participation Indicator dummy variable, pre-retrofit consumption, weather, and any other significant variables that are readily available for the participants and control groups. During the multivariate

[6] The justification for this approach is from the statistical theory of maximum likelihood estimation. Although the WLS is different, the mathematical derivation of the methodology is the same as used by Box and Cox in their paper *An Analysis of Transformations*, (Journal of the Royal Statistical Society, Series B, 1964). A good summary of the approach is given in the text *Econometrics,* by G.S. Maddala, McGraw-Hill, 1977, pp. 315-317. A similar methodology is given in *Elements of Econometrics*, by J. Kmenta, to deal with autoregression in time series analysis.

approach, the inclusion of variables collected through the survey process will be incorporated.

After the development of the unabridged model, a residual analysis is performed. This analysis is used to diagnose, analyze, and correct if necessary, any outliers. After the outlier analysis is performed, the next step is to re-analyze the *unabridged model* using the reduced data. Under WLS, this step is used to determine the best *gamma* for use in creating the optimal weights.

Step 5: The Refined Model

The fifth step develops the *refined model*, based on the *unabridged model*, and if using WLS, the optimal value of *gamma*. A step wise regression approach is used to eliminate any insignificant variables of the *unabridged model*. After this step, the *refined model* will feature only those variables that have mathematical significance in the determination of the energy or demand savings.

Step 6: Calculation of Energy Savings

The final step in the analysis estimates the energy savings by using the resultant models. In this step the savings are calculated using both the *unabridged* and the *refined models* to examine the impact on savings of removing the statistically insignificant terms.

Savings Estimation and Results

The final analysis develops expected savings. A sample model is shown below.

$$NAC_{Post} = ?_0 + ?_1 * NAC_{Pre} + ?_2 * Savings_{LM1} + ?_3 * S_1 + ?_4 * S_2 + \ldots + ?$$

Where:

NAC_{Post}	= Pre-installation NAC
NAC_{Pre}	= Post-installation NAC
$Savings_T$	= Engineering estimate of Savings for Thermostat
S_{ii}	= Survey variable i

Equation 7: Simple Regression Model, With Individual Measure Engineering Estimates

This approach accurately determines the savings associated with programmable thermostats, as well as identify significant demographic and operational characteristics.

Billing Analysis Results

This section presents the results of the analysis in a very systematic way. We begin by examining the full complement of data available for analysis and proceed to the reduced survey supported data set.

Preliminary Analysis

The first step is to examine the full complement of data with available normalized annual consumption (NAC). Over 2,650 participants had sufficient pre-NAC and post-NAC for inclusion in the preliminary analysis. A 5:1 matched control group pool was drawn from the more than 14,000 available control group customers. Table 2 presents the preliminary findings based on the total household gas consumption. The results in the table examine the savings associated with the 2,658 participants and the 5:1 matched group of 10,688 non-participants. As evidenced by the table, the pre-NAC was a very good match (1,167 ccf versus 1,160 ccf). Gross savings are estimated to be 126 ccf. Accounting for the reduction in the control group yields a net savings of 37 ccf or approximately 3.2% of Pre-NAC.

Based On **Total House**

Group	Count (n)	Pre-NAC (ccf)	Post-NAC (ccf)	Gross Savings (ccf)	Gross Percent (%)	Net Savings (ccf)	Net Percent (%)
Control	10,688	1,167	1,077				
Parts	2,658	1,160	1,034	126	10.90%	37	3.2%

Table 2 – Preliminary Results: Total House

In Table 3 we examine just the variable load which is thought to be the load most impacted by the programmable thermostat. Here again, the results are pretty stable with a net savings of 36 ccf or approximately 4.1% of Pre-NAC.

Based On **Variable Load**

Group	Count (n)	Pre-NAC (ccf)	Post-NAC (ccf)	Gross Savings (ccf)	Gross Percent (%)	Net Savings (ccf)	Net Percent (%)
Control	10688	883	818				
Parts	2658	884	782	102	11.50%	36	4.1%

Table 3 – Preliminary Results: Variable Load

If we examine the distribution of Pre-NAC to Post-NAC we can identify some outliers. If we eliminate the top and bottom 1% of the pre/post NAC ratios then we can recalculate the results to examine the impact. The revised results are presented in Table 4. These results show a slight increase in the percentage of savings. For example, the savings based on total household consumption increases to 43ccf or 3.7%. Similarly, the savings based on just the variable load increases to 45ccf or approximately 5% of Pre-NAC.

Based On **Total House**

Group	Count (n)	Pre-NAC (ccf)	Post-NAC (ccf)	Gross Savings (ccf)	Gross Percent (%)	Net Savings (ccf)	Net Percent (%)
Control	10473	1175	1085				
Parts	2604	1168	1036	132	11.30%	43	3.7%

Based On **variable Load**

Group	Count (n)	Pre-NAC (ccf)	Post-NAC (ccf)	Gross Savings (ccf)	Gross Percent (%)	Net Savings (ccf)	Net Percent (%)
Control	10473	890	826				
Parts	2604	896	787	109	12.20%	45	3.8%

Table 4 – Preliminary Results: Edited Outliers

A number of additional regression analyses were conducted that examined total household and variable load using a simple indicator variable and an engineering estimate of savings based on the consumers pre-NAC consumption. Here, we examined these models using both ordinary least squares and weighted least squares regressions. Table 5 presents a summary of this analysis. The **basis** indicates whether the total household consumption (Total) or the variable household consumption (Variable) was used. The **savings variable** indicates whether a simple indicator variable (Indicator) or an engineering estimate of savings (Save Estimate) was used. The **regression type** identifies either the ordinary least squares (OLS) runs or the weighted least squares (WLS) analysis. In this analysis the savings range from a low of 1.8% to a high of 5.1%. The preferred model is the variable load model that uses the engineering estimate of savings and the WLS approach. We prefer this model not because it returns the highest savings estimate but because it has the following characteristics:

? The variable load focuses the analysis on the load that is effected by the programmable thermostat;

? The savings estimates allows for the size of the load to be implicitly recognized in the analysis; and

? The WLS addresses heterscedasticity not addressed by the OLS.

Basis	Savings Variable	Regression Type	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)
Total	Indictor	OLS	61	1,273	4.8%
Total	Save Estimate	OLS	71	1,273	5.5%
Variable Load	Indictor	OLS	64	1,273	5.0%
Variable Load	Save Estimate	OLS	77	1,273	6.1%
Total	Indictor	WLS	22	1,287	1.7%
Total	Save Estimate	WLS	57	1,287	4.4%
Variable Load	Indictor	WLS	23	1,287	1.8%
Variable Load	Save Estimate	WLS	66	1,287	5.1%

Table 5 – Summary of Alternative Models

Survey Supported Results

The next step in the analysis is to incorporate the survey responses. A total of 4,061 completed surveys were returned and available for the analysis. This included 2,214 participants and 1,847 non-participants. Not all of the completed surveys could be used in the analysis do to missing information, e.g., square footage data. However, 683 participants had complete and usable survey and billing information. These 683 participants were matched on an approximate 2:1 basis to the non-participant pool. Therefore, the survey supported billing analysis used a total of 683 participants and 1,264 non-participants.

