2010 KANSAS CITY POWER & LIGHT MULTIFAMILY RESIDENTIAL ENERGY AND DEMAND CONSERVATION POTENTIAL ANALYSIS

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Prepared for Kansas City Power & Light

PREPARED BY:

KEMA, INC.

200 COURT STREET

MIDDLETOWN, CT 06457

Table of Contents

Table of Tables

Table of Figures

Executive Summary

This is a draft report of the 2010 Multifamily Residential Electric Demand Side Potential Study for Kansas City Power and Light (KCPLMO, KCPLKS and GMO). This study was aimed at providing technical, economic and market potential analyses specific to the KCP&L service areas, with the goal of identifying energy efficiency opportunities throughout the multifamily customer sector.

Approach

A nested sampling methodology was employed in the study to assure the achievement of an overall statistical precision target of 10% at a 90% confidence level. KEMA utilized a dual sampling strategy, using a nested sample of 59 onsite surveys to inform and strengthen a larger sample of 160 telephone surveys. Annual kWh usage from about 79,000 multifamily utility accounts was used as the sampling variable for the telephone surveys. The onsite audit sample was drawn statistically from the telephone survey sample after individual savings estimates were calculated from the telephone data to utilize as the sub-sampling variable. KEMA successfully completed all telephone surveys in early May, and all on-site audits for this study on July 8 of 2010.

Key Findings

KEMA analyzed 84 potential building improvement options. KEMA created three DOE2 models to calculate measure impacts for the multifamily population, based on specific information from the telephone and field audits, and calibrated the models with monthly billing data from nearly 46,000 utility multifamily accounts. The 40 most promising measures, as ranked by annual electrical energy savings in MWh, offer nearly the same (about 95%) potential savings as all 84 measures combined.

Annually achievable utility-wide potential savings for all 84 measures are about 14,447 MWh, 3.38 winter MW, 1.18 summer MW and -9,396 Therms of natural gas and other non-electric fuels. The current estimated total annual electric energy usage of the multifamily sector is 885,533 MWh per year for 5,191 buildings and 103,814 living units. The number of living units was estimated by expanding the sample, which averaged about 20 units per building, to the population. The average occupancy level for 2009 was found to be about 86%, increasing to 89 or 90% by July of 2010.

The following table, Table 1, shows the annual achievable market potentials of all 84 measures (“Pot 84”) and the top 40 measures (“Pot 40”) for different rebate levels. The annual savings potential for the top 40 measures ranges from 0.76% to 3.60% of the current total electric energy consumption of the multifamily sector, depending on the average utility rebate as a percentage of the differential costs to the participant.

Rebate	MWH 84	MWH 40	Pot. 84	Pot. 40
0%	6,971	6,760	0.79%	0.76%
25%	10,181	9,925	1.15%	1.12%
50%	14,447	14,122	1.63%	1.59%
75%	20,493	20,044	2.31%	2.26%
100%	32,392	31,835	3.66%	3.60%

Table 1: Annual Achievable Market Potentials

Introduction

Kansas City Power and Light (KCPLMO, KCPLKS and GMO) retained KEMA, Inc. to conduct a Multifamily Residential Electric Demand Side Potential Study. This study was aimed at providing technical, economic and market potential analyses specific to the KCP&L service areas, with the goal of identifying energy efficiency opportunities throughout the multifamily customer sector.

The study was designed to provide KCP&L with technical, economic, maximum potential and achievable market potential for approximately 50 multifamily energy conservation measures that might be offered to multifamily building owners, managers and tenants. 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 multifamily residential sector.

Approach

The study approach required identifying and auditing a statistically representative but affordable sized sample of multifamily buildings throughout the three primary KCP&L service areas known as KCPL Missouri Operations (KCPLMO), KCPL Kansas Operations (KCPLKS) and the Greater Missouri Operations (GMO, including MPS and SJLP). KEMA chose to utilize a nested sampling methodology that provided two levels of data collection and analysis to obtain a small but statistically representative sample of multifamily buildings to audit on-site.

The larger sample of buildings was chosen to receive telephone surveys to obtain the information needed to conduct a spreadsheet analysis and obtain a rough estimate of the savings potential for each. KCP&L provided a database of about 79,000 identifiable multifamily customer accounts from which KEMA attempted to draw the telephone survey sample. This database represented a significant portion of all multifamily units, but it was not comprehensive and it was mixed with a few master metered buildings and some mis-labeled customers. Based on the coefficient of variation of the annual kWh consumption of these customers, KEMA determined that a sample size of 180 would be more than adequate to yield a statistical precision of 7% or better applying model based statistical sampling (MBSS) techniques.

After rough savings estimates were calculated for the telephone sample participants, KEMA selected a subset of customers within this sample to carry out onsite visits, again using MBSS techniques, but based on the savings estimates to minimize the sample size for the on-site audits. Early on KEMA determined, conservatively, that 70 on-site audits would be more than adequate to obtain a sampling precision of 6%, which would yield better than 10% over both samples with a confidence level of 90%. This was achievable because the nested on-site sample could be carefully controlled if the targeted customer response rate were high enough. The final on-site sample turned out to be 59, which proved to be more than adequate.

To assure the necessary high response rate for the on-site audit sample, KEMA chose to offer attractive cash incentives to the building owners/managers and tenants who were willing to cooperate. The owners/managers were offered $100 cash and each participating tenant was offered an additional $50. The auditors were required to conduct a detailed audit of the building and two to four typical tenant spaces within the building.

These visits targeted specific data, such as building envelope characteristics, cooling and heating system characteristics, domestic hot water systems, lighting, major appliances, plug load appliances with Energy Star rated alternatives and occupant demographics. Data included equipment manufacturers and model numbers, manufacture dates, efficiencies, capacities and locations, common area and total building sizes, ceiling and wall insulation, window types and areas and other detailed information necessary to create and calibrate detailed building energy simulation models with DOE2.1E and run detailed measure-level analyses.

For both the telephone and on-site surveys, the surveyors collected data on the major appliances and lighting systems in the building. The onsite surveyors collected nameplate data, age, condition and rated operating characteristics for the following appliances:

- Refrigerators
- Dishwashers
- Clothes Washers
- Clothes Dryers
- Water Heaters
- Heating Equipment
- Cooling Equipment
- Plug Load Appliances

Plug load appliances included TV's, DVD's, cable boxes, computers and monitors, printers, FAX machines, and other miscellaneous appliances that have Energy Star units available on the retail market.

For lighting, the onsite surveyors collected lamp, fixture and wattage data for each lighting fixture and bulb within the tenant spaces, as well as common area and exterior bulbs and fixtures. The surveyors collected data on attic, floor and wall construction and insulation R-values and window sizes and types. The tenants were asked what space temperature setpoints they most commonly used for the cooling and heating seasons and when they used their cooling/heating systems.

Telephone and On-Site Sample Design Issues

Using a nested sampling approach, the statistical paradigm found that 180 phone surveys and 70 onsite surveys would be more than enough to achieve a statistical sampling precision of 10% at a 90% confidence level. The targeted telephone survey sample was proportionally allocated across the utility service areas of interest to assure that all three regions (KCPLMO at about 44%, KCPLKS at about 26% and GMO at about 30%) were proportionally represented, but there was no attempt to obtain a specific relative precision within each region. The sample for the 70 onsite surveys was carefully selected from the telephone survey data, again so that each region would be proportionally represented.

Project work began in early July of 2009 with a project kickoff meeting. The proposal and original SOW were based on the assumption that KCP&L could identify, with a high degree of certainty, their entire multifamily population from their residential and commercial databases. Without a comprehensive dataset of the multifamily buildings, the study would not be feasible as designed (Using a 90/±10% double-sampling strategy at the building level). Both the budget and timeline depended on the availability of this multifamily (MF) database.

At the kickoff meeting the selection of potential analysis measures to be analyzed was formalized. While waiting for the MF database, KEMA developed a building owner/manager recruitment letter and field data entry form; created and organized the field training material; and made preparations with Matousek and Associates for most of the telephone survey work.

Around mid August, KCPL notified KEMA that they were unable to identify MF buildings at the building or premise level. Recognizing that a database of the multifamily building population was necessary to perform the statistical sampling, KEMA and KCP&L began to search for other ways to achieve the study objectives.

Since learning that it would not be readily possible to identify a MF building population, KCPL approved additional funding to allow KEMA to identify a statistically representative multifamily building sample. The new direction included tasks that dissected the available multifamily billing data using a kWh range analysis, conducted electronic commercial property-to-tenant database matching, and expanded the scope of work through greatly increased numbers of telephone surveys (from 85 to 180) and analytical work to identify and recruit the required sample sizes.

The largest addition to the original SOW was the need to conduct tenant telephone surveys to identify a sufficiently large number of building owners and managers so that 180 might be willing to cooperate. The initial goal was 600, but there was no statistical basis for this, because the response rate was not known. KEMA selected several large samples of tenant accounts based on their annual kWh usage, and KCP&L prepared and mailed letters of introduction to these sample tenants with the hope that this would encourage their cooperation with KEMA. As it turned out, the response rate was low, averaging about 7%.

Identifying the Telephone Survey Sample

With the help of Matousek and Associates, KEMA conducted about fifteen thousand telephone calls to multifamily tenants listed in the KCP&L customer account data to ask them to identify their property managers. About one third of the accounts in the database were no longer valid due to attrition, wrong or disconnected numbers, differences between tenants and mailing addresses, and other issues. Simultaneously, KEMA utilized Google Maps and Google Earth geocoding strategies to help reduce the total number of calls necessary.

After the task time, budget and sampling data were exhausted, a database of about 480 owner/manager names and telephone numbers had been created. From this list KEMA was able to conduct successful telephone surveys of 164 (119 from KCPL, 41 from MPS and 4 from SJLP) buildings. To guarantee the required statistical precision of this sample, KEMA adhered as closely as possible to a 10 stratum sampling plan, which was capable of obtaining better than 3% based on the KCP&L annual kWh usage data. KEMA was not able to calculate the actual sampling precision for the final sample because the customer account database became exhausted for these strata, and because some members of the sample had to be obtained through Google mapping and other sources, so no billing data for those were available. The stratum quota of the final sample were nearly met for all strata.

Google mapping consisted of having Google Maps online identify apartment buildings in a specified location by zip code, city, etc. and zooming in on the flags that were shown on the map. Aerial and street views of these buildings, if available, were traversed and studied visually to ascertain if they were, in fact multifamily buildings. If so, the name and address information was taken from that supplied by Google. Using the name and/or address, online information about the owner or manager were sought through various other on-line sources to identify or at least obtain a lead on a contact person and acquire a telephone number. Variations of this approach were tried until the best approach could be identified.

Identifying the On-Site Audit Sample

Based on the data obtained for these buildings KEMA estimated the annual potential kWh savings for each to be used as the sampling frame for the on-site sample. At this point, a somewhat proportional sample of buildings were analyzed for each geographic service area, but there were only 4 telephone surveys from SJLP, and nearly every prospective building owner/manager had already been contacted. Therefore, KEMA made one last attempt to obtain the cooperation of those few remaining in the SJLP region, and finally obtained permission to audit 4 buildings, providing a certainty group of the telephone surveys.

For the audits, KEMA drew a six-stratum sample from the 164 telephone surveys. With this sampling strategy it was possible to obtain a random sampling precision of under 10%, but this was not good enough due to the probability that the telephone survey sample exceeded 3%, leaving no room for the combined sample precision to be 10% or better. Therefore, KEMA resorted to a handpicked sampling strategy for each of the six strata by focusing the primary, secondary, tertiary and so forth, buildings nearest the average for each stratum.

Although a random six-stratum sample was capable of slightly over 9%, KEMA was able to obtain a final audit sample with a relative precision of better than 6% utilizing the average-focused sampling strategy.

Estimating Overall Final Sampling Precision

The overall sampling precision of the nested samples is estimated to be better than 8%, assuming the larger telephone survey sample precision is as high as 5% and the nested audit sample precision is 6%, as calculated. Even if the telephone survey sampling precision were as high as 8%, the combined precision would still be 10% at the 90% level of confidence. Hence, KEMA is confident that the targeted sampling precision for the study has been attained.

Potential Analyses and Results

Methodology for Estimating Impacts

In this study, the approach to estimating potential savings in the multifamily sector may be considered a bottom-up approach because it begins with the collection of detailed information at a sample of multifamily buildings and an analysis of those buildings to calculate potential savings for a host of conservation measures that may be applied. The existing building stock is considered to be the baseline, or starting point for all measures, but the average building is not necessarily the target for every measure. Instead, it is necessary to identify the particular buildings that qualify for, or need, each conservation retrofit, recognizing that most buildings will qualify for several measures.

The analysis for the measure level 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 KEMA elected to use the weather data from that site. The hourly dry bulb temperature data for this weather station were obtained for the 12 month period to which the monthly billing data applied, and weather normalized to estimate the 12 monthly kWh for a typical (TMY3) year.

The following graph, Figure 1, shows the actual calendarized monthly billing data averages for the three heating system types. The heat pump heated buildings apparently use more energy for cooling than the strip heated buildings, but the gas heated buildings utilize significantly more, as indicated during the cooling months of May through September of 2009. The actual 12 months spanned from April 2008 through March of 2009.

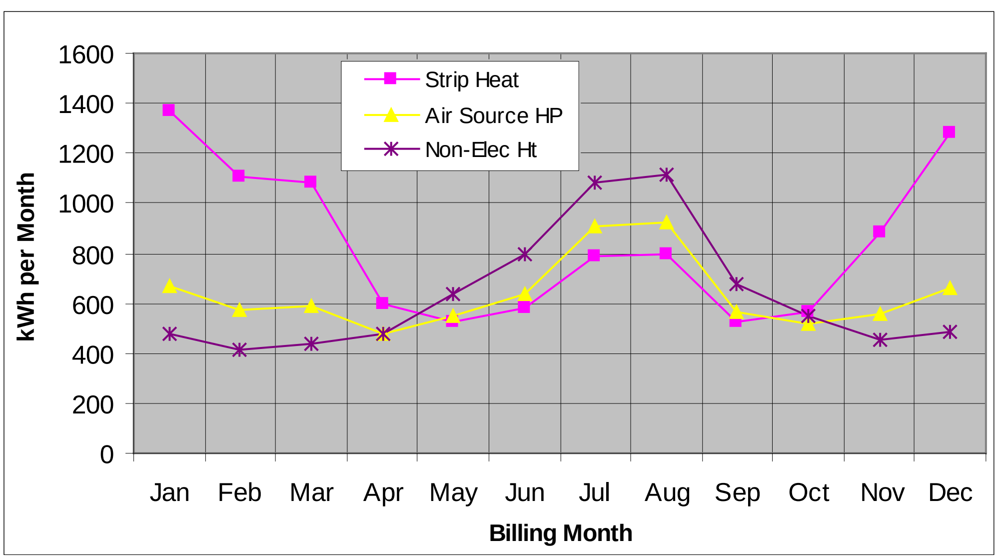

Figure 1: Actual Monthly kWh Calendarized

The next graph, Figure 2, shows the weather normalized monthly billing data for the three heating system types. The same distribution of cooling loads is evident in the typically year. Unlike the actual billing year, however, the typically predominant month appears to be July. Disaggregation of the billing data and confirmation through calibration of the DOE2 models indicate that a large portion of the increase in total usage for July is due to a significant increase in base load during that month.

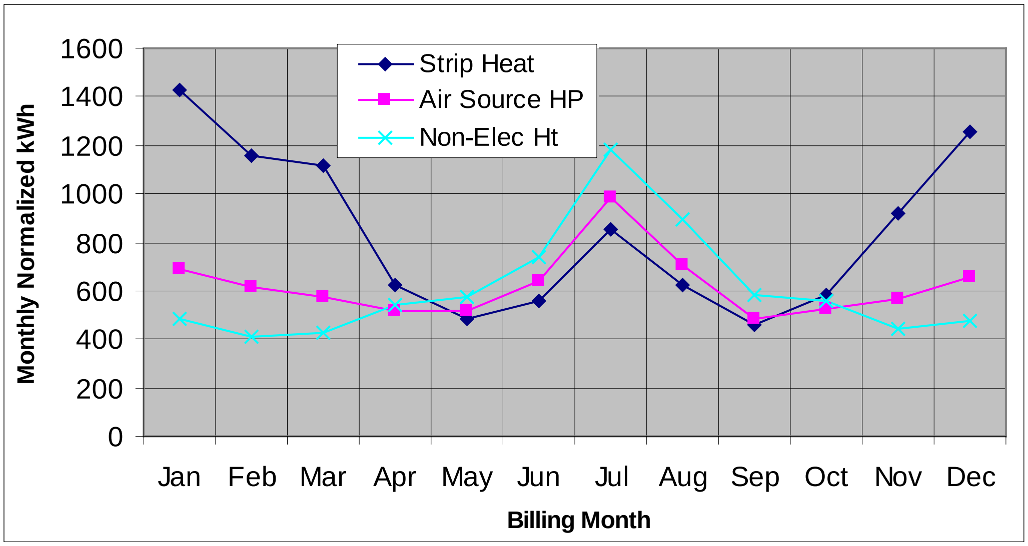

Figure 2: Weather Normalized Monthly kWh

The relative numbers of non-electric heated buildings (about 45%, mostly natural gas), proved to be significant. The split between the electric strip heated buildings and the electric heat pump heated buildings favored electric strip heat with about 37%, leaving about 18% with heat pumps. Therefore, KEMA chose to create three DOE2 physical models to represent the entire KCP&L multi-family housing stock, but to utilize one central weather file and one average building size with 20 living units based on the averages for all audited buildings. Three individual models were created from the 20 unit average model using cooling, heating, hot water, appliance, and demographic data from the field audits for each of the three heating system types. These were calibrated monthly to their corresponding electric utility billing data.

The next two graphs show the results of the non-electric heated building model, comparing the calendarized averaged monthly billing data to the DOE2 model results. Figure 3 shows the whole building kWh and the base load kWh compared to the billing data. Here the increased base load kWh for July is evident. The base load referred to here is the monthly non-weather sensitive loads such as lights, plug loads, appliances and water heaters.

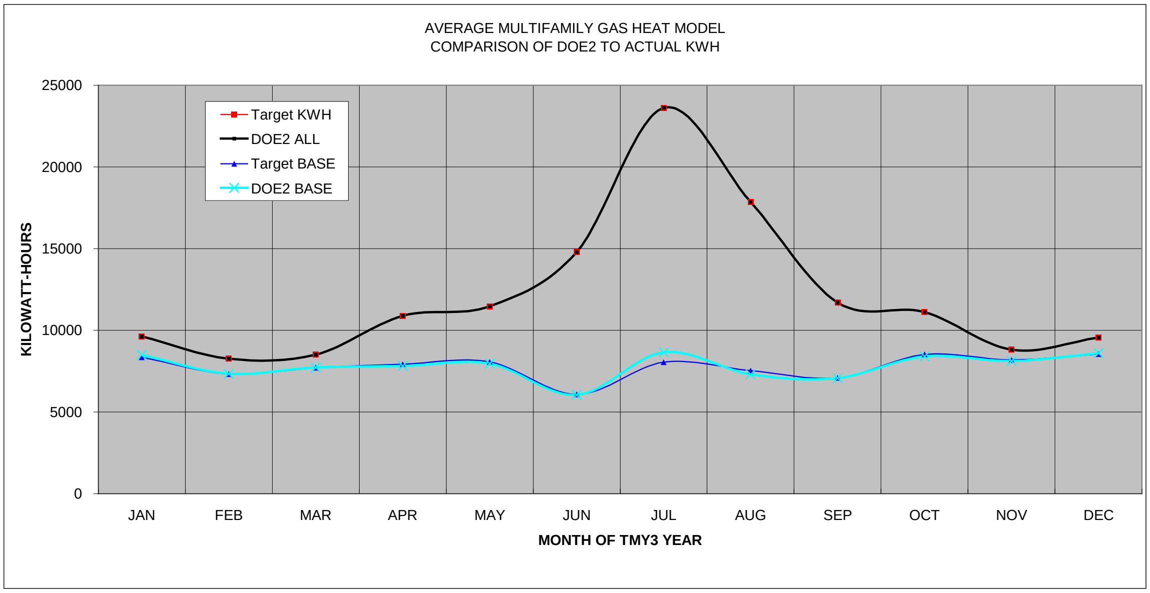

Figure 3: Targeted and Calibrated DOE2 Monthly kWh

The targeted kWh were determined from the billing data, and the calibrated kWh are the results from the calibrated DOE2 model. The closeness of these monthly kWh depicts how well calibrated the model is.

