2007 KANSAS CITY POWER & LIGHT SINGLE-FAMILY RESIDENTIAL POTENTIAL ANALYSIS

FINAL REPORT

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Prepared for Kansas City Power & Light

PREPARED BY:

RLW ANALYTICS

48 4TH STREET

TROY, NY 12180

Table of Contents

Table of Figures

Executive Summary

This is the final draft report of the 2007 Single-Family Residential Potential Study for Kansas City Power and Light (KCP&L). This study was aimed at providing technical, market, and economic analyses specific to the KCP&L service area, with the goal of identifying key characteristics for energy efficiency opportunities.

Approach

A nested sampling methodology was employed in the study to effectively reach time and analysis demands. In line with this approach RLW utilized a dual sampling strategy, using onsite surveys to strengthen phone survey data that was collected. The statistical paradigm required that at least 254 phone surveys be conducted and at least 70 onsite surveys carried out. In accord with KCP&L, RLW made use of onsite data from the recent 2006 Missouri Statewide Assessment (in which KCP&L was one of seven collaborating utilities). RLW successfully completed all phone surveys and on-site visits for this study between January 9^{th} and February 15^{th}.

Key Findings

RLW initially analyzed 32 potential home improvement options. The 20 most promising measures, as ranked by annual electrical energy savings in MWh, offer nearly the same (about 97%) potential savings as all 32 measures combined. This is largely due to the presence of one measure (ID 15) that yielded significant natural gas savings but negative electrical energy savings.

There were three generalized types of energy efficiency measures that were identified as most promising:

1. Appliances and lighting – specifically refrigerators and compact fluorescent lamps;
2. HVAC – Improvements in practices during new construction and prescriptive measures for existing systems; and
3. Weatherization – These would be both new construction and prescriptive measures for reduced air infiltration, insulation, and energy efficient windows.

Introduction

This is the final draft report for the 2007 Single-Family Residential Potential Analysis Study for Kansas City Power & Light (KCP&L). RLW Analytics, Inc. conducted the study on behalf of KCP&L.

The study was designed to provide KCP&L with technical, economic, and market potential for building measures, appliances, and lighting of single-family residential homes. The overarching goals of this assessment were to calculate and present technical, economic, and market potential analyses for energy efficiency opportunities to help target future programs that will have the largest and/or most cost effective impact on peak demand and energy consumption in the single-family residential sector.

Approach

Per KCP&L's request, RLW was requested to meet a March 1, 2007 deadline. To meet this timeline, RLW utilized a nested sampling methodology which would equally accommodate time and project analysis demands. An evenly distributed sample of single-family residential accounts was selected from KCP&L. The nested sampling methodology utilized a dual approach. The majority of the data was collected over the phone which allowed for timely data collection. RLW then randomly selected a subset of customers within this phone survey sample to carry out onsite visits. These visits acquired specific household data, such as building envelope characteristics, appliance model numbers, manufacture dates, efficiency data, and related. This data was used to strengthen the accuracy of the phone survey data.

For statistical purposes, RLW needed phone survey data for at least 254 customers and onsite data for at least 70 customers. KCP&L customers were first recruited to participate in the study by phone. Each participant was offered $20 for agreeing to participate in the phone survey. At the end of each survey, customers were asked if they would be amenable to participating in an onsite survey for an additional incentive of $30. At the end of the phone survey task, a sample of onsite customers was next randomly selected from the list of those who agreed to participate in an on-site visit.

Because of the time constraint to deliver this study, KCP&L and RLW agreed to make use of the KCP&L onsite data that was collected from the recent 2006 Missouri Statewide Assessment. RLW made use of all 28 previously collected KCP&L single-family customer onsite data, and combined it with this newest set of on-site data. A total of 232 successful phone surveys were completed from January 15-26, 2007, and a total of 42 onsite surveys completed from January 29 – February 9, 2007. Overall, RLW collected and used data from a total of 260 phone surveys and 70 on-site visits.

For both the phone and on-site surveys, the surveyors collected data on the major appliances and lighting systems in the home. The onsite surveyors collected nameplate data for the following appliances:

- Refrigerator-Freezer
- Self-standing Freezers

- Dishwashers
- Clothes Washers
- Clothes Dryers
- Water Heaters
- Heating Equipment
- Cooling Equipment

For lighting, the phone and onsite surveyors collected lamp, fixture and wattage data for each lighting fixture within the home, as well as any front porch fixtures. The on-site surveyors also collected data on attic, floor and wall insulation R-values, wall construction, and window type.

Once compiled, the data underwent quality control measures. Model numbers were matched to databases of appliance efficiencies through a number of manufacturer databases, including CEC, ARI, AHAM, and Carrier's 2003 Electronic Blue Book. Once the model numbers were linked, the corresponding efficiency was assigned to the matched appliance. Matching rates varied greatly by appliance type and age. In most cases this is due to the comprehensiveness of the efficiency databases that are available for each appliance type. RLW is confident that the great majority of model numbers found on-site were matched if they appeared in any of the efficiency databases. Matching model numbers to appliance databases is typically a long process. For example, wildcard symbols (*, /, #, etc.) are often included in the model number. The wildcards add to the complexity of the query designs and decrease match rates.

Data Collection Sample Design

Using a nested sampling approach, the statistical paradigm required a minimum of 254 phone surveys and 70 onsite surveys be completed. The targeted single-family phone survey sample of 254 homes was proportionally allocated across the utility to the total number of single-family accounts. The sample for the 70 onsite surveys was randomly selected from the phone survey data. The sample was designed at the regional level in order to achieve an error bound of +/-10% at the 90% level of confidence.

The critical element in using this particular approach is that the onsite data collected was later used to strengthen and validate the data collected over the phone. RLW utilized this approach to test and/or improve customer reported data. In this regard, a broad phone survey tool was used to collect any easily obtainable data (such as window types, basic appliance information, etc.), while the onsite data collected detail-specific data that was necessary for efficiency assessment.

To verify the relative precision of the study, we examined five key characteristics: SEER, wall R-Value, attic R-Value, home square footage, and age of the home. To effectively make use of DOE2 modeling, the data was formed into "bins", i.e. groups of sites. Hence, the analysis combined specific variables to complete the potential analyses. Using this methodology, the relative precision of the study can be computed by examining each of these five characteristics individually and then as a whole. The calculated resulting relative precision was determined to be 10%.

Potential Analyses and Results

Methodology for Estimating Impacts

The analysis for the technical impacts began with an examination of typical weather patterns for two locations within the KCP&L service area. This examination indicated that there is no significant difference between the two locations. One location was the Kansas City International Airport and the other was downtown Kansas City, Missouri. The downtown weather site appeared to be a little closer to the center of the service area, so RLW elected to use the weather data from that site.

The relative numbers of non-electric heated homes (about 77.4%, and almost exclusively natural gas), proved to be significant. The split between the electric strip heated homes and the electric heat pump heated homes was even, at 11.3% each. Therefore, RLW chose to create three DOE2 physical models to represent the entire KCP&L single family housing stock, but to utilize one central weather file. The three models were created in conjunction with three corresponding sets of field audit data and calibrated monthly to their corresponding electric utility billing data.

These three models were applied to calculate unique measure level savings for the average gas heated home, average electric strip heated home and average heat pump heated home. Any homes that are heated primarily with propane, oil and other miscellaneous fuels were included in this study among the gas heated homes. Of all the phone and on-site data used, about 3% of homeowners reported that they used propane, and one reported using wood for their primary heating fuel. However, none of the homes specifically visited for this study was heated with these alternate fuels.

All three types of homes have customer sites that utilize wood fireplaces to some degree. Heating contributions from these were accounted for in the models, hence impacting the dependence on gas and electricity, but savings on wood consumption are not considered as part of this study. RLW, therefore, assumed that wood consumption remained unchanged by the retrofits. All of the homes in the field audits and in the telephone surveys were also reported to be air-conditioned.

RLW utilized Kansas City, Missouri TMY2 weather data[1] to represent the entire service area. Monthly billing data furnished by KCP&L were first “cleaned” and “calendarized”[2], and then aggregated into the three groups by heating system type as defined by the field audits, telephone surveys and annual usage patterns by month. Finally, the monthly kWh was averaged by month to create the average monthly usage for each

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[1] TMY2 weather data, used throughout the world, have been derived from actual NOAA (National Oceanic and Atmospheric Administration) hourly measured data through an elaborate statistical and analytical procedure aimed at identifying the most typical of each of 12 months of weather from 50 years of historical data, and combining these 12 months from different years to create a “Typical Meteorological Year”.

[2] That is, meter readings and billing data were converted in calendar months to allow for proper calibration to the models.

group to calibrate each DOE2 model. The models were calibrated to match their actual average monthly kWh within 2% for each month.

Due to some obvious erroneous descriptions of heating system types in the phone survey data, RLW reviewed each set of billing histories to confirm or correct the customer responses. About 25 to 30 percent of the customer descriptions were found to be wrong (which RLW finds as typical of customer telephone surveys throughout the country) and corrected to reflect the obvious heating system types. Whenever the billing history profiles were not conclusive, RLW gave the benefit of the doubt to the customer.

The DOE2 formatted version of the TMY2 weather file contains hourly dry bulb and wet bulb temperatures, humidity ratios, direct and diffuse solar radiation, wind speed and direction, precipitation, ground temperatures and other variables utilized by DOE2 to calculate hourly cooling and heating loads.

The impacts for each measure for each group were derived by first altering the calibrated “as-is” model to create a baseline condition that exceeded a reasonable threshold value. For example, the average house may have had R-23 attic insulation, but the baseline attic insulation R-value would be much lower, say R-7 or R-11. Using this approach, RLW created a specific baseline model for each measure, recognizing that the measure would be applicable only to homes that were below a reasonable threshold value (For example R-10 or lower, so that the average for all these homes would be about R-7). These baseline models, therefore, represent homes that might be expected to participate in a conservation program offering that measure. Next, a retrofit model was created for those homes by upgrading the measure of interest to a significantly higher but reasonably attainable standard, say R-30 for attic insulation.