The primary variable gleaned from the survey was the square footage of each residence. This information has been shown to be a significant variable helping to describe the energy use of consumers. Table 6 presents the survey square footage enhanced analysis for the total household load and the variable load. The data and results are presented on a per square foot basis. The total household load shows a slightly lower savings (4.7%) compared to the analysis using just the variable load (5.0%). These results are very consistent with the full complement analysis completed earlier.

Based On **Total House**

Group	n	Pre NAC (ccf/sqft)	Post NAC (ccf/sqft)	Gross Savings (ccf/sqft)	Gross Percent (%)	Net Savings (ccf/sqft)	Net Percent (%)
Control	1238	0.643	0.595				
Parts	669	0.637	0.559	0.078	12.20%	0.03	4.71%

Based On **Variable Load**

Group	n	Pre NAC (ccf/sqft)	Post NAC (ccf/sqft)	Gross Savings (ccf/sqft)	Gross Percent (%)	Net Savings (ccf/sqft)	Net Percent (%)
Control	1238	0.643	0.595				
Parts	669	0.637	0.559	0.068	13.90%	0.032	5.02%

Table 6 – Survey Enhanced Analysis

Once again, additional analysis was conducted under OLS and WLS using the savings estimate. The results are presented in Table 7. The savings estimates range from a low of 5.3% to a high of 6.8%.

Basis	Savings Variable	Regression Type	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)
Total	Save Estimate	OLS	87	1,273	6.8%
Variable Load	Save Estimate	OLS	86	1,273	6.7%
Total	Save Estimate	WLS	68	1,287	5.3%
Variable Load	Save Estimate	WLS	70	1,287	5.4%

Table 7 – Additional Analysis

The basic estimation equation is as follows:

$$PostVariableUse/SF = \beta_0 + \beta_1 * PreVariableUse/SF + \beta_2 * EstSaving + \beta_3 * ProgTherm$$

Equation 8: Estimation Equation

Where,

PostVariableUse/SF= Post Normalized Variable Use per Square Foot,
PreVariableUse/SF = Pre Normalized Variable Use per Square Foot,
EstSaving =Estimated Savings based on 5% of PreVariableUse/SF
ProgTherm =Programmable Thermostat Indicator Variable

The best estimate of overall net savings is 70ccf, or 5.4% of Pre-NAC of the total household load. This estimate is normalized to a 2,000 square foot home with a pre-program consumption of 1,287ccf. The estimate was derived using the WLS model on a usage per square foot, and an estimated savings of 5% of the variable load, with an indicator for programmable thermostats. The relative precision associated with the estimate is calculated to be ±23.7% yielding a 90% confidence interval from 53.2ccf to 86.2ccf. This yields a percent savings ranging from a low of 4.1% to a high of 6.7% of Pre-NAC total consumption. The average number of programmable thermostats in the test group was 1.63 and 0.76 in the control group. This yields a difference of 0.87 thermostats. Using this difference to calculate the savings per thermostat yields an estimate of 80ccf per thermostat installed or 6.2% of pre-NAC consumption. The 90% confidence interval for this estimate is 61ccf to 99ccf.

Supplemental Variables

In addition to the square footage variable, a series of supplemental variables were tested to see if they provided any added explanatory power to the analysis. Table 8 presents a listing of these variables. Only the gas fireplace variable with a 21% saturation rate showed significance at the 90% level, however, the supplemental heat variable was very close.

Variable	Significant?	Pr > |t|
Heated Basement	No	0.5347
Utility Program	No	0.6756
Gas heat	No	0.8131
Supplemental Heat	No	0.1013
Thermostat Use	No	0.7038
Ceiling Fans	No	0.5015
Generators	No	0.3068
Fireplace	**Yes**	**0.0345**
Efficient Home	No	0.4049
People	No	0.8407
Adults	No	0.8314
Children	No	0.8806
Pets	No	0.8813

Table 8 – Supplemental Variables for Use in the Analysis

Table 9 shows the results of incorporating the fireplace variable into the model. This model indicates that customers without gas fireplaces (79% of the population) save approximately 5.9% of the Pre-NAC consumption versus 4.4% for those with gas fireplaces. Interestingly, the savings estimates are slightly lower than the best estimate of 5.9% due to a slightly higher normalized annual consumption.

N	Variable	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)
109	Fireplace	63	1,392	4.55%
542	No Fireplace	72	1,275	5.63%
651		70	1,295	5.43%

Table 9 – Incorporating Fireplace Variable into the Model

Additional Sub Group Analysis

Supplemental analysis was conducted to look at various subgroups including:

? Type of Home;
? Age of Home;
? Heating System Type; and
? Heating System Condition.

Once again, these estimates will vary slightly due to a change in the number of sample points used in the regression analysis.

By Type of Home. Table 10 presents the savings estimates for various types of homes. The savings estimate range from a low of 2.4% for two-story crawl (please note the sample is only 20 customers) to 8.7% for single story crawl (here again, the sample size is small at only 17 customers).

Parts (Count)	Control (Count)	Home Type	Square Feet (sqft)	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)
17	23	Single Story, Crawl	1,445	79	907	8.7%
145	288	Single Story, Basement	1,570	49	910	5.4%
20	45	Two Story, Crawl	2,016	26	1,110	2.4%
348	607	Two Story Basement	2,152	71	1,008	7.0%
52	119	Other	2,027	63	969	6.5%
40	98	Apt or Condo	1,369	40	678	6.0%
622	1,180		1,932	62	961	6.5%

Table 10 – By Type of Home

By Age of Home. Table 11 presents the estimated savings by age of home. Surprisingly new homes saved an average of 11.7% of the Pre-NAC and the oldest homes saved an average of 8.8% of the Pre-NAC consumption. Houses with an age between 5 and 49 years displayed a reduction in the 3.2% to 3.8% range.

Parts (Count)	Control (Count)	House Age	Square Feet (sqft)	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)
68	133	Less than 5 years	1,990	113	961	11.7%
115	244	5 to 24 Years	2,124	29	778	3.8%
201	321	25 to 49 Years	1,806	30	939	3.2%
238	482	Over 50 years	1,929	96	1,085	8.8%
622	1,180		1,932	64	968	6.6%

Table 11 – By Age of Home

Heating System Type. Table 12 presents the results by primary heating system types. The greatest savings were for boiler systems with a 9.1% Pre-NAC savings calculated compared to a 4.2% for forced air furnaces.