The second graph, Figure 4, shows the cooling and heating results from the DOE2 model compared against the cooling and heating degree-days from the TMY3 weather file. This provides a sanity check on the cooling and heating monthly kWh distributions of the calibrated DOE2 model. Here it is clear that July dominates the cooling season in terms of degree-days, as confirmed by the DOE2 model cooling results.

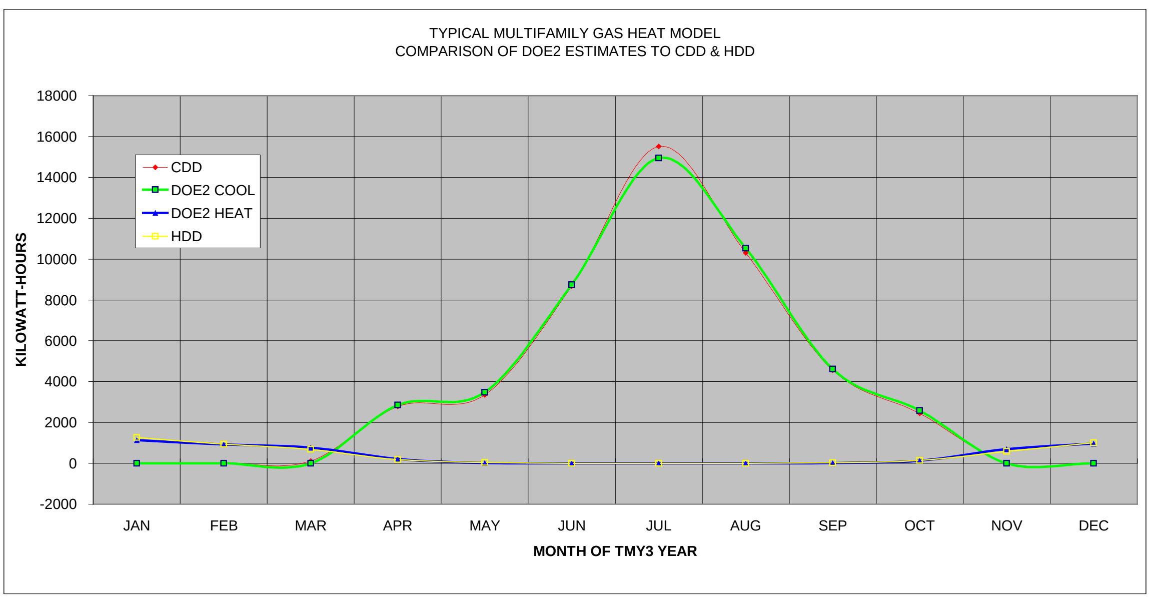

Figure 4: DOE2 Cooling and Heating Loads and Degree-Days

These three models were applied to calculate unique measure level savings for the average gas heated building, average electric strip heated building and average heat pump heated building. None of the buildings specifically visited for this study, was primarily heated with any other fuels.

All three types of buildings 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. KEMA, therefore, assumed that wood consumption remained unchanged by the retrofits. Most of the buildings in the field audits and in the telephone surveys, about 82%, were also air-conditioned. About 35% of the air-conditioned units had strip heat, about 11% had heat pumps and about 54% used natural gas for heat. 100% of the electric strip heat units were air-conditioned.

KEMA utilized Kansas City, Missouri TMY3 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 were averaged by month to create the average monthly usage for each group, and these averages were weather normalized by ratios of monthly cooling and heating degree-days to correspond to TMY2 temperature data. The models were then calibrated to match these calendarized and normalized monthly kWh within 1% for each month and 1% annually.

The DOE2 formatted version of the TMY3 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 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 building may have had R-14 attic insulation, but the baseline attic insulation R-value would be much lower, say R-7 or R-11. Using this approach, KEMA created a specific baseline model for each measure, recognizing that the measure would be applicable only to buildings that were below a reasonable threshold value (for example R-9 or lower, so that the average for all these buildings would be about R-7). These baseline models, therefore, represent buildings that might be expected to participate in a conservation program offering that measure. Next, a retrofit model was created for those buildings by upgrading the measure of interest to a significantly higher but reasonably attainable standard, say R-30 for attic insulation.

[1] TMY3 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 reading dates and billing period kWh were converted into calendar month kWh for each building. Averages of these by housing group provided monthly calibration targets for the DOE2 models.

Savings were obtained by running both the baseline and retrofit models to obtain the hourly building kWh (and kBTU, when applicable) for a typical year and subtracting the results for every hour. The sum of the hourly differences in cooling system energy represents hourly cooling savings for a typical weather year. Coincident summer electric demand savings were calculated as the average savings over the three hour window of 3-6 PM on the hottest weekday of the typical year. Coincident winter demand savings were calculated for the window of 5-8 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 peak kBTU's per hour, and Therms per year were derived the same way.

For each measure, KEMA exercised all three models to calculate unique savings for an average gas heated building (with a gas furnace in each apartment), average electric strip heated building (with electric furnaces), and average electric heat pump heated building (with supplemental electric strip heat).

Technical Assessment of Energy and Demand Impacts

Potential Energy Conservation Measures

As listed in Table 2, KEMA analyzed 84 potential building improvement options. Each measure was assigned a unique ID number to allow continuity from table to table. The table shows the heating system type (fuel), end-use category and unit of measurement, followed by the quantity (based on unit of measurement) and whether the quantity applies to the building or the dwelling units. Then the baseline and retrofit scenario is defined for each measure.

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. The savings for each measure are shown in Table 3, which also lists the input file names of the DOE2 models applied to calculate the savings. The natural gas savings fields are blank where natural gas savings do not apply. The field headings in the table are self-explanatory.

Savings for the measures applicable to strip heated buildings are listed first, followed by the measures that apply only to heat pump heated buildings or yield different savings for them. Finally, the measures that apply only to gas heated buildings or yield different savings than the other two types are listed.

Where natural gas savings are shown for the electric heated buildings, they apply to buildings or apartments where electric appliances may be converted to gas (natural gas or propane).

Several of the listed improvement options represent multiple ways of dealing with a single potential situation. For example, IDs 11, 12 and 13 represent three options for replacing an existing 7.1 SEER air conditioning system, which could be replaced with only one of three higher efficiency options.

ID	Heating System	End Use	Measure Unit	Quantity per Building	Applies To	Potential (Baseline) Situation	Improvement (Retrofit) Measure
1	Strip	Attic Insulation	Sqft	6300	Bldg.	Attic insulation = R-11	Add another R-19 attic insulation
2	Strip	Attic Insulation	Sqft	6300	Bldg.	Attic insulation = R-7	Add another R-23 attic insulation
3	Strip	Wall Insulation	Sqft	7785	Bldg.	Exposed walls not insulated	Add R-11 wall insulation
4	Strip	Air Sealing	Sqft	62000	Bldg.	Building infiltration = 35000 CFM50	Reduce infiltration to 20000 CFM50
5	Strip	Clothes Dryers	Each	20	Apts.	Apt Clothes Dryer is Electric	Switch to Gas Clothes Dryer
6	Strip	Clothes Dryers	Each	4	Apts.	CA Clothes Dryer is Electric	Switch to Gas Clothes Dryer
7	Strip	Clothes Washers	Each	20	Apts.	Apt Clothes Washer needs to be replaced	Purchase Energy Star Clothes Washer
8	Strip	Clothes Washers	Each	4	Bldg.	CA Clothes Washer needs to be replaced	Purchase Energy Star Clothes Washer
9	Strip	Cooling	Ton	32	Apts.	AC Refrigerant over charged	Remove refrigerant
10	Strip	Cooling	Ton	32	Apts.	AC Refrigerant under charged	Add refrigerant
11	Strip	Cooling	Ton	25	Apts.	Early Retire of 7.1 SEER AC	Install 14 SEER AC
12	Strip	Cooling	Ton	32	Apts.	Early Retire of 7.1 SEER AC	Install 15 SEER AC
13	Strip	Cooling	Ton	32	Apts.	Early Retire of 7.1 SEER AC	Install 16 SEER AC
14	Strip	Cooling	Ton	32	Apts.	Existing 7.1 SEER AC not serviced	Tune-up Service for AC Unit to 8.5 SEER
15	Strip	Cooling	Ton	32	Apts.	Install new 13 SEER Baseline AC	Install new 14 SEER AC
16	Strip	Cooling	Ton	32	Apts.	Install new 13 SEER Baseline AC	Install new 15 SEER AC
17	Strip	Cooling	Ton	32	Apts.	Install new 13 SEER Baseline AC	Install new 16 SEER AC
18	Strip	Cooling	Ton	32	Apts.	Existing 8.0 EER Window AC	Install 10 EER Window AC
19	Strip	Cooling	Each	20	Apts.	No Ceiling Fan	Add Ceiling Fan
20	Strip	Cooling/Heating	Ton	32	Apts.	No programmable thermostat	Install programmable thermostat
21	Strip	Cooling	Ton	32	Apts.	AC units Oversized by 70%	Downsize to Manual J (20% oversized)
22	Strip	Heating	Each	20	Apts.	Electric Strip Heating System	Replace with 90% Efficient Gas System
23	Strip	Cooling/Heating	Each	20	Apts.	Install new 13 SEER Baseline AC	Install Heat Pump. SEER = 16
24	Strip	Cooling/Heating	Ton	32	Apts.	Standard Furnace Fan Motor	Replace with ECM Fan Motor
25	Strip	Hot Water	Each	20	Apts.	Electric water heater not wrapped	Wrap electric water heater
26	Strip	Hot Water	Each	3	Bldg.	Central Electric water heater not wrapped	Wrap Central electric water heater
27	Strip	Hot Water	Lin Ft	50	Apts.	Hot water pipes in apartments not insulated	Insulate hot water pipes in apartments
28	Strip	Hot Water	Lin Ft	30	Bldg.	Central Hot water pipes not insulated	Insulate Central hot water pipes
29	Strip	Hot Water	Each	40	Apts.	No faucet aerators	Install faucet aerators
30	Strip	Hot Water	Each	20	Apts.	No low flow shower heads	Install low fow shower heads
31	Strip	Hot Water	Each	3	Bldg.	Central Water Heater is Electric	Switch to Gas Central Water Heater
32	Strip	Lighting	Watts	501	Apts.	Tenant Space Lights not Efficient	Apply High Efficiency Lighting to Tenant Spaces
33	Strip	Lighting	Watts	1193	Bldg.	Common Area Lights not Efficient	Apply High Efficiency Lighting to CA
34	Strip	Lighting	Watts	984	Bldg.	Exterior Lighting not Efficient	Apply High Efficiency Exterior Lighting
35	Strip	Misc. Plug Loads	Each	20	Apts.	Standard Efficiency Plug Load Electronics	Energy Star Plug Load Electronics
36	Strip	Refrigerators	Each	20	Apts.	Refrigerator Needs to be Replaced	Purchase Energy Star Refrigerator
37	Strip	Windows	Sqft	1164	Bldg.	No E & W window shading	Plant deciduous trees on E & W sides
38	Strip	Windows	Sqft	1164	Bldg.	Single pane windows A	Add storm windows over single pane
39	Strip	Windows	Sqft	1164	Bldg.	Single pane windows B	Install Low E double pane window 2900
40	Strip	Windows	Sqft	1164	Bldg.	Standard double pane windows	Add storm windows over double pane
41	Strip	Dishwasher	Each	20	Apts.	Dishwasher to be replaced	Purchase Energy Star dishwasher
42	ASHP	Attic Insulation	Sqft	6300	Bldg.	Attic insulation = R-11	Add another R-19 attic insulation
43	ASHP	Attic Insulation	Sqft	6300	Bldg.	Attic insulation = R-7	Add another R-23 attic insulation
44	ASHP	Wall Insulation	Sqft	7785	Bldg.	Exposed walls not insulated	Add R-11 wall insulation
45	ASHP	Air Sealing	Sqft	62000	Bldg.	Building infiltration = 30000 CFM50	Reduce infiltration to 15000 CFM50
46	ASHP	Clothes Dryers	Each	20	Apts.	Apt Clothes Dryer is Electric	Switch to Gas Clothes Dryer
47	ASHP	Clothes Washers	Each	20	Apts.	Apt Clothes Washer needs to be replaced	Purchase Energy Star Clothes Washer
48	ASHP	Cooling/Heating	Ton	32	Apts.	HP Refrigerant over charged	Remove refrigerant
49	ASHP	Cooling/Heating	Ton	32	Apts.	HP Refrigerant under charged	Add refrigerant
50	ASHP	Cooling/Heating	Ton	25	Apts.	Early Retire of 7.1 SEER HP	Install 14 SEER HP
51	ASHP	Cooling/Heating	Ton	32	Apts.	Early Retire of 7.1 SEER HP	Install 15 SEER HP
52	ASHP	Cooling/Heating	Ton	32	Apts.	Early Retire of 7.1 SEER HP	Install 16 SEER HP
53	ASHP	Cooling/Heating	Ton	32	Apts.	Existing 7.1 SEER HP not serviced	Tune-up Service for HP Unit to 8.5 SEER
54	ASHP	Cooling/Heating	Ton	32	Apts.	Install new 13 SEER Baseline HP	Install new 14 SEER HP
55	ASHP	Cooling/Heating	Ton	32	Apts.	Install new 13 SEER Baseline HP	Install new 15 SEER HP
56	ASHP	Cooling/Heating	Ton	32	Apts.	Install new 13 SEER Baseline HP	Install new 16 SEER HP
57	ASHP	Cooling/Heating	Each	20	Apts.	No Ceiling Fan	Add Ceiling Fan
58	ASHP	Cooling/Heating	Each	20	Apts.	No programmable thermostat	Install programmable thermostat
59	ASHP	Cooling/Heating	Ton	32	Apts.	HP units Oversized by 70%	Downsize to Manual J (20% oversized)
60	ASHP	Cooling/Heating	Ton	32	Apts.	Standard Indoor Fan Motor	Replace with ECM Fan Motor
61	ASHP	Lighting	Watts	480	Apts.	Tenant Space Lights not Efficient	Apply High Efficiency Lighting to Tenant Spaces
62	ASHP	Misc. Plug Loads	Each	20	Apts.	Standard Efficiency Plug Load Electronics	Energy Star Plug Load Electronics
63	ASHP	Refrigerators	Each	20	Apts.	Refrigerator Needs to be Replaced	Purchase Energy Star Refrigerator
64	ASHP	Windows	Sqft	1164	Bldg.	No E & W window shading	Plant deciduous trees on E & W sides
65	ASHP	Windows	Sqft	1164	Bldg.	Single pane windows A	Add storm windows over single pane
66	ASHP	Windows	Sqft	1164	Bldg.	Single pane windows B	Install Low E double pane window 2900
67	ASHP	Windows	Sqft	1164	Bldg.	Standard double pane windows	Add storm windows over double pane
68	ASHP	Dishwasher	Each	20	Apts.	Dishwasher to be replaced	Purchase Energy Star dishwasher
69	NG	Attic Insulation	Sqft	6300	Bldg.	Attic insulation = R-11	Add another R-19 attic insulation
70	NG	Attic Insulation	Sqft	6300	Bldg.	Attic insulation = R-7	Add another R-23 attic insulation
71	NG	Wall Insulation	Sqft	7785	Bldg.	Exposed walls not insulated	Add R-11 wall insulation
72	NG	Air Sealing	Sqft	62000	Bldg.	Building infiltration = 30000 CFM50	Reduce infiltration to 15000 CFM50
73	NG	Clothes Dryers	Each	20	Apts.	Apt Clothes Dryer is Electric	Switch to Gas Clothes Dryer
74	NG	Clothes Washers	Each	20	Apts.	Apt Clothes Washer needs to be replaced	Purchase Energy Star Clothes Washer
75	NG	Clothes Washers	Each	4	Bldg.	CA Clothes Washer needs to be replaced	Purchase Energy Star Clothes Washer
76	NG	Cooling/Heating	Ton	32	Apts.	No programmable thermostat	Install programmable thermostat
77	NG	Lighting	Watts	500	Apts.	Tenant Space Lights not Efficient	Apply High Efficiency Lighting to Tenant Spaces
78	NG	Misc. Plug Loads	Each	20	Apts.	Standard Efficiency Plug Load Electronics	Energy Star Plug Load Electronics
79	NG	Refrigerators	Each	20	Apts.	Refrigerator Needs to be Replaced	Purchase Energy Star Refrigerator
80	NG	Windows	Sqft	1164	Bldg.	No E & W window shading	Plant deciduous trees on E & W sides
81	NG	Windows	Sqft	1164	Bldg.	Single pane windows A	Add storm windows over single pane
82	NG	Windows	Sqft	1164	Bldg.	Single pane windows B	Install Low E double pane window 2900
83	NG	Windows	Sqft	1164	Bldg.	Standard double pane windows	Add storm windows over double pane
84	NG	Dishwasher	Each	20	Apts.	Dishwasher to be replaced	Purchase Energy Star dishwasher

