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EVALUATION OF THE HOME ENERGY REPORT PROGRAM

Prepared for:
City of Palo Alto Utilities

CITY of PALO ALTO

March 12, 2012

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Table of Contents

Section 1. Executive Summary 1

1.1 Evaluation Objectives 1
1.2 Evaluation Methods 1
1.3 Key Findings and Recommendations 1

Section 2. Introduction to the Program 3

2.1 Program Description 3
2.2 Evaluation Objectives 3

Section 3. Evaluation Methods 5

3.1 Description of the Data 5
3.1.1 Type of Energy Consumption 5
3.1.2 Criteria for Including Household Data in the Analysis 6
3.2 Analytical Method 6

Section 4. Program Results 9

4.1 Overall Results 9
4.2 Results by Energy Consumption Level 12

Section 5. Conclusions and Recommendations 15

5.1 Conclusions 15
5.2 Recommendations 15

Section 6. Appendix 17

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Section 1. Executive Summary

This report presents the energy impact evaluation of the first year of the City of Palo Alto Utilities (CPAU) Home Energy Reports (HER) behavioral program. The objective of the program is to alter residential customer energy use by providing particular sets of information about customer energy use and energy conservation. The information is provided in the form of Home Energy Reports, which give customers various types of information, including: a) how their recent energy use compares to their energy use in the past; b) tips on how to reduce energy consumption, some of which are tailored to the customer's circumstances; and c) information on how their energy use compares to that of neighbors with similar homes. CPAU sent the first batch of reports to nearly 20,000 residential customers during the month of November 2010. This set of information has been shown in other studies to stimulate customers to reduce their energy use, creating average energy savings in the 1% to 3% range, depending on local energy use patterns. HER programs typically target households with high energy consumption, which have been shown to be more responsive to the program than low energy consumers. The Palo Alto program does not restrict the program to high energy consumers, and so savings are expected to be lower than observed elsewhere.

1.1 Evaluation Objectives

The main objective of the evaluation is to verify the electricity and gas savings impact of the first year of the HER program. Additionally, Navigant investigates how savings vary by season and by the level of a household's energy consumption in the pre-program year.

1.2 Evaluation Methods

Navigant used a linear fixed effects regression (LFER) model to estimate program savings. We modeled gas and electricity savings separately. The LFER model combines both cross-sectional and time series data in a panel dataset. The data consists of billing data both before and after the start of the program, for both treatment (program) households receiving the Home Energy Reports, and control households that do not receive the report. Importantly, the program enlists an experimental design; household are randomly allocated to the control and treatment groups. This eliminates the issue of selection bias that complicates the evaluation of many behavioral programs. The basic LFER model casts the average daily energy consumption as a function of a household-specific constant term, a variable indicating whether the observation is in the pre- or post-program period, and a variable indicating whether the household is a treatment (program) household or a control household.

1.3 Key Findings and Recommendations

The total estimated annual energy savings for the first year of the HER program were 1,635 MWh and 17.5 MDth. On a percentage basis, average electricity savings was 1.88% for customers in the high consumption group, 2.11% for customers in the medium consumption group, and 0.52% for customers in the low consumption group, with an overall electricity savings of 1.46%. Gas savings were 2.71%, 0.93%, and 2.29%, respectively, with an overall gas savings of 2.10%. These savings estimates are slightly below savings from similar programs in the first year of the program. This is not surprising, however, as

CPAU's HER program encompasses nearly all residential customers in the service territory, whereas other utilities target customers with high energy consumption in their HER programs.

The reported savings from FY 2011 (July 2010 to June 2011) were 420 MWh and 9.3 MDth. This period is comparable to the winter 2010-2011 and spring 2011 seasons, as described in the body of the report. Navigant estimated total savings of 167 MWh and 11.6 MDth for the winter and spring seasons. The reported savings values fall within the 90% confidence intervals on Navigant's savings estimates: -560 to 894 MWh and 3.9 to 19.3 MDth, respectively.

