Framing the Audience: Describing Households That Invest in Energy Efficiency

An Evaluation of the Nexus Home Energy Analyzer

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I. Introduction

Households that purchase durables and make structural and aesthetic improvements to their homes weigh the short term and long term impacts of their decision. Households must choose to purchase standard or energy efficient appliances, and make standard or energy efficient improvements to their home. Household's make a qualitative choice between two alternatives. The choice depends upon the magnitude of the higher upfront capital cost of the efficient choice, and the energy expenditure savings that accumulate over time.

This paper focuses on residential energy efficiency. This paper is also an evaluation of the Nexus Home Energy Analyzer© that is featured on Energy Trust and its utility partners websites. The demographic and behavioral attributes of a sample of households are analyzed to determine if those who undertake energy saving measures are different from a sample of households that were found not to implement energy saving measures. Key attributes that increase the probability that a household will undertake energy efficiency measures in their home will be identified in this paper. Detailed household characteristics are presented and supplemented by an econometric model. The findings will contribute to the existing knowledge of the residential efficiency sector, and will be used to improve Energy Trust marketing and outreach efforts.

II. The Data

An important educational and marketing tool the Energy Trust employs is the Nexus Home Energy Analyzer tool that models a home's energy use. The Home Energy Analyzer is freely available on the websites of Energy Trust and three utilities in Oregon; Portland General Electric, Pacific Power, and NW Natural. The Home Energy Analyzer is advertised by all four entities. Participants are presented with a series of questions about their housing characteristics, appliance inventories, efficiency levels, and energy consuming behavior. The responses are used to simulate a home's energy use and make recommendations to participants on how they can save energy in their home. If users are ratepayers of one the three participating utilities, and complete the Home Energy Analyzer, participants are sent four free compact fluorescent light bulbs as an incentive to complete the tool. Participants are asked to provide name, address, email address, and utility account numbers, which allows the participants to be matched to recipients of energy efficiency incentives in Oregon, and to their electric and gas utility bills. These participants make up the population of households that are studied in this paper.

The household characteristics and demographic information made available by the Home Energy Analyzer provides a rich set of data for analysis. A significant portion of the households who participated in the Home Energy Analyzer are suspected to be good candidates for implementation of energy efficiency measures in their homes. The intention of this analysis is to identify which household attributes are correlated with program participation. Two sources of data allow the households who have implemented energy saving measures to be identified; Energy Trust of Oregon incentive recipients, and the Oregon Residential Energy Tax Credit recipients. The Residential

Energy Tax Credit is available to households who implement certain energy saving measures. Many Energy Trust participants also take advantage of the state tax credit, and many of the recipients of the tax credit take advantage of Energy Trust incentives. The overlap between these programs has been accounted for, as not to double count any household.

Participants of the Home Energy Analyzer who have provided a valid address can be matched to recipients of either of the energy efficiency incentives. Participants who are successfully matched will be referred to in this paper as "action takers." Home Energy Analyzer Participants who were not found to be recipients of incentives are referred to as "participants." While most of the participants have not implemented energy efficiency measures in their home, without a survey of these households, that assumption cannot be made.

Additional sources of data provide a fine supplement to this analysis. Economic theory suggests that people who use the most energy will have the greatest incentive to undertake energy saving measures. The incorporation of electric and gas utility billing data will provide an answer to this question. Home Energy Analyzer participants who provided valid electric and gas utility account numbers allows energy consumption data to be an important part of the model. Another potential determinant of undertaking energy saving actions may be geography. Zip codes given by the participants allow geographical trends to be identified.

III. Data Analysis

A substantial number of households participated in the Home Energy Analyzer. A total of 13,094 people took the Home Energy Analyzer between August 2004 and May 2006. This population allows for a relatively large sample. This analysis combines data on the participants from four different sources. The sources are combined and cases with missing observations are removed. The population available for analysis is a fraction of the survey population. As table 1 indicates, 7,457 participants provided addresses which can be matched to Energy Trust and Residential Energy Tax Credit participant databases to identify participants who have taken energy efficiency action. Table 1 shows that 1,722 of the Home Energy Analyzer participants were found to have implemented energy efficiency measures. This means that 23% of the Home Energy Analyzer participants implemented energy saving measures. If only single family detached dwellings are considered for analysis, there are 1,425 action takers from a sample of 5,840 participants, or 24% of Home Energy Analyzer users.

The availability of billing data for the participant households limits the sample which can be analyzed for consumption patterns. 5,610 survey participants provided electric utility account numbers, and 6,067 participants provided gas utility account numbers. A fraction of these account numbers were valid which resulted in 2,220 electric accounts and 4,389 gas accounts. Only 718 households provided both a valid electric and gas utility account number. This sample of 718 will be used for the consumption model. The population of households who provided addresses make up a more robust model employing the household characteristics.

Table 1
Summary of Home Energy Analyzer and Action Takers

	Number of Participants	Single Family Detached Only
All HEA Participants	13,094	10,633
Participants with Address	7,457	5,840
Energy Trust Action Takers	1,035	1,196
RETC Action Takers	964	771
Overlap	277	226
Total	**1,722**	**1,425**

Home Energy Analyzer, Cause or Effect?

The Home Energy Analyzer serves as an education tool as well as a marketing tool for energy efficient appliances as well as home improvement and weatherization repairs. Energy Trust and its utility partners want to know how many households may have been influenced to implement energy efficiency measures as a result of using the Home Energy Analyzer. Households who have implemented energy efficiency measures before taking the Home Energy Analyzer are assumed to have been un-influenced by the tool, while those who participated afterwards were likely influenced by the measures recommended by the tool. Dates recorded by the Home Energy Analyzer, Energy Trust, and Residential Energy Tax Credit allow the timing to be identified. Table 2 indicates that 56% of participants implemented measures before completing the analyzer. These households were not influenced by the Home Energy Analyzer to implement energy saving measures. 44% of the action takers implemented energy efficiency measures after taking the Home Energy Analyzer. It is assumed that these households were not influenced by the tool to implement measures.

Action takers who implemented measures before taking the Home Energy Analyzers were not driven to do so by the tool. However, many of these households have implemented additional measures which can be attributed to the Home Energy Analyzer. 24% of action takers who implemented measures before taking the Home Energy Analyzer, also implemented energy saving measures after using the tool. These households must be counted as influenced by the tool to implement an energy efficiency measure. The number of households that took action after using the tool is 964 of 7,457 households. The total action taking rate among all housing types is therefore 13% of the households who participated in the Home Energy Analyzer.

Table 2
Timing of Survey and Implemented Measures

Home Energy Analyzer Date	Action Takers
Before Measure	54%
After Measure	46%

Table 3
Rate of Action Taking in Sample

	All Housing Types	Single Family Detached
Rate of Action Takers in Sample	23%	24%
Rate of Action Takers After Using Home Energy Analyzer	13%	13%

Energy Efficiency Measure Categories

The type of energy saving measures implemented are of interest in this analysis. Table 4 shows that efficient clothes washers are by far the most commonly implemented energy saving measure. 54% of the action takers purchased efficient clothes washers that were given incentives by the Energy Trust or the tax credit. Home Energy Reviews were the next most common measure at 18% of the measures taken. A Home Energy Review is an assessment of the energy efficiency characteristics of a house. The review is free and is conducted by a trained home inspector. A Home Energy Review is often a good opportunity to push the benefits of energy saving measures to household decision makers. This is considered to be an taking action, precisely because the household is exhibiting energy efficient behavior, even if they do not implement any measures. Participants of the Home Energy Review are likely to exhibit energy efficient behavior.

Table 4
Energy Trust Measures

Measure	Number of Measures Installed	Percent of Measures
Free CFL's	571	18%
Window	42	1%
Water Heater	38	1%
Fridge	28	1%
Insulation	134	4%
Heat Pump	42	1%
Boiler	1	0%
Gas Furnace	196	6%
Clothes Washer	937	30%
Home Energy Review	314	10%
Duct Work	143	5%
Lighting	197	6%
Dishwasher	259	8%
Weatherization	67	2%
Water	123	4%
TOTAL	**3,092**	**100%**

Table 5 shows that a majority of action takers only implemented one energy saving measure, however a modest number of households implemented two measures. Action takers who implemented more than two measures are a small fraction of the action taking population. Table 6 shows that Energy Trust and the Residential Energy Tax Credit measures follow the same patterns, although the menu of measures with incentives provided by the tax credit is smaller.