Table 2: Potential Situations and Improvements Evaluated in this Study

ID	Heating System	Applies To	DOE2 Baseline Model	DOE2 Retrofit Model	Energy Savings kWh/Yr	Coinc. Demand Savings	Coinc. Demand Savings	NG Heat Savings kBTU	NG Misc Savings kBTU
1	Strip	Bldg.	MFSHB1	MFSHR1	6,180	1.65	3.43		
2	Strip	Bldg.	MFSHB2	MFSHR2	10,090	2.68	5.54		
3	Strip	Bldg.	MFSHB3	MFSHR3	48,780	6.88	30.07		
4	Strip	Bldg.	MFSHB4	MFSHR4	23,678	3.79	22.29		
5	Strip	Apts.	MFSHB5	MFSHR5	5,600	0.29	0.12		-54,243
6	Strip	Apts.	MFSHB6	MFSHR6	1,175	0.06	0.03		-11,377
7	Strip	Apts.	MFSHB7	MFSHR7	4,638	0.56	0.49		
8	Strip	Bldg.	MFSHB8	MFSHR8	6,007	0.28	1.91		
9	Strip	Apts.	MFSHB9	MFSHR9	1,762	2.15	0.00		
10	Strip	Apts.	MFSHB10	MFSHR10	3,903	4.48	0.00		
11	Strip	Apts.	MFSHB11	MFSHR11	19,979	18.38	0.00		
12	Strip	Apts.	MFSHB11	MFSHR12	21,390	19.66	0.00		
13	Strip	Apts.	MFSHB11	MFSHR13	22,640	20.78	0.00		
14	Strip	Apts.	MFSHB11	MFSHR14	6,173	5.60	0.00		
15	Strip	Apts.	MFSHB15	MFSHR15	1,588	1.46	0.00		
16	Strip	Apts.	MFSHB15	MFSHR16	3,031	2.77	0.00		
17	Strip	Apts.	MFSHB15	MFSHR17	4,268	3.91	0.00		
18	Strip	Apts.	MFSHB18	MFSHR18	5,281	5.22	0.00		
19	Strip	Apts.	MFSHB19	MFSHR19	4,887	1.38	0.00		
20	Strip	Apts.	MFSHB20	MFSHR20	4,016	-5.60	7.63		
21	Strip	Apts.	MFSHB21	MFSHR21	7,375	4.95	0.22		
22	Strip	Apts.	MFSHB22	MFSHR22	30,357	0.00	41.82	-115,085	
23	Strip	Apts.	MFSHB23	MFSHR23	12,236	3.50	7.28		
24	Strip	Apts.	MFSHB24	MFSHR24	2,754	0.52	0.35		
25	Strip	Apts.	MFSHB25	MFSHR25	2,795	0.29	0.03		
26	Strip	Bldg.	MFSHB26	MFSHR26	1,306	0.11	0.03		
27	Strip	Apts.	MFSHB25	MFSHR27	396	0.02	0.03		
28	Strip	Bldg.	MFSHB28	MFSHR28	1,227	0.09	0.34		
29	Strip	Apts.	MFSHB29	MFSHR29	1,916	0.11	0.56		
30	Strip	Apts.	MFSHB29	MFSHR30	3,821	0.21	1.12		
31	Strip	Bldg.	MFSHB31	MFSHR31	58,401	2.72	17.17		
32	Strip	Apts.	MFSHB32	MFSHR32	9,438	1.28	-0.03		
33	Strip	Bldg.	MFSHB33	MFSHR33	10,395	1.25	1.11		
34	Strip	Bldg.	MFSHB34	MFSHR34	4,748	0.23	0.82		
35	Strip	Apts.	MFSHB34	MFSHR35	869	0.22	0.02		
36	Strip	Apts.	MFSHB34	MFSHR36	562	0.02	0.00		
37	Strip	Bldg.	MFSHB37	MFSHR37	1,611	0.64	0.02		
38	Strip	Bldg.	MFSHB38	MFSHR38	12,039	1.39	6.60		
39	Strip	Bldg.	MFSHB38	MFSHR39	19,877	2.97	10.65		
40	Strip	Bldg.	MFSHB40	MFSHR40	6,998	1.12	3.76		
41	Strip	Apts.	MFSHB41	MFSHR41	2,833	0.20	0.74		
42	ASHP	Bldg.	MFHPB1	MFHPR1	4,527	1.87	3.15		
43	ASHP	Bldg.	MFHPB2	MFHPR2	7,280	3.03	5.24		
44	ASHP	Bldg.	MFHPB3	MFHPR3	35,639	8.81	33.06		
45	ASHP	Bldg.	MFHPB4	MFHPR4	15,294	4.39	17.49		
46	ASHP	Apts.	MFHPB5	MFHPR5	3,898	0.42	-0.05		-54,243
47	ASHP	Apts.	MFHPB7	MFHPR7	3,136	0.35	0.61		
48	ASHP	Apts.	MFHPB9	MFHPR9	1,103	1.28	0.73		
49	ASHP	Apts.	MFHPB10	MFHPR10	3,057	4.26	-0.09		
50	ASHP	Apts.	MFHPB11	MFHPR11	24,063	17.84	8.64		
51	ASHP	Apts.	MFHPB11	MFHPR12	25,818	19.06	9.28		
52	ASHP	Apts.	MFHPB11	MFHPR13	27,377	20.13	9.84		
53	ASHP	Apts.	MFHPB11	MFHPR14	8,127	6.59	1.05		
54	ASHP	Apts.	MFHPB15	MFHPR15	1,911	1.31	0.74		
55	ASHP	Apts.	MFHPB15	MFHPR16	3,606	2.48	1.39		
56	ASHP	Apts.	MFHPB15	MFHPR17	5,026	3.46	1.98		
57	ASHP	Apts.	MFHPB19	MFHPR19	4,071	1.08	0.00		
58	ASHP	Apts.	MFHPB20	MFHPR20	3,796	-6.31	6.77		
59	ASHP	Apts.	MFHPB21	MFHPR21	11,093	5.10	3.89		
60	ASHP	Apts.	MFHPB24	MFHPR24	3,828	2.75	2.13		
61	ASHP	Apts.	MFHPB32	MFHPR32	14,336	2.37	-0.08		
62	ASHP	Apts.	MFHPB32	MFHPR35	691	0.15	0.01		
63	ASHP	Apts.	MFHPB32	MFHPR36	1,045	0.19	0.02		
64	ASHP	Bldg.	MFHPB37	MFHPR37	1,361	0.66	0.01		
65	ASHP	Bldg.	MFHPB38	MFHPR38	6,694	1.57	6.93		
66	ASHP	Bldg.	MFHPB38	MFHPR39	11,436	3.25	11.32		
67	ASHP	Bldg.	MFHPB40	MFHPR40	3,818	1.21	4.13		
68	ASHP	Apts.	MFHPB41	MFHPR41	2,279	0.27	0.40		
69	NG	Bldg.	MFGB1	MFGR1	3,984	1.93	0.09	24,373	0
70	NG	Bldg.	MFGB2	MFGR2	6,233	3.09	0.14	39,791	0
71	NG	Bldg.	MFGB3	MFGR3	10,097	9.35	0.88	285,605	0
72	NG	Bldg.	MFGB4	MFGR4	3,167	4.96	0.49	134,250	0
73	NG	Apts.	MFGB5	MFGR5	12,465	0.86	0.14	1,027	-54,243
74	NG	Apts.	MFGB7	MFGR7	532	-0.03	0.01	-1,193	26,958
75	NG	Bldg.	MFGB8	MFGR8	537	0.01	0.01	-1,107	25,029
76	NG	Apts.	MFGB20	MFGR20	7,414	-6.71	0.18	3,707	8,538
77	NG	Apts.	MFGB32	MFGR32	36,089	2.99	0.84	18,051	-24,884
78	NG	Apts.	MFGB32	MFGR35	3,773	0.40	0.17	1,887	-2,254
79	NG	Apts.	MFGB32	MFGR36	2,837	0.24	0.10	1,419	-1,719
80	NG	Bldg.	MFGB37	MFGR37	4,644	0.68	0.00	2,322	-7,518
81	NG	Bldg.	MFGB38	MFGR38	1,135	1.68	0.17	567	54,745
82	NG	Bldg.	MFGB38	MFGR39	5,000	3.46	0.27	2,500	84,619
83	NG	Bldg.	MFGB40	MFGR40	1,965	1.29	0.10	982	29,474
84	NG	Apts.	MFGB41	MFGR41	341	0.04	0.01	0	136

Table 3: Potential Savings Evaluated in this Study

Measures Considered but Not Included in this Analysis

In addition to the measures included in this study, other measures were considered but not included. The following bullet items describe these and explain why they were not included:

- Add insulation to floor over basement areas; not enough savings. More often than not the heating energy savings do not offset the increases in cooling energy usage because the ground coupling effects are diminished.
- Increase evaporator air flow by 1) increasing blower speed or 2) increasing duct sizes. Insufficient system air flow is seldom a problem in apartments with forced air cooling or heating systems because they are typically located in a central closet adjacent a central hallway, and the ductwork is minimal. If blower speeds are increased the increased noise level may be objectionable due to the proximity of the blower to the living spaces.
- Add insulation to ductwork in attic spaces. The predominant building practice is to place forced air cooling and heating systems in closets adjacent an internal corridor and simply lower the corridor ceiling to house the ductwork. Hence, the ducts are effectively within the conditioned space.
- Reduce duct leakage. Due to the predominant location of ductwork in dropped ceiling areas, most or all the leakage is into the conditioned spaces.
- Replace standard fan motor with ECM. This could be a component of the AC and heat pump replacement measures, but it is not practical as a stand-alone measure with older existing systems because any small gains in system efficiency would not justify the installation costs.
- Remove old second refrigerator or freezer. Very few apartments or condos have a secondary refrigerator or stand alone freezer. None were found in the buildings of this study.
- Replace ventilation fan with efficient fan. Very few, if any, apartments or condos have a ventilation fan other than small toilet exhaust fans. None of the apartments audited in this study had a ventilation fan.
- Add solar screens to east, west and south glass. This was considered to be impractical due to objections of tenants and potential leasing issues in the minds of building owners and managers.

Interpretation of Field Data and Creation of DOE2 Models

As previously described, information gathered for this project included detailed building construction features and demographic information from on-site audits and telephone surveys. Monthly electric billing data obtained from the utility companies were utilized for about 46,000 individually metered multifamily customer accounts. (Data for other accounts were either not available or not used due to inconsistencies in the billing records).

KEMA employed specially created DOE2 models based on the average shell and demographic characteristics of all the sampled buildings 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 for KCP&L. As such, they are additive.

First, an "as-is" (or calibration) model for each building type was created to represent the average characteristics of all buildings 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 usage were made. These adjustments allowed proper calibration of these models to within 1% monthly and 1% annually of their weather-normalized kWh usage.

Many of the descriptive components of the "as-is" building that were used in the DOE2 models are listed in Table 4 below. These are three story buildings with 20 living units of various sizes and typical common areas (corridors, office, mechanical/laundry room) with partial (i.e. about 5%) basements where central water heating equipment and laundry areas might be located.

The models contain twenty conditioned zones, consisting of apartments and an office area. They also contain six unconditioned buffer zones to capture the effects of the heat transfer through ceilings, corridor walls and floors over unconditioned basements.

Exterior shading is modeled by two-foot eaves on the north and south sides and varying amounts of 60-foot high non-deciduous "trees" on the east, south and west faces of the building. 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 window shading options.

KEMA assumed a typical average application of natural ventilation practice during times of mild weather, based on a realistic schedule of manual opening and closing of windows, thus allowing the use of free cooling during those times. Some building tenants practice this and some do not. Therefore, KEMA assumed the average was somewhere between typical practice and non-practice. The actual amount of natural ventilation assumed was allowed to vary somewhat by model to aid in calibration.

Natural infiltration is usually expressed as ACH, or Air Changes per Hour. The measured leakage of a building is usually done in cubic feet per minute (CFM) at a standard

[3] That is, the fraction of sunlight that passes through and between the trees.

pressure of 50 Paschals negative relative to the outside because this can be measured by a large fan, called a "Blower Door" fan. This CFM50 may be converted to an estimated natural ACH that is a function of the average seasonal wind speed.

By varying the average number of occupants, KEMA was able to vary the base (non-weather sensitive) loads across the board to aid in calibration of each model. Although data were collected on the latest average occupancy levels, these levels may vary somewhat from month to month. It is not necessary to know exactly these occupancy rates because they will not change when the measure level savings are calculated.

	DOE2 Calibrated Model Value		
Model Characteristic	**Strip Heat**	**Heat Pump**	**Gas Heat**
First floor conditioned area, sq. ft.	5,400	5,400	5,400
Second floor conditioned area, sq. ft.	5,400	5,400	5,400
Third floor conditioned area, sq. ft.	5,400	5,400	5,400
Unconditioned Corridor area, sq. ft.	2,700	2,700	2,700
Unconditioned Basement area, sq. ft.	200	200	200
Office area, sq. ft.	600	600	600
Gross exterior Wall area, sq. ft.	8,600	8,600	8,600
% glass to exterior wall area	13.6%	13.6%	13.6%
Window glass type	Double-pane clear	Double-pane clear	Double-pane clear
Window area, sq. ft.	1,164	1,164	1,164
Solar screens?	No	No	No
Infiltration CFM50	20,000	15,000	15,000
Infiltration ACH	0.39	0.29	0.29
Wall insulation R-value	11.0	11.0	11.0
Attic insulation R-value	19.0	19.0	19.0
Number of occupants	1.92	1.4	2.4
Lighting connected load kW	18.90	18.90	21.30
Lighting peak usage kW	6.8	6.8	7.6
Base peak usage kW, exc. Lights	25.3	17.7	16.7
Base elec. usage, kWh/year	130,200	97,400	93,400
Base gas usage, Therms/year	0	756	2,736
Cooling system type	DX Split	DX Split	DX Split
A/C rated SEER	8.47	8.55	8.20
A/C rated tons	32.0	37.8	37.8
Metering device (TXV, Capillary)	Capillary	Capillary	Capillary
AC Air flow factor	0.85	0.85	0.85
AC Refrigerant charge factor	0.90	0.90	0.90
AC Field Operating SEER	7.14	7.21	6.92
AC Field Operating tons	27.4	32.3	32.7
AC Supply air cfm/ton	340	340	340
AC Supply duct air loss	Negligible	Negligible	Negligible
Alternate fueled fireplaces (wood)	4%	25%	10%
Heating sytem type	Elec. Furnace	Heat Pump	Gas Furnace
Heating system rated efficiency	100%	3.58 COP	81%
Heating system operating efficiency	100%	3.19 COP	75%
Heating rated capacity, Btu/hour	819,000	966,000	966,000

Table 4: 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 4. These values are typical of those observed in this study or borrowed from other similar studies [4]. 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 mimic typical field operating values.

Calculation of Individual Measure Impacts

The savings for each measure were calculated separately for each DOE2 model except when this would be redundant, as in the case of clothes washer replacements in common areas, where the savings are the same regardless of heating system type. Average savings estimates for each measure and optional retrofit improvement are summarized in Table 5.

Direct impacts for lights and appliances located within the conditioned space were first calculated and then programmed into the DOE2 models to capture their secondary impacts on cooling and heating loads.

Table 5: Electric/Natural Gas Savings by Measure and Heating System Type

Differential costs, shown in the last two columns, 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 from the building owner perspectives, so the "before rebate" costs are reduced to half when a 50% rebate is applied. Payback for all fuels is the simple payback after rebates 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.
Measure functional lifetimes were not considered in this study because this is like a snapshot of the existing conservation potential at this point in time. Unpredictable variations in many factors may tend to change these estimates over the next 5 to 20 years.

Situation (base case) 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.

Add Attic Insulation – IDs 1 & 2, 42 & 43, and 69 & 70

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

[4] "**Market Research for the Rhode Island, Massachusetts, and Connecticut Residential HVAC Market",** Dec. 2002, Prepared for National Grid USA, Northeast Utilities, NSTAR Electric and Gas, Fitchburg Gas and Electric Light Company, and United Illuminating Company, Prepared by RLW Analytics, Inc., 179 Main Street, Middletown, CT 06457

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 1, the baseline models were given an attic insulation value of R-7 with a retrofit to R-30. The calculated savings are 6,180 kWh, 1.65 summer kW and 3.43 winter kW, as shown in Table 5, and they apply to electric strip heated buildings.

In the second scenario, ID 2, the base case was R-11 and the retrofit was R-30. Savings were estimated to be 10,090 kWh, 2.68 summer kW and 5.54 winter kW. These savings also apply to electric strip heated buildings.

IDs 42 & 43 apply to savings for heat pump heated buildings, and IDs 69 & 70 apply to gas heated buildings. Their savings may be seen in Table 5.

Add Wall Insulation – ID 3, 44 and 71

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. KEMA evaluated this measure with a baseline of no wall insulation, and added R-11 insulation to represent a realistic best-case scenario. Other baseline conditions were assumed for other measures, based on the most likely conditions of the prospective program participants. Wall insulation is difficult to add if there is any existing insulation within the wall cavities because it would tend to block the flow of new blown-in insulation.

The calculated savings for electric strip heated buildings are 48,780 kWh, 6.88 summer kW and 30.07 winter kW.

IDs 44 & 71 apply to savings for heat pump and gas heated buildings, respectively. Their savings may be seen in Table 5.

Reduce Infiltration by Caulking and Weatherstripping – IDs 4, 45 and 72

For this measure, KEMA assumed a reduction in infiltration of 15,000 CFM50 (Cubic Feet per Minute at a negative pressure of 50 Paschals). This amounts to a reduction of about 0.29 ACH (Air Changes per Hour) from a baseline value of 0.68 ACH. Calculated savings for these weatherization measures are 23,678 kWh, 3.79 summer kW and 22.29 winter kW. Most of the electric energy savings (kWh and winter kW) is due to reduced heating requirements in electric heated buildings.

Replace Electric Clothes Dryer with Gas in Apartments– IDs 5, 46 and 73

For this measure, KEMA simply switched the clothes dryer primary fuel from electric to natural gas in 8 of the 20 apartments. It was found in the survey data that on average about 40% of the apartments have electric clothes dryers. Calculated savings for this measure are 5,600 kWh, 0.29 summer kW and 0.12 winter kW. The coincident demand savings are low due to low coincidence factors, especially for winter demand. Gas heated building savings, ID 73 are significantly lower because some of the dryers in these apartments already use gas.

Replace Common Area Electric Clothes Dryer with Gas– ID 6

For this measure, KEMA simply switched the clothes dryer primary fuel from electric to natural gas in the common area laundries. It was found in the survey data that on average common area laundries have about 4 electric clothes dryers. Calculated savings for this measure are 1,175 kWh, 0.06 summer kW and 0.03 winter kW. The coincident demand savings are low due to low coincidence factors, especially for winter demand. Savings for this measure are the same regardless of the heating system type.

Purchase Energy Star Labeled Clothes Washer for Apartments – IDs 7, 47 and 74

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 are achieved through the dryer. For this measure, KEMA assumed that 20 units would be purchased for the average building. KEMA estimated annual savings for the maximum savings scenario to be about 4,638 kWh, 0.56 summer kW and 0.49 winter 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.

In the gas heated buildings, most of the water heaters are also gas fired, and the electric savings are greatly reduced, to about 532 kWh, but the gas savings are significant, at about 258 therms (or CCF) per year.

Purchase Common Area Energy Star Labeled Clothes Washers – ID 8 and 75

For this measure, KEMA assumed that 4 units would be purchased for the average building. KEMA estimated annual savings for the maximum savings scenario to be about 6,007 kWh, 0.28 summer kW and 1.91 winter kW. In the gas heated buildings, most of the water heaters are also gas fired, and the electric savings are greatly reduced.

Overcharged AC Systems - ID 9 and 48

About 31% of the measured AC systems found in other studies[5] were found to be overcharged with refrigerant. The average effect of this situation, however, is not dramatic, with only a 5% reduction in both cooling capacity and efficiency. This was represented in the models by a change in refrigerant charge factor of 5%. This resulted in an estimated annual savings of 1,762 kWh, 2.15 summer kW and zero winter kW for the electric strip heated buildings.

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[5] "**Building a Better Mousetrap: A Unique Approach to Determining Reliable Savings Potential**"
Glenn C. Haynes, PE, RLW Analytics, Inc., Middletown, CT
Thomas Ledyard, RLW Analytics, Inc., Middletown, CT
Gail Azulay, NSTAR Electric and Gas, Westwood, MA
Ralph Prahl, Prahl and Assoc., Madison, WI
A technical paper presented at the 2007 International Energy Program Evaluation Conference, August 14-16, 2007, Chicago, Illinois

The heat pump heated buildings realized a winter kW reduction of 0.73 kW, as well as kWh and summer kW savings.

