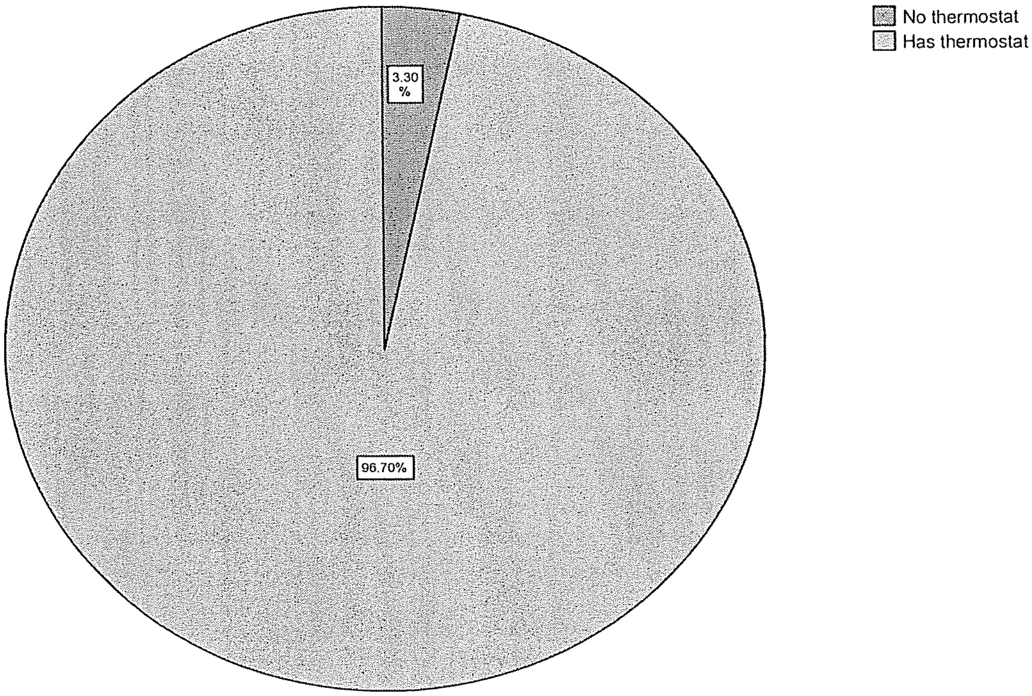
Thermostat Participants vs. No Thermostat Participants

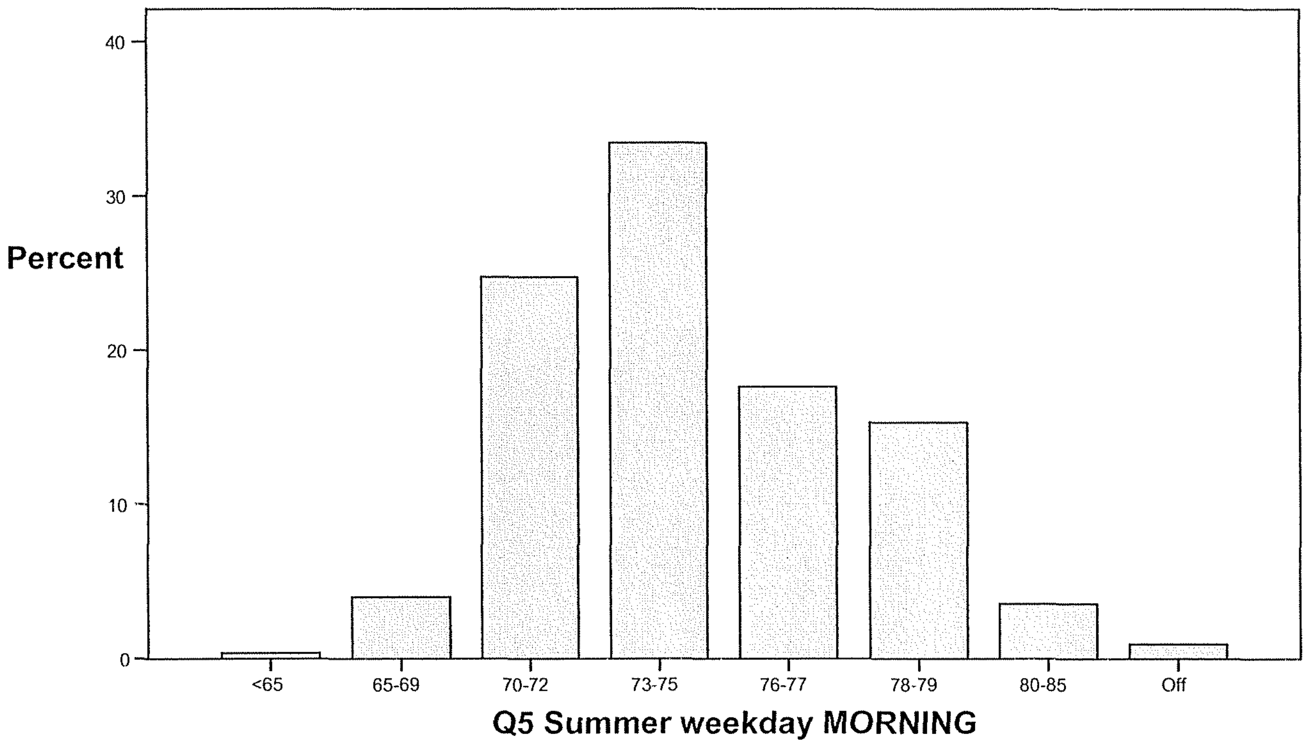
Only about 3.3% of participants have no thermostat. Not having a thermostat is a good indication of an older cooling system. Older systems with no thermostat are less efficient.



Do not have a thermostat

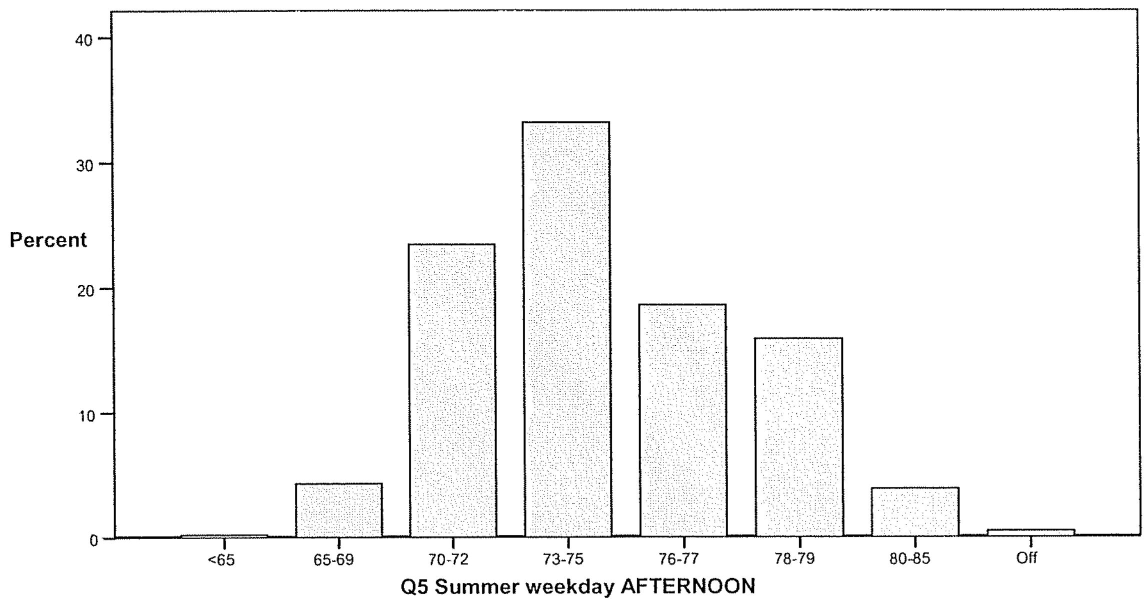
Temperature of Thermostat Summer Weekday Morning

About one third of respondents set their thermostat between 73 to 75 degrees in summer weekday mornings. 37.1% of customers set their thermostat above 76 degrees with .9% of which turn it off during summer morning weekdays.



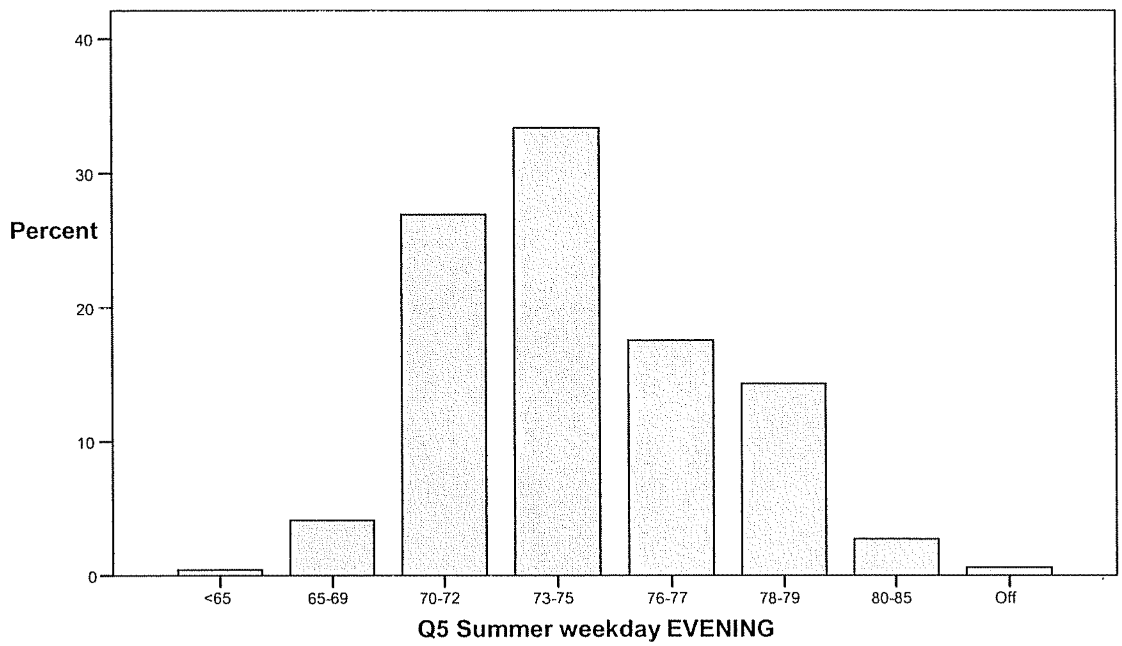
Temperature of Thermostat Summer Weekday Afternoon

About one third of respondents set their thermostat between 73 to 75 degrees. 38.9% of customers set their thermostat above 76 degrees with .5% of which turn it off during summer afternoon weekdays.



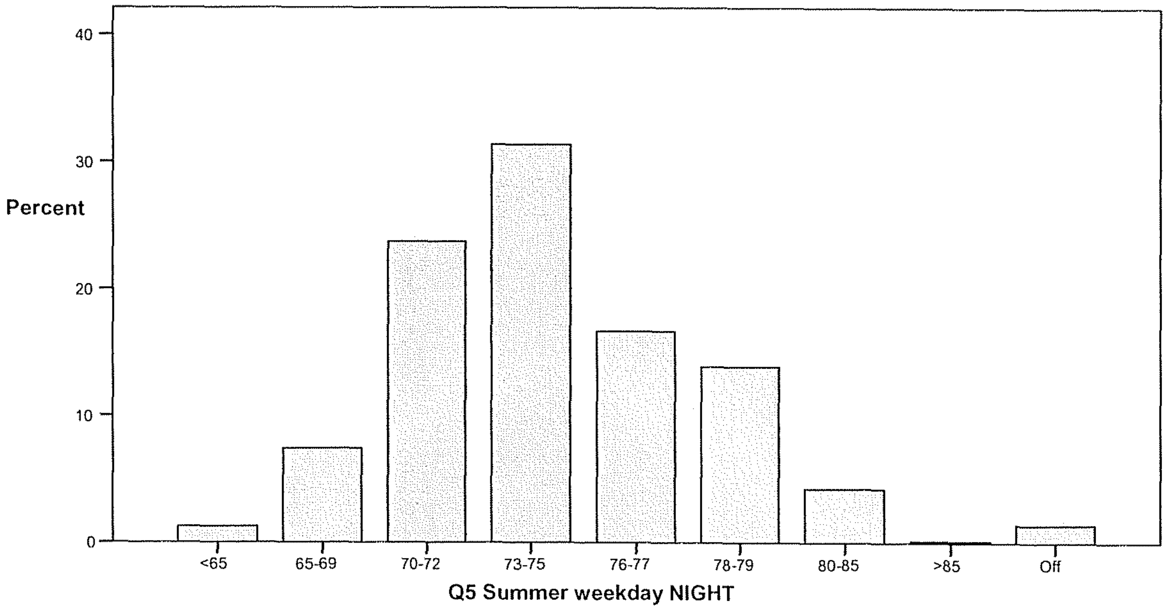
Temperature of Thermostat Summer Weekday Evening

About one third of respondents set their thermostat between 73 to 75 degrees. 35.1% of customers set their thermostat above 76 degrees with .6% of which turn it off during summer evening weekdays.