Table 5
Number of Measures Implemented

Number of Measures Implemented	Number of Households	Percent of All Households
1	1,018	59%
2	505	29%
3	122	7%
4	52	3%
5	13	0.7%
6	9	0.5%
7	3	0.1%
TOTAL	**1,722**	**100%**

Table 6
Residential Energy Tax Credit Measures

RETC Measure	No. of Measures	Overlap
Clothes Washer	671	271
Dish Washer	248	6
Fridge	28	0
Water Heater	17	0
TOTAL	**964**	**277**

Household Characteristics

We suspect households that implement energy efficiency measures will display distinct characteristics. Housing characteristics are very similar between action taking households and participants in the survey. A basic analysis of characteristics of the action taking and participant households provides insight, but no strong conclusions about what separates the two groups. Differences at the margin for each household calculated by the qualitative choice model provide stronger conclusions.

The first level of analysis of the survey data is to describe the sample of households and trends in key variables. This provides a snapshot of the sample. Significant differences in key characteristics between action takers and participants will be identified if they exist. These attributes are considered as potential variables in the qualitative choice model. If a characteristic is found to be the same between action takers and non-action takers, the statistic will be reported as that of all households.

The analysis is conducted on single family detached households who reported a valid address in the Home Energy Analyzer. Households that are apartments, condos, mobile homes, and townhouses are not included in the analysis, however a separate analysis of the measures taken in these housing types is provided in table 6a of the appendix. Limiting the analysis to single family houses provides for a homogenous sample for analysis. Energy using characteristics are significantly different in the other housing types, as well as the energy saving measures that are available to them. 83% of the action taking households and 77% of the participant households are single family detached. Households who did not provide an address could not be matched to the tax credit and Energy Trust measure databases. These households may have implemented energy efficiency measures that cannot be identified by methods used in this analysis.

There are three levels to complete in the Home Energy Analyzer. Level 1 is basic house information including name, address, square footage, levels, and number of inhabitants. Level 2 is the inventory of appliances. Level 3 goes into more detail regarding appliances, house characteristics and energy using behavior. Level 3 also includes a billing analysis which requires correct utility account numbers to link the given information to actual billing data. Table 7 in the appendix displays the completion rates between action takers and participants. Action takers completed more of each level than participants. Part of the reason for this is that survey participants who left many answers blank were removed from the sample. It is surprising to note that only 8% of action takers, and 4% of participants completed level 3.

Table 7
Home Energy Analyzer Levels Completed

Level	Action Takers	Participants
Level 1 Completed	100%	91%
Level 2 Completed	84%	58%
Level 3 Completed	8%	4%

House characteristics between action takers and participants are displayed on table 8. The average size of an action takers house is 1,938 square feet, and the average size of a participant's house is 1,840 square feet. This difference is statistically significant at the 95% confidence level, however the magnitude of the difference is not very large. A similar evaluation of the Home Energy Analyzer for Pacific Power in Washington conducted by Quantec LLC, cited an average house size of 1,700 square feet (Quantec, p. I-5). House size is normally distributed, with over 30% of houses between 1,000 – 2,000 square feet. There is a slight difference in the distribution of houses under1,500 square feet. 5% more of the participant households are less than1,500 square feet. This difference is made up in action taking households, who have a greater share of houses greater than 2,500 and 3,000 square feet. This suggests that action takers homes tend to be larger than participant homes.

The majority of participants and action takers homes were built before 1978. 70% of all houses were built before 1978. 30% of the houses were built between 1961 – 1978, and 40% of the houses were built before 1960. The Quantec study found that 37% of the houses in Washington are older than 40 years. 16% of all houses were built after 1995, and 9% were built after 2000. Age of the house is believed to be a significant determinant of implementing energy efficiency, particularly for houses greater than 40 years old that tend to be poorly insulated with air leaks.

The number of levels and people per home are nearly identical between the groups. The average number of levels is slightly higher for action taking households than for participants, which agrees with the finding that action takers houses are larger than participant houses. The number of people per household is identical between the two groups at 3. The Quantec study also found the same average number of people per household (Quantec, p. I-5). The number of action takers with an attic is only marginally higher than participant households with an attic. The proportion of homes with a basement is the same between action takers and participants.

Table 8
House Characteristics - Single Family Detached

Characteristic	Action Takers	Participants
House Size	1,938 sqft s.e.- 19.5	1,840 sqft s.e. – 10.7
House Age Over 40 Years	40%	41%
House Levels (Avg.)	1.56	1.50
Number of People (Avg.)	2.82	2.82
Have Attic	79%	78%
Have Basement	89%	89%
Have Pool	8%	8%
Own House	97%	90%
Cook Top Fuel	74% Electric 25% Gas 1% Other	81% Electric 17% Gas 2% Other
Double Paned Windows	None – 12% A few – 8% Many – 55% All – 26%	None - 14% A few - 7% Many – 54% All – 25%
Storm Windows	None – 31% A few – 55% Many – 3% All – 11%	None – 29% A few – 55% Many – 5% All – 11%
Attic Insulation Levels	Poor - 4% Good – 27% Excellent– 67%	None – 5% Good – 28% Excellent– 65%
Wall Insulation Levels	None – 18% Some – 51% A lot – 15% 13.5 – 11% 16.5 – 5%	None – 18% Some – 51% A lot – 16% 13.5 – 11% 16.5 – 4%

Survey takers were asked to state if their house is insulated and to estimate the level of insulation if present. A greater proportion of action takers believe that their attic has "excellent" insulation at 67%. A slightly greater portion of participants state they have "good" or "no insulation." Significantly less households believe that their house has adequate wall insulation. 51% of both groups state that their walls have some insulation, and 18% believe that their walls have no insulation. 15% of households believe that they have adequate wall insulation compared to the 65%-67% that believe they have adequate attic insulation. In general, there is not a significant difference between the action takers and participants answers regarding insulation levels. These results indicate that there may be significant potential for insulation measures in Oregon.

There is not a significant difference in the proportions of houses with double paned windows between the groups. 55% of all households state that they have "many" windows that are double paned, and 25% state that "all" of their windows are double paned. Significantly less households state that they have storm windows. 3-5% of the houses have "many" storm windows, while 55% have "a few" storm windows.

There is a significant difference in the type of cook top fuel used in action taking and participant households. A greater proportion of action taking households use natural gas as a cooking fuel. Electricity is the majority fuel used in both groups. 74% of action takers cook with electricity, while 81% of participants use electricity as a cooking fuel. Results below for space and water heating also suggest that natural gas is more often used in end use applications for action taking households than for participants.

As expected, there is a significant difference in the proportion of households who rent their homes. Over 97% percent of the action takers own their homes, whereas only 90% of the participants own their homes. This suggests that people who own their homes are more likely to undertake efficiency measures than those who are renters. Households who rent have very little incentive to invest in energy efficiency because they will likely not realize a majority of the long-term energy savings, and thus not regain their investment.

Heating

Heating is a major end use for homes in Oregon. It is suspected that the heating fuel is an important determinant of those who chose to implement energy efficiency measures. A majority of both groups use natural gas as a heating fuel, as the pie charts below and table 9 indicate. A greater proportion of action taking households use natural gas as a heating fuel. 71% of action takers and 58% of participants heat with natural gas. 21% of action takers and 27% of participants heat with electricity. There is a significantly greater proportion of participants that employ oil, propane, wood, and oil as primary heating fuel. Households who use these less common heating fuels cannot take advantage of Energy Trust incentives for insulation, windows, furnaces, heat pumps, weatherization and duct work. This is most likely the reason why these other heating types appear more predominantly in the participant group. A majority of both groups with electric heat use baseboard or resistance style heat, with participants using more baseboard style heat according to table 10. A slightly greater proportion of action takers use electric forced air furnaces and heat pumps than non-action takers.