Undercharged AC Systems – ID 10 and 49

Published accounts from several other studies were used to estimate the technical potential percentages for AC systems. From these studies, about 36% of the measured systems were probably undercharged enough (with refrigerant) 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 3,903 kWh, 4.48 summer kW and zero winter kW for the electric strip heated buildings.

The heat pump heated buildings realized a winter kW reduction of 4.26 kW, as well as 3,385 kWh and summer demand savings of 3.86 kW.

High Efficiency AC Retrofit – IDs 11, 12 & 13

Significant savings are potentially available for the early retirement of old, but operating low efficiency AC systems with high efficiency systems.

Modeling the savings for this measure was straightforward. The baseline DOE2 model was assigned a rated efficiency of SEER 7.1, and the retrofit models used SEER 14, 15 and 16, respectively. 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 the 14 SEER option is 19,979 kWh, 18.38 summer kW and zero winter kW for both electric strip and gas heated buildings.

Refer to Table 5 for savings with 15 and 16 SEER replacement options.

Field Servicing of Existing AC Systems – ID 14

Significant savings have been achieved for servicing of existing AC systems that haven't been serviced for several years. AC contractors routinely clean evaporator and condenser coils, check for adequate airflow through the evaporator, clean the blower wheel and check for proper refrigerant charge when they are called on to perform a routine service procedure.

Knowledge of the potential savings was necessary to set the baseline and retrofit parameters properly. The baseline DOE2 model was assigned a rated efficiency of SEER 7.1, and the retrofit models used SEER 8.5 to represent the average increase in AC performance. The estimated annual savings for the "tune-up" is 6,173 kWh, 5.6 summer kW and zero winter kW for both electric strip and gas heated buildings.

Field Servicing of Existing Heat Pump Systems – ID 14

Heat pump servicing is virtually the same as AC servicing from a contractor perspective, although the charges may be slightly higher. Modeling this measure in DOE2 was similar to the AC "tune-up" measure, but the increase in efficiency of the heating COP had to be modeled. The same percentage increase in efficiency was assumed for the COP as for the SEER. The estimated annual savings for the heat pump "tune-up" is 8,127 kWh, 6.59 summer kW and 1.05 winter kW.

High Efficiency AC Options – IDs 15, 16 & 17

Significant savings are potentially available for the installation of high efficiency AC systems instead of standard efficiency SEER 13 units. In the existing building retrofit market, this might be applied to buildings 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 building in which air conditioning was never before installed and the building owner wants to install a new central AC system.

The baseline DOE2 model was assigned a rated efficiency of SEER 13, and the retrofit models used SEER 14, 15 and 16, in turn. Additionally, the expansion device for the baseline and retrofit models was changed from a capillary tube to a thermal expansion valve (TXV). All other conditions remained unchanged. The estimated annual savings for the SEER 14 option (ID 15) is 1,588 kWh, 1.46 summer kW and zero winter kW.

High Efficiency Window AC Option – ID 18

Many apartments are cooled with window AC units installed either by the building owners or the tenants themselves.

To model this measure, the baseline DOE2 model was assigned a rated efficiency of 8.0 EER applied to all 20 apartments, and the retrofit model used a 10.0 EER. All other conditions remained unchanged. The estimated annual savings for the 20 window units is 5,281 kWh, 5.22 summer kW and, of course, zero winter kW.

Install Ceiling Fans– ID 19

Studies have found that occupants using ceiling fans can allow the room temperature to increase by two or three degrees while maintaining a sufficient comfort level. KEMA chose to model this with a conservative 1.5 degrees because the fans are not always used, or they may not be installed in every room. Calculated savings for this measure are 4,887 kWh, 1.38 summer kW and zero winter kW. Savings for this measure are the same regardless of the heating system type.

Install Programmable Thermostat – IDs 20, 58 and 76

Only 19% of the buildings visited already had programmable thermostats. KEMA modeled the potential impacts of programmable thermostats by increasing the cooling setpoints 5 degrees F and decreasing the heating setpoints by 5 degrees F daily from about 8AM to around 4PM. The actual changes were spread out over three hours to capture the fact that everyone does not start and end the setback period at the same time.

For this measure, KEMA estimated annual savings to be about 4,016 kWh, -5.6 summer kW and 7.63 winter 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.

Savings for heat pump (ID58) and gas (ID76) heated buildings are presented in Table 5.

Downsize AC and Heat Pump Systems – IDs 21 and 59

Field studies by KEMA and others have found that residential AC (and heating systems) are significantly oversized on average. In fact, some typical findings indicate that oversizing can be as high as 70% on average for single family homes in hot, mild and even cool climates. Many utility program staff throughout the country have decided that a good AC system sizing standard would be based on a Manual J calculation of load plus 20%.

This is typically a difficult standard to reach in practice because most contractors prefer to continue to utilize the sizing practice that has served them well for many years. Smaller systems not only increase the risk of callbacks, but also cost less and net them less profit.

Based on findings of other studies, KEMA assumed that the base case AC system was oversized by 70% and reduced the size to 20% over a Manual J load estimate. The annual savings were estimated to be about 7,375 kWh, 4.95 summer kW and 0.22 winter kW. The winter demand reduction is due to a reduction in the blower motor size.

Similar downsizing for heat pump systems (ID 59) yields 11,093 kWh, 5.10 summer kW and 3.89 winter kW.

Replace Electric Strip Heat with 90% Efficient Gas Furnace – ID 22

To model this measure, the heating systems in the DOE2 strip heat model were replaced with gas furnaces win all 20 apartments. The estimated annual savings is 30,357 kWh, zero summer kW and 41.82 winter kW.

The resulting increase in natural gas consumption is 1,151 therms per year.

High Efficiency Heat Pump– ID 23

Significant savings are potentially available for the installation of high efficiency heat pumps instead of market efficiency SEER 13 AC units. In the existing building retrofit market, this might be applied to buildings 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 building in which air conditioning was never before installed and the building owner wants to install a new central AC system.

To model this measure, the baseline DOE2 model assigned a rated AC system efficiency of SEER 13, and the retrofit model used SEER 16 heat pump. Additionally, the expansion device for the baseline and retrofit models 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 12,236 kWh, 3.50 summer kW and 7.28 winter kW.

ECM Motors for AC and Heat Pump Blowers– IDs 24 and 60

Small horsepower, electronically commutated motors (ECM) have been in production long enough to become attractive as replacements for standard AC and heat pump blower motors. They reduce energy consumption by allowing the systems to operate more efficiently at reduced loads.

To model this measure, KEMA used the hourly blower cooling and heating kW from the calibrated Strip heat and heat pump DOE2 models. The motor power was reduced as the loads were reduced using a power function similar to that used for a variable frequency drive (VFD).

The estimated annual savings for this measure is 2,754 kWh, 0.52 summer kW and 0.53 winter kW. Similar to VFDs, the peak demand savings are expected to be small or even slightly negative.

Insulate Electric Water Heater Storage Tanks in Apartments– ID 25

KEMA found that at least 99% of the apartments with electric water heaters had tanks that were not externally wrapped. The estimated savings for the typical building are 2,795 kWh, 0.29 summer kW and 0.03 winter kW. Savings for this measure will vary with the amount of insulation already on the tank, the water holding temperature and ambient temperatures surrounding the hot water tank, but the savings are the same for heat pump and gas heated buildings that use electric water heaters in all apartments.

Insulate Electric Water Heater Storage Tanks in Common Areas– ID 26

Common area domestic water heaters are typically 120 to 250 gallons in tank capacity. The estimated savings for the typical building with common hot water are 1,306 kWh, 0.11 summer kW and 0.03 winter kW. Savings for this measure will vary with the amount of insulation already on the tank, the water holding temperature and ambient temperatures surrounding the hot water tank, but the savings are the same for heat pump and gas heated buildings that use electric water heaters in all apartments.

Insulate Hot Water Pipes with Electric Water Heaters in Apartments– ID 27

All the audited buildings of this study have hot water piping, but only portions of the pipes are easily accessible. KEMA 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.

Assuming about 2.5 feet of insulation may be applied, the estimated savings for the typical building with electric water heaters in all apartments are 396 kWh, 0.02 summer kW and 0.03 winter kW. This measure may also be applied to electric water heaters in heat pump and gas heated buildings.

Insulate Hot Water Pipes with Electric Water Heaters in Common Areas– ID 28

Assuming about 30 feet of insulation may be applied, the estimated savings for the typical building with central electric water heaters are 1,277 kWh, 0.09 summer kW and 0.34 winter kW. This measure may also be applied to central electric water heaters in heat pump and gas heated buildings.

Install Faucet Aerators – ID 29

KEMA estimated the impacts of low flow (1.2 GPM) faucet aerators by assuming that one faucet aerator would be installed on the kitchen sink, and another on the bathroom lavatory. The energy savings occur through a reduction in the use of hot water. The buildings with gas water heaters will see no electric savings, but most of the buildings in this study have electric water heaters.

For the 81% of buildings with electric water heaters, the estimated savings for the typical building are 1,916 kWh, 0.11 summer kW and 0.56 winter kW. Some building owners and tenants may be willing to install and keep faucet aerators in the kitchen and bathroom. Although savings for these are not well defined, KEMA has previously estimated that bathroom aerators 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 30

Field observations within the tenant spaces indicate that only about 58% already use low flow showerheads. KEMA estimated the impacts of these by assuming that one low flow showerhead would be installed, and that the energy savings would occur through a reduction in the use of hot water.

The estimated savings for the typical building with electric domestic hot water heaters are 3,821 kWh, 0.21 summer kW and 1.12 winter kW.

Switch from Electric to Gas Domestic Water Heating – ID 31

Assuming a constant usage of hot water, the estimated savings for the typical building with electric domestic hot water heaters are 58,401 kWh, 2.72 summer kW and 17.17 winter kW. The increased usage of natural gas, however, will be 2,491 therms per year, assuming a standard gas steady state water heater efficiency of about 80%.

Install Compact Fluorescent Lamps in all Apartments– IDs 32, 61 and 77

Field data from the site visits indicated that the average apartment had about 9.9% CFL's (Compact Fluorescent Lamps) by bulb count. Hence, there is a high technical market potential for this measure. In the impact analysis, KEMA assumed that each apartment would install and use an average of ten 15-watt CFL's to replace ten 65-Watt (average) incandescent bulbs, for a connected load reduction of about 500 Watts per apartment.

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 KEMA has performed or examined. Calculated savings amounted to 9,438 kWh, 1.28 summer kW and -0.03 winter kW in the strip heated building. The winter kW impact is negligible because the heating system and lighting heat load reduction cancel one another.

In gas heated buildings the winter demand reduction is 0.84 kW. It is obvious that the diversity factors for this measure are low, because the whole building connected load reduction is 10 kW.

Install Compact Fluorescent Lamps in Common Areas– ID 33

Common areas consist of corridors, laundry and mechanical rooms. In the impact analysis, KEMA assumed that each building would install and use an average of thirteen 23-watt CFL's to replace thirteen 115-Watt (average) incandescent bulbs, for a connected load reduction of about 1,193 Watts.

Lighting in these areas are typically kept on continuously. Calculated savings amounted to 10,395 kWh, 1.25 summer kW and 1.11 winter kW in the strip heated building. The kW impacts are slightly more than the connected load reduction due to some small interactive effects. The common areas, although not directly cooled or heated, are enclosed and adjacent to the tenant spaces in these models.

In heat pump and gas heated buildings, the direct savings are the same, but the interactive effects are slightly different due to differences in the electric efficiencies of the tenant cooling and heating systems.

Install High Efficiency Exterior Lighting Systems– ID 34

In the impact analysis, KEMA assumed that each building would replace incandescent bulbs and fixtures with higher efficiency fixtures such as metal halide or Mercury vapor, for a connected load reduction of about 984 Watts.

These lights are assumed to be on from dusk to dawn, primarily under the control of timers or photo sensors. Calculated savings amounted to 4,748 kWh, 0.23 summer kW and 0.82 winter kW.

In heat pump and gas heated buildings, the savings are the same.

Install Energy Star Labeled Plug Load Electronic Appliances– IDs 35, 62 and 78

The average connected load for these appliances that have similar Energy Star units on the market is about 950 Watts per apartment. The connected load and energy reductions are assumed to be about 10%, or 95 Watts. Hourly usage patterns utilized in the models are based on actual measured hourly and monthly usage patterns from several long-term and short-term end-use studies KEMA has examined.

Calculated savings for the electric strip heated buildings are 869 kWh, 0.22 summer kW and 0.02 winter kW. Winter demand reduction in the average gas heated building is 0.17 kW.

Purchase Energy Star Labeled Refrigerator – IDs 36, 63 and 79

This option assumes that the existing apartment refrigerators are all at the end of their functional lives and the building owner has already decided to replace them.

KEMA estimated that a standard new refrigerator on the market today uses about 489 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 57 kWh per year per refrigerator. This direct energy reduction was modeled with DOE2, and the resultant total interactive net savings in an average electric strip heated building are 562 kWh, 0.02 summer kW and zero winter kW. Secondary impacts occur due to the fact that the refrigerators are in the conditioned spaces.

Gas heated buildings realize a reduction of 2,837 kWh and 0.10 winter kW, but electric strip heated buildings pay a heating penalty due to the fact that savings inside the conditioned spaces increase the need for heat in the winter.

Add Shading to East and West Facing Windows – IDs 37, 64 and 80

Although external window shading might be added to all four faces of a building, 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.

This measure will be applicable to buildings with little or no east and west shading from existing trees or other things. To model these measures, KEMA removed all but about 5% of the external shading from the calibration models to create a baseline model.

The most desirable method of shading windows, from both an aesthetic and practical perspective, is the planting of deciduous trees in strategic locations to the east and west of the building. KEMA assumed that three deciduous trees had been planted at about 20 feet from each side of the building (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 0.2 during the summer (June 1 through October 31) to 0.9 during the winter. Resultant savings are 1,611 kWh, 0.64 summer kW 0.02 winter kW. As these trees continue to grow, the savings will increase significantly.

Add Storm Windows to Standard Single Pane Windows – IDs 38, 65 and 81

The average building in this study has about 1,164 square feet of window area. About 31% of the windows in this study were single pane, about 68% were double pane and only about 1% were triple pane, counting those with storm windows. The overall average number of glass panes is 1.7, based on the study sample.

KEMA used a typical single pane window with a U_0 (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 over these in the retrofit case. The retrofit window structure had a U_0 of 0.57 and a SHGC of 0.75, and the estimated savings are 12,039 kWh, 1.39 summer kW and 6.60 winter kW for electric strip heated buildings. The high winter demand reduction applies only to electric heated buildings; the winter demand reduction for gas heated buildings is only 0.17 kW.

Replace Standard Single Pane Windows with Double Pane – IDs 39, 66 and 82

KEMA used 1,164 square feet of typical single pane windows with a U_0 value of 1.09 and a SHGC of 0.81 for the base case, and applied typical high performance double pane windows in the retrofit case. The retrofit windows have a U_0 of 0.32 and a SHGC of 0.60. The estimated savings are 19,877 kWh, 2.87 summer kW and 10.65 winter kW for electric strip heated buildings. Winter demand reduction for gas heated buildings is only 0.27 kW.

Add Storm Windows to Standard Double Pane Windows – IDs 40, 67 and 83

About 68% of the buildings in this study have double pane windows. KEMA used a typical double pane window with a U_0 value of 0.57 and a SHGC of 0.75 for the base case, and applied storm windows over these in the retrofit case. The retrofit window structure had a U_0 of 0.32 and a SHGC of 0.68, and the estimated savings are 6,998 kWh, 1.12 summer kW and 3.76 winter kW for electric strip heated buildings. The high winter demand reduction applies only to electric heated buildings. Winter demand reduction for gas heated buildings is only 0.10 kW.

Purchase Energy Star Labeled Dishwasher – IDs 41, 68 and 84

An average new dishwasher uses about 111 kWh per year directly, and an equivalent Energy Star dishwasher will use about only about 95 kWh per year. Most of the savings, however are due to a reduction in electric hot water usage. Estimated savings for a building with all electric water heaters are 2,833 kWh, 0.20 summer kW and 0.74 winter kW. The average gas heated building, using gas water heaters, will save only 341 kWh per year.

Replace Old Heat Pumps with High Efficiency Heat Pumps – IDs 54, 55 and 56

The installation of high efficiency heat pumps might be an option as a retrofit measure for existing buildings with old heat pumps at or near the end of their functional lifetimes, or for buildings that have plans to install heat pumps for the first time.

The base case model for a "burned out" heat pump replacement assumes SEER 13 heat pumps for all apartments. The retrofit options are SEER 14, 15 and 16, in turn. The expansion device for the baseline and retrofit models was changed from a capillary tube to a thermal expansion valve (TXV). All other conditions remained unchanged. The estimated annual savings for the SEER 14 option (ID 54) is 1,911 kWh, 1.34 summer kW and 0.74 winter kW. This measure, by definition, applies only to heat pump heated buildings.

Technical Assessment of Program Market Potentials by Measure

Preferred Energy Conservation Measures

KEMA initially analyzed 84 potential building improvement options. The 40 most promising measures, as ranked by annual electrical energy savings in MWh, offer nearly the same (about 98%) potential savings as all 84 measures combined.

Market potentials for the top 40 measures are shown in Table 6. These measures are ranked by their estimated "Annual Realistic Achievable Potential, MWh". The measure is described in the second column, followed by twelve columns of marketing metrics, all of which are defined under their respective column headings.

The state of Missouri has proposed standard definitions for the 5 levels of market potential, as shown in the 5 columns under the super heading "Based on MO Proposed Definitions 2010". These will be discussed more fully in the next section, "Calculation of Market Potentials".

The potential analysis shown in this report assumes that the program sponsors will aggressively identify all appropriate measures for existing buildings and offer rebates of 50% of the differential costs for those measures. Appropriate measures will include all existing conditions that fall below the minimum thresholds of performance. Higher or lower rebate levels may significantly affect the annual achievable market savings.

Table 7 show totals for all 84 measures and the top 40 measures. The headings are self-explanatory; the % Savings are with reference to the estimated total annual kWh usage for all multifamily buildings within the three KCP&L service areas, which is about 886,000 kWh per year. Notice that the top 40 measures capture 98% (14,115/14,447 kWh) of the annual achievable electric potential and 91% (1.07/1.18) of the summer demand market potential available through all 84 measures. On the other hand, the rebate costs necessary to capture these are reduced from $2,195 to $1,925 thousand dollars per year, which is 88%.

Notice that the gas usage is increased by 9.4 thousand Therms for all 84 measures and by 27.0 thousand for the top 40 measures.