Section 2. Introduction to the Program

2.1 Program Description

The Home Energy Reports (HER) program began on November 20, 2010. The program involved nearly 20,000 treatment households and a randomly selected control group of 1,000 households. Treatment households receive bi-monthly reports containing information about: a) how their recent energy use compares to their energy use in the past; b) tips on how to reduce energy consumption, some of which are tailored to the customer's circumstances; and c) information on how their energy use compares to that of neighbors with similar homes. Other studies have shown that this set of information stimulates customers to reduce their energy use, creating average energy savings in the 1% to 3% range, depending on local energy use patterns. These savings usually reflect the selection into the program of high energy consumers, which have been shown to be more responsive to the program than low energy consumers. The Palo Alto program does not restrict the program to high energy consumers, and so savings are expected to be lower than observed elsewhere.

2.2 Evaluation Objectives

The main objective of the evaluation is to verify the savings impact in the City of Palo Alto Utilities (CPAU) service territory during the first year of the HER program. Additionally, the evaluation investigates how savings vary by season and by a household's level of energy consumption in the pre-program year.

Section 3. Evaluation Methods

3.1 *Description of the Data*

Navigant received the monthly electric and gas billing data for all residential customers in the CPAU service territory for the period of October 2009 to November 2011. Navigant linked weather data (heating and cooling degree days) and the list of program participants and control households to the monthly billing data. The final dataset consists of data from 20,537 households.

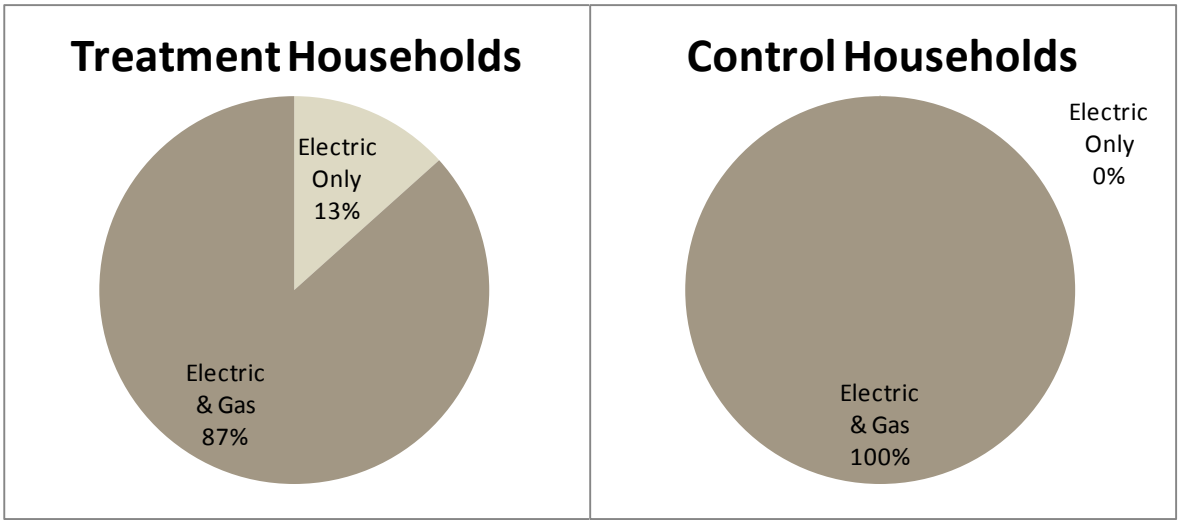
3.1.1 Type of Energy Consumption

This analysis concerns both electric and gas savings; however, not all households in the analysis consume both electricity and gas. Table 3.1 and Figure 3.1 below show the distribution of households by type of energy consumption and treatment group.

Table 3.1. Type of Energy Consumption, Number of Households

	Electric Only	Electric & Gas	Total
Control	0	992	992
Treatment	2,613	16,932	19,545
Total			20,537

