Methodology

This section presents the approach for conducting this assessment.

Development of the Customer Surveys

TecMarket Works and Integral Analytics developed a customer survey for delivery to the Personalized Energy Report (PER) Program participants after they have had time to implement the actions and recommendations included in the kit and PER that was distributed to participants. The survey asks participants about the changes that they have made to their home as a result of their receipt of the kit and the recommendations contained in the PER distributed by the Program. The survey asked the customer for information specific to each of the measures included in the Energy Efficiency Starter Kit and each of the recommendations in the PER. For each measure that was installed and for each recommendation taken, the participant completed a short battery of questions to determine the degree to which that measure was effectively placed and used. The survey was sent to two different types of customers. One of these was a group who received the kit and the PER. The second group of customers were residential program participants who only received the PER.

The customer surveys were electronic-scoring surveys. During the survey development process it was necessary to restrict questions so that they would fit on a set of double page paper that could be electronically scanned on each side of the page. This approach helped reduce the evaluation cost, but also reduced the number of questions that could be asked in order to calculate energy savings. However, this procedure did not result in overly restrictive questions and were structured to collect the data necessary to calculate savings. These two surveys can be found in Appendices A and B.

Survey Response

The surveys were sent to 5,401 participants – 3,562 customers that did not receive the kit, and 1,839 customers that did receive the Energy Efficiency Starter Kit. The data collection efforts resulted in 1,879 responses from PER participants that only received the PER (response rate = 52.8%), and 741 responses (response rate = 40.3%) from Kentucky PER participants that received the Energy Efficiency Kit.

Obtained and Cleaned Customer Information

The evaluation required participant data from Duke Energy, including the results of the survey data provided by each of the participants enrolled in the program. Once the data was delivered, TecMarket Works reviewed the data for accuracy and completeness, and coded the data to ready it for analysis in SPSS[1].

Program Impact Estimation

Using the measure-specific data collected from the customer surveys, we were able to extrapolate energy savings to the PER Program as a whole, and for each of the kit's eight measures individually. The per unit energy savings for each of the measures was

[1] Statistical Package for the Social Sciences. SPSS.com.

determined through a method in which TecMarket Works and AEC assigned the estimates of energy savings for each of the measures included in the PER Energy Efficiency Starter Kit and for each of the recommended measures. The estimates were formed via engineering estimates of savings based on survey information and on modeling results in which the calculations for the actions taken follow DOE-II residential software modeling algorithms for the expected weather in which the actions are taken. Historical weather average daily conditions were used as the predictive weather. This approach allows for reliable energy savings estimates consistent with accepted modeling approaches based on customer-provided installation and use conditions. Because the survey asks for customers to provide information on actions that were taken in part or in whole as a result of the program, the savings reported can be considered net savings with the understanding that typically actions are taken as a result of a combination of reasons and conditions. However, because the measures were obtained via the Duke-provided kit, and because the survey instrument asked for respondents to indicate only the actions taken as a result of their participation in the program the findings in this study can be considered reflective of the net program-induced savings.

The items distributed in the kit include the following measures.

1. 15-watt CFL
2. 20-watt CFL
3. Weather stripping
4. Outlet gaskets
5. Window shrink kit
6. Showerhead
7. Bathroom aerator
8. Kitchen aerator

The recommendations in the PER include the following actions:

1. Clean baseboards
2. Close off fireplace
3. Install a new central air unit
4. Install a new furnace
5. Install a new heat pump
6. Install attic insulation
7. Install sidewall insulation
8. Install window shrink kits
9. Insulate ducts
10. Insulate water heater
11. Lower the temperature in winter
12. Manage draperies
13. Purchase and install CFLs
14. Repair ducts
15. Replace furnace filter
16. Stop heating unused rooms
17. Switch to cold water for laundry

The algorithms used to calculate the impact estimates can be found in Appendix C.

Findings

Use of the Kit's Measures and Their Impacts

CFLs

The CFLs included in the PER kit were installed by more recipients than any other measure in the Energy Efficiency Starter Kit. Almost 90% of the recipients installed the 15-watt CFL, and close to 85% of them installed the 20-watt CFL. Table 1 below shows a summary of the responses to the questions about the 15-watt CFL. Most of the Kit recipients replaced a 45-70-watt bulb with the 15-watt CFL, and the replacement was done on lights that were used 3-4 hours per day on average. The same information can be found in Table 2 for the 20-watt CFL.

Table 1. Frequency of Installation: 15-watt CFL

Action	Kentucky Kits (n)	Kentucky Kits (%)
Installed 15w bulb		
Yes	654	89.3%
No	72	9.8%
Don't Know	6	0.8%
Wattage of bulb removed		
Less than 44w	52	8.1%
45-70w	459	71.5%
71-99w	69	10.7%
Greater than 100w	62	9.7%
Hours of use per day		
<1	63	10.2%
1-2	144	23.3%
3-4	237	38.3%
5-10	143	23.1%
11-12	16	2.6%
13-24	16	2.6%

Table 2. Frequency of Installation: 20-watt CFL

Action	Kentucky Kits (n)	Kentucky Kits (%)
Installed 20w bulb		
Yes	590	83.7%
No	106	15.0%
Don't Know	9	1.3%
Wattage of bulb removed		
Less than 44w	27	4.7%
45-70w	333	58.0%
71-99w	125	21.8%
Greater than 100w	89	15.5%
Hours of use per day		
<1	49	8.9%
1-2	138	25.2%
3-4	219	40.0%

5-10	118	21.5%
11-12	12	2.2%
13-24	12	2.2%

Using the information above and the algorithm for lighting impacts (which can be found in Appendix C), the estimate of savings for these customers totals 8.01 kw and 104,690 kilowatt hours per year. However, the reduction in heat output from switching the incandescent to the CFL results in an increase in therm consumption of 158.9 therms per year total. Savings can be found in Table 3.

The savings per customer for either of the CFLs can also be found Table 3 below. For instance, each customer that installed the 15-watt CFL will save 84.5 kwhs per year (55,269 / 654 = 84.5). This is the average per customer savings. The real savings will of course depend on the other factors involved (the wattage of the bulb removed and hours of use).

Table 3. Impact Estimates from the Installation of the CFL Bulbs

	Number Installed	Total kW Savings	Total kWh Savings	Total Therm Savings
15-watt CFL	654	4.148	55,269	-158.9
20-watt CFL	590	3.862	49,421	
	Per Install →	**Mean kW Savings**	**Mean kWh Savings**	**Mean Therm Savings**
15-watt CFL	654	0.00634	84.51	-0.13
20-watt CFL	590	0.00655	83.76	

Weather Stripping

Just over a third of the kit recipients (36%) installed the weather stripping, but most of those that did used 11-17 feet of the product. Given the low number of installations, the savings for this measure are modest, Table 5 below shows the energy savings from these 259 installations, with only 1,791 kilowatt hours and 41 therms saved per year.

Table 4. Frequency of Installation: Weather Stripping

Action	Kentucky Kits (n)	Kentucky Kits (%)
Installed weather stripping		
Yes	259	35.8%
No	453	62.9%
Don't Know	9	1.3%
Feet installed		
1-5	36	14.2%
6-10	95	37.5%
11-17	122	48.2%

Table 5. Impact Estimates from the Installation of the Weather Stripping

	Number	Total kW	Total kWh	Total Therm

	Installed	Savings	Savings	Savings
Weather stripping	259	.549	1,791	41.3
	Per Install →	**Mean kW Savings**	**Mean kWh Savings**	**Mean Therm Savings**
		0.00212	6.9	0.16

Outlet Gaskets

About half of the recipients installed the outlet gaskets, and most of them installed 3-5 gaskets (they were provided with 8). Despite this, the kilowatt hour savings from this measure are 5,259 kWh annually.

Table 6. Frequency of Installation: Outlet Gaskets

Action	Kentucky Kits (n)	Kentucky Kits (%)
Installed the gaskets on outlets		
Yes	366	50.6%
No	354	48.6%
Don't Know	4	0.6%
Number installed		
1-2	73	19.4%
3-5	180	47.7%
6-8	124	32.9%

Table 7. Impact Estimates from the Installation of the Outlet Gaskets

	Number Installed	Total kW Savings	Total kWh Savings	Total Therm Savings
Outlet gaskets	366	1.534	5,259	105.5
	Per Install →	**Mean kW Savings**	**Mean kWh Savings**	**Mean Therm Savings**
		0.00419	14.37	0.29

Window Shrink Kit

Most of the kit recipients did not install the window film shrink kit. Only 14% of the population installed this measure.

Table 8. Frequency of Installation: Window Film Shrink Kit

Installed window shrink kit	Kentucky Kits (n)	Kentucky Kits (%)
Yes	101	14.0%
No	611	85.0%
Don't Know	7	1.0%
Size of window		
Small	16	16.3%
Average	69	70.4%
Large	13	13.3%
Type of window		
Single Pane	37	38.1%
Single with storm	23	23.7%

Double Pane	37	38.1%

With the low numbers of installations combined with the fact that 38% of the kits were installed on double-pane windows, the savings for this measure are also quite low.

Table 9. Impact Estimates from the Installation of the Window Film Shrink Kit

	Number Installed	Total kW Savings	Total kWh Savings	Total Therm Savings
Window shrink kit	101	2.286	3,957	44.9
	Per Install →	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
		0.02263	39.18	4.41

Low-Flow Showerhead

A high percentage (64%) of the kit recipients installed the low-flow showerhead. Most of the recipients reported that there are 5-10 showers taken at the residence per week. However, the high savings comes from the larger families that indicated that they take over 21 showers per week with the new showerhead.

Table 10. Frequency of Installation: Low-Flow Showerhead

Action	Kentucky Kits (n)	Kentucky Kits (%)
Installed the showerhead		
Yes	467	63.9%
No	261	35.7%
Don't Know	3	0.4%
Number of showers per week		
0-4	77	16.7%
5-10	226	49.0%
11-15	107	23.2%
16-20	28	6.1%
21+	23	5.0%
Estimate of water flow		
Less than the old unit	251	56.5%
About the same as the old unit	176	39.6%
More than the old unit	17	3.8%

The numbers of installations vary as a result of the estimate of water flow provided. If the customer indicated that the water flow was "about the same as the old unit", their information was removed from the energy impact calculations. If they indicated that the water flow was "more than the old unit", they were included in the impact calculations but a 1.0gpm showerhead was assumed to have been replaced with the 1.5gpm showerhead included in the kit. This resulted in those 17 customers having negative savings. However, the savings from this measure are still very strong, with over 35,000 kilowatt hours and almost 4,000 therms saved annually as a result of these customers installing this measure.

Table 11. Impact Estimates from the Installation of the Low-Flow Showerhead

	Number Installed	Total kW Savings	Total kWh Savings	Total Therm Savings
Showerhead	291	4.053	36,983	3,725
	Per Install →	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
		0.01393	127.09	12.80

Faucet Aerators

The customers were also likely to install the faucet aerators included in the Energy Efficiency Starter Kit. More than half of the kit recipients installed both of the aerators. The wording of the survey questions for this measure resulted in an interesting finding: many of the customers indicated that they did not install the aerator included in the kit, but still marked that there was already an aerator in place, indicating that this energy efficient action had already been undertaken without the prompting of the Energy Efficiency Starter Kit and the Personalized Energy Report. Those that fall into this category are included in the frequency tables below (Table 12 and Table 13), but not in the energy impact estimates.

Table 12. Frequency of Installation: Bathroom Faucet Aerator

Action	Kentucky Kits (n)	Kentucky Kits (%)
Installed the bathroom aerator		
Yes	397	54.8%
No	320	44.2%
Don't Know	7	1.0%
Aerator already installed		
Yes	245[2]	55.8%
No	177	40.3%
Don't Know	17	3.9%
Estimate of water flow		
Less than the old unit	188	54.5%
About the same as the old unit	145	42.0%
More than the old unit	12	3.5%

Table 13. Frequency of Installation: Kitchen Faucet Aerator

Action	Kentucky Kits (n)	Kentucky Kits (%)
Installed the kitchen aerator		
Yes	366	50.6%
No	354	48.6%
Don't Know	4	0.6%
Aerator already installed		
Yes	236[3]	58.7%
No	153	38.1%
Don't Know	13	3.2%
Estimate of water flow		

[2] Includes 14 respondents that did not install the PER kit's aerator.
[3] Includes 22 respondents that did not install the PER kit's aerator.

Less than the old unit	175	57.4%
About the same as the old unit	114	37.4%
More than the old unit	16	5.2%

The energy impacts for this measure are in the table below, and indicate overall savings of over 4,000 kilowatt hours per year and 285 therms per year.

Table 14. Impact Estimates from the Installation of the Bathroom and Kitchen Faucet Aerators

	Number Installed	Total kW Savings	Total kWh Savings	Total Therm Savings
Bathroom aerator	397	.035	2,651	150
Kitchen aerator	366	.025	2,083	135
Per Install →		**Mean kW Savings**	**Mean kWh Savings**	**Mean Therm Savings**
Bathroom aerator		.00009	6.68	0.38
Kitchen aerator		.00007	5.69	0.37

All Kit Measures

The Energy Efficiency Starter Kit is a kit of 8 energy efficient measures. The tables below show the relative "popularity" of each of the items for the recipients of the kits and the total savings for each of the measures based on those customers that indicated they installed the measure.

The CFLs are the most likely measure to be installed, with the showerhead coming in second. Given the responses by the customers indicating the details of the installation (number of showers, wattage of bulb replaced, etc.), the showerhead provides a greater amount of savings than the CFLs.

Table 15. Summary of Total Savings for All Measures

Kentucky Kits	Installed	Percent Installed	Total kW savings	Total kWh savings	Therm savings
15-watt CFL	654	88.3%	4.148	55,269	-159
20-watt CFL	590	79.6%	3.862	49,421	
Weather stripping	259	35.0%	.549	1,791	41
Outlet gaskets	366	49.4%	1.534	5,259	106
Window shrink kit	101	13.6%	2.286	3,957	445
Showerhead	291	39.3%	4.053	36,983	3,725
Bathroom aerator	397	53.6%	.035	2,651	150
Kitchen aerator	366	49.4%	.025	2,083	135
Total Savings			**16.492**	**157,414**	**4,443**

The total savings from those that received the kits and responded to the survey is estimated to be 157,414 kilowatt-hours and 4,443 therms annually. The kilowatt impacts of the kits is estimated to be 16.492.

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those that did not get the kit indicating on the survey that they did lower the temperature in the winter as a result of reading the report. Most of the customers lowered the temperature by 1-3 or 4-6 degrees, but there were some that lowered the temperature by 11 degrees or more, saving the household a significant amount of energy.

Table 17. Frequency of Recommendation Taken: Lowering the Temperature in Winter

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Lowered the temperature at night				
Yes	608	83.4%	1,559	84.0%
No	99	13.6%	243	13.1%
No, but plan to do this	19	2.6%	36	1.9%
Don't Know	3	0.4%	17	0.9%
Number of degrees lowered during the day				
1-3	286	48.8%	689	45.6%
4-6	222	37.9%	596	39.6%
7-10	65	11.1%	176	11.7%
11+	13	2.2%	43	2.9%
Number of degrees lowered at night				
1-3	316	60.3%	778	58.1%
4-6	141	26.9%	409	30.5%
7-10	54	10.3%	123	9.2%
11+	13	2.5%	29	2.2%

The 2,167 respondents to the survey that indicated that they have turned down the temperature are realizing a savings of 178,466 kilowatt hours per year and 3,807 therms per year, an average of almost 300 kwhs and 6 therms annually per response.

Table 18. Total Impact Estimates from Lowering the Temperature in Winter

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes, lowered the temperature in winter	608			
Daytime savings		-	121,733	2,727
Nighttime savings		-	56,733	1,080
No, but plan to lower the temperature	19			
Daytime savings		-	2,727	39
Nighttime savings		-	1,361	18
Kentucky No Kits	1879			
Yes, lowered the temperature in winter	1559			

Daytime savings		-	464,354	7,255
Nighttime savings		-	96,373	2,778
No, but plan to lower the temperature	36			
Daytime savings		-	9,878	82
Nighttime savings		-	5,529	31

Table 19. Mean Impact Estimates from Participants Lowering the Temperature in Winter

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, lowered the temperature in winter	608			
Daytime savings		-	200.2	4.5
Nighttime savings		-	93.3	1.8
Kentucky No Kits	1879			
Yes, lowered the temperature in winter	1559			
Daytime savings		-	297.7	4.7
Nighttime savings		-	138.1	1.8

CFLs

The PER included the following statement: "Energy-saving compact fluorescent light bulbs use up to 75% less energy than standard bulbs and last up to 10 times longer." From this simple statement, about 50% of the recipients said that they purchased and installed more CFLs that was at least in part induced by their report. Those that received the two CFLs with the kit were slightly more likely to take this action (55% versus 50%). However, 32% that did not receive the kit indicate that they plan on purchasing and installing CFLs.

Table 20. Frequency of Recommendation Taken: Purchase and Install CFLs

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Purchased and installed CFLs				
Yes	393	55.4%	899	49.4%
No	144	20.3%	588	32.0%
No, but plan to do this	170	24.0%	319	17.3%
Don't Know	2	0.3%	25	1.4%
Number of CFLs purchased and installed				
1-2	99	24.3%	299	31.9%

3-5	143	35.1%	330	35.2%
6-9	94	23.1%	188	20.1%
10+	71	17.4%	120	12.8%
Average wattage of bulb removed				
=<44	12	2.9%	28	3.2%
45-70	267	65.4%	521	59.0%
71-99	78	19.1%	191	21.6%
=>100	51	12.5%	143	16.2%
Average hours bulbs are used per day				
=<1	4	1.0%	25	2.7%
1-2	43	11.0%	120	13.1%
3-4	142	36.2%	305	33.3%
5-9	141	36.0%	357	38.9%
10-12	41	10.5%	79	8.6%
13-24	21	5.4%	31	3.4%

The savings from installing the CFLs are shown in Table 21 below. The estimates for those that indicated that they planned on purchasing CFLs are based on the mean responses of those that provided the details of what wattage bulb was replaced and the hours of use for that bulb. Using only the savings estimates based on those that said that they took the action, those that received the kits reduced their kWh consumption by 151,396kWhs, or about 385 kwhs per person, per year. Those that did not receive kits reduced their consumption by 45,864 kWhs per year, or 51 kWhs per person, per year. These may seem like high estimates, but when you consider the responses to the questions summarized in Table 20 above, many of them made these replacements in lamps that the customer reports using 5-9 hours per day. That is, they report that they have installed the lamps in their high-use fixtures and checked the number of hours that they use the lamps per day.

Table 21. Total Impact Estimates from Installing CFLs

	Population	Total Bulbs	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741				
Yes, purchased and installed CFLs	393	2107	25.255	151,396	-67.2
No, but plan to purchase and install CFLs	170		.187	3,477	-6.8
Kentucky No Kits	1879				
Yes, purchased and installed CFLs	899	4269	5.503	45,864	-136
No, but plan to purchase and install CFLs	319		.580	7,461	-12.7

Table 22. Mean Estimates from Participants Installing CFLs

	Population	Mean kW	Mean kWh	Mean

		Savings	Savings	Therm Savings
Kentucky Kits	741			
Yes, purchased and installed CFLs	393	0.06426	385.2	-0.2
Kentucky No Kits	1879			
Yes, purchased and installed CFLs	899	0.00612	51	-0.2

Using Cold Water for Laundry

Over half of the respondents indicated that they switched from hot to cold water to do their laundry at least in part because of the PER. The total savings from this recommendation are presented in Table 24 and indicate significant savings. The mean savings are presented in Table 25.

Table 23. Frequency of Recommendation Taken: Switching to Cold Water for Laundry

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Switched from hot to cold water for laundry				
Yes	390	55.5%	993	55.5%
No	242	34.4%	643	35.9%
No, but plan to do this	53	7.5%	118	6.6%
Don't Know	18	2.6%	35	2.0%
Number of loads per week				
1-2	61	15.6%	195	19.3%
3-4	128	32.7%	356	35.2%
5-6	105	26.9%	265	26.2%
7-8	48	12.3%	116	11.5%
9-10	28	7.2%	56	5.5%
11-12	10	2.6%	8	0.8%
13+	11	2.8%	16	1.6%

Table 24. Total Impact Estimates for Switching to Cold Water

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes, switched to cold water	386	5.582	27,404	3,875.6
Plan to switch	53	.234	2,059	450
Kentucky No Kits	1879			
Yes, switched to cold water	987	7.159	62,702	10,210.6
Plan to switch	118	0.753	6,601	1,130

Table 25. Mean Impact Estimates for Participants Switching to Cold Water

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, switched to cold water	386	0.01446	71	10.0
Kentucky No Kits	1879			
Yes, switched to cold water	987	.00725	63.5	10.3

Replacing Furnace Filter

This recommendation is the only one that resulted in overall negative savings. Many of those that indicated that they changed their furnace filters reported that they change their filters *less* frequently now compared to before they received the PER recommendations. This resulted in an overall increase in energy consumption. As a result we separated the results for this measure to show the savings for those that increased the frequency of filter changes and those that decreased the frequency of filter changes.

Table 26. Frequency of Recommendation Taken: Replacing Furnace Filter

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Replaced furnace filter				
Yes	613	86.5%	1,574	87.8%
No	66	9.3%	136	7.6%
No, but plan to do this	26	3.7%	75	4.2%
Don't Know	4	0.6%	8	0.5%
Frequency of filter changes before PER				
Less than once a year	18	3.1%	47	3.2%
Once a year	51	8.7%	134	9.2%
Twice a year	128	21.9%	342	23.5%
More than twice a year	380	65.1%	897	61.6%
Don't Know	7	1.2%	35	2.4%
Frequency of filter changes since PER				
Less than once a year	8	1.3%	22	1.5%
Once a year	39	6.6%	111	7.5%
Twice a year	125	21.0%	307	20.7%
More than twice a year	420	70.7%	1,035	69.7%
Don't Know	2	0.3%	10	0.7%

Table 27. Total Impact Estimates for Changing Furnace Filter

	Population	Number Changing Filters	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741	143			
Increasing Frequency		68	8.800	11,943	122
Decreasing Frequency		75	-11.040	-15,877	-143

Total Savings			-2.240	-3934	-21
Kentucky No Kits	1879	458			
Increasing Frequency		241	32.240	43,359	433
Decreasing Frequency		217	-33.120	-47,976	-392
Total Savings			-.880	-4617	41

Table 28. Mean Impact Estimates for Participants Changing Furnace Filter

	Population	Number Changing Filters	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741	143			
Increasing Frequency		68	0.12941	175.63	1.79
Decreasing Frequency		75	-0.14720	-211.69	-1.91
Total Savings			-0.01779	-36.06	-0.12
Kentucky No Kits	1879	458			
Increasing Frequency		241	0.13378	179.91	1.80
Decreasing Frequency		217	-0.15263	-221.09	-1.81
Total Savings			-0.01885	-41.18	-0.01

Closed Off Fireplace

The survey asked if the respondent stopped using the fireplace, and then asked if they closed off the fireplace. Those that indicated that they stopped using the fireplace were removed, as there are no savings from this action, but if they also indicated that they closed up or sealed up the fireplace, then the savings were estimated.

Table 29. Frequency of Recommendation Taken: Closing Off Fireplace

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Stopped using fireplace				
Yes	211	38.7%	559	42.5%
No	305	56.0%	708	53.8%
No, but plan to do this	19	3.5%	26	2.0%
Don't Know	10	1.8%	23	1.8%
Closed off fireplace				
Yes	191	39.0%	509	46.2%
No	265	54.1%	531	48.2%
No, but plan to do this	24	4.9%	36	3.3%
Don't Know	10	2.0%	25	2.3%

Table 30. Total Impact Estimates for Closing Off Fireplace

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kits	191	0.642	1,103	20.7
No Kits	509	0.340	1,201	22.5

Table 31. Mean Impact Estimates for Participants Closing Off Fireplace

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kits	191	0.00336	5.8	0.1
No Kits	509	0.00067	2.40	0.0

Stopped Heating Unused Rooms

More than half said that they stopped heating unused rooms in their homes, and significant savings were realized from this action. Most of them indicated that they stopped heating one or two rooms in the house, 15% of those that did not get kits said they stopped heating three unused rooms.

Table 32. Frequency of Recommendation Taken: Stop Heating Unused Rooms

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Stopped heating unused rooms				
Yes	405	56.6%	1,032	56.2%
No	282	39.4%	735	40.0%
No, but plan to do this	27	3.8%	63	3.4%
Don't Know	1	0.1%	7	0.4%
Number of rooms no longer being heated				
1	138	36.6%	320	31.6%
2	159	42.2%	419	41.3%
3	41	10.9%	152	15.0%
4	15	4.0%	59	5.8%
5	13	3.4%	33	3.3%
6+	11	2.9%	31	3.1%

The savings from this recommendation are shown in

Table 33 below.

Table 33. Total Impact Estimates for Not Heating Unused Rooms

	Population	Number Closing Off Rooms	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741				
Yes		405	86.488	35,061	437
No, but plan to		27	1.523	2,120	33.1
Kentucky No Kits	1879				
Yes		1032	81.334	123,535	1,270.4
No, but plan to		63	5.992	9,529	74.9

Table 34. Mean Impact Estimates for Participants Not Heating Unused Rooms

	Population	Number Closing Off Rooms	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741				
Yes		405	0.21345	86.6	1.1
Kentucky No Kits	1879				
Yes		1032	0.07881	119.7	1.2

Window Shrink Kits

Only 14% of those receiving the Energy Efficiency Starter Kit installed the shrink kit that was included. Here, less than 10% state that they purchased and installed additional kits per the PER recommendations, and another 3-4% indicated that they plan to purchase and install window kits. Obviously, this is not a popular measure.

Table 35. Frequency of Recommendation Taken: Installed Window Kits

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Purchased and installed window kits				
Yes	68	9.4%	166	9.1%
No	614	85.3%	1,600	87.9%
No, but plan to do this	32	4.4%	50	2.7%
Don't Know	6	0.8%	5	0.3%
Number of windows				

covered				
1-3	38	57.6%	72	49.7%
4-7	18	27.3%	44	30.3%
8-10	7	10.6%	12	8.3%
11+	3	4.5%	17	11.7%
Size of window				
Small	4	5.9%	13	9.4%
Average	47	69.1%	80	57.6%
Large	17	25.0%	46	33.1%
Type of window				
Single pane	25	35.7%	54	34.9%
Single with storm	19	27.1%	31	22.6%
Double pane	26	37.1%	52	38.0%

The savings from this measure are relatively low, with the exception of therm savings of those that did not get the kits. This group was able to reduce their therm consumption by 49 therms annually, however these savings amounts to 0.3 therms per household, per year.

Table 36. Total Impact Estimates for Installing Window Shrink Kits

Window shrink kit	**Number Installed**	**Total kW Savings**	**Total kWh Savings**	**Total Therm Savings**
Kits				
Yes, installed	68	2.127	1,018	18.9
Plan to install	32	0.637	1,179	12.8
No Kits				
Yes, installed	166	2.147	3,516	48.9
Plan to install	50	0.564	1,060	8.7

Table 37. Mean Impact Estimates for Participants Installing Window Shrink Kits

Window shrink kit	**Number Installed**	**Mean kW Savings**	**Mean kWh Savings**	**Mean Therm Savings**
Kits				
Yes, installed	68	0.03128	15.0	0.3
No Kits				
Yes, installed	166	0.01293	21.1	0.3

Insulated Water Heater

The second most common response to the recommendation to insulate the hot water heater was "No, but I plan to", with about 11-17% of both groups providing this response. Only about 14-15% of the respondents report that they have taken the action as a result of the PER.

Table 38. Frequency of Recommendation Taken: Insulated Water Heater

Action	**Kentucky Kits**	**Kentucky Kits**	**Kentucky No**	**Kentucky No**

	(n)	(%)	Kits (n)	Kits (%)
Insulated hot water heater tank				
Yes	103	14.4%	267	14.8%
No	488	68.4%	1,304	72.2%
No, but plan to do this	119	16.7%	201	11.1%
Don't Know	3	0.4%	35	1.9%
Capacity of water heater, in gallons				
30	15	12.8%	75	26.0%
50	58	49.6%	117	40.5%
60	21	17.9%	31	10.7%
75	7	6.0%	9	3.1%
80+	7	6.0%	19	6.6%
Don't Know	9	7.7%	38	13.1%

Table 39. Total Impact Estimates for Insulating Water Heater

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes	102	1.134	3,282	354.1
No, but plan to	119	0.474	4,153	460.8
Kentucky No Kits	1879			
Yes	265	1.288	11,278	901.4
No, but plan to	201	0.698	6,111	915.3

Table 40. Mean Impact Estimates for Participants Insulating Water Heater

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes	102	0.01112	32.2	3.5
Kentucky No Kits	1879			
Yes	265	0.00486	42.6	3.4

Manage Draperies

This recommendation has one of the highest response rates, with about 80% of both groups indicating that they are now managing their drapes in the winter to let the sun shine in during the day. Again, the survey asked respondents to record what they were doing that was at least in part caused by the information presented on their PER report.