Savings were obtained by running the baseline and retrofit models to obtain the hourly building demands for a typical year and subtracting the results for every hour. The sum of the hourly differences in cooling system demand represents hourly cooling savings for a typical weather year. Coincident summer electric demand savings were calculated as the average savings over the two hour window of 3-5 PM on the hottest weekday of the typical year. Coincident winter demand savings were calculated for the window of 6-8 AM (the heating peak period) on the coldest weekday. Annual energy savings are the sum of the hourly demand savings for the whole year. Natural gas savings estimates in terms of peak BTU’s per hour and Therms per year were derived the same way.

For each measure RLW exercised all three models to calculate unique savings for an average gas heated home (with a gas furnace), average electric strip heated home (with an electric furnace), and average electric heat pump heated home (with a 15kW supplemental electric strip heating element). In the potential analysis the individual results for each measure were combined by weight-averaging them with the fraction of the population represented by each house/model type (0.774 gas heat, 0.113 strip heat, 0.113 heat pump), respectively.

Technical Assessment of Energy and Demand Impacts

Potential Energy Conservation Measures

As listed in Table 1, RLW analyzed 32 potential home improvement options. Average annual savings were calculated for each in terms of kWh and kW electrical energy and demand, and Therms (100,000 BTU) and peak BTUh (British Thermal Units per hour) of natural gas. Shaded IDs represent 20 measures and options that have been identified as priority measures based on their potential savings, and are more fully developed in the market assessment section of this report.

ID	Potential Situation	Improvement	Quantity
1	AC Refrigerant under charged	Add refrigerant	2 hr & 2 Lb R-22
2	AC Refrigerant over charged	Remove refrigerant	2 hours
3	Low evaporator airflow A	Increase duct sizes or add new ducts	75 SF
4	Low evaporator airflow B	Increase blower speed	2 hours
5	High duct leakage (25%)	Reduce duct leakage to 5%	3.41 tons
6	Oversized AC units A	Size AC units to 100% of Manual J	3.09 tons
7	Oversized AC units B	Size AC units to 100% of Manual J	3.09 tons
8	One inch insul. on ducts in attic	Add two more inches of insulation	3.41 tons
9	Gas heat and 13 SEER AC	Install AC SEER = 16	3.41 tons
10	Home has 13 SEER heat pump	Install Heat Pump SEER = 16	3.78 tons
11	Home has electric strip heat	Install Heat Pump SEER = 16	2.65 tons
12	Attic insulation = R-7	Add another R-23 attic insulation	1344 SF
13	Attic insulation = R-11	Add another R-19 attic insulation	1344 SF
14	Exposed walls not insulated	Add R-11 wall insulation	1355 SF
15	Floor over basement not insulated	Add R-19 Insulation to floor	614 SF
16	House infiltration = 0.8 ACH	Reduce infiltration to 0.35 ACH	2077 SF
17	Single pane windows A	Add storm windows	240 SF
18	Single pane windows B	Install Low E double pane window 2904	240 SF
19	Standard double pane windows	Install Low E double pane window 2904	240 SF
20	No E & W window shading A	Add solar screens to E & W glass	86 SF
21	No E & W window shading B	Plant deciduous trees on E & W sides	6 each
22	No Compact Fluorescent Lamps	Use 10 more CFLs throughout house	10 CFLs
23	Refrigerator needs to be replaced	Purchase Energy Star refrigerator	1 each
24	Refrigerator early retirement	Removed unit uses no energy	1 each
25	Dishwasher to be replaced	Purchase Energy Star dishwasher	1 each
26	Clothes washer to be replaced	Purchase Energy Star clothes washer	1 each
27	No prgrammable thermostat	Install programmable thermostat	1 each
28	No faucet aerators	Install faucet aerators	1 each
29	No low flow shower heads	Install low fow shower heads	2 each
30	Hot water pipes not insulated	Insulate hot water pipes	1 each
31	Electric water heater not wrapped	Wrap electric water heater	1 each
32	Gas water heater not wrapped	Wrap gas water heater	1 each

Table 1: Potential Situations and Improvements Evaluated in this Study

Several of the listed improvement options represent multiple ways of dealing with a single potential situation. For example, low evaporator airflow (ID 3 and 4) may be rectified by increasing duct capacities or increasing the speed of the blower. The potential situation in this case is denoted as "A" or "B", respectively. The cost of implementation of each improvement option is based on the "Quantity" defined in the last column of the table, where labor costs are assumed at $50/hour.

Interpretation of Field Data and Creation of DOE2 Models

As previously described, information gathered for this project included detailed house construction features and demographic information from on-site audits and telephone surveys. Monthly electric billing data obtained from the utility companies were utilized for 259 of these homes (data for the other homes were either not available or not used due to inconsistencies in the billing records).

RLW employed specially created DOE2 models based on the average shell and demographic characteristics of all the sampled homes to estimate potential savings. These models were designed to exhibit weekday, weekend and monthly variations in energy consumption derived from over 100 hourly schedules, which in turn were created from previously metered hourly end-use data. Each model is capable of producing valid seasonal energy savings and peak demand savings. Savings are actually based on differences in hourly demand over a full 8,760 hours. Demand savings can be observed for any hour or demand window of interest, but those reported for this study are coincident summer and coincident winter peak demand savings. As such, they are additive.

First, an "as-is" model for each house type was created to represent the average characteristics of all homes in the sample for that type. Individually calenderized, averaged and weather-normalized monthly billing data were used to calibrate the models. Each group was averaged monthly to establish actual monthly electric energy kWh to be used as calibration targets. Independent adjustments of uncertain variables (within their ranges of uncertainty) for monthly lighting, miscellaneous appliance loads, and monthly temperature setpoints for cooling and heating were made. These adjustments allowed for proper calibration of these models to within 1% annually of their weather-normalized kWh usage.

Many of the descriptive components of the "as-is" home that were used in the DOE2 models are listed in Table 2 below. These are two-story houses (the areas of the second stories vary with house type) with partial (i.e. about 75%) basements, portions of which are heated and cooled. The total heated floor area of each house model is the average of those measured during the site visits. The total conditioned areas of these houses were 2000 square feet (gas heated), 2120 sq. ft. (electric strip heated) and 2496 sq. ft. (heat pump heated).

The models contain three conditioned zones, consisting of a first floor, a second floor and a conditioned portion of the basement. They also contain six unconditioned zones to capture the effects of the heat transfer through ceilings, garage walls and floors over the garage and unconditioned portions of the basements. These buffer zones also provide a means for modeling duct supply and return air leakage to and from these spaces, as well as duct conduction heat transfer to and from the attic.

Exterior shading is modeled by two-foot eaves on the north and south sides and varying amounts of 40-foot high non-deciduous "trees" on the east, south and west faces of the house. The solar transmissivities[3] of these "trees" are varied by height and from model to model to aid in calibration. Interior shading of the glass is modeled by light drapes that are fully open at times and partially closed at other times, which would follow a realistic schedule of occupant behavior. These input parameters are varied as required to model the baseline and retrofit conditions of the two window shading options, IDs 20 and 21.

[3] That is, the amount of sunlight that still passes through the tree's summer foliage.

	DOE2 Calibrated Model Value		
Model Characteristic	**Gas Heat**	**Strip Heat**	**Heat Pump**
Number of audits in sample	205	30	30
First floor conditioned area, sq. ft.	1,064	1,064	1,064
Second floor conditioned area, sq. ft.	750	756	1092
Conditioned basement area, sq. ft.	186	300	340
Unconditioned basement area, sq. ft.	614	500	460
Garage area, sq. ft.	280	280	280
% glass to heated floor area	13.7%	14.5%	13.5%
Window glass type	Double-pane clear	Double-pane clear	Double-pane clear
Solar screens?	No	No	No
Infiltration ACH	0.50	0.50	0.44
Wall insulation R-value	11.0	14.0	14.0
Attic insulation R-value	21.0	25.6	23.4
Number of occupants	2.9	2.8	2.8
Lighting connected load kW	4.08	5.3	4.0
Lighting peak usage kW	1.9	2.5	1.9
Misc connected load kW	5.9	8.5	7.6
Misc peak usage kW	4.2	6.3	5.4
Base elec. usage, kWh/year	8,686	12,616	10,135
Base gas usage, Therms/year	322.9	84.4	217.7
Cooling system type	DX Split	DX Split	DX Split
A/C rated SEER	11.20	11.20	12.00
A/C rated tons	3.41	4.07	4.03
Metering device (TXV, Capillary)	Capillary	Capillary	Capillary
AC Air flow factor	0.85	0.85	0.85
AC Refrigerant charge factor	0.94	0.85	0.95
AC Field Operating SEER	9.87	8.92	10.68
AC Field Operating tons	3.06	3.27	3.66
AC Supply air cfm/ton	340	340	340
AC Supply duct air loss	15%	17%	15%
Duct heat gain factor U*A	29.0	34.6	24.2
Portion of ductwork in attic	50%	60%	50%
Alternate fueled fireplaces (wood)	4%	19%	8%
Heating sytem type	Gas Furnace	Elec. Furnace	Heat Pump
Heating system rated efficiency	81%	100%	3.58 COP
Heating system operating efficiency	75%	100%	3.19 COP
Heating rated capacity, Btu/hour	85,500	51,180	53,000

Table 2: DOE2 Calibrated Model Characteristics

Internal and external energy (both electricity and gas) used for lighting, appliances, and hot water vary hourly according to end-use metered data from other studies. These also vary monthly to follow a typical pattern and allow calibration of the model to match actual utility billing data. Cooling and heating temperature set points were also allowed to vary both hourly and monthly to represent measured data from other studies, as well as to provide fine tuning of the model for calibration.