Parts (Count)	Control (Count)	Heating System	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)
275	539	Force Air Furnace	38	888	4.24%
328	607	Boiler	101	1,101	9.14%

Table 12 – By Heating System Type

Heating System Condition. Table 13 presents the savings estimated based on responses to the question regarding heating system condition. While the sample size is small, those customers indicating a "poor" heating system condition had the largest percent savings at nearly 8.7%. For those with "average" system conditions the savings were 7.6% and 8.5% for those classified as "good".

Parts (Count)	Control (Count)	Heating System Condition	Square Feet (sqft)	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)
10	45	Poor	1,828	84	967	8.7%
153	334	Average	1,800	76	990	7.6%
445	770	Good	1,984	63	965	6.5%
608	1,149	Total	1,935	66	971	6.8%

Table 13 – By Heating System Condition

Isolating the Impacts of the Thermostats

There was concerned expressed by the sponsors that the impacts of the programmable thermostat not be conditioned by the replacement of a heating system. To isolate the impacts we conducted the following supplemental analyses:

? Heating System Age;
? Participation in Utility Heating Program;
? Participation in Utility Heating Program with a New Heating System.

Heating System Age. As conjectured, the age of the heating system has a material impact on program savings. Table 14 presents the savings based on heating systems that were installed during the test period (i.e., less than or equal to 2 years) and older systems. There are significantly more savings for the newer systems with an estimate of 104ccf or 10.7% for the new systems compared to 61ccf for the older systems. In this table we have included the net change in program thermostats in order to calculate the **net savings** per added thermostat. The savings per thermostats are calculated to be 180ccf for the new systems and 67ccf for the older systems.

Parts (Count)	Control (Count)	Age of Heating System	Square Feet (sqft)	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)	Net Change in Program Thermos	Savings Per Thermostat
106	117	<=2 Years	1,971	104	973	10.7%	0.58	180
345	751	>2 Years	1,927	61	955	6.3%	0.90	67
451	868	Total	1,937	71	959	7.4%	0.85	83

Table 14 – By Heating System Age

Participation in Utility Sponsored Heating Program. Similarly, we examined the impact of customers participating in a utility sponsored heating program. Table 15 summarizes these findings. Customers participating in a utility sponsored program saved 111ccf or 10.4% of their pre-NAC consumption. On a per thermostat basis the savings were calculated to be 183ccf. For those customers not participating in a utility sponsored program the savings were calculated to be 57ccf or 5.9% of the pre-NAC consumption. Here again, on a per thermostat basis the estimate was calculated to be 63ccf per thermostat.

Parts (Count)	Control (Count)	Program	Square Feet (sqft)	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)	Net Change in Program Thermos	Savings Per Thermostat
67	48	Program	1,968	111	1,073	10.4%	0.61	183
447	987	No Program	1,931	57	962	5.9%	0.91	63
514	1,035	Total	1,936	64	976	6.6%	0.89	72

Table 15 – Participation in Utility Sponsored Heating Program

Participation in a Utility Heating Program with a New Heating System. Finally, to isolate just the impacts of the programmable thermostat program from the new heating system replacements, we examined customers that indicated they had participated in a utility sponsored heating program that had a new heating system installed during our participation window, i.e., less than or equal to 2 years. Table 16 presents theses results. Customers that participated in a heating system program and installed a new heating system in the past two years saved on average 112ccf or 10.1% of their pre-NAC consumption. This translates to a per thermostat savings of 232ccf. For all other customers, the savings were estimated to be 64ccf or 6.8% of the pre-NAC consumption for a per thermostat savings of 75ccf. We believe the 75ccf is the best estimate to use for the addition of a programmable thermostat installed through the program.

Parts (Count)	Control (Count)	Age of Heating System	Square Feet (sqft)	Savings Estimate (ccf)	Pre-NAC (ccf)	Pct Savings (%)	Net Change in Program Thermos	Savings Per Thermostat
415	838	Programmable Thermostats	1,932	64	945	6.8%	0.86	75
38	30	Heating Pgm w/ New System	1,999	112	1,118	10.1%	0.49	232
453	868	Total	1,937	68	960	7.1%	0.84	81

Table 16 – Participation in a Utility Sponsored Heating Program

Non-participants Who Controlled their Manual Thermostats. A final analysis was conducted to examine customers in the control group with manual thermostats that indicated they invoked some form of manual control[7]. The results of this analysis are interesting in that the customers that indicated they manually controlled their thermostats actually increased their usage by 25ccf in the post period compared to other control group

[7] These customers indicated one or more of the following:

? We manually turn the thermostat down (winter time) or up (summer) when we are away

? We manually change the temperatures during sleeping periods in the winter

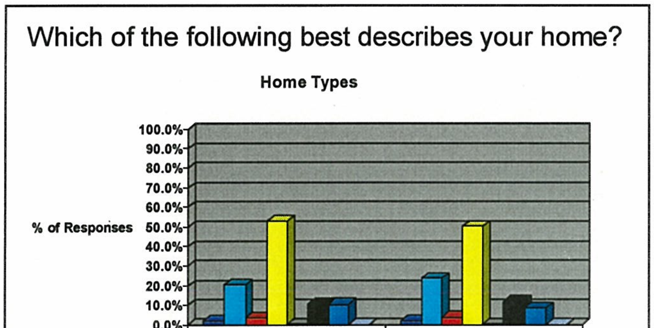
? We turn thermostat up and down throughout the day as needed to be comfortable customers with manual thermostats. The combined sample size for this analysis was over 800 with 36% indicating some form of manual control. This provides compelling evidence to indicate that in spite of the customer's good intentions they are actually doing a poor job of reducing their overall natural gas consumption.

Survey Results

This section presents additional findings from the mail survey for the participants and non-participants.

Home Characteristics

Customers were asked how to best describe their home. Figure 1 below shows the customer reported descriptions of their homes. A two story home with basement represented the majority of the responses for both the participants and the control groups.



	Participants	Control
1-Story w/Crawl	2.0%	1.7%
1-Story w/Bsmt	20.4%	23.8%
2-Story w/Crawl	3.5%	3.7%
2-Story w/Bsmt	53.1%	50.1%
Mobile Home	0.1%	0.4%
Apt or Condo	10.6%	11.9%
Other	10.3%	8.4%
No Answer	0.0%	0.0%

Figure 1 – Home Description

Figure 2 shows the results of the question "Do you own your home or rent it? The majority of participants (96%) and the control group (91%) own their homes.