Figure 1

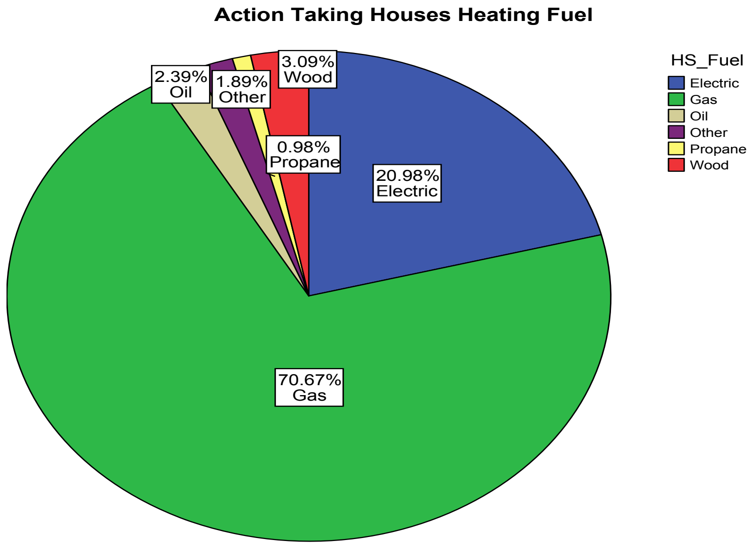


Figure 2

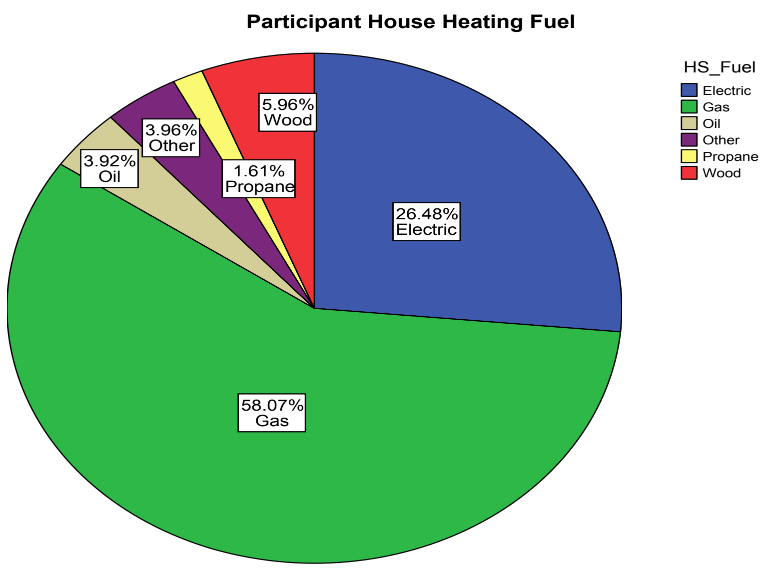


Table 9
Heating

	Action Takers	Participants
Fireplace	56%	46%
Fireplace Fuel	77% Wood 22% Gas	82% Wood 17% Gas
Space Heaters (Have one?)	18%	22%

Table 10
Electric Heating Style

Type	Action Takers	Participants
Baseboard / Resistance	71%	76%
Forced Air Furnace	13%	10%
Air Source Heat Pump	16%	12%
Water Boiler	1%	2%

Secondary heating sources can have a noticeable effect on household energy consumption depending on their frequency and timing of use. Fireplaces are the most common secondary heating source for both groups. A greater proportion of action taking houses have fireplaces than participant houses. Action takers are more likely to use gas as a fireplace fuel, however a majority of both groups use wood as the main fireplace fuel. A greater proportion of participant households report having space heaters in their homes. The Qualitative choice model reveals more about the influence of heating fuel on efficiency choice.

Cooling

Air conditioning is a growing trend in Oregon. A greater share of new homes are constructed with central air conditioning than has traditionally been the case in Oregon. This has changed the peak load from winter to summer in recent years. A "Residential New Construction Characteristics and Practices Study" conducted by RLW Analytics for the Northwest Energy Efficiency Alliance indicates that 98% of new homes in the Northwest have central air conditioning, and 2% use room air conditioners (RLW, P. 81). Table 11 in the appendix indicates that 44% of Action takers have central air conditioning systems, compared to 41% of participant houses who indicate the same. Participant households have a greater proportion of room air conditioners. 14% of action takers have at least one room air conditioner, and 19% of participants have at least one room air conditioner. It is assumed that households that have a room air conditioner do not have central air conditioning, therefore, a slightly greater proportion of participants have air conditioning in their homes. If the central air conditioner percentage is added to the room air conditioners, 58% of action takers and 60% of participant houses have air conditioning.

Table 11
Cooling

Characteristic / Appliance	Action Takers	Participants	No. of Appliances Action Takers	No. of Appliances Participants
Central AC	44%	41%		
Ceiling Fans	51%	52%	1 - 30% 2 - 12% 3 - 6%	1 - 29% 2 - 12% 3 - 7%
Room AC	14%	19%	1 - 10% 2 – 4%	1 -14% 2 – 4%

Common Household Appliances

While the characteristics of the house itself and its inhabitants are important determinants of electricity consumption, the inventory and efficiency of appliances are a significant share of electricity use. This is especially true in the Pacific Northwest where a majority of homes are heated with natural gas. A main task of the Home Energy Analyzer is to inventory the appliances in the home to accurately model the home's electricity load, and make recommendations for efficient appliances.

Appliance holdings are very similar between action takers and participants as indicated by table 12. The appliances analyzed here are a small portion of the inventory asked for in the Home Energy Analyzer. The appliances mentioned are common appliances, other common appliances such as clothes washers and dryers are covered in their own section below.

Table 12
Appliances

Appliance	Have Appliance? Action Takers	Have Appliance? Participants	No. of Appliances Action Takers	No. of Appliances Participants
Second Fridge	16%	17%	-	-
Computers	81%	80%	1 – 52% 2 – 22% 3 – 7%	1 - 55% 2 - 19% 3 - 6%
Television	100%	100%	1 – 29% 2 – 46% 3 – 25%	1 - 28% 2 - 44% 3 - 28%
Dishwasher	91%	86%		
Hot Tub	11%	10%	1 – 100%	1 – 100%

The fridge is a major source of electricity consumption in a typical house. The existence of a second fridge which is typically older and less efficient can add a significant amount of energy consumption to a typical household. Both groups indicate that 16-17% of all households have two fridges. Color television holdings are similar between the two groups. Every household indicates that they have at least one television. Participants indicate that a greater share of them have three televisions. The number of computers is similar between the groups. There is a significant difference in the frequency of dishwashers between groups. Action takers report that 91% have a dishwasher, while 86% of participants have one. Hot tub and pool ownership is similar between groups.

Water Heating and Clothes Washers and Dryers

There is a significant difference in the proportions of water heating fuel between the action takers and participants. Table 13 in indicates that 57% of action takers use natural gas for water heating fuel, whereas 48% of non-action takers use gas. The remaining households employ electricity as their water heating fuel. Only 1% of both groups indicated that they use another fuel for water heating, such as propane. Small proportions of all households indicate that they have a high efficiency water heater, or state that their water heater tank is insulated.

Table 13
Water Heating

Water Heater Characteristic	Action Takers	Participants
Water Heating Fuel	42% Electric 57% Gas 1% Other	51% Electric 48% Gas 1% Other
High Efficiency	5%	6%
Tank is Insulated	5%	5%

Clothes washer and dryer holdings are extremely common and similar between action takers and participants as table 14 indicates. Virtually all households indicate that they have a both a clothes washer and dryer. Action takers report that they have significantly more frontloading washers than participants. Less than a half of a percent of each group reports that they have an Energy Star clothes washer. A majority of all households report that they have a dishwasher. Significantly more action taking households indicate that they have dishwashers. These results are influenced by the fact that efficient clothes washers and dishwashers are two appliances that are eligible for incentives.

Table 14
Clothes Washers and Dryers

Appliance	Action Takers	Participants
Have Clothes Washer	99%	99%
Clothes Washer – Number of Loads Per Week	5.65	5.65
Front Loading Clothes Washer	11%	4%
Clothes Washer Energy Star?	0.4%	0.1%
Have Dryer	99%	98%
Dryer – Number of Loads Per Week	5.66	5.67

Thermostat Setting Behavior

Home Energy Analyzer participants were asked to state their preferences in setting the thermostat and water heater temperature. Participants were asked heating and cooling season preferences, as well as water heating preferences. The participants were asked about their behavior for different parts of the day and different parts of the house. Results appear in table 15. There is a statistical difference between the average temperatures for night time settings, however the magnitude is small. The daytime and evening average temperatures are not statistically different. It may be optimistic to conclude that there is a difference in temperature setting behavior given the small magnitude of the differences. However, the averages are taken from a relatively large sample, so a small difference may indeed indicate significant differences at the individual household level. Water heater temperature settings are less precise, so averages could not be calculated. Water heater temperature settings are very similar between the groups as shown in table 16. A majority of both groups set the water heater temperature between 130 - 140 degrees.

