LG&E
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Mr. Jeff DeRouen
Executive Director
Kentucky Public Service Commission
211 Sower Boulevard
Frankfort, Kentucky 40602-0615

December 20, 2013

RE: ***Request of Louisville Gas and Electric Company to Cancel and Withdraw the Tariffs for its Responsive Pricing and Smart Metering Pilot Program***
Case No. 2011-00440

Dear Mr. DeRouen:

Pursuant to the Commission's Order of March 22, 2012, in the above-referenced proceeding, Ordering Paragraph No. 2, Louisville Gas and Electric Company ("LG&E") hereby files an update[1] describing its efforts to develop a new dynamic pricing or smart meter program.

LG&E selected DNV KEMA to conduct a comprehensive assessment to identify specific operational areas where the deployment of smart meter and smart grid technologies may provide additional customer value. A copy of this assessment is included in this update.

DNV KEMA concludes that smart meter technology continues to emerge and pricing for meters and related infrastructure is declining, but the economic benefits to customers do not justify full smart meter deployment throughout the entire service territory. However, the assessment suggests that smart meter deployments in high density and high use customer areas may provide benefits for customers and LG&E.

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[1] Order issued on July 25, 2013 in Case No. 2013-00290 granted LG&E an extension to file the next status report on or before December 20, 2013.

While LG&E considers further options in this area, LG&E proposes that its next update be filed in June of 2014, rather than in March.

Please place the file stamp of your Office on the enclosed additional copy and return it in the envelope provided.

Should you have any questions, please do not hesitate to contact me.

Sincerely,

Rick E. Lovekamp

Enclosure

LG&E and KU

Smart Meter Business Case Assessment

Prepared by: DNV KEMA Energy and Sustainability (DNV KEMA)
Revised on December 13, 2013

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List of Acronyms

ACEEE	American Council for an Energy-Efficient Economy
ACS	American Community Survey (Census)
AMI	Advanced Metering Infrastructure
AMR	Automated Meter Reading
ARRA	American Recovery and Reinvestment Act (2009)
CAIDI	Customer average interruption duration index
CPP	Critical Peak Pricing
DA	Distribution Automation
DER	Distributed Energy Resources
DLC	Direct Load Control
DMS	Distribution Management System
DOE	Department of Energy
DSM	Demand-Side Management
EEI	Edison Electric Institute
EERS	Energy Efficiency Resource Standards
EIA	Energy Information Administration
EISA	Energy Independence and Security Act (2007)
EM&V	Evaluation, Measurement and Verification
EPACT	Energy Policy Act (2005)
EPRI	Electric Power Research Institute
FERC	Federal Energy Regulatory Commission
FCI	Fault Circuit Indicator
FLISR	Fault Location, Isolation and Service Restoration
IBB	Inclined Block Base
IHD	In-Home Display
IRP	Integrated Resource Plan (Filing)
LBNL	Lawrence Berkeley National Labs
LIHEAP	Low-Income Home Energy Assistance Program

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MAIFI	Momentary Average Interruption Frequency Index
MAS	Multiple Address System (Radio)
MED	Major Event Day
NARUC	National Association of Regulatory Utility Commissioners
NES	Nashville Electric Service (Utility Co.)
NPV	Net Present Value
NMS	Network Management System
OC-48	Optical Carrier (2.488 Gbps)
OMS	Outage Management System
PCT	Programmable Communicating Thermostat
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
PLC	Power Line Carrier
PSC	Public Services Commission
PTR	Peak Time Rebate
PUC	Public Utilities Commission
RASS	Residential Appliance Saturation Survey
RECS	Residential Energy Consumption Survey
RPP	Responsive Pricing Pilot
RPS	Renewable Portfolio Standard
SaaS	Software as a Service (software distribution model)
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SCADA	Supervisory Control and Data Acquisition
SCF	Sectional Center Facility (Zip Code component)
SG	Smart Grid
SGCC	SG Consumer Collaborative
SGIG	SG Investment Grant
SONET	Synchronous Optical Network (Fiber Optic network technology)
TOU	Time of Use

1. Executive Summary

The report presents the results of an investigation into the prospects and potential features of a Smart Meter Strategy for LG&E and KU ("The Companies"). This study addresses the business case for Smart Meter deployment in the service territory, and includes a high level assessment of the costs and benefits of such a transformation to the utility and its customers. The work reflected in this document consists of an analysis of Companies, customer and industry data, and builds upon two important Smart Meter activities carried out by LG&E and KU: 1) the Responsive Pricing and Smart Meter Pilot Program conducted in 2009-2011, and 2) a customer survey conducted in 2012 to gauge consumer awareness and potential responsiveness to Smart Meters and related services.[1]

The overall conclusion of this assessment is that LG&E and KU may have opportunities to benefit from a targeted AMI deployment, but that system-wide conversion is not justified at this time given the data analyzed. The most favorable strategy for AMI deployment would be one that is focused on urban/suburban areas where infrastructure needs coincide with geographic locations where high concentrations of customers reside. AMI technology is typically less costly to deploy in urban/suburban areas compared to rural areas. Here the economics of Smart Meters are most attractive from both an operational and a customer benefits standpoint, based on our analysis.

The relatively low costs of the existing meter reading and other services infrastructure in the LG&E and KU service territory does not justify full scale conversion based on our high level cost benefit analysis. Average customer electric bills are low as compared to the region and nationally, which makes customer reported expectations for engaging in time-varying rates unrealistic and unlikely to be realized.[2] In addition, customer response to existing DSM and demand response offerings, combined with the results of the pilot and an attitudinal survey indicate that large levels of customer engagement to Smart Meter related services are unlikely and thus would be inadequate to justify system-wide investment based on customer benefits.[3] These outcomes are most likely a partial result of the low rates and low average electric bills paid by LG&E and KU customers.

Other key findings from this study are highlighted below.

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[1] Bellomy Research, Inc., Residential Smart Meter Study, January 17, 2012.

[2] Customers indicated an expectation of $25 per month savings on their electric bills to engage in time-varying rate programs, which would represent fully 24 percent savings, whereas the pilot program results showed a realized average savings of only 1.4 percent.

[3] Customer participation in energy efficiency programs was used as a proxy for voluntary or "opt-in" behavior, and is indicative of the level of interest that LG&E and KU customers have in saving energy and money on their bills.

- The cost of system-wide AMI deployment and operations over 20 years is estimated to be between $204M - $340M. The benefits from meter reading automation and automation of various field services over the same period are estimated up to $141M.
- There are potentially other operational benefits that are not quantified in this report, including improvements in billing and collection, distribution system engineering and management, outage management, call center operations, customer management, and vehicle expenses.
- Were the Companies to offer time-differentiated rates as part of Smart Meter conversion, there is limited evidence that customers would respond in adequate number, or have the technological capability to take action.
- While customers responding to a Smart Meter survey indicated interest in time-varying rate options, their expectations for savings on the monthly bill are high - $25 per month or 24 percent savings – when compared to actual pilot program savings of $7.58 over the four month summer period, or $1.89 per month (1.4 percent bill savings).

This investigation shows that the overall costs of a system-wide AMI deployment are somewhat higher compared to the quantified benefits of meter reading automation and automation of various field services. At the same time, taking into account the geographic character of the LG&E and KU service territory suggests that targeted deployments of AMI (i.e., in urban/suburban areas) might produce positive cost-benefit results.

The customer engagement results are less encouraging for the overall residential population, but are favorable within certain socio-demographic and geographic pockets of the service territory, as revealed in DNV KEMA's analysis of available data. These locations are likely to overlap with the urban/suburban locations that show the most promise for achieving operational benefits. Research indicates a high level of customer skepticism about the benefits of Smart Meters, with less than one quarter (22 percent overall) of interested households indicating a likelihood to engage with enhanced services such as time varying rates. The size of customer engagement is insufficient for a large scale deployment

These conclusions are based upon our findings from interviews with company staff across various departments that would be involved in Smart Meter deployment, extensive analysis of LG&E and KU customer data (primary and from secondary sources), comparative information from similar utilities, and a review of relevant industry literature on the experience of other pilot programs and early implementation programs.

Finally, the potential success of a Smart Meter program for LG&E and KU will depend on the following additional factors that are outside of the control of the Companies:

- **Macroeconomic factors** such as high unemployment rate and vacancy rates, and the general low cost-of-living profile in the service territory, are not generally conducive to high levels of participation in innovative rate or energy efficiency programs. While customer control is a culturally attractive concept for this population, survey results showed that those who indicated higher levels of awareness of Smart Meters were less likely to engage.

- **Customer attitudes** are considered an "external factor" in that they are ultimately outside of the Companies' control. While they can be influenced through education and marketing, evidence shows that LG&E and KU's customer base has limited receptivity to time varying rates that might be offered with Smart Meter conversion, or have unrealistic expectations for the monetary benefits that might result from their level of engagement.
- **Technological development** is an issue of concern to both the Companies and consumers. AMI products have evolved and will continue to demonstrate new features, making it challenging to commit to a specific product line of Smart Meter equipment. Similarly, product developments for consumers have advanced significantly since the original design of the pilot, with many non-traditional new entrants in the home energy management and control space including ADT (security systems), Google, Verizon, etc. Consumers are therefore faced with technology obsolescence in making decisions about tools to adopt in their daily lives, further complicating the range of choices they have for controlling household costs.