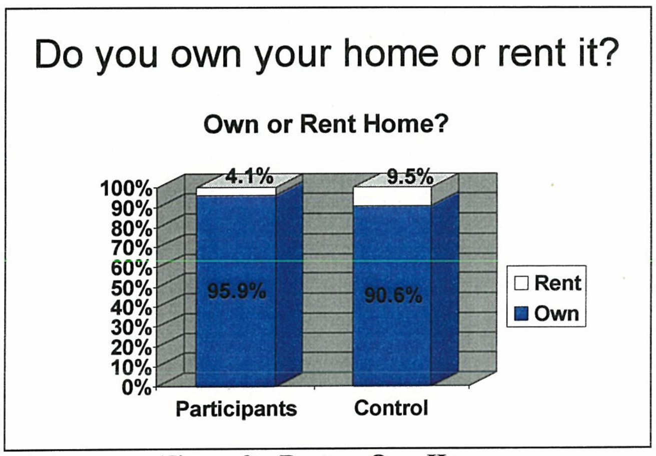


Figure 2 – Rent or Own Home

Table 17 below shows additional demographic data about the customer's homes. Both the participant and the control groups reported home ages with a mean of over 50 years. The reported length of time in their home for the participants was 14.5 years and 19.4 years for the control group. Next, the customers were asked how many square feet of living space their home had. Both the participants and the control group reported their homes to have 1,975 ft^2 and 1,958 ft^2 respectively.

	Mean Response		Median Response	
Question	Participants	Control Group	Participants	Control Group
How old is your home?	55 years	53 years	46 years	45 years
How long have you lived in your home?	14.5 years	19.4 years	9 years	15 years
How many ft^2 of living space does your home have?(exclude heated basement and garages)	1,975 ft^2	1,958 ft^2	1,800 ft^2	1,792 ft^2

Table 17 – Home Demographics

Renovations and Utility Program Participation

Figure 3 provides the answer to the question of what percentage of customers completed an addition or major renovation in the past two years. Approximately 27% of participants and 20% of the control group reported an addition or major renovation project.

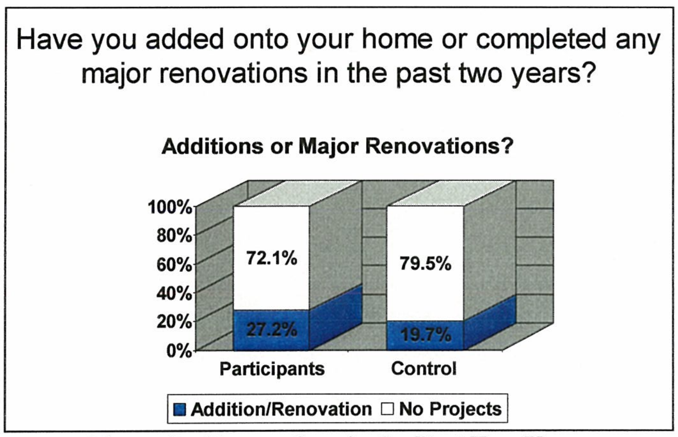
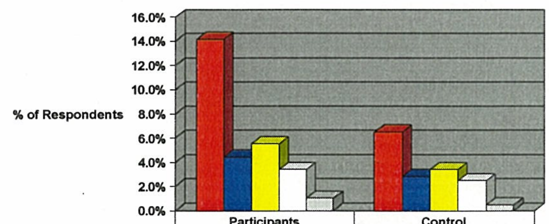


Figure 3 – Renovations in the Past Two Years

Next, customers were asked: "Have you participated in a Utility Sponsored energy efficiency program in the past two years?" The participant group reported 30% of customers having participated in a utility program. The control group reported 15% participating in a utility program.

Figure 4 shows the participant and control group reported types of programs they participated in. The majority of participation for both the participant (14%) and the control (6.5%) groups was for heating systems.



	Participants	Control
Heating System	14.1%	6.5%
HWH System	4.4%	2.8%
Added Insulation	5.5%	3.4%
Windows	3.4%	2.5%
Audit/Blower Door	1.0%	0.5%

Figure 4 – Participation in Utility Programs

Heating Systems

Table 18 reports the customer heating system information. Both participants and the control group report boiler systems as their primary heating source. The participant group reported the average age of heating systems at 11.9 years, and the control group had an average age of 14.9 years. Most of the customers reported that they felt their heating system was in "good" condition.

Question	Participants	Control Group
Types of Heating System:		
Forced Air Furnace	40.9%	47.4%
Boiler (Steam or Hot Water)	55.2%	48.0%
Other	2.9%	3.7%
Mean Age of Heating System	11.9 Years	14.9 Years
Customer Reported Condition of Heating System		
Poor	2.2%	3.6%
Average	26.3%	30.0%
Good	69.7%	63.7%

Table 18 – HVAC System Characteristics

Air-Conditioning Systems

In Figure 5 the customers were asked "What type of air-conditioning does your home have?" The majority of customers reported having window a/c units (50% for parts and 49% of the control group), additionally, 35% of parts and 34% of the control group had central a/c units. Only 14% of parts and 16% of the control group reported no air-conditioning at the moment.

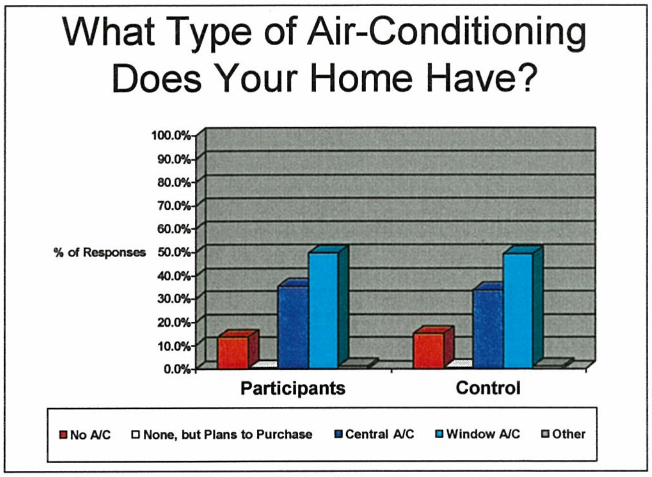


Figure 5 – Type of Air-Conditioning in Home

Customers that reported having air-conditioning were then asked the following question: "How do you use your air-conditioner during a typical summer?"

As Figure 6 below shows, the majority of customers reported using their a/c only on very hot days (40% of participants and 38% of the control group).