Table 41. Frequency of Recommendation Taken: Managing Draperies

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)

Manages draperies				
Yes	589	80.7%	1,446	78.6%
No	124	17.0%	342	18.6%
No, but plan to do this	11	1.5%	43	2.3%
Don't Know	6	0.8%	8	0.4%
Number of window coverings managed				
1-3	152	30.0%	410	32.5%
4-7	250	49.3%	601	47.7%
8-12	84	16.6%	198	15.7%
13+	21	4.1%	52	4.1%

Table 42. Total Impact Estimates for Managing Draperies

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes	589	0	36,371	1.641
No, but plan to	11	0	176	32.1
Kentucky No Kits	1,879			
Yes	1,446	0	96,373	4,371.6
No, but plan to	43	0	338	84.8

Table 43. Mean Impact Estimates for Participants Managing Draperies

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes	589	0.00000	61.8	2.8
Kentucky No Kits	1,879			
Yes	1,446	0.00000	66.6	3.0

Cleaned Electric Baseboards

As this measure only applies to those that have both electric heat and baseboards, and the impacts of the action are small - little savings are realized from this recommendation. Many of those that said they took the action did not have electric heat, so most of the cases were removed from the impact estimation calculations. This response indicates that many participants do not know what baseboard units are, and most likely cleaned the warm air registers leading from the central heating unit. An action that provides no savings.

Table 44. Frequency of Recommendation Taken: Cleaning Baseboards

Action	Kentucky Kits	Kentucky Kits	Kentucky No	Kentucky No

	(n)	(%)	Kits (n)	Kits (%)
Cleaned electric baseboards				
Yes	112	39.6%	231	37.7%
No	143	50.5%	317	51.7%
No, but plan to do this	18	6.4%	43	7.0%
Don't Know	10	3.5%	22	3.6%
Number of electric baseboards cleaned				
1-3	21	22.6%	52	27.8%
4-7	42	45.2%	62	33.2%
8-12	22	23.7%	55	29.4%
13+	8	8.6%	18	9.6%

Table 45. Total Impact Estimates for Cleaning Baseboards

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes	5	-	40	-
No, but plan to	1	-	8	-
Kentucky No Kits	1879			
Yes	7	-	51	-
No, but plan to	1	-	8	-

Table 46. Mean Impact Estimates for Participants Cleaning Baseboards

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes	5	-	8.0	-
Kentucky No Kits	1879			
Yes	7	-	7.2	-

Attic Insulation

The recommendation to insulate the attic was taken by over 45% of the respondents. Another 6-10% plan to take this action. Most respondents report that they have or will insulate the entire attic with fiberglass insulation, adding 2-6 inches.

Table 47. Frequency of Recommendation Taken: Attic Insulation

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Attic insulated				
Yes	303	45.4%	833	48.9%
No	286	42.9%	707	41.5%
No, but plan to do this	64	9.6%	107	6.3%

Don't Know	14	2.1%	56	3.3%
All or part of ceiling insulated				
Part of ceiling	39	12.7%	82	11.2%
All of ceiling	267	87.3%	649	88.8%
Type of insulation				
Fiberglass	191	68.5%	505	71.8%
Cellulose	58	20.8%	126	17.9%
Foam	15	5.4%	38	5.4%
Other	15	5.4%	34	4.8%
Inches of thickness added				
1-2	21	8.2%	81	12.8%
2-4	84	32.7%	223	35.1%
5-6	81	31.5%	163	25.7%
7-8	36	14.0%	77	12.1%
9-10	21	8.2%	49	7.7%
11+	14	5.4%	42	6.6%
Inches of thickness already there				
1-2	75	34.7%	207	41.5%
2-4	66	30.6%	174	34.9%
5-6	38	17.6%	61	12.2%
7-8	18	8.3%	30	6.0%
9-10	7	3.2%	9	1.8%
11+	12	5.6%	18	3.6%

The myriad of responses in the survey regarding this recommendation (and the following recommendation of insulation of sidewalls) require a more complex table than the other measures. Those that responded are broken down into six groups:

1. Yes, installed attic insulation. These respondents provided full details by answering all of the four follow-up questions.
2. Yes, installed attic insulation, but only partial detail. These respondents answered only 2 or 3 of the follow-up questions.
3. Yes, installed attic insulation, but little or no detail. These respondents answered 0 or 1 of the follow-up questions.
4. No, but plan to install attic insulation. These respondents provided full details by answering all of the four follow-up questions.
5. No, but plan to install attic insulation, but only partial detail. These respondents answered only 2 or 3 of the follow-up questions.
6. No, but plan to install attic insulation but little or no detail. These respondents answered 0 or 1 of the follow-up questions.

The impacts for groups 2, 3, 5 and 6 are estimated using the mean value of the responses of those that provided the needed details. The impacts are presented in Table 48 below.

Table 48. Total Impact Estimates for Attic Insulation

	Population	Total kW	Total kWh	Total Therm

		Savings	Savings	Savings
Kentucky Kits	741			
Yes, installed attic insulation	247	25.107	15,843	267.5
Yes, installed, but only partial detail	38	1.644	3,119	57.1
Yes, installed, but little or no detail	18	0.894	1,494	27.0
No, but plan to, with full detail	5	0.098	97	3.6
No, but plan to, but only partial detail	2	0.052	51	2.8
No, but plan to, but little or no detail	57	4.465	9,367	85.1
Kentucky No Kits	1879			
Yes, installed attic insulation	628	31.440	56,639	875.4
Yes, installed, but only partial detail	81	5.578	10,798	136.1
Yes, installed, but little or no detail	124	8.589	17,726	211.1
No, but plan to, with full detail	9	0.299	593	3.9
No, but plan to, but only partial detail	1	0.028	27	1.4
No, but plan to, but little or no detail	97	6.801	13,031	149.8

Table 49. Mean Impact Estimates for Participants Installing Attic Insulation

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, installed attic insulation	247	0.10165	64.1	1.1
Yes, installed, but only partial detail	38	0.04326	82.1	1.5
Yes, installed, but little or no detail	18	0.04967	83.0	1.5
Kentucky No Kits	1879			
Yes, installed attic insulation	628	0.05006	90.2	1.4
Yes, installed, but only partial detail	81	0.06886	133.31	1.7
Yes, installed, but little or no detail	124	0.06927	142.95	1.7

Sidewall Insulation

Less than 10% have taken this action as a result of the PER recommendation, with another 3-5% planning on doing this. The energy savings are higher for this measure than for attic insulation, since the base assumption is that the wall is uninsulated.

Table 50. Frequency of Recommendation Taken: Sidewall Insulation

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Sidewalls insulated				
Yes	34	5.0%	133	7.7%
No	606	88.5%	1,486	86.3%
No, but plan to do this	32	4.7%	57	3.3%
Don't Know	13	1.9%	45	2.6%
Number of sidewalls insulated				
1	4	14.3%	5	5.1%
2	1	3.6%	8	8.2%
3	6	21.4%	15	15.3%
4+	17	60.7%	70	71.4%
Type of insulation				
Fiberglass	12	42.9%	59	60.2%
Cellulose	3	10.7%	14	14.3%
Foam	9	32.1%	13	13.3%
Other	4	14.3%	12	12.2%
Inches of thickness added				
1-3	14	53.8%	46	50.9%
4-6	11	42.3%	34	39.3%
7-12	1	3.8%	6	8.0%
13+	0	0.0%	2	1.8%

Table 51. Total Impact Estimates for Sidewall Insulation

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes, installed sidewall insulation	20	6.948	2,656	61.9
Yes, installed, but only partial detail	8	1.273	752	31.0
Yes, installed, but little or no detail	62	4.509	9,232	238.1
No, but plan to, with full detail	1	.447	499	31
No, but plan to, but only partial detail	0	0	0	0
No, but plan to, but little or no detail	31	2.415	7,003	101.9
Kentucky No Kits	1879			

Yes, installed sidewall insulation	76	5.746	13,714	276.3
Yes, installed, but only partial detail	16	1.284	3,503	54.6
Yes, installed, but little or no detail	199	15.919	41,563	700.9
No, but plan to, with full detail	4	0.329	1,104	3.5
No, but plan to, but only partial detail	2	0.134	500	3.9
No, but plan to, but little or no detail	51	4.084	10,591	173.3

Table 52. Mean Impact Estimates for Participants Installing Sidewall Insulation

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, installed sidewall insulation	20	0.34738	132.8	3.1
Yes, installed, but only partial detail	8	0.15913	94	3.9
Yes, installed, but little or no detail	62	0.07273	149	3.8
Kentucky No Kits	1879			
Yes, installed sidewall insulation	76	0.07561	180.4	3.6
Yes, installed, but only partial detail	16	0.08025	218.9	3.4
Yes, installed, but little or no detail	199	0.07999	208.9	3.5

Duct Insulation/Repair

Respondents were more likely to repair the ducts than to insulate them, but many report that they plan on taking both actions. Unfortunately, over 60% of the ducts are located in heated areas of the home in which insulation or repair will not provide savings.

Table 53. Frequency of Recommendation Taken: Duct Insulation or Repair

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Insulated ducts				
Yes	75	10.7%	202	11.7%
No	558	79.8%	1,403	81.6%
No, but plan to do this	48	6.9%	64	3.7%
Don't Know	18	2.6%	51	3.0%

Repaired holes in ducts				
Yes	77	23.2%	173	19.9%
No	230	69.3%	599	68.9%
No, but plan to do this	8	2.4%	24	2.8%
Don't Know	17	5.1%	73	8.4%
Location of ducts insulated				
Unheated area	74	26.2%	193	25.9%
Heated area	183	64.9%	462	62.0%
Don't Know	25	8.9%	90	12.1%

The tables below present the savings for the duct work, and the breakdown of how many of them repaired or insulated ducts in heated areas.

Table 54. Total Impact Estimates for Duct Insulation

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes, insulated ducts	41	4.071	3,896	88.1
Yes, insulated ducts, but they were in a heated area	32	0	0	0
No, but plan to	48	1.213	2,808	45.6
Kentucky No Kits	1879			
Yes, insulated ducts	104	6.688	16,648	210.1
Yes, insulated ducts, but they were in a heated area	96	0	0	0
No, but plan to	64	3.173	6,692	65.7

Table 55. Mean Impact Estimates for Participants Installing Duct Insulation

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, insulated ducts	41	0.09928	95.0	2.1
Kentucky No Kits	1879			
Yes, insulated ducts	104	0.06431	160.1	2.0

Table 56. Total Impact Estimates for Duct Repair

	Population	Total kW	Total kWh	Total Therm

		Savings	Savings	Savings
Kentucky Kits	741			
Yes, repaired ducts	37	7.495	4,408	58.1
Yes, repaired ducts, but they were in a heated area	36	0	0	0
No, but plan to	8	.155	362	9.9
Kentucky No Kits	1879			
Yes, repaired ducts	92	7.754	16,255	94.1
Yes, repaired ducts, but they were in a heated area	79	0	0	0
No, but plan to	24	1.155	2,486	23.9

Table 57. Mean Impact Estimates for Participants Performing Duct Repair

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, repaired ducts	37	0.20257	119.1	1.6
Kentucky No Kits	1879			
Yes, repaired ducts	92	0.08429	176.7	1.0

Installed a New Central Air Unit

Just over 20% of the respondents indicated that they have installed a new central air unit at least in part because of the PER program. Over half of the participants report that their new units are high efficiency units. Most of the respondents did not know the SEER number for their new unit, and many of the responses had to be adjusted in this analysis as a result. For example, some respondents said that they installed a high efficiency unit and also reported that it had an SEER of 12. When this occurred, we assumed the SEER number was correct and changed the efficiency to "standard". We also distributed the SEER values of the people who could report them across the values for the individuals that could not report them. This provided a way to adjust the SEER ratings for the people who reported buying a high efficiency unit, but did not know the SEER rating to account for the fraction of the participants who actually purchased a more standard SEER unit.

Close to 3% of the respondents indicated that they planned on installing a new central air unit.

Table 58. Frequency of Recommendation Taken: New Central Air Unit

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Installed a new central air unit				
Yes	154	22.1%	386	22.3%
No	519	74.6%	1,291	74.8%
No, but plan to do this	18	2.6%	43	2.5%
Don't Know	5	0.7%	6	0.4%
Efficiency of unit				
High efficiency	139	52.1%	325	49.2%
Standard	65	24.3%	135	20.4%
Don't Know	63	23.6%	201	30.4%
SEER number for unit				
=<11	14	6.0%	16	2.8%
12	12	5.2%	26	4.5%
13	21	9.1%	53	9.2%
14+	20	8.6%	33	5.7%
Don't Know	165	71.1%	451	77.9%

Only 58 respondents who also received the kits provided any details on the new central air unit they installed. The other 96 cases provided partial or no details, so we used the mean responses from the 58 cases that provided purchase details to determine impact estimates. We used this same method for the 269 cases in the "no kits" group who also were unable to provide full details about the efficiency of their units. We only calculated estimated savings for those that plan to install a new central air unit if they provided the details on the efficiency level that they planned to purchase.

Table 59. Total Impact Estimates for New Central Air Units

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes, installed a new central air unit	58	12.865	17,411	0
Yes, installed, but little or no detail	96	19.463	22,531	0
No, but plan to, with full detail	1	0.129	118	0
No, but plan to, but little or no detail	17	2.439	3,597	0
Kentucky No Kits	1879			
Yes, installed a new central air unit	117	26.778	34,523	0
Yes, installed, but little or no detail	269	58.680	68,558	0
No, but plan to, with full detail	7	1.545	2,244	0
No, but plan to, but little or no detail	36	4.988	4,939	0

Table 60. Mean Impact Estimates for Participants Installing New Central Air Units

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, installed a new central air unit	58	0.79103	300.2	0
Yes, installed, but little or no detail	96	0.20274	234.7	0
Kentucky No Kits	1879			
Yes, installed a new central air unit	117	0.22887	295.1	0
Yes, installed, but little or no detail	269	0.21814	254.9	0

Installed a New Heat Pump

About 7% of the respondents indicated that they installed a new heat pump, but most of them do not know the SEER of their new units. However, they indicated that more than half of them were high efficiency. Here again, we used the efficiency distributions from the participants who did report their SEER, at the same ratio for those who did not know the SEER.

Table 61. Frequency of Recommendation Taken: Installed a New Heat Pump

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Installed a new heat pump				
Yes	48	7.3%	110	6.8%
No	549	83.6%	1,363	84.6%
No, but plan to do this	54	8.2%	119	7.4%
Don't Know	6	0.9%	19	1.2%
Efficiency of heat pump				
High efficiency	34	54.8%	74	50.7%
Standard	9	14.5%	20	13.7%
Don't Know	19	30.7%	52	35.6%
SEER number for heat pump				
=<11	4	7.4%	8	6.6%
12	1	1.9%	6	5.0%
13	6	11.1%	18	14.9%
14+	9	16.7%	15	12.4%
Don't Know	34	63.0%	74	61.2%

Table 62. Total Impact Estimates for New Heat Pumps

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings

Kentucky Kits	741			
Yes, installed a new heat pump	16	5.126	11,288	0
Yes, installed, but little or no detail	32	9.831	18,921	0
No, but plan to, with full detail	0			
No, but plan to, but little or no detail	54	13.410	18,474	0
Kentucky No Kits	1879			
Yes, installed a new heat pump	33	10.626	24,289	0
Yes, installed, but little or no detail	77	25.318	48,152	0
No, but plan to, with full detail	5	1.184	1,910	0
No, but plan to, but little or no detail	114	30.079	36,313	0

Table 63. Mean Impact Estimates for Participants Installing New Heat Pumps

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, installed a new heat pump	16	0.32038	705.5	0
Yes, installed, but little or no detail	32	0.30722	591.3	0
Kentucky No Kits	1879			
Yes, installed a new heat pump	33	0.32199	736.0	0
Yes, installed, but little or no detail	77	0.32881	625.4	0

Installed a New Furnace

About 20% of the respondents indicated that they installed a new furnace at least in part because of the PER report, and about 2-3% indicated that they plan on taking this action.

Table 64. Frequency of Recommendation Taken: New Furnace

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)
Installed a new furnace				
Yes	131	19.3%	278	16.9%
No	526	77.4%	1,323	80.6%
No, but plan to do this	18	2.6%	30	1.8%

Don't Know	5	0.7%	11	0.7%
Exhaust/efficiency				
Plastic pipe	133	78.7%	245	62.0%
Chimney or flue	27	16.0%	94	23.8%
Don't Know	9	5.3%	56	14.2%

Most of the respondents that plan to install a new furnace did not provide details on the efficiency of the units, so only a small number of participants have impact estimates applied. The 409 respondents that did install a new furnace and who could provide information on energy efficiency are saving an estimated 61 therms annually.

Table 65. Total Impact Estimates for New Furnaces

	Population	Total kW Savings	Total kWh Savings	Total Therm Savings
Kentucky Kits	741			
Yes, installed a new furnace	131	-	-	381.9
No, but plan to	18	-	-	94.9
Kentucky No Kits	741			
Yes, installed a new furnace	131	-	-	841.3
No, but plan to	18	-	-	104.7

Table 66. Mean Impact Estimates for Participants Installing New Furnaces

	Population	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Kentucky Kits	741			
Yes, installed a new furnace	131	0.00000	0.00	2.9
Kentucky No Kits	1,879			
Yes, installed a new furnace	278	0.00000	0.00	3.0

Visited the Duke Energy Web Site

Most of the respondents have not visited the Duke Energy web site. Only about 20-30% said that they have or that they plan to visit the site. Of those that have visited the site, over half of them said that they found the web site helpful.

Action	Kentucky Kits (n)	Kentucky Kits (%)	Kentucky No Kits (n)	Kentucky No Kits (%)

Visited Duke web site				
Yes	96	13.6%	155	8.6%
No	498	70.6%	1,427	79.6%
No, but plan to do this	107	15.2%	191	10.7%
Don't Know	4	0.6%	19	1.1%
Web site was helpful				
Yes	53	55.2%	70	53.8%
Somewhat	40	41.7%	54	41.5%
Don't Know	3	3.1%	6	4.6%

All Recommendations

The following tables summarize the number of recommendations taken and the savings estimates based on those recommendations. These tables do not include the savings estimates of those that plan to take the recommendation.

Those customers who received the kits followed about 21.7% of the recommendations overall, and were able to save 406 kW, over 2 million kilowatt hours, and almost 47,000 therms. If the information they provided on their survey is accurate. The following table summarizes the savings achieved.

Table 67. Summary of Total Savings for All Recommendations Taken by Those Receiving Kits

	Population	Percent Installed	Total kW Savings	Total kWh Savings	Total Therm Savings
Lowered the temperature in winter	608	82.1%			
Daytime savings			-	121,733	2,727
Nighttime savings			-	56,733	1,080
Purchased and installed CFLs	393	53.0%	25.255	151,396	-67
Switched to cold water	386	52.1%	5.582	27,404	3,876
Replaced furnace filter	143	19.3%	-2.24	-3,934	-21
Closed off fireplace	191	25.8%	0.642	1,103	21
Stopped heating unused rooms	405	54.7%	86.488	35,061	437
Window Shrink	68	9.2%	2.127	1,018	19
Insulated water heater	102	13.8%	1.134	3,282	354
Manages draperies	589	79.5%	-	36,371	1,641
Cleaned baseboards	5	0.7%	-	40	-
Installed attic insulation	247	33.3%	25.107	15,843	268
Installed, but only partial detail	*38*	*5.1%*	*1.644*	*3,119*	*57*
Installed, but little or no detail	*18*	*2.4%*	*0.894*	*1,494*	*27*
Installed sidewall insulation	20	2.7%	6.948	2,656	62
Installed, but only partial detail	*8*	*1.1%*	*1.273*	*752*	*31*
Installed, but little or no detail	*62*	*8.4%*	*4.509*	*9,232*	*238*
Insulated ducts	41	5.5%	4.071	3,896	88
Repaired ducts	37	5.0%	7.495	4,408	58
Installed a new central air unit	58	7.8%	12.865	17,411	-
Installed a central air unit, but little or no detail	*96*	*13.0%*	*19.463*	*22,531*	-
Installed a new furnace	131	17.7%	-	-	382
Installed a new heat pump	16	2.2%	5.126	11,288	-

Installed heat pump, but little or no detail	*32*	*4.3%*	*9.831*	*18,921*	-
Total			**180.6**	**485,709**	**10,925**

Those that did not receive the kits also followed 21.7% of the recommendations, but had much higher total savings due to the number of participants providing the survey.

Table 68. Summary of Total Savings for All Recommendations Taken by Those Not Receiving Kits

	Population	Percent Installed	Total kW Savings	Total kWh Savings	Total Therm Savings
Lowered the temperature in winter	1559	83.0%			
Daytime savings			-	464,354	7,255
Nighttime savings			-	96,373	2,778
Purchased and installed CFLs	899	47.8%	5.503	45,864	-136
Switched to cold water	987	52.5%	7.159	62,702	10,211
Replaced furnace filter	458	24.4%	-0.880	-4617	41
Closed off fireplace	509	27.1%	0.340	1,201	23
Stopped heating unused rooms	1032	54.9%	81.334	123,535	1,270
Window Shrink	166	8.8%	2.147	3,516	49
Insulated water heater	265	14.1%	1.288	11,278	901
Manages draperies	1,446	77.0%	-	96,373	4,372
Cleaned baseboards	7	0.4%	-	51	-
Installed attic insulation	628	33.4%	31.440	56,639	857
Installed, but only partial detail	*81*	*4.3%*	*5.578*	*10,798*	*136*
Installed, but little or no detail	*124*	*6.6%*	*8.589*	*17,726*	*211*
Installed sidewall insulation	76	4.0%	5.746	13,714	276
Installed, but only partial detail	*16*	*0.9%*	*1.284*	*3,503*	*55*
Installed, but little or no detail	*199*	*10.6%*	*15.919*	*41,563*	*701*
Insulated ducts	104	5.5%	6.688	16,648	210
Repaired ducts	92	4.9%	7.754	16,255	94
Installed a new central air unit	117	6.2%	26.778	34,523	-
Installed a central air unit, but little or no detail	*269*	*14.3%*	*56.590*	*68,558*	-
Installed a new furnace	278	14.8%	-	-	841
Installed a new heat pump	33	1.8%	10.626	24,289	-
Installed heat pump, but little or no detail	*77*	*4.1%*	*25.318*	*48,152*	-
Total			**185.923**	**1,062,698**	**29,042**

The following two tables show the mean savings for the recommendation based on the total savings and the number of respondents following the recommendation.

Table 69. Summary of Mean Savings for All Recommendations Taken by Those Receiving Kits

	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Lowered the temperature in winter			
Daytime savings	-	200.2	4.5
Nighttime savings	-	93.3	1.8

Purchased and installed CFLs	0.06426	385.2	-0.2
Switched to cold water	0.01446	71.0	10.0
Replaced furnace filter	-0.01779	-36.06	-0.12
Closed off fireplace	0.00336	5.8	0.1
Stopped heating unused rooms	0.21345	86.6	1.1
Window Shrink	0.03128	15.0	0.3
Insulated water heater	0.01112	32.2	3.5
Manages draperies	-	61.8	2.8
Cleaned baseboards	-	8.0	-
Installed attic insulation	0.10165	64.1	1.1
Installed, but only partial detail	*0.04326*	*82.1*	*1.5*
Installed, but little or no detail	*0.04967*	*83.0*	*1.5*
Installed sidewall insulation	0.34738	132.8	3.1
Installed, but only partial detail	*0.15913*	*94*	*3.9*
Installed, but little or no detail	*0.07273*	*149*	*3.8*
Insulated ducts	0.09928	95.0	2.1
Repaired ducts	0.20257	119.1	1.6
Installed a new central air unit	0.79103	300.2	-
Installed a central air unit, but little or no detail	*0.020274*	*234.7*	-
Installed a new furnace	-	-	2.9
Installed a new heat pump	0.32038	705.5	-
Installed heat pump, but little or no detail	*0.30722*	*591.36*	-
Mean Total Savings, if all measures installed	**2.18243**	**2,339.7**	**34.58**

Table 70. Summary of Mean Savings for All Recommendations Taken by Those Not Receiving Kits

	Mean kW Savings	Mean kWh Savings	Mean Therm Savings
Lowered the temperature in winter			
Daytime savings	-	297.9	4.7
Nighttime savings	-	138.1	1.8
Purchased and installed CFLs	0.00612	51	-0.2
Switched to cold water	0.00725	63.5	10.3
Replaced furnace filter	-0.01885	-41.18	-0.01
Closed off fireplace	0.00067	2.4	0.0
Stopped heating unused rooms	0.07881	119.7	1.2
Window Shrink	0.01293	21.2	0.3
Insulated water heater	0.00486	42.6	3.4
Manages draperies	-	66.6	3.0
Cleaned baseboards	-	7.2	-
Installed attic insulation	0.05006	90.2	1.4
Installed, but only partial detail	*0.06886*	133.31	1.7
Installed, but little or no detail	*0.06927*	142.95	1.7
Installed sidewall insulation	0.07561	90.2	3.6
Installed, but only partial detail	*0.08025*	*218.9*	*3.4*
Installed, but little or no detail	*0.07999*	*208.9*	*3.5*
Insulated ducts	0.06431	160.1	2.0

Repaired ducts	0.08429	176.7	1.0
Installed a new central air unit	1.22887	295.1	-
Installed a central air unit, but little or no detail	*0.21814*	254.9	-
Installed a new furnace	-	-	3.0
Installed a new heat pump	1.32199	736.0	-
Installed heat pump, but little or no detail	*0.32881*	625.4	-
Mean Total Savings, if all measures installed	**2.91692**	**2,317.32**	**35.49**

Savings Distributions

There are substantial risks associated with relying on self-reported behavioral changes, because the foundation of the savings estimates are based solely on the participant's responses, with no means to verify that the respondent has installed the kit's measures or has actually taken the recommendation provided in the Personalized Energy Report. There are two main sources of bias with these types of surveys that directly impact the conclusions drawn from the responses. These sources of bias are Self-Selection Bias and False Response Bias. There is also an issue regarding the accuracy of the baseline energy use conditions used by the evaluation contractor to estimate savings in that many of these conditions need to be based on assumptions rather than on measurements. These three conditions significantly impact the evaluation contractor's ability to provide accurate estimates of energy impact. These issues are discussed in more detail in the following paragraphs.

Self-Selection Bias

The survey was sent to 5,401 PER Program participants – 3,562 customers that did not receive the kit, and 1,839 customers that did receive the Energy Efficiency Starter Kit. The data collection efforts resulted in 1,879 responses from PER participants who only received the PER (response rate = 52.8%), and 741 responses (response rate = 40.3%) from Kentucky PER participants who received the Energy Efficiency Kit. The people that filled out and returned the survey are the participants that are more likely to install measures from the Energy Efficiency Kit and consider taking actions based on the recommendations from the Personalized Energy Report. That is, they self-selected themselves to return the survey because they have a higher interest in the subject matter than the people who did not. These individuals also will often respond to a survey in order to let it be known that they did the right thing, and that they are taking steps to be more energy efficient. The customers that did not return the survey are more likely to have a lower interest in the subject matter, and are less likely to take actions. Thus, the people who returned the survey are not the typical participant, but rather are the participant that is more likely to take actions. With 47.2% of the PER group and 59.7% of the Kit group not responding, we are setting the self-selection bias used to estimate the potential range of impacts at half of the non-response rate. As a result, all estimated energy impact estimates will be discounted 29.9% for customers that received the Energy Efficiency Kit and the Personalized Energy Report, and 23.6% for those that only received the Personalized Energy Report. All impact estimates will be discounted by this percentage in order to calculate the low end of the range of savings estimates for each measure and recommendation. This adjustment approach is subjective, and is not based on the evaluation literature or on completed research within the energy program evaluation field. Within the energy program evaluation field there is a substantial lack of research indicating the range of self-selection bias associated with energy efficiency programs. As a result, the authors of this study elected to apply a significant self-selection bias factor in order to be conservative in our estimates of program impacts. Setting the factor at half of the non-response rate is based on professional conservative judgment from conducting surveys and metering studies of energy efficiency programs for over 28 years and interacting with the evaluation community regarding these rates, but we can point to no research that objectively assesses if this level of self-selection bias is too high or too low.

False Response Bias

False Response Bias is a problem with many self-reporting surveys. The participants respond not with the truth, but with the socially acceptable response. In short, they give the answer that they think is the *right answer* about what measures they installed or what actions they have taken as a result of the Personalized Energy Report. False response bias is typically not a large adjustment, depending on the controversy around the subject being discussed. False response bias adjustments typically range from a low of two or three percent to a high of 15 percent depending on the topic and the population being tested. The False Response Bias for this assessment was set at from a low of 10% to a high of 50% because of a specific rational relating to the conditions that act to increase or decrease this estimated average rate. A 10 % to 50% discount is be applied to each PER recommended measure impact estimate to calculate the low-end of the range of savings estimates for each measure and recommendation.