Smart Meter Benefits

Smart Meter deployments have multiple costs, including converting customer meters to AMI to support Smart Metering with related infrastructure upgrades and installations, and organizational and programmatic changes necessary to make the system function. Understanding and quantifying the potential benefits of Smart Meter implementation is therefore critical to ensure that a deployment's likely benefits exceed its likely costs. Figure 1 summarizes some key benefits identified in this investigation and compiled from industry sources and pilot programs launched elsewhere. Each of these is discussed in more detail in the full report.

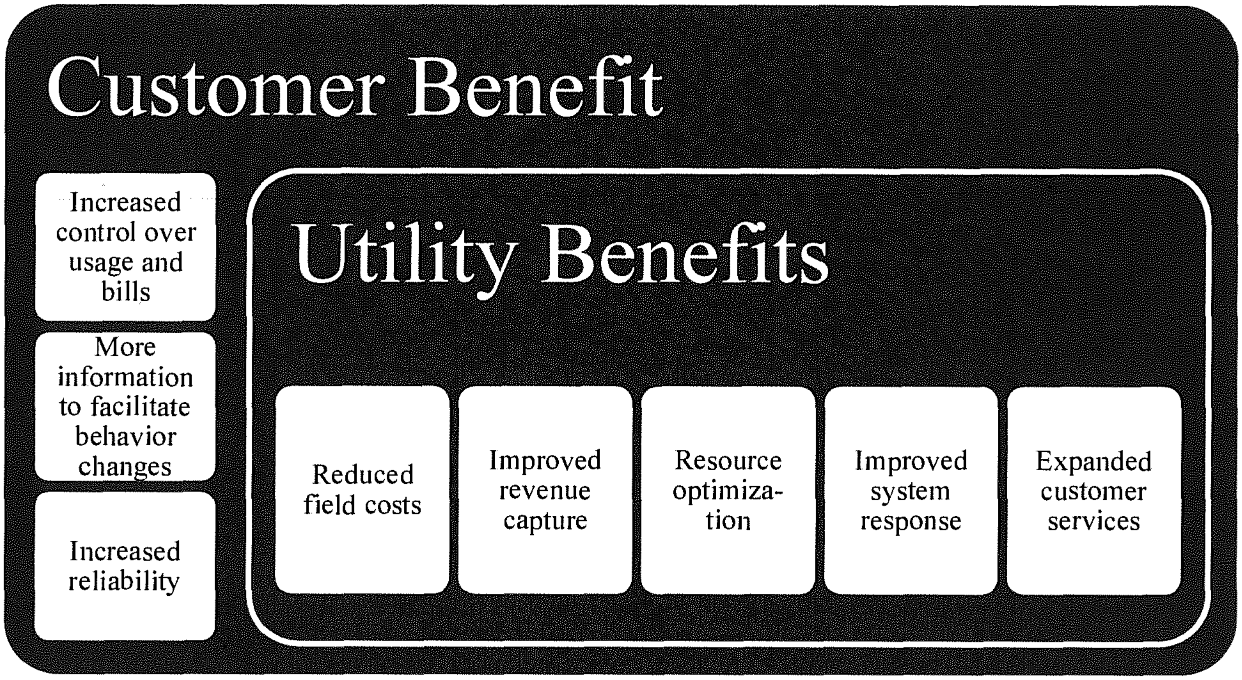


Figure 1: Smart Grid Benefit Categories

Customer Propensity to Participate

The Residential Smart Meter Study (2012) conducted by LG&E and KU provides insight into the likelihood of customer participation from the segment of the Companies' customers deemed most likely to participate in a Smart Meter program: customers who have email addresses on file with the Companies and who have access to the Internet. While this sample of just under 500 respondents skews to a younger population than the overall customer base, the responses are indicative of what one would consider to be representative of technology-engaged households. DNV KEMA conducted an analysis of the survey data and presents the results in a map of the service territory, below in Figure 2. Data at the zip-code level was aggregated into larger postal regions to account for the low number of respondents in some zip codes. "Time-Varying pricing plans" in the legend refers to the four time-varying options that were offered by the Companies during the pilot and tested in the survey.[4]

[4] The time-varying rate options tested were Time of Use (TOU), Critical Peak Pricing (CPP), Peak Time Rebates (PTR), and Inclined Block Base (IBB).

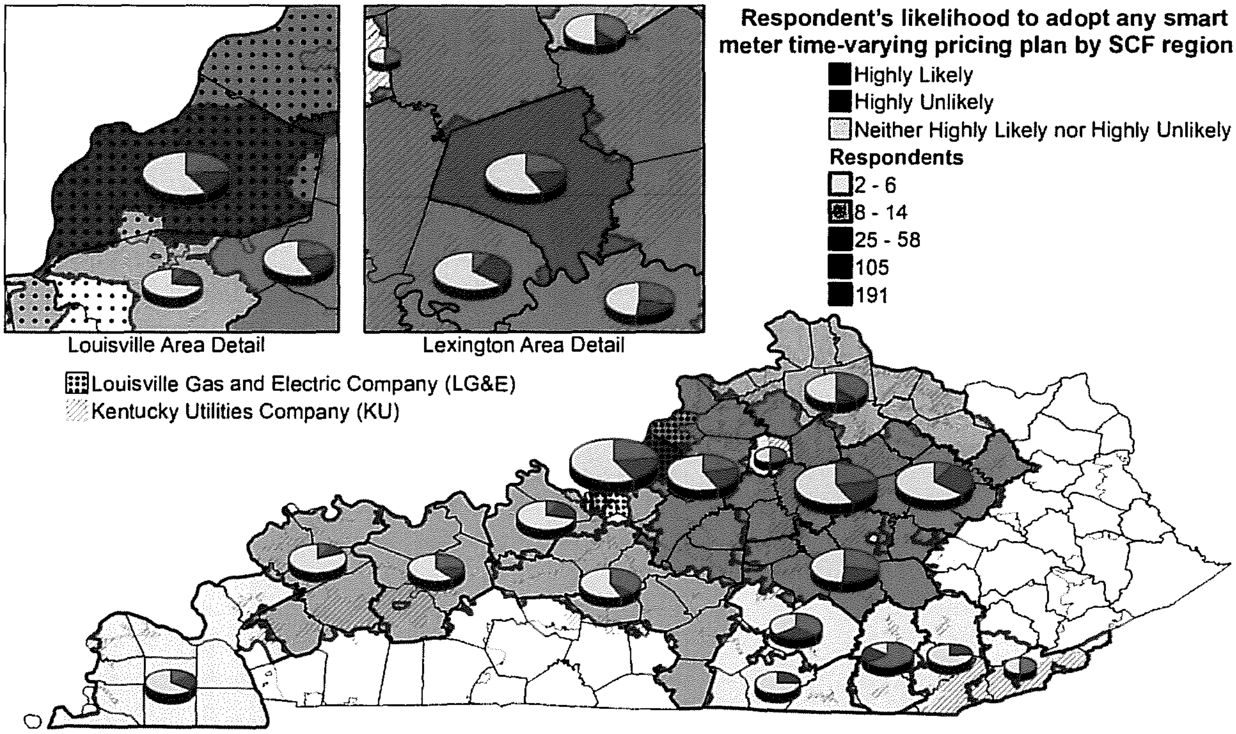


Figure 2: Geographic Distribution of Propensity to Participate in Time-Varying Pricing Plans

This map shows the areas of highest concentration of households that indicate a willingness to engage with Smart Meter-related pricing plans, most of which are in urban/suburban areas. These are also the areas that produced the largest number of survey responses. AMI is also typically less costly to deploy in urban/suburban areas compared to rural areas. Therefore, these areas are most likely to produce Smart Meter benefits for the utility and its customers who choose to engage in time-varying rate options if they were offered. Note, however, that customers who do not elect to engage would presumably not receive any direct benefits.

A second map below shows the five top areas by their urban-versus-rural designation where customer participation – and therefore benefits – would be expected to be highest, according to the data. The areas generally follow I-64 and encompass the greater urban areas of Louisville, Frankfort, and Lexington.