Cooling and heating system characteristics are shown in Table 2. These values are typical of those observed in this study or borrowed from other similar studies. The airflow factor and AC refrigerant charge factors, for example, are from other studies in which air conditioner performance data were measured. These are used in the models to adjust rated capacity and efficiency to typical operating values.

Calculation of Individual Measure Impacts

The savings for each measure were calculated separately for each DOE2 model. The average savings per house were then calculated as the population-weighted averages of the model savings. For purposes of this study, the KCP&L population of single family detached homes was set at 333,207. The related weighting fractions, based on the sample populations, are 0.774, 0.113 and 0.113, for gas, strip and heat pump homes, respectively.

Weighted average savings estimates for each measure and optional retrofit improvement are summarized in Table 3. Although electric savings for all three house types and all thirty-two measures were calculated, they are not explicitly represented by these averages due to the weighting. Instead, they represent average savings per measure for the mixed population.

The shaded ID numbers represent the measures and options that have been identified by RLW as priority measures. These are the top 20 measures ranked by annual energy savings potential for KCP&L. The blank shaded cells represent housing types where the respective measure does not apply. For example, ID 10 is a heat pump replacement measure that applies only to homes with heat pump heating systems, and ID 11 is a heat pump replacement of an existing electric strip heating system.

Savings for ID numbers 28 through 32 in Table 3 are not directly calculated by DOE2, and the savings for these were taken from the results of previous studies. Direct impacts for lights and appliances located within the conditioned space were programmed into the DOE2 models, however, to capture their secondary impacts on cooling and heating loads.

ID	Therms	Total kW	Cool kWh	Heat kWh	Other kWh	Total kWh	Payback, kWh Only	Payback, all Fuels	Diff. Costs Before Rebate	Diff. Costs After Rebate
1	0	0.18	640	49	0	689	2.6	2.6	$250	$125
2	0	0.12	167	9	0	176	4.1	4.1	$100	$50
3	56	0.82	938	43	0	981	7.0	3.4	$950	$475
4	67	0.67	758	49	0	807	0.9	0.4	$100	$50
5	64	0.45	494	112	0	606	7.2	2.5	$600	$300
6	0	0.27	286	47	0	333	6.9	6.9	$314	$157
7	0	0.83	947	99	0	1046	1.5	1.5	$210	$105
8	45	0.24	184	58	0	242	18.1	4.1	$600	$300
9	0	-0.11	921	0	0	921	6.6	6.6	$840	$420
10	0	-0.52	693	565	0	1258	4.3	4.3	$750	$375
11	0	-0.48	952	3109	0	4061	8.6	8.6	$4,800	$2,400
12	83	0.54	523	357	0	879	8.8	3.2	$1,058	$529
13	50	0.35	326	215	0	541	10.9	4.0	$809	$405
14	360	0.69	1006	1627	0	2634	9.7	2.8	$3,500	$1,750
15	33	-0.12	-408	185	0	-223	-12.8	7.5	$393	$197
16	195	0.43	140	906	0	1046	2.8	0.6	$400	$200
17	143	0.28	196	712	0	908	8.2	2.1	$1,020	$510
18	124	0.54	801	627	0	1428	1.8	0.7	$350	$175
19	-19	0.26	644	-124	0	520	5.0	15.5	$357	$179
20	0	0.22	172	0	0	172	10.9	10.9	$258	$129
21	0	0.18	627	0	0	627	10.4	10.4	$900	$450
22	-9	0.05	129	-89	504	543	1.1	1.5	$80	$40
23	-2	0.02	65	-47	134	152	9.6	11.8	$200	$100
24	-13	0.12	179	-90	865	954	0.4	0.5	$50	$25
25	6	0.01	14	0	93	107	10.2	4.8	$150	$75
26	9	0.02	18	0	93	110	26.4	11.0	$400	$200
27	27	-0.22	566	100	0	666	2.2	1.3	$200	$100
28	7	0.00	4	0	27	31	1.9	0.4	$8	$4
29	22	0.00	9	0	165	174	0.8	0.3	$20	$10
30	11	0.00	0	0	80	80	8.6	2.5	$95	$48
31	0	0.00	0	0	58	58	3.1	3.1	$25	$13
32	11	0.04	118	0	0	118	N/A	1.4	$60	$30

Table 3: Electric/Natural Gas Savings by Measure and Heating System Type

Differential costs shown in the last two columns for each measure are the average costs to install the measure, or, the difference in cost between a standard retrofit and the high efficiency option. These costs are homeowner perspectives, so they are reduced to half when a 50% rebate is applied. Payback for all fuels is the simple payback in years, or the ratio of annual fuel dollars saved - including natural gas therms and electric total kWh - and differential installed cost. Paybacks based on kWh savings alone (excluding therms) are also shown in the table.

Dollars saved are based on annual electric and gas savings and their respective marginal residential customer rates. Differential costs for ID numbers 6 and 7 had to be defined based on their net effects on contractor sales (assumed here to be 20% of the differential installed costs) because they cost less to install than their standard retrofit choices. Otherwise their differential costs would be negative, and their payback values would also be negative, and therefore cannot not be defined.

For this one exception we will assume that the homeowner pays the contractor for the loss of sales revenue to put this net cost differential onto the homeowner. Contractors who participate could add these costs to their bids so that they break even financially, and the homeowners would still realize the 80% remaining savings in differential costs. In this case, both the perceived costs (20% of the differential cost savings) and energy savings apply to the homeowner, and a payback period becomes (loosely) meaningful. This is all hypothetical, and incentives for this measure would have to be directed to the AC installation contractors, and not the homeowners. This situation imposes a formidable market barrier.

Situation and Measure Improvement Descriptions

The following are descriptions of each listed measure and improvement option, explanations of the assumptions made, and the technical approach to estimating impacts.

Undercharged AC Systems – ID 1

Published accounts from several other studies, including a New England HVAC study conducted by RLW in 2002, were used to estimate the technical potential percentages for AC systems. From these studies, about 36% of the measured systems are probably undercharged with refrigerant, which would be enough to exhibit recognizable symptoms. The average undercharged condition was modeled as a 20% reduction in both cooling capacity and efficiency. This 20% reduction represents a general consensus of the other studies.

In the baseline DOE2 models, the refrigerant charge factor was adjusted to 0.8 to reflect this 20% loss. In the retrofit models this factor was set to 1.00 to reflect a properly charged system. At this point the operating capacities and efficiencies were still slightly below rated values due to the fact that evaporator airflow is still a little low. This refrigerant charge correction resulted in an estimated annual savings of 689 kWh, and a peak demand reduction of 0.18 kW per application.

Overcharged AC Systems - ID 2

About 31% of the measured AC systems found in other studies were found to be overcharged with refrigerant. The average effect of this situation, however, is not nearly as dramatic, with only a 5% reduction in both cooling capacity and efficiency. This was represented in the models by a refrigerant charge factor of 0.95, which is in fact the average operating condition. The frequency, degree, and impact of overcharging are not as great as undercharging.

In the retrofit models the refrigerant charge factor was set to 1.00. This resulted in an estimated annual savings of 176 kWh, and a peak demand reduction of 0.12 kW.

AC Systems with Low Evaporator Air Flow – IDs 3 and 4

According to recent studies, about 70% of residential AC systems have a problem of significantly low evaporator airflow. The threshold for this performance characteristic is considered 350 CFM per ton, which is generally used as the lowest acceptable flow rate before capacity and efficiency are appreciably reduced. The average airflow for all those below the threshold was about 300 CFM per ton.

In the baseline DOE2 models the system airflow rate was set at 300 CFM per ton. In the retrofit models this was increased to 400 CFM per ton.

Two different approaches to the correction of a low airflow problem were examined because the associated costs and impacts of each are significantly different. The easiest, and least expensive, solution is to increase the blower speed whenever practical. In many cases, however, this will not be practical due to the presence of single speed blowers or a limited remaining blower capacity.

The other approach is to reduce airside system operating pressures by locating and removing restrictions or by increasing duct capacities. In an existing system the only practical ways to increase supply duct capacity are to replace existing ductwork with larger runouts to several rooms, or add more runouts at or near the supply plenum to new supply grilles.

In past studies, it was found that many return duct systems are simple but undersized. Return duct undersizing often occurs with systems in the attic that have one central return air filter grille in the ceiling of a corridor with one large flexible duct to a return plenum. In most, if not all, cases these can be replaced with larger ducts and return grilles, or new ducts and grilles can be added in parallel.

Any reliable and practical correction to the problem of low airflow would have to be determined by a careful on-site analysis of each problematic system. Often it may be necessary to combine fan speed corrections with increased supply and return duct capacities to obtain proper airflow at a reasonable cost.

The retrofit DOE2 model for increased duct capacity, ID 3, assumed that the total static pressure of the air distribution system could be reduced enough to allow the existing blower to deliver the required air flow without increasing the blower speed. The blower power was increased linearly with the increased airflow rate, and the system capacities and efficiencies were increased to rated conditions. This resulted in an estimated annual savings of 981 kWh, and a peak demand reduction of 0.82 kW.

The retrofit model for increasing blower speed, ID 4, required an increase in motor power equal to the square of the ratio of the flow rates. The increased fan power offset some of the energy savings due to increases in system capacity and efficiency. This resulted in an estimated annual savings of 807 kWh, and a peak demand reduction of 0.67 kW.

AC Systems with High Duct Leakage – ID 5

In the recent New England study that RLW conducted, it was found that about 73% of the AC systems had a problem of significantly high supply duct leakage to the outside. The threshold for supply air leakage was 15% of actual system airflow. The average leakage for all those above the threshold was 25 percent. The systems with high duct leakage do not seem to correlate at all with duct location or plenum static pressure. Based on field observation, however, these systems were characterized by poor installation workmanship, and they tended to be older than others.