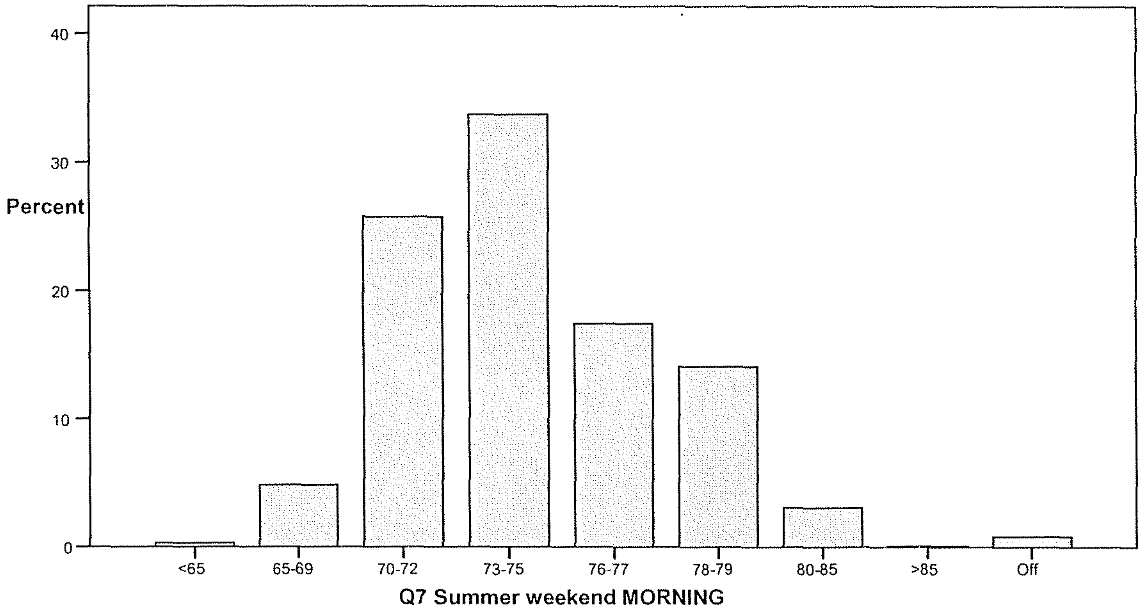
Temperature of Thermostat Summer Weekday Night

Less than one third (31.3%) of respondents set their thermostat between 73 to 75 degrees. 36.4% of customers set their thermostat above 76 degrees with 1.4% of which turn it off during summer night weekdays.



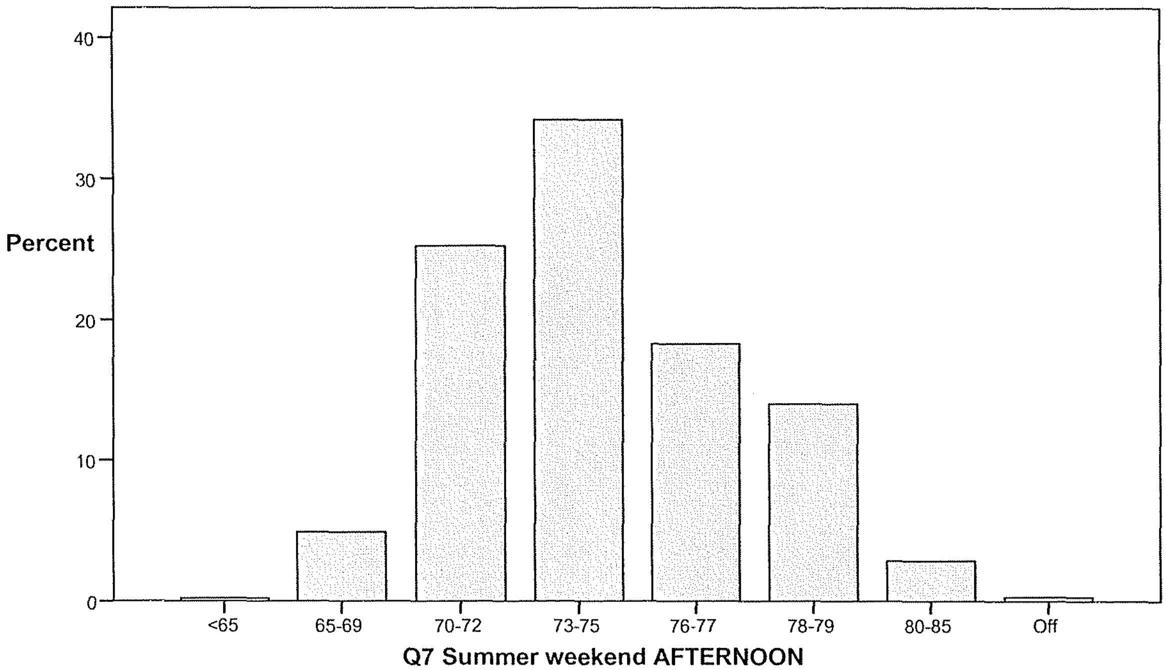
Temperature of Thermostat Summer Weekend Morning

About one third of respondents set their thermostat between 73 to 75 degrees. 35.5% of customers set their thermostat above 76 degrees with .9% of which either set it on higher than 85 degrees or turn it off during summer weekend mornings.



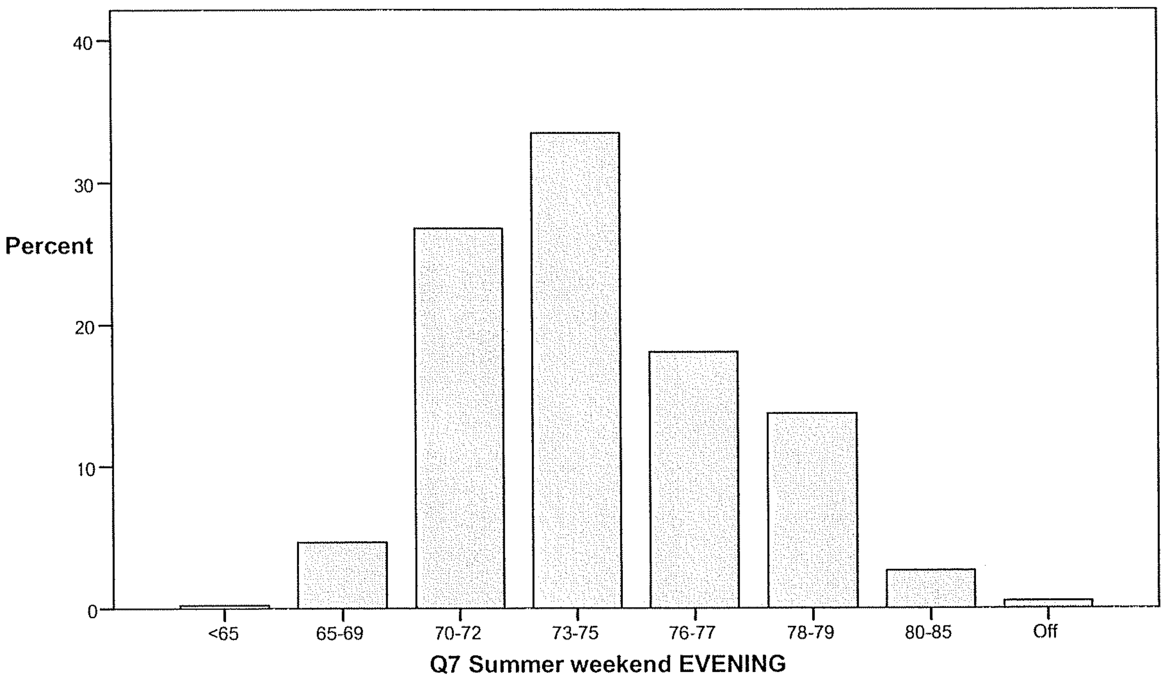
Temperature of Thermostat Summer Weekend Afternoon

More than one third of respondents set their thermostat between 73 to 75 degrees. 35.5% of customers set their thermostat above 76 degrees with .3% of which turn it off during summer weekend afternoons.



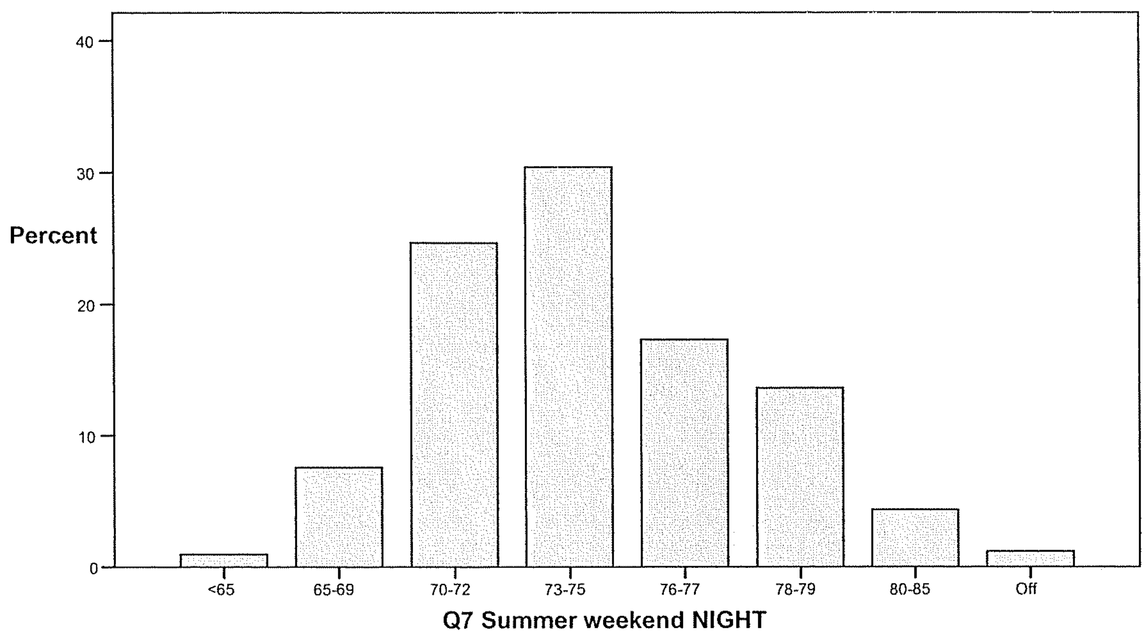
Temperature of Thermostat Summer Weekend Evening

About one third of respondents set their thermostat between 73 to 75 degrees. 35% of customers set their thermostat above 76 degrees with .5% of which turn it off during summer weekend evenings.



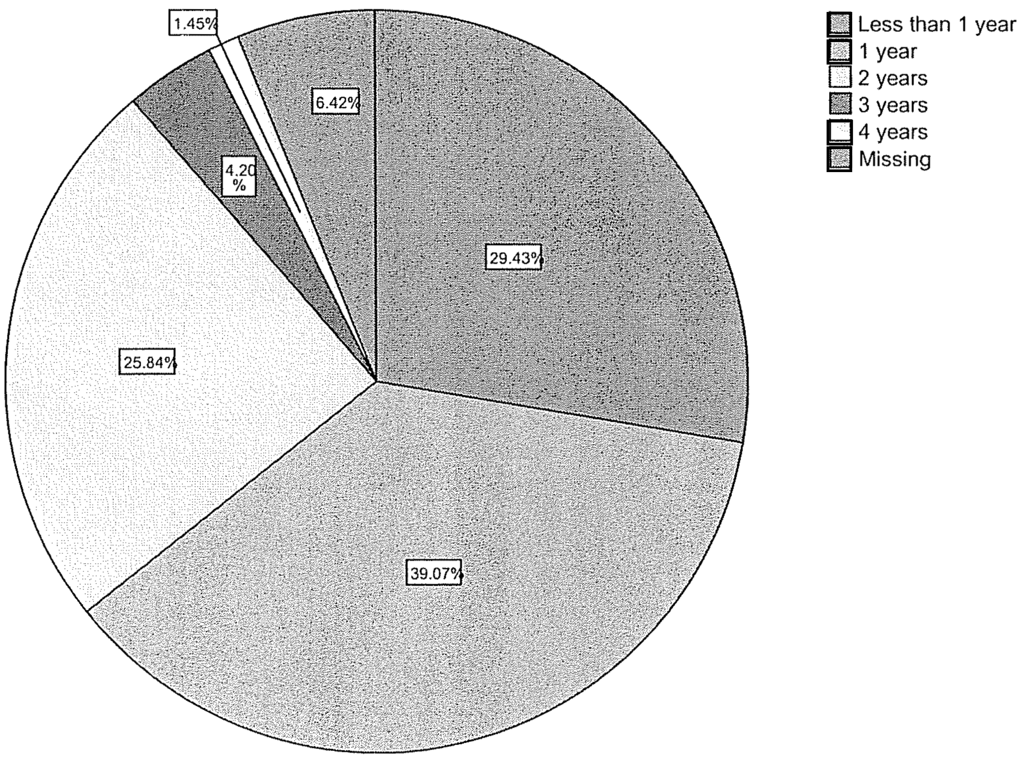
Temperature of Thermostat Summer Weekend Night

Less than one third of respondents set their thermostat between 73 to 75 degrees. 36.4% of customers set their thermostat above 76 degrees with 1.2% of which turn it off during summer weekend nights. It is recommended to target customers with thermostats set in cooler degrees during peak hours of weekdays.