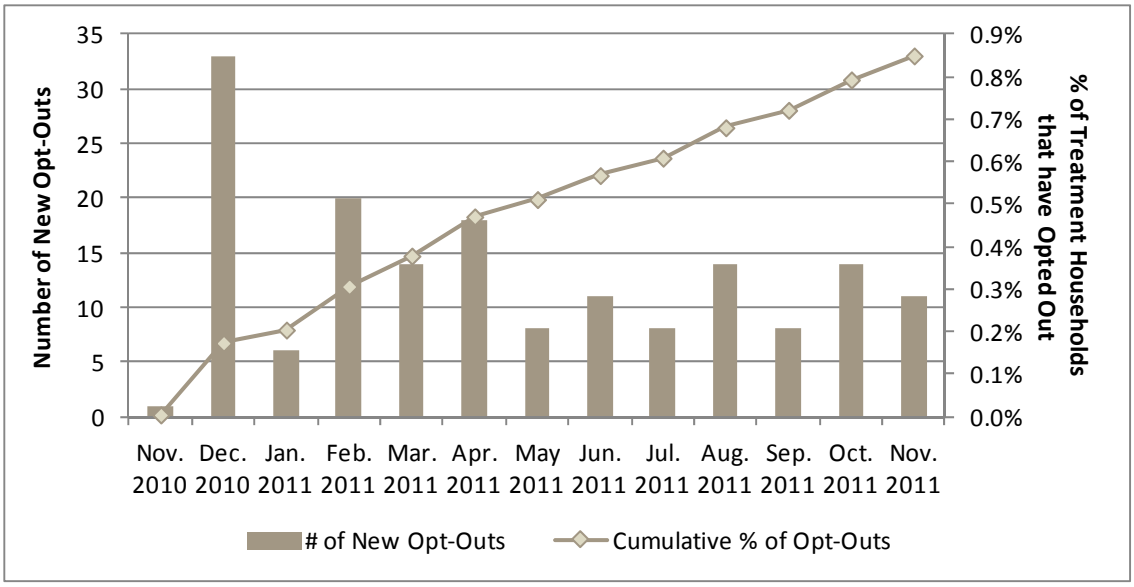
Figure 3.1. Type of Energy Consumption, Percentage of Homes



3.1.2 Criteria for Including Household Data in the Analysis

Treatment households have the option to opt out of receiving the reports. In the first year of the program, less than 1% of treatment households opted out of the program. Figure 3.2 shows the distribution of opt-out households by month. Households that opted out of the program are excluded from this analysis.

Figure 3.2. Frequency Distribution of Opt-Out Households, by Month and Cumulative Percent



The regression analysis described below is based on only those customers with at least six months each of pre-program and post-program billing data. As the first reports were delivered in the weeks following November 20, 2010, the post-program period begins on December 20, 2010. In other words, the post-program period begins on the date of the bill after the first Home Energy Report was received, allowing the customers a chance to respond to the information contained in the report.

3.2 Analytical Method

We used a linear fixed effects regression (LFER) model to estimate program savings. The LFER model combines both cross-sectional and time series data in a panel dataset. The regression equation is given by:

Equation 1

$$ADC_{kt} = \alpha_{0k} + \alpha_1 Post_t + \alpha_2 Treatment_k \cdot Post_t + \varepsilon_{kt}$$

Where,

ADC_{kt}	= The average daily consumption (measured in kWh for electricity, or in therms for gas) for customer *k* during billing cycle *t*. This is the dependent variable in the model.
$Post_t$	= A binary variable indicating whether bill cycle *t* is in the post-program period (taking a value of 1) or in the pre-program period (taking a value of 0).
$Treatment_k$	= A binary variable indicating whether customer *k* is in the treatment group (taking a value of 1) or in the control group (taking a value of 0).
α_{0k}	= The customer-specific fixed effect (constant term) for household *k*. The fixed effect controls for all customer-specific effects on energy consumption that do not change over time, such as the number of household members, the size of the dwelling, or a thermostat that is always set at 62F.
α_1, α_2	= Regression parameters corresponding to the independent variables.

The α_1 parameter captures the average effect *among control customers* of being in the post-program period. In other words, it captures the effects of exogenous factors, such as an economic recession, that affect all customers in the post-program period but not in the pre-program period. The sum $\alpha_1 + \alpha_2$ captures the average effect *among treatment customers* of being in the post-program period. The direct effect of the HER program on energy consumption is captured by the α_2 parameter. In other words, this coefficient captures the *difference-in-difference* in average daily energy consumption between the treatment group and the control group across the pre- and post-program periods.