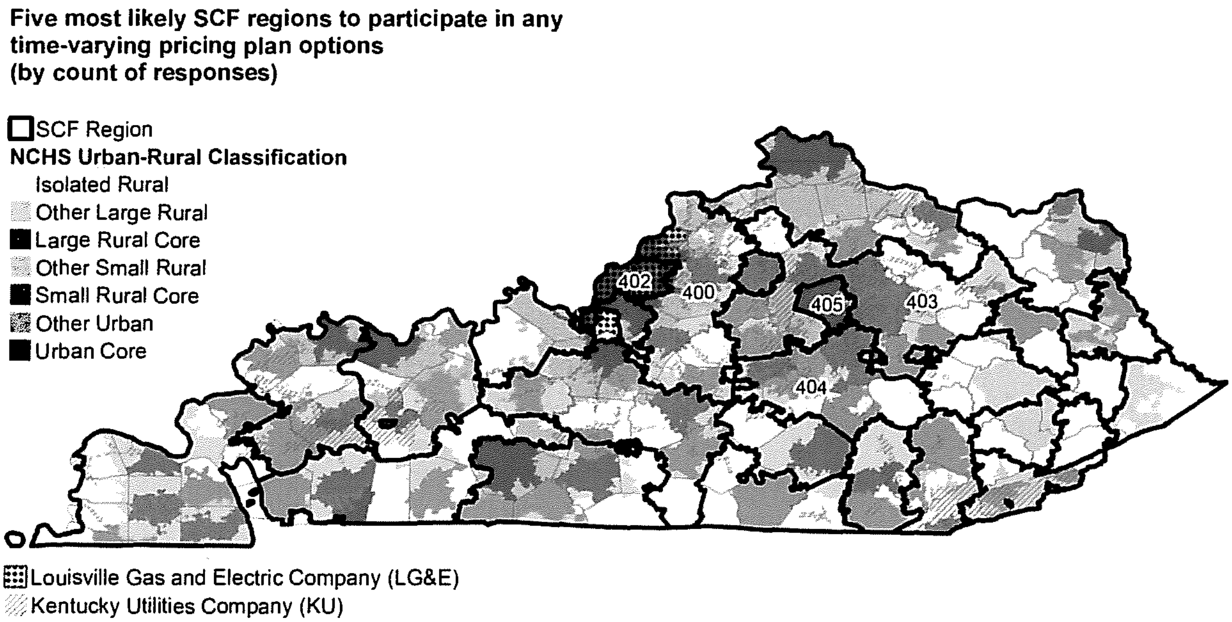


Figure 3: Top Five Areas of Most Likely Participation in Time-Varying Pricing Options with Smart Meters, by Urban/Rural Designation

These areas are also important from two other perspectives:

- Because of the higher concentration of people, outages in the urban/suburban areas affect more people;
- Urban/suburban Smart Meter deployment is less costly to carry out than conversions in rural areas

Given the correlation between these benefits with likelihood of household engagement, it is clear that a staged deployment of Smart Meters in urban/suburban areas presents the most advantageous strategy for LG&E and KU as based on our research.

2. Introduction

LG&E and KU are investigating the role of Smart Meters in advancing system reliability and relevance in a rapidly changing market while remaining a low-cost provider of electric and gas service in the region, and a respected and well-liked service provider to its customers. As such, the Companies have been investigating whether and how migration to a Smart Meter platform can best serve the needs of ratepayers and the communities in which they live and work while making good business sense to the Companies and their shareholders.

2.1 Background

The Companies have been engaged with the Kentucky Public Service Commission and various stakeholders since 2007 in considering the potential benefits and costs of Advanced Metering Infrastructure (AMI) or Smart Meter deployment and related service offerings. As part of this review, LG&E and KU conducted a pilot test from 2009-2011of Smart Meters and pricing alternatives within a geographically targeted area of the service territory. The study tested the functionality of the equipment and provided findings regarding customer engagement with rate and enabling technology options, presented to the Commission in a final report (July 2012). In approving the cancellation of the pilot-tested rates, the Commission's Order encourages ongoing study into the efficacy and potential costs and benefits of further Smart Meter deployment. The Companies continued to investigate the most appropriate path for continued Smart Meter deployment; this report is part of that process.

2.2 Objectives of this Study

LG&E and KU engaged DNV KEMA to conduct a review of the current status and outcomes of Smart Meter activities based on the experience of the Companies, their peers in the region and nationally, with the objective of offering recommendations for appropriate next steps that the Companies should consider. This report presents the results of this research and our recommendations.

Specific research questions addressed in this study are:

1. Determine customer value and overall impacts on energy efficiency, energy bills and other potential outcomes through understanding customer perspectives and acceptance of advanced meter technology and dynamic pricing offers;
2. Develop an assessment of cost and capabilities associated with investing in new technologies on a full-scale, through pilot or targeted deployments, or other strategic direction;
3. Cost and benefits of integrating new technology with existing systems and the Companies' current IT infrastructure; and

4. Quantify the risk associated with investing while technology continues to emerge in metering, communications, distribution system, and data management systems.

The report summarizes multiple paths of investigation:

- Operational Considerations
- Customer Considerations
- Regulatory & Legislative Considerations

To address these areas of research, DNV KEMA conducted a series of informational interviews with LG&E and KU management to assess the landscape and corporate context within which the investigation was to take place. Key findings from the initial interviews and review of past documents reveal that, like many others in the utility industry, the Companies are evaluating how to approach Smart Meter adoption in a manner that is consistent with its corporate mission and philosophy to "deploy technology at the speed of value." [5] The companies have pursued a parallel path of internal research regarding the value of AMI coupled with keeping abreast of other pilot efforts and early roll outs nationally to examine lessons learned and how they might be applied in Kentucky,

To assess the customers' perceptions of value from Smart Meter deployment, the Companies conducted two important investigations: a Commission-sanctioned Responsive Pricing Pilot (RPP) from 2009-2011, and a Residential Smart Meter Survey conducted by Bellomy Research, Inc. in 2011 (published in 2012).

2.3 Overview of Approach

DNV KEMA was hired to build upon the results of these two primary activities through a more comprehensive assessment of potential benefits and costs of advanced meter technology and recommended strategic direction for AMI deployment. To address these questions, DNV KEMA pursued the following overall approach:

- Independent review of existing data and experience
- Analysis of customer data from companies, records, surveys and secondary sources
- Identification of benefit streams and assignment of values where appropriate
- High level cost-benefit analysis
- Preliminary recommendations

[5] Interview with David Huff, Director of Customer Energy Efficiency and Smart Grid Strategy for LG&E and KU.

2.4 Organization of the Report

The next section of this report describes our methodology and sources used in carrying out this investigation. This is followed by the body of the report as shown in Figure 4 with each section numbered to correspond with the Table of Contents.

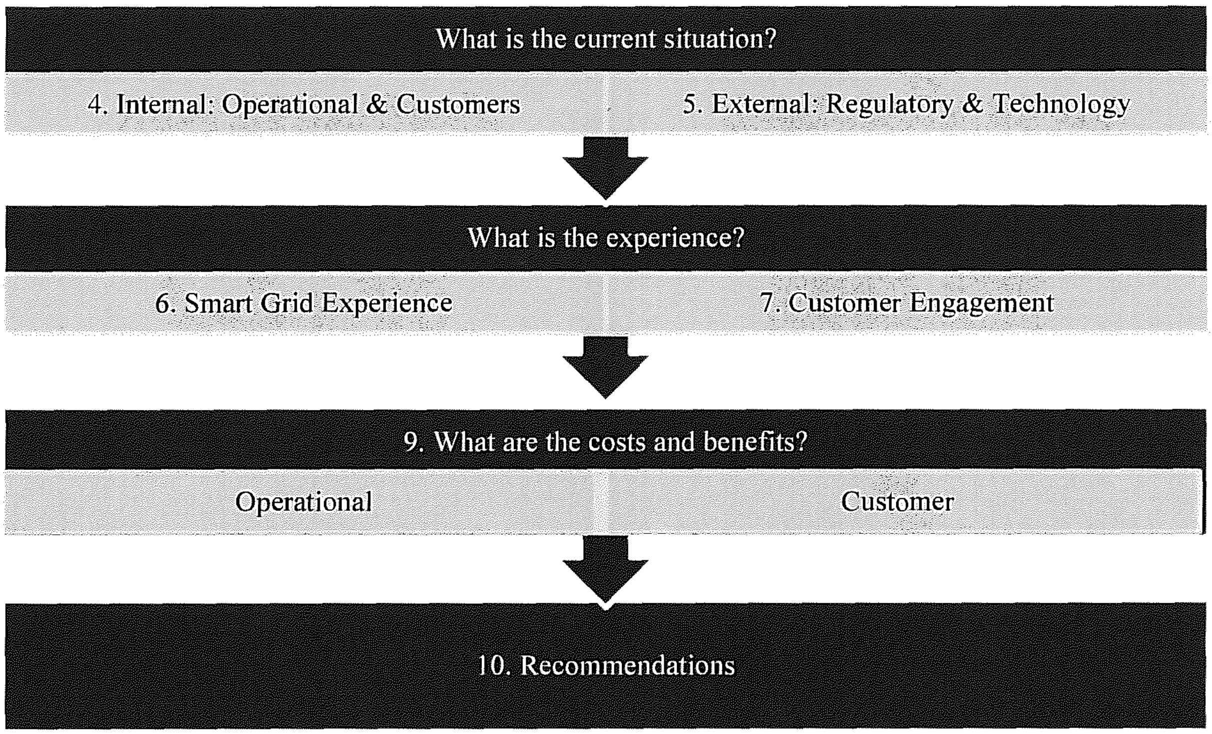


Figure 4: Report Layout

3. Methodology

3.1 Review of Sources

The study team relied on a combination of LG&E and KU specific data and reports, regulatory filings and documents, external industry reports, and secondary data sources such as the US Census.

3.1.1 Operational Analysis Sources

Primary sources of information used in the operational analysis include:

- Publicly available information from other utilities on their AMI business cases and deployments
- Private information from DNV KEMA through its involvement with numerous AMI deployments
- Information from groups within LG&E including the reliability, communications, distribution systems engineering, metering, field maintenance and operations dispatch, revenue assurance and other groups.