The DOE2 model treats duct leakage as primary air delivered to and returning from unconditioned spaces such as attics and basements. About one third of the leakage was assigned to the unconditioned portion of the basement, and the remainder went to the first and second floor attic spaces. This leakage air actually tends to cool these spaces slightly, and they are modeled as buffer zones so that return leakage from them approximates the actual zone conditions. In this way, the primary effects of both supply and return air leakage to these spaces are captured in the model.

The baseline model used 25% duct leakage, and this was reduced to 5% in the retrofit case. This resulted in an estimated annual savings of 606 kWh, and a peak demand reduction of 0.45 kW.

In this analysis the inherent but small reduction in evaporator airflow was not modeled because an average value was not known.[4] Many systems with leaky ductwork also suffer from insufficient airflow. In the New England study RLW found that about 79% of those with high duct leakage also had low airflow below 350 CFM per ton. Additionally, it was observed that 29% had a high blower motor power over 150 Watts per ton. The sealing of leaky ducts will tend to reduce air flow through the evaporator coil. In practice, therefore, it is necessary to measure the existing system airflow and blower motor power to determine if these other two potential problems need to be corrected before duct sealing is attempted.

Proper Sizing of AC Systems – IDs 6 and 7

An oversized system in this study is defined as having a rated cooling capacity greater than 100% of a valid Manual J cooling load estimate[5]. Based on an average Manual J estimate of capacity in terms of square feet per ton and the individually observed home sizes and installed capacities, about 80% of the AC systems of this study are oversized relative to this criterion. It was found in the 2002 study by RLW that those that qualified as oversized averaged about 50% above the Manual J estimate.

[4] The effect on energy usage is even smaller due to offsetting effects of fan power and system efficiency.

[5] The Air Conditioner Contractors of America (www.acca.org) maintains a Manual J Residential Load Calculation Procedure. This is the accepted industry standard, approved by ANSI, for the proper sizing and selection of HVAC equipment in residential homes.

The DOE2 models estimate the cooling system efficiency each hour as a function of a part load ratio. This is the ratio of system load and cooling capacity, and the function is empirically designed to approximate the efficiency penalty due to system cycling.

In the baseline model for ID 6 the systems were oversized by about 1.6 tons, and the retrofit was sized to 100% of Manual J, while the airflow and duct sizing was maintained at 360 CFM per ton. The rationale for maintaining this airflow rate is the probability that the same duct sizing practice will be applied by the contractor based on system size. This would be applicable to new AC systems that are installed where there is no existing ductwork. The estimated annual savings is 333 kWh, with a peak demand reduction of 0.27 kW.

On the other hand, if a new system is to be installed to replace an old system or with an existing forced air furnace that already has supply and return ductwork, the contractor may not install new ductwork. In this scenario, ID 7, there is even more to gain by keeping the system size to a minimum. This is due to the fact that the existing ductwork would be able to deliver the same airflow in CFM as before with the same fan power (which would become a higher CFM per ton as the tons are reduced), thus reducing the system losses due to low airflow and excessive system cycling.

The retrofit DOE2 models for this case assume that the duct sizes, airflow rates, and fan static pressures remain unchanged. Even though the fan power is not increased, the annual fan energy consumption increases due to the fact that the system operates for longer periods of time, and this is accounted for in the models. The estimated annual savings for this scenario is 1046 kWh, with a peak demand reduction of 0.83 kW.

The advantages of reducing system size are all positive as long as the system capacity is sufficient to maintain acceptable comfort conditions about 97.5% of the time (which are all but a few hours of the typical cooling season). The smaller system will typically maintain better humidity control, last longer, make less noise, use less energy and cost less to install.

Most of the problems of low evaporator airflow in houses with evaporator coils added to existing forced air furnaces could be greatly reduced or avoided if the AC system is properly sized for the application. In recent studies, about 70% of the systems that are oversized also have evaporator airflow below 350 CFM per ton.

Unfortunately, downsizing is not a viable option after the system has been installed. Therefore, as an effective conservation program component, information and incentives will need to be presented to prospective homeowner participants before they even contact a contractor. Information and incentives should also be directed toward the contractors.

Addition of Duct Insulation – ID 8

It was observed that most ducts in the basements were not insulated, whereas nearly all ducts in the attics had at least one inch of insulation. The only appreciable savings available would be due to the addition of another inch or two of insulation to exposed ducts in the attic. Exact modeling of this was not within the scope of this project, but some assumptions were made regarding the duct heat gains due to conduction from a hot attic.

In the baseline DOE2 models it was assumed that 90% of the ducts were located in the attic and the product of U*A (i.e. thermal conduction coefficient times duct surface area) would be about 49.7, yielding an approximate peak air temperature rise of 1.0 degree Fahrenheit during the cooling cycle. In the retrofit case this U*A value was reduced to about 20.5. The estimated annual savings for this measure is 242 kWh, with a peak demand reduction of 0.24 kW.

High Efficiency SEER 16 AC in Gas Heated Homes – ID 9

Significant savings are potentially available for the installation of high efficiency AC systems instead of standard efficiency SEER 13 units. In the existing home retrofit market this might be applied to homes with old existing systems that are at the end of their useful operating lifetimes and need to be replaced. This might also apply to an existing home in which air conditioning was never before installed and the homeowner wants to install a new central AC system. Modeling the unit savings for this measure was straightforward. The baseline DOE2 model was assigned a rated efficiency of SEER 13, and the retrofit model used SEER 16. Additionally, the expansion device for both was changed from a capillary tube to a thermal expansion valve (TXV). All other conditions remained unchanged. The estimated annual savings for this measure is 921 kWh, with a peak demand reduction of -0.11 kW. The peak demand reduction is negative because a practical SEER 16 AC unit is achieved by applying a dual-speed compressor to an otherwise lower efficiency system. RLW found that a combination of an SEER 11 system and a dual speed compressor would yield a system that would be ARI rated at about SEER 16. The retrofit peak efficiency, however, is actually lower than the baseline peak efficiency.

High Efficiency SEER 16 Heat Pump – IDs 10 and 11

The installation of a high efficiency heat pump might be an option as a retrofit measure for existing homes with old heat pumps or with electric resistance heat.

The base case model for an old heat pump replacement, ID 10, assumed the baseline replacement heat pump would have been an SEER 13 heat pump. The retrofit model was similar to the SEER 16 AC, except it was equipped for reverse cycle operation. Potential savings for this option are about 1258 kWh and -0.52 kW for the average home.

The base case models for an electric resistance heat system replacement, ID 11, assumed the replacement equipment would be same as above. Potential savings calculated for this option were 3109 kWh and -0.48 kW. Average savings for electric strip heated homes is a little lower than anticipated due to the fact that the average electric strip heated home is slightly better insulated, and the occupants are more frugal in their energy usage practices (due to naturally reoccurring high heating costs). Additionally, there may be some significant “takeback” behavior involved. After upgrades are done, a homeowner would perceive heating bills are lower, and take some of the potential savings back in terms of increased comfort

Add Attic Insulation – IDs 12 and 13

Savings achievable for increasing attic insulation vary greatly with the amount of insulation already in place, as well as the amount of extra insulation added. Whether this is cost effective depends more on the amount of existing insulation. Two different baseline insulation values of R-7 and R-11 were assumed. In both retrofit scenarios the final R-value was R-30. Addition of any more than this is typically not cost-effective.

In the first scenario, ID 12, the baseline models were given an attic insulation value of R-7 with a retrofit to R-30. The calculated savings are 879 kWh and 0.54 kW. In the second scenario, ID 13, the base case was R-11 and the retrofit was R-30. Savings were estimated to be 541 kWh and 0.35 kW.

Add Wall Insulation – ID 14

Similar to attic insulation, achievable savings by increasing wall insulation vary greatly with the amount of insulation already in place, as well as the amount of extra insulation added. Whether this is cost effective depends more on the amount of existing insulation. RLW evaluated this measure with a baseline of no wall insulation, and added R-11 insulation to represent a realistic best-case scenario.

The calculated savings are 2634 kWh and 0.69 kW. Due to the high cost of adding insulation to existing walls, however, the simple payback for this measure based on kWh savings alone is relatively long at about 9.7 years. But this measure achieves some significant gas savings on average of about 360 Therms, and the simple payback to the average homeowner is only 2.8 years after rebate.

Although the potential savings are high, the long payback suggests that it would not be cost-effective to insulate existing walls with some insulation already in place. In fact, the existence of any batt insulation in existing walls renders it impractical to add more insulation by the normal method of blowing it through holes drilled into the stud cavities, because the batts would tend to block the flow of new insulation in many places.

Add Insulation to Floor over Unheated Basement – ID 15

Most basements are enclosed by thick masonry foundation walls and have direct contact with the earth. As such, they are naturally cooled by relatively low ground temperatures typical of Kansas City, where the averages are about 67 degrees Fahrenheit during the summer and about 43 during the winter.

As a result of the low ground temperatures, the savings are negative for most of the cooling season. The base case for this measure assumed no insulation and the retrofit provided for the addition of R-19 to the floors over the unconditioned basement areas. Calculated savings are -223 kWh and -0.12 kW. Due to differences in the costs of electricity and gas, the monetary savings from gas offset the increase in electricity usage, and the simple payback is about 7.5 years.

Reduce Infiltration by Caulking and Weatherstripping – ID 16

For this measure RLW assumed a baseline infiltration value of 0.8 ACH (Air Changes per Hour) and a retrofit of 0.35 ACH. RLW learned from several studies in different parts of the country that the average home infiltration rate is about 0.5 ACH. Calculated savings for weatherization measures are 1046 kWh, most of which (about 90%) is due to reduced heating requirements in electric heated homes, and 0.43 kW.