Table 15
Thermostat Setting Behavior – Average Temperatures

Time and Place	Action Takers	Participants	T Statistic
Daytime Living Area	**61.46**	**61.62**	**1.60**
Evening Living Area	**69.28**	**69.28**	**0**
Night Living Area	**60.6**	**60.8**	**2.53**
Daytime Sleeping Area	**60.42**	**60.47**	**0.94**
Evening Sleeping Area	**69.65**	**69.59**	**1.17**
Night Sleeping Area	**60.37**	**60.27**	**2.23**

Table 16
Water Heating Temperature Setting Behavior

Temperature (degrees)	Action Takers	Participants
120	2%	2%
120-130	11%	10%
130-140	83%	84%
140-150	3%	3%
150 +	0%	0%

Lighting Behavior

Home Energy Analyzer participants were asked to describe the quantity and type, as well as use of lighting used in their homes. A slightly greater proportion of participants state that they are careful to turn unnecessary lights off as indicated in table 17. A greater proportion of action takers state that they "sometimes" leave unnecessary lights on. The wattage of light bulbs used between the two groups are virtually the same, as well the quantity of halogen lamps. Table 18 shows that action takers indicate that they have significantly less wall and ceiling light fixtures than participants. Action takers have an average of 8.33 wall and ceiling fixtures, while participants have an average of 7.90 fixtures. The difference in means is statistically significant at the 95% confidence level.

Table 17
Lighting Behavior

Lighting Usage	Action Takers	Participants
Often leave unnecessary lights on	0%	0%
Sometimes leave unnecessary lights on	13%	11%
Careful to turn unnecessary lights off	87%	89%

Table 18
Type of Lighting

Lighting Characteristic	Action Takers	Non-Action Takers
Wattage of Light Bulbs	40-70 watts – 11% 75 watts – 79% 70-110 watts – 5% 110-115 watts – 0%	40-70 watts – 12% 75 watts – 80% 70-110 watts – 4% 110-115 watts – 0%
Quantity of Halogen Lights	1 – 31% 2 – 4% 3 – 1%	1 – 28% 2 – 3% 3 – 1%
Quantity of Inside Lights	8 and less – 60% Mean – 8.33	8 and less – 65% Mean – 7.90

Electric and Natural Gas Consumption

A household's energy consumption is thought to be a major indicator of efficiency choice in this analysis. There are two different ways to interpret energy consumption with regard to indicating energy efficient behavior. One perspective is that households with a greater consumption are more likely to implement energy saving measures. Households with greater consumption would benefit more from energy saving measures, and are likely to have a greater number of areas they could implement energy saving measures. Households with greater consumption are also more likely to have larger houses with more appliances, and larger incomes. If this is assumed, these households have more income available to invest in energy saving measures. A counter perspective is that households with greater consumption are so because they do not implement energy saving measures or display energy efficient behavior. Additionally, the previously implemented energy saving measures and energy efficient behavior of action taking households may result in significantly reduced energy consumption. The lower consumption may show up in the billing analysis.

The most interesting and valid inferences in this paper involve household annual energy consumption. A majority of Home Energy Analyzer Participants provided utility account numbers. Account numbers of Energy Trust participants supplemented the Home Energy Analyzer account numbers when one was not given. Many of the self reported account numbers are not valid, however, enough billing histories were matched to participants for a fairly robust sample. Table 19 presents the proportions of the sample with each type of billing data. It should be noted that households with gas heat are considerably over represented in the sample of households for which both electric and gas heat billing histories are available. For this reason, consumption averages are calculated for all of the participants whose billing histories are available in that category. Sample sizes differ among all categories. The normalized annual consumption was calculated for each household, and is the unit of consumption for this analysis. This calculation of Normalized Annual Consumption is described in the appendix.

Table 19
Billing Data (All Housing Types)

	Action Takers	Participants	Total
Provided Electric Account Number	408 24%	5,202 46%	5,610 43%
Full Year of Electric History Located	498 29%	1,722 15%	2,220 17%
Provided Gas Account Number	726 42%	5,341 47%	6,067 46%
Full Year of Gas History Located	648 38%	3,741 33%	4,389 34%
Have Both Electric and Gas Histories	207 12%	511 4%	718 5%

Significant differences exist in the electric and gas consumption between action takers and participants. Tables 20 – 27 present the results of the energy consumption analysis. Households are grouped into two consumption categories; electric heat and gas heat. Households are further stratified into specific space and water heating categories because their consumption patterns are different. Households with different heating fuel for space and water heat display vastly different consumption patterns. In general, action takers display significantly lower electricity consumption, and in most categories display no difference in gas consumption. Differences in average consumption are verified statistically by calculating t-statistics using group averages of Normalized Annual Consumptions and their standard errors.

The current rate schedules published by each utility (Portland General Electric, Pacific Power, and NW Natural, 2007) were used to calculate participants energy costs. In general, there is no statistically significant difference in total energy costs between households that heat with electricity and natural gas. The electric rates for Portland General Electric are slightly higher than those of Pacific Power, so higher electric consumption may not always equate to higher average electricity costs depending on the proportion households in each utility territory per consumption group.

There is not a significant statistical difference in the electric and gas consumptions or their associated costs in households with electric heat. There is a significant difference in the electric consumption of households with gas heat. Action taking households with gas space heat use 10% less electricity than participant households. No difference is found in the gas consumption of households with gas heat. Action takers average electricity costs are 4% less than participants, however this difference is not significant at the 95% confidence level. These results suggest that action taking households with gas heat use electricity more efficiently than their participant counterparts. The gas consumption is nearly identical, however because action taking households are known to be larger than participant households, action takers may be consuming gas more efficiently than participant households.

A majority of homes with electric or gas space heat use the same fuel for water heating, however a small proportion of homes use different fuels. Homes were grouped into four different categories to more precisely analyze differences in their energy consumption. There is not a significant difference in the electric normalized annual consumption of households with electric space and electric water heat. The sample size of homes with electric heat and gas water heat is so small that it cannot be reported with accuracy.

Similar to the less stratified group of homes with gas heat, action taking homes with gas space and water heat have significantly lower electric consumption than participant homes. Action taking homes with gas space and water heat use 8% less electricity than participant homes, and the difference is statistically significant. There is not a significant difference in the gas consumption, or total energy costs for this group.

The only group of homes that overturns what is found in the less stratified consumption groups, is homes with gas space and electric water heat. There is a significant difference in gas consumption between action taking and participant homes. Action taking homes with gas space and electric water heat use 13% less electricity and 10% less gas. Total energy costs of action taking homes are also significantly different than participants homes (electricity costs are only significantly different at the 90% confidence level). Stratifying the consumption groups into more precise space and water heating groups, verifies and contributes additional information to the two more general consumption groups.

There is not a significant difference in the total energy costs between homes heated with electricity and natural gas. It may be possible however that the distribution of measures is different for households with different heating fuels. This hypothesis is tested by comparing the distribution of measures between the two heating types. Table 28 in the appendix shows that in general there is no difference in the number of insulation, windows, or weatherization measures as a proportion of all measures. As expected, there is a difference in the percentages of electric heat pumps and gas furnaces which typically are installed in homes with the same previous heating fuels. Fuel switching cannot be determined in this analysis, but is believed to be a small proportion of households.

The consumption analysis shows that lower average annual energy consumption by action takers, suggests that implemented energy saving measures, and or their household's energy efficient behavior is resulting in lower total energy consumption. The magnitude of the difference is larger in energy and cost units as well as in statistical significance for households that heat with gas. Homes with electric space heat display no difference in energy consumption between action takers and participants. This initial analysis allows us to conclude with confidence that action takers with gas heat consume less electricity and gas than participants. However, the analysis of consumption was not conducted at the individual household level. The econometric model is needed to test this hypothesis.