Baseline Energy Use Assumptions

When a mail survey is used to conduct an evaluation, the evaluation contractors are unsure of the actual conditions in the home that have experienced a change. For example, while a new showerhead may have been installed, it is impossible to estimate precise savings unless the flow rates and use conditions associated with the previous showerhead are well understood. For this study we established our baseline assumptions based on the survey results and our past research and experience with programs and program evaluations that have taken measurement of baseline conditions. We have also used housing-type computer models to estimate baseline conditions and behaviors. As a result, we are not adjusting the baseline conditions applied in this study, but rather using the survey results, the literature, our past research and field experience to set baseline conditions. However, because these are not program-participant measured baseline conditions, it is important to let the reader know that the baselines used in this study are estimated.

Methodology

The level of discounting used to determine the ranges for each of the measures and recommendations can be found in the table below. The self-selection bias discount factor for all measures and recommendations for the Kentucky PER is 29.9% for customers that received the Energy Efficiency Kit and the Personalized Energy Report, and 23.6% for those that only received the Personalized Energy Report.

Measure	False Response Bias	Other Discounting and Notes
CFLs	10%	Used ranges for wattage of bulb removed (as opposed to most common wattage in range) and hours of use for the lamp (as opposed to the mean of the range).
Weatherstripping	10%	
Outlet gaskets	10%	
Window shrink kit	10%	Adjusted square footage of window: if customer

		indicated "small" window, sq ft reduced by 1/3; if "average" or "large", sq ft reduced by ½.
Showerhead	20%	Used 2.75 gpm for base showerhead (as opposed to 3.1 gpm) to get the low range.
Aerators	20%	Removed the savings from cases in which there was already an aerator installed for the low estimates.

Recommendation	False Response Bias	Other Discounting and Notes
CFLs	50%	Used ranges for wattage of bulb removed (as opposed to most common wattage in range) and hours of use for the lamp (as opposed to the mean of the range). Used ranges for wattage of CFL installed. For high range, used 15 CFL replacements when respondent indicated they replaced 10+ bulbs.
Clean baseboards	50%	
Close off fireplace	50%	
Install new central air unit	50%	Low end of savings obtained by further cutting savings by half under the assumption that half of new installations were normal replacement instead of early replacement.
Install new furnace	50%	Low end of savings obtained by further cutting savings by half under the assumption that half of new installations were normal replacement instead of early replacement.
Install a new refrigerator	50%	Used 1700 for base.
Install a new heat pump	50%	Low end of savings obtained by further cutting savings by half under the assumption that half of new installations were normal replacement instead of early replacement.
Install attic insulation	50%	For partial installation, used a range of 25% coverage instead of 50%. Used a low range of 225 square feet per room.
Install sidewall insulation	50%	Removed savings for those that indicated that they installed 7-12" or 13"+ of sidewall insulation. Used a low range of 225 square feet per room. Halved the fraction used in calculating wall area as a fraction of floor area.
Install window shrink kits	50%	Adjusted square footage of window: if customer indicated "small" window, sq ft reduced by 1/3; if "average" or "large", sq ft reduced by ½.
Insulate or repair ducts	50%	Savings cut in half based on having less insulation than before and lower leakage rates.
Insulate water heater	50%	UA table modified to reflect a 1" blanket. Also used a lower set point of 120 degrees.
Lower temperature in winter	50%	
Manage draperies	50%	Reduced the savings by ½ for 2/3 of the windows to account for direction of window.
Replace furnace filter	50%	
Stop heating unused rooms	50%	Further reduced savings by 20% because of the inability to completely shut off a room, and the conductive losses through the uninsulated walls.

Switch to cold water for laundry	50%	

Savings Estimates

Each of the Kit measures and PER recommendations are recalculated here in order to provide reasonable ranges of energy savings associated with each item. The tables below provide the low and high estimates for each of the measures and recommendations provided to the Indiana participants. Savings estimates are provided for only those participants who indicated that they installed the measure. For recommendations, savings are provided for only those who indicated that they took the action, and provided full details on follow-up questions on the survey.

Table 71. Kentucky Kit Participants' Range of Kilowatt Savings

Measure	Total kW Savings		Mean kW Savings (per install)	
	Low	High	Low	High
15-watt CFL	1.928	5.243	0.00295	0.00802
20-watt CFL	1.867	5.166	0.00316	0.00876
Weatherstripping	0.327	0.683	0.00126	0.00264
Outlet gaskets	0.768	1.850	0.00210	0.00505
Window shrink kit	0.737	2.286	0.00730	0.02263
Showerhead	1.759	4.053	0.00377	0.00868
Bathroom aerator	0.020	0.035	0.00005	0.00009
Kitchen aerator	0.014	0.025	0.00004	0.00007

Table 72. Kentucky Kit Participants' Range of Kilowatt-Hour Savings

Measure	Total kWh Savings		Mean kWh Savings (per install)	
	Low	High	Low	High
15-watt CFL	19,966	88,829	30.5	135.8
20-watt CFL	18,737	82,917	31.8	140.5
Weatherstripping	853	2,231	3.3	8.6
Outlet gaskets	2,629	6,351	7.2	17.4
Window shrink kit	1,279	3,957	12.7	39.2
Showerhead	16,048	36,983	34.4	79.2
Bathroom aerator	1,513	2,651	3.8	6.7
Kitchen aerator	1,168	2,083	3.2	5.7

Table 73. Kentucky Kit Participants' Range of Therm Savings

Measure	Total Therm Savings		Mean Therm Savings (per install)	
	Low	High	Low	High
15-watt CFL	-31.7	-141.3	0.0	-0.2
20-watt CFL	-29.5	-130.8	-0.1	-0.2
Weatherstripping	19.7	51.3	0.1	0.2
Outlet gaskets	533.3	126.4	1.5	0.3
Window shrink kit	14.5	44.9	0.1	0.4
Showerhead	1,624.4	3,724.6	3.5	8.0
Bathroom aerator	85.7	149.5	0.2	0.4

Kitchen aerator	75.5	134.6	0.2	0.4

Table 74. Kentucky Kit Participants' Range of Kilowatt Savings for Recommendations

Recommendation	Total kW Savings		Mean kW Savings (per install)	
	Low	High	Low	High
CFLs	25.255	45.505	0.06426	0.11579
Clean baseboards	-	-	-	-
Close off fireplace	0.642	0.898	0.00336	0.00470
Install new central air unit	12.865	73.408	0.79103	1.26566
Install new furnace	-	-	-	-
Install a new heat pump	5.126	29.242	0.32038	1.82763
Install attic insulation	25.107	40.171	0.10165	0.16264
Install sidewall insulation	6.948	11.116	0.34738	0.55580
Install window shrink kits	2.127	3.832	0.03128	0.05635
Insulate ducts	4.071	6.513	0.09928	0.15885
Repair ducts	7.495	11.992	0.20257	0.32411
Insulate water heater	1.134	2.044	0.01112	0.02004
Lower temp in winter - day	-	-	-	-
Lower temp in winter - night	-	-	-	-
Manage draperies	-	-	-	-
Replace furnace filter	-2.240	-2.240	-0.01779	-0.01779
Stop heating unused rooms	86.448	86.448	0.21345	0.21345
Switch to cold water for laundry	5.582	8.931	0.01446	0.02314

Table 75. Kentucky Kit Participants' Range of Kilowatt-Hour Savings for Recommendations

Recommendation	Total kWh Savings		Mean kWh Savings (per install)	
	Low	High	Low	High
CFLs	151396	640,140	385.2	1628.9
Clean baseboards	40	115	8.0	23.0
Close off fireplace	1103	3,277	5.8	17.2
Install new central air unit	17411	99,349	300.2	1712.9
Install new furnace	-	-	-	-
Install a new heat pump	11288	64,407	705.5	4025.4
Install attic insulation	15843	67,490	64.1	273.2
Install sidewall insulation	2656	22,796	132.8	1139.8
Install window shrink kits	1018	5,795	15.0	85.2
Insulate ducts	3896	22,228	95.0	542.1
Repair ducts	4408	25,155	119.1	679.9
Insulate water heater	3282	17,904	32.2	175.5
Lower temp in winter - day	121733	347,312	200.2	571.2
Lower temp in winter - night	56733	161,864	93.3	266.2
Manage draperies	36371	43,960	61.8	74.6
Replace furnace filter	-3,934	-3,934	-36.1	-36.1

Stop heating unused rooms	35061	125,041	86.6	308.7
Switch to cold water for laundry	27404	78,186	71.0	202.6

Table 76. Kentucky Kit Participants' Range of Therm Savings for Recommendations

Recommendation	Total Therm Savings		Mean Therm Savings (per install)	
	Low	High	Low	High
CFLs	-67.2	-980	-0.2	-2.5
Clean baseboards	-	-	-	-
Close off fireplace	20.7	68	0.1	0.4
Install new central air unit	-	-	-	-
Install new furnace	381.9	2,178	2.9	16.6
Install a new heat pump	-	-	-	-
Install attic insulation	267.5	1,159	1.1	4.7
Install sidewall insulation	61.9	554	3.1	27.7
Install window shrink kits	18.9	106	0.3	1.6
Insulate ducts	88.1	504	2.1	12.3
Repair ducts	58.1	333	1.6	9.0
Insulate water heater	354.1	1,868	3.5	18.3
Lower temp in winter - day	2727.0	7,781	4.5	12.8
Lower temp in winter - night	1080.0	3,080	1.8	5.1
Manage draperies	1641.0	2,145	2.8	3.6
Replace furnace filter	-21	-21	-0.1	-0.1
Stop heating unused rooms	437.0	1,560	1.1	3.9
Switch to cold water for laundry	3875.6	11,057	10.0	28.6

Table 77. Kentucky No Kit Participants' Range of Kilowatt Savings for Recommendations

Recommendation	Total kW Savings		Mean kW Savings (per install)	
	Low	High	Low	High
CFLs	5.503	47.649	0.00612	0.05300
Clean baseboards	-	-	-	-
Close off fireplace	0.340	0.891	0.00067	0.00175
Install new central air unit	26.778	140.328	0.22887	1.19938
Install new furnace	-	-	-	-
Install a new heat pump	10.626	55.632	0.32199	1.68582
Install attic insulation	31.440	123.745	0.05006	0.19705
Install sidewall insulation	5.746	50.692	0.07561	0.66700
Install window shrink kits	2.147	11.163	0.01293	0.06725
Insulate ducts	6.688	35.017	0.06431	0.33670
Repair ducts	7.754	40.600	0.08429	0.44130
Insulate water heater	1.288	6.303	0.00486	0.02378
Lower temp in winter - day	-	-	-	-
Lower temp in winter - night	-	-	-	-
Manage draperies	-	-	-	-
Replace furnace filter	-0.880	-1.520	-0.0185	-0.00332
Stop heating unused rooms	81.334	266.144	0.07881	0.25789
Switch to cold water for laundry	7.159	18.741	0.00725	0.01899

Table 78. Kentucky No Kit Participants' Range of Kilowatt-Hour Savings for Recommendations

Recommendation	Total kWh Savings		Mean kWh Savings (per install)	
	Low	High	Low	High
CFLs	45,864	1,132,047	51	1259.2
Clean baseboards	51	133	7.2	19.0
Close off fireplace	1201	3,142	2.4	6.2
Install new central air unit	34523	180,749	295.1	1544.9
Install new furnace	-	-	-	-
Install a new heat pump	24289	127,167	736.0	3853.5
Install attic insulation	56639	222,542	90.2	354.4
Install sidewall insulation	13714	105,277	180.4	1385.2
Install window shrink kits	3516	18,294	21.2	110.2
Insulate ducts	16648	87,162	160.1	838.1
Repair ducts	16255	85,106	176.7	925.1
Insulate water heater	11278	55,215	42.6	208.4
Lower temp in winter - day	464354	1,215,587	297.9	779.7
Lower temp in winter - night	96373	563,414	138.1	361.4
Manage draperies	96373	756,481	66.6	523.2
Replace furnace filter	-4594	-4,594	-3.4	-10.0
Stop heating unused rooms	123535	404,237	119.7	391.7
Switch to cold water for laundry	62702	164,141	63.5	166.3

Table 79. Kentucky No Kit Participants' Range of Therm Savings for Recommendations

Recommendation	Total Therm Savings		Mean Therm Savings (per install)	
	Low	High	Low	High
CFLs	-136.0	-1,852.9	-0.2	-2.1
Clean baseboards	-	-	-	-
Close off fireplace	22.5	58.9	0.0	0.1
Install new central air unit	-	-	-	-
Install new furnace	841.3	4,404.8	3.0	15.8
Install a new heat pump	-	-	-	-
Install attic insulation	857.4	3,389.7	1.4	5.4
Install sidewall insulation	276.3	2,121.1	3.6	27.9
Install window shrink kits	48.9	253.6	0.3	1.5
Insulate ducts	210.1	1,100.1	2.0	10.6
Repair ducts	94.1	492.7	1.0	5.4
Insulate water heater	901.4	4,358.4	3.4	16.4
Lower temp in winter - day	7255.2	18,992.8	4.7	12.2
Lower temp in winter - night	2778.1	7,272.6	1.8	4.7
Manage draperies	4371.6	34,315.0	3.0	23.7
Replace furnace filter	5.5	16.0	0.0	0.0
Stop heating unused rooms	1270.4	4,157.0	1.2	4.0
Switch to cold water for laundry	10210.6	26,729.3	10.3	27.1

Appendix A: PER and Energy Efficiency Kit Survey

Please answer the questions in this survey by darkening the circles next to the responses associated with each question using blue or black ink. For example ○ is fully filled in when it looks like this: ●

Duke Energy.

QUESTIONS FOR KIT MATERIAL USE

The first set of questions ask about the materials you received in the Energy Efficiency Kit mailed to you from Duke Energy. This kit included a number of items such as a showerhead, aerators, compact florescent light bulbs and other items. Please provide your response to each of the following questions about the materials your received in the kit.

---

15 WATT MINI COMPACT FLORESCENT LIGHT (CFL)

1. Have you installed the 15-watt CFL bulb in a light fixture? ○ Yes ○ No ○ Don't know

If yes...

2. How many watts was the old bulb you took out? ○ ≤44 ○ 45-70 ○ 71-99 ○ 100≥
3. On average, how many hours per day do you use this bulb? ○ <1 ○ 1-2 ○ 3-4 ○ 5-10 ○ 11-12 ○ 13-24

20-WATT MINI COMPACT FLORESCENT LIGHT

1. Have you installed the 20-watt CFL bulb in a light fixture? ○ Yes ○ No ○ Don't know

If yes...

2. How many watts was the old bulb you took out? ○ ≤44 ○ 45-70 ○ 71-99 ○ 100≥
3. On average, how many hours per day do you use this bulb? ○ <1 ○ 1-2 ○ 3-4 ○ 5-10 ○ 11-12 ○ 13-24

CLOSED CELL WEATHER-STRIPPING – 17 FEET

1. Have you installed any of the weather-stripping on your doors or windows or used it to seal cracks? ○ Yes ○ No ○ Don't know
2. If yes, how many feet of the 17-foot roll have you used? ○ 1-5 ○ 6-10 ○ 11-17

WINDOW COVERING SHRINK-FIT STORM WINDOW

1. Have you installed the window shrink-fit kit? ○ Yes ○ No ○ Don't know

If yes...

2. What size would you consider the window on which you used the kit to be? ○ Small ○ Average ○ Large
3. What type of window is it? ○ Single pane ○ Single with storm ○ Double pane

---

SHOWERHEAD

1. Have you installed the energy-efficient showerhead? ○ Yes ○ No ○ Don't know

If yes...

2. Typically how many showers per week are taken using this showerhead? ○ 0-4 ○ 5-10 ○ 11-15 ○ 16-20 ○ 21≥
3. Would you estimate that the amount of water coming through the new showerhead is: ○ Less than the old unit ○ About the same ○ More than the old unit

---

BATHROOM FAUCET AERATOR

1. Have you installed the faucet aerator in your bathroom? ○ Yes ○ No ○ Don't know

If yes...

2. Was there an aerator on the faucet that you had to remove? ○ Yes ○ No ○ Don't know
3. If yes, would you estimate that the amount of water coming through the new aerator is: ○ Less than the old unit ○ About the same, or ○ More than the old unit

KITCHEN FAUCET AERATOR

1. Have you installed the faucet aerator in your kitchen? ○ Yes ○ No ○ Don't know

If yes...

2. Was there an aerator in the faucet that you had to remove? ○ Yes ○ No ○ Don't know

3. If yes, would you estimate that the amount of water coming through the new aerator is: ○ Less than the old unit ○ About the same ○ More than the old unit

WALL PLUG OUTLET AND SWITCH INSULATORS

1. Have you installed the insulating gaskets in any outlet boxes or wall switches? ○ Yes ○ No ○ Don't know

2. If yes, how many have you installed? ○ 1-2 ○ 3-5 ○ 6-8

REPORT RECOMMENDATIONS

This set of questions ask about the actions you have taken or plan to take based on the recommendations that were included on your Personalized Energy Report. These questions are only about things that you have done after receiving your report.

LOWERED THE TEMPERATURE IN THE HOME DURING THE WINTER

1. Have you lowered the temperature of your home to save money or energy during the winter months?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. How many degrees have you lowered the temperature at night? ○ 1-3 ○ 4-6 ○ 7-10 ○ 11≥

3. How many degrees have you lowered the temperature during the day? ○ 1-3 ○ 4-6 ○ 7-10 ○ 11≥

PURCHASED AND INSTALLED COMPACT FLORESCENT LIGHTS (CFLS)

1. Have you purchased and used additional compact florescent light bulbs in your home? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. How many CFLs have you purchased and installed since reading the report? ○ 1-2 ○ 3-5 ○ 6-9 ○ 10≥

3. On average, what wattage bulb did you remove from the fixture before you installed the CFL? ○ ≤44 ○ 45-70 ○ 71-99 ○ 100≥

4. Considering all CFL locations and uses, on average, how many hours per day do you use these bulbs?

○ ≤1 ○ 1-2 ○ 3-4 ○ 5-9 ○ 10-12 ○ 13-24

WASHED LAUNDRY IN COLD WATER

1. Have you switched from using hot water to do your laundry instead of cold water? ○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many loads of laundry do you do per week? ○ 1-2 ○ 3-4 ○ 5-6 ○ 7-8 ○ 9-10 ○ 11-12 ○ 13≥

REPLACED FURNACE FILTERS

1. Have you replaced your furnace filter? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. How often do you now change the filter? ○ Less than once a year ○ Once a year ○ Twice a year ○ More than twice a year ○ Don't know

3. How often did you change your filter prior to reading the personalized energy report? ○ Less than once a year ○ Once a year ○ Twice a year ○ More than twice a year ○ Don't know

TURNED OFF HEAT IN UNUSED ROOMS

1. Have you closed the heating vents or chosen not to heat unused rooms? ○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many rooms do you not heat in the winter? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6≥

INSTALLED WINDOW COVERING SHRINK-FIT STORM WINDOWS

1. Have you purchased and installed any plastic wrap-type window kits that cover the entire window to help keep the cold out?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. How many windows have you covered with these kits? ○ 1-3 ○ 4-7 ○ 8-10 ○ 11≥

3. On average, what size would you consider the window on which you used the kit to be? ○ Small ○ Average ○ Large

4. What type of window is it? ○ Single pane ○ Single with storm ○ Double pane

INSULATED HOT WATER HEATER TANK

1. Have you insulated your hot water tank? ○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many gallons of water does your tank hold? ○ 30 ○ 50 ○ 60 ○ 75 ○ 80≥ ○ Don't know

KEEP DRAPERIES OPEN ON SUNNY DAYS AND CLOSED AT NIGHT

1. Do you manage your window coverings and draperies so that they are open when the sun is shining in and closed at other times?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many windows do you manage the coverings to save energy? ○ 1-3 ○ 4-7 ○ 8-12 ○ 13≥

CLEANED ELECTRIC BASEBOARD HEATING REGISTERS OF DUST

1. For electrically heating homes, have you cleaned any of the baseboards?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many baseboards have you cleaned? ○ 1-3 ○ 4-6 ○ 7-10 ○ 11≥

INSULATED THE CEILING OR ATTIC

1. Have you had your attic insulated? ○ Yes ○ No but plan to do this ○ No ○ Don't know

2. Did you insulate part of the ceiling or all of it? ○ Part of ceiling ○ Entire ceiling

3. What type of insulation did you add? ○ Fiberglass ○ Cellulose ○ Foam ○ Other

4. How many inches of thickness did you add? ○ 1-2 ○ 3-4 ○ 5-6 ○ 7-8 ○ 9-10 ○ 11≥

5. How thick was the insulation before you added more? ○ 1-2 ○ 3-4 ○ 5-6 ○ 7-8 ○ 9-10 ○ 11≥

INSULATED SIDEWALLS OF HOME

1. Have you had the sidewalls of your home insulated since you received your Personalized Energy Report?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. How many walls did you have insulated? ○ 1 ○ 2 ○ 3 ○ 4≥

3. What type of insulation did you add? ○ Fiberglass ○ Cellulose ○ Foam ○ Other

4. How many inches of thickness did you add? ○ 1-3 ○ 4-6 ○ 7-12 ○ 13≥

CLOSED-OFF OR SEAL-UP THE FIREPLACE

1. Have you stopped using a fireplace to reduce the heat loss going up the chimney during the winter?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. Have you closed-off or sealed the fireplace to reduce the heat loss?

○ Yes ○ No but plan to do this ○ No ○ Don't know

INSULATED OR REPAIRED HEATING OR AIR CONDITIONING DUCTS

1. Have you insulated any of your heating or cooling ducts that deliver air to the rooms of the home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Are these ducts located in a heated or unheated part of the home?

○ Unheated area ○ Heated area ○ Don't know

3. Have you repaired or fixed holes in any of your heating or cooling ducts that deliver air to the rooms of the home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

INSTALLED NEW CENTRAL AIR CONDITIONING

1. Have you installed a new central air conditioning unit in your home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Is the air conditioner a high efficiency unit (> 13 SEER) or a standard efficiency unit (< 13 SEER)? ○ High efficiency ○ Standard ○ Don't know

3. What is the SEER number for your unit? ○ <11 ○ 12 ○ 13 ○ 14+ ○ Don't know

---

INSTALLED A NEW NATURAL GAS OR PROPANE FURNACE

1. Have you installed a new natural gas or propane furnace in your home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, is the furnace a high efficiency unit in which the exhaust exits a plastic pipe coming through the side of the home, or does the exhaust go up a chimney or flue similar to a standard efficiency unit? ○ Plastic pipe ○ Chimney or flue ○ Don't know

---

INSTALLED NEW HEAT PUMP

1. Have you installed a new heat pump in your home? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Is the heat pump a high efficiency unit (> 13 SEER) or a standard efficiency unit (< 13)? ○ High efficiency ○ Standard ○ Don't know

3. What is the SEER number for your unit? ○ <11 ○ 12 ○ 13 ○ 14+ ○ Don't know

---

INSTALLED NEW REFRIGERATOR

1. Have you purchased a new refrigerator? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Is the refrigerator Energy Star compliant? ○ Yes ○ No ○ Don't know

3. Are you keeping your old refrigerator plugged in as a backup? ○ Yes ○ No ○ Don't know

---

THE DUKE ENERGY WEB SITE

1. Have you visited the Duke Energy Web site that is referenced in your Personalized Energy Report to identify additional ways to save energy in your home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, did you find this Web site helpful? ○ Yes ○ Somewhat ○ No

Revised 2.28.07

Appendix B: PER Survey

Please answer the questions in this survey by darkening the circles next to the responses associated with each question using blue or black ink. For example ○ is fully filled in when it looks like this: ●

Duke Energy

REPORT RECOMMENDATIONS

This set of questions ask about the actions you have taken or plan to take based on the recommendations that were included on your Personalized Energy Report. These questions are only about things that you have done after receiving your report.

LOWERED THE TEMPERATURE IN THE HOME DURING THE WINTER

1. Have you lowered the temperature of your home to save money or energy during the winter months?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes ...

2. How many degrees have you lowered the temperature at night? ○ 1-3 ○ 4-6 ○ 7-10 ○ 11≥
3. How many degrees have you lowered the temperature during the day? ○ 1-3 ○ 4-6 ○ 7-10 ○ 11≥

PURCHASED AND INSTALLED COMPACT FLORESCENT LIGHTS (CFLs)

1. Have you purchased and used additional compact florescent light bulbs in your home? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes ...

2. How many CFLs have you purchased and installed since reading the report? ○ 1-2 ○ 3-5 ○ 6-9 ○ 10≥
3. On average, what wattage bulb did you remove from the fixture before you installed the CFL? ○ ≤44 ○ 45-70 ○ 71-99 ○ 100≥
4. Considering all CFL locations and uses, on average, how many hours per day do you use these bulbs?

○ ≤1 ○ 1-2 ○ 3-4 ○ 5-9 ○ 10-12 ○ 13-24

WASHED LAUNDRY IN COLD WATER

1. Have you switched from using hot water to do your laundry instead of cold water? ○ Yes ○ No but plan to do this ○ No ○ Don't know
2. If yes, how many loads of laundry do you do per week? ○ 1-2 ○ 3-4 ○ 5-6 ○ 7-8 ○ 9-10 ○ 11-12 ○ 13≥

REPLACED FURNACE FILTERS

1. Have you replaced your furnace filter? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes ...

2. How often do you now change the filter? ○ Less than once a year ○ Once a year ○ Twice a year ○ More than twice a year ○ Don't know
3. How often did you change your filter prior to reading the personalized energy report? ○ Less than once a year ○ Once a year ○ Twice a year ○ More than twice a year ○ Don't know

---

TURNED OFF HEAT IN UNUSED ROOMS

1. Have you closed the heating vents or chosen not to heat unused rooms? ○ Yes ○ No but plan to do this ○ No ○ Don't know
2. If yes, how many rooms do you not heat in the winter? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6≥

INSTALLED WINDOW COVERING SHRINK-FIT STORM WINDOWS

1. Have you purchased and installed any plastic wrap-type window kits that cover the entire window to help keep the cold out?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes…

2. How many windows have you covered with these kits? ○ 1-3 ○ 4-7 ○ 8-10 ○ 11+

3. On average, what size would you consider the window on which you used the kit to be? ○ Small ○ Average ○ Large

4. What type of window is it? ○ Single pane ○ Single with storm ○ Double pane

INSULATED HOT WATER HEATER TANK

1. Have you insulated your hot water tank? ○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many gallons of water does your tank hold? ○ 30 ○ 50 ○ 60 ○ 75 ○ 80+ ○ Don't know

KEEP DRAPERIES OPEN ON SUNNY DAYS AND CLOSED AT NIGHT

1. Do you manage your window coverings and draperies so that they are open when the sun is shining in and closed at other times?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many windows do you manage the coverings to save energy? ○ 1-3 ○ 4-7 ○ 8-12 ○ 13+

CLEANED ELECTRIC BASEBOARD HEATING REGISTERS OF DUST

1. For electrically heating homes, have you cleaned any of the baseboards?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, how many baseboards have you cleaned? ○ 1-3 ○ 4-6 ○ 7-10 ○ 11+

INSULATED THE CEILING OR ATTIC

1. Have you had your attic insulated? ○ Yes ○ No but plan to do this ○ No ○ Don't know

2. Did you insulate part of the ceiling or all of it? ○ Part of ceiling ○ Entire ceiling

3. What type of insulation did you add? ○ Fiberglass ○ Cellulose ○ Foam ○ Other

4. How many inches of thickness did you add? ○ 1-2 ○ 3-4 ○ 5-6 ○ 7-8 ○ 9-10 ○ 11+

5. How thick was the insulation before you added more? ○ 1-2 ○ 3-4 ○ 5-6 ○ 7-8 ○ 9-10 ○ 11+

INSULATED SIDEWALLS OF HOME

1. Have you had the sidewalls of your home insulated since you received your Personalized Energy Report?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. How many walls did you have insulated? ○ 1 ○ 2 ○ 3 ○ 4+

3. What type of insulation did you add? ○ Fiberglass ○ Cellulose ○ Foam ○ Other

4. How many inches of thickness did you add? ○ 1-3 ○ 4-6 ○ 7-12 ○ 13+

CLOSED-OFF OR SEAL-UP THE FIREPLACE

1. Have you stopped using a fireplace to reduce the heat loss going up the chimney during the winter?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. Have you closed-off or sealed the fireplace to reduce the heat loss?

○ Yes ○ No but plan to do this ○ No ○ Don't know

INSULATED OR REPAIRED HEATING OR AIR CONDITIONING DUCTS

1. Have you insulated any of your heating or cooling ducts that deliver air to the rooms of the home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Are these ducts located in a heated or unheated part of the home?