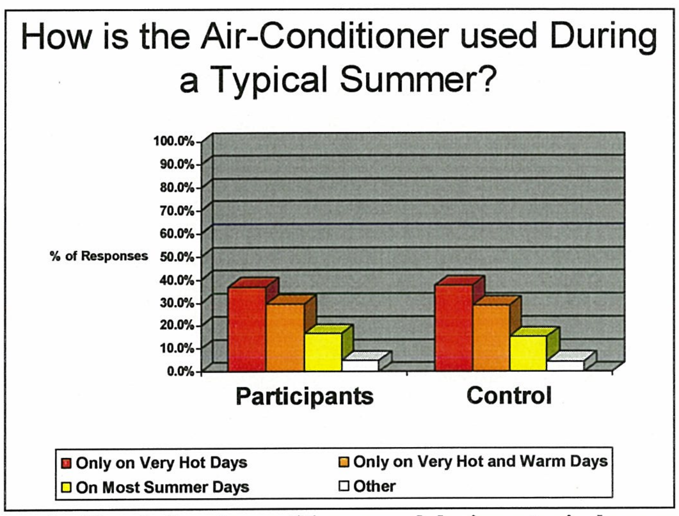
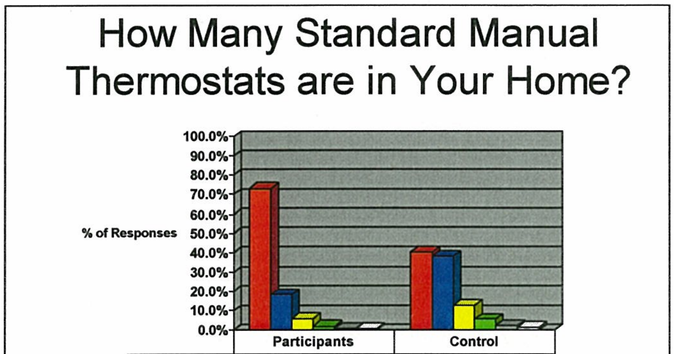


Figure 6 – How is the air-conditioner used during a typical summer?

Thermostats

This section covers the questions regarding types of thermostats and their use in the customer's homes. Figure 7 shows the customer reported numbers of manual thermostats in homes. Not surprisingly, 73% of the participants reported not having any manual thermostats in their home, whereas, only 40% of the control group reported no manual thermostats in their home.

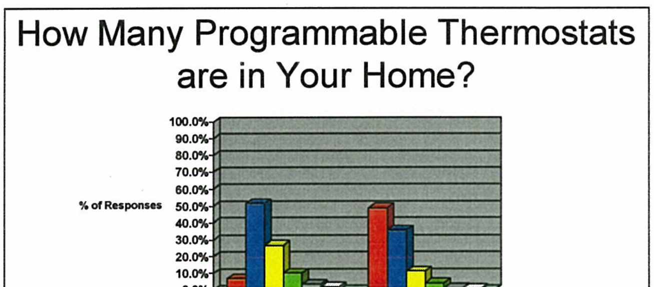


	Participants	Control
Zero	73.2%	40.2%
One	18.0%	37.9%
Two	5.7%	12.8%
Three	1.9%	5.5%
Four	0.7%	2.2%
Five or More	0.5%	1.4%

*Participant Mean Number of Manual Thermostats In Home = 0.40
*Control Group Mean Number of Manual Thermostats In Home = 0.96

Figure 7 – Number of Standard Manual Thermostats in Home

Figure 8 reflects the customer responses regarding the number of programmable thermostats in the home. As one might expect over 93% of the participants reported having one or more programmable thermostats in the home, conversely, only about 50% of the control group reported having a programmable thermostat in the home.



	Participants	Control
Zero	6.7%	48.8%
One	51.5%	35.3%
Two	26.8%	10.8%
Three	10.1%	3.9%
Four	3.4%	0.8%
Five or More	1.5%	0.4%

*Participant Mean Number of Programmable Thermostats In Home = 1.56
*Control Group Mean Number of Programmable Thermostats In Home = 0.74

Figure 8 – Number of Programmable Thermostats in Home

Customers were next asked to report how they used their thermostat. Figure 9 shows the results of that question. Here we see that nearly 60% of the participants report using a unique schedule that they have programmed into their thermostat. Only 28% of the control group responded that they used a unique program schedule.

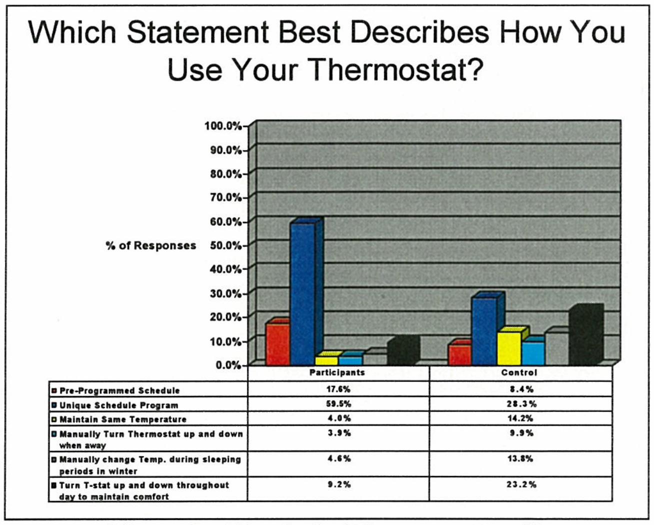


Figure 9 – How is the Thermostat used?

Table 19 presents the mean and median temperature settings reported by the participants and control group customers. The participants seemed more energy efficient in their thermostat settings with higher temperatures in the summer and lo wer temperature in the winter.

	Temperature Settings			
	Participants		Control Group	
Daytype	Mean	Median	Mean	Median
Summer Weekdays	70.4	74.0	68.1	72.0
Summer Weekends	70.1	73.0	67.8	72.0
Summer Night Time	69.7	73.0	67.2	70.0
Winter Weekdays	66.4	68.0	67.5	68.0
Winter Weekends	68.0	68.0	68.5	68.0
Winter Night Time	63.8	64.0	64.9	65.0

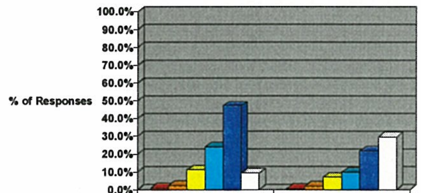
Table 19 – Temperature Settings

Customer Ratings of Programmable Thermostats

This section reports the customer responses in regards to the installation and use of their programmable thermostats. The customers were asked to rate on a scale of 1–Impossible to 5-Easy the following characteristics.

Figure 10 shows the results for "Ease of Installation". The majority of the respondents (47% of participants and 22% of the control group) reported that their programmable thermostat was "Easy" to install. Approximately 1% of the respondents thought the programmable thermostat was impossible to install.