Add Storm Windows to Standard Single Pane Windows – ID 17

The average house in this study has about 240 square feet of window area. Less than 6% of the windows in this study were single pane, about 68% were double pane and 26%, were triple pane, counting those with storm windows. The overall average number of glass panes is 2.2, based on the study sample.

RLW used a typical single pane window with a U0 (thermal transmission coefficient) value of 1.09 and a SHGC (Solar Heat Gain Coefficient) of 0.81 for the base case, and applied storm windows in the retrofit case. The retrofit window structure had a U0 of 0.46 and a SHGC of 0.76, and the estimated savings were 908 kWh and 0.28 kW.

Replace Standard Single Pane Windows – ID 18

RLW used a typical single pane window with a U_0 value of 1.09 and a SHGC of 0.81 for the base case, and applied a typical high performance double pane window in the retrofit case. The retrofit window had a U_0 of 0.40 and a SHGC of 0.55, and the estimated savings were 1428 kWh and 0.54 kW.

Replace Standard Double Pane Windows – ID 19

RLW used a typical double pane window with a U_0 (thermal transmission coefficient) value of 0.46 and a SHGC (Solar Heat Gain Coefficient) of 0.76 for the base case, and applied a typical high performance double pane window in the retrofit case. The retrofit window had a U_0 of 0.40 and a SHGC of 0.55, and the estimated savings were 520 kWh and 0.26 kW.

Add Shading to East and West Facing Windows – IDs 20 and 21

Although external window shading might be added to all four faces of a house, the east and west faces offer the greatest potential savings. Also, to obtain maximum energy savings, the shade would have to be applied during the cooling season and removed during the heating season to avoid increasing the heating loads during the winter.

RLW considered and analyzed two different ways of shading east and west facing windows for this study, because one method will apply to some, while the other method is better for others. Neither alternative will be applicable to homes with significant east

and west shading from existing trees or other things. To model these measures RLW removed all but about 5% of the external shading from the calibration models.
One practical method, ID 20, of shading windows from the exterior is the addition of solar screens that can be removed during the heating season. To model this retrofit, RLW increased the calibrated model east and west building shade transmissivities from about 0.7 to about 0.95 for the base case and the U_0 value from 0.8 to 0.7 for the period of June 1 to October 31. To simulate the addition of solar screens, RLW reduced the SC of the east and west windows by half and the U_0 value from 0.9 to 0.8 for July 1 through August 31. Estimated savings for this scenario are 172 kWh and 0.22 kW.

The other (and more desirable from both an aesthetic and practical perspective) method is the planting of deciduous trees in strategic locations to the east and west of the house. In this scenario, (ID 21) RLW assumed that three deciduous trees had been planted at about 20 feet from each side of the house (a total of six trees) to shade the windows as much as possible, and that they had grown to an effective height of 20 feet. Their solar transmissivities were changed from 0.1 during the summer (June 1 through October 31) to 0.9 during the winter. Resultant savings are 627 kWh, 0.18 kW. As these trees continue to grow, the savings will increase.

Install Compact Fluorescent Lamps – ID 22

Field data from the site visits indicated that the average home had about 9.7% CFL's (Compact Fluorescent Lamps) by bulb count. Hence, there is a high technical market potential for this measure. In the impact analysis RLW assumed that each program participant would install and use an average of ten 15-watt CFL's to replace ten 60-watt incandescent lamps, for a connected load reduction of about 450 Watts.

Lighting hourly usage patterns utilized in the models are based on actual measured hourly residential lighting usage patterns from a large number of long-term and short-term end-use studies RLW has performed or examined. Calculated savings amounted to 504 kWh and 0.05 kW. The peak heating load was not measurably affected because it occurred during the night when the lights are not being used.

One may note that the peak kW savings was 0.05 kW, or 50 Watts, whereas the reduction in connected load was 450 Watts. This is due to natural diversity in the lighting usage patterns so that all ten of these lamps are never on at the same time. These electric savings include both direct and indirect savings due to the reduction in internal heat gains that reduce the need for cooling.

Purchase Energy Star Labeled Refrigerator – IDs 23 and 24

Two options for replacing an existing refrigerator with an Energy Star certified unit were examined in this study. The first option assumes that an existing refrigerator is at the end of its functional life and the homeowner has already decided to replace it. The other option examines the potential of enticing a homeowner to retire an existing refrigerator before the end of its functional life.

For the firs option, ID 23, it was assumed that a standard new refrigerator on the market today uses about 564 kWh per year, and an Energy Star refrigerator will use about 432 kWh per year (10% below the 2001 federal standard average of about 480). The difference is 132 kWh per year. This direct energy reduction was modeled into the retrofit DOE2 models, and the resultant total interactive net savings are 152 kWh and 0.02 kW. Some secondary impacts are seen due to the fact that the refrigerator is in the conditioned spaces. Gas heated homes realize the full operating reduction of 132 kWh, but electrically heated homes pay a heating penalty due to the fact that savings inside the house increase the need for heat in the winter.

The baseline for the second option, ID 24, was 850 kWh per year. The resultant total interactive savings due to removal of this unit are 954 kWh and 0.12 kW. In addition to interactive effects, it was assumed that the primary refrigerator will be used more, thus adding slightly to its annual kWh usage.

Purchase Energy Star Labeled Dishwasher – ID 25

An average new dishwasher uses about 121 kWh per year directly, and an equivalent Energy Star dishwasher will use about only about 78 kWh per year. Estimated savings for a house with a weighted combination of electric and gas water heaters are 107 kWh and 0.01 kW, most of which is due to savings in weighted average electric hot water usage.

On the other hand, more substantial electric savings are possible if the water heater is electric. In this scenario, the savings would be about 240 kWh per year and 0.02 kW peak demand.

Purchase Energy Star Labeled Clothes Washer – ID 26

Maximum electric savings for high efficiency clothes washers can be achieved if both the water heater and dryer are electric, although by far most of the savings is due to the dryer. The most common KCP&L home, however, uses natural gas for hot water. A significant number of homes had electric dryers (76%) and about 19% had electric water heaters.

For the typical home, RLW estimated annual savings to be about 110 kWh and 0.02 kW. The Energy Star clothes washer actually uses slightly more electric energy during the spin cycle to wring more water out, consequently reducing the time required for drying.

For the all-electric scenario, RLW estimated annual savings to be about 400 kWh and 0.04 kW.

Install Programmable Thermostat – ID 27

More than half of the homes visited already had programmable thermostats. RLW modeled the potential impacts of programmable thermostats by increasing the cooling setpoints 3.75 degrees F and decreasing the heating setpoints by 3.75 degrees F daily from 8AM to 3PM.

For this scenario RLW estimated annual savings to be about 666 kWh and -0.22 kW. Demand savings may actually be negative, as they are in this case, depending upon the setback schedule, the building mass and a thermal flywheel effect that causes the system to run longer to "make up" for the hours during which it was set back.

Install Faucet Aerators – ID 28

It was assumed, based on RLW's previous study for Missouri, that about 63% of all single family detached homes in Kansas City do not have a faucet aerator. RLW estimated the impacts of these by assuming that one faucet aerator would be installed on the kitchen sink, and that the energy savings would occur through a reduction in the use of hot water. The homes with gas water heaters will see no electric savings, but many of the homes in this study had electric water heaters.

The estimated savings for the typical home are 31 kWh and no measurable demand savings. For the 19% of homes with electric water heaters, the annual electric savings would be about 120 kWh and no peak demand. Actual demand savings may exist in some homes, but the schedule of kitchen faucet usage is small during the peak demand window.

Some homeowners may be willing to install and keep a faucet aerator in the bathroom. Although savings for these are not well defined, RLW has previously estimated that they might achieve about one tenth to one third the savings of the kitchen aerator. The reduced savings are, of course, due to the fact that the average bathroom sink utilizes significantly less hot water.

Install Low Flow Showerheads – ID 29

Field results of the previous study for Missouri indicate that about 40% of all single-family detached homes in Kansas City already use a low flow showerhead. RLW estimated the impacts of these by assuming that two low flow showerheads would be installed, and that the energy savings would occur through a reduction in the use of hot water. Again, the most common water heater is gas fired.

The estimated savings for the typical home are 174 kWh per year, and demand savings are negligible. For the 19% with electric water heaters the annual savings would be about 725 kWh and negligible coincident peak demand.

If there are more than two showers in a home, the low flow showerheads should be installed on the two most frequently used showers. If more than two devices are installed in a single home, the savings for the third one will probably be significantly less than those of the first two, but it will depend on how much the showers are actually used. On the other hand, if only one showerhead is installed because there is only one shower present, the savings for the one will probably be more than half the savings for two.

Insulate Hot Water Pipes – ID 30

All the audited homes of this study have hot water piping, but only portions of the pipes are easily accessible. RLW estimated conservation impacts by assuming that the exposed pipes could be insulated, and that the energy savings would occur through a reduction in the hot water standby losses. Again, the typical water heater is gas fired.

The estimated savings for the typical home are 80 kWh per year and negligible coincident peak demand. For the 19% with electric water heaters the annual electric savings would be about 355 kWh and negligible kW peak demand. Actual savings will vary significantly, depending on the amount and locations of exposed piping and the hot water usage patterns.

Insulate Electric Water Heater Storage Tanks – ID 31

RLW found that about 90% of the homes had electric water heaters that were not externally wrapped. The estimated savings for the typical home are 58 kWh per year and negligible kW. Savings for this measure will vary with the ambient temperatures surrounding the hot water tank.

Insulate Gas Water Heater Storage Tanks – ID 32

RLW found that about 91% of the homes had gas water heaters that were not externally wrapped. The estimated savings for the typical home are 11 Therms per year. Savings for this measure will vary with the ambient temperatures surrounding the hot water tank. Also, since some of the hot water tanks are located adjacent to or within conditioned spaces, RLW found that there were potential indirect electrical savings of about 118 kWh due to reductions in the cooling loads.