Length of Participation in Power Manager Program

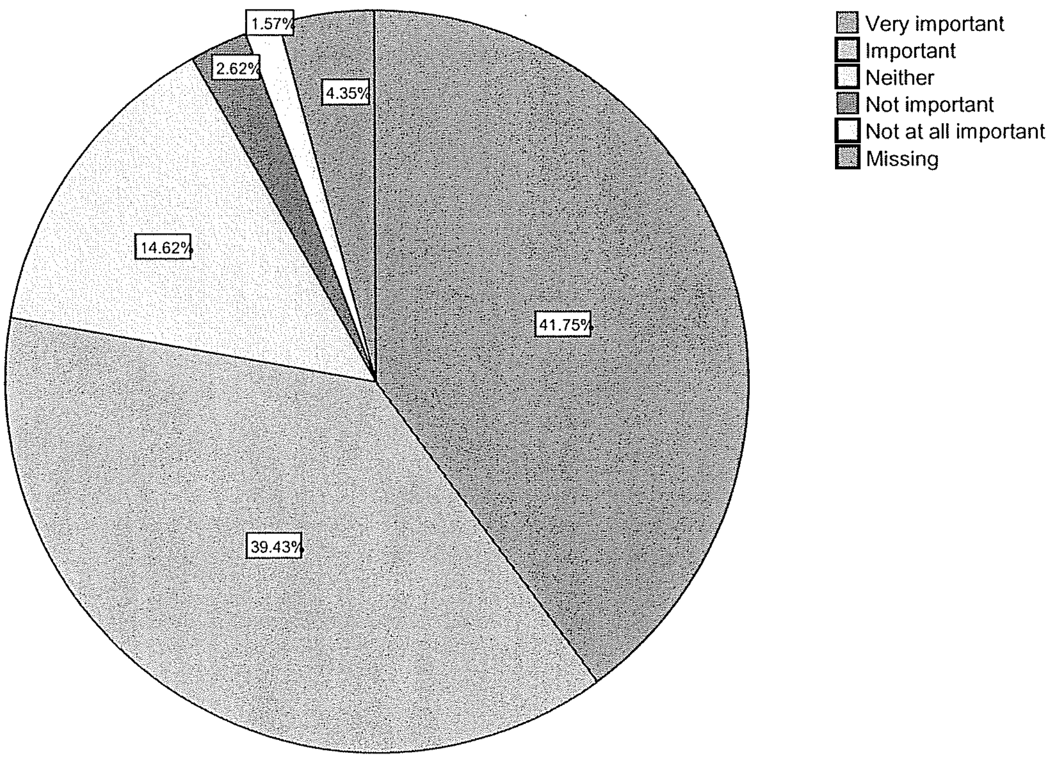
Less than one third of the customers have been participating in the program for less than 1 year, while 39.07% have been in the program for one year. One fourth of participants have been with the program for two years and less than 6% have been with the program for three to four years. It might be a good idea to send an appreciation note to customers who are in their first or second year of participation.



How long have you participated in the Power Manager Program?

Importance of Monetary Incentive

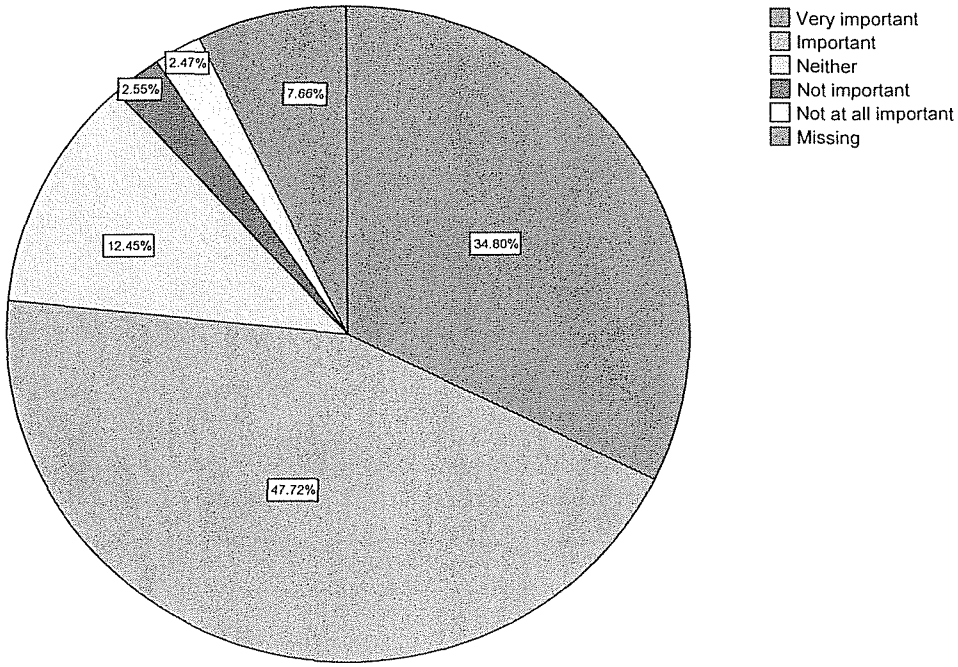
Money is a significant factor for more than 80% of participants while only less then 4% of participants claim that money is not an important factor for them. Depending on budget limitations, increasing monetary rewards would satisfy most participants.



Q10 Factors - MONEY

Importance of Environment

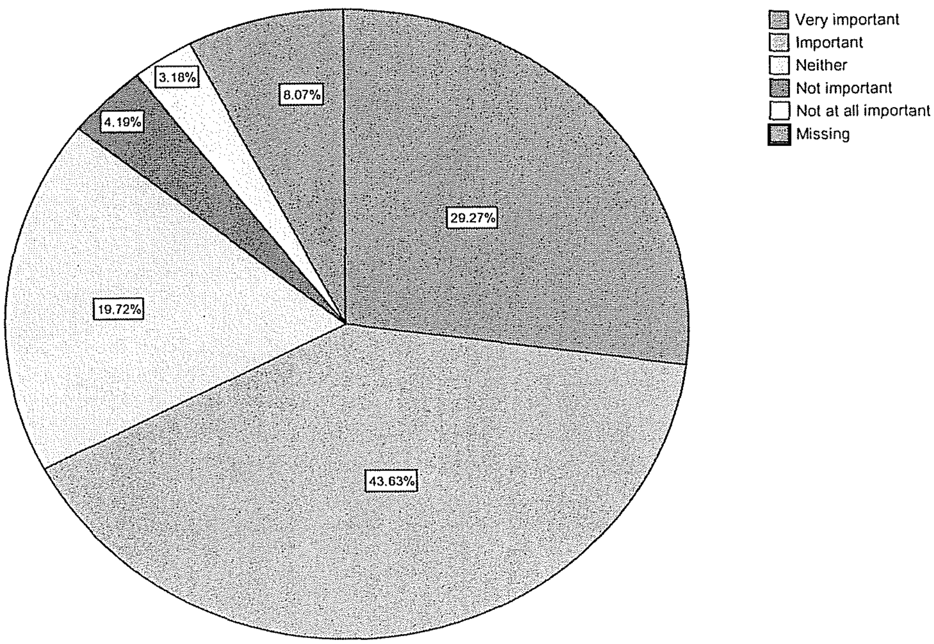
More than 82% of participants consider environment as an important or very important factor while only about 5% claimed that environment is not an important factor for them. Improving the environment is as strong of a factor as monetary rewards. It is recommended to send participants information on the impact their participation in the program is making on the environment.



Q10 Factors - ENVIROMENT

Importance of Not Building Power Plants

For almost two third or 67.5% of participants "Not Building a Power Plant" is either important or very important. About 20% of participants are indifferent. While only 7.37% of participants believe that "Not Building a Power Plant" is not important. It could be beneficial to send participants information on the impact that their participation in the program has on plans to build additional power plants since for the majority of participants not building a Power Plant is an important factor.



Q10 Factors - NOT BUILD POWER PLANTS

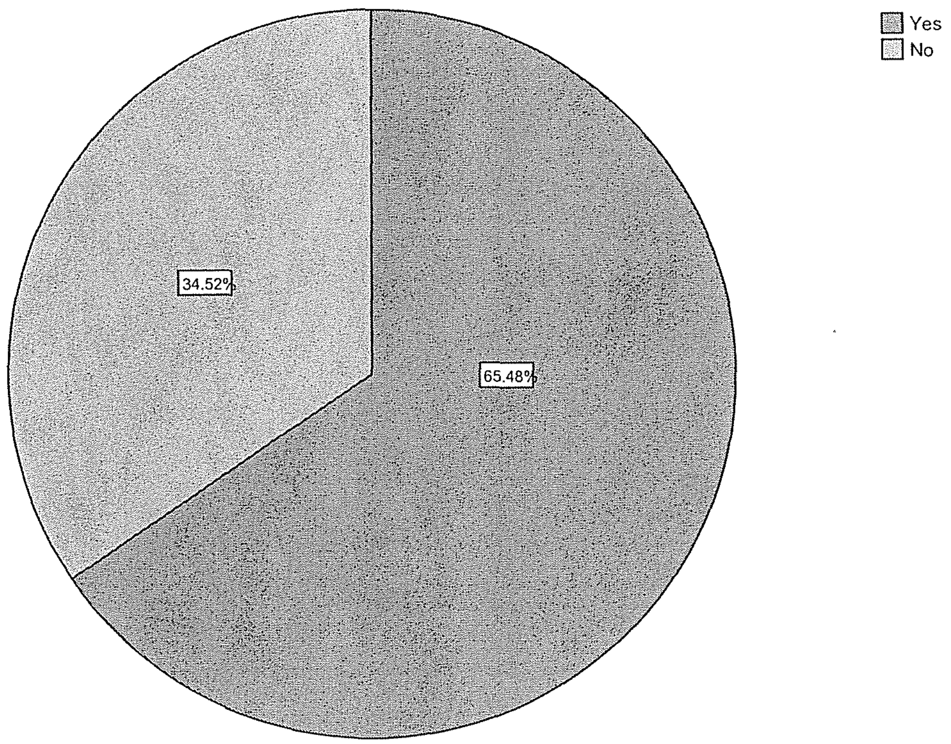
Option to Opt out of Control Event

Only about 1.77% of participants would choose to opt out of one of the control events.

Did you ever choose to opt out of one of the control events?

Participants that were Home during Control Events

About two third of participants were home during the control events. 30.22% of participants did not answer this question suggesting that they might not have noticed when the control event happened, indicating they did not experience any discomfort.

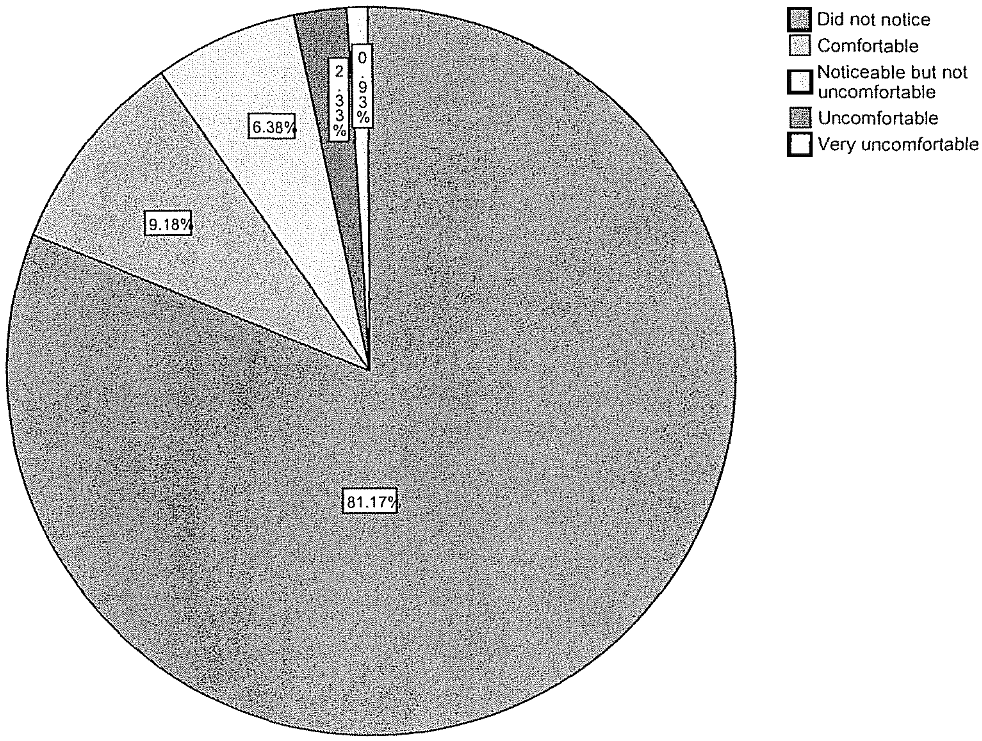


Were you usually home during control events that occurred?

How Comfort Level was Affected during Control Event

More than 90% of participants either did not notice or were comfortable during the control event.