Table 20
Electric and Gas Consumption – Electric Heat

	Action Takers	Participants	% Difference and T- Stat
NAC Electricity	19,583 kWh N= 90	19,061 kWh N = 365	3% t = 0.61
NAC Gas	N/A	N/A	N/A

Table 21
Electric and Gas Consumption Costs – Electric Heat

	Action Takers	Participants	% Difference and T - Stat
Annual Electricity Cost	$1,665	$1,620	3% t = 1.03
Annual Gas Cost	N/A	N/A	N/A

Table 22
Electric and Gas Consumption – Gas Heat

	Action Takers	Participants	% Difference and T - Stat
NAC Electricity	8,722 kWh N= 272	9,602 kWh N = 628	10% t = 3.49
NAC Gas	695 N= 570	693 N = 978	0.2% t = 0.15

Table 23
Electric and Gas Costs – Gas Heat

	Action Takers	Participants	% Difference and T - Stat
Annual Electricity Cost	$748	$778	4% t = 1.36
Annual Gas Cost	$980	$978	0.2% t = 0.11
Average Total Energy Cost	$1,728	$1,756	

Table 24
Electric and Gas Consumption – Gas Space and Gas Water Heat

	Action Takers	Participants	% Difference and T - Stat
NAC Electricity	8,158 kWh N= 205	8,806 kWh N = 460	8% t = 2.42
NAC Gas	745 N= 436	726 N = 754	3 t = 1.27

Table 25
Electric and Gas Costs – Gas Space and Gas Water Heat

	Action Takers	Participants	% Difference and T - Stat
Annual Electricity Cost	$ 710	$717	1% t = 0.29
Annual Gas Cost	$1050	$1023	3% t = 1.29
Average Total Energy Cost	$1,760	$1,740	

Table 26
Electric and Gas Consumption – Gas Space and Electric Water Heat

	Action Takers	Participants	% Difference and T - Stat
NAC Electricity	kWh 10,447 N= 67	kWh 11,780 N = 168	13% t = 2.36
NAC Gas	533 N = 134	585 N = 224	10% t = 2.6

Table 27
Electric and Gas Costs – Gas Space and Electric Water Heat

	Action Takers	Participants	% Difference and T - Stat
Annual Electricity Cost	$865	$946	10% t = 1.65
Annual Gas Cost	$ 751	$ 825	10% t = 2.55
Average Total Energy Cost	$1,616	$1,771	

Energy Intensity

The energy intensity of a home is the energy consumed expressed in another unit of measure. For this analysis, energy intensity is total energy cost per square foot of house. The lower the energy intensity, the more efficient a household is at consuming energy. In general, there is not a substantial difference is energy intensity between action takers and participants. There is a slight difference in means and distribution for houses with gas heat, however the difference is not statistically significant. Action takers with gas heat have an average energy intensity of 0.92 $/Sqft while participants with gas heat have an average of 0.99 $/Sqft. Figures 3 and 4 display the distribution of total energy cost per square foot between action takers and participants. It is apparent that the distribution of energy intensity is more spread out in the tails for participants than for action takers. This means that while there is not a strong difference in means, participants are more likely to have high energy intensity figures. In fact, no action taking household has an energy intensity over 1.80 $/Sqft, while there are 16 participant households with an energy intensity greater than 1.8 $/Sqft with the highest being 3.77 $/Sqft. Action taking households do not display abnormally high energy intensity.

Figure 3: Participant Energy Intensity

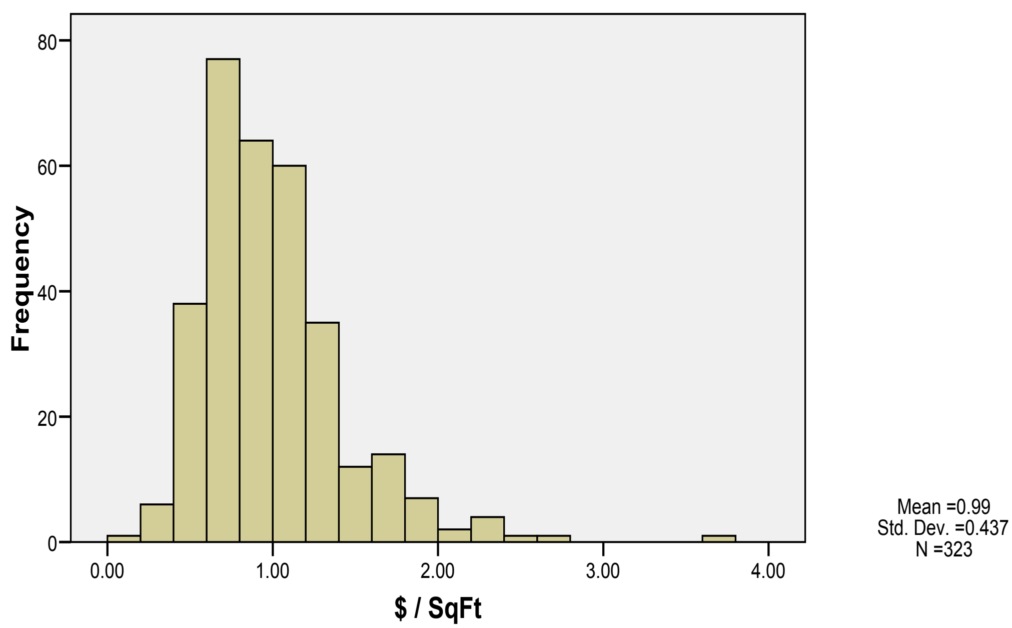
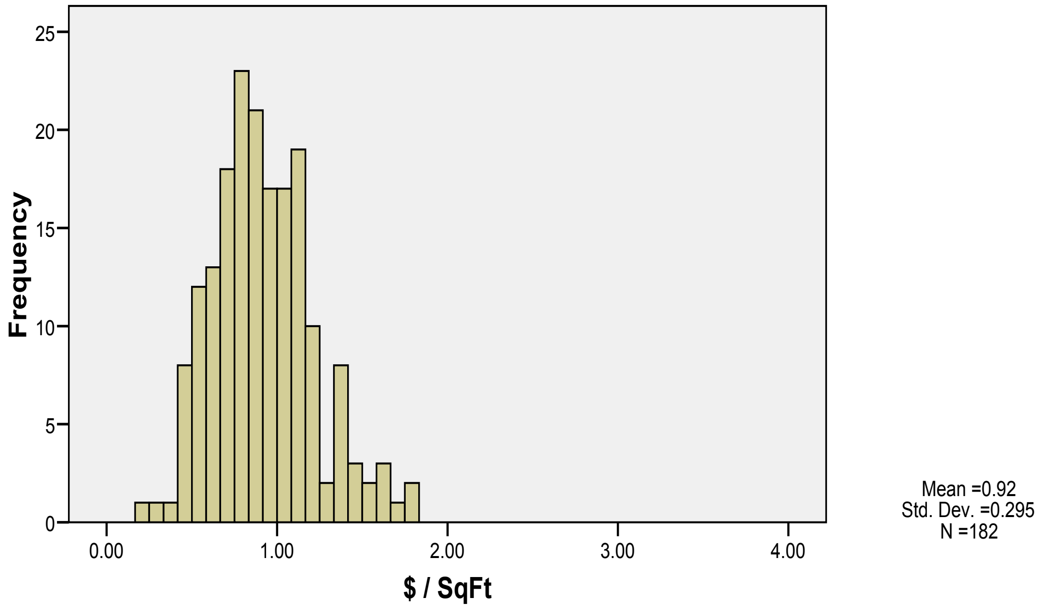


Figure 4: Action Taker Energy Intensity



Geographical Trends

Energy Trust and its utility partners strive to educate households and offer incentives throughout its service territory. The number of households that took the Home Energy Analyzer in each city or area of the state is important to Energy Trust and its partners. It may identify areas of Oregon where the outreach is successful, and where more outreach is needed. Table 29 in the appendix presents the number of households that took action as a proportion of households that took the Home Energy Analyzer for each city in Oregon. The survey population column is for all households even if they did not provide a full address. This provides a better geographical picture of the survey population.

In general, the survey population mirrors the population of Oregon. There are a some wide differences in participation rates however. There are only a handful of cities that have action taking rates greater than 20%. The cities represented here represent 86% of all action takers. Aloha and Clackamas have the highest action taking rate at 24%. Other cities that have a rate of over 20% are Bend, Dallas, Prineville, and Tigard. Portland by far has the biggest number of participants at 3,573, followed by Beaverton, Salem, and Hillsboro.

Portland is the city with the most action takers and Home Energy Analyzer participants. We would like to know more detailed information about the Portland action takers, as the greatest potential to increase the number of households who implement energy saving measures is there. Portland accounts for 32% of all the action takers, and 36% of all the Home Energy Analyzer survey population. An analysis of the Portland participants who provided valid zip codes presented in table 28 reveals that South East Portland has the greatest number of action takers. The neighborhood with the next greatest proportion of action takers is South West Portland. Northwest Portland has the highest rate of implementation among the Portland neighborhoods.

Table 28
Distribution by Portland Quadrant

Quadrant	Action Takers	HEA Population	Participation Rate
North	77	579	13%
Northeast	103	799	13%
Southeast	198	1,431	14%
Southwest	178	1,107	16%
Northwest	72	424	17%

IV. The Model

We seek to identify the probability that households will implement energy saving measures to their home given the available explanatory characteristics. Each household has a discreet qualitative choice to make regarding energy efficiency investment. Households with certain characteristics may be more likely to implement energy saving measures. The simple analysis of household characteristics does not give any strong conclusions about which characteristics are unique to the action taking households. The econometric model that follows will test the attributes that are suspected to be significant, and in what magnitude those attributes are influential.