Technical Assessment of Program Market Potentials by Measure

Preferred Energy Conservation Measures

RLW initially analyzed 32 potential home improvement options. The 20 most promising measures, as ranked by annual electrical energy savings in MWh, offer nearly the same (about 97%) potential savings as all 32 measures combined. This is largely due to the presence of one measure (ID 15) that yielded significant natural gas savings but negative electrical energy savings.

Market potentials for all measures are shown in Table 4, with the top 20 highlighted. These measures are ranked by their estimated “Electric Savings Potential, MWh”. The base case situation is described in the third column, followed by seven columns of marketing metrics, all of which are defined in their respective column headings.

The market potentials of this study were calculated under the assumption that the program sponsors would identify appropriate measures for each home and would offer rebates of 50% of the differential costs for all measures. Appropriate measures would include all existing situations that fall below the minimum thresholds of performance.

The last three rows of the table show sums for the first six columns and averages for the last column. They are also self-explanatory. Notice that the top 20 measures capture 97.3% of the electric savings and 95.9% of the demand savings available through all 32 measures, while capturing 92.4% of the total potential gas savings and 94.9% of the customer annual fuel bill savings. On the other hand, the rebate costs necessary to capture these are reduced significantly, to 87.7%, and the average program rebate costs are reduced from $0.50 to $0.47 dollars per kWh saved. The gray cell in the last column has no meaning because the electric energy savings are either zero or negative for that measure.

KCP&L Energy Savings Measure			Potential Installs Per Year	Multiple Options	Demand Technical Potential	Demand Economic Potential	Demand Market Potential	Electric Technical Potential	Electric Economic Potential	Electric Market Potential	Gas Market Potential	Annual Fuel Savings	Utility Rebate Costs	Electric Rebate Costs
Pri	ID	Potential Situation	Count	Fraction	MW-S	MW-S	MW-S	MWh	MWh	MWh	kTherms	k$	k$	$/kWh
1	27	No prgrammable thermostat	17121	1.00	-43.7	-43.7	-3.7	133,143	133,143	11,402	464	$1,363	$1,712	$0.15
2	22	No Compact Fluorescent Lamps	18948	1.00	10.3	10.3	1.0	108,624	108,624	10,295	-161	$506	$758	$0.07
3	24	Refrigerator early retirement	5326	1.00	18.3	7.3	0.6	149,329	59,732	5,080	-70	$261	$133	$0.03
4	16	House infiltration = 0.8 ACH	3567	1.00	35.5	35.5	1.5	87,143	87,143	3,732	695	$1,126	$713	$0.19
5	29	No low flow shower heads	19992	1.00	0.0	0.0	0.0	34,775	34,775	3,478	439	$788	$200	$0.06
6	4	Low evaporator airflow B	3387	1.00	29.9	29.9	2.3	36,141	36,141	2,733	228	$473	$169	$0.06
7	1	AC Refrigerant under charged	3698	1.00	22.0	22.0	0.7	82,630	82,630	2,547	0	$175	$462	$0.18
8	32	Gas water heater not wrapped	17247	1.00	0.0	0.0	0.0	31,848	28,663	2,035	190	$377	$517	$0.25
9	3	Low evaporator airflow A	2039	1.00	190.8	190.8	1.7	228,775	228,775	2,000	115	$281	$969	$0.48
10	30	Hot water pipes not insulated	22684	1.00	0.0	0.0	0.0	22,677	22,677	1,816	247	$434	$1,077	$0.59
11	5	High duct leakage (25%)	2543	1.00	87.7	87.7	1.2	117,198	117,198	1,542	163	$310	$763	$0.49
12	19	Standard double pane windows	1801	1.00	66.3	19.0	0.5	132,033	37,907	937	-35	$21	$322	$0.34
13	2	AC Refrigerant over charged	4373	1.00	11.8	11.8	0.5	17,919	17,919	771	0	$53	$219	$0.28
14	21	No E & W window shading B	2363	0.50	26.8	19.6	0.2	94,081	68,679	741	0	$51	$1,063	$1.43
15	28	No faucet aerators	20992	1.00	0.0	0.0	0.0	6,573	6,573	657	146	$228	$84	$0.13
16	25	Dishwasher to be replaced	4874	1.00	1.8	0.6	0.1	16,472	5,238	524	32	$76	$366	$0.70
17	12	Attic insulation = R-7	479	1.00	180.8	14.6	0.3	293,038	23,736	421	40	$78	$253	$0.60
18	7	Oversized AC units B	382	1.00	221.8	15.5	0.3	278,891	19,522	399	0	$27	$40	$0.10
19	20	No E & W window shading A	4362	0.50	36.0	26.3	0.5	28,577	20,918	374	0	$26	$563	$1.50
20	26	Clothes washer to be replaced	3115	1.00	2.6	1.1	0.1	17,333	7,141	344	27	$57	$623	$1.81
21	14	Exposed walls not insulated	130	1.00	32.4	32.4	0.1	122,851	122,851	343	47	$82	$228	$0.66
22	31	Electric water heater not wrapped	5698	1.00	0.3	0.3	0.0	3,306	3,306	331	0	$23	$71	$0.22
23	23	Refrigerator needs to be replaced	1767	1.00	3.3	0.4	0.0	26,984	2,941	268	-3	$15	$177	$0.66
24	13	Attic insulation = R-11	485	1.00	7.3	7.3	0.2	11,363	11,363	262	24	$49	$196	$0.75
25	18	Single pane windows B	125	1.00	10.7	3.1	0.1	28,549	8,222	179	15	$32	$22	$0.12
26	9	Gas heat and 13 SEER AC	189	1.00	-28.2	-2.0	0.0	236,300	16,541	174	0	$12	$79	$0.46
27	8	One inch insul. on ducts in attic	670	1.00	40.0	12.0	0.2	39,902	11,970	162	30	$49	$201	$1.24
28	17	Single pane windows A	112	1.00	5.6	4.0	0.0	18,154	12,890	102	16	$27	$57	$0.56
29	6	Oversized AC units A	192	1.00	71.7	3.6	0.1	88,799	4,440	64	0	$4	$30	$0.47
30	11	Home has electric strip heat	9	1.00	-18.0	-1.3	0.0	152,910	10,704	38	0	$3	$22	$0.59
31	10	Home has 13 SEER heat pump	23	1.00	-15.6	-1.1	0.0	37,908	2,654	29	0	$2	$9	$0.30
32	15	Floor over basement not insulated	2316	1.00	-26.0	-13.0	-0.3	(49,351)	(24,675)	-516	77	$61	$455	
		Sums and Average, All Measures	171,008	**All 32**	982	494	7.8	2,634,874	1,330,339	53,265	2,727	$7,068	$12,555	$0.50
		Sums and Average, Top 20	159,292	**Top 20**	899	448	7.5	1,917,198	1,147,133	51,829	2,520	$6,710	$11,006	$0.47
		Top 20 Percent of All	93.1%	**% Top 20**			95.9%			97.3%	92.4%	94.9%	87.7%	94.7%

Table 4: Market Potential Metrics for All 32 Measures

Calculation of Market Potentials

The realizable market potential of a measure may be defined to represent the extent to which a measure might actually be applied annually throughout the service area over a reasonable period of time, which can be 5 to 15 years of full implementation of a well-designed conservation program.

KCP&L market potentials for each measure were calculated by multiplying together the individual savings per measure, the realizable market potentials in terms of percentages, and the total current number of single-family detached homes throughout the service area. These realizable potential savings are presented in terms of a) total electric demand in megawatts, b) electric energy savings in megawatt-hours, c) natural gas in kilotherms and d) thousands of dollars. Effects of possible population growth over the projected time period were not considered in this study.

Figure 1 below shows a general market potential schematic. Moving from left to right, the “Technical Potential” for the intended program or measure can be defined as the percentage of all targeted customers that a measure may be applied to, regardless of cost. The “Raw Economic Potential” reflects the percentage of eligible homes in which the measure can be economically applied.

The expected actual penetration rates under different program scenarios, or the “Market Potential”, involves the estimation of how many customers might participate in a specific program over a given time period. That is, the “Market Potential” indicates the percentage of targeted homes that would install the measures delivered by well-defined and aggressively executed programs. The values, of course, depend on the measures, the length of time the program is offered, the specific markets, numbers of customers targeted, and finally the level of subsidy (if any).

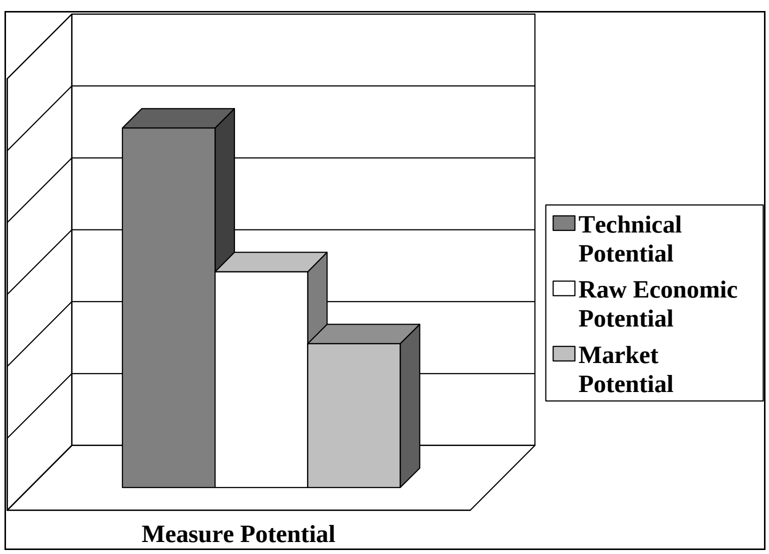

Figure 1: Market Potential Schematic

This measure potential schematic can be applied to the residential population of KCP&L as follows:

(1) The "Technical Potential" is the total number of single-family detached homes that a measure might actually be applied to without regard to cost. Using deciduous shade trees as an example, the "Technical Potential" for this study is the percentage of all single-family detached residential customers who have air-conditioned homes and have space in their yards to plant trees on the east and west sides of their houses. Homes that are not air-conditioned will not be eligible for this measure because there would be no technical basis for obtaining energy savings.