An important assumption in the estimation of the model for electricity use is that the set of control households –all of which use natural gas – is an adequate comparison group for the electric-only households. This assumption is not ideal, but is the best available modeling alternative given that: (a) there are no electric-only control households in the data; (b) electric-only households are only 13% of the program households; and (c) natural gas savings are roughly the same on a percentage basis as electricity savings, in which case one can make the argument that the electricity percent savings by electric-only households is roughly the same as that for households with electric and natural gas.

We estimated Equation 1 at the seasonal level. Seasons are defined as:

- Winter — Bill periods ending between December 20th and March 19th
- Spring — Bill periods ending between March 20th and June 19th
- Summer — Bill periods ending between June 20th and September 19th
- Fall — Bill periods ending between September 20th and December 19th

Average household savings for the season are generated by multiplying a season's estimate of household average daily savings (ADS) by the number of days in the season (90 days for winter, 92 days for spring, 92 days for summer, and 91 days for fall). Importantly, this is an estimate of average household seasonal savings *conditional on the household remaining in the program for the entire season.*

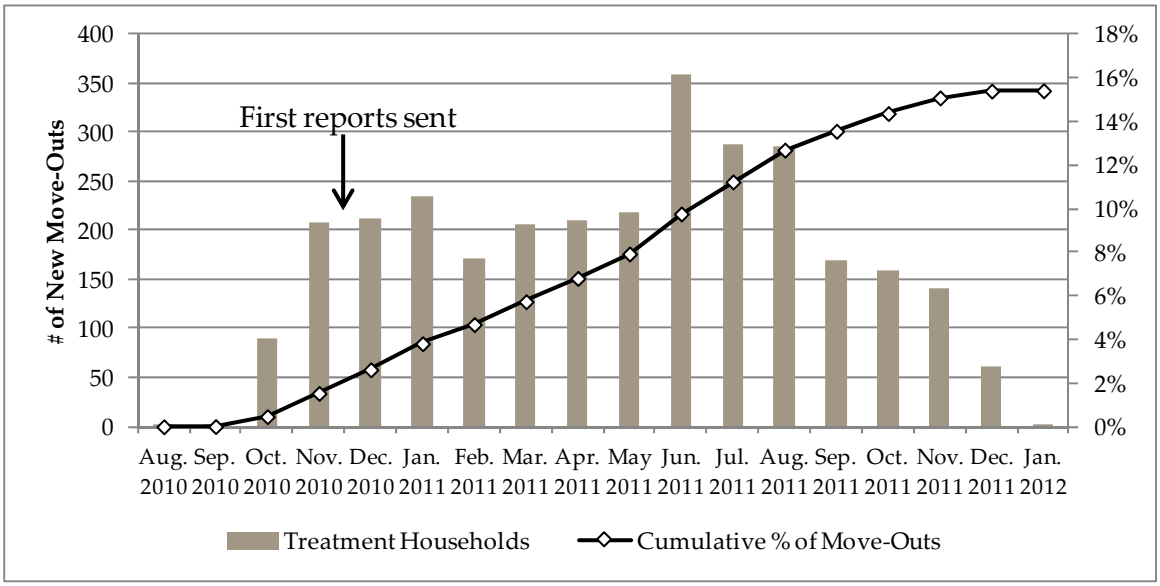
Average annual savings are simply the sum of average savings in each season. *This estimate of average annual savings applies to households that remain in the program for the full year.*

Total program savings in the first year of the program are obtained by summing over savings in each season. Savings in each season are the product of average household seasonal savings and the number of household-days in the sample for the season. This approach takes account of the large number of "move-outs" –households terminating the program due to a change in residence –during the program year. Figure 3.3 shows the number and percentage of move-outs during the program year. This is a much larger percentage than observed in similar home energy report programs evaluated by Navigant, likely due to the fact that, unlike other programs, the Palo Alto program is not restricted to high energy-consuming households, which tend to be located in single-family, owner-occupied dwellings.

The estimate of total program savings is conservative, as it excludes savings by households that opted out of the program (some of whom likely achieved at least some savings from the program), and does not account for the possibility that households that moved out of a program premise may stay in the service area and continue to use the energy tips in the Home Energy Reports to save energy.

Finally, we investigated how program savings vary by the level of household energy consumption. We split the sample into high, medium, and low energy consumption groups for each energy source, based on household energy consumption during the pre-program year (November 20, 2009 to November 19, 2010). We then estimated Equation 1 separately for each group in each season.