3.1.2 Customer Characteristics and Engagement Sources

Primary sources of information used in the customer characteristics and engagement analysis include:

The customer characterization examines specific characteristics of LG&E and KU customers and compares these statistics with regional and national statistics when applicable. When LG&E and KU data is not available, Kentucky or regional (Kentucky, Alabama and Mississippi) data are used as being the closest approximation of data to the service territories from available public sources.

The results from this section can be split into the LG&E and KU based results and the comparison results. The LG&E and KU statistics come from three distinct sources:

1. LG&E and KU customer data. This data source is the most reliable, coming from the utility customer database. DNV KEMA requested specific information and received aggregated results at the utility level and the zip code level for specified variables of interest to the Smart Meter investigation. Data were also examined from the Responsive Pricing Pilot (RPP) as a separate group for comparison to the overall population of LG&E and KU customers.
2. LG&E and KU's 2010 Residential Appliance Saturation survey. This survey was conducted as a phone and web-based survey. The phone portion was conducted by Strategic Marketing Research.

About 73 percent of the surveys were conducted as phone surveys, with about 27 percent being filled out online.

Bellomy Research's 2011 Residential Smart Meters Study. Bellomy Research conducted an online survey with 496 LG&E and KU customers with email addresses about Smart Meter awareness. The respondents to this online-only survey tended to be younger, more technologically advanced, and have higher levels of education than the general Kentucky population. Fifty-nine percent of respondents had a bachelor's degree or higher, compared to 22 percent of the larger Kentucky community as based on Census data.[6] While biases in the survey design limit the ability to expand these survey results to the whole LG&E and KU population, it still presents an illustrative view of how this population views Smart Meter technology.

Regional and national level data help place the characteristics of the LG&E and KU customer base into a larger context. Knowing how a group compares with other groups that have implemented Smart Meter successfully or unsuccessfully can be useful in terms of planning. The data for the regional and national statistics come from two main sources:

1. Department of Energy's (DOE) Energy Information Administration's (EIA) 2009 Residential Energy Consumption Survey (RECS). The 2009 RECS had a sample size of 12,083, allowing for increased estimates at regional and state levels. The survey is administered only to primary residences. These are 2009 estimates, so they will not be exact comparisons.
2. Census Bureau's 2011 and 2012 American Community Survey (ACS). The ACS is a continuing statistical survey that samples and interviews a small percentage of the population every year.

3.1.3 Regulatory & Legislative Analysis Sources

DNV KEMA performed a review and analysis of key relevant research reports, regulatory filings, trade publication articles and other documents to develop the regulatory and legislative analysis in Section 5. This analysis also supported other conclusions in this report.

We sought to answer the following primary questions related to state and national regulatory and legislative treatment of Smart Meter:

- **Landscape**. What regulatory and legislative conditions exist currently in the U.S. and by state?
- **Impacts**. How may these regulatory and legislative conditions impact a LG&E and KU Smart Meter Business Case?

[6] 2011 American Community Survey

To answer these questions, we undertook six major steps. These included:

1. Compiled documents related to regulatory and legislative treatments of Smart Meter investments from over 35 sources. These include, among others: US Department of Energy, National Association of Regulatory Utility Commissioners (NARUC), American Council for an Energy-Efficient Economy (ACEEE), EPRI, Edison Electric Institute (EEI), and industry trade groups such as the Smart Meter Alliance.
2. Reviewed and analyzed Kentucky PSC rulings and potential cost recovery strategies.
3. Reviewed and analyzed literature, trade and news articles, regulatory proceedings and orders, governmental reports, and other documents for national and other states.
4. Compared state-level Smart Meter related cost recovery strategies and determined impacts and potential implications for LG&E and KU.
5. Reviewed Kentucky PSC regulatory treatment of Smart Meter-related research and analyzed possible implications for LG&E and KU.
6. Discussed regulatory treatment options for Smart Meter-related investments and implications for LG&E and KU.

4. Internal Situational Analysis

This section presents a description of the current operational and customer/market conditions in which a Smart Meter business case is considered, followed by an overview of the infrastructure presently in place per the information gleaned from the companies' representatives.

Internal elements include those that can be directly engaged or influenced by LG&E and KU.

4.1 Operational Characteristics

Operational features of the utility system include physical facilities, equipment, hardware and software that are associated with the distribution of electricity to customers, and associated business functions such as customer billing, communications and reliability. All of these types of features would be impacted by a Smart Meter strategy. The primary focus of this report is on AMI. AMI has the most impact on customer related operations and distribution related operations. Hence for this report, we are limiting our review to a discussion of customer and distribution-related operations, and do not include transmission and generation functions.

LG&E and KU supply electricity and natural gas services to customers primarily located in Kentucky. The companies own and operate generation, transmission and distribution facilities.

LG&E supplies electricity and natural gas in the Louisville area, providing electric service to a service area of about 700 square miles. KU supplies electric service over a non-contiguous service area of about 6,600 square miles.

4.1.1 Meter reading system

Key components of utility operations that would be impacted by conversion to Smart Meter equipment are meter related functions, both in terms of the metering technology itself and the manner in which it is read or queried now and under a Smart Meter scenario.

At present 7 percent of the LG&E and KU meters are read using automated meter reading (AMR) - both drive by and walk by remote/wireless means - and the remaining meters are read manually, through a contract to a third party. LG&E and KU's average meter reading cost is below nationwide average.

In addition, LG&E and KU do off-cycle reads (i.e., when a customer moves out), disconnects/reconnects for non-paying customers and reads to validate misreads etc. These require field visits to the customer. Costs associated with these may be avoided or reduced by automating these functions.

4.1.2 Distribution System

The distribution system is the infrastructure from the substations to the meters (consisting of substations, feeders, distribution transformers etc.) over which the power is delivered to customers. The design, efficiency and reliability of this system determine the reliability and efficiency with which the power is delivered to the end consumer.

LG&E distribution substations are monitored and controlled using a Supervisory Control and Data Acquisition (SCADA) system. About 90 percent of the feeder circuits on the LG&E network are connected to other feeders via tie switches. LG&E serves mostly an urban/suburban area, and nearly 100% of load within the LG&E territory is presently monitored or controllable through SCADA communications.

In the KU network, many of the distribution substation feeders in the urban areas are connected to other feeders via tie switches; however, most feeders in the rural areas are not connected to other feeders. Thus, about 25 percent of these substations are on SCADA, however approximately 75% of load within the KU territory is presently monitored or controllable through SCADA communications.

At present, most of the devices on the feeders (i.e., capacitor banks, reclosers, regulators, switches, etc.) do not have communication capability; fewer than 20 reclosers on the feeders in the LG&E and KU network have communication capability. Improved communication to these devices would enable better monitoring and control, which may in turn permit improved reliability and reduction in technical losses.

4.1.3 Communication System

A Smart Meter network requires a robust communication infrastructure between the Smart Meters and the utility and between devices on the utility network and the control center.

The wide area network in LG&E is based on SONET rings (using OC-48 or being upgraded to OC-48). The core network in KU is based on collapsed OC-48 rings backed up by microwave.

Most of the substations on the LG&E network are served by the private fiber network (about 103 transmission and distribution substations are on the private network, 3 are using leased lines and several have no communication).

About 100 substations in the KU network are on the private network. About 50 distribution substations are served using 900 MHz MAS radio and about 76 are served using leased lines. There are also a large number of substations in the KU network which have no communications (about 75 percent of the 433 distribution substations in KU do not have SCADA).

There are few devices on feeders that benefit from communications (about 10 on the LG&E network and about 3-4 on the KU network) limiting the ability to detect and remedy faults in an automated fashion and mitigate service impacting events. These devices are communicating using the 900 MHz MAS radio.

In addition to communications with distribution and transmission system elements, the Companies have communications with a significant number of direct-load-control switches installed at customers' premises. As of September 2013, LG&E and KU had 181,689 users on its Direct Load Control program. The service is presently supported by a 1-way paging system: the 2-way communication capability enabled by AMI may enhance the offering in the future.

4.1.4 Reliability

Improved system reliability is typically a benefit that is associated with use of smart grid technology. Reliability is defined through a variety of metrics, the most common of which are:

- SAIDI – System average interruption duration index
- SAIFI – System average interruption frequency index
- CAIDI – Customer average interruption duration index

The reliability indices are typically reported without MEDs (Major Event Days). The definition of MEDs is defined by an IEEE group to exclude days where the SAIDI value exceeds a calculated threshold.

The following are the reliability metrics (SAIDI, SAIFI and CAIDI) excluding MEDs for LG&E and KU for the last several years as reported to the Kentucky Public Service Commission.

Table 1: Annual Metrics for LG&E

	SAIFI	SAIDI	CAIDI
2012	1.15	97	84.0
2011	1.05	94	90.3
2010	1.22	105	86.7

They can be compared with the median values for SAIDI, SAIFI and CAIDI excluding MEDs for other U.S. utilities.

Table 2: Annual Metrics for Other Utility Operators

	Median SAIFI	Median SAIDI	Median CAIDI
Utilities in U.S. overall	1.31	146	111

(Tracking the Reliability of the U.S. Electric Power System: An Assessment of Publicly Available Information to State Public Utility Commissions (October 2008), LBNL Report 1092E n.d.).

Potentially AMI and other smart grid technologies could provide further improvement. The reliability metrics for LG&E and KU are better than the median values for U.S. utilities overall and for utilities in the East North Central U.S.