Predicting human choice is a difficult task. Human behavior is not easily captured in or subject to the quantitative form. Decisions are typically made on a qualitative basis influenced by unobservable and exogenous factors. It is possible to represent these factors with suitable proxy variables. However, causation between the chosen variables and the dependent variable is often difficult to establish. However, this analysis does not require causation for the results to be useful. Having certain household characteristics does not in itself cause people to make energy savings investments. Having certain characteristics however, may increase the probability that households take action. The shortfalls of modeling such behavior are many, but this has never discouraged an economist.

This model will employ the probit method of estimation. The primary reason for choosing the probit model is the qualitative nature of our dependant variable, taking action or not taking action to implement energy efficiency in your home. For appliance purchases which the household will purchase regardless, the qualitative choice is between the standard model, or the energy efficient model. A model of this sort requires a binary dependent variable. The most similar model on qualitative choice of residential appliances in the literature is a paper by Dubin and McFadden (Dubin, Mcfadden, 1974). In this model, the authors model the space and water heating portfolio choice of households. A binary dependant variable is created and estimated by the different capital and operating costs of the choices. Dubin and Mcfadden employ the discreet choice logit model to estimate the probabilities of space and water heating choice, which then enters their residential electricity demand model.

The efficiency of appliance holdings and heating choice are typically left out of residential energy demand models. Energy efficiency choice is assumed to be exogenous to the model. Dubin and Mcfadden show that including energy efficient choice can have significant explanatory power in a residential energy demand model. Energy efficiency choice may also be a proxy for unobservable energy saving consumption behavior. An authoritative review of econometric studies of energy demand behavior by Bohi and Zimmerman also alludes to the fact that all residential energy demand models assume that the appliance stock is given and perfectly elastic (Bohi & Zimmermann, p.112). Including appliance choice in an energy demand model makes it more dynamic.

The Probit Model

The discreet choice model employs data from single family detached homes from home energy analyzer participants that provided a valid address that could be matched to Energy Trust, RETC, and billing history databases. Two different specifications of the model are presented here. A model making use of the energy consumption data is presented, and a model of household characteristics is presented. There are two reasons for doing this: 1) Energy consumption and their costs are correlated with many important household characteristics. 2) The sample of households in the housing characteristics model is much larger than the sample of households for which gas and electric consumption data is available. Variables that considered for inclusion in the model are listed on table 30.

The probit model has the following general form:

$$\mathbf{I^i = \beta 1 + \beta 2X^i \ldots n}$$

$$\mathbf{P^i = P(Y = 1|X) = P(I^{i*} = I^i) = P(Z^i = \beta 1 + \beta 2X^i)}$$

The dependant variable is a dummy representing a household that has implemented an energy efficiency measure. The independent variables are a combination of continuous and dummy variables. The model is estimated using maximum likelihood estimation. The parameters are then translated into their more understandable marginal effects. The probability of implementing an energy efficiency measure is calculated at each observation given the explanatory variables. A probability greater than .50 indicates that the household is likely to implement an energy saving measure. For our purposes, we would like to know if a household is more or less likely to implement an energy saving measure than the average household. The marginal effects are expressed in terms of a unit change in the explanatory variable, which changes the probability of implementing an energy efficiency measure by x from the sample average.

The marginal effects are calculated at the means of explanatory variables as recommended by Greene (Greene, p. 668). Dummy variables have a slightly different interpretation in their marginal effects, because it may not be proper to examine the marginal effect at the mean of a dummy variable. The dummy variable equivalent of an average is the mode of the variable in the sample. This would be the typical case, or an average case in the sample of observations. However, Green counters this hypothesis by stating that, "Simply taking the derivative with respect to the binary variable as if it were continuous provides an approximation that is often surprisingly accurate" (Green, p. 668). The distribution of ones and zeros in the samples presented are heavily skewed distributions, so taking the average of the binary variable will not vastly differ in its marginal effect from using the mode of the binary variable. Both of the models presented here employ the marginal effect of a dummy variable at the modes, however, the difference is within one percent of calculating the dummy variables at the mean.

The Consumption Model

The specification of the energy consumption model is:

$$\textbf{Action} = \alpha + \beta 1 \textbf{ (Total Energy Cost / Square Footage)} + \beta 2 \textbf{ Old House}$$
$$\beta 3 \textbf{ Pool} + \beta 4 \textbf{ Rent} + \varepsilon$$

The Variables are:

Action = 1 or 0, 1 if took action to implement energy efficiency measures, 0 otherwise

Total Energy Cost = Annual household energy cost for electric and gas consumption. This is the Normalized Annual Consumption multiplied by the marginal cost of fuel for each fuel source summed together (refer to appendix for explanation)

Square Footage = The square footage of house

Old House = 1 or 0, 1 if older than 40 years, 0 otherwise

Pool = 1 or 0, 1 if household owns pool, 0 otherwise

Rent = 1 or 0, 1 if inhabitant rents house, 0 if inhabitant owns house

The total energy cost represents both the energy consumption of the household, and the economic cost to the household of consuming the energy. The energy cost is divided by square footage to control for the influence of house size in the model. The variable now represents the relative energy intensity per square foot of home. Our consumption analysis would suggest that as energy cost per square feet increases, the probability of implementing an energy efficiency measure should decrease.

Owning a home is thought to greatly increase the payback of implementing an energy efficiency measure, therefore increasing the probability of taking action. Renters are not likely to make permanent energy efficiency improvements to their homes, as they have no incentive to do so. Renters can and do buy energy efficient appliances that they can take with them when they move to a different home. Renters can also take advantage of a home energy review that informs households of immediate and temporary energy saving measures. The rent variable is a dummy variable signifying that the household rents. There is a significant number of renters who implemented energy saving measures, we wish to include this in the model.

The Home Energy Analyzer does not gather household income from the participants. There are a number of suitable proxy variables that are likely to be correlated with household income. Economic theory would suggest that households with a higher income have the upfront capital needed to invest in energy saving measures. Model one tests this hypothesis. Square footage is likely to be correlated with household income. Larger homes should be positively correlated with a higher household income. Owning a pool is very likely to be correlated with a higher household income. The consumption model employs a dummy variable that identifies households with a pool to investigate an income effect in the model.

Old homes are more likely to benefit from energy saving measures than new homes. Many old homes were not built with wall, floor, or attic insulation. Old homes are likely to have older windows with substantial heat loss, and more likely to have developed air leaks over time. The consumption model employs a dummy variable for houses that are older than 40 years old. Homes older than 40 years are chosen because the Home Energy Analyzer asks participants about the age of their home, and this was the oldest category that could be chosen.

The results of the model are listed on table 31, along with the marginal effects on table 32. The sample distribution of the energy cost per square foot is provided in figure 5 of the appendix, as well as the distribution of dummy variables in table 33. Only cost per square foot and rent variables are significant at the 95% confidence level.

The average probability of any household in the model being an action taking household is 32%. The ratio of total energy cost to square footage is an index of energy intensity per home. If energy intensity increases by one dollar per square foot, the probability of taking action decreases by 12%. If the home is older than 40 years, the probability that the household is an action taker increases by 4%. If the household owns a pool, the probability of taking action decreases by 10%. It must be noted that the old home and pool variables are not significant in the model. These variables appear due to their theoretical significance. If the household is renting the home, the probability of taking action decreases by 28%. As expected, this means that renting decreases the probability of taking action to only 3%.

Table 31
Probit Model Results for Consumption Model

Variable	Coefficient	Standard Error	T - Ratio
Energy Cost / Sqft	-0.45	0.15	-2.94
Old House	0.12	0.10	1.17
Pool	-0.28	0.23	-1.21
Rent	-0.79	0.31	-2.58
Constant	-0.25	0.15	-1.66
Log Likelihood Value		-422.26	

Table 32
Probit Model Marginal Effects for Consumption Model

Average Probability of Taking Action = 32%

Variable	Marginal Effect
Energy Cost / Sqft	- 12%
Pool	-10%
Old House	4%
Rent	- 28%

The results of this model verifies our hypothesis that action takers consume less total energy per year and have lower energy costs relative to house size than participant homes. In this sample of homes, decreasing the dollars spent on energy per square foot increases the likelihood that the home is an action taking household. Action taking households may use energy more efficiently because they have implemented energy saving measures that lower their annual consumption, or they practice unobservable energy efficient behavior.

The House Characteristics Model

Housing characteristics and appliances are the main determinants of energy consumption. The Home Energy Analyzer has provided us with many variables which are significant drivers of energy use, and have significant explanatory power in determining which households are likely to be action takers. Many variables are correlated with each other, so the final specification of the model employs variables that are the most statistically significant, and most important theoretically.