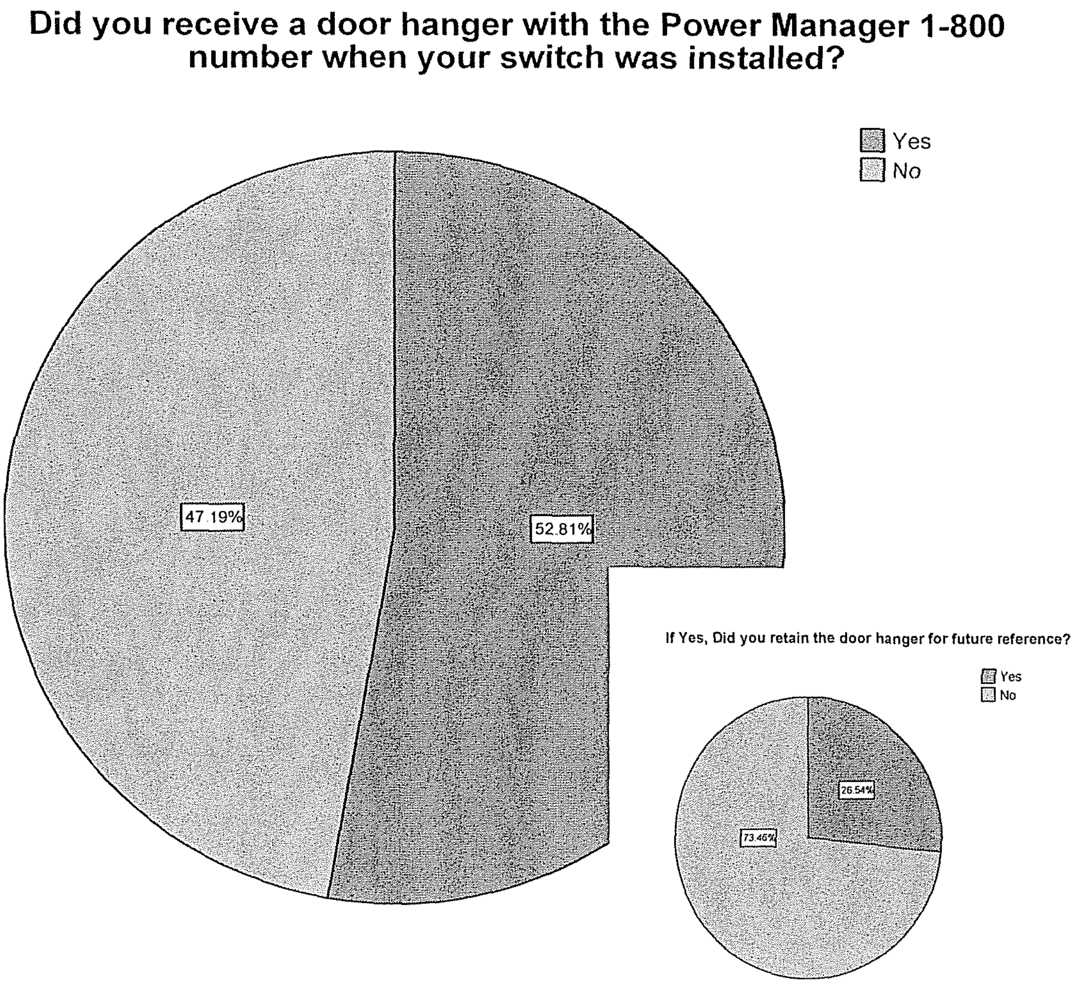
Only less than 1% of participants were very uncomfortable while 3.2% were either uncomfortable or very uncomfortable. It could be recommended to give the people who are uncomfortable the option to receive a notice a day in advance about the control event occurring and give them the option to opt out.



How much did the control event affect your comfort level?

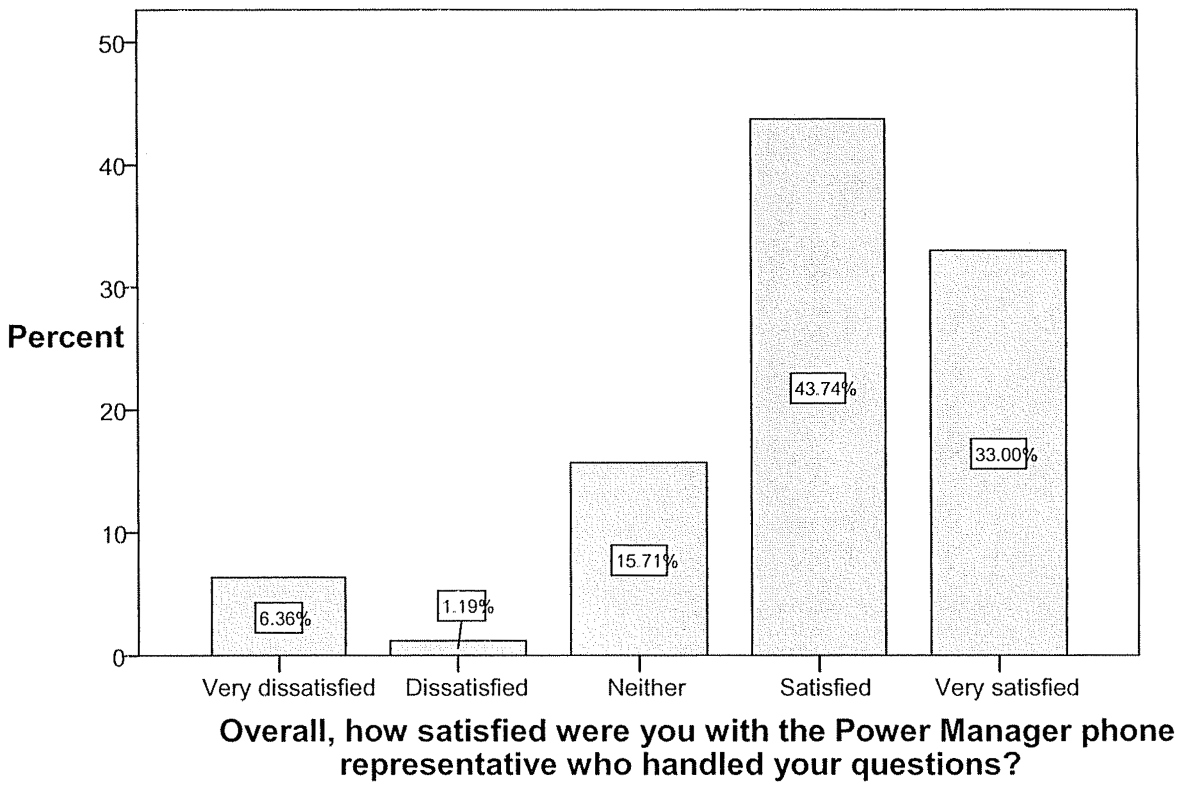
Retention of Informational Door Hanger

More than half of the participants received a door hanger with the power manager 1-800 number on it, more than one fourth of which kept it.



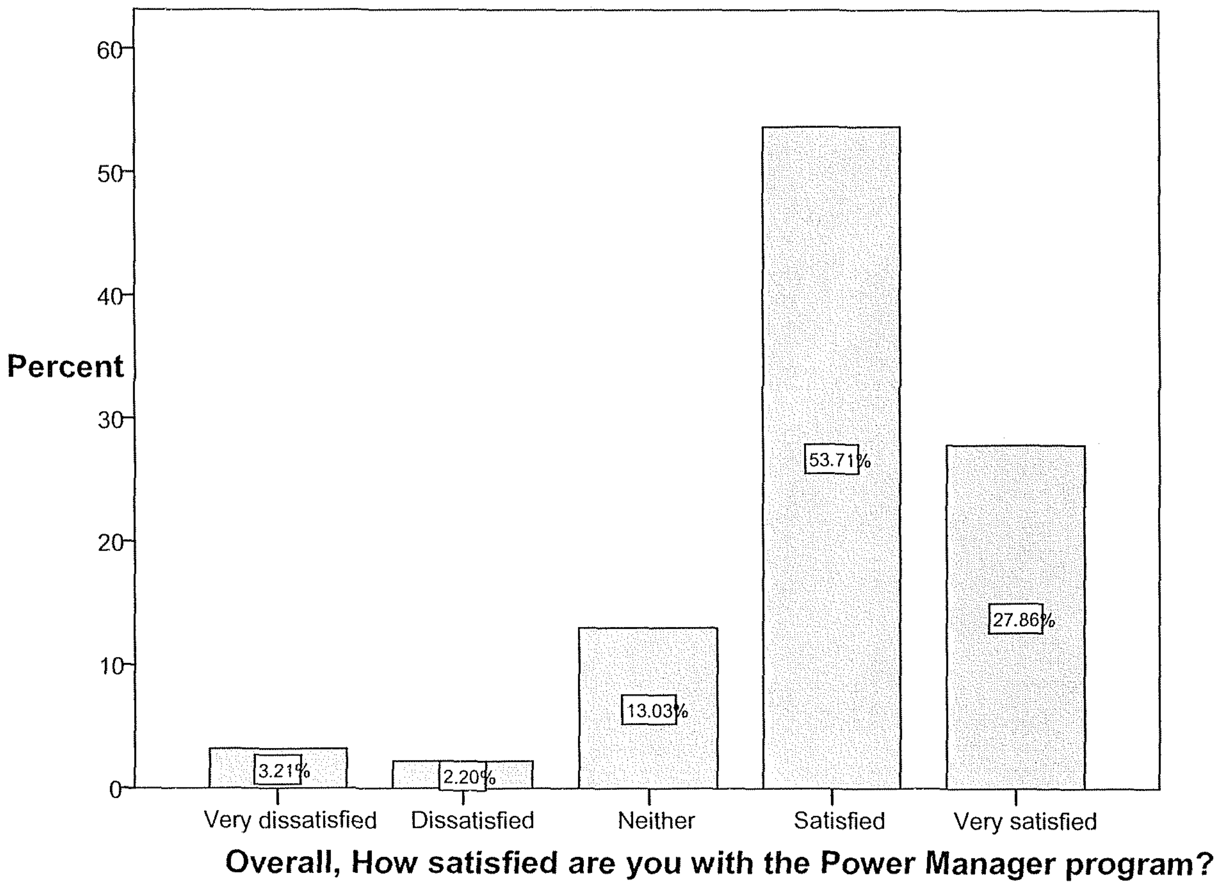
Satisfaction with Power Manager Phone Representative

76.74% of participants were either satisfied or very satisfied with the Power Manager phone representative whereas 7.55% were dissatisfied or very dissatisfied with phone representatives. More research could be done to uncover what made them unsatisfied with the phone representative. Based on the research the phone representative could than be trained better in those areas.



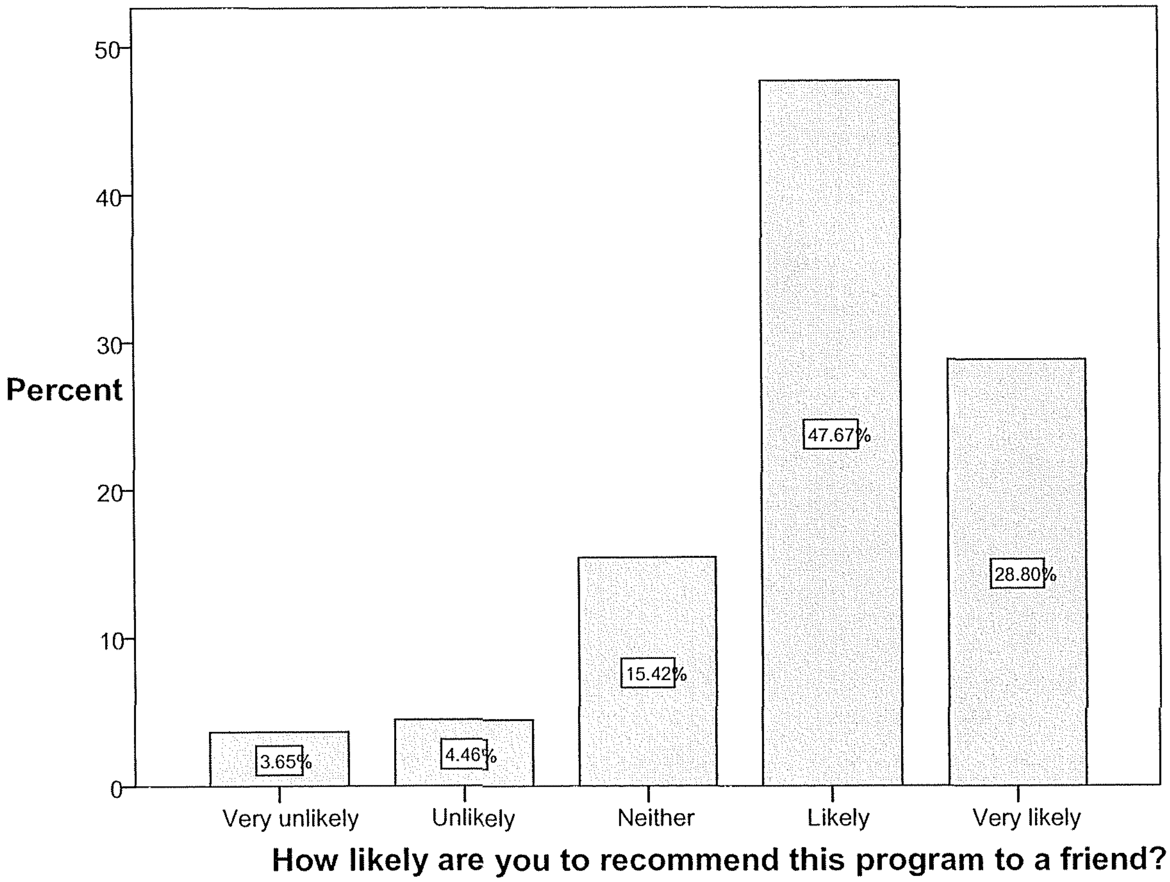
Overall Satisfaction with Power Manager Program

81.57% of participants were either satisfied or very satisfied with the Power Manager program whereas only 5.41% were dissatisfied or very dissatisfied.