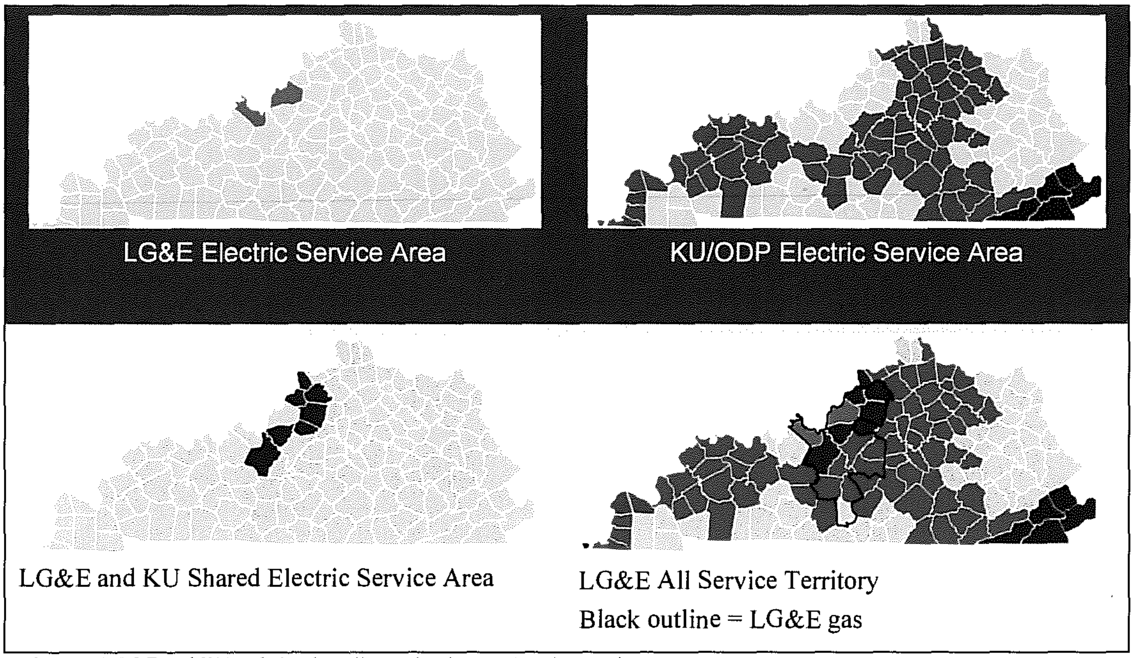
4.1.5 Outage Management

Another benefit of AMI is the ability for the system to provide real time information on the location and nature of faults and outages, and potentially to enable self-healing in the distribution system. This may reduce response time and using FLISR potentially limits the amount of field operations required to repair the system. Not having to rely on customers to call in outage information also potentially reduces the burden on call centers.

Both LG&E and KU each have a distribution control center. The information on incidents in the distribution system is currently obtained either from customer calls or from the SCADA system. The input is received in an outage management system (OMS) based on Oracle's Network Management System (NMS). The OMS then predicts the location of the incident based on the information received. A crew is dispatched to locate the incident and make appropriate repairs.

4.2 Customer Characteristics

While there are operational benefits that can be identified and associated with a Smart Meter strategy, utility customers will also be impacted in a variety of ways. It is therefore important to understand the existing characteristics of the Companies' customer base so as to identify potential customer benefits and challenges that may exist in regard to Smart Meter deployment. This section discusses various aspects of the LG&E and KU residential and small commercial customer classes with a focus on characteristics most indicative of potential response to Smart Meter related issues and/or service offerings.
Combined, LG&E and KU have about 791,000 residential customers and 108,000 commercial customers. KU has about 419,000 residential electric customers and LG&E has about 372,000 residential electric customers. Figure 4 shows the distribution of the electric and gas territories of LG&E and KU.



Source: LG&E and KU website (http://www.lge-ku.com/service_territory.asp)

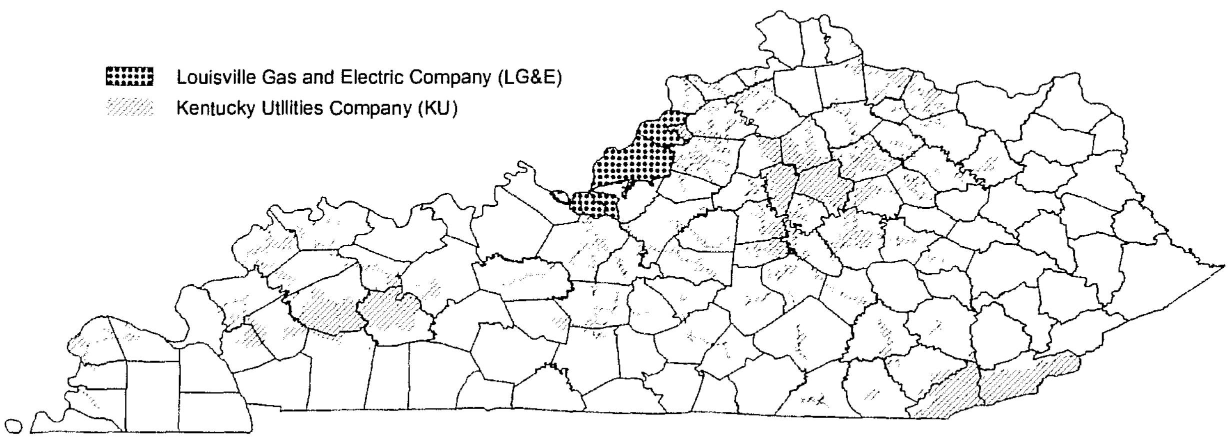


Figure 5: LG&E and KU Service Territory

4.2.1 Residential Customer Characteristics

We summarize the presence of characteristics in the LG&E and KU populations that are most indicative of Smart Meter engagement, as based on other studies and Smart Meter pilot programs. Results from the Smart Meter Pilot and Residential Smart Meter Survey show many factors affect interest in Smart Meters. This section explores general demographics that could affect uptake of a Smart Meter program in the residential sector.

Homeownership - The average LG&E and KU customer owns and lives in a single family home and uses more electricity than the national average household. Homeownership is at 68 percent, virtually the same as the national average.

Usage and Bills - The average annual electric bill for LG&E and KU customers is lower than the average bills in the region and nationally due to lower rates, even though their consumption is higher. Despite having lower electricity rates than most other states, the average annual electricity bill in the Kentucky, Alabama and Mississippi region is higher than the national average due to higher usage levels. The average household in the Kentucky, Alabama and Mississippi region uses almost 4,000 kWh more per year than the US average household.

Table 3: Electric Usage and Bill - Distribution

	[illegible]		[illegible]		National	
	[illegible]	[illegible]	[illegible]	[illegible]	USD	kWh
Average	$1,257	15,488	$1,586	15,236	$1,340	11,320

**Source: LG&E and KU customer billing records.*

Interest in Bill Reductions - Customer expectations of direct monetary gains were the most cited benefit of Smart Meter related programs in both LG&E and KU and industry studies. However, the amount of savings expected on the bill for LG&E and KU customers is higher than the actual results from pilots. Fifty-one percent of respondents in the Residential Smart Meter Survey said they would want to see at least $25 in savings per month to be interested in implementing Smart Meter technology.[7] With an average monthly bill of $104.75, that would represent a 24 percent savings, whereas the actual dollar savings experienced in the RPP was significantly lower due to lower levels of customer response.

Controllable Appliances - Between the two companies, LG&E customers have both a greater saturation of central AC systems (62 percent versus 24 percent for KU) and at least one of the three primary controllable appliances tapped in the Direct Load Control Program (66 percent), whereas KU customers are more likely to have two of the three controllable appliances than LG&E customers (45 percent versus 26 percent).

[7] Question from Residential Smart Meter Study: "How much would you need to save on your monthly electric bill in order to change your behavior, such as adjusting your thermostat to sometimes less comfortable settings, changing the time of day you use appliances, etc.?

Other Socio-demographic Indicators - Local research done after the pilot in 2011 indicates that the households most interested in Smart Meters tend to have higher levels of education, higher income, and are more technologically driven than the average household. [8] The Residential Smart Meter Survey found that customers who agree with the statement "Technology makes my life easier" had a higher likelihood of participating in a Smart Meter program.[9] This survey also suggested that among the respondent pool, once the program is explained to them, younger people tend to be more interested in Smart Meter programs.[10]

Customer Attitudes and Perceptions - Of those that responded to the Residential Smart Meter Survey:

- Twenty-seven percent reported being aware of Smart Meters. This varied both by age and income with younger and lower-income households being less likely to be aware of Smart Meters.
- When those who were aware of Smart Meters were asked about the advantages and disadvantages of Smart Meters, many people could not provide a response. Forty-six percent said they did not know of any advantages and fifty-nine percent said they did not know of any disadvantages.
- Advantages listed by at least five percent of the respondents included: ability to track electricity usage, conserve energy, save money, rate plans based on electricity usage. About eight percent said there were no benefits of Smart Meters.
- Disadvantages included loss of control, inaccurate/possibility of malfunction, uncomfortable temperature and lack of privacy. About 5 percent said there were no disadvantages of Smart Meters.