							Based on MO Proposed Definitions 2010							
			Potential Installs Per Year	Summer Demand Market Potential	Winter Demand Market Potential	N-C Demand Market Potential	Technical Potential	Economic Potential	Maximum Achievable Potential	Annual Realistic Achievable Potential	Annual Gas Realistic Potential	Annual Customer Energy Savings	Annual Utility Rebate Costs	Electric Rebate Cost per kWh
Pri	**ID**	**Improvement (Retrofit) Measure**	**Count**	**MW-S**	**MW-W**	**MW-NC**	**MWh**	**MWh**	**MWh**	**MWh**	**kTherms**	**k$**	**k$**	**$/kWh**
1	33	Apply High Efficiency Lighting to CA	282	0.35	0.31	0.56	53,957	31,094	9,820	2,935	0.0	$261	$84	$0.03
2	31	Switch to Gas Central Water Heater	42	0.12	0.73	1.07	66,760	35,383	35,383	2,481	-105.8	$90	$33	$0.01
3	32	Apply High Efficiency Lighting to Tenant Space	210	0.27	-0.01	1.43	18,166	17,030	8,917	1,979	0.0	$176	$26	$0.01
4	19	Add Ceiling Fan	142	0.20	0.00	2.11	18,725	7,743	4,616	693	0.0	$62	$149	$0.21
5	78	Energy Star Plug Load Electronics	189	0.08	0.03	0.57	8,802	7,570	3,564	715	-0.7	$63	$76	$0.11
6	25	Wrap electric water heater	209	0.06	0.01	0.55	11,900	6,188	2,640	584	0.0	$52	$63	$0.11
7	4	Reduce infiltration to 20000 CFM50	19	0.07	0.42	0.45	45,571	22,785	22,368	443	0.0	$39	$145	$0.33
8	77	Apply High Efficiency Lighting to Tenant Space	12	0.04	0.01	0.15	40,007	4,543	4,543	220	-3.0	$16	$2	$0.01
9	2	Add another R-23 attic insulation	41	0.11	0.23	0.23	17,478	5,042	5,042	416	0.0	$37	$123	$0.30
10	30	Install low fow shower heads	99	0.02	0.11	0.18	10,920	4,543	3,610	380	0.0	$34	$2	$0.01
11	70	Add another R-23 attic insulation	52	0.16	0.01	0.30	13,087	3,775	3,775	326	20.8	$55	$156	$0.48
12	76	Install programmable thermostat	72	-0.49	0.01	0.99	8,648	6,095	3,502	268	6.2	$31	$87	$0.32
13	8	Purchase Energy Star Clothes Washer	48	0.01	0.09	0.14	12,874	3,476	3,476	291	0.0	$26	$10	$0.03
14	3	Add R-11 wall insulation	5	0.03	0.14	0.14	93,884	19,095	19,095	227	0.0	$20	$50	$0.22
15	20	Install programmable thermostat	55	-0.31	0.42	0.99	7,342	5,174	3,794	221	0.0	$20	$66	$0.30
16	34	Apply High Efficiency Exterior Lighting	36	0.01	0.03	0.04	24,646	2,799	2,799	171	0.0	$15	$31	$0.18
17	39	Install Low E double pane window 2900	4	0.01	0.04	0.05	9,564	2,918	2,918	83	0.0	$7	$4	$0.05
18	1	Add another R-19 attic insulation	23	0.04	0.08	0.08	10,705	3,911	3,911	143	0.0	$13	$62	$0.43
19	43	Add another R-23 attic insulation	11	0.03	0.06	0.06	6,114	1,764	1,764	82	0.0	$7	$34	$0.41
20	35	Energy Star Plug Load Electronics	156	0.03	0.00	0.14	1,672	1,438	821	136	0.0	$12	$63	$0.46
21	57	Add Ceiling Fan	23	0.03	0.00	0.28	3,419	1,414	1,414	95	0.0	$8	$24	$0.26
22	69	Add another R-19 attic insulation	29	0.06	0.00	0.10	8,365	3,056	3,056	116	7.1	$19	$78	$0.67
23	45	Reduce infiltration to 15000 CFM50	8	0.03	0.13	0.15	14,271	7,136	7,136	115	0.0	$10	$58	$0.51
24	29	Install faucet aerators	62	0.01	0.03	0.06	5,475	1,424	1,424	119	0.0	$11	$3	$0.03
25	58	Install programmable thermostat	27	-0.17	0.18	0.35	3,365	2,371	2,371	101	0.0	$9	$32	$0.32
26	38	Add storm windows over single pane	4	0.01	0.03	0.03	5,793	1,767	1,767	50	0.0	$4	$17	$0.34
27	27	Insulate hot water pipes in apartments	230	0.00	0.01	0.21	2,057	1,090	374	91	0.0	$8	$20	$0.22
28	72	Reduce infiltration to 15000 CFM50	22	0.11	0.01	0.12	7,388	3,694	2,992	69	29.3	$42	$169	$2.45
29	44	Add R-11 wall insulation	2	0.02	0.06	0.06	33,257	6,764	6,764	66	0.0	$6	$20	$0.30
30	7	Purchase Energy Star Clothes Washer	7	0.00	0.00	0.03	2,231	893	893	33	0.0	$3	$7	$0.22
31	80	Plant deciduous trees on E & W sides	10	0.01	0.00	0.06	1,354	1,083	1,083	49	-0.5	$4	$6	$0.12
32	61	Apply High Efficiency Lighting to Tenant Space	2	0.01	0.00	0.02	13,378	1,519	1,519	31	0.0	$3	$0	$0.01
33	82	Install Low E double pane window 2900	6	0.02	0.00	0.03	2,916	890	890	30	5.3	$9	$6	$0.20
34	47	Purchase Energy Star Clothes Washer	19	0.01	0.01	0.04	2,926	1,171	1,171	58	0.0	$5	$19	$0.32
35	71	Add R-11 wall insulation	6	0.05	0.01	0.06	23,554	4,791	4,791	58	16.3	$25	$61	$1.06
36	79	Purchase Energy Star Refrigerator	19	0.00	0.00	0.04	6,617	1,494	1,494	53	-0.1	$5	$26	$0.49
37	22	Replace with 90% Efficient Gas System	2	0.00	0.07	0.09	23,370	23,370	23,370	49	-1.9	$2	$34	$0.69
38	42	Add another R-19 attic insulation	11	0.02	0.03	0.05	3,802	1,389	1,389	48	0.0	$4	$28	$0.59
39	62	Energy Star Plug Load Electronics	76	0.01	0.00	0.10	645	554	554	52	0.0	$5	$30	$0.58
40	41	Purchase Energy Star dishwasher	13	0.00	0.01	0.02	5,452	1,156	1,156	38	0.0	$3	$20	$0.53

 Page 36 of 78

Table 6: Market Potential Metrics for Top 40 Measures

Page 37 of 78

Summer Demand Market Potential, MW/yr	Winter Demand Market Potential, MW/yr	N-C Demand Market Potential, MW/yr	Technical Potential, MWh	Economic Potential, MWh	Maximum Achievable Potential, MWh	Annual Realistic Achievable Potential, MWH	Annual Gas Realistic Potential, kTherms	Annual Customer Energy Savings, k$	Annual Utility Rebate Costs, k$	Electric Rebate Cost, $/kWh
1.18	3.38	**All 84**	732,930	280,946	233,521	14,447	-9.4	$1,272	$2,195	$0.15
1.05	3.32	**Top 40**	650,450	259,665	212,240	14,122	-32.8	$1,215	$1,931	$0.14
% Savings		**All 84**	82.8%	31.7%	26.4%	1.63%				
% Savings		**Top 40**	73.5%	29.3%	24.0%	1.59%				

Table 7: Summary Metrics for All 84 and the Top 40 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. The program may operate for more than 15 years, but the savings potential per year will be declining as the market approaches saturation.

This study captures a "snapshot" of the currently existing energy and demand savings potential of existing buildings and predicts a generic estimate of how much of this may reasonably be captured in a year by a well designed and staffed, established and fairly aggressive utility program. The actual annual capture rate will depend on many factors, including program design choices, design and implementation staffing levels, budgets allocated, marketing strategies and available plus emerging market actors. Changing costs of fuels, public awareness and economic uncertainty will also play a role in the actual market capture rates each year.

Standard "S curve" theory predicts that penetration rates start small and gradually increase for the first few years, then gain momentum over the next few years, reaching a maximum annual penetration rate before the mid-point of market saturation. After that, the penetration rates decrease slowly for a few years and then decrease more rapidly as the potential market approaches about 80% of saturation. At that point it becomes much more difficult and expensive to gain significant annual savings.

The numbers presented herein represent 100% of the current potential savings, assuming there will be some new potentials added over the program life to offset the reasonably unattainable last 20% of the current market. They also represent simple accumulated savings without regard to measure lifetimes and persistence issues.

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 buildings 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 to the customer. Effects of possible population growth over the projected time period were not considered in this study.

The expected actual penetration rates under different program scenarios, or the "Annual Realistic Achievable Potential", involves the estimation of how many customers might participate in a specific program in a year. The values, of course, depend on the measure, the length of time the program is offered, the specific markets, numbers of customers targeted, and finally the level of subsidy (rebate level).

The 2010 proposed Missouri definitions of stepped marketing potentials, which have been applied in this study, are defined as follows:

(1) The "Technical Potential" is the percent of all multifamily buildings that qualify technically from a theoretical construct that assumes all feasible measures are adopted regardless of cost or customer preference.

It is the total number of multifamily buildings 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 multifamily buildings that have space in their yards to plant trees near the east and west faces.

(2) The "Economic Potential" is the percent of all multifamily buildings resulting from customer adoption of all cost-effective measures, regardless of customer preference. In this study, it was determined for each measure through analysis of the in-building audits 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 building owner to replace existing double pane windows with higher performance windows solely for the purpose of saving energy, even though the building 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 "Maximum Achievable Potential" is the percentage of the Economic Potential of managers and/or tenants who might actually participate annually. It is based on the attractiveness of each measure in terms of first cost and simple payback. This establishes a maximum target of annual achievable demand-side savings that a utility can expect to achieve through its demand side programs and involves incentives that represent a very high portion of total program costs (99%) and very short customer payback periods (one month), because it presumes conditions that are ideal and not typically observed.

(4) The final "Realistic Achievable Potential" is the percent of all multifamily buildings that might be expected to participate each year of a fully operational program. This establishes a realistic target for DSM savings that a utility can expect to achieve and involves incentives that represent a moderate portion of total program costs as defined in Maximum Achievable Potential. This 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 6 above lists the top 40 measures that were analyzed in this study. This table shows ID numbers, their retrofit improvement options, the potential number of installations per year, summer, winter and non-coincident demand savings and the four levels of previously defined market potential estimates.

The last four columns show the annual natural gas savings potentials, annual customer energy bill savings, utility rebate costs and the electric utility rebate cost ratios in dollars per kilowatt-hour saved.

The third column is the estimated numbers of installations (or number of buildings affected) for each respective measure that may be performed each year. Many of the affected buildings will have multiple measures installed.

The final "Annual Realistic Achievable 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 These factors capture effects of known market barriers (other than first cost or payback) by entering 1, 2, 3 or 4. A 1 indicates little or no known barriers exist, a 2 indicates average barriers, a 3 indicates formidable barriers and a 4 indicates very formidable barriers.

The "Quantity per Building" column in Table 5 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 building owner 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 typically designed to render the first cost and payback of a measure beneficial and desirable to a qualifying building owner or tenant.

The bottom-up modeling approach utilized by KEMA for this study does not lend itself easily to the MO state definitions for 2010. To adapt to those definitions, it was necessary to insert four steps between the "Maximum Achievable Potential" and the "Realistic Achievable Potential", and present the latter as an annual value. This allowed the KEMA model to be calibrated to annual results from other studies while providing estimates at the measure level.

The primary analytical function for this model takes into account the Simple Payback in years, Customer installed cost after rebate, Maximum Achievable Potential and the "Reluctance factor" (or market barrier number) to jump the gap between economic potential and realistic achievable potential. KEMA calls this the "annual potential with barriers", and it is expressed in Percent of Economic Potential Buildings. The following equation shows these relationships for each measure:

Percent of Economic Potential Buildings =
MIN(V13,8.78%*(1.324/(MAX(W13,1)^0.3)),0.000267*(28695/S13+12.3/Q13)*9/(W13+1)^2),

Where,

V13 = Maximum Achievable Potential,
W13 = Reluctance Factor,
S13 = Customer installed cost after rebate, and
Q13 = Simple Payback in years

The constant 28695 = 3 times the average of the installed cost before rebate. This suggests that the installed cost on average is three times as important as the simple payback period in the mind of the customer.

For this model to work properly, the constants must be calculated and adjusted so that comparable measure level savings calculated this way agree with known measure level savings from similar historical studies when averaged over all the available (from other studies) measures. Then the Annual Realistic Achievable Potential is calculated as the product of the Economic Potential and this "calibrated" Percent of Economic Potential Buildings for each measure. In other words, Annual Realistic Achievable Potential is the product of Economic Potential and this Percent of Economic Potential Buildings.

		Technical Potential	Economic Potential	Maximum Achievable Potential	Market Barrier	Annual Potential with Barriers	Other Studies	This Study	Annual Realistic Achievable Potential	Annual Realistic Achievable Potential
Pri	ID	% of Buildings	% of Buildings	% of Buildings	Reluctance Factor	% of Buildings	%	%	% of Market Realizable	MWh
1	33	100.0%	57.6%	18.20%	2	9.44%			5.44%	2,935
2	31	22.0%	11.7%	11.67%	4	6.99%			0.82%	2,474
3	32	37.1%	34.8%	18.20%	1	11.62%	2.00%	11.62%	4.04%	1,979
4	78	44.9%	38.7%	18.20%	2	9.44%			3.65%	715
5	19	73.8%	30.5%	18.20%	2	8.93%			2.73%	692
6	76	44.9%	31.7%	18.20%	3	4.99%			1.58%	608
7	25	82.0%	42.7%	18.20%	2	9.44%	3.17%	9.44%	4.03%	584
8	4	37.1%	18.5%	18.20%	2	1.94%			0.36%	442
9	2	33.4%	9.6%	9.63%	1	8.22%	3.14%	8.22%	0.79%	415
10	30	55.1%	22.9%	18.20%	3	8.36%			1.91%	380
11	70	40.4%	11.7%	11.67%	1	8.60%	3.14%	8.60%	1.00%	325
12	8	41.3%	11.1%	11.15%	3	8.36%			0.93%	291
13	3	37.1%	7.5%	7.54%	3	1.19%			0.09%	226
14	20	35.2%	24.8%	18.20%	3	4.27%			1.06%	221
15	77	42.7%	4.8%	4.85%	1	4.85%	2.00%	4.85%	0.24%	220
16	34	100.0%	11.4%	11.36%	3	6.10%			0.69%	171
17	58	17.1%	12.0%	12.04%	3	6.79%			0.82%	161
18	1	33.4%	12.2%	12.19%	2	3.65%	6.69%	3.65%	0.44%	143
19	35	37.1%	31.9%	18.20%	2	9.44%			3.01%	136
20	29	55.1%	14.3%	14.31%	3	8.36%			1.20%	119
21	69	40.4%	14.8%	14.78%	2	3.78%	6.69%	3.78%	0.56%	116
22	45	18.0%	9.0%	8.99%	2	1.61%			0.14%	115
23	57	16.2%	6.7%	6.69%	2	6.69%			0.45%	95
24	27	100.0%	53.0%	18.20%	3	8.36%			4.43%	91
25	39	9.3%	2.8%	2.83%	3	2.83%	2.02%	2.83%	0.08%	83
26	43	16.2%	4.7%	4.67%	1	4.67%	3.14%	4.67%	0.22%	82
27	72	44.9%	22.5%	18.20%	2	1.87%			0.42%	69
28	44	18.0%	3.7%	3.66%	3	0.98%			0.04%	66
29	47	18.0%	7.2%	7.19%	3	4.98%	3.36%	4.98%	0.36%	58
30	71	44.9%	9.1%	9.14%	3	1.20%			0.11%	58
31	79	44.9%	10.1%	10.15%	3	3.52%	7.34%	3.52%	0.36%	53
32	62	18.0%	15.5%	15.46%	2	9.44%			1.46%	52
33	38	9.3%	2.8%	2.83%	1	2.83%	1.52%	2.83%	0.08%	50
34	22	14.8%	14.8%	14.83%	4	0.21%			0.03%	49
35	80	5.6%	4.5%	4.49%	4	4.49%			0.20%	49
36	42	16.2%	5.9%	5.91%	2	3.46%	6.69%	3.46%	0.20%	48
37	41	37.1%	7.9%	7.86%	3	3.29%	5.43%	3.29%	0.26%	38
38	73	11.2%	4.5%	4.49%	3	3.22%			0.14%	37
39	7	9.3%	3.7%	3.71%	1	3.71%	3.36%	3.71%	0.14%	33
40	61	18.0%	2.0%	2.04%	1	2.04%	2.00%	2.04%	0.04%	31

Table 8: Annual Market Potential of Top 40 Ranked by MWh

A qualitative "Market Barrier (Reluctance Factor)" is shown in Table 8. This factor captures the effects of known non-economic market barriers by using a discreet value of 1, 2, 3 or 4. A 1 indicates that little or no known barriers exist, a 2 indicates average barriers, a 3 indicates the existence of formidable barriers and a 4 represents very formidable barriers. For example, ID 31 represents the replacement of central electric water heaters with gas units. This option was assigned a market barrier factor of 4 because the barrier is very formidable, requiring the building owner to pipe natural gas to the mechanical room and provide combustion air and safe venting of the combustion gases.

The analytical model includes a scaling constant to permit overall calibration of the model to historical conservation program performance results. The "Annual Potential with Barriers" for each measure is an empirical function that is inversely proportional to the market barrier factor, the installed cost after rebate and the payback in years. It is the percentage of the "Economic Potential" that can be captured annually, and it must always be less than or equal to the "Maximum Achievable Potential".

The analytical model was calibrated by iteratively adjusting the scaling factor until the model agreed with the overall average of the percentages of the corresponding measures of existing programs.

The "Annual Realistic Achievable Potential" % column is the product of the "Economic Potential" % and the "Annual Potential With Barriers" %.

The third column of Table 6 shows the actual counts of potential applications per year for each measure. This is the product of the "Annual Realistic Achievable Potential" % and the target population (5,191 multifamily buildings).

Some measures were analyzed with multiple retrofit options that represent different improvement choices. Three AC replacement options, ID numbers 11, 12 and 13, for example, were analyzed to represent three possible choices, each with a different rated efficiency. For a single building, however, only one of the retrofit options can be applied. Each option was assigned a market fraction of 1/3 in the model. This was necessary to avoid triple counting of the annual savings when they are summed across all the measures and options.

The top 40 measures in the previous tables were based on the 40 measures that yielded the most electrical energy savings. All measure potentials were estimated assuming a 50% rebate to the building owner or tenant.

The next table, Table 9, shows how the metrics for the top 40 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), winter coincident demand (MW-W), GigaWatt-hours per year (GWh) and thousands of Therms of gas savings per year (kTherms).

KCP&L customer savings in millions of dollars are shown, followed by total rebate costs 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 are shown.

	Program Savings Potentials				Millions of Dollars		Rebate $/kWh	
Rebate	MW-S	MW-W	GWh	kTherms	Savings	Rebate	Yr 1	10 Yrs
0%	0.51	1.67	6.8	-15.5	$0.58	$0.00	$0.00	$0.000
25%	0.78	2.29	9.9	-23.0	$0.85	$0.67	$0.07	$0.007
50%	1.05	3.32	14.1	-32.8	$1.21	$1.93	$0.14	$0.014
75%	0.99	5.45	20.0	-14.2	$1.76	$4.74	$0.24	$0.024
100%	2.14	14.20	32.7	155.7	$3.10	$16.85	$0.53	$0.053

Table 9: Top 40 Measures Ranked by GWh vs. Rebate %

For comparison purposes, KEMA also ranked these 40 measures from a utility cost perspective based on increasing rebate dollars per kWh saved. The results for the new top 40 measures are shown in the next table, Table 10. 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 $1.13 million to obtain nearly the same savings as before, which required $1.93 million, and the levelized rebate costs per kWh saved is reduced from $1.402 to $0.690. Put another way, the savings in GWh is reduced by only 8.4% ((14.1-12.9)/14.1), while the corresponding rebate costs are reduced by 41.3% (($1.93-$1.13)/$1.93).