Rating of Programmable Thermostat Characteristics
"Ease of Installation"
(1 to 5 scale with 1 being "impossible" and 5 meaning "easy")



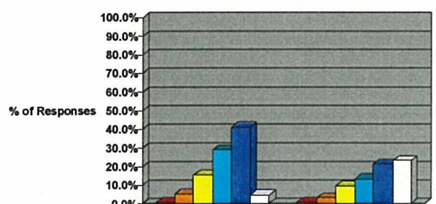
	Participants	Control
1	1.1%	0.6%
2	2.6%	2.1%
3	11.3%	7.1%
4	23.9%	9.9%
5	47.0%	21.8%
N/A	9.4%	29.7%

*Participant Group Mean for Ease of Installation = 4.3
*Control Group Mean for Ease of Installation = 3.5

Figure 10 – Programmable Thermostat "Ease of Installation"

Customers were also asked about the "Ease of Use" of the programmable thermostat. As Figure 11 below shows 41% of participants and 21% of the control group found their programmable thermost at easy to use. Less than 1% found it to be impossible to use.

Rating of Programmable Thermostat Characteristics
"Ease of Use"
(1 to 5 scale with 1 being "impossible" and 5 meaning "easy")

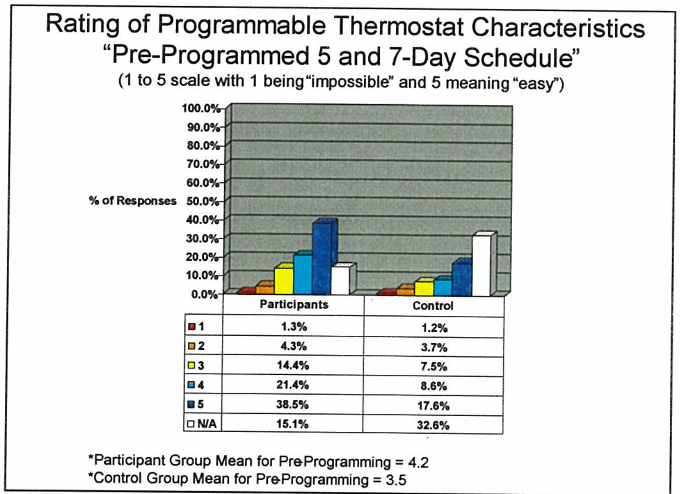


	Participants	Control
1	0.8%	0.8%
2	5.2%	3.3%
3	15.5%	9.5%
4	28.8%	13.4%
5	40.9%	21.3%
N/A	4.8%	23.1%

*Participant Group Mean for Ease of Use = 4.1
*Control Group Mean for Ease of Use = 3.3

Figure 11 – Programmable Thermostat "Ease of Use"

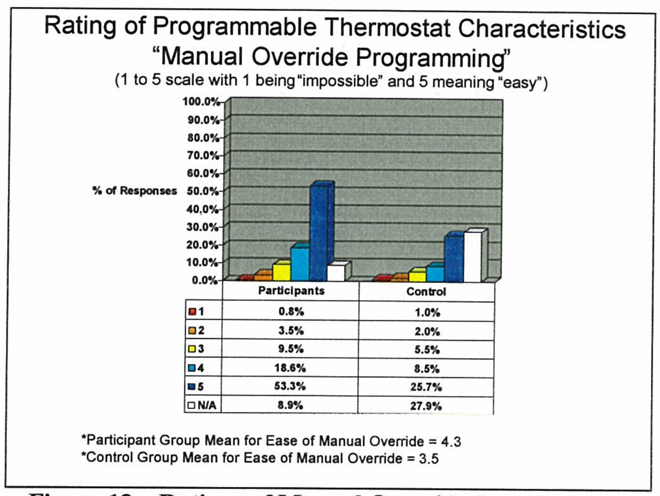
Figure 12 summarizes the customer responses when asked to give a rating of the programmable thermostats pre-programmed 5 and 7-day schedule. Nearly 60% of the participants gave it a 4 or 5 rating while only 26% of the control group gave the same 4 or 5 easy to use rating.



	Participants	Control
1	1.3%	1.2%
2	4.3%	3.7%
3	14.4%	7.5%
4	21.4%	8.6%
5	38.5%	17.6%
N/A	15.1%	32.6%

Figure 12 – Ratings of Pre-Programmed 5 and 7-Day Scheduling

Figure 13 reflects customer responses regarding the ease of using the manual override programming for their programmable thermostat. The mean for the participants was 4.3 and the control group reported a mean of 3.5. Nearly 72% of the participants and 34% of the control group rated it a 4 or 5.



	Participants	Control
1	0.8%	1.0%
2	3.5%	2.0%
3	9.5%	5.5%
4	18.6%	8.5%
5	53.3%	25.7%
N/A	8.9%	27.9%

Figure 13 – Ratings of Manual Override Programming

Importance of Rebate

Customers were asked to rate on a 1 "Not Important" to 5 "Very Important" scale how important the rebate was on their decision to purchase a programmable thermostat.
The vast majority of participants (82% of respondents) indicated that the rebate was an important factor in their decisi on to purchase a programmable thermostat.

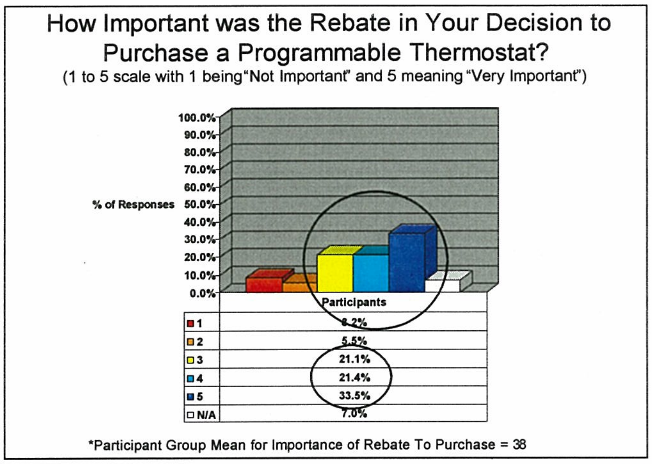


Figure 14 – Importance of Rebate to Purchase a Programmable Thermostat

Energy Efficiency

Customers were asked to give a rating of their homes current energy efficiency level on a 1 "Very Inefficient" to a 5 "Very Efficient" scale. Both participants and the control group gave their homes an average score of only around 3 as seen in Figure 15. This would lead one to believe that they feel more can be done to make their homes more energy efficient and provides opportunities for the utility to offer additional energy efficiency programs to its customers.