Participation in Energy Efficiency and Demand Response Programs –LG&E and KU already has several energy efficiency demand response programs, some voluntary or opt-in, and some provided to all customers with the caveat that they may opt-out if they wish (e.g., the Smart Energy Profile program). This information provides evidence of the propensity of LG&E and KU customers to take advantage of services related to energy use and costs similar to what might be offered as part of a Smart Meter strategy. Participation in opt-in programs ranges from 1 to 2 percent across 7 programs, with 5 percent

[8] LG&E 2009 Smart Rate Program Assessment, Executive Summary Report; Bellomy Research, Residential Smart Meter Survey

[9] Other statements that correlated with higher likelihood of participating in a Smart Meter program across different segments of the LG&E and KU populations included "Reducing Carbon Footprint", "Low carbon energy is future", "Consider myself green", "Look for Energy Star Ratings".

[10] Younger respondents were less likely to be aware of Smart Meters when asked unprompted, but once the program was explained, they tend to like the program more than other segments. Conversely, while older respondents were more aware of Smart Meters, they liked the concepts less.

participation in the incentive programs. Direct load control is the program of choice for 23 percent of the residential customer class, representing the highest proportion of opt-in program participation. As an example of an opt-out service, a more recent behavior change informational program called Smart Energy Profile has been successful in retaining 99 percent of the original enrollees, or 42 percent of the residential customer sector.

The data analyzed in this section presents information on customer characteristics that are typically associated with Smart Meter acceptance and engagement. Most of the analysis centers on residential households since there are more data readily available for this sector from secondary sources, the pilot program, the residential survey, and the Companies' DSM program databases.

The data on customer characteristics suggests several results favorable to Smart Meter program acceptance: Among households with email addresses, there is a relatively high percent of smart phone use; 23 percent of households participate in the Demand Conservation Devices (Direct Load Control) program, and customers in a survey (again, households with email addresses on file with the Companies) were most interested in peak time rebates among four hypothetical time-varying rate options.

At the same time, there are also a few characteristics that are negatively associated with Smart Meter engagement as revealed in the data for Kentucky – e.g., there is a higher proportion of unemployed or retired households in the service territory (50.2 percent) as compared to regional and national data, and a comparable percentage of households with small children or elderly. These characteristics represent temperature sensitive groups and households with family members in the home during the day at peak time periods, where limited behavior change might be expected. Overall, one in four customers participates in some form of DSM. The vast majority of these participate in DLC (23 percent).

Finally, the percentages of households participating in LG&E and KU's DSM programs to date is from 2 percent for information and audit programs to 5 percent for the rebate programs, which is indicative of the interest levels in energy efficiency programs where customers voluntarily elect to participate. The exception is the Direct Load Control program, where 23 percent of residential households participate. It should be noted that these figures reflect the low energy costs in the region, and relatively low average bills that LG&E and KU residential customers pay.

5. External Assessment

External features are those that can impact a Smart Meter business case but are not within the direct control of the Companies. These include federal and State regulatory policies and market conditions, including technology developments. Federal and state legislation and regulatory policies are primary external features which can impact a Smart Meter business case that fall outside the direct control of LG&E and KU. We begin this chapter with a summary of regulatory research and analysis of federal and state level legislation and standards, Kentucky PSC actions and decisions and timeline, and implications for a Smart Meter business case in Kentucky. This is followed by a discussion of the applicable technologies and a summary of Smart Meter technology developments.

5.1 Regulatory and Legislative Policies

5.1.1 Federal Legislation and Standards

New federal policy or standards are not likely to impact a Smart Meter Business Case in Kentucky in the near term. We base this conclusion on several factors described in this subsection. Federal changes require relatively long lead times and recent FERC activity does not indicate this will occur in the next few years. For example, FERC declined to institute a rulemaking procedure on Smart Meter-related standards in 2011, and indicated it will not so do until specific conditions are met. One such condition is that relevant stakeholders reach sufficient consensus. As of 2013, there is no indication this has been achieved.

As background, two major relevant federal policies, enacted in 2005 and 2007, spurred state level regulatory activity in Kentucky and other states. First, the Energy Policy Act of 2005 (EPACT 2005) contained articulation of federal policy on electric metering. Second, the Energy Independence and Security Act (EISA) of 2007 addressed Smart Meter development to modernize the grid. The 2007 legislation directs FERC to:

> "...institute a rulemaking proceeding to adopt such standards and protocols as may be necessary to insure Smart-Grid functionality... once it is satisfied that the work of the National Institute of Standards and Technology has led to 'sufficient consensus' on Smart Meter interoperability standards." [Source: EISA § 1305(d), Public Law No. 110-140, 121 Stat. 1492, 1788 (2007) (to be codified at 15 U.S.C. § 17385(d))].

As noted, FERC did not find sufficient consensus for five types of standards in 2011, and terminated the docket while encouraging these stakeholders to reach consensus.

5.1.2 Kentucky Regulations

The Kentucky Public Service Commission is considering policies on AMI, Smart Meter and Dynamic pricing, while existing policies already adopted cover net metering and distributed generation. The Commission treats energy efficiency as part of Integrated Resource Plan (IRP). Table 4 summarizes the Kentucky PSC positions and decisions related to five major Smart Meter policy areas: AMI, net metering, distributed generation, energy efficiency, dynamic pricing, and interconnection standards. Table 5 presents Smart Meter related state regulatory and federal actions that impact Kentucky.

Table 4: Summary of Actions and Decisions Relating to Smart Meter in Kentucky

	Action	Authority	Summary	Date(s)
Advanced Metering Infrastructure (AMI)	--	--	Under consideration; see Case No. 2012-00428 for AMI and Dynamic Pricing.	--
Net metering	Legislation	SB 83 KRS §278.465 et seq. KY PSC Order 2008-00169	Follows eligibility rules for interconnection standards. limit 30 kW system capacity.	Enacted 4/22/2004 Amended 07/15/2008 01/08/2009
Distributed generation	--	--	See net metering and interconnection standards that affect DG systems.	--
Energy efficiency treatment	Legislation	Kentucky Revised Statute 278.285	Allows utilities to recover full costs of DSM programs through customer rates; legislation encourages cost-effective DSM programs.	1994
Dynamic pricing	--	--	Under consideration	--
Interconnection Standards	Legislation	KRS § 278.465 et seq.	Limit 30kW system capacity	enacted 04/22/2004 amended 2008

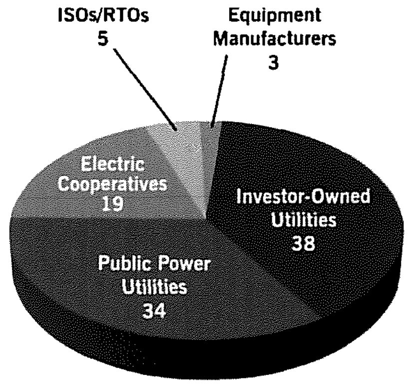
Table 5: Timeline of Smart Meter-related Federal and State Regulatory Actions Impacting Kentucky

Date	Federal / State	Action Taken	Summary
Oct 1, 2012	State regulation	KY PSC issues Order to study smart grid	Marked the third time since 2006 that the PSC has studied smart grids.
Mar 22, 2012	State regulation	KY PSC issues Order in Case No. 2011-00440	KY PSC approved discontinuing LG&E's Smart Meter Pilot and cancelling Rate RRP and Rate GRP tariffs.
Oct 6, 2011	State regulation	KY PSC adopts federal SG standards	Adopted one Smart Grid investment standard; declined to adopt four standards; deferred action on two others.
2009	Federal legislation introduced, referred to committee		Storage Technology of Renewable and Green Energy (Act of 2009) (s.1091)
Nov 13, 2008	State regulation	KY PSC opens Administrative Case No. 2008-00408	KY PSC's Administrative Case (No. 2008-00408) to address EISA 2007 - Smart Grid Investment
Oct 7, 2008	State regulation	Amendment - KY PSC	KY PSC's Order subsequently amended to allow General Electric employees to participate in the Smart Meter Pilot.
Dec 19, 2007	Federal legislation	EISA 2007 signed	The Energy Independence and Security Act of 2007 (EISA 2007) added four new Federal standards relating to SG (to existing PURPA Section 111(d)): (16) INTEGRATED RESOURCE PLANNING (Sec. 532(a)) (17) RATE DESIGN MODIFICATIONS TO PROMOTE ENERGY EFFICIENCY INVESTMENTS (Sec. 532(a)) (16) CONSIDERATION OF SMART GRID INVESTMENTS (Sec. 1307(a)) (17) SMART GRID INFORMATION (Sec. 1307(a))
Jul 12, 2007	State regulation	KY PSC issues Order approving LG&E pilot	KY PSC approved LG&E's 3-year Responsive Pricing and Smart Meter Pilot Program. Pilot included two tariffs: 1) the Residential Responsive Pricing Service tariff and 2) the General Responsive Pricing Service tariff.
Feb 7, 2006	State regulation	KY PSC opens Administrative Proceeding Case No. 2006-00045 to comply with federal legislation	KY PSC considers EPAct 2005, Subtitle E requirements for smart metering (Section 1252) and interconnection (1254)
Aug 8, 2005	Federal legislation	Energy Policy Act of 2005 (EPAct 2005) signed	Two sections relevant to Smart Grids: interconnection (Subtitle E, Section 1254) and time-based metering (smart metering) (Section 1252)

5.1.3 States' Smart Meter-Related Regulatory Treatment

Most state-level regulatory policy for Smart Meter-related activity was implemented in response to federal legislative requirements (e.g. EISA 2007 and EPACT 2005 as noted above). Subsequently, progress on grid modernization varies from state to state. For example, some states started Smart Grid related policy development before 2005, while other states have decided on other methods for developing demand response and advanced metering and did not strictly implement the EPACT requirement.