The house characteristics model specification is:

$$\text{Action} = \alpha + \beta 1 \log(\text{Square Footage}) + \beta 2 \text{ AC's} + \beta 3 \text{ Second Fridge} + \beta 4 \text{ Gas Heat} + \beta 5 \text{ Rent} + \varepsilon$$

The Variables Are:

Square Footage = Square footage of the house

AC's = The number of room air conditioners in the household

Second Fridge = 1 or 0, 1 if has a second fridge, 0 otherwise

Gas Heat = 1 or 0, 1 if gas heat, 0 if otherwise

Rent = 1 or 0, 1 if inhabitant rents house, 0 if inhabitant owns house

These household characteristics are shown to be correlated with households taking or not taking action to implement energy saving measures in their home. Action takers have a larger average house size in square feet than participants. The square footage variable will verify or overturn this hypothesis. The square footage is logged because it fits better with the rest of the variables, which have a small quantitative range or are dummy variables. The log of square footage is also useful for ease of interpretation. A percent change in square footage will influence a percent change in probability of taking action.

Owning a second fridge is a proxy for energy using behavior and consumerism. Households that are energy conscious are unlikely to have a second fridge. Refrigerators are a significant end use of electricity in a typical home, especially older less efficient fridges that tend to be second fridges. The second fridge variable is a proxy for the personality of the inhabitants. Households with two fridges are also likely to have increased holdings of other common appliances. Having a second fridge is highly correlated with the quantity of light fixtures, number of inhabitants, and the number of showers per week, and the number of televisions.

The number of room air conditioners represents households that do not have central air conditioning, but use window mounted air conditioners. Most houses built ten years ago and previous in Oregon do not have central air conditioning. Central air conditioning is not a significant variable for this reason. The number of room air conditioners represents a households desire for air conditioning. The basic analysis suggests that action takers are thought to have less of a desire for air conditioning. Similar to the second fridge variable, this variable also is a proxy for energy using behavior. Energy conscious households may not desire air conditioning, the model tests this hypothesis.

The basic analysis suggests that households with gas heat should be more likely to be action takers than households with electric or other heating fuels. The model will reveal if this hypothesis holds up at the individual household level. The house characteristics model includes a dummy variable that represents a house with gas space heating. The rent variable which was included in the consumption model, also appears in the house characteristics model. It adds significant explanatory power to the model, and is not correlated with other independent variables.

Table 34
Probit Model Results for House Characteristics Model

Variable	Coefficient	Standard Error	T - Ratio
Square Feet	0.13	0.05	2.63
Air Conditioners	-0.08	0.03	-2.34
Second Fridge	0.10	0.05	-2.01
Gas Heat	0.29	0.04	7.57
Rent	-0.59	0.08	-7.19
Constant	-1.81	0.38	-4.76

Log Likelihood Value	-3166.8

Table 35
Probit Model Marginal Effects for House Characteristics Model

Average Probability of Taking Action = 30%

Variable	Marginal Effect
Square Feet	5%
Air Conditioners	- 3%
Second Fridge	-4%
Gas Heat	10%
Rent	-20%

The results of the model are presented in table 34 along with the relevant marginal effects on table 35. The distribution of square footage and other variables are presented in figure 6 and table 36 in the appendix. All of the variables are significant at the 95% confidence level.

The probability of a house in the sample population of 5,840 taking action is 30%. The marginal effects are a change in the probability from the average probability. A 1% increase in square footage, increases the probability of taking action by 5%. The model verifies our hypothesis that action takers have larger homes. If a household adds a room air conditioner to its stock of appliances, the probability that it is an action taking household decreases by 3%. The model verifies our hypothesis that action takers are less likely to have air conditioning. Households that have two fridges are 4% less likely to be action takers. If a house is heated with natural gas, the probability that the household is an action taker increases by 10%. The model verifies our finding in the basic analysis that households with gas heat are more likely to be action takers. Finally, if a household is renting the home, the probability that it is an action taker decreases by 20%. A household that rents only has a 10% probability that it has or will implement an energy saving measure in their home.

The House Characteristics model verifies findings from the basic analysis. The square footage, air conditioning, gas heat, and rent variables in the model all have the correct sign and agree with the preliminary findings. The second fridge variable was not found to be influential in the basic analysis, but is found to have explanatory power in the model. Qualitative choice regression modeling allows influential household and demographic characteristics to be identified at the household level, where influence at the aggregate level was not identified.

V. Conclusion

Qualitative choice modeling is a powerful tool to explain human behavior. This type of modeling, as with any other econometric modeling is not with out its weaknesses however. A good model is best used to supplement a more general statistical analysis of data, and refute or verify the hypotheses reached. The probit model verified hypotheses that were developed from a basic analysis of the households and their characteristics. The model also found one significant variable that was not found to be important in the basic analysis.

Some inferences can be made regarding the demographics and characteristics of action takers. Action takers are shown to have slightly larger homes than participants, but lower energy consumption for those with gas heat. Larger household energy consumption decreases the probability of taking action, as does owning a pool and having the amenities of air conditioning and a second fridge. This suggests that action takers may be middle income households that are energy conscious. These households are not conspicuous consumers, and appear to own less appliances than participants. Households that do not take action appear to have significantly more consumption as a result of increased appliance holdings, that are more likely to be standard efficiency models.

Inferences from the model agree with economic theory in the sense that low income and high income households appear not to implement energy saving measures. Low income households cannot afford the incremental and extraordinary costs that are associated with energy saving appliances and measures. High Income households may choose not to implement energy saving measures because the economic benefit of saving energy is not large enough for them to care about. The fact that households with higher levels of consumption and increased appliance holdings are less likely to implement energy saving measures disagrees with economic theory. Unobservable forces are at work. Further analysis is required to determine to what extent environmental benefits and long term societal benefits cause households to act. Environmental concern is entirely absent from this analysis, but is arguably the most important unobservable factor.

There are many more and dynamic ways to make use of this rich dataset to study household energy using behavior. This paper sought to explain which households are likely to implement energy saving measures in their homes, given the characteristics that describe them and their house. The basic analysis and the qualitative choice model successfully identified certain key characteristics that are correlated with, and may identify energy efficient behavior.

To summarize, this analysis finds that:

- 23% - 25% of households that participate in the Home Energy Analyzer have implemented energy efficiency measures in their home. These people are considered “action takers.”
- 56% of action takers implemented energy efficiency measures prior to taking the Home Energy Analyzer.
- 24% of action takers who implemented a measure before using the tool, also implemented an energy saving measure after using the tool.
- 13% of households who were found to implement energy efficiency measures, were caused to do so by the Home Energy Analyzer.
- Clothes Washers and Home Energy Reviews are the most common measures implemented.

- Action taking homes tend to be larger than homes that were not found to implement energy saving measures, these are called "participants"
- Action taking homes use less total energy per square foot, and have lower total energy costs per square foot than participants.
- Households that rent are very unlikely to implement energy efficiency measures.
- Action taking households are less likely to have a second fridge.
- Action taking households use air conditioning less than participant households.
- Households that space heat with natural gas are more likely to be action takers.
- The energy consumption model does a better job than the house characteristics model at explaining action taking households.

Appendix

Table 6a
Action Taking Non Single Family Detached Households

Housing Type	Number of Households	Most Common Measures
Apartment / Condo	95 (32%)	Clothes Washer - 59 Dishwasher - 15
Mobile Home	123 (41%)	Clothes Washer - 78 Duct Sealing - 42
Semi Detached Duplex	15 (5%)	Clothes Washer - 11
Townhouse / Duplex	46 (15%)	Clothes Washer - 20 Home Energy Review - 7
Other	18 (7%)	Clothes Washer - 8
TOTAL	**297**	

Table 28
Electric and Gas Space Heating Measures

Measure	Installed Measures – Electric Heat	Installed Measures – Gas Heat
Free CFL's	95 (18%)	397 (19.4%)
Window	9 (1.7%)	26 (1.3%)
Water Heater	4 (0.7%)	24 (1.1%)
Fridge	5 (1%)	21 (1%)
Insulation	30 (5.8%)	96 (4.6%)
Heat Pump	32 (6.2%)	6 (0.2%)
Boiler	0 (0%)	1 (0%)
Gas Furnace	11 (2.1%)	176 (8.6%)
Clothes Washer	164 (31.7%)	580 (28.3%)
Home Energy Review	50 (9.7%)	234 (11.4%)
Duct Work	13 (2.5%)	82 (4%)
Lighting	26 (5%)	115 (5.6%)
Dishwasher	46 (8.9%)	156 (7.6%)
Weatherization	8 (1.5%)	43 (2.1%)
Water	24 (4.6%)	89 (4.3%)
TOTAL	**517**	**2046**