○ Unheated area ○ Heated area ○ Don't know

3. Have you repaired or fixed holes in any of your heating or cooling ducts that deliver air to the rooms of the home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

INSTALLED NEW CENTRAL AIR CONDITIONING

1. Have you installed a new central air conditioning unit in your home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Is the air conditioner a high efficiency unit (>13 SEER) or a standard efficiency unit (<13 SEER)? ○ High efficiency ○ Standard ○ Don't know

3. What is the SEER number for your unit? ○ <11 ○ 12 ○ 13 ○ 14+ ○ Don't know

INSTALLED A NEW NATURAL GAS OR PROPANE FURNACE

1. Have you installed a new natural gas or propane furnace in your home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, is the furnace a high efficiency unit in which the exhaust exits a plastic pipe coming through the side of the home, or does the exhaust go up a chimney or flue similar to a standard efficiency unit? ○ Plastic pipe ○ Chimney or flue ○ Don't know

INSTALLED NEW HEAT PUMP

1. Have you installed a new heat pump in your home? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Is the heat pump a high efficiency unit (>13 SEER) or a standard efficiency unit (<13)? ○ High efficiency ○ Standard ○ Don't know

3. What is the SEER number for your unit? ○ <11 ○ 12 ○ 13 ○ 14+ ○ Don't know

INSTALLED NEW REFRIGERATOR

1. Have you purchased a new refrigerator? ○ Yes ○ No but plan to do this ○ No ○ Don't know

If yes...

2. Is the refrigerator Energy Star compliant? ○ Yes ○ No ○ Don't know

3. Are you keeping your old refrigerator plugged in as a backup? ○ Yes ○ No ○ Don't know

THE DUKE ENERGY WEB SITE

1. Have you visited the Duke Energy Web site that is referenced in your Personalized Energy Report to identify additional ways to save energy in your home?

○ Yes ○ No but plan to do this ○ No ○ Don't know

2. If yes, did you find this Web site helpful? ○ Yes ○ Somewhat ○ No

Appendix C: Impact Algorithms Used

CFLs

General Algorithm

Gross Summer Coincident Demand Savings

$$\Delta kW_S = \text{units} \times \left[\frac{(Watts \times DF_s)_{base} - (Watts \times DF_s)_{ee}}{1000}\right] \times CF_S \times (1 + HVAC_{d,\ s})$$

Gross Annual Energy Savings

$$\Delta kWh = \text{units} \times \left[\frac{(Watts \times DF)_{base} - (Watts \times DF)_{ee}}{1000}\right] \times FLH \times (1 + HVAC_c)$$

$$\Delta therm = \Delta kWh \times HVAC_g$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
$\Delta therm$	= gross annual therm interaction
units	= number of units installed under the program
$Watts_{ee}$	= connected (nameplate) load of energy-efficient unit
$Watts_{base}$	= connected (nameplate) load of baseline unit(s) displaced
FLH	= full-load operating hours (based on connected load)
DF	= demand diversity factor
CF	= coincidence factor
$HVAC_c$	= HVAC system interaction factor for annual electricity consumption
$HVAC_d$	= HVAC system interaction factor for demand
$HVAC_g$	= HVAC system interaction factor for annual gas consumption

15 W CFL Measure

$Watts_{ee}$ = 15, which is the input power of program supplied CFL

$Watts_{base}$ - calculated from survey responses as shown below:

Wattage of bulb removed	$Watts_{base}$	Notes
<= 44	40	Most popular size < 44 W
45 - 70	60	Lumen equivalent of 15 W CFL
71 - 99	75	Most popular size in range
> = 100	100	Most popular size in range

FLH - calculated from survey responses as shown below:

Hours of use per day	FLH	Notes
<1	183	Average value over range
1-2	548	Average value over range
3-4	1278	Average value over range
5-10	2738	Average value over range
11-12	4198	Average value over range
13-24	6753	Average value over range

DF = 1.0 and CF = 0.10

The coincidence factor for this analysis was taken as the average of the coincidence factors estimated by PG&E and SCE for residential CFL program peak demand savings. The PG&E and SCE coincidence factors are combined factors that consider both coincidence and diversity, thus the diversity factor for this analysis was set to 1.0

$HVAC_C$ - the HVAC interaction factor for annual energy consumption depends on the HVAC system, heating fuel type, and location. The HVAC interaction factors for annual energy consumption were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix.

Covington, KY

Heating Fuel	Heating System	Cooling System	HVACc	HVACg
Other	Any except Heat Pump	Any except Heat Pump	0	0
Any	Heat Pump	Heat Pump	-0.16	0
Gas Propane Oil	Central Furnace	None	0	-0.0021
		Room/Window	0.079	-0.0021
		Central AC	0.079	-0.0021
	Other	None	0	-0.0021
		Room/Window	0.079	-0.0021
		Central AC	0.079	-0.0021
Electricity	Central furnace	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0
	Electric baseboard	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0
	Other	None	-0.45	0
		Room/Window	-0.36	0
		Central AC	-0.36	0

$HVAC_d$ - the HVAC interaction factor for demand depends on the cooling system type. The HVAC interaction factors for summer peak demand were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix.

Covington, KY

Cooling System	HVACd
None	0
Room/Window	.17
Central AC	.17
Heat Pump	.17

20W CFL Measure

$Watts_{ee}$ = 20, which is the input power of program supplied CFL
$Watts_{base}$ - calculated from survey responses as shown below:

Wattage of bulb removed	$Watts_{base}$	Notes
<= 44	40	Most popular size < 44 W
45 - 70	60	Most popular size in range
71 - 99	75	Lumen equivalent of 20 W CFL
> = 100	100	Most popular size in range

Weatherstripping, Outlet Gaskets, and Fireplace Closure

Gross Summer Coincident Demand Savings

$$\Delta kW_S = units \times (\Delta cfm/unit) \times (kW / cfm) \times DF_S \times CF_S$$

Gross Annual Energy Savings

$$\Delta kWh = units \times (\Delta cfm/unit) \times (kWh / cfm)$$

$$\Delta therm = units \times (\Delta cfm / unit) \times (therm / cfm)$$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings

units = number of buildings sealed under the program
Δcfm/unit = unit infiltration airflow rate (ft^3/min) reduction for each measure
DF = demand diversity factor = 0.8
CF = coincidence factor = 1.0
kW/cfm = demand savings per unit cfm reduction
kWh/cfm = electricity savings per unit cfm reduction
therm/cfm = gas savings per unit cfm reduction

Unit cfm savings per measure

The cfm reductions for each measure were estimated from equivalent leakage area (ELA) change data taken from the ASHRAE Handbook of Fundamentals (ASHRAE, 2001). The equivalent leakage area changes were converted to infiltration rate changes using the Sherman-Grimsrud equation:

$$Q = ELA \text{ x } \sqrt{A \times \Delta T + B \times v^2}$$

where:

A = stack coefficient (ft^3/min-in^4-°F)
= 0.015 for one-story house
ΔT = average indoor/outdoor temperature difference over the time interval of interest (°F)
B = wind coefficient (ft^3/min-in^4-mph^2)
= 0.0065 (moderate shielding)
v = average wind speed over the time interval of interest measured at a local weather station at a height of 20 ft (mph)

The location specific data are shown below:

Location	Average outdoor temp	Average indoor/outdoor temp difference	Average wind speed (mph)	Specific infiltration rate (cfm/in^2)
Covington	33	35	22	1.92

Measure ELA impact and cfm reductions are as follows:

Measure	Unit	ELA change (in^2/unit)	ΔCfm/unit (KY)
Outlet gaskets	Each	0.357	0.69
Weather strip	Foot	0.089	0.17
Fireplace	Each	1.86	3.57

Unit energy and demand savings

The energy and peak demand impacts of reducing infiltration rates were calculated from infiltration rate parametric studies conducted using the DOE-2 residential building prototype models, as described at the end of this Appendix. The savings per cfm reduction by heating and cooling system type are shown below:

Heating Fuel	Heating System	Cooling System	kWh/cfm	kW/cfm	therm/cfm
Other	Any except Heat Pump	Any except Heat Pump	1.14	0.00000	0.000
Any	Heat Pump	Heat Pump	12.85	0.00248	0.000
Gas Propane Oil	Central Furnace	None	0	0	0.124
		Room/Window	1.14	0.00000	0.124
		Central AC	1.14	0.00000	0.124
	Other	None	0	0	0.124
		Room/Window	1.14	0.00000	0.124
		Central AC	1.14	0.00000	0.124
Electricity	Central furnace	None	23.27	0.01238	0.000
		Room/Window	23.84	0.01485	0.000
		Central AC	23.84	0.01485	0.000
	Electric baseboard	None	23.27	0.01238	0.000
		Room/Window	23.84	0.01485	0.000
		Central AC	23.84	0.01485	0.000
	Other	None	23.27	0.01238	0.000
		Room/Window	23.84	0.01485	0.000
		Central AC	23.84	0.01485	0.000

Window Shrink Kit

Gross Summer Coincident Demand Savings
ΔkW_S = no. windows ×SF/window × (ΔkW/SF) × DF_S × CF_S

Gross Annual Energy Savings
ΔkWh = no. windows ×SF/window × (ΔkWh/SF)

Δtherm = no. windows ×SF/window × (Δtherm/SF)

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
No windows = quantity of windows treated with window film from survey

SF/window = window square feet based on window size
DF = demand diversity factor
CF = coincidence factor
ΔkW/SF `= electricity demand savings per square foot of window treated
ΔkWh/SF `= electricity consumption savings per square foot of window treated
Δtherm/SF `= gas consumption savings per square foot of window treated

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential cooling loads in summer peaking utilities.

Window area assumptions (per window):

Window Type	Size (SF)
Small	9
Average	18
Large	30

Unit energy and demand savings data

The unit energy savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The basic simulation assumptions for window U-value and solar heat gain coefficient (SHGC) were taken from the ASHRAE Handbook of Fundamentals (ASHRAE, 2001), and are described below:

	Without window film		**With window film**	
Window type	**U-value (Btu/hr-SF-°F)**	**SHGC**	**U-value (Btu/hr-SF-°F)**	**SHGC**
Single	1.27	0.86	0.81	0.76
Single with storm	0.81	0.76	0.67	0.68
Double	0.81	0.76	0.67	0.68

The unit energy savings depend on the heating fuel, heating system, cooling system and window type:

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System None

Window	**ΔkWh/SF**	**ΔkW/SF**	**Δtherm/SF**

type			
All	0	0	0

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System Room/Window or Central AC

Window type	ΔkWh/SF	ΔkW/SF	Δtherm/SF
Single	0.795	0.000853	0
Single with storm	0.566	0.000498	0
Double	0.566	0.000498	0

Heating Fuel Any
Heating System Heat Pump
Cooling System Heat Pump

Window type	ΔkWh/SF	ΔkW/SF	Δtherm/SF
Single	4.757	0.001280	0.000
Single with storm	1.621	0.000711	0.000
Double	1.621	0.000711	0.000

Heating Fuel Gas, propane or oil
Heating System Any except Heat Pump
Cooling System None

Window type	ΔkWh/SF	ΔkW/SF	Δtherm/SF
Single	0	0	0.039
Single with storm	0	0	0.011
Double	0	0	0.011

Heating Fuel Gas, propane or oil
Heating System Any except Heat Pump
Cooling System Room/Window or Central AC

Window type	ΔkWh/SF	ΔkW/SF	Δtherm/SF
Single	0.795	0.000853	0.039
Single with storm	0.566	0.000498	0.011
Double	0.566	0.000498	0.011

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	None

Window type	ΔkWh/SF	ΔkW/SF	Δtherm/SF
Single	8.748	0.004979	0.000
Single with storm	2.431	0.001351	0.000
Double	2.431	0.001351	0.000

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	Room/Window or Central AC

Window type	ΔkWh/SF	ΔkW/SF	Δtherm/SF
Single	9.335	0.005690	0.000
Single with storm	2.940	0.001849	0.000
Double	2.940	0.001849	0.000

Low-Flow Showerhead

Gross Summer Coincident Demand Savings

$$\Delta kW_S = units \times \frac{(GPD_{base} - GPD_{ee}) \times 8.33 \times \overline{\Delta T}}{3413_s} \times DF_x \times CF_s$$

Gross Annual Energy Savings

$$\Delta kWh = \text{units} \times \frac{(GPD_{base} - GPD_{ee}) \times 8.33 \times \overline{\Delta T}}{3413} \times 365$$

$$\Delta therm = units \times \frac{(GPD_{base} - GPD_{ee}) \times 8.33 \times \overline{\Delta T}}{\eta_{waterheater}} \times \frac{365}{100000}$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= number of units installed under the program

GPD_{base} = daily hot water consumption before installation
GPD_{ee} = daily hot water consumption after flow reducing measure installation
ΔT = average difference between entering cold water temperature and the shower use temperature
DF = demand diversity factor for electric water heating
CF = coincidence factor
8.33 = conversion factor (Btu/gal-°F)
3413 = conversion factor (Btu/kWh)
24 = conversion factor (hr/day)
365 = conversion factor (days/yr)
100000 = conversion factor (Btu/therm)

Showerhead

GPD_{base} = showers/week / 7 x 3.1 gpm x 5 minutes/shower

GPD_{ee} = showers/week / 7 x 1.5 gpm x 5 minutes/shower

ΔT

City	Average cold water temperature	Shower use temperature	Average ΔT
Covington	53.9°F	100°F	46.1°F

Water heater efficiency

Combustion efficiency for residential gas water heater = 0.70

Demand diversity factor = 0.1

Coincidence factor = 0.4

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for the residential water heating end-use in a summer peaking utility.

Faucet Aerators

This measure used the Efficiency Vermont deemed savings (Efficiency Vermont, 2003) adjusted for entering water temperature:

Demand Savings
$\Delta kW = 0.0171 \text{ kW} \times \Delta T / \Delta T_{VT} \times DF \times CF$

Energy Savings
$\Delta kWh_i = 57\ kWh \times \Delta T / \Delta T_{VT}$
$\Delta therms = 2.0 \times \Delta T / \Delta T_{VT\ i}$

City	Average cold water temperature	Hot water use temperature	Average ΔT
Covington	53.9°F	100°F	46.1°F
Burlington VT	44.5	100°F	55.5

Demand diversity factor = 0.1

Coincidence factor = 0.4

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for the residential water heating end-use in a summer peaking utility.

Lowering the Temperature in Winter

Gross Annual Energy Savings
ΔkWh = (ΔkWh/unit)

Δtherm = (Δtherm/unit

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
DF	= demand diversity factor
CF	= coincidence factor
ΔkWunit	`= electricity demand savings per dwelling
ΔkWh/SF	`= electricity consumption savings per dwelling
Δtherm/SF	`= gas consumption savings dwelling

Unit energy savings data

The unit energy savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The basic assumptions used in the simulations are shown below:

Setback strategy	Setback schedule	Setback temperature
Night 1-3	10 pm to 5 am 7 days per week	68°F
Night 4-6		65°F
Night 7-10		61.5°F

Night 11+		59°F
Day 1-3	5 am to 10 pm 7 days per week	68°F
Day 4-6		65°F
Day 7-10		61.5°F
Day 11+		59°F

The baseline heating setpoint is assumed to be 70°F with no setback.

The unit energy savings depend on the heating fuel, heating system, cooling system and setback strategy. Since this is a heating season measure, there are no summer peak demand savings.

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System None

Setback strategy	ΔkWh/unit	Δtherm/unit
All	0	0

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System Room/Window or Central AC

Setback strategy	ΔkWh/unit	Δtherm/unit
Night 1-3	58	0
Night 4-6	107	0
Night 7-10	138	0
Night 11+	149	0
Day 1-3	80	0
Day 4-6	159	0
Day 7-10	204	0
Day 11+	232	0

Heating Fuel Any
Heating System Heat Pump
Cooling System Heat Pump

Setback strategy	ΔkWh/unit	Δtherm/unit
Night 1-3	386	0.0
Night 4-6	1,114	0.0
Night 7-10	2,080	0.0
Night 11+	2,767	0.0

Day 1-3	951	0.0
Day 4-6	2,518	0.0
Day 7-10	4,394	0.0
Day 11+	5,715	0.0

Heating Fuel Gas, propane or oil
Heating System Any except Heat Pump
Cooling System None

Setback strategy	ΔkWh/unit	Δtherm/unit
Night 1-3	0.0	4.0
Night 4-6	0.0	10.0
Night 7-10	0.0	16.0
Night 11+	0.0	19.8
Day 1-3	0.0	8.5
Day 4-6	0.0	20.5
Day 7-10	0.0	33.3
Day 11+	0.0	41.3

Heating Fuel Gas, propane or oil
Heating System Any except Heat Pump
Cooling System Room/Window or Central AC

Setback strategy	ΔkWh/unit	Δtherm/unit
Night 1-3	58	4.0
Night 4-6	107	10.0
Night 7-10	138	16.0
Night 11+	149	19.8
Day 1-3	80	8.5
Day 4-6	159	20.5
Day 7-10	204	33.3
Day 11+	232	41.3

Heating Fuel Electricity
Heating System Any except Heat Pump
Cooling System None

Setback strategy	ΔkWh/unit	Δtherm/unit
Night 1-3	918	0.0
Night 4-6	2,164	0.0
Night 7-10	3,390	0.0
Night 11+	4,095	0.0

Day 1-3	1,863	0.0
Day 4-6	4,419	0.0
Day 7-10	7,030	0.0
Day 11+	8,615	0.0

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	Room/Window or Central AC

Setback strategy	ΔkWh/unit	Δtherm/unit
Night 1-3	957	0.0
Night 4-6	2,228	0.0
Night 7-10	3,467	0.0
Night 11+	4,171	0.0
Day 1-3	1,903	0.0
Day 4-6	4,492	0.0
Day 7-10	7,100	0.0
Day 11+	8,686	0.0

Using Cold Water for Laundry

The energy and demand savings for this measure were taken from the Efficiency Vermont Technical Reference Manual (Efficiency Vermont, 2001), based on the savings per load and the number of loads reported by the survey respondents.

	Gas	Electric	
Loads/wk	therm/yr	kWh/yr	kW
1-2	13.2	166	0.019
3-4	30.8	388	0.044
5-6	48.3	609	0.070
7-8	65.9	830	0.095
9-10	83.5	1052	0.120
11-12	101.0	1273	0.145
13+	114.2	1439	0.164

Replacing Furnace Filter

Gross Summer Coincident Demand Savings
$\Delta kW_S = (kW/unit_{pre} - kW/unit_{post}) \times DF_S \times CF_S$

Gross Annual Energy Savings

$\Delta kWh = (kWh/unit_{pre} - kWh/unit_{post})$

$\Delta therm = (therm/unit_{pre} - therm/unit_{post})$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
DF	= demand diversity factor
CF	= coincidence factor
$kWunit_{pre}$	= HVAC electricity demand per dwelling based on pre report filter change frequency
$kWunit_{post}$	= HVAC electricity demand per dwelling based on post report filter change frequency
$kWh/unit_{pre}$	= HVAC electricity consumption per dwelling based on pre report filter change frequency
$kWh/unit_{post}$	= HVAC electricity consumption per dwelling based on post report filter change frequency
$therm/unit_{pre}$	= HVAC gas consumption per dwelling based on pre report filter change frequency
$therm/unit_{post}$	= HVAC gas consumption per dwelling based on post report filter change frequency

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential cooling loads in summer peaking utilities.

Unit energy and demand data

The unit energy and demand savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The analysis assumes that furnace filter change outs result in a 5% savings relative to an un-maintained system. The 5% overall savings were allocated to the survey responses as follows:

Filter change frequency	Percent savings
< 1/yr	0%
1x / yr	1.7%
2x / yr	3.3%
> 2x / yr	5%

Data depend on the heating fuel, heating system, cooling system type and the pre and post filter change frequency

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System None

Filter change frequency	kWh	kW	therm
all	0	0	0

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System Central AC

Filter change frequency	kWh	kW	therm
< 1/yr	4,453	5.2	0
1x / yr	4,375	5.1	0
2x / yr	4,302	5.0	0
> 2x / yr	4,231	4.9	0

Heating Fuel Any
Heating System Heat Pump
Cooling System Heat Pump

Filter change frequency	kWh	kW	therm
< 1/yr	21,793	11.7	0
1x / yr	21,410	11.5	0
2x / yr	21,054	11.3	0
> 2x / yr	20,704	11.1	0

Heating Fuel Gas, propane or oil
Heating System Furnace
Cooling System None

Filter change frequency	kWh	kW	therm
< 1/yr	0	0	148

1x / yr	0	0	146
2x / yr	0	0	143
> 2x / yr	0	0	141

Heating Fuel Gas, propane or oil
Heating System Furnace
Cooling System Central AC

Filter change frequency	kWh	kW	therm
< 1/yr	4,453	5.2	148
1x / yr	4,375	5.1	146
2x / yr	4,302	5.0	143
> 2x / yr	4,231	4.9	141

Heating Fuel Electricity
Heating System Furnace
Cooling System None

Filter change frequency	kWh	kW	therm
< 1/yr	31,073	19.5	0
1x / yr	30,527	19.2	0
2x / yr	30,020	18.8	0
> 2x / yr	29,520	18.5	0

Heating Fuel Electricity
Heating System Furnace
Cooling System Central AC

Filter change frequency	kWh	kW	therm
< 1/yr	34,936	24.3	0
1x / yr	34,322	23.9	0
2x / yr	33,752	23.5	0
> 2x / yr	33,190	23.1	0

Stopping Heating Unused Rooms

Gross Summer Coincident Demand Savings
$\Delta kW_S = (\Delta kW/unit) \times DF_S \times CF_S$

Gross Annual Energy Savings
$\Delta kWh = (\Delta kWh/unit)$

$\Delta therm = (\Delta therm/unit$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
DF	= demand diversity factor
CF	= coincidence factor
ΔkWunit	`= electricity demand savings per dwelling
ΔkWh/SF	`= electricity consumption savings per dwelling
Δtherm/SF	`= gas consumption savings dwelling

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential cooling loads in summer peaking utilities.

Unit energy and demand savings data

The unit energy and demand savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The analysis assumes that each room is 220 SF in size. Savings data depend on the heating fuel, heating system, cooling system and duct treatment

Heating Fuel	Other
Heating System	Any except Heat Pump
Cooling System	None

Number of rooms	ΔkWh/unit	ΔkW/unit	Δtherm/unit
All	0	0	0

Heating Fuel Other

Heating System Any except Heat Pump
Cooling System Central AC

Number of rooms	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1	80	0.09	0
2	161	0.19	0
3	241	0.28	0
4	321	0.37	0
5	401	0.47	0
6+	482	0.56	0

Heating Fuel Any
Heating System Heat Pump
Cooling System Heat Pump

Number of rooms	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1	393	0.21	0
2	786	0.42	0
3	1,179	0.63	0
4	1,571	0.84	0
5	1,964	1.05	0
6+	2,357	1.26	0

Heating Fuel Gas, propane or oil
Heating System Furnace
Cooling System None

Number of rooms	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1	0	0	3
2	0	0	5
3	0	0	8
4	0	0	11
5	0	0	13
6+	0	0	16

Heating Fuel Gas, propane or oil
Heating System Furnace

Cooling System Central AC

Number of rooms	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1	80	0.09	3
2	161	0.19	5
3	241	0.28	8
4	321	0.37	11
5	401	0.47	13
6+	482	0.56	16

Heating Fuel Electricity
Heating System Furnace
Cooling System None

Number of rooms	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1	560	0.35	0
2	1,120	0.70	0
3	1,680	1.05	0
4	2,241	1.41	0
5	2,801	1.76	0
6+	3,361	2.11	0

Heating Fuel Electricity
Heating System Furnace
Cooling System Central AC

Number of rooms	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1	630	0.44	0
2	1,260	0.88	0
3	1,889	1.31	0
4	2,519	1.75	0
5	3,149	2.19	0
6+	3,779	2.63	0

Insulated Water Heater

Gross Summer Coincident Demand Savings

$$\Delta kW_S = units \times \frac{(UA_{base} - UA_{ee}) \times \Delta T_s}{3413} \times DF_s \times CF_s$$

Gross Annual Energy Savings

$$\Delta kWh = units \times \frac{(UA_{base} - UA_{ee}) \times \overline{\Delta T}}{3413} \times 8760$$

$$\Delta therm = units \times \frac{(UA_{base} - UA_{ee}) \times \overline{\Delta T}}{\eta_{waterheater}} \times \frac{8760}{100000}$$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
units	= number of water heaters installed under the program
UA_{base}	= overall heat transfer coefficient of base water heater (Btu/hr-°F)
UA_{ee}	= overall heat transfer coefficient of improved water heater (Btu/hr-°F)
ΔT	= temperature difference between the tank and the ambient air (°F)
DF	= demand diversity factor
CF	= coincidence factor
3413	= conversion factor (Btu/kWh)
8760	= conversion factor (hr/yr)
100000	= conversion factor (Btu/therm)
$\eta_{waterheater}$	= water heater efficiency

Water heater tank UA

Water heater size (gal)	Electric		Gas	
	UAbase	UAee	UAbase	UAee
30	3.84	1.69	4.21	1.76
50	4.67	1.83	5.13	1.91
60	4.13	2.06	4.54	2.14
75	5.00	2.42	5.50	2.52
80+	5.72	2.53	6.28	2.64

ΔT = 140°F water setpoint temp – 65°F room temp = 75°F

DF = 1.0
CF= 1.0
$\eta_{waterheater} = 0.7$

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential water heaters meeting standby losses.

Manage Draperies

Gross Summer Coincident Demand Savings
ΔkW_S = windows × (ΔkW/window) × DF_S × CF_S

Gross Annual Energy Savings
ΔkWh = windows × (ΔkWh/ window)

Δtherm = windows × (Δtherm/ window)

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
Windows	= number of windows managed
DF	= demand diversity factor
CF	= coincidence factor
ΔkW/ window	`= electricity demand savings per window
ΔkWh/window	`= electricity consumption savings per window
Δtherm/window	`= gas consumption savings per window

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential cooling loads in summer peaking utilities.

Unit energy and demand savings data

The unit energy and demand savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The analysis assumes drapes open during daylight hours on south facing windows only. The savings depend on the heating fuel, heating system, cooling system and number of windows managed.

Heating Fuel	Other
Heating System	Any except Heat Pump
Cooling System	Any or none

Number of windows	ΔkWh/unit	ΔkW/unit	Δtherm/unit
All	0	0	0

Heating Fuel	Any
Heating System	Heat Pump
Cooling System	Heat Pump

Number of windows	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1-3	99	0	0
4-7	274	0	0
8-12	497	0	0
13+	647	0	0

Heating Fuel	Gas, propane or oil
Heating System	Any except Heat Pump
Cooling System	Any or none

Number of windows	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1-3	0	0	3
4-7	0	0	5
8-12	0	0	8
13+	0	0	11

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	Any or none

Number of windows	ΔkWh/unit	ΔkW/unit	Δtherm/unit
1-3	164	0	0
4-7	451	0	0
8-12	821	0	0
13+	1067	0	0

Cleaned Electric Baseboards

Savings are based on reduced heat losses from back of electric baseboard unit through insulated wall to the outside. Cleaning unit is assumed to reduce the average temperature inside the unit from 115°F to 90°F. Heat losses are estimated based on an R-11 wall and 40°F outside temperature. Each unit is assumed to be 8 ft long. Heat loss reductions are estimated to be 0.13% of the baseboard rated input, resulting in 4.25 kWh per baseboard unit cleaned. Apply only when heating fuel = electric and heating system type = baseboard. No kW savings.

Attic Insulation

Gross Summer Coincident Demand Savings
$\Delta kW_S = SF \times (kW/SF_{base} - kW/SF_{ee}) \times DF_S \times CF_S$

Gross Annual Energy Savings
$\Delta kWh = SF \times (kWh/SF_{base} - kWh/SF_{ee})$

$\Delta therm = SF \times (therm/SF_{base} - therm/SF_{ee})$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings
SF = insulation square feet installed
DF = demand diversity factor
CF = coincidence factor
kW/SF `= electricity demand per square foot of insulation installed
kWh/SF `= electricity consumption per square foot of insulation installed
therm/SF `= gas consumption per square foot of insulation installed

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential cooling loads in summer peaking utilities.

Insulation square foot assumptions:

Average house size from site data (Carolinas), or estimated from number of rooms (Kentucky)

Size of house = number of rooms * 330 SF/room

Average ceiling area = house size / 1.2

If partial insulation, then reduce ceiling area by 50%

R value assumptions

Rbase:

Base thickness	R_{base}
2	7
4	14
6	21
8	28
10	35

Assumes existing insulation is fiberglass or cellulose, at R-3.5 per inch. This assumption addresses insulation R-value only. The R-value assumptions for other materials within the ceiling construction are embedded in the simulation model.

Ree

The R-value of the wall with added insulation depends on base thickness, added insulation thickness and insulation type: Fiberglass, cellulose and "other" insulation is assumed to have an R-value of 3.5 per inch. Foam insulation is assumed to have an R-value of 5.6 per inch.