In response to EISA2007, LG&E and KU, as well as other comparable utilities in other states, developed and ran pilot programs incorporating advanced metering. The figure below shows the number of entities that have implemented pilots or full scale programs with US DOE funding, as of March 2012.



*Note: ISOs/RTOs = Independent System Operators and Regional Transmission Operators.

Figure 6: SGIG Projects by Type of Recipient[11]

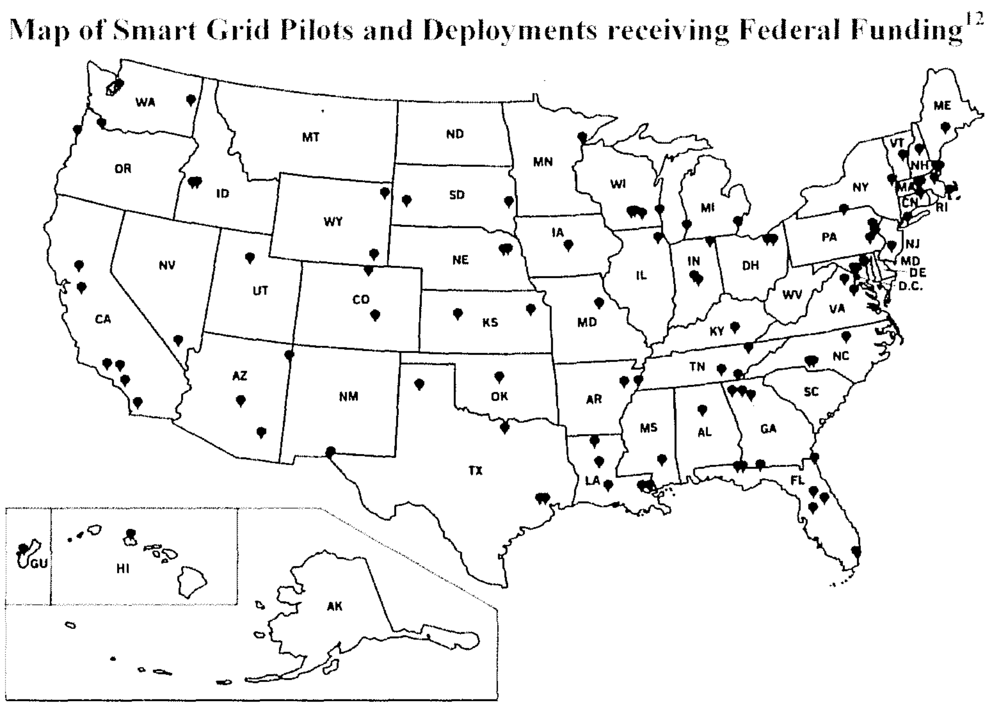


Figure 7: Federal Funding of Smart Grid

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[11] US DOE – SGIG, July 2012.

[12] US DOE- SGIG, July 2012

5.1.4 Advanced Metering Legislation & Regulation

In this section, we consider regulatory actions for six key Smart Meter-related activities and treatment at the state level. These include: Advanced Metering Infrastructure (AMI); net metering; distributed generation; energy efficiency treatment; dynamic pricing; and interconnection standards.

These activities are important considerations for a utility Smart Meter-related Business Case. Rules, standards and regulations for these activities may impact utility motivations for Smart Meter investments, cost recovery issues, and customer participation.

- **Advanced Metering Infrastructure (AMI).** Approximately 46 million Smart Meters have been installed as of 2013 (constituting about 40 percent of U.S. households), according to a report from the Institute for Electric Efficiency dated August 2013.[13] This includes states primarily in the Northeastern, Southern, and Western U.S. Kentucky has conducted pilot programs using AMI technologies.
- **Energy efficiency and demand response program treatment.** Energy efficiency programs are encouraged by the Kentucky PSC, with cost recovery available through the rate process. To the extent that Smart Meters facilitate participation in energy efficiency and demand response programs, they may be impacted by this regulatory treatment.
Kentucky utilities are not required to operate energy efficiency or DR programs, but many do include DR as part of their DSM program suite.
- **Interconnection Standards.** Interconnection standards are an important consideration for owners of renewable generation systems and lay the foundation by establishing processes and technical requirements for grid connections. . Kentucky has PSC-approved interconnection standards which apply to net-metered systems.

[13] Report accessible at: http://www.edisonfoundation.net/iee/Documents/IEE_SmartMeterUpdate_0813.pdf

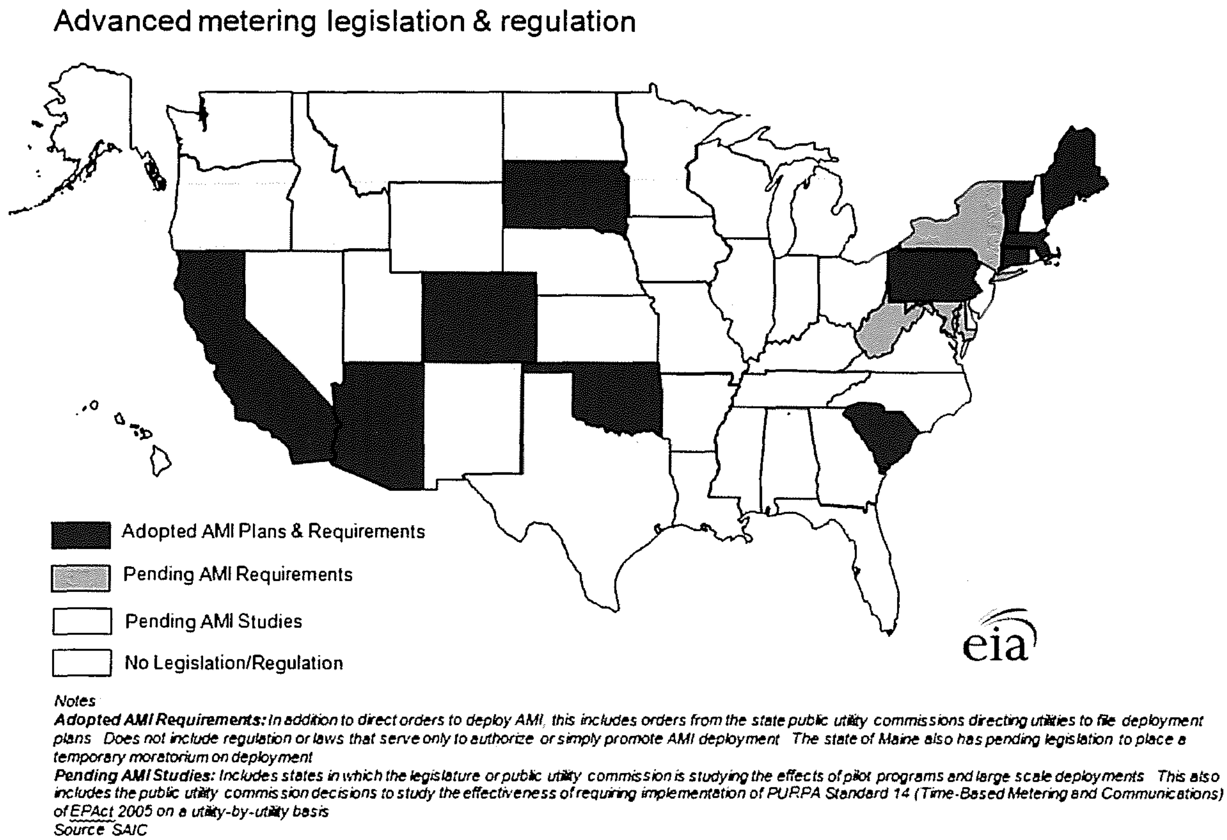

Figure 8: Status of AMI Legislation and Regulation (2011)

5.2 Applicable Technologies

5.2.1 Advanced Metering Infrastructure (AMI) and Smart Meter

LG&E and KU selected and installed the equipment for their Smart Meter pilot in 2007. The Smart Meter and AMI market has matured significantly since then. At present a number of vendors offer AMI solutions including Landis+Gyr, Itron, Elster, Silver Spring Networks and Sensus.

AMI enables 2-way communications with the meters. This can be done via a variety of communication technologies including wireless, cellular and power line communications (PLC). A typical architecture for an AMI system is shown below.