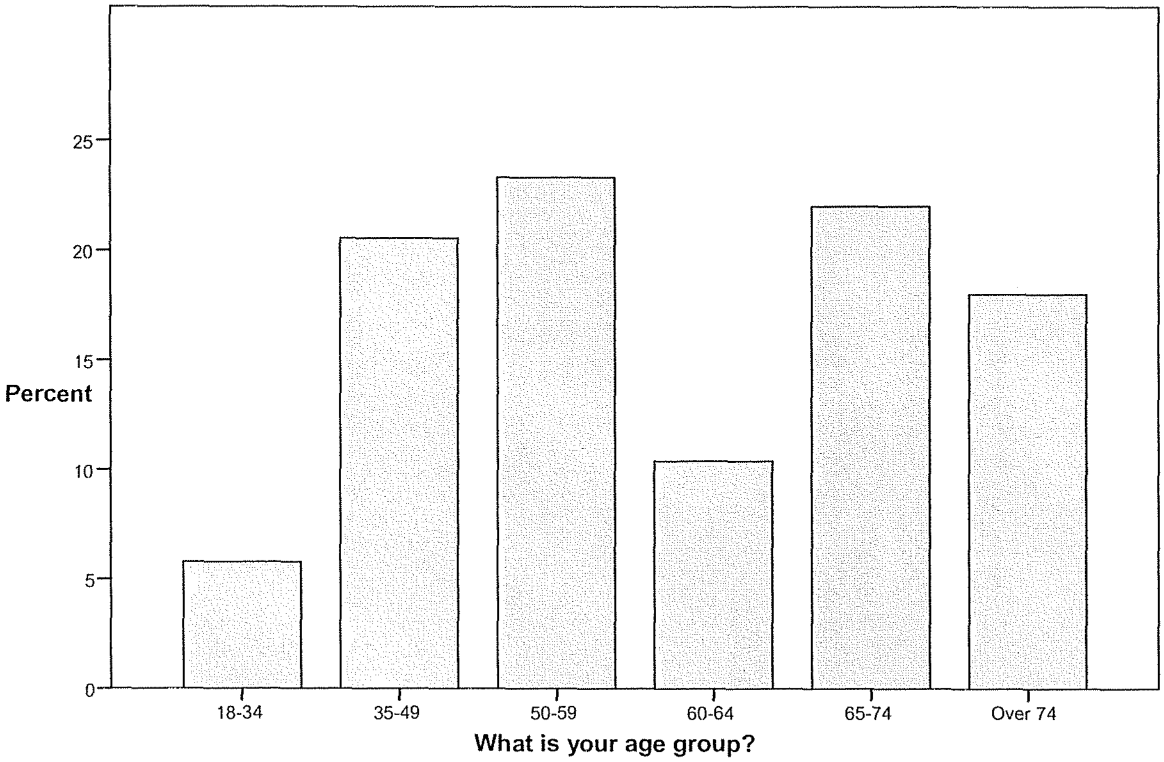
Likelihood to recommend Power Manager to a Friend

76.47% of participants are either likely or very likely to recommend this program to a friend whereas 8.11% of them are unlikely or very unlikely to do so. To increase the word of mouth about the program, a monetary reward to get a friend to sign up could be implemented.



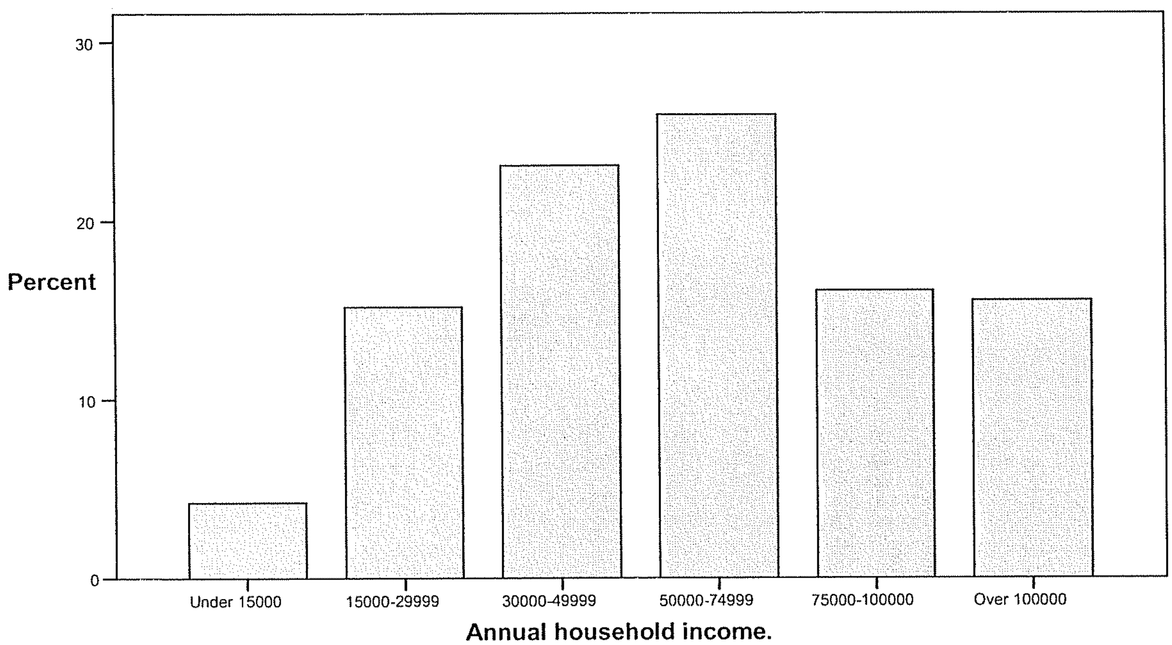
Age of Participants

More than half of the participants (53.8%) are between 35 and 59 years of age while 40% of them are 65 and over.



Annual Income of Participants

About 49% of the participants had annual income of 30,000 to 74,999. While 19.4% of people had annual income of less than 30,000, over 31% of participants have an annual income of 75,000 or more.



Drivers of the Power Manager Program Participant's Satisfaction

A regression analysis was done to discover which variables are the most important attributes at contributing to satisfaction of the Power Manager program. The following is the results of the analysis.

Participant's satisfaction of how the power manager phone representative handled their questions is the most important indicator of overall satisfaction of the power manager program. This may suggest:

- Special attention to training phone representatives is viable.
- Constant tracking of the performance of phone representatives is important.
- Placing courtesy thank you calls after control events may sustain/increase satisfaction.

To what extent participants become uncomfortable during control events is the second most important indicator of participant's satisfaction. The more uncomfortable they become the greater the dissatisfaction. Recommendations are:

- Targeting younger customers may increase participation as they are less sensitive to change in temperature during control events.
- Targeting customers who are not at home during control events is recommended.

Helping the environment is an important factor in satisfying participants. Recommendations are:

- Emphasizing on environmental outcomes in marketing campaign is an effective tool in obtaining customers in the program.
- Reminding participants of the environmental benefits when they call the 800 number.

There is a relationship between temperature settings and summer weekend nights. This indicates that participants who have the habit of setting their thermostat on higher degrees during the summer are generally more satisfied with the program since they have a higher tolerance for heat. This may suggest:

- Targeting customers with such habits as turning their thermostat up in the summer.

Target Marketing Recommendations

A correlation analysis was performed on the most important Power Manager attributes from the regression analysis to discover how those attributes related to each other. Using focused cluster and regression analysis makes it possible to have a better understanding of causes of satisfaction and dissatisfaction of participants and will provide more effective ways to promote and keep these participants.

Details regarding the correlation analysis can be found in Appendix A.

Grouping the participants based on income and age provides very accurate results for deciding which groups to target for future marketing in the program.

Participants with lower income are more likely to witness the control event and call the 1-800 number and in general feel more uncomfortable during the event. On the other hand the very wealthy people are more likely to have newer and more efficient cooling system and are less likely to have heat pumps in their homes. In general, the wealthy people are less concerned about the Power Manager Program. So we could conclude that the very low income and very high income households would not make a good candidate for the program while the middle income households (income between 30,000 and 100,000) would be the best candidates.

Older people are more likely to own older cooling systems as well as using window unit as cooling systems. Older people are also more likely to have less income and to keep the informational door hanger. They are also less likely to call the 1-800 numbers and they tend to stay in the program longer. Despite the fact that in general participants who were home during control events experienced more discomfort and would leave the program, the older group of participants tend to stay longer in the program even though they were more likely to be home more often during control events than the younger participants.

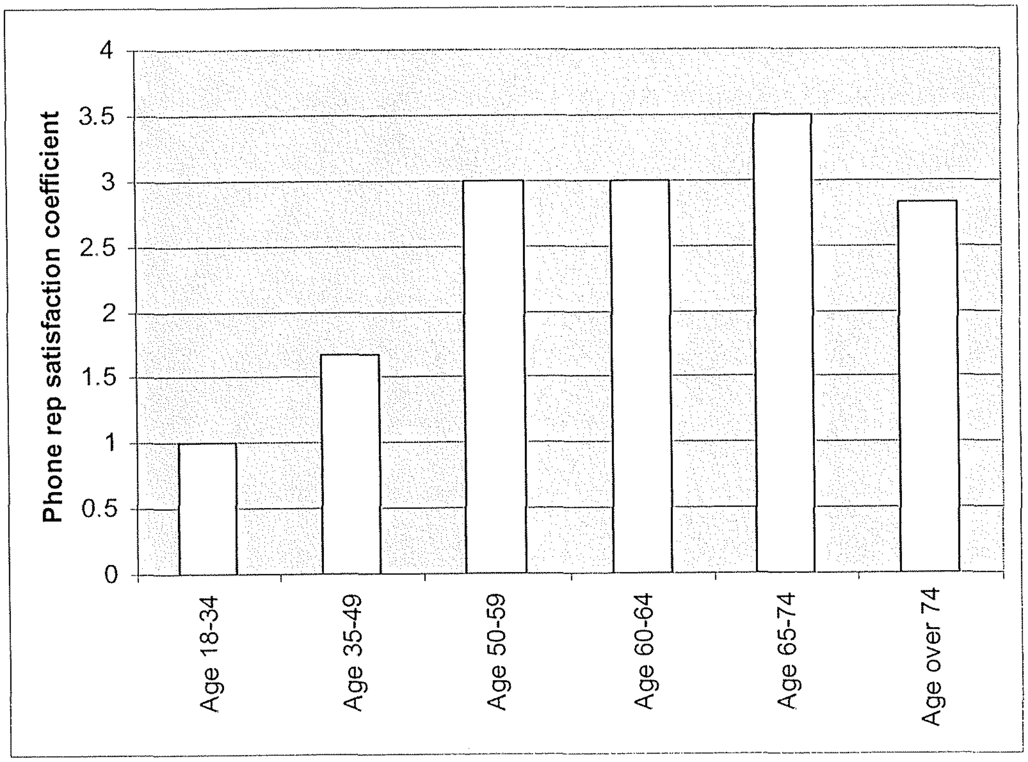
In order to maximize participation in the future, the study also suggests a closer look at people with homes between 1,000 and 2,999 square feet. Customers with homes in the above mentioned range make up 75% of total participants in the program thus a significant target for any promotional campaign. Targeting residents of smaller homes (less than 500 square feet) does not seem to be effective since these are low usage customers also make up less than one percent of participants in the program.

Satisfaction of the Power Manager Phone Representatives

The most important indicator of overall satisfaction was the participant's satisfaction of the power manager phone representative that handled their call. Due to this attributes importance further analysis was done on the satisfaction of the phone representative and overall satisfaction.

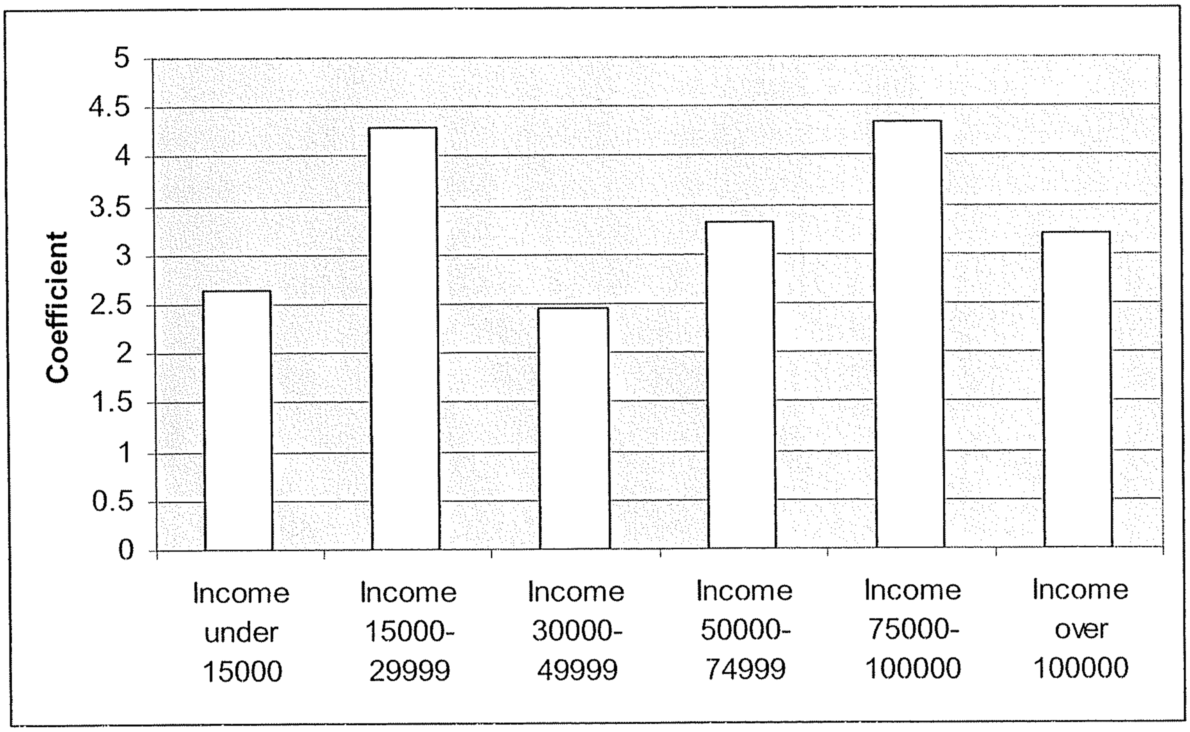
Satisfaction of Power Manager Phone Representative by Age Groups

Regressing overall satisfaction against satisfaction of phone representatives for different age groups for those customers who called power manager phone representative shows a lower coefficient for younger customers. This suggests that participants younger than 50 years, especially age 35 and below, are less satisfied with the service they received from the Power Manager phone representative.