Base thickness	Added thickness	Ree	
		fiberglass, cellulose or other	Foam
	2	14.00	18.20
	4	21.00	29.40
	6	28.00	40.60
	8	35.00	51.80
	10	42.00	63.00
2	12	49.00	74.20
	2	21.00	25.20
	4	28.00	36.40
	6	35.00	47.60
	8	42.00	58.80
	10	49.00	70.00
4	12	56.00	81.20
6	2	28.00	32.20
	4	35.00	43.40
	6	42.00	54.60

	8	49.00	65.80
	10	56.00	77.00
	12	63.00	88.20
8	2	35.00	39.20
	4	42.00	50.40
	6	49.00	61.60
	8	56.00	72.80
	10	63.00	84.00
	12	70.00	95.20
10	2	42.00	46.20
	4	49.00	57.40
	6	56.00	68.60
	8	63.00	79.80
	10	70.00	91.00
	12	77.00	102.20
12	2	49.00	53.20
	4	56.00	64.40
	6	63.00	75.60
	8	70.00	86.80
	10	77.00	98.00
	12	84.00	109.20

Unit energy and demand data

The unit energy savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The unit energy and demand savings depend on the heating fuel, heating system, cooling system type and Rvalue

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System None

R-value	kWh/SF	kW/SF	therm/SF
All	0	0	0

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System Room/Window or Central AC

R-value	kWh/SF	kW/SF	therm/SF

7	1.339	0.00157	0
14	1.272	0.00149	0
21	1.245	0.00145	0
28	1.231	0.00143	0
35	1.220	0.00142	0
42	1.214	0.00141	0
49	1.210	0.00141	0
56	1.206	0.00140	0
63	1.203	0.00140	0
70	1.201	0.00140	0
77	1.200	0.00140	0
84	1.196	0.00139	0
109	1.194	0.00139	0

Heating Fuel Any
Heating System Heat Pump
Cooling System Heat Pump

R-value	kWh/SF	kW/SF	therm/SF
7	6.550	0.00387	0.00000
14	6.121	0.00378	0.00000
21	5.937	0.00374	0.00000
28	5.833	0.00371	0.00000
35	5.768	0.00370	0.00000
42	5.724	0.00368	0.00000
49	5.689	0.00368	0.00000
56	5.665	0.00367	0.00000
63	5.644	0.00366	0.00000
70	5.628	0.00366	0.00000
77	5.616	0.00366	0.00000
84	5.605	0.00366	0.00000
109	5.576	0.00365	0.00000

Heating Fuel Gas, propane or oil
Heating System Any except Heat Pump
Cooling System None

R-value	kWh/SF	kW/SF	therm/SF
7	0	0	0.04418
14	0	0	0.04058
21	0	0	0.03908
28	0	0	0.03828
35	0	0	0.03768

42	0	0	0.03738
49	0	0	0.03708
56	0	0	0.03688
63	0	0	0.03668
70	0	0	0.03658
77	0	0	0.03648
84	0	0	0.03638
109	0	0	0.03618

Heating Fuel	Gas, propane or oil
Heating System	Any except Heat Pump
Cooling System	Room/Window or Central AC

R-value	kWh/SF	kW/SF	therm/SF
7	1.339	0.00157	0.04418
14	1.272	0.00149	0.04058
21	1.245	0.00145	0.03908
28	1.231	0.00143	0.03828
35	1.220	0.00142	0.03768
42	1.214	0.00141	0.03738
49	1.210	0.00141	0.03708
56	1.206	0.00140	0.03688
63	1.203	0.00140	0.03668
70	1.201	0.00140	0.03658
77	1.200	0.00140	0.03648
84	1.196	0.00139	0.03638
109	1.194	0.00139	0.03618

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	None

R-value	kWh/SF	kW/SF	therm/SF
7	9.063	0.00501	0.00000
14	8.254	0.00463	0.00000
21	7.915	0.00447	0.00000
28	7.728	0.00439	0.00000
35	7.610	0.00432	0.00000
42	7.528	0.00429	0.00000
49	7.468	0.00426	0.00000

56	7.423	0.00424	0.00000
63	7.387	0.00422	0.00000
70	7.358	0.00421	0.00000
77	7.334	0.00420	0.00000
84	7.313	0.00419	0.00000
109	7.262	0.00417	0.00000

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	Room/Window or Central AC

R-value	kWh/SF	kW/SF	therm/SF
7	10.184	0.00646	0.00000
14	9.327	0.00601	0.00000
21	8.969	0.00581	0.00000
28	8.773	0.00571	0.00000
35	8.645	0.00564	0.00000
42	8.560	0.00560	0.00000
49	8.497	0.00557	0.00000
56	8.448	0.00554	0.00000
63	8.410	0.00552	0.00000
70	8.380	0.00551	0.00000
77	8.356	0.00550	0.00000
84	8.331	0.00548	0.00000
109	8.279	0.00546	0.00000

Sidewall Insulation

Gross Summer Coincident Demand Savings
$\Delta kW_S = SF \times (kW/SF_{base} - kW/SF_{ee}) \times DF_S \times CF_S$

Gross Annual Energy Savings
$\Delta kWh = SF \times (kWh/SF_{base} - kWh/SF_{ee})$

$\Delta therm = SF \times (therm/SF_{base} - therm/SF_{ee})$

where:

ΔkW = gross coincident demand savings
ΔkWh = gross annual energy savings

SF = insulation square feet installed
DF = demand diversity factor
CF = coincidence factor
kW/SF `= electricity demand per square foot of insulation installed
kWh/SF `= electricity consumption per square foot of insulation installed
therm/SF `= gas consumption per square foot of insulation installed

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential cooling loads in summer peaking utilities.

Insulation square foot assumptions:

Average house size from site data (Carolinas), or estimated from number of rooms (KY)

Size of house = number of rooms * 330 SF/room

Number of walls	Wall area as a fraction of floor area
1	0.26
2	0.52
3	0.72
4+	0.92

R value assumptions

Rbase:

Base thickness	R_{base}
0	0.91

The base case assumes an uninsulated wall with 3.5 inch air gap. This assumption addresses "insulation" R-value only. The R-value assumptions for other materials within the wall construction are embedded in the simulation model.

Ree

The insulated wall R-value depends on added insulation thickness and insulation type. Fiberglass, cellulose and "other" insulation is assumed to have an R-value of 3.5 per inch. Foam insulation is assumed to have an R-value of 5.6 per inch.

Added thickness	Ree	
	fiberglass, cellulose or other	Foam
1-3	7.9	12.1
4-6	18.4	28.9
7-12	30.7	48.5
13+	46.4	73.7

Unit energy and demand data

The unit energy and demand savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The unit energy and demand savings depend on the heating fuel, heating system, cooling system type and wall Rvalue:

Heating Fuel	Other
Heating System	Any except Heat Pump
Cooling System	None

R-value	kWh/SF	kW/SF	therm/SF
All	0	0	0

Heating Fuel	Other
Heating System	Any except Heat Pump
Cooling System	Room/Window or Central AC

R-value	kWh/SF	kW/SF	therm/SF
0.91	2.361	0.00273	0
7.9	2.046	0.00238	0
18.4	1.950	0.00227	0
30.7	1.908	0.00224	0
46.4	1.887	0.00220	0
12.1	1.988	0.00230	0
28.9	1.917	0.00224	0
48.5	1.886	0.00220	0
73.7	1.874	0.00220	0

Heating Fuel	Any
Heating System	Heat Pump
Cooling System	Heat Pump

R-value	kWh/SF	kW/SF	therm/SF

0.91	12.078	0.00655	0.00000
7.9	9.865	0.00605	0.00000
18.4	9.160	0.00588	0.00000
30.7	8.892	0.00581	0.00000
46.4	8.734	0.00578	0.00000
12.1	9.477	0.00597	0.00000
28.9	8.918	0.00583	0.00000
48.5	8.721	0.00578	0.00000
73.7	8.620	0.00575	0.00000

Heating Fuel	Gas, propane or oil
Heating System	Any except Heat Pump
Cooling System	None

R-value	kWh/SF	kW/SF	therm/SF
0.91	0	0	0.08530
7.9	0	0	0.06565
18.4	0	0	0.05974
30.7	0	0	0.05751
46.4	0	0	0.05623
12.1	0	0	0.06230
28.9	0	0	0.05767
48.5	0	0	0.05623
73.7	0	0	0.05543

Heating Fuel	Gas, propane or oil
Heating System	Any except Heat Pump
Cooling System	Room/Window or Central AC

R-value	kWh/SF	kW/SF	therm/SF
0.91	2.361	0.00273	0.08530
7.9	2.046	0.00238	0.06565
18.4	1.950	0.00227	0.05974
30.7	1.908	0.00224	0.05751
46.4	1.887	0.00220	0.05623
12.1	1.988	0.00230	0.06230
28.9	1.917	0.00224	0.05767
48.5	1.886	0.00220	0.05623
73.7	1.874	0.00220	0.05543

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	None

R-value	kWh/SF	kW/SF	therm/SF
0.91	17.807	0.00963	0
7.9	13.354	0.00749	0
18.4	12.045	0.00685	0
30.7	11.552	0.00663	0
46.4	11.277	0.00650	0
12.1	12.616	0.00712	0
28.9	11.599	0.00665	0
48.5	11.254	0.00649	0
73.7	11.075	0.00641	0

Heating Fuel	Electricity
Heating System	Any except Heat Pump
Cooling System	Room/Window or Central AC

R-value	kWh/SF	kW/SF	therm/SF
0.91	12.078	0.00655	0.00000
7.9	9.865	0.00605	0.00000
18.4	9.160	0.00588	0.00000
30.7	8.892	0.00581	0.00000
46.4	8.734	0.00578	0.00000
12.1	9.477	0.00597	0.00000
28.9	8.918	0.00583	0.00000
48.5	8.721	0.00578	0.00000
73.7	8.620	0.00575	0.00000

Duct Insulation and Repair

Gross Summer Coincident Demand Savings
$\Delta kW_S = (\Delta kW/unit) \times DF_S \times CF_S \times LF$

Gross Annual Energy Savings
$\Delta kWh = (\Delta kWh/unit) \times LF$

$\Delta therm = (\Delta therm/unit) \times LF$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
DF	= demand diversity factor
CF	= coincidence factor
LF	= location factor
ΔkWunit	`= electricity demand savings per dwelling
ΔkWh/SF	`= electricity consumption savings per dwelling
Δtherm/SF	`= gas consumption savings dwelling

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential air conditioners and heat pumps in summer peaking utilities.

The location factors used are as follows:

Heated Area	Unheated Area	DK/No Response
0	1	.43

Unit energy and demand savings data

The unit energy and demand savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The basic assumptions are listed below:

Assumption	Pre treatment	Post treatment	Notes
Duct insulation	Uninsulated	R-19	Consistent with Smart Saver program requirements
Duct sealing	26% leakage	8% leakage	Duct leakage assumptions used in CA for Title 24 and utility program design. Evenly distributed between supply and return

The unit energy and demand savings depend on the heating fuel, heating system, cooling system and duct treatment as follows:

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System None

Duct treatment	ΔkWh/unit	ΔkW/unit	Δtherm/unit
All	0	0	0

Heating Fuel Other
Heating System Any except Heat Pump
Cooling System Central AC

Duct treatment	ΔkWh/unit	ΔkW/unit	Δtherm/unit
Insulate	384	0.10	0
Seal	466	0.25	0

Heating Fuel Any
Heating System Heat Pump
Cooling System Heat Pump

Duct treatment	ΔkWh/unit	ΔkW/unit	Δtherm/unit
Insulate	1,520	0.48	0.0
Seal	2,422	0.78	0.0

Heating Fuel Gas, propane or oil
Heating System Furnace
Cooling System None

Duct treatment	ΔkWh/unit	ΔkW/unit	Δtherm/unit
Insulate	0.0	0.0	17.3
Seal	0.0	0.0	16.5

Heating Fuel Gas, propane or oil
Heating System Furnace
Cooling System Central AC

Duct treatment	ΔkWh/unit	ΔkW/unit	Δtherm/unit
Insulate	384	0.10	17.3
Seal	466	0.25	16.5

Heating Fuel	Electricity
Heating System	Furnace
Cooling System	None

Duct treatment	ΔkWh/unit	ΔkW/unit	Δtherm/unit
Insulate	3,917	3.13	0.0
Seal	3,798	2.98	0.0

Heating Fuel	Electricity
Heating System	Furnace
Cooling System	Central AC

Duct treatment	ΔkWh/unit	ΔkW/unit	Δtherm/unit
Insulate	4,285	3.18	0.0
Seal	4,211	3.18	0.0

Installed a New AC or Heat Pump

Gross Summer Coincident Demand Savings
$\Delta kW_S = (\Delta kW/unit) \times DF_S \times CF_S$

Gross Annual Energy Savings
$\Delta kWh = (\Delta kWh/unit)$

$\Delta therm = (\Delta therm/unit$

where:

ΔkW	= gross coincident demand savings
ΔkWh	= gross annual energy savings
DF	= demand diversity factor
CF	= coincidence factor
ΔkWunit	`= electricity demand savings per dwelling
ΔkWh/SF	`= electricity consumption savings per dwelling
Δtherm/SF	`= gas consumption savings dwelling

Coincidence and Diversity Factors:

DF = 0.8
CF = 1.0

The diversity and coincidence factors were taken from *Engineering Methods for Estimating the Impacts of DSM Programs, Volume 2* (EPRI, 1993). These values are typical for residential air conditioners and heat pumps in summer peaking utilities.

Unit energy and demand savings data

The unit energy and demand savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. Unit energy savings are based on replacement of an existing SEER 8.5 air conditioner or heat pump. The unit energy and demand savings depend on the heating fuel, heating system, cooling system and replacement efficiency.

Heating Fuel	Other
Heating System	Any except Heat Pump
Cooling System	None

Replacement efficiency	ΔkWh/unit	ΔkW/unit	Δtherm/unit
All	0	0	0

Heating Fuel	Other
Heating System	Any except Heat Pump
Cooling System	Central AC

Replacement efficiency	ΔkWh/unit	ΔkW/unit	Δtherm/unit
<11	674	0.92	0
12	944	1.28	0
13	1,213	1.65	0
14+	1,346	1.80	0

Heating Fuel	Any
Heating System	Heat Pump
Cooling System	Heat Pump

Replacement efficiency	ΔkWh/unit	ΔkW/unit	Δtherm/unit
<11	2,941	1.36	0
12	2,941	1.36	0
13	5,294	2.45	0
14+	6,496	2.98	0

Heating Fuel Gas, propane or oil
Heating System Any except Heat Pump
Cooling System None

Replacement efficiency	ΔkWh/unit	ΔkW/unit	Δtherm/unit
All	0.0	0.0	0

Heating Fuel Gas, propane or oil
Heating System Any except Heat Pump
Cooling System Central AC

Replacement efficiency	ΔkWh/unit	ΔkW/unit	Δtherm/unit
<11	674	0.92	0
12	944	1.28	0
13	1,213	1.65	0
14+	1,346	1.80	0

0

Heating Fuel Electricity
Heating System Any except Heat Pump
Cooling System None

Replacement efficiency	ΔkWh/unit	ΔkW/unit	Δtherm/unit
All	0.0	0.0	0

Heating Fuel Electricity
Heating System Any except Heat Pump
Cooling System Central AC

Replacement efficiency	ΔkWh/unit	ΔkW/unit	Δtherm/unit
<11	674	0.92	0
12	944	1.28	0
13	1,213	1.65	0
14+	1,346	1.80	0

Installed a New Furnace

Gross Annual Energy Savings
Δtherm = (Δtherm/unit)

where:

Δtherm/SF `= gas consumption savings dwelling

Unit energy and demand savings data

The unit energy and demand savings were taken from DOE-2 simulations of the residential prototype building described at the end of this Appendix. The basic assumptions are listed below:

Furnace Type	AFUE
Baseline	0.78
Standard efficiency (metal flue pipe) replacement	0.80
Condensing furnace (plastic flue pipe) replacement	0.90

The unit energy and demand savings depend on the heating fuel, heating system type, and replacement furnace type:

Heating Fuel Gas, propane or oil
Heating System Furnace

Replacement efficiency	Δtherm/unit
Standard (metal pipe)	3.0
Condensing (plastic pipe)	18.8

Otherwise 0

Prototypical Building Model Description

The impact analysis for many of the HVAC related measures are based on DOE-2.2 simulations of a set of prototypical residential buildings. The prototypical simulation models were derived from the residential building prototypes used in the California Database for Energy Efficiency Resources (DEER) study (Itron, 2005), with adjustments make for local building practices and climate. The prototype "model" in fact contains 4 separate residential buildings; 2 one-story and 2 two-story buildings. The each version of the 1 story and 2 story buildings are identical except for the orientation, which is shifted by 90 degrees. The selection of these 4 buildings is designed to give a reasonable average response of buildings of different design and orientation to the impact of energy efficiency measures. A sketch of the residential prototype buildings is shown in Figure 1.

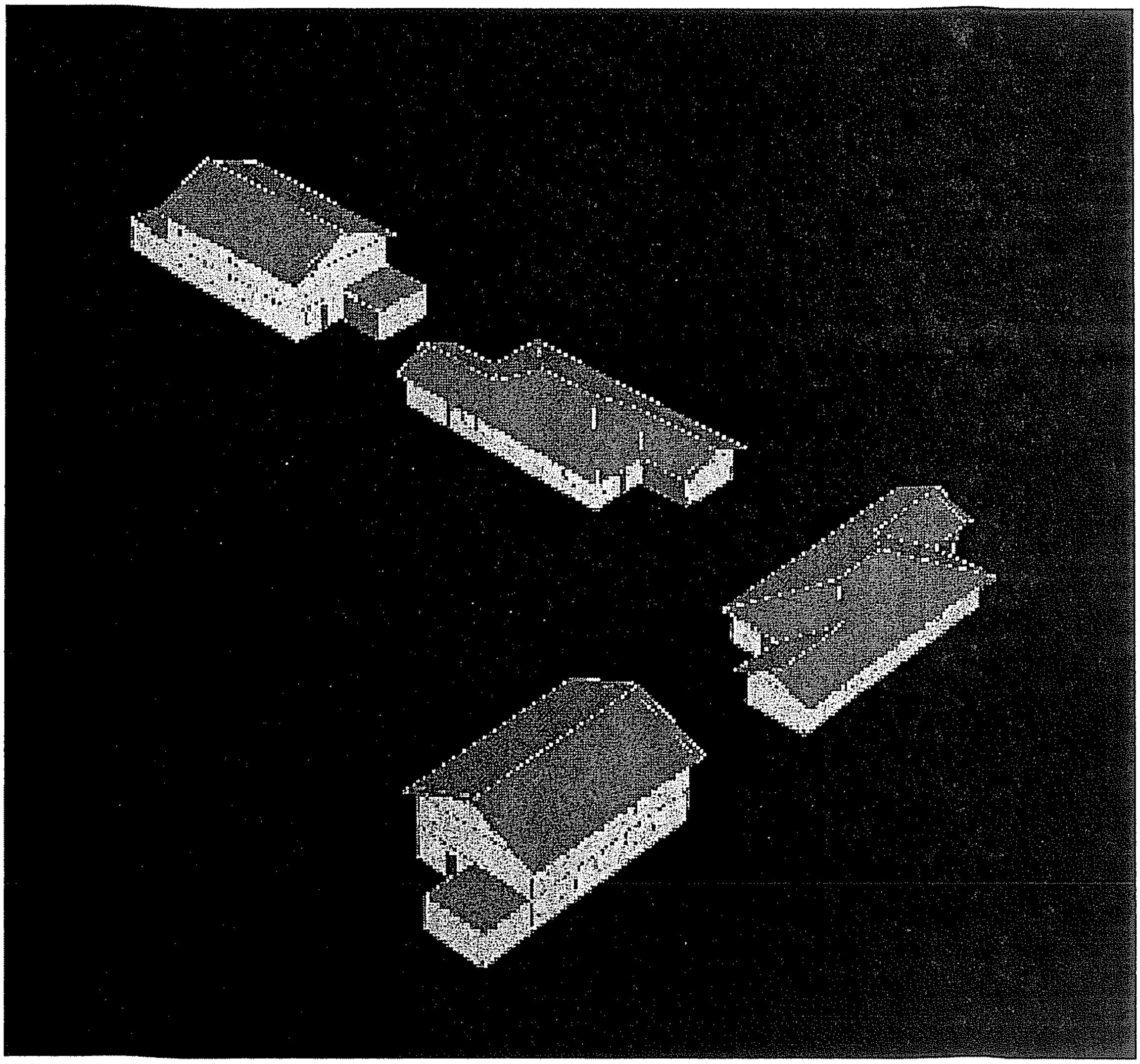

Figure 1. Computer Rendering of Residential Building Prototype Model

The general characteristics of the residential building prototype model are summarized below:

Residential Building Prototype Description

Characteristic	Value
Conditioned floor area	1 story house: 1465 SF 2 story house: 2930 SF
Wall construction and R-value	Wood frame with siding, R-11
Roof construction and R-value	Wood frame with asphalt shingles, R-19
Glazing type	Single pane clear
Lighting and appliance power density	0.51 W/SF average

Characteristic	Value
HVAC system type	Packaged single zone AC or heat pump
HVAC system size	Based on peak load with 20% oversizing. Average 640 SF/ton
HVAC system efficiency	SEER = 8.5
Thermostat setpoints	Heating: 70°F with setback to 60°F Cooling: 75°F with setup to 80°F
Duct location	Attic (unconditioned space)
Duct surface area	Single story house: 390 SF supply, 72 SF return Two story house: 505 SF supply, 290 SF return
Duct insulation	Uninsulated
Duct leakage	26%; evenly distributed between supply and return
Cooling season	Charlotte – April 17 to October 6 Covington
Natural ventilation	Allowed during cooling season when cooling setpoint exceeded and outdoor temperature < 65°F. 3 air changes per hour

References

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Itron, 2005. "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report," Itron, Inc., J.J. Hirsch and Associates, Synergy Consulting, and Quantum Consulting. December, 2005. Available at http://eega.cpuc.ca.gov/deer

Appendix D: Housing Characteristics

Type of home

	Kentucky Kits			Kentucky No Kits		
	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
Detached single-family	654	88.26%	88.26%	1681	89.46%	89.46%
Manufactured/Modular home	23	3.10%	3.10%	56	2.98%	2.98%
Condominium	41	5.53%	5.53%	111	5.91%	5.91%
Duplex/2-family	14	1.89%	1.89%	23	1.22%	1.22%
Multi-family (3 or more units)	9	1.21%	1.21%	8	0.43%	0.43%
Total	741	100.00%	100.00%	1879	100.00%	100.00%

Year home was built

	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
Don't Know	5	0.67%	0.67%	16	0.85%	0.85%
Before 1959	227	30.63%	30.63%	548	29.16%	29.16%
1960-1979	177	23.89%	23.89%	514	27.35%	27.35%
1980-1989	83	11.20%	11.20%	183	9.74%	9.74%
1990-1997	103	13.90%	13.90%	269	14.32%	14.32%
1998-2000	65	8.77%	8.77%	157	8.36%	8.36%
2001-2006	81	10.93%	10.93%	192	10.22%	10.22%
Total	741	100.00%	100.00%	1879	100.00%	100.00%

Number of rooms in home (excluding bathrooms)

	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
Don't Know	3	0.40%	0.40%	8	0.43%	0.43%
1-3	11	1.48%	1.48%	34	1.81%	1.81%
4	40	5.40%	5.40%	91	4.84%	4.84%
5	111	14.98%	14.98%	279	14.85%	14.85%
6	145	19.57%	19.57%	377	20.06%	20.06%
7	158	21.32%	21.32%	426	22.67%	22.67%
8	131	17.68%	17.68%	305	16.23%	16.23%
9	68	9.18%	9.18%	156	8.30%	8.30%
10+	74	9.99%	9.99%	203	10.80%	10.80%
Total	741	100.00%	100.00%	1879	100.00%	100.00%

Number of occupants

	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
Don't Know	1	0.13%	0.13%	4	0.21%	0.21%
1	131	17.68%	17.68%	387	20.60%	20.60%
2	359	48.45%	48.45%	928	49.39%	49.39%
3	114	15.38%	15.38%	256	13.62%	13.62%
4	86	11.61%	11.61%	205	10.91%	10.91%
5	35	4.72%	4.72%	62	3.30%	3.30%
6	11	1.48%	1.48%	29	1.54%	1.54%
7	2	0.27%	0.27%	5	0.27%	0.27%
8+	2	0.27%	0.27%	3	0.16%	0.16%
Total	741	100.00%	100.00%	1879	100.00%	100.00%

Heating fuel

	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
electric	139	18.76%	18.86%	415	22.09%	22.12%
natural gas	524	70.72%	71.10%	1312	69.82%	69.94%
oil	2	0.27%	0.27%	4	0.21%	0.21%
propane	4	0.54%	0.54%	5	0.27%	0.27%
other	68	9.18%	9.23%	140	7.45%	7.46%
Total	737	99.46%	100.00%	1876	99.84%	100.00%
No Response	4	0.54%		3	0.16%	
Total	741	100.00%		1879	100.00%	

Heating system

		Kentucky Kits			Kentucky No Kits		
		Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
	Central furnace	600	80.97%	81.74%	1555	82.76%	83.11%
	Electric baseboard	7	0.94%	0.95%	11	0.59%	0.59%
	Other	49	6.61%	6.68%	114	6.07%	6.09%
	Heat pump	78	10.53%	10.63%	191	10.16%	10.21%
	Total	734	99.06%	100.00%	1871	99.57%	100.00%
	No Response	7	0.94%		8	0.43%	
Total		741	100.00%		1879	100.00%	

Age of furnace

		Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
	Don't Know	21	2.83%	2.83%	68	3.62%	3.62%
	0-4	213	28.74%	28.74%	491	26.13%	26.13%
	5-9	220	29.69%	29.69%	548	29.16%	29.16%
	10-14	124	16.73%	16.73%	383	20.38%	20.38%
	15+	163	22.00%	22.00%	389	20.70%	20.70%
Total		741	100.00%	100.00%	1879	100.00%	100.00%

Type of cooling system

		Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
	Central air conditioning	595	80.30%	80.84%	1524	81.11%	81.45%
	Room window unit	43	5.80%	5.84%	107	5.69%	5.72%
	Central and room	12	1.62%	1.63%	22	1.17%	1.18%
	Heat pump	78	10.53%	10.60%	191	10.16%	10.21%
	None	8	1.08%	1.09%	27	1.44%	1.44%
	Total	736	99.33%	100.00%	1871	99.57%	100.00%
	No Response	5	0.67%		8	0.43%	
Total		741	100.00%		1879	100.00%	

Age of cooling system

		Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
	Don't Know	30	4.05%	4.05%	104	5.53%	5.53%
	0-4	235	31.71%	31.71%	517	27.51%	27.51%
	5-9	243	32.79%	32.79%	607	32.30%	32.30%
	10-14	127	17.14%	17.14%	382	20.33%	20.33%
	15+	106	14.30%	14.30%	269	14.32%	14.32%
Total		741	100.00%	100.00%	1879	100.00%	100.00%

Water heater fuel

		Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
	Electric	246	33.20%	33.47%	596	31.72%	31.92%
	Natural gas	482	65.05%	65.58%	1252	66.63%	67.06%
	Other	7	0.94%	0.95%	19	1.01%	1.02%
	Total	735	99.19%	100.00%	1867	99.36%	100.00%
	No Response	6	0.81%		12	0.64%	
Total		741	100.00%		1879	100.00%	

Water heater age

		Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
	Don't Know	7	0.94%	0.94%	20	1.06%	1.06%
	0-4	291	39.27%	39.27%	704	37.47%	37.47%
	5-9	305	41.16%	41.16%	746	39.70%	39.70%
	10-14	112	15.11%	15.11%	321	17.08%	17.08%
	15+	26	3.51%	3.51%	88	4.68%	4.68%
Total		741	100.00%	100.00%	1879	100.00%	100.00%

Stove fuel

	Kentucky Kits			Kentucky No Kits		
	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
Electric	556	75.03%	75.75%	1437	76.48%	76.76%
Natural gas	165	22.27%	22.48%	410	21.82%	21.90%
Other	13	1.75%	1.77%	25	1.33%	1.34%
Total	734	99.06%	100.00%	1872	99.63%	100.00%
No Response	7	0.94%		7	0.37%	
	741	100.00%		1879	100.00%	

Oven fuel

	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
Electric	513	69.23%	78.20%	1315	69.98%	79.12%
Natural gas	135	18.22%	20.58%	324	17.24%	19.49%
Other	8	1.08%	1.22%	23	1.22%	1.38%
Total	656	88.53%	100.00%	1662	88.45%	100.00%
No Response	85	11.47%		217	11.55%	
Total	741	100.00%		1879	100.00%	

Dryer fuel

	Frequency	Percent	Valid Percent	Frequency	Percent	Valid Percent
Electric	604	81.51%	82.18%	1504	80.04%	80.38%
Natural gas	114	15.38%	15.51%	336	17.88%	17.96%
No clothes dryer	17	2.29%	2.31%	31	1.65%	1.66%
Total	735	99.19%	100.00%	1871	99.57%	100.00%
No Response	6	0.81%		8	0.43%	
Total	741	100.00%		1879	100.00%	

APPENDIX I

Final Report

An Evaluation of the Kentucky Small Commercial and Industrial Incentive Program

Results of a Process and Impact Evaluation

July 16, 2007

Prepared for

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Table of Contents

Executive Summary

About This Report

This report presents the results of a process and impact evaluation of Duke Energy's Small Commercial and Industrial Incentive Program as it operates in Kentucky. This program provides incentives for commercial and industrial electric customers not on rate TT (Time-of-Day Rate for Service at Transmission Voltage) . The incentives can be applied to new buildings or retrofits, and cover lighting, HVAC and Pumps/Motors. This report presents the results from a process and impact evaluation.