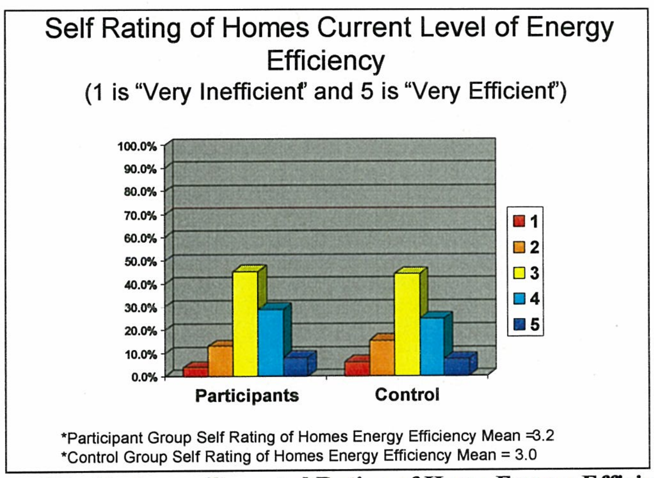


Figure 15 – Customer Reported Rating of Home Energy Efficiency

Customers were then asked "Over the next 12 months, what do you plan on replacing to improve the efficiency of your home?"

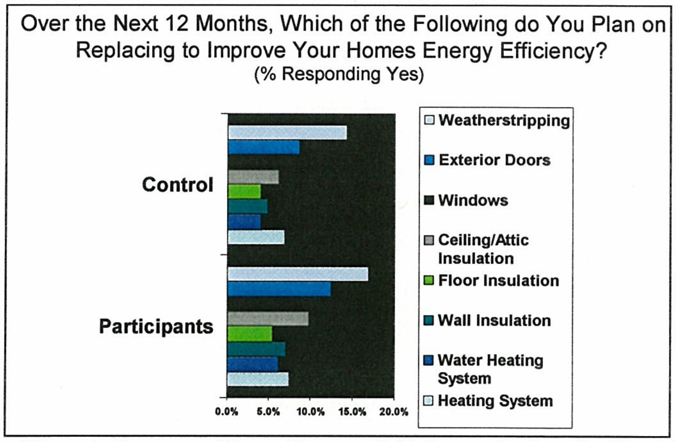


Figure 16 – Plans to Improve Home Energy Efficiency during the Next 12 Months

Weatherstripping (participants 17% and con trol 14%) was the number one item customers planned on accomplishing over the next 12 months to improve their homes energy efficiency. This was followed by windows, doors, insulation measures, water heating system replacements and lastly heating system re placements.

Appendix A – Billing Analysis Data Request

Billing Data

We need to secure monthly billing data for the full population of programmable thermostat participants and a relatively large sample of potential non -participants. The following record layout describes the information typically included in the population billing file:

- ? Utility identifier, e.g., utility name;
- ? Customer identifier, e.g., customer account number;
- ? Any available customer descriptors, e.g., housing type (i.e., single family or multifamily) geographic region, congestion region, customer class, rate class, etc.,
- ? Addressing information including customer name, service address, service city, service zip code, mailing address, mailing city, mailing zip code, and telephone number.
- ? 24 months to 36 months of billing history. This information should include at least 12 months pre-period participation, and 12 months of post-participation data. At a minimum the monthly billing data should encompass the period April 2004 through March 2006. The data should include:
    - Monthly billed usage,
    - Read dates (i.e., from and to),
    - Number of days in the billing cycle, and
    - Billing code (e.g., estimated, or actual).

In addition, we would like to obtain a large pool (i.e., 10,000+) of non -participants for use as a potential control group. Ideally, these would be customers that had not participated in the programmable thermostat program. The same type billing information listed above will be needed for the control group pool.

Tracking Data

Available program information for each of the programmable thermostat participants will be needed. This information includes:

- Participation/measure purchase date;
- Utility name;
- Customer type (i.e., residential or commercial);
- Customer name, street address (where install ed), city, state and zip code;
- Landlord/Owner name if different, street, city state, zip code;
- Thermostat manufacturer 1 and model number 1; and
- Thermostat manufacturer 2 and model number 2

Appendix B – Establishing a Control Group

The Control Group for the billing analysis was developed following a five step algorithm:

1. An appropriate pool of potential control group customers will be established,
2. Criterion will be developed to match control group pool customers to participants.
3. Known participants will b e eliminated from the control group pool.
4. The participant information will be summarized in a manner to allow for the efficient matching with control group pool members.
5. The control group pool customers will be compared to each participant and selected to fairly represent the participant pool. We anticipate selecting up to five control group participants for each test group participant.

Each of these steps is explained in detail below.

Step 1: The Establishment of a Control Group Pool

In order to efficiently develop a control group, the sponsoring utilities have been asked to provide billing information for a large random sample of residential customers that are otherwise eligible for the programmable thermostat program. Each bill for the "control group pool" will be examined. This examination will be consistent with the editing procedure applied to the participants.

Step 2: Eliminating Known Participants

After the initial edits, any known past or current programmable thermostat participant will be eliminated from the control group pool. This will be done by matching the control group pool to current and past participants derived from the available tracking data.

Step 3: The Establishment of Control Group Matching Criteria

This billing analysis is somewhat unique in that the variable we are trying to control for is the presence of a programmable thermostat. Since this is not an indicator that will be contained on the billing records at the utility, we will be conducting a mail survey to establish the actual control group pool. The draft survey is provided in Appendix B. The survey is being sent to both the control and participant groups. Once the standard thermostat customers have been established they will be matched to the participant pool based on annualized usage and correlation of monthly bills.

Step 4: Preparing the Participant Files

To accurately match the participants to the control group a file will be created with all relevant participant information. This file is expected to in clude participant account number, rate code and annualized pre -installation usage. Up to five stratum will be structured for use in selecting the control group pool.

Step 5: The Establishment of the Control Group

During this step, each control group pool customer will be compared to each participant in that stratum. For each control group pool customer, the correlation between the control group customer's and the participant's pre -installation period usage will be examined. The control group pool customers with the highest correlation, i.e., slope closest to 1 and intercept closest to zero, will be selected as a control group member. For each participant, we will select up to five control group pool customers with the highest correlation in normalized annualized usage to represent each participant. These customers will be designated the final control group.

The control group will be chosen *with replacement*. Selecting a sample with replacement allows a customer to have the potential of being designated a control group member for more than one participant.

The billing information for the control group members will be retained. Each control group member will be assigned its corresponding participant's installation window in order to separate the consumption between pre- and post-installation periods.

Appendix C – Introductory Letter

July 24, 2006

Dear <<name>>
Address
City State Zipcode

GasNetworks continually works to help its customers purchase proven energy saving products. We need your help now in determining how much natural gas is saved by using ENERGY STAR® programmable or set-back thermostats. It's real easy to help - simply answer the questions on the enclosed survey and return the survey to us in the postage paid self-addressed envelope provided. Please, we need your help even if you just have a manual thermostat(s) in your home.