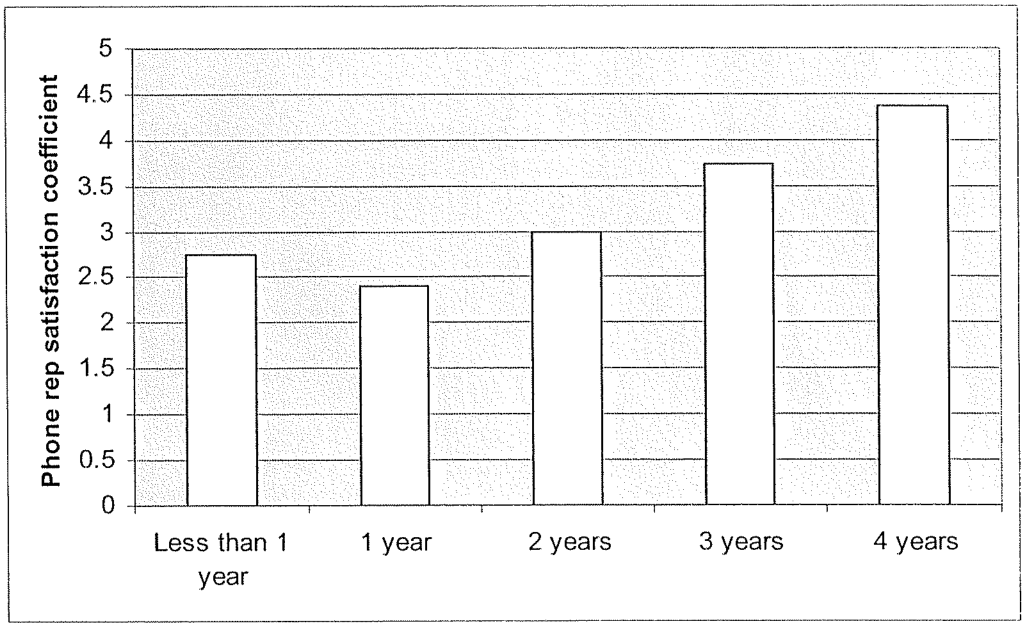
Satisfaction of Power Manager Phone Representative by Income Groups

Regressing overall satisfaction against satisfaction of phone representatives for different household income groups shows a lower coefficient for customers with annual income of 50K to 30K as well as customers having lower income of fewer than 15K suggesting these income groups are less satisfied with the service they received from the Power Manager phone representative.



Satisfaction of Power Manager Phone Representative by Length of Participation

The results of regressing overall satisfaction against satisfaction of phone representatives for different participation time period shows a higher coefficient for customers who have been with the program longer. This might suggest that participants who stay longer with program find the phone representatives more helpful or the upward coefficient trend is because satisfied participants stay longer in the program.

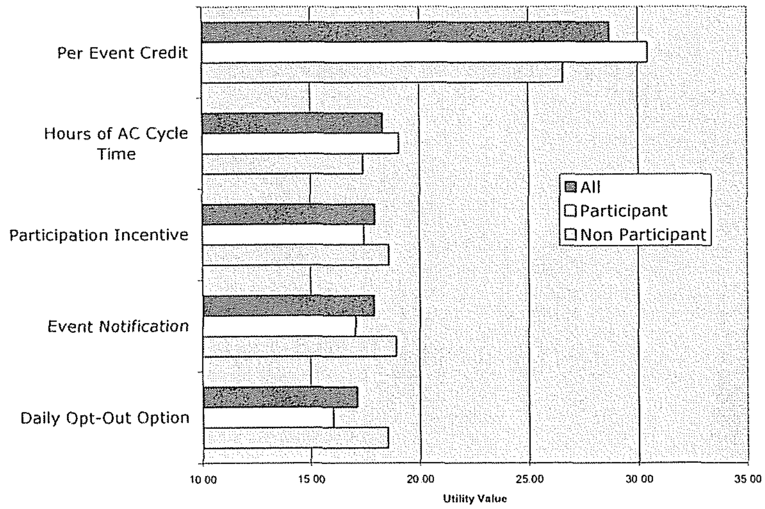


Additional insight on increasing participation in the Power Manager Program

To gain further insight on ways to increase participation in the Power Manager program a conjoint study was conducted was conducted in November 2006 in the Duke Energy Midwest Region to over 100 respondents. Respondents included a blend of current Power Manager Customers, and non-Power Manager Customers. All customers surveyed were eligible for the Power Manager program.

Results indicate that the current program offering sign up incentive of $25 (and $35) obtain the highest participation likelihood scores compared to a proposed free thermostat as a participation incentive. The free thermostat sign up incentive was still a viable option, but would need a considerable amount of marketing to communicate the benefits and value of a programmable thermostat, as well as educational material and additional features such as a toll free technical assistance phone number for operational questions. Over 60% of the customers indicate they do not adjust their thermostats settings (programmable or non-programmable) throughout the day.

Additional results indicate a per event incentive is the most important feature to customers considering signing up for a Power Manager program option, compared to features such as sign-up incentive, event credit, notification, and opt-out options.



(How important the attribute is compared to the others)

The current program offering includes a $25 sign-up incentive for a 1 kW reduction in load, and a $35 incentive for 1.5 kW reduction in load. Average AC cycle times for 2006 in total were around 3 hours. Event credits were given on a per kW basis. Customers were offered a 1 time per month opt-out option. This current opt-out offering is preferred by customers, and increases participation. Offering more than 1 opt-out option is not recommended, as it will not increase participation likelihood significantly.

Based on the conjoint results, three (3) hours of AC cycle time obtained a positive utility value. Increasing the cycling time from three (3) hours to five (5) hours reduces the probability of participation from 37% to 27%. But adding program feature enhancements will offset this difference.

Increased sign-up likelihood can come from program enhancements such as an email notification of an event occurring 1 day ahead, which moreover would be the least cost notification method. Respondents preferred email notification to phone call notification, and some notification to no event notification.

Additional suggestions include a per event credit instead of a per kW credit. Per Event is defined as any day that Duke Energy cycles a customer's AC unit on and off.

	Option A	**Option B**	
Sign Up Incentive	$25	$35	
Hours Cycle Time	3	3	
Event Credit	1	2	
Event Notification	None	None	
Monthly Opt-Out	1	1	
CURRENT OFFERINGS	10%	15%	**Relative Share**
Increase Cycle Time to 5 hours	7%	13%	**New Relative Share**
Add Event Notification	**11%**	**17%**	**Final Relative Share**

Relative Share of preference can be thought of as how many consumers would chose one option over another in the same menu. Share of Preference scores capture information about what product is most preferred and also the relative desirability of the remaining products. Share of preference does not represent market share potential. However, to some extent it can be viewed as a relative gauge, if both programs were offered by Duke Energy to every eligible customer and external effects were applied. An external effects multiplier can be included to better represent a market share potential, but again does not represent market share, as it is missing factors such as level and effectiveness of advertising, length of time on the market, and competitive or similar programs on the market. External Effects have been applied above to obtain the relative share estimates based on current share of participants to eligible customers. Current share of eligible customers is .047 for Option A and .082 for Option B.

Temperature Settings

- On average, respondents set their thermostats in the summertime to between 73 and 75 degrees.

- Regardless of temperature setting, it can be determined that having a thermostat set at 2 degrees warmer than current setting, customers will experience no difference in comfort level.
- 4 degrees warmer, causes customers to feel slightly less comfortable, except those setting their temperatures initially at 65 – 69.

Evaluating the impacts of the Power Manager Program

To evaluate the impacts of the program a load research study was conducted during summer 2006 of Power Manager. During summer 2006, nearly 29,000 Duke Energy Indiana residential customers in Indiana and 5,900 Duke Energy Kentucky residential customers in Kentucky participated in Power Manager load control events. The main purposes of the load research study is to evaluate how well load reduction targets were achieved during load control events and provide data for modeling purposes to support the program in future years. A new control model was developed for the 2006 Power Manager program based on data captured during 2005. This model called for substantially greater cycling percentages to achieve 1.0 or 1.5 kw target reduction levels than were in effect in the 2005 model. Overall load reduction achieved in 2005's program was generally too low according to the impact evaluation. The difference in the model is largely due to better capturing the "flattening" of the AC KW curve at higher temperatures. The summer of 2005 had many days with temperatures above 89 degrees; so this flattening was well represented in the dataset. This was not the case for the summer of 2004, the basis for 2005's model.

The results from this study are estimates of the load impact of the Power Manager program during five load control events conducted in summer 2006. These estimates are significantly below the targeted load reduction. Potential sources of this discrepancy include failures in paging communication and incorrect programming of switches, both of which have been encountered in spot field tests. A QA plan addressing how these problems will be investigated and remedied is presented. It may also be that expected load reductions from the Power Manager control model are too high for the moderate to low temperatures that prevailed during control periods this summer (see Table 2 below). To address this possibility, model methodology and data sources will be carefully reviewed and model results will be compared to studies in other areas. Lastly, model error in estimating realized shed kWh within the research sample during load control periods may also contribute to the discrepancy. Other results in this study include a small study with apartments, and estimates of payback during the two hours immediately following Power Manger load control events.

Power Manager Control Events

In a Power Manager control event, air conditioner units on the program are cycled off for a portion of each 30-minute interval; a random delay of up to 30 minutes at the beginning of the control period is used to stagger the off and on periods. The cycling percentage (i.e., percentage off) is chosen to achieve a specific load reduction target. This is accomplished with the Power Manger control model, which uses forecasted weather for the control period to calculate the cycling level needed to achieve a specified target reduction, on average, over the program population. A choice of program options with different target reduction levels is offered. The two commonly used program options are identified by typical target levels, "1.0 kW" and "1.5 kW," but other load reduction targets can be specified for either program option.

Power Manager load control was implemented on five days during summer 2006; July 17, 19, 26 and August 2, 7. The time period for each load control event was 2:00 – 5:00 PM (EDT). A simplified cycling strategy was adopted this year. Rather than modifying the cycling in each hour to achieve a fixed hourly load reduction, a fixed cycling percentage was imposed in all hours of an event. This cycling percentage was calculated with the Power Manager control model to achieve the load reduction target over the event as a whole, but not necessarily in each hour of the event. The load reduction targets (total kWh for the three hour event) and corresponding cycling percentages specified for the control events of summer 2006 are shown in Table 1. Cycling percentages for Duke Energy Kentucky were calculated with the CVG weather forecast, and cycling percentages for Duke Energy Indiana were calculated with the IND weather forecast.

Table 1. Control Event Cycling

	1.5 kW			1.0 kW		
	Target	DEK %	DEI %	Target	DEK %	DEI %
July 17	3.3	62	58	3.0	58	52
July 19	3.6	65	65	3.0	58	58
July 26	3.9	76	73	3.0	63	60
August 2	4.5	71	71	3.0	48	48
August 7	4.5	75	75	3.0	56	56

An initial estimate of load impact after a control event can be obtained with the control model algorithm, using actual weather during the control period together with the cycling percentages imposed. Deviation of actual weather from the weather forecast results in a total impact estimate different than the load reduction target. These estimates are the starting point for load impact results developed later in this report (see Table 6-a). Table 2 provides an overview of the weather experienced during Power Manager load control events f summer 2006, showing average hourly temperature and heat index during the control period. Notice the very low temperature at IND during the August 7 event.

Table 2. Temperature and Heat Index (deg-F) during Control Periods

	CVG		IND		SDF	
July 17	90	93	89	93	91	95
July 19	91	97	89	95	93	100
July 26	86	89	83	88	88	95
August 2	91	99	91	99	94	104
August 7	90	96	77	80	94	101

Load Research Sample

The 2006 load research sample consists of 159 single-family residences in the main load impact study, and 12 apartments in a side study of the effectiveness of Power Manager for multi-tenant properties. Interval KWH (15-minute) is collected for all research sample participants. State data loggers were installed on the air-conditioner units for about half (83) of the main study and all in the apartment study, which allow air-conditioner duty cycles to be constructed. The research sample for the main study was chosen to achieve reasonable geographic representation of the Power Manager population in Indiana and Kentucky, while also allowing for reasonably efficient data collection (residences with data loggers were visited every 4 weeks for data collection). Participants with data loggers are distributed in clusters in the Indianapolis area (32), Kokomo (10), Terre Haute (9), Jeffersonville-New Albany (9), and Cincinnati area (23). The rest of the sample for the main study, with interval meters only, was selected from areas not represented in the clusters.