(2) The "Raw Economic Potential" was determined through analysis of the in-home audits and telephone surveys to assess what percent of qualified customers could achieve savings through installation of the measure, within the realm of economic feasibility. For example, it would not be economically feasible for a homeowner to replace existing double pane windows with higher performance windows solely for the purpose of saving energy, even though the home is technically eligible. The total cost of replacing windows is far too great to incur on these terms alone. If, however, the windows need to be replaced for other reasons (such as excessive age and unacceptably poor condition) the much smaller differential cost of choosing high performance windows over standard windows is economically feasible from an energy savings perspective.

(3) The final "Market Potential" was estimated through existing utility research and past participation rates in other programs. The primary factors that influence marketing potential at the customer level are first cost, annual savings, payback and intangible market barriers. Necessary driving factors include the existence of energy and demand conservation programs with aggressive marketing strategies, meaningful rebates or other incentives to offer and effective delivery mechanisms and strategies.

Table 5 below lists the 32 measures that were analyzed in this study. This table shows ID numbers, their potential situations, improvement options, and three columns of market potential estimates. The "Technical Potential (% of Homes that Qualify)" is the "Technical Potential" previously described. The last column, "Raw Economic Potential (% of Population)" is the previously defined "Raw Economic Potential". It is simply the product of the "Technical Potential (% of Homes that Qualify)" and the "Economically Feasible (% of Technical Potential)".

ID	KCP&L Energy Savings Measure: Potential Situation	Improvement	Technical Potential (% of Homes that Qualify)	Economically Feasible (% of Technical Potential)	Raw Economic Potential (% of Population)
1	AC Refrigerant under charged	Add refrigerant	36%	100%	36%
2	AC Refrigerant over charged	Remove refrigerant	31%	100%	31%
3	Low evaporator airflow A	Increase duct sizes or add new ducts	70%	100%	70%
4	Low evaporator airflow B	Increase blower speed	13%	100%	13%
5	High duct leakage (25%)	Reduce duct leakage to 5%	58%	100%	58%
6	Oversized AC units A	Size AC units to 100% of Manual J	80%	5.0%	4.00%
7	Oversized AC units B	Size AC units to 100% of Manual J	80%	7.0%	5.6%
8	One inch insul. on ducts in attic	Add two more inches of insulation	49.5%	30%	14.9%
9	Gas heat and 13 SEER AC	Install AC SEER = 16	77.0%	7.0%	5.4%
10	Home has 13 SEER heat pump	Install Heat Pump SEER = 16	9.0%	7.0%	0.63%
11	Home has electric strip heat	Install Heat Pump SEER = 16	11.3%	7.0%	0.79%
12	Attic insulation = R-7	Add another R-23 attic insulation	100.0%	8.1%	8.1%
13	Attic insulation = R-11	Add another R-19 attic insulation	6%	100%	6%
14	Exposed walls not insulated	Add R-11 wall insulation	14%	100%	14%
15	Floor over basement not insulated	Add R-19 Insulation to floor	66%	50%	33%
16	House infiltration = 0.8 ACH	Reduce infiltration to 0.35 ACH	25%	100%	25%
17	Single pane windows A	Add storm windows	6.0%	71%	4%
18	Single pane windows B	Install Low E double pane window 2904	6.0%	29%	2%
19	Standard double pane windows	Install Low E double pane window 2904	76%	29%	22%
20	No E & W window shading A	Add solar screens to E & W glass	100%	73%	73%
21	No E & W window shading B	Plant deciduous trees on E & W sides	90%	73%	66%
22	No Compact Fluorescent Lamps	Use 10 more CFLs throughout house	60%	100%	60%
23	Refrigerator needs to be replaced	Purchase Energy Star refrigerator	53%	11%	6%
24	Refrigerator early retirement	Purchase Energy Star refrigerator	47%	40%	19%
25	Dishwasher to be replaced	Purchase Energy Star dishwasher	46%	32%	15%
26	Clothes washer to be replaced	Purchase Energy Star clothes washer	47%	41%	19%
27	No prgrammable thermostat	Install programmable thermostat	60%	100%	60%
28	No faucet aerators	Install faucet aerators	63%	100%	63%
29	No low flow shower heads	Install low fow shower heads	60%	100%	60%
30	Hot water pipes not insulated	Insulate hot water pipes	85%	100%	85%
31	Electric water heater not wrapped	Wrap electric water heater	17%	100%	17%
32	Gas water heater not wrapped	Wrap gas water heater	81%	90%	73%

Table 5: Technical and Raw Economic Market Potentials for Preferred Measures

The final "Market Potential" estimates of this study are based partly on historical penetrations of existing programs in other states and partly on an analytical model designed to utilize the differential costs and simple payback periods calculated, and a market barrier factor for each measure.

Table 6 shows the results of the market analyses for the program measures included in this study. The "Quantity" column shows the quantity of each item that was modeled in the impact analysis and used as a basis for estimating the associated differential installed cost of each measure. For example, if the homeowner has to choose between installing a measure or not installing it, the cost is total installed cost. On the other hand, if the choice is between a standard efficiency unit and a high efficiency unit, the applicable cost is the incremental cost between the two options. Utility program rebates are designed to render the first cost and payback of a measure beneficial and desirable to a qualifying homeowner.

"Raw Economic Potential %" is the same as that shown in Table 5 under "Raw Economic Potential (% of Population)". The qualitative "Market Barrier Factor" is shown in the next column of Table 6. The column labeled "Annual Market Capture %" shows the results of the analytical model previously mentioned. It represents the probability that a given measure will be adopted based solely on its installed cost, simple payback, and market barrier factor. In the model this probability is inversely proportional to the installed cost, the simple payback and the market barrier factor. First cost was assigned an importance equal to three times that of the payback period.[6]

The market barrier factor captures the effects of known non-economic market barriers by using a discreet value of 1, 2 or 3. A 1 indicates that little or no known barriers exist, a 2 indicates average barriers and a 3 indicates the existence of formidable barriers. For example, ID 21 represents the option of adding solar screens to the east and west facing windows for shading. This option was assigned a market barrier factor of 3 because major non-economic market barriers here are the diminished appearance of the home perceived by most homeowners, and the fact that they have to be removed and replaced each year to achieve their potential savings.

The analytical model also includes a scaling constant to permit calibration of the model to known conservation program results. Annual market penetrations expressed as percentages were found for recent programs throughout the country for several of the measures, including high performance windows, compact fluorescent light bulbs, and Energy Star appliances (refrigerators, dishwashers and clothes washers). The analytical model was calibrated by iteratively adjusting the scaling factor until the model agreed with the overall average of the percentages of these existing programs.

The "Yearly Realizable Potential %" column shows the actual estimated "Market Potential" for each measure. It is the product of the "Raw Economic Potential %" and the "Annual Market Capture %".

The last column of Table 6 shows the actual counts of potential applications per year for each measure. This is the product of the yearly realizable potential and the target population (333,207 single family detached homes).

[6] In previous market assessment and market potential studies done by RLW, we have found that after other barriers are diminished or eliminated, first cost continues to remain as the primary barrier by about a 3 to 1 margin.

KCP&L Energy Savings Measure				Raw Economic Potential	Market Barrier	Annual Market Capture	Yearly Realizable Potential	Potential Installs Per Year
Pri	ID	Potential Situation	Quantity	%	Factor	%	%	Count
7	1	AC Refrigerant under charged	2 hr & 2 Lb R-22	36.0%	2	3.08%	1.11%	3698
13	2	AC Refrigerant over charged	2 hours	30.5%	3	4.30%	1.31%	4373
9	3	Low evaporator airflow A	75 SF	70.0%	2	0.87%	0.61%	2039
6	4	Low evaporator airflow B	2 hours	13.4%	2	7.56%	1.02%	3387
11	5	High duct leakage (25%)	3.41 tons	58.0%	2	1.32%	0.76%	2543
29	6	Oversized AC units A	3.09 tons	4.0%	3	1.44%	0.06%	192
18	7	Oversized AC units B	3.09 tons	5.6%	3	2.05%	0.11%	382
27	8	One inch insul. on ducts in attic	3.41 tons	14.9%	2	1.35%	0.20%	670
26	9	Gas heat and 13 SEER AC	3.41 tons	5.4%	2	1.05%	0.06%	189
31	10	Home has 13 SEER heat pump	3.78 tons	0.6%	2	1.11%	0.01%	23
30	11	Home has electric strip heat	2.65 tons	0.8%	2	0.36%	0.00%	9
17	12	Attic insulation = R-7	1344 SF	8.1%	1	1.77%	0.14%	479
24	13	Attic insulation = R-11	1344 SF	6.3%	1	2.31%	0.15%	485
21	14	Exposed walls not insulated	1355 SF	14.0%	2	0.28%	0.04%	130
32	15	Floor over basement not insulated	614 SF	33.2%	2	2.09%	0.69%	2316
4	16	House infiltration = 0.8 ACH	2077 SF	25.0%	1	4.28%	1.07%	3567
28	17	Single pane windows A	240 SF	4.3%	2	0.79%	0.03%	112
25	18	Single pane windows B	240 SF	1.7%	2	2.17%	0.04%	125
12	19	Standard double pane windows	240 SF	21.9%	2	2.47%	0.54%	1801
19	20	No E & W window shading A	86 SF	73.2%	3	1.79%	1.31%	4362
14	21	No E & W window shading B	6 each	65.7%	2	1.08%	0.71%	2363
2	22	No Compact Fluorescent Lamps	10 CFLs	60.0%	2	9.48%	5.69%	18948
23	23	Refrigerator needs to be replaced	1 each	5.8%	1	9.11%	0.53%	1767
3	24	Refrigerator early retirement	1 each	18.8%	3	8.51%	1.60%	5326
16	25	Dishwasher to be replaced	1 each	14.6%	1	10.00%	1.46%	4874
20	26	Clothes washer to be replaced	1 each	19.4%	1	4.82%	0.93%	3115
1	27	No prgrammable thermostat	1 each	60.0%	1	8.56%	5.14%	17121
15	28	No faucet aerators	1 each	63.0%	3	10.00%	6.30%	20992
5	29	No low flow shower heads	2 each	60.0%	3	10.00%	6.00%	19992
10	30	Hot water pipes not insulated	1 each	85.0%	2	8.01%	6.81%	22684
22	31	Electric water heater not wrapped	1 each	17.1%	1	10.00%	1.71%	5698
8	32	Gas water heater not wrapped	1 each	72.9%	3	7.10%	5.18%	17247