	Program Savings Potentials				Millions of Dollars		Rebate $/kWh	
Rebate	MW-S	MW-W	GWh	kTherms	Savings	Rebate	Yr 1	10 Yrs
0%	0.28	1.46	6.2	-46.0	$0.49	$0.00	$0.00	$0.000
25%	0.45	2.01	9.1	-65.5	$0.73	$0.39	$0.04	$0.004
50%	0.56	2.93	12.9	-99.1	$1.03	$1.13	$0.09	$0.009
75%	0.13	4.72	18.0	-138.7	$1.43	$2.63	$0.15	$0.015
100%	0.02	8.90	25.3	-157.1	$2.06	$6.43	$0.25	$0.025

Table 10: Top 40 Measures Ranked by $/kWh vs. Rebate %

Market Characterization Report

Introduction

KEMA has identified and surveyed a number of multi-family building owners and managers throughout the territory to characterize the multi-family market and its potential for future Kansas City Power and Light (KCP&L) programs. The findings are aggregated and summarized in this section.

Methodology

KEMA identified multi-family building owners and managers using the customer account data that was provided by KCP&L. Matousek and Associates conducted phone surveys to a sample of customers to determine if they resided in multi-family buildings and to gather other contact information. However, many of the contact samples had missing fields of contact information needed for the first mailing from KCP&L. Therefore, progress on identifying our target population was supplemented by KEMA with Google mapping and other similar methods during the final stages of recruiting.

The approach to identifying the multi-family market and its potential for future KCP&L programs was two-fold. For the first component, KEMA conducted telephone surveys with building owners and managers. In the telephone surveys, building owners and managers were asked to provide general information about their residential building or buildings. Participants were also asked to provide information on heating, cooling, and lighting systems as well as questions pertaining to building envelope, such as insulation and windows. KEMA proceeded with a on-site surveys at a subset of properties and followed up with telephone phone call to obtain data on annual occupancy rates.

Overview of Multifamily Sector for the service areas

KCP&L services more than 880,000 customers in 47 northwestern Missouri and eastern Kansas counties – a service territory of approximately 18,000 square miles. For the purpose of this study, the data were collected and analyzed under three utility regions in accordance with the division of these territories based on KCP&L data provided. These utility regions are Missouri KCP&L (KCP&L MO), Kansas State KCP&L (KCP&L KS), and Greater Missouri Operations (GMO). GMO consists of those territories that fall under the previously held St. Joseph Light and Power (SJLP) utility company and the Aquila (MPS) utility company.

Figure 5 below is a map of the KCP&L service areas, showing Kansas City (MO and KS) in the middle.

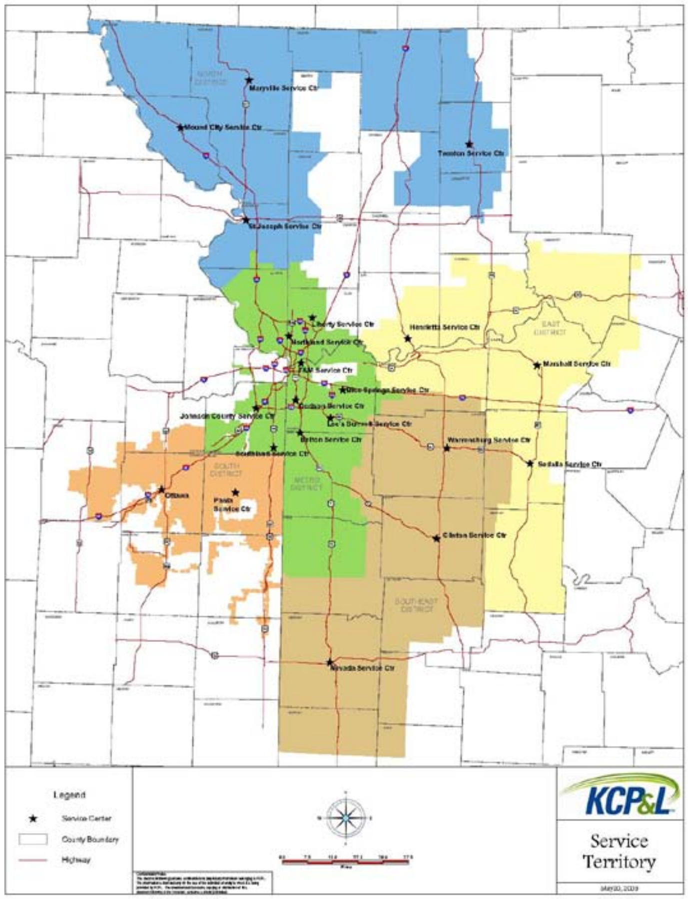

Figure 5 - KCP&L Service Area

KEMA surveyed 59 properties for the whole building audits in the utility regions of the KCP&L – MO, KCP&L – KS, and the GMO area. Of the buildings surveyed, 20% are in the KCP&L – KS region, 48% are in the KCP&L – MO, and the remaining 32% are in the GMO area. See Figure 6 for pie chart showing this distribution.

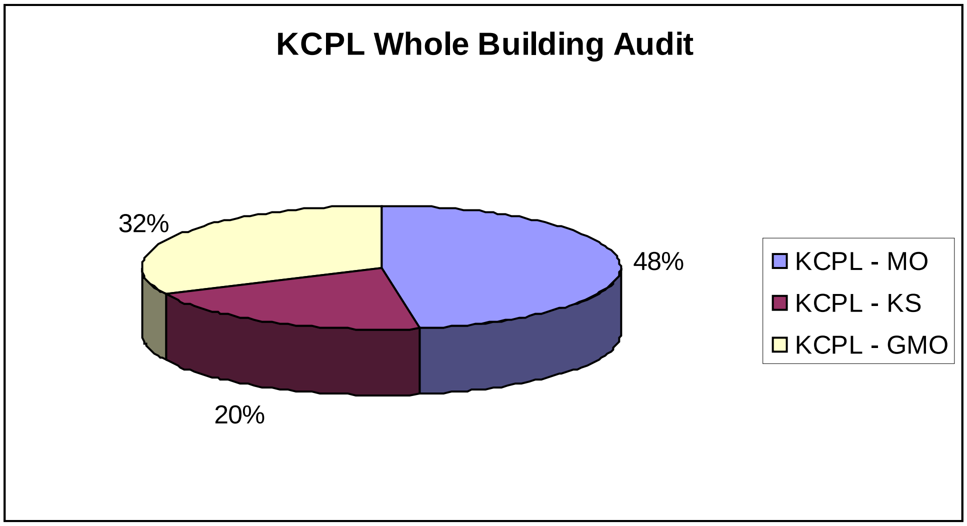

Figure 6: KCP&L Whole Building Audit

Throughout the service area KEMA surveyed 55 apartment buildings, two dormitories, and two townhouse complexes. Of the 59 surveyed buildings, 28 are located in Missouri, 12 in Kansas, and the remaining 19 are in the GMO region. As seen in Table 11, 93% of the buildings surveyed are apartments, three percent are dormitories, and another three percent are townhouses.

Building Type	KCPL - MO	KCPL - KS	KCPL - GMO	KCPL- Total	Percent of Total
Apartment	27	12	16	55	93%
Dormitory	0	0	2	2	3%
Townhouse	1	0	1	2	3%
Total	28	12	19	59	100%

Table 11: Number of Building Types in Each Utility Region

Multifamily Building Characteristics

Of the 59 buildings surveyed, we found that 37% fall between the ranges of 4,001 and 8,000 square feet of conditioned area. In both Kansas and Missouri, the most common building size is within the 4,001 to 8,000 square feet. However, in the GMO area approximately 75% of the multi-family buildings are split evenly between the 8,001 and 12,000 square feet range and under 4,000 square feet.

Range in Sqft	KCPL - MO	KCPL -KS	KCPL-GMO	KCPL - Total	Percent of Total
0-4,000	6	3	7	16	27%
4,001-8,000	12	7	3	22	37%
8,001-12,000	8	2	7	17	29%
12,001-16,000	2	0	2	4	7%
Total	28	12	19	59	100%

Table 12: Gross Footprint of Buildings Surveyed

In all three service areas of KCP&L-MO, KCP&L-KS and KCP&L-GMO, KEMA found that all but five of the buildings surveyed have four or less stories. Conversely, only one building in our survey has more than 12 floors. Across all utility areas, 92% of the buildings surveyed have one to four stories, seven percent have five to eight stories, and only two percent have more than 12 stories, as shown below in Table 13.

No. of Stories	KCPL-MO	KCPL - KS	KCPL-GMO	KCPL-Total	Percent of Total
1 to 4	26	12	16	54	92%
5 to 8	2	0	2	4	7%
9 to 12	0	0	0	0	0%
More than 12	0	0	1	1	2%
Total	28	12	19	59	100%

Table 13: Number of Stories in Each Building Surveyed

Throughout the total KCP&L service area, we found that the most common number of units in a building (32%) was six to ten units. Twenty-four percent of the buildings surveyed have between 16 and 20 units. Overall, 78% of buildings have between 6 and 20 units. The minimum number of tenant units required to define a multifamily building is five. See Table 14 below for a full breakdown by number of dwelling units.

No. of Units	KCPL - MO	KCPL - KS	KCPL - GMO	KCPL - Total	Percent of Total
0 to 5	1	0	0	1	2%
6 to 10	7	9	3	19	32%
11 to 15	6	0	7	13	22%
16 to 20	7	3	4	14	24%
21 to 25	5	0	1	6	10%
More than 25	2	0	4	6	10%
Total	28	12	19	59	100%

Table 14: Number of Units in Each Building Surveyed

The most widespread common areas throughout all KCP&L regions are Corridors and Patio/Porch spaces. Following the first two frequent common spaces are Exterior Walkways, Foyers/ Entrance ways, and Exterior Safety/ Decorative areas.

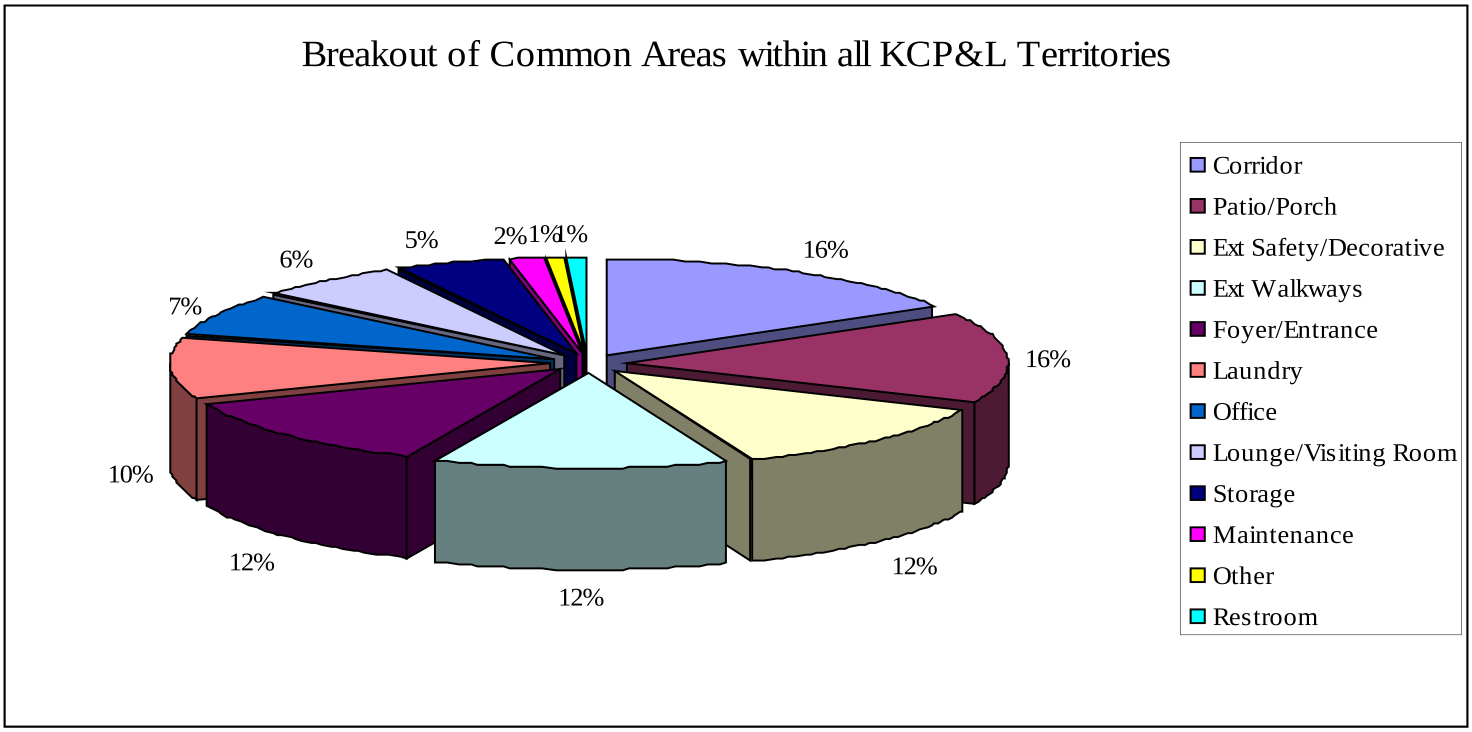

Figure 7: Breakout of Common Areas within all KCP&L Territories

Next, KEMA identified what types of lighting systems were found in each common area. The majority of CFLs (26%) are located in the Foyer/Entrance spaces of multi-family buildings. Table 15 shows that 19% of CFLs can be found in the Exterior Safety/Decorative areas and 17% are located in Corridors.

Room Type	Total Number of CFL	Percent of Total
Foyer/Entrance	50	26%
Ext Safety/Decorative	37	19%
Corridor	32	17%
Laundry	17	9%
Office	16	8%
Ext Walkways	12	6%
Storage	11	6%
Patio/Porch	10	5%
Lounge/Visiting Room	7	4%
Other	0	0%
Maintenance	0	0%
Total	192	100%

Table 15: Number of CFLs Installed by Room Type

In Table 16, KEMA identified the most common locations of incandescent light bulbs throughout a multi-family residence. Thirty-seven percent of incandescent light blubs can be found in the Patio/Porch area, 16% were located in the Lounge/Visiting rooms, and 14% were located in the Foyer/Entrance way.

Room Type	Total Number of Incandescents	Percent of Total
Patio/Porch	231	37%
Lounge/Visiting Room	100	16%
Foyer/Entrance	86	14%
Ext Safety/Decorative	73	12%
Ext Walkways	53	8%
Corridor	42	7%
Storage	19	3%
Office	12	2%
Laundry	7	1%
Restroom	6	1%
Maintenance	0	0%
Other	0	0%
Grand Total	629	100%

Table 16: Number of Incandescent Light Bulbs Installed by Room Type

The following table, Table 17, identifies the most commonly used light fixtures installed in common areas other than the screw-in CFL and incandescent bulbs. These fixtures are located primarily in Corridors, Exterior safety/Decorative, Foyers/Entrance ways, as well as Storage areas. Forty-three percent of total hard-wired fluorescent fixtures found in multi-family buildings are T12s, 24% are T8's, and 26% are pin-based CFLs.

Wired Fluorescent Fixture Type	Wired Fluorescent Fixture Total	Percent of Total
T12	20	43%
CFL Pin	12	26%
T8	11	24%
Circline	3	7%
Total	46	100%

Table 17: Number of Wired Fluorescent Fixtures Found in Common Areas

Other than building common areas already listed, KEMA identified a second tier of commonly found areas within multifamily building complexes (or campuses) throughout the KCP&L territories. According to the table below, swimming pools, office and administration buildings, and clubhouses are among the most frequent campus common areas and buildings in the KCP&L service area. Outdoor vending areas are the least frequent common area in the utility region.

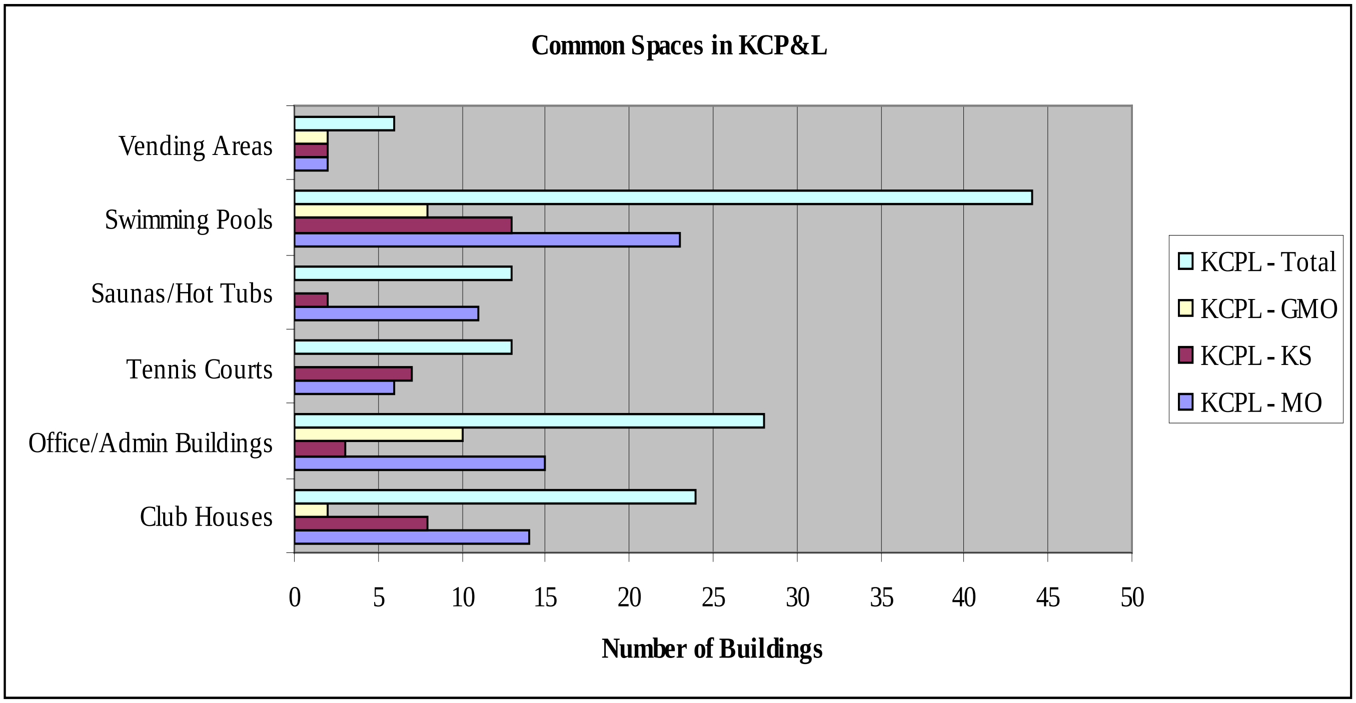

Figure 8: Common Spaces and Buildings in Apartment Complexes

Occupancy Rates

Figure 9 represents the total number of buildings surveyed for occupancy rate data in all of the KCP&L service areas. Of the buildings surveyed for occupancy data, 53% were located in the KCP&L MO region, 24% were located in the KCP&L KS region, and the remaining 23% were located in the GMO service areas. The occupancy data was collected from the building owners and managers during the on-site visits as well as from building owners and managers that had not participated in the onsite survey.