Our consultant, *RLW Analytics*, will use your response to help determine how much natural gas is saved by using these devices. Your individual responses will be kept strictly confidential. As an added incentive, if you complete the online survey or return the mail survey by Wednesday, September 6, 2006 your name will be entered in our "prize" pool drawing. The prize pool includes several very exciting items i ncluding a large flat screen television (a $1,500 value), a $500 gift certificate to Home Depot, and three IPOD shuffles.

Your survey response can be provided in one of two ways:

1.) Fill-out and return the attached survey in the enclosed postage paid stamped envelope, OR
2.) Go to http://www.energysurveys.org/gasnetworks enter the following survey code <<Survey ID Code>> in the text box provided and then proceed with the survey.

Thank you in advance for your help with this very important project. If you have questions or concerns about the survey, please contact your utility representative. A list is provided on the back of this letter.

Sincerely,

Curt D. Puckett, President
RLW Analytics

GasNetworks

2006 Residential Survey

Utility Contact Sheet

GasNetworks utility contact information:

New England Gas Company
James Carey
Manager, Trade Relations &
Conservation
(401) 574-2061

NSTAR Gas
David Weber
Senior Research Analyst
(781) 441-8763

KeySpan Energy Delivery
Subid Wagley
Program Manager Research Evaluation
(781) 466-5448

Unitil
Lisa Glover
Energy Efficiency Program Analyst
(603) 773-6483

Berkshire Gas
Ken Sadlowski
Lead Analyst
(413) 445-0345

Bay State Gas
Marjorie Izzo,
Residential Program Manager
(508) 836-7350

Northern Utilities, Inc.
Marjorie Izzo,
Residential Program Manager
(508) 836-7350

Appendix D – Draft Residential Survey

GasNetworks
Residential Survey – ENERGY STAR® Thermostats

Unique ID:	
Name:	
Address:	
City, State Zip:	

Q1. Which of the following best describes your home:

- o Single-story with crawlspace
- o Single-story with basement
- o Two-story with crawlspace
- o Two-story with basement
- o Mobile Home or Trailer
- o Apartment or Condominium
- o Other, Describe________________ ______________________________

Q2. Do you own your home, or is it rented? ? Own ? Rent

Q3. How many rooms are in your home? _________ (please exclude hallways, bathrooms, and basements)

Q4. How old is your home? ________ Years

Q5. How long have you lived in this home? (If not sure, please estimate) ________ Years

Please answer one, or both, of the following questions to help us assess the square footage of your home.

Q6a. Approximately how many square feet of living space does your house have? (Please exclude un-heated basements and garages) __________ Square ft.

Q6b. If you are unsure of the square footage, please provide the approximate outside dimensions of your home? (Example 30' X 50') _______ ft. X ______ ft.

Q7. What fraction of the basement is heated?
? None/No Basement ? All ? ¾ ? ½ ? ¼

Q8. Have you added onto your home or completed any major renovations in the past two years?
? No ? Yes

Q9. Have you participated in a ***utility sponsored*** energy efficiency program in the past two years?
? No ? Yes If you answered "Yes", did the program involve any of the following:

? Heating System ?Water Heating System ? Added Insulation ? Windows ? Audit/Blower Door

Q10a. Is natural gas the ***primary*** heating fuel used to heat your home? ? Yes ? No

Q10b. What other fuels are used to heat your home?

- o None
- o Wood
- o Electric
- o Oil
- o Propane
- o Other:__________________________ __________________________

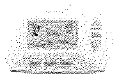
Q10c. What type of heating system do you have?

- o Forced Air Furnace
- o Boiler (Steam or Hot Water Radiant)
- o Other:__________________________ __________________________

Q10d. Please specify the age and condition of your heating system. ______ Years

Condition: ? Poor ? Average ? Good

Q13a. How many of each of the following thermostats do you have in your home?

	Standard Manual Thermostats:	? 0	? 1	? 2	? 3	? 4	? 5 or More
	Programmable Thermostats:	? 0	? 1	? 2	? 3	? 4	? 5 or More

Q13b. Which statement best describes how you use your thermostat:

- o We are using the pre-programmed schedule to control the temperature in our home
- o We programmed in a unique schedule for controlling the temperature in our home
- o We really don't use it – we simply maintain the same temperature setting night and day
- o We manually turn the thermostat down (winter time) or up (summer) when we are away
- o We manually change the temperatures during sleeping periods in the winter
- o We turn thermostat up and down throughout the day as needed to be comfortable

Q13c. Please indicate your usual thermostat settings during the following times and seasons. (Please record your answers in degrees Fahrenheit.)

	Summer:	Winter:
Weekdays:	_______	_______
Weekends:	_______	_______
Night Time:	_______	_______

Q14. Please rate each of the following characteristics of your **programmable thermostat** on a scale of 1-Impossible to 5-Easy? (Please skip if you only have standard manual thermostats).

	Impossible				Easy	
Ease of Installation:	? 1	? 2	? 3	? 4	? 5	
Ease of Use:	? 1	? 2	? 3	? 4	? 5	
Finding a style/color to match your home's decor:	? 1	? 2	? 3	? 4	? 5	
Pre-programmed 5-day/7-day schedule:	? 1	? 2	? 3	? 4	? 5	? N/A
Manual Override Programming:	? 1	? 2	? 3	? 4	? 5	? N/A

Q15. On a scale of 1 to 5 with 1 being "**Not Important**" and 5 being "**Very Important**", please rate how important the rebate was on your decision to purchase the programmable thermostat.

	Not Important			Very Important		
Importance of rebate on purchase:	? 1	? 2	? 3	? 4	? 5	? N/A

Q16. Please specify the quantity of each of the following appliances you currently have in your home:

Appliance:	**Quantity:**					
Electric Ceiling Fan(s):	? 0	? 1	? 2	? 3	? 4	? 5 or more
Natural Gas Range/Stove:	? 0	? 1	? 2			
Natural Gas Clothes Dryer:	? 0	? 1	? 2			
Natural Gas Hot Water Heater:	? 0	? 1	? 2	? 3	? 4	
Water Heater Temperature Setting:	? Low	? Medium		? High	? Other, Specify _____	
Natural Gas Fireplace:	? 0	? 1	? 2	? 3	? 4	
How frequently do you use gas fireplace:	? Low	? Medium		? High	? Other, Specify _____	
Natural Gas fired back-up generator	? 0	? 1	? 2			

Q17a. Please rate your home's current level of energy efficiency on a scale of 1 (very inefficient) to 5 (very efficient)?

Very Inefficient				Very Efficient
? 1	? 2	? 3	? 4	? 5

Q19. Do you have any **indoor** pet dog(s) that you let out frequently? ? Yes ? No