Research sample participants with data loggers were separated into two control groups, RS1 and RS2, with about an equal split in each cluster. In Power Manager events, one group was controlled along with the general population and the other group was not controlled, and so provided information on the natural duty cycle. For evaluation of load impact, participants in the main study are grouped according to weather region (CVG, IND, SDF), and control group. The control group is RS1 or RS2 for participants with data loggers, or MET for participants with interval meters only. Table 3 below shows the breakdown into these evaluation groups.

Table 3. Evaluation Groups

Weather Region	Control Group	Participants
CVG	RS1	11
CVG	RS2	12
CVG	MET	17
IND	RS1	26
IND	RS2	25
IND	MET	49
SDF	RS1	5
SDF	RS2	4
SDF	MET	10

Weather regions are assigned by zip code. All Kentucky zip codes are assigned to CVG (Cincinnati airport). Zip codes in southeast Indiana are assigned to CVG, in south-central and southwest Indiana to SDF (Louisville airport), and in central Indiana to IND (Indianapolis airport). Appendix E lists Indiana zip codes assigned to CVG or SDF.

The research sample was also chosen to achieve balanced representation of high and low kWh usage. Quartile statistics of monthly kWh during summer 2005 were used to divide (separately for DEI and DEK) Power Manager participants into low (below Q25), medium (between Q25 and Q75), and high (above Q75) usage segments. About 25% of the research sample participants were drawn from each of the low and high segments, and the remaining 50% were drawn from the medium segment. Table 4 illustrates this balance, comparing quantiles of overall 2006 summer usage for the research sample (main study) and the Power Manager population in each weather region. The numbers in Table 4 are total monthly KWH for June – September, 2006 billing cycles.

Table 4. Quantile Statistics for Summer-2006 KWH

	CVG		IND		SDF	
Q	Population	Sample	Population	Sample	Population	Sample
0.1	3312	3020	3154	2758	3106	3571
0.2	3853	3794	3786	3586	3782	3786
0.3	4351	4199	4266	3930	4215	4050
0.4	4819	4580	4743	4488	4721	4744
0.5	5315	5518	5259	5099	5255	4822
0.6	5828	6160	5832	5616	5902	6600
0.7	6505	6807	6529	6032	6569	8114
0.8	7446	7139	7446	7465	7552	8803
0.9	8824	8564	9024	9678	9164	10011

Load Reduction within Research Sample

This section describes the method used to estimate load reduction within the portion of the research sample controlled during each Power Manager event of summer 2006. Group MET was controlled on all event days, group RS1 was controlled July 17, 26 and August 2, and group RS2 was controlled July 19 and August 7.

Impact evaluation is based on separate models for average 30-minute interval KWH within each of the evaluation groups in Table 3. Explanatory variables in these models are linear temperature splines based at 66, 77, and 88 deg-F, a humidity adjustment factor, the hour of the day, and interventions for intervals during control events. The humidity variable in the model depends upon both temperature and humidity, and is defined as the natural logarithm of the ratio of heat index to temperature. The models are estimated with research sample interval KWH for 1:00–7:00 PM (EDT) on non-holiday weekdays from Memorial Day to Labor Day (May 30 – September 1, 2006). By including the hour prior to control period and two hours subsequent to the control period in the model, it will be possible to investigate additional effects such as autocorrelation and payback. Interaction variables between temperature splines and hour of the day were investigated but discarded from all models. The temperature spline at 88 deg-F was retained in IND models, but was not significant and was dropped from CVG and SDF models.

The load reduction achieved within each evaluation group of Table 3 during load control is estimated by coefficients of corresponding intervention variables in the model for this group. A unique intervention variable is specified for each 30-minute interval during a control event, and so the models estimate average load reduction within each group during every 30-minute interval of the control event. Intervention variables are also specified for the intervals subsequent to a control event (four 30-minute intervals for the period 5:00 – 7:00), and coefficients of these variables estimate payback, which will be discussed further later in the report.

For overall impact evaluation of the Power Manager program, we focus on the total load reduction achieved in evaluation groups on a control event day. This is the sum of intervention coefficients for the control period, 2:00 – 5:00 PM for all control days in summer 2006. In summing estimated intervention coefficients, a positive coefficient is treated as zero load reduction. Table 5 gives the results obtained for total load reduction within evaluation groups on control event days. In blocks with results, the middle row is the weighted average of total KWH reduction for two evaluation groups identified in the leftmost column. The top row gives the expected total KWH reduction calculated with the Power Manager control model using actual weather and event cycling levels, and reflecting the mix of program option (1.5 KW or 1.0 KW) in the evaluation groups. The bottom row shows the ratio of realized KWH reduction (middle row) to expected KWH reduction (top row). A complicating factor is that MET groups are subject to a random delay of up to 30 minutes in the start of the control period, the same as for the general program population. This means that initial MET intervention coefficients (for 2:00 – 2:30) will be somewhat reduced. The remaining MET intervention coefficients during the control period are not affected. RS1 and RS2 groups are not subject to random delay. To deal with this, sums were calculated both with and without the initial 30-minute interval of the control period. Results with the greater ratio appear in Table 5 and are used in the impact evaluation.

Table 5. Estimated load reduction within research sample by weather region.

Group	July 17	July 19	July 26	August 2	August 7
CVG RS1-MET	2.80 0.49 18%		3.41 1.06 31%	3.25* 1.42 44%	
CVG RS2-MET		2.82* 1.77 63%			3.63 1.32 36%
IND RS1-MET	2.42 0.35 14%		2.38* 1.36 57%	3.12* 1.90 61%	
IND RS2-MET		2.69* 1.35 50%			0.93 0.0 0%
SDF	2.34*		3.06*	3.55*	

RS1-MET	1.23 52%		0.74 24%	1.02 29%	
SDF RS2-MET		3.61 1.55 43%			3.75* 0.85 23%

* load reduction excludes initial half-hour of event period

Figures 1(a)-(c) provide a graphic representation of load reduction estimates within the research sample - Figure 1(a) shows estimates for the CVG weather region, Figure 1(b) for IND and Figure 1(c) for SDF. The horizontal axis in each individual graph corresponds to the period 1:00 – 7:00 PM, the hours covered by our model, on a Power Manager control day. The vertical axis corresponds to KWH within 30-minute intervals. The solid blocks show KWH at 30-minute intervals averaged over research sample groups controlled that day. The line with open blocks shows the composite model fit for the controlled groups, excluding intervention terms. Moving left to right in the graphs, the first two points (open or closed blocks) correspond to the hour prior to the control period, the next 6 points correspond to the three-hour control period, and the final 4 points correspond to the two hours immediately after control is released (ignoring random delay, which complicates the picture a bit for the first interval of the control period and the first interval after the control period). During the control period, the distance of the solid block below the line is the estimated load reduction. After the control period, the distance of the solid block above the line is the estimated payback. In both cases, since the estimate is for a 30-minute interval, it must be doubled to correspond to kWh.

Figure 1(a). Controlled Groups in CVG Weather Region

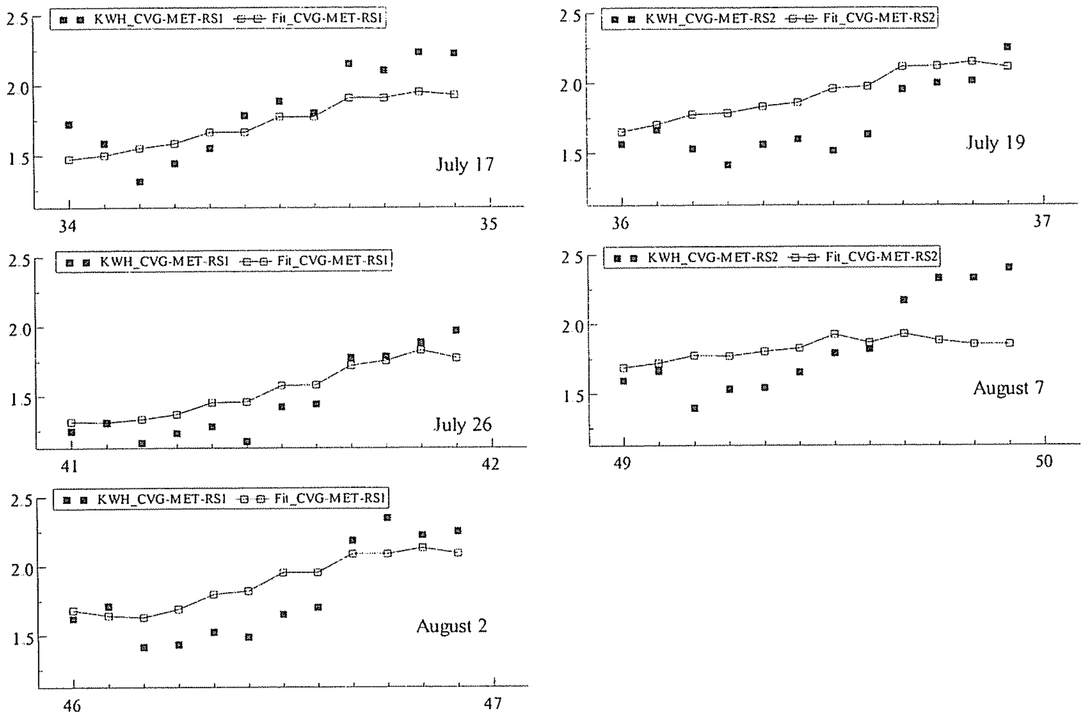


Figure 1(b). Controlled Groups in IND Weather Region

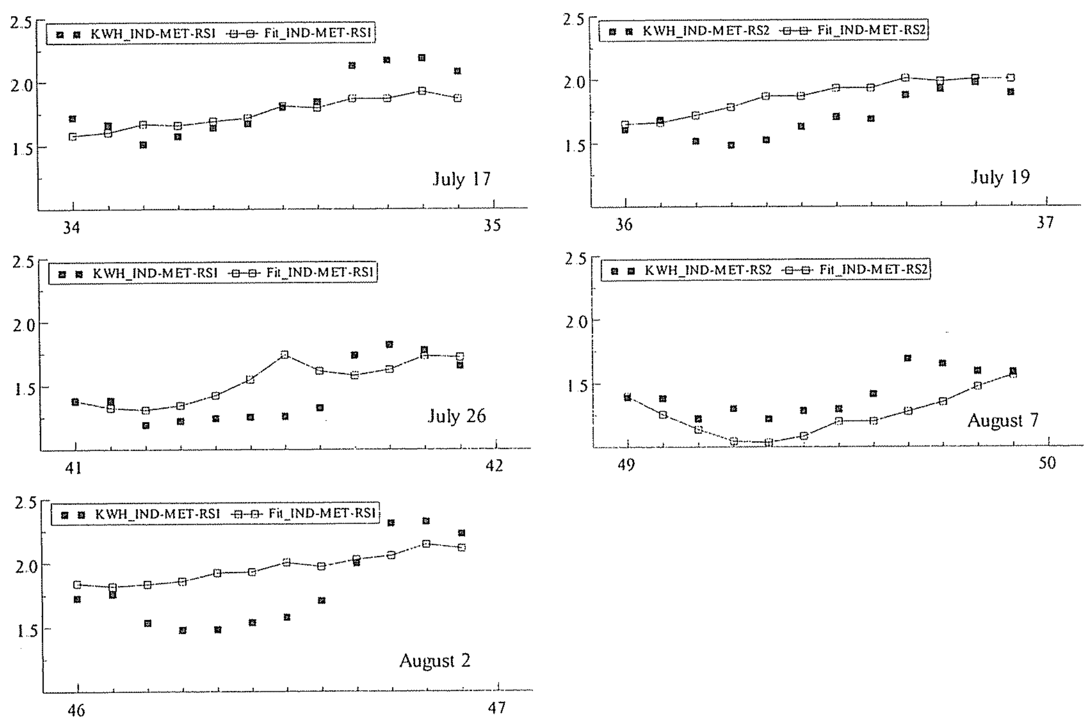
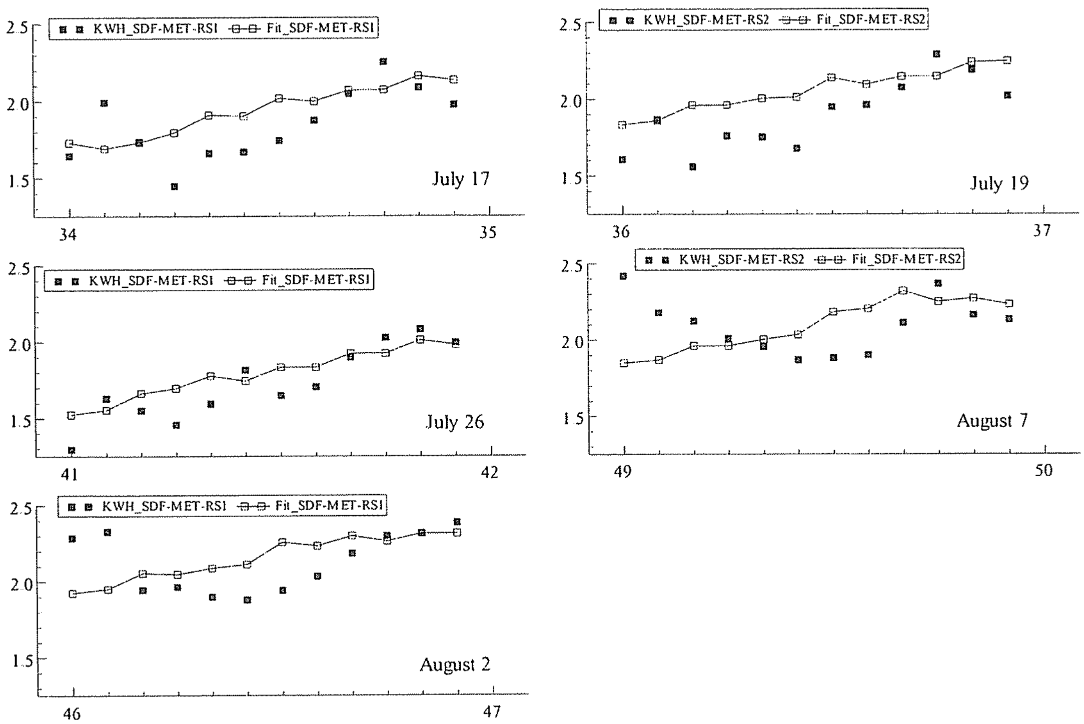


Figure 1(c). Controlled Groups in SDF Weather Region



Power Manager Program Load Impact

This section presents hourly impact estimates for Power Manager load control events of summer 2006. Tables 6(a)-(b) illustrate intermediate steps in the calculation of these estimates, and final impact results are in Table 6(c).