Table 29
Distribution by City – All Housing Types – All Participants

City	Number of Action Takers	Population	Participation Rate
Albany	36	249	14%
Aloha	28	114	24%
Astoria	4	74	5%
Beaverton	124	833	15%
Bend	36	177	20%
Central Point	10	63	16%
Clackamas	22	91	24%
Coos Bay	7	101	7%
Cornelius	5	46	1%
Corvallis	61	401	15%
Cottage Grove*	3	33	9%
Dallas	22	97	23%
Eugene*	7	205	3%
Forest Grove	3	37	8%
Grants Pass	24	212	11%
Grants Pass	12	239	5%
Gresham	31	235	13%
Hillsboro	70	488	14%
Hood River	7	40	17%
Keizer	9	66	14%
Klamath Falls	17	113	15%
Lake Oswego	29	196	15%
Medford	41	270	15%
Milwaukie	30	169	15%
Molalla	4	36	11%
Newberg	14	84	17%
Oregon City	18	167	11%
Portland	551	3573	15%
Pendleton	1	28	4%
Prineville	6	30	20%
Redmond	7	33	21%
Roseburg	17	124	14%
Salem	104	648	16%
Sherwood	13	87	15%
Silverton	9	37	24%
Springfield*	3	48	6%

Sweet Home	7	34	21%
Tigard	49	221	22%
Troutdale	13	93	14%
Tualatin	17	123	14%
Vancouver (WA)	0	53	0%
West Linn	23	128	18%
Wilsonville	13	71	18%
Total	**1,489**	**9,858**	**15%**

* Not in Energy Trust electric territory

Table 30
Variables Considered in for the Model

Computers	Number of computers
Ceiling Fans	Number of ceiling fans
Air Conditioners	Number of air conditioners
Space Heaters	Number of space heaters
Square Feet	Square footage of house
People	Number of people in house
Dishwashers	Number of dishwashers
House Age	Age of house – 5 classes
Levels	Number of house levels
Electric Heat	Dummy for electric heat
Gas Heat	Dummy for gas heat
Other Heat	Dummy for other heat
North Portland	Dummy for house in N Portland
South East	Dummy for house in SE Portland
South West	Dummy for house in SW Portland
North West	Dummy for house in NW Portland
North East	Dummy for house in NE Portland
Water Heater Temperature	Temperature in degree classes
Lighting	Classes for lighting behavior
Double Paned Window	Number of windows double paned
Electric Water Heater	Dummy for water heating fuel
Rent	Dummy for renting house
Basement	Dummy for house with basement
Hot Tub	Dummy for having hot tub
Pool	Dummy for having pool
Central Air	Dummy for central air
Old House	Dummy for house > 40 years
Oven Fuel	Dummy for electric oven

Attic	Dummy for house with attic
Clothes Washer Loads	Number of loads per week
Dryer Loads	Number of loads per week
Dishwasher Loads	Number of loads per week
TV's	Number of Televisions
Day Heating	Degree setting of thermostat in living area
Evening Heating	Degree setting of thermostat in living area
Night Heating	Degree setting of thermostat in living area
Baths	Number of baths per week
Showers	Number of showers per week
Attic Insulation	Level of attic insulation
Second Fridge	Dummy for having second fridge
Lighting Fixtures	Number of light fixtures in house
Water Heater Tank	Size of water heater tank

Table 33
Distribution of Dummy variables in Consumption Model

Action	1 = 29% 0 = 71%
Rent	1 = 5% 0 = 95%
Pool	1 = 6% 0 = 94%

Distribution of Cost Per Square Foot

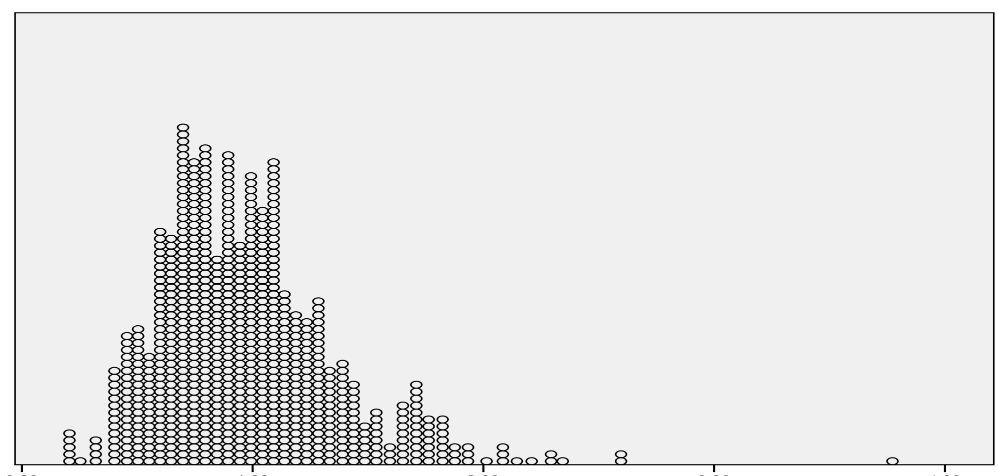
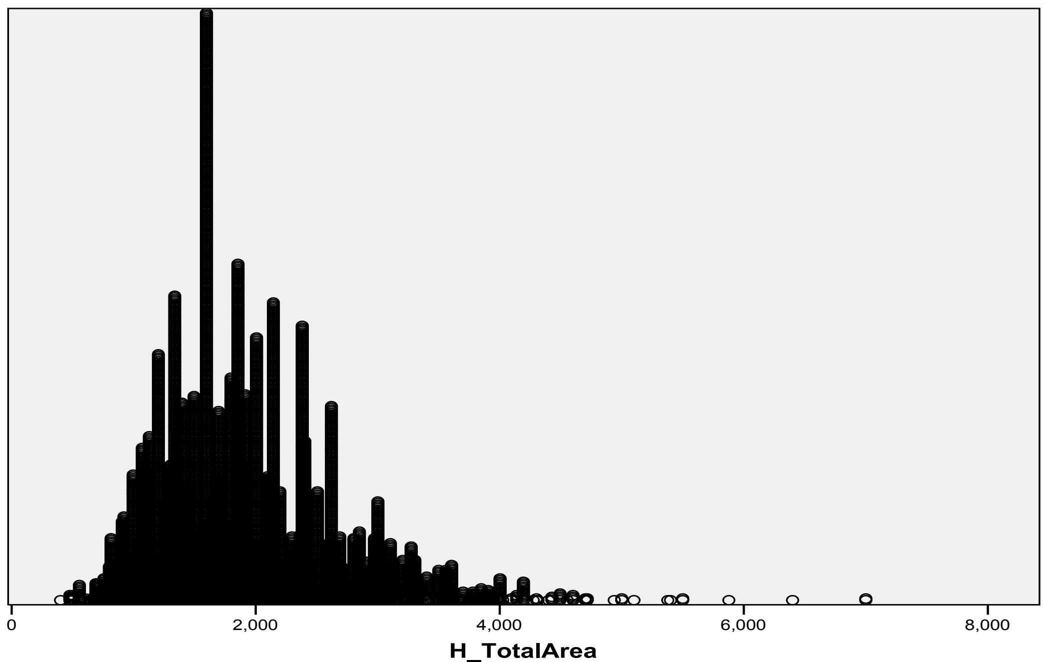


Table 36
Distribution of Dummy Variables in House Characteristics Model

Action	1 = 24% 0 = 76%
Second Fridge	1 = 17% 0 = 83%
Gas Heat	1 = 61% 0 = 39%
Rent	1 = 8% 0 = 92%

Distribution of Square Feet



Normalized Annual Consumption

The consumption for each household was calculated by taking monthly meter reads from October 2005 – September 2006 for households that had a full one years worth of data available. One year was considered to be 360 – 370 days, since meter reads are not always on the same length. To normalize the consumption to account for this, the kWh and therm consumption was summed for the 12 months and then divided by 365 to get an average daily consumption rate. This was then multiplied by 365 to get the normalized annual consumption (NAC).

Energy Cost Calculations

The cost estimates employed the marginal cost of electricity and gas as published on each utilities regulatory affairs portion of their websites. The NAC for each participant with billing data was multiplied by their respective marginal rates. The marginal rates used are:
Portland General Electric - $0.0961 / kWh
Pacific Power - $0.0755 / kWh
NW Natural Gas - $1.41 / Therm

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