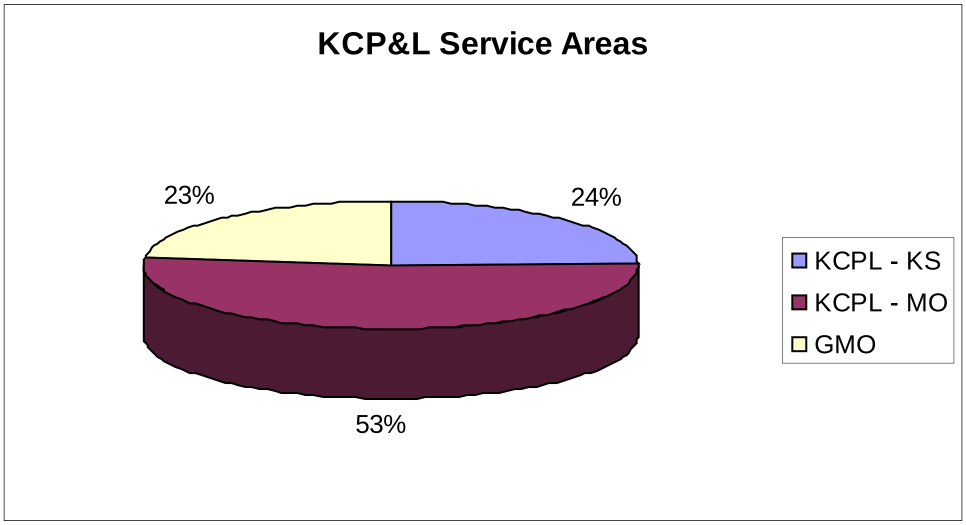

Figure 9: Surveyed Multi-Family Buildings for Occupancy Data

For the buildings surveyed in the KCP&L service area, KEMA found that the majority of buildings have an occupancy rate between 76% and 100%. Additionally, KEMA broke the data down to represent the Kansas KCP&L, the Missouri KCP&L, and the Greater Missouri Operations.

Table 18 below shows a strong majority, 34 of the 43 buildings in Missouri, have an occupancy rate of 76 to 100%, 14 of the 19 buildings surveyed in Kansas have an occupancy rate of 76 to 100%, and 16 of the 19 buildings surveyed in the Greater Missouri areas have an occupancy rate of 76 to 100%. Out of the 82 participants, only five were unable to determine their current occupancy rate.

Occupancy Rate	KCPL - MO	KCPL - KS	KCPL - GMO	KCPL - Total	Percent of Total
0 - 25%	0	0	0	0	0%
26 - 50%	3	0	0	3	4%
51 - 75%	5	2	2	9	11%
76 - 100%	34	14	16	65	79%
DK	1	3	1	5	6%
Total	43	19	19	82	100%

Table 18: Current Occupancy Rate for Buildings Surveyed

KEMA then determined if these rates increased, decreased, or stayed the same within the past 12 months. As seen inTable 19, 46% of properties in the KCP&L service area saw no change in their occupancy rate in the past 12 months. The second most common response among building owners (29%) in each utility area is that the occupancy rate increased over the past 12 months. When probed, building owners and managers commented that the downturn in the economy made apartment living more desirable among homeowners and single family house renters. This change in preference had lead to an increase in the overall building occupancy rates.

Change	KCPL -MO	KCPL - KS	KCPL -GMO	KCPL - Total	Percent of Total
Decreased	9	0	3	12	15%
Increased	13	5	6	24	29%
Same	19	12	9	40	49%
DK	2	3	1	6	7%
Total	43	20	19	82	100%

Table 19: Have those rates increased, decreased or stayed the same over the last 12 months for building?

When applicable, the building owner or manager was asked if he could provide the occupancy rate for the entire multifamily complex that the particular building surveyed building was part of. They reported that the majority of complexes have an occupancy rate between 76 and 100%. This is consistent with the occupancy rates that were common for the buildings surveyed.

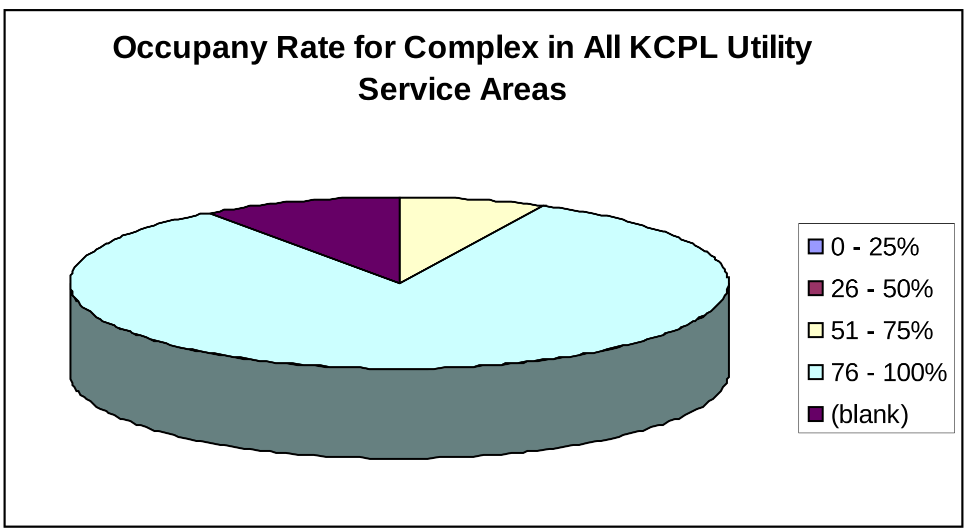

Figure 10: Occupancy Rate for Complexes in All of the KCP&L Service Areas

Of the 82 complexes surveyed, 83% have an occupancy rate of 76 to 100%, while 7% of the complexes surveyed have an occupancy rate of 51 to 75%. The remaining 10% of the properties were unable to determine overall occupancy rates for their complexes.

Occupancy Range	KCPL - MO	KCPL -KS	KCPL-GMO	KCPL - Total	Percent of Total
0 - 25%	0	0	0	0	0%
26 - 50%	0	0	0	0	0%
51 - 75%	4	0	2	6	7%
76 - 100%	35	17	16	68	83%
DK	4	3	1	8	10%
Total	43	20	19	82	100%

Table 20: Current Occupancy rate of Multifamily Complexes

Unlike the buildings surveyed, the majority of complexes surveyed saw an increase in the occupancy rate in the past 12 months. In fact, 40% of the total complexes surveyed saw an increase in occupancy rate, 26% saw no change in the occupancy rate, and 15% percent experienced a decrease in the occupancy rate. When prompted, building owners and managers cited that the economy was the cause of the change in overall occupancy. This breakdown is shown in Table 21 below.

Change	KCPL - MO	KCPL - KS	KCPL-GMO	KCPL-Total	Percent of Total
Decreased	12	1	9	16	12%
Increased	15	9	6	33	1%
Same	11	5	1	22	20%
Both (fluctuates up and down)	0	1	0	1	40%
DK	5	4	3	10	27%
Total	43	20	19	82	100%

Table 21: Have those rates increased, decreased or stayed the same over the last 12 months for the complex?

Conclusions and Recommendations

Most utility companies and state and regional agencies have not attempted to define a comprehensive multifamily rebate program due to the inherent complexities involved. There are several things that make the multifamily sector difficult to reach with conservation program offerings.

One of these is the difficulty associated with identification of the multifamily building population. This makes it impossible to calculate with certainty the total potential savings achievable with this customer group, so it is difficult to establish reliable goals and conservation budgets.

Another difficulty associated with multifamily customers is the inability to identify and contact building owners and managers. Most buildings are individually metered, so the utility typically has only tenant information, but tenants are not in a position to make decisions regarding conservation retrofits to the buildings they live in.

Another difficulty arises with regard to marketing conservation measures due to the fact that most buildings are individually metered, so the owners/managers have little or nothing to gain with the reductions in the utility bills.

Following are some suggestions for increasing the effectiveness of a comprehensive multifamily conservation program.

Utilize a wide variety of marketing tools and elements. The best program designs for reaching the target market utilize 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 awareness and recognition. Conversely, program managers that KEMA 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 (eg. 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.

***Promote the concepts to multifamily tenants and sell them on opportunities to reduce their energy bills*.** If tenants can become interested in reducing their energy costs and can be convinced their opinions matter to their landlords, they will put pressure on their landlords to do something.

***Market the program directly to building owners and managers by helping them to see the intangible benefits*.** These last two strategies working together will create a push and pull effect on the landlords, encouraging them to consider options. Then work closely with them to understand their needs, abilities and limitations. Finally, design the program to meet those needs, scale rebates and incentives to mitigate the limitations and sell to their abilities.

During the early years of the program, go for the gravy! Target the more lucrative measures and be generous with rebates and incentives. A 50% rebate level may be effective for other programs, but probably will not be as powerful in the multifamily market due to the increased difficulties associated with it. The more effective the program is and the more success stories it can produce, the more it will attract attention. This is necessary to build awareness and whet interest in the program. It will also buy time for program staff to become familiar with the market and program strategies while they are able to enjoy early program success stories. If the program staff enjoy their work and derive a sense of accomplishment from it, their enthusiasm will go a long way toward making the program a long term success.

***Create job opportunities for renovation and HVAC contractors*.** Market the program to them and offer them incentives to sell it to customers. They will be able to identify the owners and managers, and they will want to do more work for them. Bring them on board during the design phase of the program and allow them to offer ideas. Create in them a sense of partnership with the utility and keep them informed on construction successes and opportunities.

Appendix A: Owner / Manager Telephone Survey Form

KCP&L 2010 MULTIFAMILY POTENTIAL ANALYSIS AND

MARKET CHARACTERIZATION STUDY: MANAGER/OWNER TELEPHONE SURVEY

Customer: ____ KEMA ID# ___________________

Address: ____________________________ City: ____________________ Phone: __________

Date: ________________ Surveyor's Initials _________

Stratum # _____ Time: __________ AM PM

Occupant Interview - Introduction

Hello, this is ________________ calling on behalf of Kansas City Power and Light, your utility services provider. I'm trying to reach (CUSTOMER NAME or PROPERTY MANAGER).

(SCRIPT)

Recently KCP&L sent a letter describing an important research project that they are conducting for their multi-family residential customers. This project is meant to identify the most important energy efficiency needs of their multi-family buildings, including the one(s) you own or manage. Do you recall receiving the letter?

IF NO OR UNSURE > The letter was sent last week by KCP&L to describe this research project and introduce you to us. It described how you have been selected to participate. This is not a sales call nor is it meant to obligate you to do or change anything. Is it possible that someone else received this letter?

IF NO OR STILL UNSURE > It may have taken longer to reach you than we expected. We can call back later or send another letter – would that be alright with you?

__ YES, Call back later. > Ask what might be the most convenient time to call. _________________________

__ YES, Send another letter > CONFIRM NAME AND ADDRESS ABOVE

__ NO, > Is there someone else I should ask to talk with?

__ NO, > **Thank politely, offer to give your return telephone number and terminate call.**

As I've mentioned, KCP&L wants to understand how and where it may offer energy efficiency services or incentives to help reduce the energy costs of multi-family buildings and their residents. This research will collect information specific only to this goal. The first part of the study involves a 10-15 minute telephone survey that can be conducted at this time or at a time more convenient to you. The survey would ask you some general questions about the building energy usage characteristics. For example, we are interested in the building's age, the number of floors, approximate square footage, number or apartment units, roof and wall insulation, heating and cooling equipment, built-in appliances, and common area characteristics such as lighting.

Do you have time now to answer these questions?

IF NO, ASK TO RESCHEDULE

Date and time for survey: _________________>> Confirm date with customer. Thank and end call.

IF REFUSAL TO PARTICIPATE, Thank politely, offer to give your return telephone number and terminate.

General Information

1. We are focusing on both apartment and condominium buildings with 5 or more units. Do you own or manage a building with 5 living units or more at or near (give address)?

1a. IF YES> How many living units? ______________

Are they □ Apartments or □ Condos

1b. IF NO> Explain that at this time we are considering only buildings with 5 or more units, thank and terminate.

2. Is the building part of a complex or campus?

Yes.. 1

No 2

2a. IF YES> How many buildings with 5 or more units are in the complex? ____________

2b. AND SAY> "For this survey let's pick a typical building within the complex."

AND GET> **The building address** ____________________________________

2c. AND GET> **The number of units with in the building of reference**____________

2d. Ask how the addresses are set up. All one address, one for each building? ___________

Note: If there are 5 or more qualifying buildings in the complex, at the end of this survey ask if you could do another typical building survey, either now or at a later date.

3. About what year was the building built? ___________ IF NOT SURE, READ LIST

1950 or earlier 1	1981-1990 5
1951-1960 2	1991-2000 6
1961-1970 3	2001-2010 7
1971-1980 4	Don't know 98

4. What is the floor space in the building? ________ IF NOT SURE, READ LIST

Fewer than 3000 square feet..... 1	15000-20000 square feet........... 5
3000 -5000 square feet 2	20000-30000 square feet........... 6
5000 -10000 square feet 3	30000 or more square feet 7
10000-15000 square feet 4	Don't know 98

(50) Notes: ____

5. Is there a finished basement?

Yes ………..1 % Finished _____	
No 2	
Notes 50	Don't know 98

COOLING SYSTEMS

Next, I have questions about air conditioning.

6. Is there a central cooling system serving the whole building?

Yes.. 1	No .... 2 If No, Skip to Q7

6a. What type of cooling system is it?

Air Cooled Direct Expansion...... 1	Air Cooled Chiller 3
Water Cooled Chiller 2	Hydronic Heat Pump.................. 4

Air Cooled Heat Pump............... 5
Other... 50
Don't know 98

6b. How efficient would you estimate this system to be? _______ □ EER □ COP □ kW/Ton
IF NOT SURE, PICK BEST GUESS FROM LIST.

High efficiency 1
Average efficiency 2
Low efficiency 3
Don't know 98

SKIP TO Q. 8

7. Does each living unit come furnished with its own independent cooling system?

Yes.. 1
No .... 2 Skip to Q. 8

7a. What type of cooling system is it?

Air Cooled split system AC 1
Air Cooled split system HP 2
Window/Wall AC 3
Window/Wall HP 4
Other 5
Don't know 98

7b. How efficient would you estimate these units to be? _______ □ SEER □ EER
IF NOT SURE, PICK BEST GUESS FROM LIST.

High efficiency 1
Average efficiency 2
Low Efficiency 3
Don't know 98

HEATING SYSTEMS

Now let's talk about heating systems.

8. What is the primary heating fuel used?

Fuel oil 1
Electric Heat 2
Natural Gas................................ 3
Kerosene.................................... 4

Coal 5
Solar 6
Propane 7
Wood.. 8
Pellet 9
Don't know 98

9. Is there a central heating system serving the whole building?

Yes.. 1
No .... 2 Skip to Q. 10

9a. What type of heating system is it?

Hot Water Boiler 1
Steam Boiler 2
Boiler for Hydronic Heat Pump.. 3
Other 4
Don't know 98

9b. How efficient would you estimate this system to be? _______ □ % □ COP □ HSPF

IF NOT SURE, PICK BEST GUESS FROM LIST.

High efficiency 2
Average Efficiency..................... 3
Low efficiency 4
Don't know 98

SKIP TO Q. 11

10. Does each living unit have its own independent heating system?

Yes.. 1
No ....2 Ask how the apartments are heated. If DK, Skip to Q. 11

Describe how units are heated.____

10a. What type of heating system is it? (Reflect all that apply)

Furnace with Blower 1
Baseboard Units 2
Wall Units................................... 3
Portable Heaters........................ 4
Stove or Fireplace...................... 5
Hydronic Heat Pump.................. 6
Air Cooled Heat Pump 7
Window/Wall Unit Heat Pump.... 8
Cast Iron Radiators.................... 9
Other 50

10b. How efficient would you estimate these units to be? _______ □ % □ COP □ HSPF

IF NOT SURE, PICK BEST GUESS FROM LIST.

Very high efficiency 1
High efficiency 2
Average Efficiency..................... 3
Low efficiency 4
Very low efficiency 5
Don't know 98

Appliances Furnished by Property Owner

11. Does each living unit come furnished with a Dishwasher?

Yes.. 1
No .... 2 Skip to Q. 12
Don't know .... 98 Skip to Q. 12

11a. What percentage of these dishwashers are Energy Star Certified? ________ DK - 98

12. Does each living unit come furnished with a Clothes Washer?

Yes.. 1
No .... 2 Skip to Q. 13
Hook ups available 3
Unknown ....98 Skip to Q. 13

12a. What % of these Clothes Washers are Energy Star Certified? ________ DK -98

13. Does each living unit come furnished with a Clothes Dryer?

Yes.. 1
No 2
Hook ups available 3
Don't know 98

14. Does each living unit come furnished with a Refrigerator?

Yes......................................1
No ....2 Skip to Q. 15
Don't know ....98 Skip to Q. 15

14a. What percentage of these Refrigerators are Energy Star Certified? ________ DK -98

(14_50) Notes:____

Common Area Appliances

15. Is there a common area laundry within the building? (Just this building).

Yes.. 1
No 2
Other 50
Don't know 98

If No or Unknown, Skip to Q. 16

15a. How many Clothes Washers are in this building's laundry area? ________ DK-98

15b. What % of these Clothes Washers are Energy Star Certified? ________ DK-98

15c. How many Clothes Dryers are in this building's laundry area? ________ DK-98

15d. Notes:(Managed by 3rd party?):____

Domestic Water Heating Equipment:

16. What is the main fuel used for domestic hot water?

Natural Gas................................ 1
Electric 2
Oil 3
Propane 4
Other 5
Don't know 98

16a. Is the hot water system solar assisted?

Yes.. 1
No 2
Don't know 98

17. Is there a central hot water system serving the whole building?

Yes.. 1
No .... 2 Skip to Q. 18

17a. What type of water heating system is it?

Standard Storage Tank 1
Instantaneous 2
Heat Pump Water Heater 3
Inside the Boiler, no external Storage tank 4
Inside the Boiler plus external Storage tank 5
Other 50
Don't know 98

17b. .... If there is storage, how many gallons is the total storage tank capacity? _________

SKIP TO Q. 19

18. .... Does each living unit have its own water heater?

Yes.. 1 Go to 18b

No 2

18a. Then how do they get hot water? ____________________________________

18b. What type of water heater is it?