Table 6(a) shows separate estimates of average hourly shed kWh during control events for each weather region (CVG, IND, SDF) and program option (1.5 kW, 1.0 kW). These estimates were computed with the Power Manager control model algorithm using the control event cycling percentage (see Table 1) and actual weather during the control period. Also shown in Table 6(a) are participant counts by operating company (DEI, DEK) for each weather region and program option. Participants are assigned to weather regions according to their zip code.

In Table 6(b), the results from Table 6(a) are accumulated for each operating company. These numbers represent expected impacts immediately after an event, before any consideration of results from the research sample.

The upper section of Table 6(c) lists the adjustment factors from Table 5 of the previous section, derived from the research sample. The lower sections of Table 6(c) contain the final hourly impact estimates by operating company. These estimates start with the product of three factors which have been described:

1) Control model average kWh reduction with event cycling and actual weather;
2) Participant count by operating company;
3) Adjustment within weather regions based upon research sample results.

Factors 1 and 2 appear in Table 6(a) and factor 3 is from the upper section of Table 6(c) (and also Table 5). For each operating company, these products are summed over weather regions and program options to get overall hourly impact estimates.

Table 6(a). Expected Hourly Shed with Control Model Algorithm

	Jul_17	Jul_19	Jul_26	Aug_2	Aug_7
CVG-DEK 1.5_kw					
Model Shed - Hr 15	0.85	1.00	1.08	1.22	1.18
Model Shed - Hr 16	0.94	1.14	1.18	1.35	1.36
Model Shed - Hr 17	1.06	1.27	1.31	1.48	1.40
Count	4210	4215	4228	4264	4260
CVG-DEK 1.0_kw					
Model Shed - Hr 15	0.77	0.84	0.77	0.71	0.77
Model Shed - Hr 16	0.86	0.97	0.86	0.82	0.90
Model Shed - Hr 17	0.98	1.10	0.98	0.92	0.92
Count	1465	1470	1482	1565	1550
CVG-DEI 1.5_kw					
Model Shed - Hr 15	0.77	1.00	0.99	1.22	1.18
Model Shed - Hr 16	0.86	1.14	1.09	1.35	1.36
Model Shed - Hr 17	0.98	1.27	1.21	1.48	1.40
Count	483	483	483	480	480
CVG-DEI 1.0_kw					
Model Shed - Hr 15	0.67	0.84	0.69	0.71	0.77
Model Shed - Hr 16	0.75	0.97	0.78	0.82	0.90
Model Shed - Hr 17	0.85	1.10	0.89	0.92	0.92
Count	358	358	358	355	354
IND-DEI 1.5_kw					
Model Shed - Hr 15	0.73	0.99	0.82	1.23	0.24
Model Shed - Hr 16	0.85	1.08	1.17	1.38	0.37
Model Shed - Hr 17	0.92	1.20	0.96	1.42	0.44
Count	16568	16579	16596	16643	16623
IND-DEI 1.0_kw					
Model Shed - Hr 15	0.62	0.82	0.55	0.73	0.10
Model Shed - Hr 16	0.74	0.91	0.84	0.83	0.16
Model Shed - Hr 17	0.79	1.01	0.67	0.85	0.20
Count	6969	7059	7104	7316	7238
SDF-DEI 1.5_kw					
Model Shed - Hr 15	0.84	1.10	1.17	1.32	1.33
Model Shed - Hr 16	0.93	1.25	1.23	1.47	1.50
Model Shed - Hr 17	1.04	1.29	1.35	1.60	1.66
Count	2533	2552	2561	2575	2568
SDF-DEI 1.0_kw					
Model Shed - Hr 15	0.73	0.94	0.86	0.81	0.90
Model Shed - Hr 16	0.81	1.07	0.91	0.93	1.05
Model Shed - Hr 17	0.91	1.11	1.01	1.03	1.20
Count	1422	1463	1480	1529	1521

Table 6(b). Operating Company Total Expected Hourly Shed (MW)

	Jul_17	Jul_19	Jul_26	Aug_2	Aug_7
DEK					
Hr 15	3.5	4.1	4.3	4.7	4.7
Hr 16	5.2	6.2	6.3	7.0	7.2
Hr 17	5.9	7.0	7.0	7.8	7.4
DEI					
Hr 15	15.1	20.4	16.9	23.5	7.7
Hr 16	23.5	30.0	30.8	35.1	13.7
Hr 17	25.4	33.0	26.5	36.6	15.9

Note: First event hour reduced 25% to account for random delay

Table 6(c). Operating Company Hourly Impact Estimates (MW)

	Jul_17	Jul_19	Jul_26	Aug_2	Aug_7
Research Sample Adjustment					
CVG	18%	63%	31%	44%	36%
IND	14%	50%	57%	61%	0%
SDF	52%	43%	24%	29%	23%
DEK Impact					
Hr 15	0.6	2.6	1.3	2.1	1.7
Hr 16	0.9	3.9	1.9	3.1	2.6
Hr 17	1.1	4.4	2.2	3.4	2.7
DEI Impact					
Hr 15	3.0	10.0	8.4	13.1	1.1
Hr 16	4.6	14.8	15.8	19.6	1.6
Hr 17	5.1	16.3	13.2	20.3	1.8

Note: First event hour reduced 25% to account for random delay

Apartment Study

Twelve participants were recruited from apartment complexes in Franklin, IN (IND weather region) and New Albany, IN (SDF weather region) to investigate the suitability of multi-tenant properties for Power Manager program. Both state data loggers and interval meters were installed for the apartment sample, but data for the bulk of summer 2006 is available for only 8 of these participants. These apartment accounts are listed in Table 7 below, with apartment size and total kWH for June – September bill cycles. Notice the comparatively low KWH usage for two accounts, even though one is the largest apartment in the study.

Table 7. Apartment Research Sample Characteristics

Account	Size (Sq Ft)	Summer KWH
26502594	1066	3577
90602594	833	3311
79802594	962	3189
06202929	1360	3797
91602946	1000	3756
45602946	840	4740
93302929	1440	1943
96302929*	1080	1845

* tenant changes in July and August

Separating apartment accounts into evaluation groups and modeling average kWh usage within these groups is not feasible due to the small sample size. Instead, load reduction by apartment accounts is estimated individually for each account by comparing kWh usage during a control period to kWh usage during the same time period on days with similar weather. For each control event and account, three weekdays are selected to most closely match temperature and heat index during the control period, avoiding any days where load control was implemented or kWh data is not available for that account. Total kWh during the control period is subtracted from total kWh during the same time period, averaged for the three comparable days. Table 8 below gives results for each apartment account and Power Manger control event. The layout of Table 8 is similar to Table 5; the top row in each block is the estimated load reduction for the apartment, the middle row is the expected load reduction computed by the Power Manager control model (with 1.0 kw program option and appropriate weather region), and the bottom row is the ratio between the top and middle rows. The bottom row of Table 8 shows averages for all apartments controlled in each Power Manager control event.

Table 8. Estimated Load Reduction for Apartments

Account	July 17	July 19	July 26	August 2	August 7
26502594 IND-RS1	2.48 2.15 115%		1.29 2.06 63%	1.43 4.02 36%	
90602594 IND-RS1	0.00 2.15 0%		1.39 2.06 67%	0.00 4.02 0%	
79802594 IND-RS2		0.00 2.74 0%			0.00 0.46 0%
06202929 SDF-RS1	2.05 2.45 84%		0.55 2.78 20%	1.42 4.40 32%	
91602946 SDF-RS1	3.57 2.45 146%		1.06 2.78 38%	0.00 4.40 0%	
45602946 SDF-RS2		1.65 3.12 53%			0.00 3.15 0%
93302929 SDF-RS2		0.00 3.12 0%			0.00 3.15 0%
96302929 SDF-RS2		1.57 3.12 50%			0.00 3.15 0%
Event Average	2.03 2.30 88%	0.81 3.03 27%	1.07 2.42 44%	0.71 4.21 17%	0.00 2.48 0%

Payback

As discussed previously, the models used to measure average kWh impact within the evaluation groups during control events include intervention coefficients for four 30-minute intervals subsequent to each control event (the time period 5:00 – 7:00 PM). These intervention coefficients measure the increase in average kWh usage within evaluation groups above the expected level (i.e., the model) immediately after a control period, which is often referred to as payback. The sum of these intervention coefficients estimates the total payback during the two hours immediately after a control event, on average within the evaluation group. Payback results are given in the bottom row of blocks in Table 9. For comparison, the top row of these blocks contains the estimated total load reduction during the control period (the sum of intervention coefficients during the control period).

Table 9. Payback (kWh) over Two-Hour Period After Control

Group	July 17	July 19	July 26	August 2	August 7
CVG	-0.49		-1.06	-1.63	
RS1-MET	1.02		0.34	0.61	
CVG		-2.03			-1.32
RS2-MET		0.0			1.83
IND	-0.35		-1.48	-2.20	
RS1-MET	1.04		0.33	0.54	
IND		-3.16			0.0
RS2-MET		0.0			-
SDF	-1.23		-0.85	-1.13	
RS1-MET	0.0		0.19	0.10	
SDF		-1.55			-0.85
RS2-MET		0.0			0.0

Power Manager Quality Assurance Action Plan

As a result of the Power Manager impact evaluation analysis, and in order to maximize the impact of the program, Duke Energy has developed the following action plan for 2006-7 to insure that the full program impacts can be realized prior to the execution of the 2007 control season. During November and December, 2006, discussions took place Duke Energy personnel and service provider partners, so that we could better understand control equipment performance issues. The lower than expected load reductions during the 2006 season could possibly have been due to somewhat milder peak temperatures than expected, but it is also possible that other structural causes may be the cause. To insure that all causes are systematically analyzed and corrected, where needed, prior to the 2007 season, Duke Energy intends to pursue the following quality assurance action plan.

Validate Data and Complete On-site Assessments

Work started in December 2006 is targeted to insure that the data used to complete the analysis of impacts is accurate and representative of the actual load reductions during the control events. Verification of the data received from the interval meters (measures actual energy usage in 15 minute intervals), data loggers (shows time stamped on/off cycling of A/C units) and weather data will be completed before Jan 2007. The modeling logic used to forecast load reduction potential will also be reviewed to ensure proper representation.

An on-site visit will be made to more than 100 homes that encompass the representative data sample. Technicians will visit each site with portable diagnostic equipment that will determine the operational condition of each switch. The inspection will evaluate the following:

- Switch programming
- Event history – did the switch receive the commands
- Signal strength
- Proper installation and functionality
- Switch tampering

If required, technicians will make repairs while on site and they will document their findings, so that the system integrity can be evaluated.

Analyze the results

The information gathered from the site visits will point the way to improving system performance and ultimate load reduction potential. The data will be analyzed and a list of prioritized initiatives will be developed and implemented to maximize performance for the 2007 Power Manager event season. A list of modification or repairs includes, but is not limited to the following:

- Programming enhancements to software (switch or command software)
- Changes in the paging or command protocol
- Paging company coverage improvements
- Antennae modifications
- Additional site visits assessments
- Switch replacement
- On site monitoring during a simulated command event

These options and others will be considered as opportunities to improve load reduction impacts. The items listed above have varied timeframes for implementation, so a comprehensive solution will incorporate short and long term solutions. Ideally, the chosen remedies will be implemented in parallel when possible and test will be conducted to verify results. The following chart represents the proposed timeline for implementing the action plan.

Actions	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*
Consult with experts											
Validate data											
On-site assessments											
Analyze the on-site data											
Develop an improvement plan											
Phase 1 improvements											
Phase 2 improvements											

Initial results

The initial stage of the Power Manger QA program involved site visits to 96 program participants in late December and early January. 45 of these were selected from the 2006 research sample, after analysis of interval load data indicated little or no load reduction from these households during load control events. 51 were selected from the general population of Indiana program participants. Key registers in the switches still contained values from the final Power Manger event of the summer, on August 7. Analysis of the switch register data collected in the test has identified two types of switch problems that contributed to lower than expected impact: some switches were not correctly programmed prior to the August 7 event, and many switches (24 from the research sample and 8 from the other group) apparently correctly programmed did not actually shed during the event period. The first problem will be addressed by re-programming all Power Manger switches (remotely, by paging) prior to next summer. Further QA tests will be conducted early in 2007 to identify the source of the second problem. No significant problems with paging signal strength, installation, or switch tampering were found in the site visits.