Table 6: Market Potential Summary for the Preferred Measures

One measure was analyzed with multiple retrofit options that represent different improvement choices. Two window shading options, ID numbers 20 and 21, were analyzed to represent different possible homeowner choices. For a single house, however, only one option can be applied. Each option was assigned a special market fraction of 0.5 in the model. This was necessary to avoid double counting of the annual savings when they are summed across all the measures and options.

The preferred measures highlighted in the previous tables were based on the 20 measures that yielded the most electrical energy savings. These were all estimated assuming a 50% rebate to encourage adoption. The next table, Table 7, shows how the metrics for the top 20 electric energy savings measures might vary with rebate percentage, where the rebates are used to "buy down" the costs of installing these measures. Savings are expressed in summer coincident demand (MW-S), GigaWatt-hours per year (GWh) and millions of Therms of gas savings per year (MTherms).

KCP&L customer savings in millions of dollars are shown, followed by total rebate expenses for each rebate level. Then the normalized savings in terms of rebate costs per customer dollar saved for the first year and for ten years levelized.

Ranked by GWh Saved

	Program Savings Potentials			Millions of Dollars		Rebate $/kWh	
Rebate	**MW-S**	**GWh**	**MTherms**	**Savings**	**Rebate**	**Yr 1**	**10 Yrs**
0%	4.3	29.4	1.6	$4.0	$0.0	$0.00	$0.000
25%	5.3	36.7	1.9	$4.9	$4.0	$0.24	$0.024
50%	7.5	51.8	2.5	$6.7	$11.0	$0.47	$0.047
75%	14.4	70.1	3.8	$9.5	$25.6	$0.71	$0.071

Table 7: Top 20 Measures Ranked by GWh vs. Rebate %

For comparison purposes RLW also ranked these 32 measures from a utility cost perspective based on increasing rebate dollars per kWh saved. The results for the new top 20 measures are shown in the next table. The interesting result of this table is the last three rows, which show that this ranking method optimizes the market capture achievable with rebate money. With rebates set at 50%, it will take only $7.3 million to obtain nearly the same savings as before, which required $11.0 million, and the levelized rebate costs per kWh saved is reduced from $0.047 to $0.025. Put another way, the savings in GWh is reduced by only 6.4% ((51.8-48.5)/51.8), while the corresponding rebate costs are reduced by 33.6% (($11.0-$7.3)/$11.0).

Ranked by Rebate $/kWh

	Program Savings Potentials			Millions of Dollars		Rebate $/kWh	
Rebate	**MW-S**	**GWh**	**MTherms**	**Savings**	**Rebate**	**Yr 1**	**10 Yrs**
0%	3.7	27.4	1.4	$3.7	$0.0	$0.00	$0.000
25%	4.6	34.4	1.7	$4.5	$2.6	$0.12	$0.012
50%	6.6	48.5	2.2	$6.1	$7.3	$0.25	$0.025
75%	12.8	65.3	3.4	$8.7	$17.0	$0.37	$0.037

Table 8: New Top 20 Measures Ranked by $/kWh vs. Rebate %

The next table, Table 9**,** shows the measures ranked by rebate dollars per kWh saved ($/kWh), with the new top 20 measures highlighted, and summary statistics in the last three rows. This shows that 91% of the total electric energy savings may be achieved at a rebate cost of only $7.3 million, and at a levelized cost of only $0.25 dollars per kWh saved.

KCP&L Energy Savings Measure		Potential Installs Per Year	Demand Market Potential	Electric Market Potential	Gas Market Potential	Annual Fuel Savings	Utility Rebate Costs	Electric Rebate Costs
ID	Potential Situation	Count	MW-S	MWh	kTherms	k$	k$	$/kWh
24	Refrigerator early retirement	5326	0.6	5,080	-70	$261	$133	$0.03
29	No low flow shower heads	19992	0.0	3,478	439	$788	$200	$0.06
4	Low evaporator airflow B	3387	2.3	2,733	228	$473	$169	$0.06
22	No Compact Fluorescent Lamps	18948	1.0	10,295	-161	$506	$758	$0.07
7	Oversized AC units B	382	0.3	399	0	$27	$40	$0.10
18	Single pane windows B	125	0.1	179	15	$32	$22	$0.12
28	No faucet aerators	20992	0.0	657	146	$228	$84	$0.13
27	No prgrammable thermostat	17121	-3.7	11,402	464	$1,363	$1,712	$0.15
1	AC Refrigerant under charged	3698	0.7	2,547	0	$175	$462	$0.18
16	House infiltration = 0.8 ACH	3567	1.5	3,732	695	$1,126	$713	$0.19
31	Electric water heater not wrapped	5698	0.0	331	0	$23	$71	$0.22
32	Gas water heater not wrapped	17247	0.0	2,035	190	$377	$517	$0.25
2	AC Refrigerant over charged	4373	0.5	771	0	$53	$219	$0.28
10	Home has 13 SEER heat pump	23	0.0	29	0	$2	$9	$0.30
19	Standard double pane windows	1801	0.5	937	-35	$21	$322	$0.34
9	Gas heat and 13 SEER AC	189	0.0	174	0	$12	$79	$0.46
6	Oversized AC units A	192	0.1	64	0	$4	$30	$0.47
3	Low evaporator airflow A	2039	1.7	2,000	115	$281	$969	$0.48
5	High duct leakage (25%)	2543	1.2	1,542	163	$310	$763	$0.49
17	Single pane windows A	112	0.0	102	16	$27	$57	$0.56
11	Home has electric strip heat	9	0.0	38	0	$3	$22	$0.59
30	Hot water pipes not insulated	22684	0.0	1,816	247	$434	$1,077	$0.59
12	Attic insulation = R-7	479	0.3	421	40	$78	$253	$0.60
23	Refrigerator needs to be replaced	1767	0.0	268	-3	$15	$177	$0.66
14	Exposed walls not insulated	130	0.1	343	47	$82	$228	$0.66
25	Dishwasher to be replaced	4874	0.1	524	32	$76	$366	$0.70
13	Attic insulation = R-11	485	0.2	262	24	$49	$196	$0.75
8	One inch insul. on ducts in attic	670	0.2	162	30	$49	$201	$1.24
21	No E & W window shading B	2363	0.2	741	0	$51	$1,063	$1.43
20	No E & W window shading A	4362	0.5	374	0	$26	$563	$1.50
26	Clothes washer to be replaced	3115	0.1	344	27	$57	$623	$1.81
15	Floor over basement not insulated	2316	-0.3	-516	77	$61	$455	
	Sums and Average, All Measures	171,008	7.8	53,265	2,727	$7,068	$12,555	$0.50
	Sums and Average, Top 20	127,755	6.6	48,487	2,206	$6,088	$7,330	$0.25
	Top 20 Percent of All	74.7%	84.3%	91.0%	80.9%	86.1%	58.4%	49.6%

Table 9: Measures Ranked By Rebate $/kWh, Highlighting Top 20

Conclusions

This section provided a comparative overview of recent programs that have been implemented towards raising share and consumer acceptance of high efficiency home products and measures. The strategies and program designs, to be sure, are driven in large part by the existing markets for the "standard" product the promoted item is meant to replace. Given that, there are common threads that can be incorporated into the program designs for any of these measures that were analyzed at length here.

Utilize a wide variety of marketing tools and elements. As discussed earlier, the best programs for sustainable market share growth utilized a comprehensive set of marketing and promotional tools to build and sustain knowledge, interest, and product desirability. Successful strategies have not just used the traditional means – bill inserts, advertising – but also used creative and highly visible promotional campaigns and events to build "top of mind" awareness and recognition. Conversely, program managers that RLW interviewed in a recent study felt that a marketing campaign built on only one or two elements made only limited impact and will not generally move consumers to any notable degree.

Engage the market actors at all levels of the product sales cycle. Successful programs have outreach tasks that identify and engage key players on each step of the product sales cycle – manufacturer, distributor, retailer, contractor, and consumer. The complementary "push" and "pull" strategy creates buy-in from the market actors on each level, and helps reinforce the message between them (ex. in a balanced approach, the distributor knows and understands the energy efficient product as well as the contractor, who in turn can reinforce or corroborate the information known by the consumer).

Position the energy efficient product as a desirable "high quality, high value" item. Appliance manufacturers in particular have added a variety of special features and functions to their ENERGY STAR models. Although no literature explicitly explains why, it appears these features, many of which are "high tech" in design and function, creates a "high value" perception. This high value perception is likely geared toward those consumers who can afford, and less likely to balk at, the higher price premium comparable to "standard" models that lack these specialized designs and functions. This kind of product positioning is typically built towards consumers who are comfortable paying a premium for products that are perceived to be of a high quality, reliability, or safety, whether it's cars, appliances, or organically grown foods.