Standard Storage Tank 1
Instantaneous 2
Heat Pump Water Heater 3
Don't know 98

18c. If there is storage, how many gallons is the storage tank capacity? _________

Insulation

19. What type of construction are the walls?
2 x 4 Framing............................ 1
2 x 6 Framing 2
Masonry plus Framing............... 3
All Masonry 4
Other ___________ 50
Don't Know................................ 98

20. Could you estimate the number of inches of wall insulation? _______

21. How would you characterize the wall insulation in this building?
Very Poor.................................. 1
Poor 2
Average 3
Good 4
Excellent 5
Don't Know................................ 98

22. What type of Attic/Ceiling insulation does the building have?

Fiberglass Batts 1
Blown-in.. 2
Combination (both batten and blown) 3
None 4
Don't Know 98

23. Could you estimate the number of inches of attic insulation? _______

24. How would you characterize the attic insulation in the building?
Poor 1
Average 2
Excellent 3
Don't know 98

25. Regarding air leakage (infiltration) into this building, would you consider it to be:
Very Drafty................................ 1
Moderately Drafty 2
Average 3
Tight.. 4
Very Tight 5
Don't Know (Do Not Read) 98

Windows

26. What is the predominant window type in the building?

a. Frame Type		**b. Panes**		**c. Low e Coating**		**d. Storm Windows**	
1	Metal	1	Single	1	Yes	1	Yes
2	Wood	2	Double	2	No	2	No
3	Vinyl	3	Triple	98	Don't know	98	Don't know
4	Other	4	Other				

27. Approximately what percentage of the total exterior walls is glass? __________

Interior Lighting

28. What % of the building common area light bulbs are incandescent? __________

29. What % of building common area light bulbs are screw-in CFLs? __________

30. What % of the tenant light fixtures are hard wired fluorescent? __________

30a. Notes:____

SURVEY WRAP-UP

That's about it for the questions. We appreciate your time in completing the survey.

The second phase of this study involves conducting actual on-site visits of this building and two to four typical residences in the building. We may want to visit this building, and possibly even another typical building if it is part of a large complex. In these on-site visits or audits, if you have two to four significantly different residence layouts, we would like to audit one of each. If you have only one unique layout, we would like to audit two of those units.

As a thank you for your participation in these on-site audits, KCP&L would like to give you a $100 postal money order for each building we audit. Additionally, to encourage the participation of your tenants, KCP&L will give each participating residence a $50 postal money order upon completion of the audit. These money orders will be given to you and your participating tenants at the time of the audit.

Furthermore, we request that each residence you select be currently occupied because data from vacant units will be of limited value to the study. To minimize our time and yours at your facility, we ask that you try to arrange the tenant visits before our arrival.

These on-site audits are a critical part of the study because the technical data gathered will help us to understand the energy savings potential of your building and other multifamily buildings. It will enable us to design an effective multifamily energy conservation program that will help our multifamily customers save energy, reduce our region's dependence on fossil fuels, and reduce the global emissions of greenhouse gases.

While on-site, we are interested in gathering energy related information about the building and the individual residences, including heating and cooling equipment, major appliances, windows, insulation, lighting fixtures, and some small appliances like TVs and computers.

We will randomly select about 55 buildings altogether across KCP&L's territory to assess on site. If your building is selected for this portion of the study,

31. Would you be willing to participate?
    Yes.. 1
    Call Back/Unsure....................... 2
    Call Back to speak with .... 3 Notes________________________
    Refused 4
    Don't Know 98

IF NO >> May I ask why you prefer not to participate at this time? RECORD RESPONSE VERBATIM:

____
____

>>Try to resolve the issue and encourage participation before Thanking and Terminating the call.

IF YES >> Great. We thank you for your participation. How many unique layouts does your building have?

>> IF MORE THAN 1, REQUEST TO VISIT UP TO 4 DIFFERENT UNITS.

>> IF ONLY 1 LAYOUT, REQUEST TO VISIT 2 OF THOSE UNITS.

Ok, we would like to walk through ________ residences if possible. If selected for this portion of the study, we will call back in the near future to schedule a day and time to conduct these audits. At that time we will ask that you determine which unique and occupied residences in your building we could visit.

Thank you for your participation in this important research study.

Do you have any questions that we or KCP&L may be able to answer for you?

>>IF QUESTIONS ARISE THAT CANNOT BE ANSWERED, SAY:

That's a question I am not sure about but I will have someone on the study team get back to you as soon as possible.

Thank and Terminate.

Appendix B: Building On-Site Audit Form

KCP&L Multifamily Whole Building Audit Form

Verify Name of Building/Complex:

Site (building) ID No.

General Information

Contact Name:

Contact Phone:

Auditor ______ Date of Audit ______ Outdoor Temp. ______ (Degrees F)

Utility Service Area ______ Dwelling Type ______

CA Primary Heating Fuel ______ Gross Footprint SqFt ______ Number of Floors ______

Basement type ______ Basement Area ______ Basement % Cond. ______

CA Primary Thermostat Type: ______ Other Type ______ Normal Temperature: ______

Office Area SqFt ______ Storage/Maint Area SqFt ______ No of Office/Maint Staff: ______

Insulation/Shell

Exterior Walls

Wall Description	Location next to	Gross Area, SqFt	Insulation Type	Inches

Notes:

Ceiling Insulation

Ceiling Construction	Flat/Cathedral	Area, SqFt	V Barrier	Insulation Type	Inches

Notes:

Floor

Floor Description	Location next to	Area, SqFt	Insulation Type	Inches

Notes:

Glazing

Windows/glass doors and skylights.

Type of Glass	SqFt	Frame	Location	U-value	Win/Sky	T Break	Storm	Orient

Notes:

Ext. Doors

Door Type	Material	Insulated	Storm?	Type of Glass	Gl SqFt

Notes:

Slab Floors	*Do not input slabs for unconditioned Basements.*			
Grade/Below Grade	***Insulated?***	**Area, SqFt**	**Type**	**Inches**
Notes:				

Foundation Wall	*For foundations, include ALL insulation (even walls in unconditioned space)*				
Wall Type	**Location**	**Area, SqFt**	**Thickness**	**Insulation Type**	**Inches**
Notes:					

Mechanicals

Heating Equipment							
Manufacturer	**Model**	**Type**	**Age**	**Fuel**	**Location**	**BTU Out**	**Efficiency**
	For Forced Air System, How is Fan Controlled?			Indoor Temperature:		Zones:	
	How many Fireplaces or Stoves?			Fireplace/ Stove Fuel:		T'stats:	
	How many Portable Space Heaters?			Space Heater Fuel:			
	R-value for hydronic piping insulation:						

Water Heating							
Make	**Model**	**Type**	**Age**	**Fuel**	**Location**	**Gallons**	**Efficiency**
	R-value for water heater wrap:						
	R-value for water heater piping insulation:						
Notes:							

Cooling						
Make	**Model**	**Type**	**Age**	**Evap. Location**	**Tons**	**Efficiency**
Notes:						

Duct Insulation							
		For Insulation Only			**Duct**	**Duct**	**Duct**
Supply/Return	**Location***	**Type**	**Quality**	**Inches**	**Type**	**Sealing**	**Leakage**
Notes:	cooool						

Building Air Leakage Estimate:	
Notes:	

Lighting

	Incandescent and Fluorescent Bulbs				Fluorescent Fixtures		Other Fixtures	
Space/Area	No. of CFL Screw in Bulbs	Est. Total CFL Watts	No. of Incand. Bulbs	Est. Total Incand. Watts	Wired Fluor. Fixture Type & No.	Est. Total Fluor. Watts	Other Fixture Type	Est. Total Other Fixture Watts
Notes:								

Appliances

CA Appliance	Mfg.	Model No	Type	CuFt/Fuel	Age	Condition	E-Star?
Refrigerator:							
Clothes Washer:							
Clothes Dryer:							
Other Major Appliance							

ERV Manufacturer	ERV Model No.	Efficiency	Notes:

Fans, Etc.	Count	Total HP	Total W
Ventilation Fan			
Exhaust Fan			
Ceiling Fan			
Other Fan			

Whole Complex

Count of Apt./Condo. Buildings:		Including the building being audited.			
Approx Total Count of Units:		Including the building being audited.			
Club Houses:					
Office/Admin Buildings:					
Tennis Courts:					
Saunas/Hot Tubs:		**Enclosed?**			
Swimming Pools:		**Enclosed?**		**Heated?**	
Vending Areas:		**Enclosed?**		**Heated?**	
Other (describe):					
Other (describe):					

Tables of Input Options for Pull-Down Lists

Auditor
Darcy/Curtiss
Dave Runge
Brad Hoover
Glenn Haynes

Thermostat type
Manual
Digital, non-prog
Digital, 1-day
Digital, 7-day
Integral
None

Fluorescent Ltg.
CFL Pin
Circline
T12
T8
T5
Other Fluor.

Other Ltg.
Mercury Vapor
Metal Halide
LPS
HPS
LED

Wall Location
Conditioned/Ambient
Conditioned/Garage
Conditioned/Basement
Conditioned/Attic
Other

Service Are
KCPL
MPS
SJLP

Unit Type
Apartment
Condo
Town Hous
Dormitory
Other

Insulation Type
Fiberglass Batts
Blown-in Fiberglass
Cellulose
Icynene
Panel Construction
Rigid Foam
Rock Wool
None
Other (define)

Duct Location
Attic
Uncond. Space
Cond. Space

Duct Insulation
Uninsulated
1" Wrap, R3.3
2" Wrap, R5
Internal
Other (define)

Duct Type
Metal
Duct Board
Flexible
Joist Pan

Basement
None
Full Basement
Partial Basement
Crawl space
Slab on Grade
Other

Wall Description
2 x 4
2 x 6
Steel Stud
Masonry and Stud
All Masonry
Other

Door Types
Panel
Hollow Core Insulated
Hollow Core Uninsul
Solid Core

Ceiling Construction
2 x 4
2 x 6
2 x 8
2 x 10
2 x 12
Truss
Other

Flat/Cathedral
Flat joists covered
Flat joists NOT covered
Cathedral

Type of Glass
Single Pane
Double Pane clear
Double Pane low e
Double Pane low e Argon
Triple Pane
Other

Window/Skylight
Operable
Fixed
Glass Door
Skylight
Glass Block

Floor Construction
2 x 4
2 x 6
2 x 8
2 x 10
2 x 12
Truss
Beam
Other

Floor Location for heat transfer
Conditioned/Basement
Conditioned/Garage
Conditioned/Ambient
Conditioned/Unvented CS
Conditioned/Vented CS

Grade/Below Grade
On Grade
Below Grade
Mix (on/below grade)
Other

Room/Area Names
Foyer/Entrance
Mailboxe area
Corridor
Office
Storage
Maintenance
Restroom
Laundry
Lounge/Visiting Room
Patio/Porch
Sun Room
Spa/Sauna/Hot tub
Ext Walkways
Parking Areas
Ext Safety/Decorative
Other

Foundation Wall Type
Poured concrete
CMU
Brick
Combination masonry
Masonry & Stud Framing

Foundation Wall Location
>50% Above Grade Cond
>50% Above Grade Uncond
<50% Above Grade Cond
<50% Above Grade Uncond
Unvented Crawl Space

Slab Insulation Location
Slab Edge only (vertical)
Slab Edge and Perimeter (L shape)
Under only (whole slab)
Under (whole slab) and Slab Edge
Unable to determine

Slab Insulation
Extruded PS
Xpanded PS
ISO
None
Unknown

Central Water Heatr Type
Storage, stand alone
Instantaneous
Integrated, tankless
Integrated, w/tank
Heat Pump WH
Other

Heating Equipment Type
Furnace
HW Boiler
Steam Boiler
Air Source HP
Water Source HP
Ground Source HP
District
Other

Fuel
Electric
Oil
Nat. Gas
Propane
Wood
Pellet
Kerosene
Other

Loc of Heating Equip
Basement
Mechanical Room
Detached Building
Roof
Attic
Other

Cooling Equipment Type
Central Air Split
Central Air Packaged
Air Source HP
Water Source HP
Ground Source HP
Air Cooled Chiller
Water Cooled Chiller
Other

Appendix C: Tenant On-Site Audit Form

KCP&L Multifamily Tenant Unit Audit Form

Verify Name of Building/Complex:

Site (building) ID No. | Unit | of

General Information

Tenant Name:

Tenant Phone:

Auditor ______ Date of Audit ______ Outdoor Temp. ______ (Degrees F)

Unit Primary Heating Fuel ______ Gross SqFt ______ Unit Floor ______ Number of Floors ______

Basement type ______ Basement Area ______ Basement % Cond. ______

Unit Primary Thermostat Type: ______ Other Type ______ Normal Temperature: ______

Insulation/Shell

Exterior Walls

Wall Description	Location next to	Gross Area, SqFt	Insulation Type	R-Value

Notes:

Ceiling Insulation

Ceiling Construction	Flat/Cathedral	Area, SqFt	V Barrier	Insulation Type	R-Value

Notes:

Floor

Floor Description	Location next to	Area, SqFt	Insulation Type	R-Value

Notes:

Glazing *Windows/glass doors and skylights.*

Type of Glass	SqFt	Frame	Location	U-value	Win/Sky	T Break	Storm	Orient

Notes:

Ext. Doors

Door Type	Material	Insulated	Storm?	Type of Glass	Gl SqFt

Notes:

Foundation Wall *For foundations, include ALL insulation (even walls in unconditioned space)*

Wall Type	Location	Area, SqFt	Thickness	Insulation Type	R-Value
Notes:					

Mechanicals

Heating Equipment

Manufacturer	Model	Type	Age	Fuel	Location	Cap. Out	Efficiency

For Forced Air System, How is Fan Controlled?		Indoor Temperature:		Zones:	
How many Fireplaces or Stoves?		Fireplace/ Stove Fuel:		T'stats:	
How many Portable Space Heaters?		Space Heater Fuel:			
R-value for hydronic piping insulation:					

Water Heating

Make	Model	Type	Age	Fuel	Location	Gallons	Efficiency

R-value for water heater wrap:	
R-value for water heater piping insulation:	
Notes:	

Cooling

Make	Model	Type	Age	Cond. Location	Tons	Efficiency
Notes:						

Duct Insulation

		For Insulation Only			Duct	Duct	Duct
Supply/Return	Location*	Type	Quality	R-Value	Type	Sealing	Leakage
Notes:							

Building Air Leakage Estimate:	
Notes:	

Lighting

	Incandescent and Fluorescent Bulbs				Fluorescent Fixtures		Other Fixtures	
Space/Area	No. of CFL Screw in Bulbs	Est. Total CFL Watts	No. of Incand. Bulbs	Est. Total Incand. Watts	Wired Fluor. Fixture Type & No.	Est. Total Fluor. Watts	Other Fixture Type	Est. Total Other Fixture Watts
Notes:								

Appliances

Unit Appliance	Mfg.	Model No	Type	CuFt/Fuel	Age	Condition	E-Star?
Refrigerator:							
Clothes Washer:							
Clothes Dryer:							
Other Major Appliance							

ERV Manufacturer	ERV Model No.	Efficiency	Notes:

Fans, Etc.	Count	Total HP	Total W
Ventilation Fan			
Exhaust Fan			
Ceiling Fan			
Other Fan			

Tables of Input Options for Pull-Down Lists

Auditor
Darcy/Curtiss
Dave Runge
Brad Hoover
Glenn Haynes

Thermostat type
Manual
Digital, non-prog
Digital, 1-day
Digital, 7-day
Integral
None

Fluorescent Ltg.
CFL Pin
Circline
T12
T8
T5
Other Fluor.

Other Ltg.
Mercury Vapor
Metal Halide
LPS
HPS
LED

Wall Location
Conditioned/Ambient
Conditioned/Garage
Conditioned/Basement
Conditioned/Attic
Other

Service Are
KCPL
MPS
SJLP

Unit Type
Apartment
Condo
Town Hous
Dorm. Roo
Other

Insulation Type
Fiberglass Batts
Blown-in Fiberglass
Cellulose
Icynene
Panel Construction
Rigid Foam
Rock Wool
None
Other (define)

Duct Location
Attic
Uncond. Space
Cond. Space

Duct Insulation
Uninsulated
1" Wrap, R3.3
2" Wrap, R5
Internal
Other (define)

Duct Type
Metal
Duct Board
Flexible
Joist Pan

Basement
None
Full Basement
Partial Basement
Crawl space
Slab on Grade
Other

Wall Description
2 x 4
2 x 6
Steel Stud
Masonry and Stud
All Masonry
Other

Door Types
Panel
Hollow Core Insulated
Hollow Core Uninsul
Solid Core

Ceiling Construction
None
2 x 4
2 x 6
2 x 8
2 x 10
2 x 12
Other

Flat/Cathedral
Flat joists covered
Flat joists NOT covered
Cathedral

Type of Glass
Single Pane
Double Pane clear
Double Pane low e
Double Pane low e Argon
Triple Pane
Other

Window/Skylight
Operable
Fixed
Glass Door
Skylight
Glass Block

Floor Construction
None
2 x 6
2 x 8
2 x 10
2 x 12
Concrete
Beam
Other

Floor Location for heat transfer
Conditioned/Basement
Conditioned/Garage
Conditioned/Ambient
Conditioned/Unvented CS
Conditioned/Vented CS

Grade/Below Grade
On Grade
Below Grade
Mix (on/below grade)
Other

Room/Area Names
Foyer/Entrance
Living Room
Bedroom
Kitchen
Dining
Full Bathroom
Half Bath
Hallway
Closet
Laundry Room
Mech/Elec Closet
Office
Patio/Porch
Sun Room
Basement
Other

Foundation Wall Type
Poured concrete
CMU
Brick
Combination masonry
Masonry & Stud Framing

Foundation Wall Location
>50% Above Grade Cond
>50% Above Grade Uncond
<50% Above Grade Cond
<50% Above Grade Uncond
Unvented Crawl Space

Slab Insulation Location
Slab Edge only (vertical)
Slab Edge and Perimeter (L shape)
Under only (whole slab)
Under (whole slab) and Slab Edge
Unable to determine

Slab Insulation
Extruded PS
Xpanded PS
ISO
None
Unknown

Tenent Water Heatr Type
Storage, stand alone
Instantaneous
Integrated, tankless
Integrated, w/tank
Heat Pump WH
Other

Heating Equipment Type
Furnace
Baseboard
Air Source HP
Water Source HP
Ground Source HP
Mini Split
Hot water fan/coil
Other

Fuel
Electric
Oil
Nat. Gas
Propane
Wood
Pellet
Kerosene
Other

Loc of Cond. Unit
No Cond. Unit
Ground Outside
Patio/Balcony
Roof
Attic
Other

Cooling Equipment Type
Central Air Split
Central Air Packaged
Air Source HP
Water Source HP
Ground Source HP
Window/wall AC
Window/wall HP
Chilled water fan/coil
Other

Appendix D: Owner / Manager Introductory Letter

October 13, 2010

Dear KCP&L Customer,

KCP&L is currently conducting an important research study to better understand the energy usage characteristics of its multifamily residential customers and to help determine which benefits and services will be most useful to them. To assist us with this research, we have hired a professional energy consulting firm, KEMA Inc., to collect the necessary on-site information.

On-site audits are a critical part of the study because the technical data gathered will help us to calculate the energy savings potential of your building and other multifamily buildings within KCP&L's service territory. They will enable us to design an effective multifamily energy conservation program that will help our multifamily customers save energy, reduce our region's dependence on fossil fuels, and reduce the global emissions of greenhouse gases. We are interested in gathering specific energy information about the building as a whole and two to four of the individual residences. The items of interest will include heating and cooling equipment, major appliances, windows, insulation, lighting fixtures, televisions and associated equipment, and computers.

The on-site visit within each living unit should last about 20 to 30 minutes, and as a thank you to those who participate, KCP&L is providing a $50 postal money order to the tenant upon completion of the audit.

If you…	Who to Contact	Phone Number
Would like more information about the on-site visits and scheduling matters	Amber Watkins, KEMA, Inc.	1-866-439-8006 Toll Free
Have questions about the study or the contractors	Phil Gooch, KCP&L	816-701-0525

Thank you in advance for your assistance. We look forward to working with you!

Sincerely,

Phil Gooch
Manager, Market Research & Analytics