Figure 3.3 Frequency Distribution of Move-Out Households, by Month and Cumulative Percent



Section 4. Program Results

4.1 Overall Results

The seasonal parameter estimates for Equation 1 are given in Table 6.1 in the Appendix. This model is the source of annual and seasonal estimates of program savings, given in Table 4.1. Figure 4.1 graphically presents the seasonal percent savings and average savings. The following results emerge from The negative estimate of electric savings in winter 2010-2011 is not statistically significantly different from zero and should be interpreted as no program.

Table 4.1:

- The total estimated annual energy savings for the first year of the HER program were 1,635 MWh and 17.5 MDth.
- Estimated electric savings increase throughout the year on both an absolute and percentage basis. Savings increased from -0.26% savings in winter 2010-2011 (not statistically significant) to 3.68% savings in fall 2011 (statistically significant at the 5% significance level).
- Estimated gas savings follow a different pattern, peaking on an absolutebasis in winter 2010-2011.
- At the 5% significance level, annual electric savings are statistically significantly different from zero. Electric savings are statistically significant in the summer and fall months.
- Annual gas savings are statistically significantly different from zero. Annual gas savings are largely driven by the winter gas savings, which also are statistically significant.

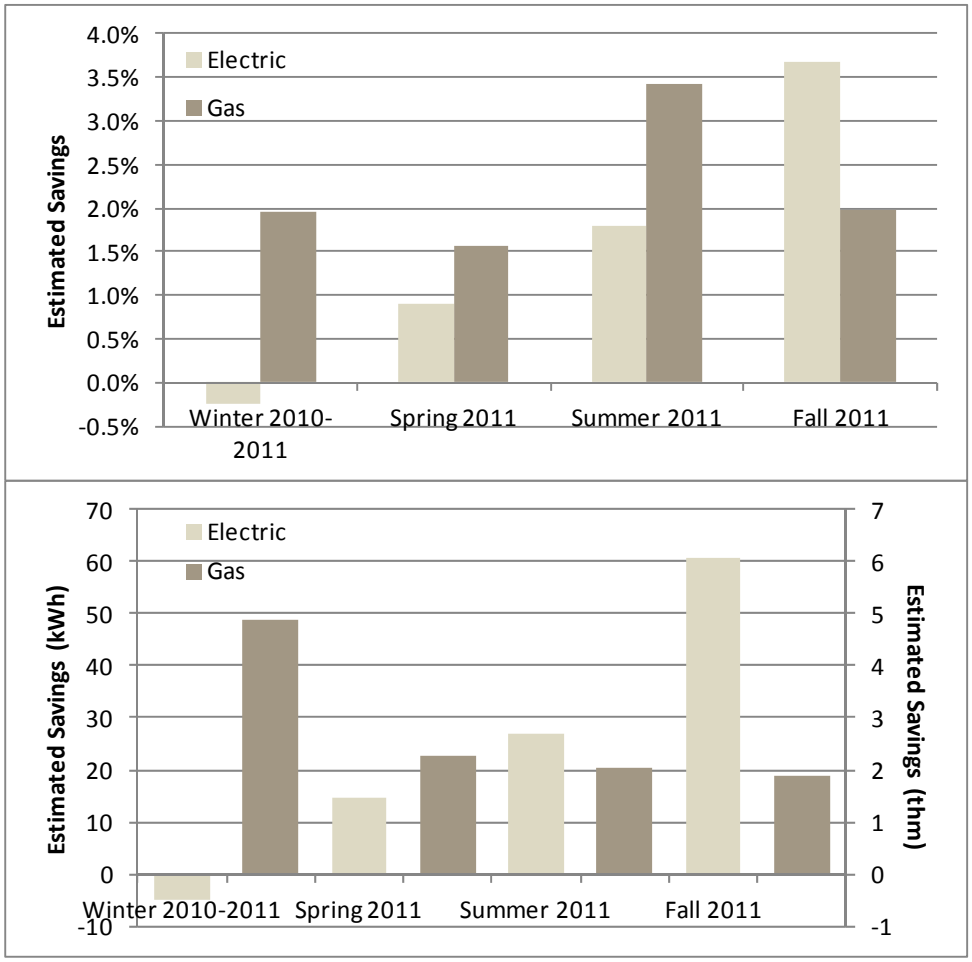
The negative estimate of electric savings in winter 2010-2011 is not statistically significantly different from zero and should be interpreted as no program.