The first section provides the results from the process evaluation. The process evaluation employed in-depth interviews with program design, planning and implementation staff, and short interviews with program participants.

The second section provides findings from the impact evaluation efforts. The impact evaluation employed a tracking system review, engineering review of lighting energy savings calculations, and building energy simulation modeling of typical commercial buildings to estimate the HVAC program savings.

Summary of Findings

An overview of the key findings identified through this evaluation is presented in this section.

Significant Process Evaluation Findings

Program Technologies

The equipment incentivized under the Kentucky C&I Program are selected by a panel of industry experts and reviewed regularly. This practice ensures that the most efficient technologies are covered and incentivized by the program.

Changes in technologies and incentives will bring on customer dissatisfaction, but are necessary as the technologies in the market become more efficient. When the technologies being offered are updated and certain equipment is no longer incentivized, there should be two to three month window for those technologies to remain on the list and be incentivized for those that provide receipts showing that the purchase was made before the equipment was removed from the program.

The Incentives

The incentives are altered according to the suggestions of the industry expert panel and are subject to change, resulting in some participant dissatisfaction when they change. However, this condition cannot be avoided. The incentives are not to exceed 50 percent of the incremental price of the energy efficient equipment. As a result, when changes to the incremental efficiency costs are observed, changes are required in the incentives accordingly.

The participants are generally happy with the level of the incentives, however some participants believe it takes too long for the incentives to be processed. At the current size of the program this is not a substantial problem, however, this issue should be addressed by the program's management. Incentives should be paid quickly to support strong participant satisfaction and encourage participation. If the program expands to serve more customers, it is recommended that additional efforts be implemented to reduce incentive payment durations. Participants report that incentives take from 4 to 8 weeks to obtain, so we recommend changes to the processing process be incorporated into the process to allow payments within two weeks of the receipt of the appropriate applications for non-inspected participants and 4 weeks for inspected participants. We understand that changes to the rebate process are underway. An outside contractor has been hired and beginning March 1, 2007, all checks should be delivered to the customers within 2-3 weeks provided that the applications are accurate and complete.

Program Satisfaction

The participants are satisfied with the program overall, and think it is a great program that provides an extra push to help customers make an energy efficient choice.

Significant Impact Findings

Energy and demand savings from this evaluation exceeded the tracking system estimates and the program planning estimates used by Duke Energy by a significant margin. The differences are due to a combination of data entry errors within the tracking system and differences in the methods used to estimate savings. The gross energy and demand savings estimated by this evaluation are summarized in Table 1 and Table 2 below:

Table 1. Lighting Program Gross Energy and Demand Savings

Savings Basis	Source	kW	kWh
Savings/measure	Planning Estimate		130
	Tracking System	0.12	56
	Evaluation Estimate	0.11	365
Savings/participant	Tracking System	28.5	13,186
	Evaluation Estimate	26.1	86,743

Table 2. HVAC Program Gross Energy and Demand Savings

Savings Basis	Source	kW	kWh
Savings/measure	Planning Estimate		130
	Tracking System	0.16	443
	Evaluation Estimate	0.69	763
Savings/participant	Tracking System	1.3	3,673
	Evaluation Estimate	5.7	6,336

The impact analysis was confounded by several factors that could be improved in the future:

1. **Uncertainty in lighting measure baseline**. The tracking system contained information on lighting fixtures installed, but no data were available on the type of lighting fixtures removed. We made assumptions on the type of fixture removed based on a review of the program engineering documentation. Recording the number and type of fixtures removed within the tracking system will remove this uncertainty. We understand that this information is not always readily available or reliable, but applying some effort in this regard should improve the overall impact estimates in the future.
2. **Ambiguity in measure descriptions**. The lighting measure descriptions in the tracking system for T-8 fluorescent lamps were somewhat ambiguous. Although the lamp type, length and number of lamps per fixture were recorded, the lamp watts were not. Several styles of T-8 lamps with varying input watts are available, and adding a lamp wattage description will better define the specific type of the installed measure.
3. **Lack of building type information.** Lighting and HVAC measure savings calculations rely on an understanding of the building type. We were able to identify the building type from the customer name in most cases, but an additional field indicating the building type or customer SIC or NAICS code would be helpful in making this determination in the future.

Introduction

This report presents the results of a process and impact evaluation of the Small Commercial and Industrial Incentive Program as it is provided in Kentucky. To conduct the process evaluation we interviewed program managers and program participants. To conduct the impact evaluation, we relied on an engineering analysis of information provided in the program tracking system.

Program Description

Duke Energy encourages its business customers to increase the energy efficiency of their facilities through their Commercial and Industrial Energy Efficiency Rebate Program. The equipment rebates provided through this program are available to Duke Energy's Kentucky commercial and industrial customers who are not in rate group TT (Time-of-Day Rate for Service at Transmission Voltage). Eligible products include lighting, HVAC and Motors/Pumps. The energy efficient equipment can be installed in new or existing facilities, however some of the lighting product rebates apply only to retrofit applications (this change to retrofit only application was made on 4/15/06). Customers may, depending on the size of the project, install the equipment themselves, however, those installations have to be inspected by Duke Energy before the rebate is awarded.

Evaluation Methodology

The study methodology consists of the following general parts:

1. A process evaluation in which TecMarket Works surveyed 15 participants from a pool of available Kentucky customers, and an in-depth interview with the program manager.
2. An impact analysis that combined a review of the program tracking system, engineering review of lighting program savings estimates, and building energy simulations of typical buildings to estimate HVAC program savings.

Process Evaluation

The process evaluation included a telephone interview with the Duke Energy program manager and interviews with program participants. The management interview focused on the design, planning, and implementation of the program and a review of the program's goals and objectives. This interview was conducted with Connie Rhodes, Duke's Small Commercial and Industrial Program Manager. Interviews were also conducted with participants, these interviews focused on their participation experiences, satisfaction with the program, the operations of the program and other subjects presented in this report.

The interviews were conducted in January 2007. Both sets of interviews followed formal evaluation interview protocols. These protocols are provided in Appendix A and B of this report and allow the reader to examine the range and scope of the questions addressed during the interviews.

Ninety-six participant interviews were conducted with both Indiana (81) and Kentucky (N=15) participants. The low number of interviews with Kentucky participants is because of the small number of participants in that program, consistent with the current level of the budgeted offerings in that region. The Indiana interviews are discussed in this report in order to compare the two programs and to provide information on programs that are operated with a similar approach. While the two programs are not identical, the differences are minor from a process evaluation perspective. The participants interviewed were randomly selected from the following location/technology groups: Kentucky-HVAC, Kentucky-Lighting, Indiana-Lighting, Indiana-HVAC, and Indiana-Motors. Table 3 below presents the number of participants in each of the five groups, and indicates the number that were randomly targeted from each group. Due to the low numbers of customers in HVAC and Motors, we were unable to obtain the number of interviews planned due to refusals, closed businesses, and personnel changes.

Table 3. Interviewed Participants in the Small C&I Incentive Program

Program	Number of Participants	Target: Number of Interviews, n=100	Conducted: Number of Interviews, n=96
Indiana HVAC	61	15	11
Indiana Lighting	260	61	68
Indiana Motors	7	5	2
Kentucky HVAC	10	8	4
Kentucky Lighting	46	11	11

Energy Impact Evaluation

The impact evaluation used an engineering-based approach to estimate program savings. Separate impact analyses were conducted for the lighting and HVAC components of the program. The evaluation effort consisted of the following steps:

1. Review of program savings estimates developed by Balance Engineering
2. Review of program participation data
3. Review of secondary research relevant to the measures covered under the program
4. Development of building energy simulation models of typical buildings treated under the program
5. Development of revised engineering estimates for lighting and HVAC measures

Engineering review of the lighting program savings involved review of lamp wattage, light output and lamp life assumptions against manufacturers' catalog data. The assumptions regarding the equivalencies between the assumed baseline and efficient lighting fixtures were reviewed. Lighting design and measure applications issues identified during the data review were highlighted. Operating hour assumptions embedded in the program estimates were identified for later comparison to data gleaned from the secondary research review. Engineering review of the HVAC program savings involved a review of the measure baseline efficiency assumptions and measure energy savings calculation methodology. These data were compared to program savings calculations used in other programs in other states through a secondary research review.

The secondary research review focused on program design "workpapers" and other research conducted in support of program design efforts elsewhere in the country. The review incorporated research conducted in support of the California Database for Energy Efficiency Resources (DEER), the Pacific Gas and Electric Company (PG&E) commercial mass markets program, the Southern California Edison Company (SCE) workpapers for their commercial retrofit programs, and the Efficiency Vermont technical reference manual[1]. The research review collected information on lighting system operating hours and coincidence factors by lamp and building type, HVAC baseline efficiency assumptions, and HVAC system equivalent full-load hour data. These data were used to test the assumptions used in the Duke program, as well as to develop data resources for conducting the impact study.

The tracking system review was used to identify the measures and building types covered under the program, thus focusing the scope of the engineering analysis. Tracking system savings estimates were also compared to the program assumptions to identify potential problems with tracking system data entry or data processing algorithms.

The secondary research revealed a lack of sufficient data for estimating HVAC measure impacts with the level of rigor that we would like, therefore detailed impacts were established by using a set of prototypical building models were developed using the DOE-2.2 building energy simulation program. Prototype models were developed for small retail, small office and full service restaurant, covering the building types represented by the HVAC program participants. The prototypes are based on the models used in the California DEER study, with appropriate modifications to adapt these models to local design practices and climate. Energy savings estimates were developed from the prototype models and applied to the HVAC program tracking system to estimate program savings.

The databases received from Duke Energy contained participants from January 2005 through October 2006. Since the program period ended in December 2006, the analysis is based on most but not all of the program participants. Thus, the results are normalized per participant and per measure installed. These results will be applied by Duke Energy to the final participant database to estimate the final program savings.

[1] Efficiency Vermont Technical Reference Manual, Master Manual #4. Measure Savings Algorithms and Cost Assumptions, January, 2003.

Section I: Process Interview Results

A total of ninety-six interviews were conducted with participants of the Small C&I Incentive Program, 15 of which were Kentucky customers. All of the interviewees took part in one or more program offerings. At the time of the evaluation, there was a small sample of Kentucky customers that had completed the full participation process for TecMarket Works to interview.

There are suggestions for improvement for the program discussed in this report, however, the program is meeting its objectives as it is currently operated. In summary, some participants would like to have energy audits made available through the program, or have more program-related contact with their vendors when program offerings are changed or when new technologies are added to the program. The program seems to be experiencing a slow but steady increase in participation. This may be due to marketing and participant networking, to higher energy costs increasing interests in the program, to the falling price of energy efficient technologies relative to the program incentive levels, or a combination of these reasons. The participant population, at this time, is too small to be able to define the exact cause of the increased interest. However, the program managers have noticed the increase. This increase has led to the program being able to process the program's budget allocations to participants. Additional participation will require additional program budgets.

Awareness and Understanding of the Program

All of the Kentucky customers contacted remembered participating in the program. Most of the customers found out about the Program through a brochure mailed by Duke (40%), or from their contractor (33%). Other sources were Duke's web site and word of mouth. Table 4 below presents the responses.

Table 4. Awareness of the Kentucky Small C&I Program

	Number	Percent
Remember Participating	15	100%
How Participants Discovered Program		
Duke brochure	6	40%
Contractor	5	33%
Duke web site	1	7%
Owner of business told me	1	7%
Owner of another business told me	1	7%
Don't recall	1	7%

Over half (60%) of the customers were able to make a participation decision based on the information they received when they first learned about the program, while the other 40 percent had to obtain further information about the program in order to decide to participate. Of the customers that had to find more information, five of them (83%) were able to have their questions answered by visiting the program web site, calling their contractor, or calling Duke Energy. One customer with further questions went to the web site to find more information about the program, but found the information there was too vague and confusing for a "lay person", yet decided to participate without a complete understanding of the program. The other customer with additional unanswered questions could not recall what the specific issue was.

Table 5. Understanding of the Kentucky Small C&I Program

	Number	Percent
The Program Information was Adequate	9	60%
Not adequate: went to web site	3	20%
Not adequate: called contractor	2	13%
Not adequate: called Duke	1	7%
Did you have Questions About the Program that were not Answered?		
Yes	2	13%
No	13	87%

Program Paperwork

The participants themselves filled out the application forms 60 percent of the time, while the others were filled out by their contractors. However, the participants were more likely to submit the forms (73%). All the participants indicated that the program's forms were easy to understand. This finding indicates that at this time, there does not seem to be an issue with the complexity or structure of the participation forms that acts as a barrier to participant understanding of the form's requirements.

Table 6. Participants' Reaction to the Small C&I Program Paperwork

	Number	Percent
Who Filled Out the Forms?		
Participant	9	60%
Contractor	6	40%
Who Submitted the Forms?		
Participant	11	73%
Contractor	4	27%
Were the Forms Easy to Understand?		
Yes	15	100%
No	0	0%

While a participant may understand a form, that does not mean that they are satisfied with its structure, function and use. To help get at satisfaction we asked participants about their satisfaction with the forms. Of the 15 participants interviewed 13 were able to address this question. These participants rated their satisfaction with the forms on a 1 to 10 scale, with 1 meaning very dissatisfied and 10 meaning very satisfied. The mean score from this question is 7.15 indicating acceptance, but some level of dissatisfaction among the participants. The median satisfaction score was 8. Satisfaction scores for this and other aspects of the Kentucky program are covered later in this report.

Program Incentives

We asked the participants about the program's incentives. First, we asked if participants had any problems receiving the incentive. Only three of the 15 (20%) indicated that they had problems. When we asked the participants to explain the problem, the following explanations were provided:

- Our two incentive checks were sent to our old address, one was returned to Duke, but they are now waiting for the second check to be returned before re-processing.
- Duke lost our paperwork.
- We did the remodeling in mid-2005 and put the new equipment in service in 2006. When filling out the application I put 2006 as our date of installation, however, the efficiency level changed in that period and I was no longer eligible to receive the incentive. If I would have put 2005 as the year on the installation I would have received the incentive.

Program Participation

Reasons for Participating

We asked the participants what their primary reason was for their participation decision. Thirty-three percent of the participants indicated that the primary reason for purchasing or upgrading their equipment was for the energy savings. Another 33 percent said the reason for the purchase was because of a remodeling project. Twenty-five percent of the participants indicated that the main reason for the purchase was because it was recommended by their contractor. The other reasons provided relate in one way or another to the project. These responses are presented in Figure 1 below.

We then asked the participants how important the incentive was in the decision to purchase a more energy efficient model. We asked if it was the primary reason, an important reason, one of the reasons but not the most important, one of the reasons but a minor one, or not a reason at all. Forty percent indicated that it was an important reason, and 33 percent indicated that it wasn't a reason at all.

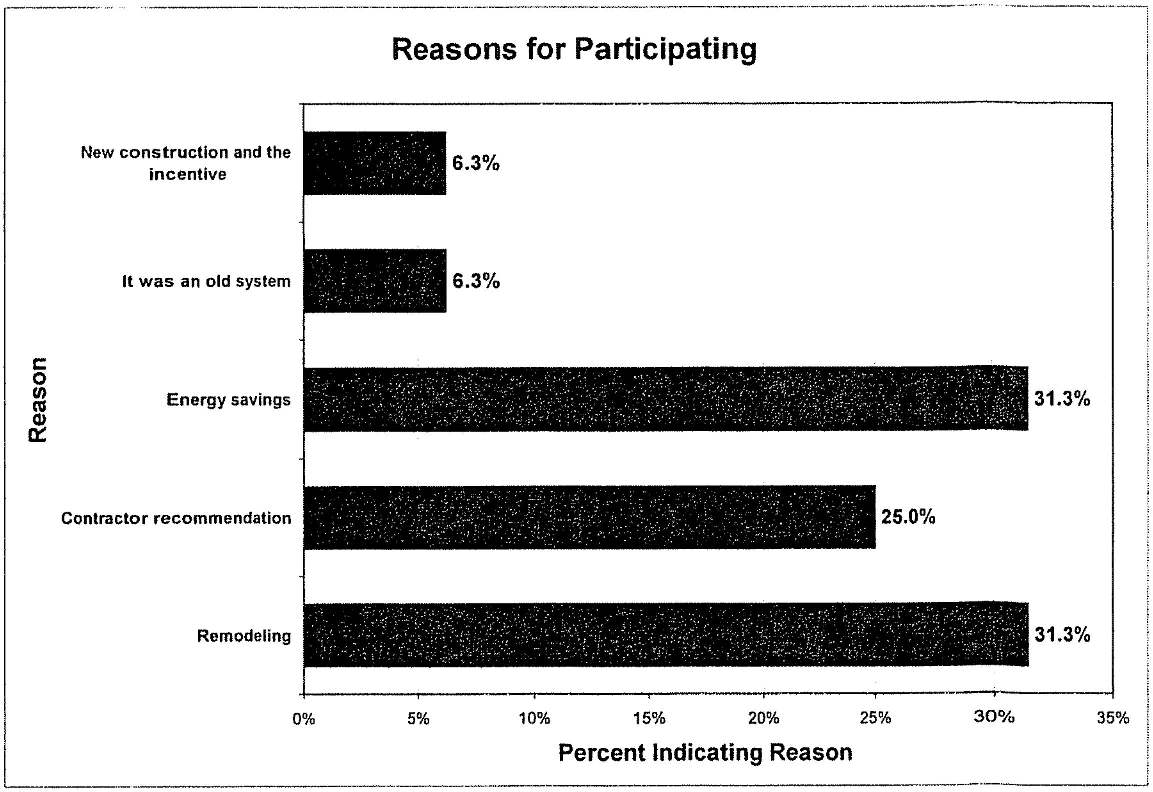

Figure 1. Reasons for Participation

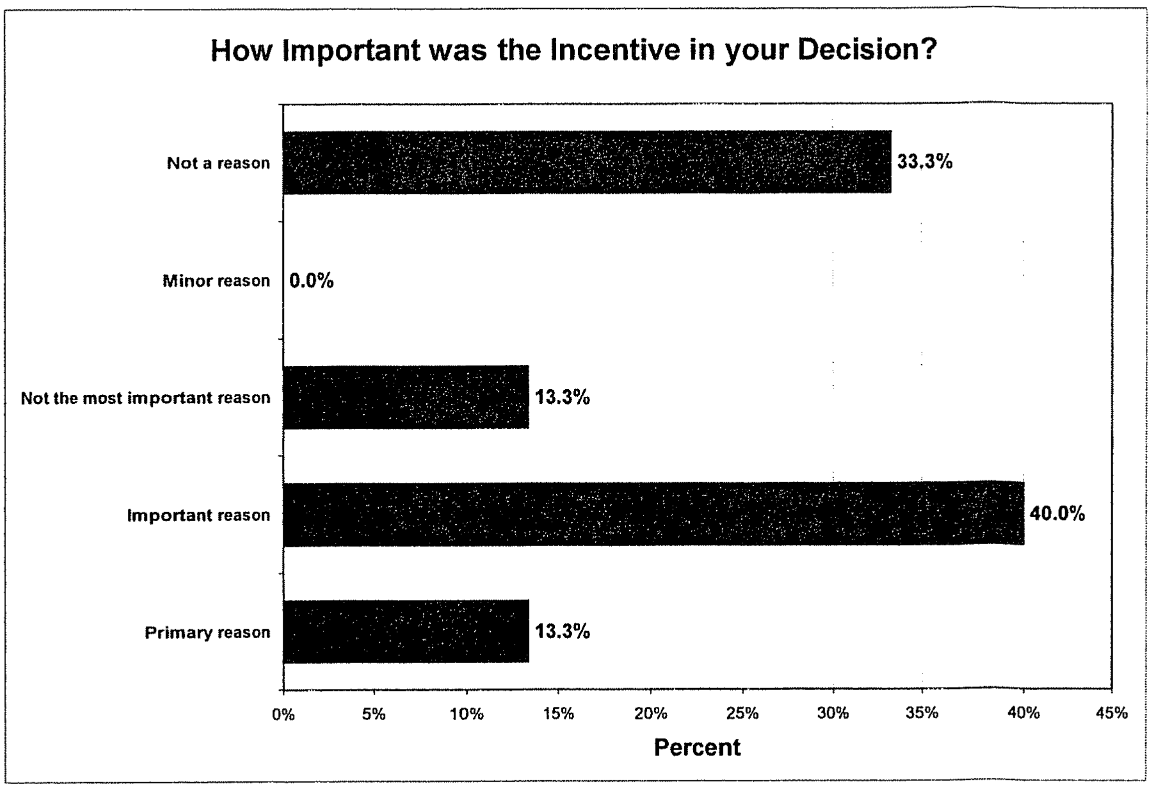

Figure 2. Importance of Incentive in Decision

Other reasons given for the participants deciding to go with the more energy efficient options include:

- Had to fit existing space, and this option fit
- Energy efficient model is cheaper to run
- EPACT credit
- Improved lighting quality
- It makes sense to go as efficient as feasible on new projects
- The lights put out the lumens we wanted, and were high quality
- It was recommended by our contractor

Other Actions (Spillover)

We asked the participants if they had taken any other energy efficiency actions as a result of their experiences with the program. Twenty percent indicated that they had taken other steps towards more energy efficient operations that were in some way influenced by their participation. These included:

- Chalking, sealing and weatherstripping
- replacing lights with energy efficient bulbs
- putting in skylights
- working with other programs, such as KEEPS

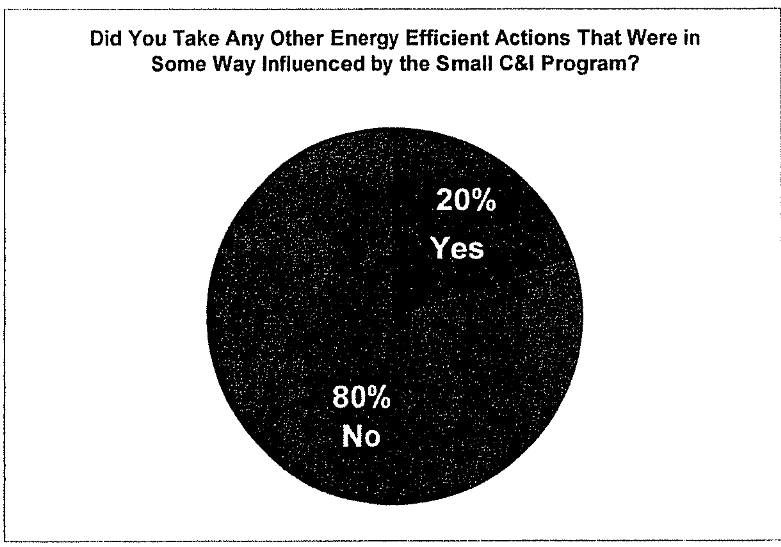

Figure 3. Participants Taking Other Energy Efficiency Actions

Freeridership

Participants were asked a series of questions about why they participated, their intentions before discovering the program, what they would have done if the program were not offered, etc. These and other questions in this section determine the levels of free-ridership with the Kentucky program.

We asked the participants the following question: "*Did you originally plan on purchasing the exact same efficiency level in the equipment you purchased before you knew that there was an incentive offered by Duke Energy*?" The responses to this question indicate that the program is not the motivating factor for these participants to make an energy efficient choice. Most (67%) of the participants said that they had already planned on purchasing the exact same efficiency level before they knew about the program. While we are not suggesting that the freerider rate is 67 percent, (as discussed in the impact section of this report) this strongly suggests that there is a need to focus attention on ways to reduce the level of freeridership. See Figure 4 below.

The next question asked: "*In your decision process, did you search for or consider other less energy efficient equipment that might have cost less*?". The responses to this question confirmed the responses of the previous question, as 73 percent did not consider less energy efficient equipment, indicating that a significant majority of the participants had intended to buy the energy efficient models regardless of the program's objectives (see Figure 5 below).

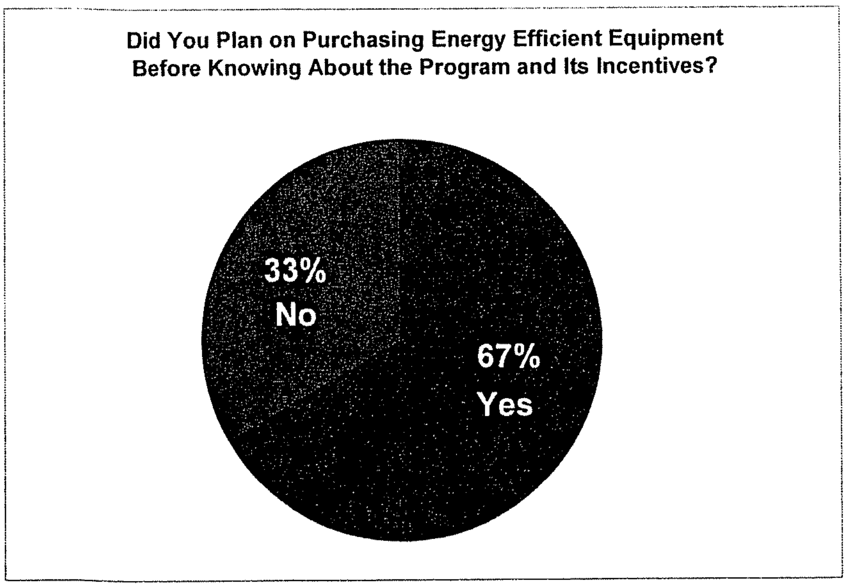

Figure 4. Intended Efficiency Levels Before the Program

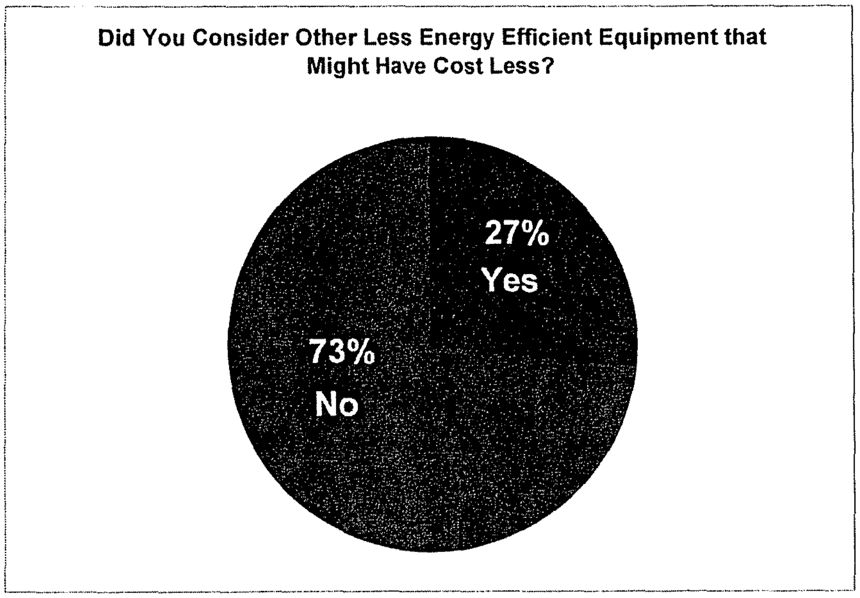

Figure 5. Participants Searching for Less Energy Efficient Options

We also asked the participants if they would have delayed their purchase if the incentives offered through the program would not have been available. The responses to this question reduce the level of free-ridership slightly, because half (47%) said that the project would have been delayed if the incentive was unavailable, meaning that the incentive pushed several participants forward with their energy efficient project. Likewise, some of the participants indicated that they would have never implemented their project without the incentive, or that it would have been delayed indefinitely. The length of delay varied from less than one year to indefinitely (see Figure 6 and Table 7 below).

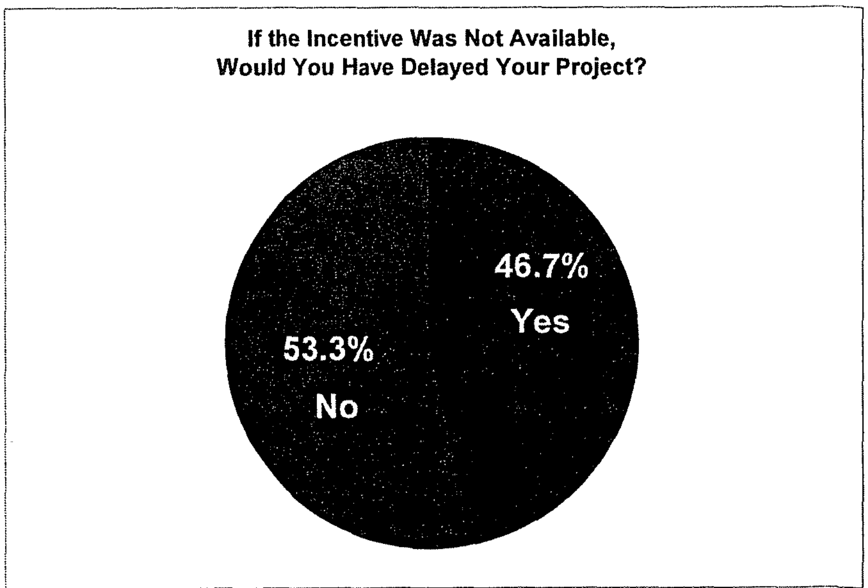

Figure 6. Effects of Incentive on Timing of Project

Table 7. Length of Delay of Project if Incentive Was Not Available

n=	Length of Delay
1	Less than a year
1	1-2 year
2	Don't Know
2	Indefinitely
1	Wouldn't Have Done Project

Calculation of Freeridership

Because the sampling frame within Kentucky alone was not large enough to calculate freerider levels exclusively for Kentucky programs as a stand alone program, we combined the freerider question results from the Kentucky participants with the participants from the Indiana Small Commercial Program evaluation. The Kentucky and Indiana programs are operated in the same way, using the same technologies and rebate levels, and are managed by the same program staff. Together, the two evaluations provided 85 participants who were able to answer the freerider questions to support the analysis.