Table 4.1. Estimated Program Savings, Annual and Seasonal

Type of Statistic	Annual	Winter 2010-2011	Spring 2011	Summer 2011	Fall 2011
Electric Model					
Sample Size, Treatment	-	17,710	17,703	17,324	16,608
Sample Size, Control	-	926	926	916	880
Percent Savings	**1.46%**	-0.26%	0.89%	**1.79%**	**3.68%**
(standard error)	*(0.48%)*	*(0.87%)*	*(0.79%)*	*(0.82%)*	*(0.81%)*
kWh Savings per customer	**97.24**	-4.93	14.48	**27.00**	**60.69**
(standard error)	*(27.89)*	*(16.82)*	*(12.76)*	*(12.43)*	*(13.33)*
Total MWh Savings	**1,635**	-93	260	**472**	**996**
(standard error)	*(539)*	*(316)*	*(309)*	*(217)*	*(219)*
Gas Model					
Sample Size, Treatment	-	15,540	15,540	15,277	14,714
Sample Size, Control	-	929	929	919	884
Percent Savings	**2.10%**	**1.95%**	1.57%	3.42%	1.98%
(standard error)	*(0.70%)*	*(0.97%)*	*(1.13%)*	*(2.00%)*	*(2.04%)*
thm Savings per customer	**11.10**	**4.89**	2.27	2.04	1.90
(standard error)	*(3.72)*	*(2.43)*	*(1.64)*	*(1.19)*	*(1.97)*
Total MDth Savings	**17.5**	**8.0**	3.6	3.2	2.8
(standard error)	*(5.8)*	*(4.0)*	*(2.6)*	*(1.8)*	*(2.9)*

*Note: **Bold** values are statistically significant at the 5% level.*

Figure 4.1. Household Percent and Absolute Program Savings, Seasonal



4.2 Results by Energy Consumption Level

Parameter estimates obtained by applying Equation 1 to three separate data sets defined by household energy consumption in the pre-program year are given in Table 6.2 through Table 6.4. This model sheds light on how program savings, given in Table 4.2, vary with level of energy consumption. Figure 4.2 graphically presents the percent savings and average savings by energy consumption level. The following results emerge from Table 4.2:

- Customers in the high consumption group are driving the overall program savings for both electricity and gas. They have the highest estimates of absolute gas and electric savings, and these estimates are statistically significant.
- Estimated savings across the three consumption groups are statistically significantly different, with the exception of electric savings for customers in the high and medium consumption groups and gas savings for customers in the medium and low groups.

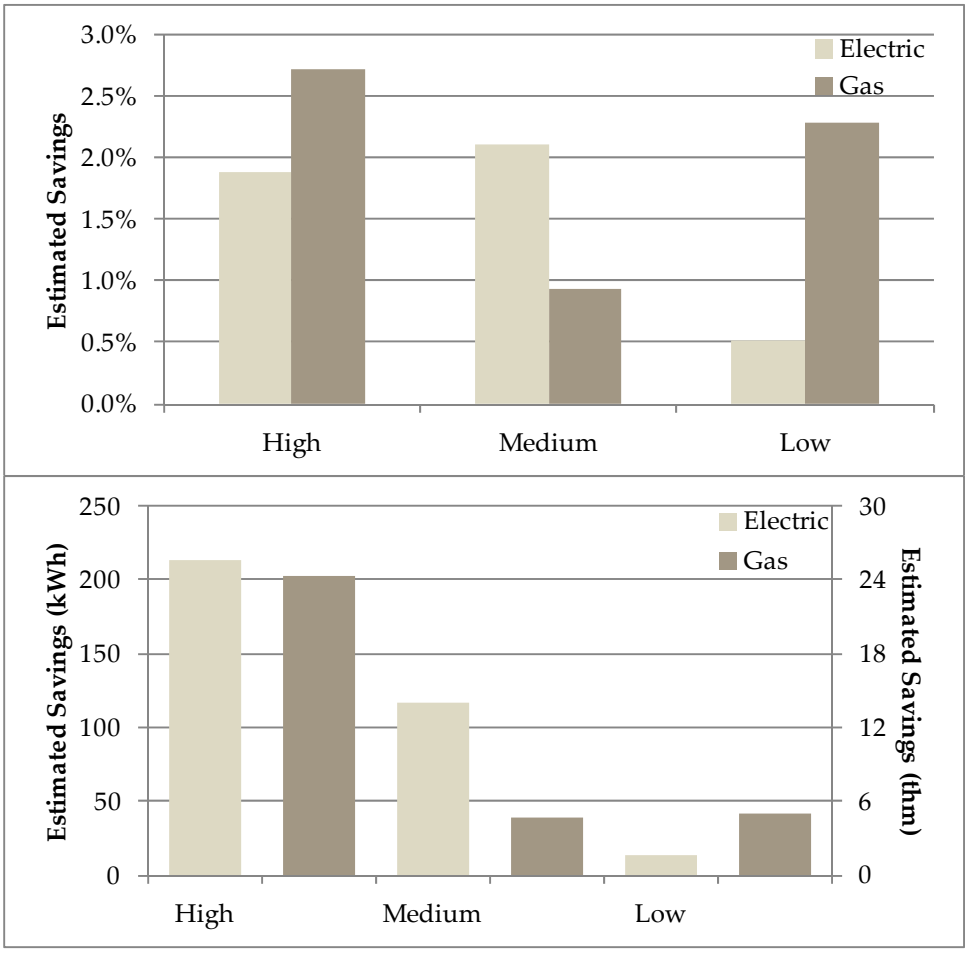
» Despite having moderate electric savings, customers in the medium consumption group had little gas savings.

Table 4.2. Estimated Program Savings, by Energy Consumption Level

Type of Statistic	High	Medium	Low
Electric Model			
Group Definition (kWh/day)	<11.65	11.65 - 20.06	>20.06
Sample Size, Treatment	5,765	5,824	5,747
Sample Size, Control	361	286	266
Percent Savings	**1.88%**	**2.11%**	0.52%
(standard error)	*(0.55%)*	*(0.67%)*	*(1.13%)*
kWh Savings per Customer	**212.96**	**116.28**	13.36
(standard error)	*(59.92)*	*(36.38)*	*(30.14)*
Total MWh Savings	**1,199**	**678**	85
(standard error)	*(351)*	*(216)*	*(185)*
Gas Model			
Group Definition (thm/day)	<1.05	1.05 – 1.79	>1.79
Sample Size, Treatment	5,040	5,047	5,181
Sample Size, Control	312	298	306
Percent Savings	**2.71%**	0.93%	2.29%
(standard error)	*(0.99%)*	*(0.93%)*	*(1.77%)*
thm Savings per Customer	**24.25**	4.70	5.06
(standard error)	*(8.84)*	*(4.62)*	*(4.08)*
Total MDth Savings	**12.4**	2.4	2.8
(standard error)	*(4.5)*	*(2.4)*	*(2.2)*

*Note: **Bold** values are statistically significant at the 5% level.*

Figure 4.2. Percent and Absolute Program Savings, by Energy Consumption Level



Section 5. Conclusions and Recommendations

5.1 Conclusions

The savings estimates from the Home Energy Reports program are slightly below savings from similar programs. This is to be expected, as the City of Palo Alto Utilities program encompasses nearly all residential customers in the service territory, whereas other utilities target customers with high energy consumption in their HER programs. Key findings include:

- The total estimated annual energy savings for the first year of the HER program were 1,635MWh and 17.5 MDth.
- The reported savings from FY 2011 (420 MWh, 9.3 MDth) fall within the 90% confidence intervals around Navigant's estimates of the winter 2010-2011 and spring 2011 savings (167 MWh, 11.6 MDth). Navigant's estimates are not statistically different from the reported savings for FY 2011.
- On a percentage basis, average electricity savings was 1.88% for customers in the high consumption group, 2.11% for customers in the medium consumption group, and 0.52% for customers in the low consumption group.
- On a percentage basis, average gas savings was 2.71% for customers in the high consumption group, 0.93% for customers in the medium consumption group, and 2.29% for customers in the low consumption group.
- In absolute terms, customers in the high consumption group contributed about twice as much electric savings as those in the medium and low groups (1,199 MWh compared to 762 MWh), and roughly twice as much gas savings (12.4 MDth compared to 5.2 MDth).