In calculating freeridership levels we used a per-participant calculation of the influence of the program on their decision to make the change, on the role the incentive played in the decision to go to the high efficiency model, and the amount of delay that would have occurred to the upgrade without the incentive. We informed this analysis by the responses to the questions on whether or not the participant searched or considered equipment of lower efficiency and the reason for upgrading to the high efficiency equipment. As in all freerider analysis this process requires the application of professional judgment because typically from 20 to 40 percent of the participants give responses that are not consistently logical. For example, customers will say that they that they originally planned on buying the same level of efficiency, and then respond that the incentive was important to their decision to go to the energy efficient model. In cases where the responses appear contradictory we gave a partial credit to the program for helping to speed the project forward when the incentive was important in that timing. For these reasons the approach for estimating freeridership is controversial within the evaluation community, with many top-of-the-field evaluation professionals agreeing that it is an inexact and problematic science. However, the use of a partial credit is a standard practice in the freerider estimation process and is used in all evaluation approaches.

Using this approach we provided the following credits based on the responses received:

Type of participant	Credit provided to the program for driving the energy efficient decision	Number of respondents in group
Before hearing about the program did not originally plan on going with the energy efficient equipment and the rebate was a reason for the decision.	100	33
Had originally planned on the same efficiency level, but the rebate was a reason and the project would have been delayed without it	75	9
Not sure if they considered the same equipment at first, but the rebate was a reason for going forward with the project with or without a delay	75	8
Did not originally plan on the energy efficient equipment before hearing about the program incentive, but said the incentive had no effect on their final decision	50	2
Had originally planned on going with the same equipment, but said the incentive was a reason for the choice, but did not speed the project forward	25	15
Planned on the same equipment, the incentive had no effect, did not speed the project.	0	29
Calculated freerider level	Average .50	N=85

Using the distributions presented above, the average freerider rate for this program is 0.50. This means that it is estimated that somewhat less than half of the energy saved would have been saved even if the program had not provided the incentives to the participants. While the field of evaluation has no reliable approach for estimating freeridership, our professional judgment suggests that the rate for this program is in the .4 to .6 range and can be assumed to be from 45 to 55 percent as currently implemented. Within the field of evaluation, freerider rates for these types of programs range from a low of 25 to 30 percent for programs with enrollment screeners that refuse participation to customers who say they are going to take the same actions, to a high of 60 to 65 percent for programs that allow open enrollment. Duke's program holds a position about mid-point in the range of expected values. However this rate indicates that there is a need to educate both customers and equipment contractors and trade allies that the program's incentives are to be provided only to the customers that will not take the energy efficient choice without the incentive.

We also point out that the above freerider estimate is not adjusted to account for spillover. As with most purchase decisions, the decisions that are considered to be successful or correctly made are often repeated by the same decision makers. For example, if a participant has two facilities and takes the action because of the program in one of the facilities, that same individual is likely to take the same action in the second facility with or without the program. Thus, program spillover, or the replications of actions taken via the program, often offset the freerider rate and act to increase the net energy impacts associated with a program. When we asked participants what additional actions they took at their facilities because of the information provided by the program, about 35 percent of the respondents indicated that they took one or more actions (see Other Actions – Spillover section of this report). While the calculation of the savings from the other program-influenced actions is beyond the scope of this study, these actions act to increase the savings from the program. As a result, while the freerider rate for this program is estimated at 0.47, the net rate, once the freerider rate is adjusted for spillover, appears to be in the .20 to .30 range. Again, this estimate is beyond the scope of this study.

Contact with Duke Energy

Almost half of the participants had to contact Duke at some point during their participation experience. Of the participants that contacted Duke for program information or clarification, 43 percent did not think their questions or needs were handled effectively by Duke Energy. However, a review of the comments indicate that the problem may not rest in the communication approach, but with the processes used for processing rebates. Never-the-less, this data indicates that it may be necessary to monitor the communications between Duke and the program participant to determine if there is a communication issue that needs to be addressed. Because of the small sample size and the nature of the comments, these data should not be considered conclusive of an issue that needs to be resolved, yet when 43 percent of interviewees indicate that they do not think Duke handled their issues effectively there is cause for concern over why these were not handled effectively.

Often times vendors would call in and ask for exceptions to be made to the rules for different measures (different configurations, different technologies) and they would get very frustrated with managers when they were told that this is a prescriptive, not a customized program. There was a lot of frustration with the "first come- first served" but program managers have since implemented a "reservation" process driven by the number of applications we received and the amount of the incentives.

	Number	Percent
Participant Contacted Duke		
Yes	7	47%
No	8	53%
Were your Questions Effectively Handled?		
Yes	4	57%

No	3	43%

The reasons for their dissatisfaction with the responses are:

- Duke answered my questions with vague responses
- The incentive should be sent within a month, takes too long now
- Still waiting for my incentive check, takes too long, it's a mess
- It would be better if the incentive check was sent within 2 months, it takes too long
- Duke needs to fully explain the reasons for changes in efficiency levels

Increasing Participation

We asked the participants for ways in which Duke Energy could increase interest and participation in the program. The most popular response received centered around a suggestion to increase the incentive levels. Thirty-nine percent of the participants provided this response. Fifteen percent had other suggestions including:

- Provide energy audits through the program
- Eliminate $50,000 cap so you get bigger projects
- Provide potential customers with objective case studies to support claims
- Decrease the amount of paperwork involved, speed up the process, takes too long

The program manager interviewed in this study suggested that increasing the marketing efforts would result in an increase the levels of participation. This is something that should be assessed to identify cost effective ways to market the program. For example, other programs use bill inserts to their commercial customers, presentations and discussions with trade ally groups, presentations and discussions with contractors and business partners, advertising or public service announcements in trade journals, case stories in business publications, journals, industry newsletters, industry awards ceremonies, etc. etc. Duke should explore these potential avenues to see which marketing efforts are cost effective and can be developed within the programs management and marketing budgets.

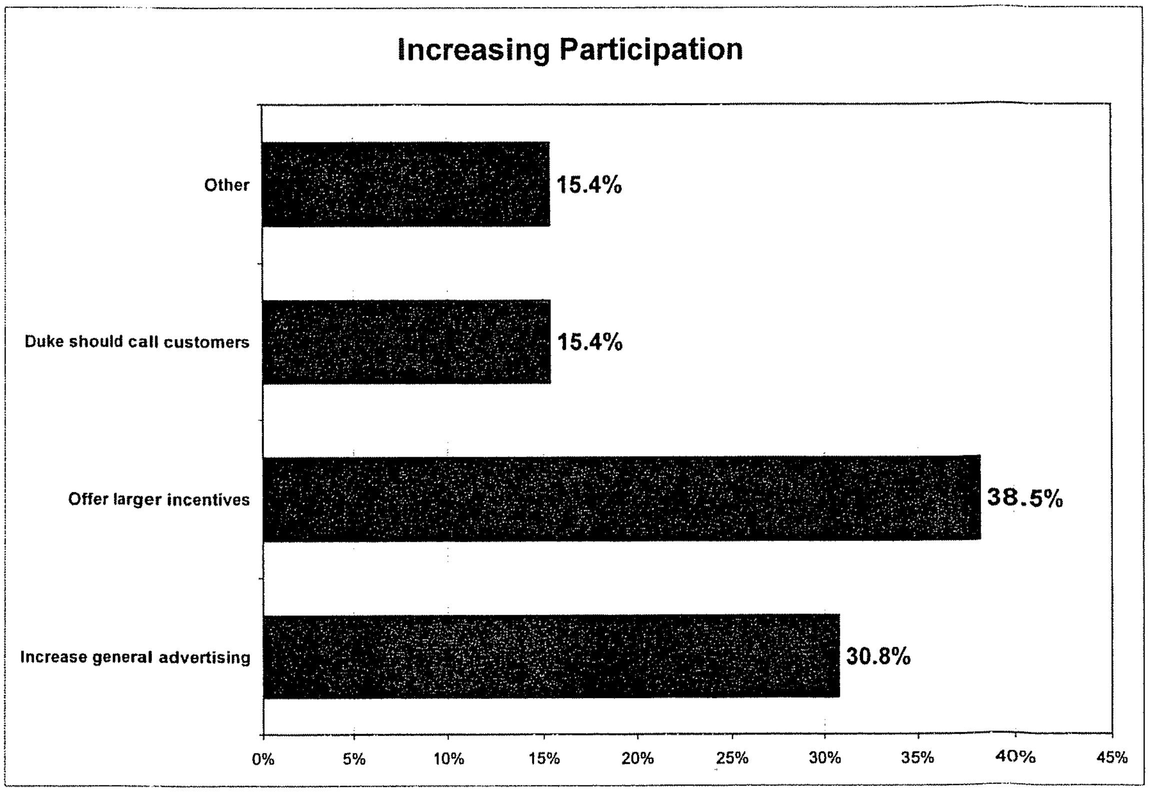

Figure 7. Suggestions for Increasing Participation

Program Satisfaction

We asked the participants about their satisfaction with various program components. We asked them to rate their satisfaction on a 10-point scale with 1 meaning they were very dissatisfied and 10 meaning they were very satisfied. If a participant scored any of the aspects with a score of 8 or lower, we asked the participant how that aspect could be improved. The program overall received an average score of 7.42 and a median score of 8. This indicates that the program has some areas in which at least half the participants are, to some degree, dissatisfied with some component of the program. Dissatisfaction with a program impacts the level of support that participants can provide to the program. This in-turn impacts the most effective information dissemination method by which word of the program spreads in a market – peer-networking. If 50 percent of the participants in some way are dissatisfied with a program, that program cannot be expected to ever have strong demand. Each of the program aspects that contractors voices some level of dissatisfaction with are discussed below. The contractor's satisfaction scores are provided in Figure 8.

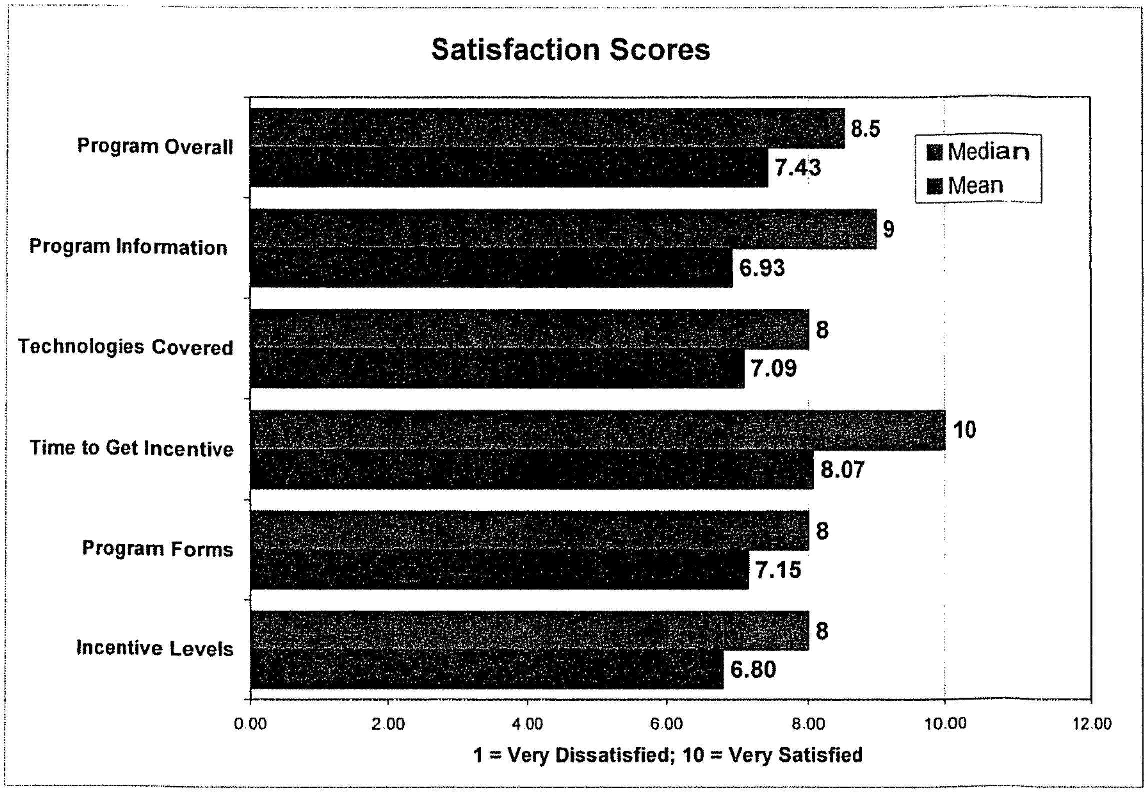

Figure 8. Program Satisfaction Scores

Incentive Levels

The incentive levels are set by a panel of industry experts and are limited to rebate no more than 50 percent of the incremental equipment cost difference between the standard efficiency model and the high efficiency model. This differential is set by policy. When prices change, the advisors review the typical equipment cost and the appropriate changes to the incentives are made so that the 50 percent level is maintained.

The median satisfaction score for the incentive levels is 8, meaning that half of the respondents scored their satisfaction with the incentive levels at 8 or above and the other half scored less than eight. However, the mean score for the incentive levels is 6.80. This data means that while most participants scored the incentive level higher, a few were significantly dissatisfied with the incentive to provide a significantly lower score. This somewhat low mean-score can be explained by the participants' comments on how to improve satisfaction with the incentive amount. These comments are:

- remove the $50,000 incentive cap so more energy can be saved
- the incentive was cut in half from the time we viewed the web site [and decided to participate] and the time we talked to someone [about the rebate amount]
- the incentives decreased to covering 25 percent of added cost [rather than 50 percent]
- they [incentives] were cut in the middle of the project
- too much program hassle for the amount of money we received

- too much time to participate and too little incentive
- my installation no longer qualified because it was installed in 2005, but instead started in 2006 [even thought our participation decision was made in 2005]. The program changed in the middle of our process

While a few participants indicated that the incentive levels are too low compared to the effort it takes to be a participant, others participants stated that they were dissatisfied because of the changes that took place during the time of their participation (see above comments).

Program Forms

Satisfaction with the program forms received a median score of 8, and a mean score of 7.14. These scores indicate that while the forms were not an issue for most of the participants, for a few the forms presented challenges. The reasons given for the scores 8 or lower are below.

- some of it was confusing to me, had to ask the electrician to get some of the answers
- they are not written for the lay person to understand
- more explanations are needed for the technologies covered and the participation and incentive requirements
- I had to resend the forms, the first copies I sent were lost by Duke

Time to Get Incentive

Over half (53%) of the participants gave the time it took to receive the incentive check from the time they submitted with the forms with a 10, indicating very strong satisfaction with the time to get paid. The mean score provided by the participants is 8.07, also a good score. However, the distance between the 10 score and the mean score is almost a full two points, indicating that there is some significant level of dissatisfaction with a subset of the participants. Those that gave a score of 8 or lower provided the following comments:

- it should only take 2-3 weeks to get the check
- they need to send us the incentive within a month
- I am still waiting for the payment, it's a mess
- Payment in less than 2 months would be better

While most customers are very satisfied with the payment periods, the frequency of these comments in relationship to the small sample size suggests that there is a need to monitor these periods to determine if there is a process issue. The small sample size of this study precludes definitive conclusions, but the fact that there are a several participants who are not receiving payments in what they consider to be a reasonable period suggest that attention be placed into determining if there is a process issue and if so, how it can be solved.

Technologies Covered

The technologies covered by the program are determined by a panel of industry experts, and the participants seem satisfied with the options available. The changes in technologies that are rebated are needed in order to keep the participants moving towards increasing efficiency. However, given the current estimate of 50 percent free ridership, it is likely that the number and/or type of appliances and equipment incented should be reviewed and updated once more.

Participants scored their satisfaction with the technologies covered by the program with a mean score of 7.09 and a median score of 8. These are reasonable technology satisfaction scores. It is not unusual to find some level of dissatisfaction with the technologies or with the program's conditions relating to the technologies. However, one of the responses is more about the efficiency level change than the technology itself. Two of the low scores were provided by participants who felt that their equipment should have been covered by the program, and in one case, the exact model and efficiency was covered in 2005 when she purchased it, but not covered when she installed it. This goes back to the issue of timing, which is discussed earlier in this report. While this participant is not talking about changes in the incentive level, but rather the dropping of a covered technology from a decision that was made when the technology was covered. These conditions damage the reputation of the programs if they are not well structured with plenty of advanced notice provided to match the business decision cycle. Other comments received included:

- include more lights - some were the same fixtures but not included (T8 was limited to 6 bulbs, they needed 8-bulb)

Program Information

The level of satisfaction with the program information provided received a low mean satisfaction score of 6.93, however, this aspect also received a high median score of 9, again indicating that most participants were very satisfied and a few participants were not satisfied. Comments received include:

- keep the web site's program language simple
- materials are too complicated for the general public

What Works

The program's web site is a good tool that allows customers to see what technologies are covered by the program and identify the incentives levels at the time the examination is made. The web site has the most up-to-date information available on the program and is the least expensive method of providing the information to a large number of customers. As a result, the program should continue to encourage customers to visit the site to learn more about the program and current program offerings. Expanded use of the web site can help eliminate the problem of incentive and technology changes. That is, the web site can be structured to post the changes months before they become active. At the same time the program promotional materials should instruct customers to check the web site for the most up-to-date information on what technologies are covered and the incentive levels.

Another effective promotional approach rests in the technology vendors and contractors that can tell their customers about the program. If the vendors and contractors are kept current on program operations they can pass the information on to their customers. Vendors and contractors need to be encouraged to check the web site for current information when they deal with their customers. To help ensure that the vendors are keeping up with the program's operations and changes, they are required to apply to Duke to be listed as a program vendor every 18 months and become exposed to the program's current information. They are also encouraged to help the customers with the applications to help reduce application error rates. This information, provided by the program manager, linked to the participant comments may indicate that the application forms may need to be adjusted to help the "typical" customer deal with the application process. Discussions with the program manager indicate that vendors and contractors are able to provide more accurate application forms because they are used to dealing with the equipment and are more familiar with the application terminology.

We asked the participants to tell us what they thought worked well, and provided them an opportunity to say what they liked most about the program. Their responses are listed below:

- it's an effective tool for helping to install more costly equipment that will save businesses money in the long run (3 responses)
- the program helps shorten the payback period (2 responses)
- the program provides an extra push to make the right choice, it gave us confidence that it would work and save us money
- it provided us with a financial incentive in exchange for Duke getting energy savings
- gave us another incentive to save energy (3 responses)
- gives us money-back on our upgrades

What Doesn't Work

We also asked the participants what they thought did not work well. We received about half as many responses to this question than to the question of what worked well. The following responses were provided by participants:

- the incentive cap is too low (2 responses)
- [not] getting the incentive check as promised by Duke
- not enough people know about the program
- nobody would give me accurate incentive information, I spent 5 hours of my time to get a $34 incentive check
- the decrease in the incentives did not help

- too much paperwork required from us

We also asked the program manager what changes are needed to the program operations and management. The managers noted that the program is working reasonably well for the available resources and staff time. The manager noted that the program was managed and staffed by two people and that the staffing was recently reduced to a single individual, however, a subcontractor has been hired to assist Duke Energy with the program.

Section II: Energy Impact Analysis and Findings

Overview of Impact Evaluation Approach

The impact evaluation used an engineering-based approach to estimate program savings. Separate impact analyses were conducted for the lighting and HVAC components of the program. The evaluation effort consisted of the following steps:

1. Review of program savings estimates developed by Balance Engineering
2. Review of program participation data
3. Review of secondary research relevant to the measures covered under the program
4. Development of building energy simulation models of typical buildings treated under the program
5. Development of revised engineering estimates for lighting and HVAC measures

Program Savings Calculation Review

Measure savings estimates used by Duke Energy for program planning purposes were developed by Cascade Engineering. Savings estimates were developed for the following lighting and HVAC measures:

- **Compact Fluorescent Lamps (CFL).** This measure category covers replacement of incandescent lamps with screw-in compact fluorescent lamps in standard incandescent fixtures and installation of compact fluorescent fixtures utilizing compact fluorescent lamps with integral ballasts. Energy savings estimates were developed for eight different CFL sizes ranging from 5 watts to 42 watts.

- **Linear fluorescent lamps (T-5 and T-8).** This measure category covers replacement of fixtures with T-12 lamps and magnetic ballasts with efficient fixtures utilizing T-5 lamps or T-8 lamps and electronic ballasts. The T-5 measure category contains 14 specific measures developed from combinations of 2, 3 and 4 lamp fixtures with 4 foot normal light output and high output (HO) lamps. The T-8 measure category contains 28 specific measures developed from combinations of 2, 3 and 4 lamp fixtures with 2, 4 and 8 foot normal and HO lamps.

- **Light tubes.** This measure category addresses installation of light tubes (also know as daylight pipes or tubular skylights). These devices capture natural light through a dome-shaped skylight on the roof and channel it down through an internal reflective system to the building interior. At the ceiling level, a diffuser resembling a recessed lighting fixture spreads the light evenly to the designated space. During daylight hours a photocell or control system shuts off a conventional 400-watt probe-start metal halide fixture in response to the availability of natural light.

- **High Bay Fluorescent and Pulse Start HIDs.** This measure category covers the use of high bay fluorescent and pulse-start metal halide fixtures as a replacement for 400-

watt probe-start metal halide fixtures. Four specific measures are covered: a 4 lamp high output T-5 fixture, a 6 lamp normal light output T-8 fixture, an 8 lamp compact fluorescent fixture with 42 watt CFLs, and a 320 watt pulse-start metal halide fixture.

- **LED Exit Signs.** This measure category covers replacement of incandescent and CFL exit signs with energy efficient LED exit signs.

- **Packaged HVAC systems.** This measure category covers the upgrade of standard efficiency packaged HVAC systems with high efficiency units. The program addresses single package rooftop air conditioners and heat pumps, split system air conditioners and heat pumps, packaged terminal air conditioners and heat pumps, and ground source and water loop heat pumps in a variety of size ranges. The program baseline is defined by the National Appliance Energy Conservation Act (NAECA) minimum efficiency for single phase equipment and ASHRAE 90.1 – 2004 minimum efficiency for three phase equipment.

The measure savings estimates for each of these measure categories were reviewed by energy engineers and lighting designers at Architectural Energy Corporation. The review comments are listed below:

Compact Fluorescent Lamp Measure Review Comments

Light output. The energy savings estimates are based on replacement of standard incandescent lamps with compact fluorescent lamps at an equivalent level of light output. Lumen output is generally consistent between incandescent and the CFL equivalents, but diverges at the higher wattage end. The 150W and 200W incandescent lamps put out 18 percent more initial lumens than their CFL equivalents. (See Figure 9, below.)

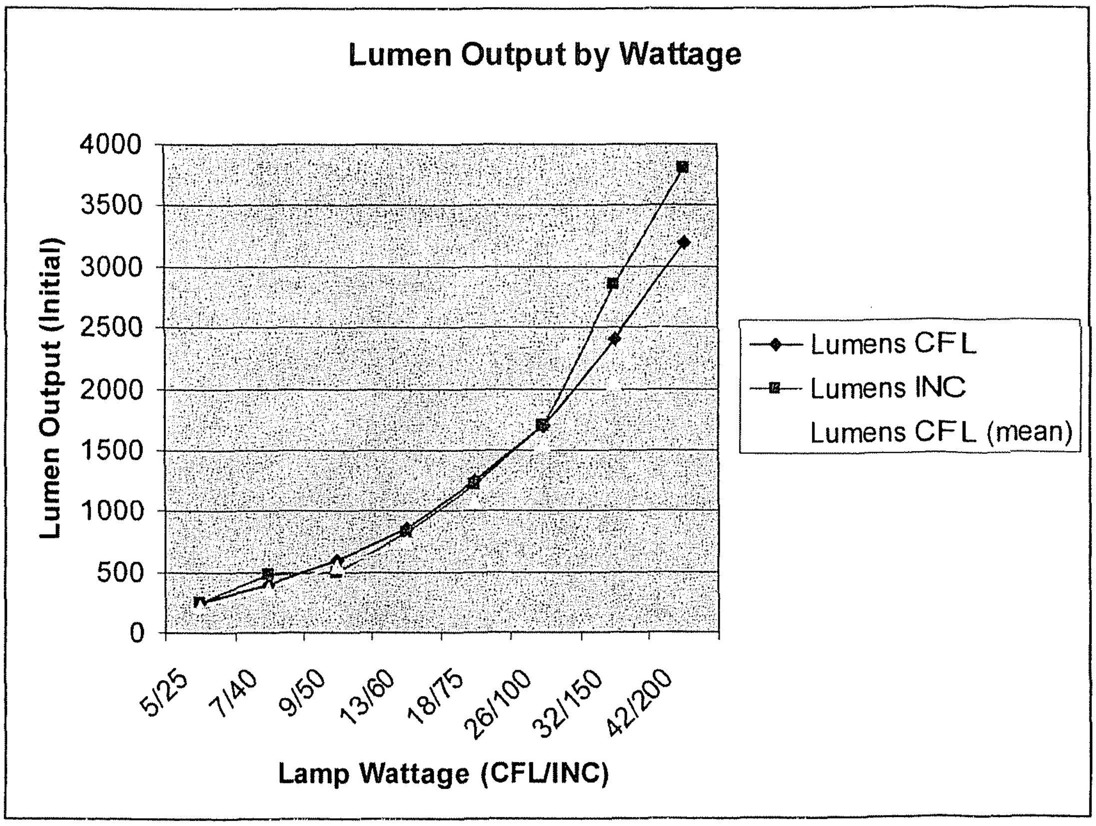

Figure 9: Lamp Lumen output by Wattage[2]

When one considers *mean lumens* instead of initial lumens, there is between an 8 percent and 39 percent decrease in output between the incandescent lamp and the replacement compact fluorescent lamp, again with the disparity increasing with the higher wattages. There is no clear alternative to better match the lumen output differences at the upper end of the wattage range, either. The 42W lamp has been the highest-wattage lamp available in the compact fluorescent line for some time. Philips recently released a 57W lamp, but the mean lumens are significantly *higher* than the 200W incandescent, and as brand-new technology, facilities managers may be reluctant to adopt this product.

Lamp life. The lamp life for incandescent lamps is a reasonable average between the commonly-used "long life" and regular incandescents; CFL lamp life is accurate and consistent with industry sources.

Lighting design issues. In general, we have a concern about the way the program is pushing the higher wattage CFLs as screw-in replacements for incandescent lamps. In our view, the higher the lamp wattage, the higher potential for glare. The higher wattage incandescent lamps tend to be significantly larger than their CFL replacements, with higher mean operating lumens. As a result, high-wattage screw-in replacements tend to be improperly shielded in fixtures designed for incandescent sources. Additionally, the

[2] Lumen figures derived from 2006 Philips lamp catalog for typical lamps for each wattage

luminaire efficiency generally suffers, as the "luminous centers" of the lamps are different.

Fixture watts and measure kW savings. The screw in CFL and incandescent lamp wattage assumptions are quite reasonable. The hardwired CFL measure does not take into account the additional ballast loads that will be incurred; wattage savings are still directly compared lamp-to-lamp. We recommend revising the fixture watts and energy savings assumptions to include ballasts losses in these fixture types.

Annual Operating Hours. Program savings estimates are developed for two operating hour assumptions – a minimum level of 1800 hours per year and a typical commercial building assumption of 4160 hours per year. The typical operation assumes lighting system operation for 16 hours per day, 5 days per week, 52 weeks per year. Naturally, the lighting system operating hours vary by building type and lamp application. As is evident from the secondary research review, 4160 hours per year is on the high end of most commonly accepted estimates of lighting operating hours.

Linear Fluorescent Lamp Measure Review Comments

Measure Baseline. The baseline fixture assumes a 34W T-12 lamp, however the *basest* baseline lamp for this fixture and application is the 40W T-12, which is still commercially available. Additional energy savings will result when upgrading from a 40W T-8 system, thus the savings estimates used by the program are conservative.

T-8 lamp types and ballast factors. There are additional T-8 lamp types available beyond the lamp wattages covered in the program calculations. There is a trend in the lighting industry to treat lamps and ballasts as a "system," thus a particular lamp may perform differently depending on the ballast used in the fixture.

Lighting Design Issues. Given the large increase in light output with the newer system, consideration should be given to the potential for overlighting the retrofit spaces. A T-8 rather than a T-5 solution may make more sense to realize some energy savings while better matching the existing designed luminous environment. Philips offers a range of 4' T-8 lamp wattages to balance energy savings with light output. For example, their "Energy Advantage" product comes as a 25W T-8, which produces 2280 mean lumens -- the same light output as the 34W T-12 current baseline system. This solution would use roughly the same energy at the proposed T-5 system, but with a light output that is better matched to the baseline. It can be argued that in some environments, "more is not better". Another consideration is that the T-5HO is proposed to replace two-lamp T-12 fixtures in one case. This could become an issue if there was any stepped switching scheme employed, as the T-5HO solution utilizes a single lamp.

Luminaire Efficiency. There is a wide range of fixtures that could utilize the lamp and ballast combinations offered under the program, with an attendant wide range in luminaire efficiencies. While this does not affect energy savings per se, there could be significant impacts on the amount of light delivered to the task plane. Typically, T-12 luminaires are utilitarian fixtures such as open reflector striplights and troffers with 100 percent direct components (i.e. no indirect, uplight component, to the distribution). These typically range in efficiency from between 92-75 percent (the lower efficiency fixtures being the lensed variety). Luminaires for T-5 and T-8 lamps are available in direct/indirect versions with efficiencies as low as 40 percent. Perhaps a lower limit on luminaire efficiency should be included in the measure specification.

Lamp Life. Rated lamp life estimates are in line with manufacturer's data.

Fixture watts and measure kW savings. The fixture wattage assumptions for the lamp and ballast combinations presented are quite reasonable and consistent with industry sources.

Light Tubes Measure Review Comments

Based on the program participation data received from Duke Energy, light tube measures were not adopted by program participants. Therefore, we did not do an extensive analysis of this measure. However, we do offer the following general comments on the measure savings calculations.

Energy Savings Estimates. The light tube analysis assumes 13,900 lumens as the average output, but this is more appropriate for sunnier climates such as those found in Colorado. Energy savings from light tubes (a.k.a. tubular skylights) is difficult to quantify, as output data only exists for a few select cities. The nearest cities to the Duke Energy territory that have tubular skylight data are Chicago, IL and St. Louis MO. The use of climate-driven performance numbers for cities that are potentially far from the retrofit site makes these savings numbers somewhat dubious.

Measure Installation Issues. There are certainly practical issues associated with the tubular skylight retrofit scenario. Because these units need an interface between the roof and the ceiling, and because the tubes must be as straight as possible to limit efficiency losses, a successful retrofit can be difficult in an existing plenum that was not designed with the skylights in mind. Efficient, uniform skylight lens layouts may be difficult or impossible given the realities of typical plenum spaces.

The success of this strategy is highly dependent on proper design and execution of the tubular skylight additions. Since this is not a simple one-for-one swap, some thought must be applied to the layout of the skylights. Since the spacing criteria is different for the skylights than it is for the luminaires, this adds complexity to the design of the layout.

Measure Cost Assumptions. The cost assumption is reasonable for the unit itself, but the complexity of the installation can vary widely, so the actual installed cost is a large variable in this strategy. Also, for energy savings to be realized, a photosensor needs to be ties into the lighting system so that the metal halide fixtures get turned off when the tubular skylights are delivering adequate light. This does not appear to be accounted for in the analysis.

High Bay Fluorescent and Pulse-start HID Measure Review Comments

Fixture watts and lumen equivalents. We are in agreement with the Balance Engineering analysis of the fixture wattage and equivalent lumen output.. The 16 percent decrease in lumen output of the 4 lamp T-5 HO retrofit scenario is most likely acceptable for most applications, but the 28 percent decrease in lumen output in the 6 lamp 32W T-8 scenario is not.

Lighting Design. The T-5 and T-8 luminaire/lamp measures have different physical characteristics. These high bay fluorescent fixtures are large-footprint, area sources, whereas the pulse-start metal halide sources they are replacing in a retrofit application are more like the point sources. This may have implications regarding the original design intent.

Measure Baseline. The most probable alternate baseline fixtures other than 400 watt metal halide likely to be found in this scenario are low pressure sodium, high pressure sodium, and mercury vapor. These lamps have varying efficacies and therefore different wattages would be found for the 400W Metal halide baseline scenario. Depending on the lamp type replaced, a significant *increase* in energy use could result.

LED Exit Sign Measure Review Comments

The input power assumptions for the standard and energy efficient exit sign systems are fair, conservative averages. There is a range of system input power available under the general description of "LED Exit sign". The range is from 1.3 - 5.0 watts, according to our research. Four watts is a good average for these systems.

HVAC Measure Review Comments

Energy and demand savings calculations for HVAC measures developed by Balance Engineering were reviewed. The savings calculations covered single package rooftop air conditioners and heat pumps, split system air conditioners and heat pumps, packaged terminal air conditioners and heat pumps, and ground source and water loop heat pumps in a variety of size ranges. The program baseline was defined by the National Appliance Energy Conservation Act (NAECA) minimum efficiency for single phase equipment and ASHRAE 90.1 – 2004 minimum efficiency for three phase equipment. The equipment covered, the size ranges, and the program baseline efficiency assumptions are shown in Table 8.

Table 8. HVAC Equipment Baseline Efficiency Assumptions

Equipment Category	Capacity Range Btu/hr	Baseline Efficiency SEER	Baseline Efficiency EER	Source
Packaged Terminal A/C	All		10	ASHRAE 90.1-2004
Packaged Terminal HP	All		10	ASHRAE 90.1-2004
Unitary A/C (1) phase	<65,000 1 Ph	13		NAECA
Unitary A/C (3) phase	<65,000 3 Ph	12		ASHRAE 90.1-2004
Unitary A/C (3) phase	65,000 - 135,000		10.1	ASHRAE 90.1-2004
Unitary A/C (3) phase	135,000 - 240,000		9.5	ASHRAE 90.1-2004
Unitary A/C (3) phase	240,000 - 760,000		9.3	ASHRAE 90.1-2004
Unitary A/C (3) phase	>760,000		9	ASHRAE 90.1-2004
Unitary HP (1) phase	<65,000 1 Ph	13		NAECA
Unitary HP (3) phase	<65,000 3 Ph	12		ASHRAE 90.1-2004
Unitary HP (3) phase	65,000 - 135,000		9.9	ASHRAE 90.1-2004
Unitary HP (3) phase	135,000 - 240,000		9.1	ASHRAE 90.1-2004
Unitary HP (3) phase	>240,000		8.8	ASHRAE 90.1-2004
Rooftop A/C (1) phase	<65,000 1 Ph	13		NAECA
Rooftop A/C (3) phase	<65,000 3 Ph	12		ASHRAE 90.1-2004
Rooftop A/C (3) phase	65,000 - 135,000		10.1	ASHRAE 90.1-2004
Rooftop A/C (3) phase	135,000 - 240,000		9.5	ASHRAE 90.1-2004
Rooftop A/C (3) phase	240,000 - 760,000		9.3	ASHRAE 90.1-2004
Rooftop A/C (3) phase	>760,000		9	ASHRAE 90.1-2004
Rooftop HP (1) phase	<65,000 1 Ph	13		NAECA
Rooftop HP (3) phase	<65,000 3 Ph	12		ASHRAE 90.1-2004
Rooftop HP (3) phase	65,000 - 135,000		9.9	ASHRAE 90.1-2004
Rooftop HP (3) phase	135,000 - 240,000		9.1	ASHRAE 90.1-2004
Rooftop HP (3) phase	>240,000		8.8	ASHRAE 90.1-2004
Ground Source HP Closed Loop	<135,000 & 59 F EWT		16.2	ASHRAE 90.1-2004
Ground Source HP Closed Loop	<135,000 & 77 F EWT		13.4	ASHRAE 90.1-2004
Water Source Heat Pump	<17,000		11.2	ASHRAE 90.1-2004
Water Source Heat Pump	17,000 - 65,000		12.0	ASHRAE 90.1-2004
Water Source Heat Pump	65,000 - 135,000		12.0	ASHRAE 90.1-2004

Energy savings estimates per HVAC unit were developed based on difference the baseline and as-installed unit efficiency and the unit size. A representative unit was selected for each size range, and an estimate of the typical annual cooling load and cooling kWh consumption at a variety of efficiency levels was developed. Savings were estimated by subtracting the cooling kWh at the baseline efficiency assumption from the cooling kWh at the installed measure efficiency.

An estimate of the annual equivalent cooling full load hours was developed from the program assumptions. The results of these calculations are summarized in Table 9.

Table 9. HVAC Annual Cooling Load Assumptions by Unit Size

Typical Building	Unit size (ton)	Total cooling load (kBtu/yr)	Equivalent Full-load Cooling hours
1	1	17,139	1,428
2	5	41,355	689
3	10	113,804	948
4	20	227,608	948
5	25	438,026	1,460
6	65	1,206,401	1,547

As is evident from the table above, the equivalent full-load hour estimates vary according to unit size. In general, equivalent full load hours are a function of building type and operating schedule, HVAC system type and control, and climate. Estimating equivalent full load cooling hours by building type may be more representative than by unit size alone.

Secondary Research Review

Secondary research review was conducted to obtain estimates of engineering parameters used in the energy savings calculations. The secondary research review focused on program design "workpapers" and other research conducted in support of program design efforts elsewhere in the country. The review incorporated research conducted in support of the California Database for Energy Efficiency Resources (DEER), the Pacific Gas and Electric Company (PG&E) commercial mass markets program, the Southern California Edison Company (SCE) workpapers for their commercial retrofit programs, and the Efficiency Vermont (EVT) technical reference manual. The research review collected information on lighting system operating hours and coincidence factors by lamp and building type, HVAC baseline efficiency assumptions, and HVAC system equivalent full-load hour data. These data were used to test the assumptions used in the Duke program, as well as to develop data resources for conducting the impact study.

Lighting Operating Hours

Review of lighting operating hour assumptions in the literature showed a wide variety of average lighting operating hours across the different types of commercial buildings. A summary of the assumptions used by various groups across the country, along with our best judgment on a representative value for use in this study is shown in Table 10.

Table 10. General Lighting Operating Hours by Building Type

Building Type	PG&E	SCE	EVT	DEER	Evaluation Assumption
Assembly				3164	3164
Education - Community College	3,792	3,900	5,010	2180	3,846
Education - Primary School	1,440	2,150	2,080	1579	1,440
Education - Secondary School	2,305	2,150	2,080	1666	2,305
Education - University	3,073	3,900	5,010	2172	3,487
Grocery	5,824	5,800	4,612	4081	5,812
Health/Medical - Hospital	8,736	4,400	4,532	6229	8,736
Health/Medical - Nursing Home	8,736	4,400	4,532	3817	8,736
Lodging – Guest Room	8,736	5,500	2,697		8,736
Lodging - Hotel	8,736	5,500	2,697	6971	8,736
Lodging - Motel	8,736	5,500	2,697	4754	8,736
Lodging- Blend	8,736	5,500	2,697		8,736
Manufacturing - Light Industrial	2,860	4,400	2,235	2730	2,548
Office - Large	2,808	4,000	3,435	4006	3,414
Office - Small	2,808	4,000	3,435	3025	3,414
Process Industrial	2,860	6,650	2,235		6,650
Restaurant - Fast-Food	6,188	4,600	4,156	6348	6,188
Restaurant - Sit-Down	4,368	4,600	4,156	3366	4,375
Retail - 3-Story Large	4,259	4,450	3,068	3221	4,355
Retail - Single-Story Large	4,368	4,450	3,068	3981	4,409
Retail - Small	4,004	4,450	3,068	3094	4,227
Storage - Conditioned	2,860	3,550	2,388	3695	2,624
Storage - Unconditioned	2,860	3,550	2,388	3695	2,624
Warehouse - Refrigerated	2,600	3,550	2,388	3379	2,494
Other		4500	2278		3,389

Appropriate values for CFL operating hours in commercial buildings has been the subject of intense study recently, especially in California. Traditionally, programs have not assigned different operating hours to CFLs verses general lighting systems. Due to the importance of CFLs in commercial program energy savings portfolios, specific operating hour assumptions for both screw-in and hardwired CFLs have been developed. A summary of the literature on screw-in and hard-wire CFL operating hours is presented in Table 11 and Table 12. These data are shown along with our best judgment on appropriate operating hour assumptions for this study.

Table 11. CFL Hard-wired Fixture Operating Hour Assumptions

Building Type	PG&E	SCE	EVT	Evaluation Assumption
Education - Community College	3,792	3,900	5,010	3,846
Education - Primary School	1440	2,150	2,080	1,440
Education - Secondary School	2,305	2,150	2,080	2,305
Education - University	3,073	3,900	5,010	3,487
Grocery	5,824	5,800	4,612	5,812
Health/Medical - Hospital	8,736	4,400	4,532	8,736
Health/Medical - Nursing Home	8,736	4,400	4,532	8,736
Lodging – Guest Room	8,736	5,500	2,697	8,736
Lodging - Hotel	8,736	5,500	2,697	8,736
Lodging - Motel	8,736	5,500	2,697	8,736
Lodging- Blend	8,736	5,500	2,697	8,736
Manufacturing - Light Industrial	2,860	4,400	2,235	2,548
Office - Large	2,808	4,000	3,435	3,414
Office - Small	2,808	4,000	3,435	3,414
Process Industrial	2,860	6,650	2,235	6,650
Restaurant - Fast-Food	6,188	4,600	4,156	6,188
Restaurant - Sit-Down	4,368	4,600	4,156	4,375
Retail - 3-Story Large	4,259	4,450	3,068	4,355
Retail - Single-Story Large	4,368	4,450	3,068	4,409
Retail - Small	4,004	4,450	3,068	4,227
Storage - Conditioned	2,860	3,550	2,388	2,624
Storage - Unconditioned	2,860	3,550	2,388	2,624
Warehouse - Refrigerated	2,600	3,550	2,388	2,494
Other		4500	2278	3,389

Table 12. CFL Screw-in Lamp Operating Hour Assumptions

Building Type	PG&E	SCE	EVT	Evaluation Assumption
Assembly				
Education - Community College	3,792	3,900	5,010	3,846
Education - Primary School	1,440	2,150	2,080	1,440
Education - Secondary School	2,305	2,150	2,080	2,305
Education - University	3,073	3,900	5,010	3,487
Grocery	5,824	5,800	4,612	5,812
Health/Medical - Hospital	8,736	4,400	4,532	8,736
Health/Medical - Nursing Home	8,736	4,400	4,532	8,736
Lodging – Guest Room	1,145	5,500	2,697	1,145
Lodging - Hotel	8,736	5,500	2,697	8,736
Lodging - Motel	8,736	5,500	2,697	8,736
Lodging- Blend	3,675	5,500	2,697	3,675
Manufacturing - Light Industrial	2,860	4,400	5,913	5,157
MF Housing	1278			1278
Office - Large	2,739	4,000	3,435	3,391
Office - Small	2,492	4,000	3,435	3,309
Process Industrial	2,860	6,650	5,913	6,282
Restaurant - Fast-Food	6,188	4,600	4,156	6,188
Restaurant - Sit-Down	3,444	4,600	4,156	4,067
Retail - 3-Story Large	4,259	4,450	3,068	4,355
Retail - Single-Story Large	4,368	4,450	3,068	4,409
Retail - Small	3,724	4,450	3,068	4,087
Storage - Conditioned	2,860	3,550	2,388	2,624
Storage - Unconditioned	2,860	3,550	2,388	2,624
Warehouse - Refrigerated	2,600	3,550	2,388	2,494
Other		4500	2278	3,389

Summer coincident diversity factors (CDF) have been developed by PG&E and SCE for their commercial programs. This factor is defined as the ratio of the connected lighting load that is on during the summer peak hour to the total connected lighting load. The values used by the California utilities are derived from load research studies that examined hourly commercial building lighting load by building type, and the coincidence of lighting use with the utility peak period. A summary of these data is shown in Table 13.

Table 13. Lighting Coincident Diversity Factors for PG&E and SCE

Building Type	CDF
Church	0.76
College	0.68
Community Center	0.76
Elem/Middle School	0.42
hotel/motel	0.67
Industrial	0.99
Medical Office	0.81
Multifamily	0.67
Office	0.81
Police/Fire	1
Restaurant	0.68
Retail	0.88
University	0.68
Warehouse	0.84
Other/DK	0.76

HVAC equivalent full load hour (EFLH) and coincident diversity factor assumptions were also researched. Equivalent full load hours are defined as the ratio of the total annual consumption (Btu) to the peak cooling load (Btu/hr). In some contexts, this is also defined as the annual cooling electricity consumption (kWh) divided by the peak cooling demand (kW). Strictly speaking, differences between the HVAC system efficiency under seasonal average and peak conditions make these different definitions incompatible. Cooling equivalent full-load hours are highly influenced by local climate, building operating schedule, building design, HVAC system design and controls, making it difficult to transfer data from different parts of the country. However, it is useful to examine full load hour assumptions from various utilities as an overall reasonableness check against the assumptions used in the Duke program. The coincident diversity factor also estimates the fraction of the total connected HVAC load that is running during the utility peak period. A compilation of the cooling EFLH used in the PG&E and SCE program is shown in Table 14.

Table 14. PG&E and SCE Equivalent Full Load Cooling Hours for HVAC Technologies

Building Type	Equivalent Full-Load Cooling Hours	HVAC CDF
Office	1,000	0.87
Retail	800	0.85
University	1,200	0.73
School	500	0.24
Grocery	600	0.83
Restaurant	1,300	0.86
Health Care/Hospital	1,900	0.89
Hotel/Motel	700	0.77
Warehouse	300	0.8
Process Industrial	800	0.75
Assembly Industrial	2,100	0.75
All Other	1,200	0.78

The Efficiency Vermont commercial programs use EFLH assumptions based on HVAC system type, not building type. Since heating is an important end-use in Vermont, both heating and cooling EFLH data have been developed. These data are shown in Table 15.

Table 15. Efficiency Vermont Equivalent Full Load Cooling Hours for HVAC Technologies

HVAC System Type	Equivalent Full-load Cooling Hours	Equivalent Full-load Heating Hours
Split system and single package rooftop A/C units	800	
Split system and single package rooftop heat pumps	800	1600
Packaged terminal A/C	830	
Packaged terminal heat pumps	830	1640
Water source heat pumps	2088	2248

In the Efficiency Vermont programs, the summer coincident diversity factor is set to 0.36, and the winter coincident diversity factor is set to 0.372.

Tracking System Review

Lighting and HVAC program participation records covering the period from January, 2005 through October, 2006 were obtained from Duke Energy. The data, delivered as a series of Excel spreadsheets, contained customer name and address, installing vendor contact information, measure descriptions, unit energy savings estimates, number of measures installed, rebate amounts, and so on. Separate spreadsheets were obtained for lighting and HVAC measures. These data were examined to identify which of the measures promoted by the program were adopted by program participants and in what numbers, how the energy savings in the tracking system compared to the program savings estimates, and the availability of any customer description data that could be used in the analysis.

Lighting program participation

The lighting program tracking system showed lighting measures installed in a total of 47 buildings. Since some installations were done in multiple buildings owned by the same company, a total of 41 individual companies participated in the program. Customer name and address data were used to assign a building type to each customer in the database. In most cases, the customer name was recognizable (e.g. a national chain). In other cases, customer name and address information was searched over the internet to determine the building type. The building type and number of participants by building type are show in Table 16.

Table 16. Lighting Program Participation by Building Type

Building Type	Count
Church	1
College	1
Community Center	1
Elem/Secondary School	4
Grocery	1
Industrial	8
Medical Office	1
Office	4
Other/DK	1
Restaurant	1
Retail	17
University	2
Warehouse	5
Total	47

The types and quantity of measures installed are shown in Table 17.

Table 17. Lighting Measures Installed Under Program

Measures Installed	Measure Group	Count
CFL 26W HARDWIRED	CFL hard-wire	16
CFL 5W HARDWIRED	CFL hard-wire	12
CFL 7W HARDWIRED	CFL hard-wire	6
CFL 13W SCREW-IN	CFL screw in	131
CFL 18W SCREW-IN	CFL screw in	93
CFL 26W SCREW-IN	CFL screw in	156
CFL 32W SCREW-IN	CFL screw in	210
CFL 42W SCREW-IN	CFL screw in	53
CFL 5W SCREW-IN	CFL screw in	80
LED Exit Signs	Exit sign	340
T-5 HO 4 ft 4 lamp high bay	High Bay	1,049
T-8 4 ft 6 lamp high bay	High Bay	4,072
T-5 - 4 ft 4 lamp 28W	Linear Fluorescent	5
T-5 HO 4 ft 1 lamp 54W	Linear Fluorescent	95
T-8 2 ft 1 lamp	Linear Fluorescent	9
T-8 2 ft 2 lamp	Linear Fluorescent	360
T-8 3 ft 1 lamp	Linear Fluorescent	26
T-8 3 ft 2 lamp	Linear Fluorescent	5
T-8 4 ft 1 lamp	Linear Fluorescent	341
T-8 4 ft 2 lamp	Linear Fluorescent	1,671
T-8 4 ft 3 lamp	Linear Fluorescent	374
T-8 4 ft 4 lamp	Linear Fluorescent	1,920
T-8 8 ft 2 lamp	Linear Fluorescent	121
T-8 8 ft 2 lamp HO	Linear Fluorescent	15

Energy and demand savings estimates were provided for each measure in the tracking system. The watts saved per fixture by fixture type in the tracking system matched the values recommended in the Balance Engineering reports. The 4 foot T-8 lamp measure description in the database is not complete, since there are a variety of T-8 lamp wattages available, including 28W, 30W and 32W T-8 lamps. The database wattage savings estimates indicated that 30W T-8 lamps were assumed to be installed.

Several of the database entries showed no kWh savings, presumably due to data entry errors. The equivalent full load hours for measures with energy savings varied from 4800 to 5400 hours per year, with the exception of exit signs, which were based on 8760 hours per year. Based on the secondary literature research review, the lighting full load hour estimates used in the database are high for most building types, and exceeded the values recommended by Balance Engineering.

HVAC program participation

The HVAC program tracking system showed measures installed in a total of 10 buildings. Customer name and address data were used to assign a building type to each customer in the database. In most cases, the customer name was recognizable (e.g. a national chain). In other cases, customer name and address information was searched over the internet to determine the building type. The building type and number of participants by building type are show in Table 18.

Table 18. HVAC Program Participants by Building Type

Building Type	Number
Office	2
Full Service Restaurant	2
Retail	6
Total	10

HVAC unit make and model number were also provided in the tracking system database. These data were used to assign an equipment type, cooling capacity and cooling efficiency to each unit in the database. A combination of manufacturers' catalog data and the Air-conditioning and Refrigeration Institute (ARI) searchable database was used to assign these data.

The HVAC units installed under the program included packaged terminal heat pumps, packaged terminal air conditioners and rooftop air conditioners. The number and size range of the measures installed are summarized in Table 19.

Table 19. Type of HVAC Equipment Installed Under the Program

Unit type	Size Range	Number installed
Packaged terminal air conditioner	All sizes	2
Packaged terminal heat pump		35
Rooftop air conditioner	< 5.4 tons	15
	5.4 tons – 11.25 tons	10
	11.25 tons – 17.5 tons	21

Unit kW and kWh savings data were included in the database. From these data, the equivalent full-load cooling hours for each unit were inferred. The estimated cooling full load hours ranged from about 2300 to 3100 hours, which are substantially higher than the estimates in the Balance Engineering calculations.

Summary of Energy Savings

The energy savings calculations and program savings results for the lighting and HVAC programs are summarized as follows:

Lighting Gross Energy and Demand Savings

Energy and demand savings estimates were developed for each measure in the database using the following engineering equations:

$$kW_{savings} = \sum_{i}^{buildings} \sum_{j}^{measures} units_{i,j} \times kWsaved_j \times CDF_i$$

$$kWh_{savings} = \sum_{i}^{buildings} \sum_{j}^{measures} units_{i,j} \times kWsaved_j \times FLH_{i,j}$$

where:

units	= quantity of each measure installed in each building type
kWsaved	= unit kW savings for each measure
CDF	= coincident demand factor by building type
FLH	= full load lighting hours by measure and building type

The unit kW savings assigned to each lighting measure are shown in Table 20.

Table 20. Lighting Fixture Wattage Savings Assumptions

Measure	Unit kW savings	Notes
CFL 13W SCREW-IN	0.047	
CFL 18W SCREW-IN	0.057	
CFL 26W HARDWIRED	0.073	Hardwired CFL savings revised to reflect ballast losses
CFL 26W SCREW-IN	0.074	
CFL 32W SCREW-IN	0.118	
CFL 42W SCREW-IN	0.158	
CFL 5W HARDWIRED	0.016	Hardwired CFL savings revised to reflect ballast losses
CFL 5W SCREW-IN	0.020	
CFL 7W HARDWIRED	0.030	Hardwired CFL savings revised to reflect ballast losses
LED Exit Signs	0.013	
T-5 - 4 ft 4 lamp 28W	0.024	
T-5 HO 4 ft 1 lamp 54W	0.015	
T-5 HO 4 ft 4 lamp high bay	0.212	
T-8 2 ft 1 lamp	0.010	
T-8 2 ft 2 lamp	0.002	
T-8 3 ft 1 lamp	0.011	
T-8 3 ft 2 lamp	0.010	
T-8 4 ft 1 lamp	0.016	F30T8 savings used per database
T-8 4 ft 2 lamp	0.019	F30T8 savings used per database
T-8 4 ft 3 lamp	0.034	F30T8 savings used per database
T-8 4 ft 4 lamp	0.040	F30T8 savings used per database
T-8 4 ft 6 lamp high bay	0.231	
T-8 8 ft 2 lamp	0.020	
T-8 8 ft 2 lamp HO	0.050	

The lighting full-load hours and coincident diversity assumptions were developed from the secondary research described in the previous section. These data were applied to each measure according to the measure type and building type.

The lighting program gross energy and demand savings were summed across all entries in the database, and normalized on a per-measure and per-program-participant basis. The estimates embedding in the program tracking system, the savings estimated by this evaluation, and the estimates used by Duke Energy for program planning purposes are compared in Table 21.

Table 21. Lighting Program Gross Energy and Demand Savings

Savings Basis	Source	kW	kWh
Savings/measure	Planning Estimate		130
	Tracking System	0.12	56
	Evaluation Estimate	0.11	365
Savings/participant	Tracking System	28.5	13,186
	Evaluation Estimate	26.1	86,743

Since the evaluation is based on partial participation data for 2006, the total program savings will be calculated by Duke Energy from these averages applied to the final program tracking database. Note, the demand savings estimates from the evaluation match quite well with the tracking system estimates. However, the energy savings estimates vary substantially, due to apparent errors in the tracking system noted above.

The energy and demand savings were also tabulated by measure group for the partial database. These results are shown in Table 22.

Table 22. Lighting Program Gross Energy and Demand Savings by Measure Group

Measure group	Measures installed	Total kWh savings	Average kWh savings per measure	Total kW savings	Average kW savings per measure
CFL hardwired	34	4,231	124.	1	0.033
CFL screw-in	723	180,067	249.	39	0.054
Exit	340	38,719	114	4	0.011
High Bay	5,121	3,503,784	684.	1,071	0.209
Linear Fluorescent	4,942	350,109	71	110	0.022

Note, the high bay fixture measure group accounted for the majority of the lighting installations and energy savings for this set of participants.

HVAC Gross Demand and Energy Savings

Secondary research conducted for this evaluation did not reveal any reliable sources of data for estimating cooling full load hours. Thus, a series of prototype building energy simulation models were developed for the building types served under the program. The prototypical simulation models were derived from the California Database for Energy Efficiency Resources (DEER) study, with adjustments make for local building practices and climate. A description of each prototype simulation model follows.

Small Retail Prototype

A prototypical building energy simulation model for a small retail building was developed using the DOE-2.2 building energy simulation program. The characteristics of the small retail building prototype are summarized in Table 23.

Table 23. Small Retail Prototype Description

Characteristic	Value
Vintage	Existing (1970s) vintage
Size	6400 square foot sales area 1600 square foot storage area 8000 square feet total
Number of floors	1
Wall construction and R-value	Concrete block with brick veneer, R-11
Roof construction and R-value	Wood frame with built-up roof, R-19
Glazing type	Single pane clear
Lighting power density	Sales area: 3.4 W/SF Storage area: 0.9 W/SF
Plug load density	Sales area: 1.2 W/SF Storage area: 0.2 W/SF
Operating hours	10 – 10 Monday-Saturday 10 – 8 Sunday
HVAC system type	Packaged single zone, no economizer
HVAC system size	Sales floor: 240 SF/ton Storage area: 380 SF/ton
Thermostat setpoints	Occupied hours: 76 cooling, 72 heating Unoccupied hours: 81 cooling, 67 heating

A computer-generated sketch of the small retail building prototype is shown in Figure 10.