5.2 Recommendations

Navigant recommends that the HER program remain in its current form for another year. Program savings are rising, and continuing the program for another year will allow for examination of the persistence of program effects.

Section 6. Appendix

Table 6.1. Equation 1 Seasonal Parameter Estimates

Electric Model (kWh)			Gas Model (therms)		
Variable	Coefficient	t-statistic	Variable	Coefficient	t-statistic
Winter 2010 -2011Model					
Post	-0.201	-1.10	Post	0.106	4.00
Post*Treatment	0.055	0.29	Post*Treatment	-0.054	-2.01
Spring 2011 Model					
Post	-0.010	-0.08	Post	0.045	2.59
Post*Treatment	-0.157	-1.13	Post*Treatment	-0.025	-1.38
Summer 2011 Model					
Post	0.045	0.34	Post	0.018	1.43
Post*Treatment	-0.293	-2.17	Post*Treatment	-0.022	-1.71
Fall 2011 Model					
Post	-0.856	-6.04	Post	-0.326	-15.41
Post*Treatment	-0.667	-4.55	Post*Treatment	-0.021	-0.97

Table 6.2. Equation 1 Parameter Estimates, High Consumption Group

Electric Model (kWh)			Gas Model (therms)		
Variable	Coefficient	t-statistic	Variable	Coefficient	t-statistic
Winter 2010 -2011Model					
Post	-0.953	-2.50	Post	0.110	1.82
Post*Treatment	0.159	0.40	Post*Treatment	-0.115	-1.86
Spring 2011 Model					
Post	-0.486	-1.78	Post	-0.012	-0.30
Post*Treatment	-0.319	-1.09	Post*Treatment	-0.042	-1.00
Summer 2011 Model					
Post	-0.262	-0.89	Post	0.026	0.74
Post*Treatment	-0.578	-1.89	Post*Treatment	-0.048	-1.35
Fall 2011 Model					
Post	-1.329	-4.45	Post	-0.536	-10.78
Post*Treatment	-1.591	-5.11	Post*Treatment	-0.061	-1.20

Table 6.3. Equation 1 Parameter Estimates, Medium Consumption Group

Electric Model (kWh)			Gas Model (therms)		
Variable	Coefficient	t-statistic	Variable	Coefficient	t-statistic
Winter 2010 -2011Model					
Post	0.151	0.67	Post	0.065	1.99
Post*Treatment	-0.189	-0.81	Post*Treatment	0.003	0.09
Spring 2011 Model					
Post	0.133	0.73	Post	0.077	3.31
Post*Treatment	-0.196	-1.04	Post*Treatment	-0.033	-1.37
Summer 2011 Model					
Post	0.271	1.63	Post	0.003	0.29
Post*Treatment	-0.386	-2.28	Post*Treatment	-0.002	-0.18
Fall 2011 Model					
Post	-0.712	-3.57	Post	-0.285	-10.44

Post*Treatment	-0.503	-2.47	Post*Treatment	-0.020	-0.70

Table 6.4. Equation 1 Parameter Estimates, Low Consumption Group

Electric Model (kWh)			Gas Model (therms)		
Variable	**Coefficient**	**t-statistic**	**Variable**	**Coefficient**	**t-statistic**
Winter 2010 -2011Model					
Post	0.485	2.20	Post	0.144	4.11
Post*Treatment	-0.046	-0.21	Post*Treatment	-0.049	-1.38
Spring 2011 Model					
Post	0.490	2.89	Post	0.072	3.86
Post*Treatment	-0.110	-0.64	Post*Treatment	-0.002	-0.09
Summer 2011 Model					
Post	0.221	2.22	Post	0.025	2.76
Post*Treatment	-0.011	-0.10	Post*Treatment	-0.016	-1.73
Fall 2011 Model					
Post	-0.337	-2.52	Post	-0.134	-7.99
Post*Treatment	0.021	0.15	Post*Treatment	0.011	0.66