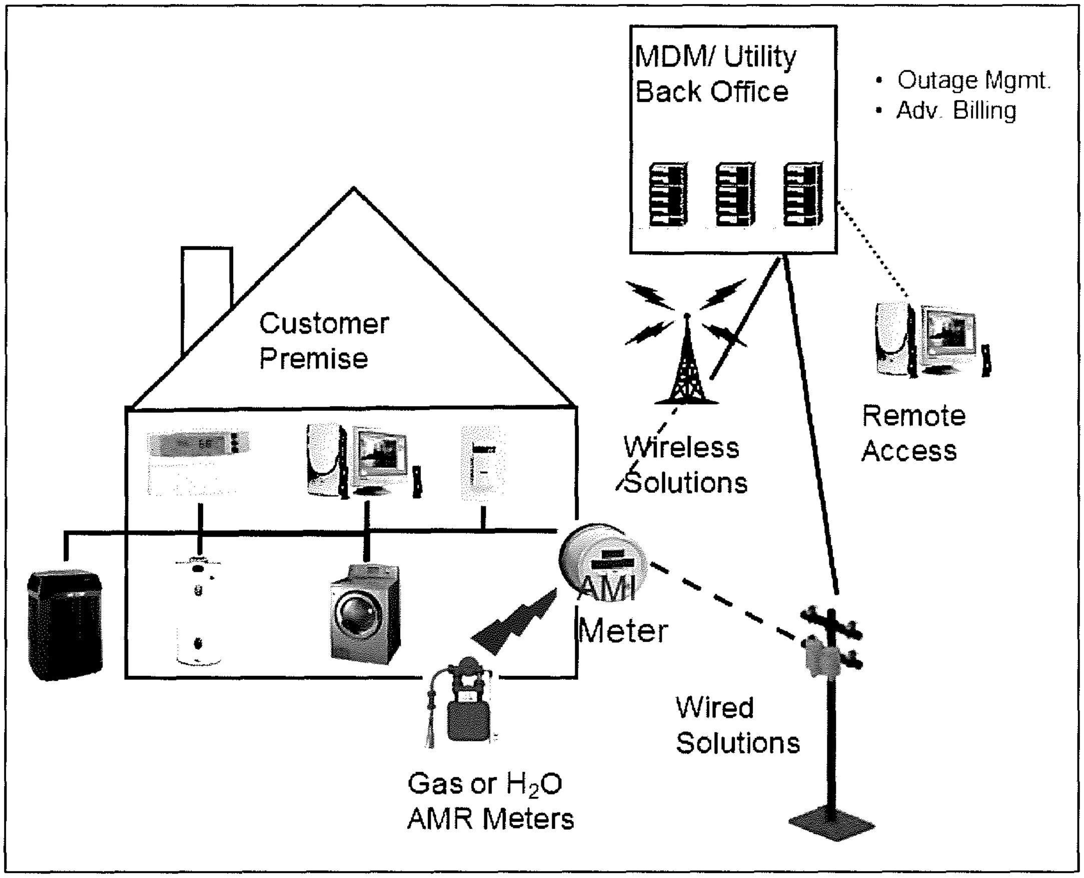

Figure 9: Typical AMI Architecture

In the RF mesh architecture, the data is routed from meter to meter via wireless until it reaches an access point. From the access point, the data is backhauled to the utility data center using fiber, cellular, or other communications method. At the utility data center, the data may be managed using a meter data management system. The meter may also communicate with in-home devices such as in-home displays, smart thermostats using either wireless technologies such as ZigBee or PLC.

There are several applications enabled by AMI. These include:

- Remote meter reading – typically meters send back 15 minute interval data about 4-6 times daily;
- Time of use billing – PTR and TOU rates are enabled because the utility receives interval usage data;
- Power quality monitoring at the meter – in addition to energy usage data, the meters can report back voltage quality. This can be used by the Distribution management system (DMS) for Volt/VAR control and for automatic reporting of power quality issues;

- Power outage detection and restoration – the meters can send outage messages which can be used by the OMS to reduce outage detection time and also potentially to more accurately identify the location of the outage; power restoration to the customer can be confirmed by pinging the meter;
- Remote connect/disconnect and rate limiting – connection and disconnection of service can be done remotely;
- Reducing non-technical losses and unaccounted for energy via tamper detection, more accurate billing, identification of dead meters, etc.;
- Direct load control and demand response – utility may send individual load control and demand response messages to customers using the 2-way AMI communication network
- Providing energy usage information to customers –daily energy usage information can be provided to the customer on a website or smart phone;
- Data analytics using the collected load data for load forecasting, contingency analysis, asset monitoring, etc.;
- Support for PEVs though TOU billing ;
- 2-way communication infrastructure to support other applications including distribution automation, demand response and DERs.

5.2.2 Distribution Automation Technologies

There may be a number of devices installed on the distribution feeders:

- Voltage regulators
- Capacitor banks
- Reclosers
- Fault Circuit Indicators (FCIs)
- Switches/Sectionalizers

Distribution automation is enabled by communications to the devices which permits alarms and other data collection from devices and allows the devices to be controlled. Among the distribution automation applications are Fault Location Isolation and Service Restoration (FLISR) and Volt/VAR control. The system can be controlled via a Distribution Management System (DMS).

5.2.3 Fault Location Isolation and Service Restoration (FLISR)

FLISR is used to improve feeder reliability. FLISR detects a fault on the feeder section based on information received from breakers, FCIs, etc., and isolates the faulted feeder section by opening switches and then restores service to the unfaulted feeder sections – potentially serving them from alternate substations. FLISR has the potential to improve reliability by reducing SAIFI, SAIDI, CAIDI, etc.

5.2.4 Volt/VAR Control

Volt/VAR control is used to reduce network losses via use of capacitor banks, maintain an optimum voltage profile along the feeder and reduce peak load through feeder voltage reduction by controlling the transformer tap positions in substations and voltage regulators on feeders.

5.2.5 Distribution Management System (DMS)

The DMS provides a graphical display of the distribution system to the operator. It can support a number of applications including:

- FLISR – fault location, isolation and service restoration – autonomous reconfiguration upon faults – results in some customers suffering momentary rather than sustained outages;
- Volt/VAR control – coordinating settings on capacitor banks, voltage regulators and transformer tap settings to reduce losses while maintaining power quality constraints;
- Load modeling and load forecasting – estimate distribution network loading and load forecasting;
- Distribution state estimation – using measured data and potentially historical load profiles
- Calculation of reliability indices such as SAIFI, SAIDI, CAIDI and MAIFI;
- Optimum feeder reconfiguration – determines the optimal feeder configuration to minimize losses;
- Contingency analysis – analyze potential switching and fault scenarios;
- Relay protection coordination.

6. Smart Meter Experience

6.1 Operational Results

In its report to the Kentucky Public Service Commission in April 2011, LG&E and KU reported that 99 percent of electric meters and 69 percent of the gas modules in its Smart Meter pilot were reporting energy usage on a regular basis. LG&E also reported that "non-reporting meters continue to be generally related to foliage issues, location of meters and occasional hardware malfunctions." [14]

LG&E also reported that it has gained "valuable insight into the operations of network infrastructure in rural areas. In particular, LG&E has learned that network performance can be improved through deployment of additional signal repeating equipment to overcome natural barriers such as foliage and distance between meters and communication gates."[15]

These insights will be valuable in any future deployments, though some of the observed issues and problems may no longer be applicable as the AMI equipment and technology has significantly matured since 2007.

6.2 Customer Engagement Results

6.2.1 Responsive Pricing Pilot Results

The RPP pilot was designed primarily to gain experience in the functionality of the AMI equipment in selected geographies in close proximity to LG&E headquarters in Louisville, as well as to gauge customers' responsiveness to different rate structures with different combinations of AMI equipment. The pilot also provided valuable initial feedback as to potential customer engagement issues.

LG&E noted the rapid emergence of new metering technologies in the marketplace, although they required additional study. Insights were also gained regarding related equipment requirements in rural areas, and the relative cost effectiveness of such investments.

[14] Responsive Pricing and Smart Metering Pilot Program Annual Report for Louisville Gas and Electric Company, April 1, 2011.
[15] Ibid

Table 6: Maximum Summer Average Load Reductions (kW) by Pilot Study Subgroup (2010)

	Maximum avg. kW reduction at hour 15:00 (2010)	Change in kWh Usage June – Sept months (2007-2010)	Total Billed Cost June-Sept (2010)
Pilot Group	0.98 kW reduction	+18 percent Year 1 -14 percent Year 2 +10 percent Year 3	$516.08 (4 months of summer bills)
Comparison Group:	0.54 Demand Conservation Participants*	n/a	$523.66
Incremental benefits	0.96-0.54 = 0.42 (44 percent more peak load reduction than DLC)	None observed	$7.58 (1.4 percent bill savings)

Source: Based on EM&V analysis conducted by Good Cents on 90 RPP and 1400 control customers.
**Comparable degree days from 2006.*

The subgroup within the pilot program participants that demonstrated the most responsiveness to the TOU and CPP price signals was the GE group, where the combination of smart appliances and the Responsive Pricing signals produced the highest reduction in demand on the system.[16]

The average monthly bill for all LG&E residential customers combined is approximately $104.75. The pilot group, located in an urban/suburban area, showed an average bill for the summer months of $129.02 per month ($516.08 divided by 4 months). Among this higher bill paying group, the savings realized were 1.4 percent of the bill. This means that on average, if all LG&E customers performed in the same manner as the pilot group in terms of responsiveness to the rate signals, they could be expected to save $1.47 per month on their summer electric bill.

Table 7: Summer 2009 Changes in Bills for Participants

Customer segment of the pilot group	percent change in electric bill
Average bill savings across all participants:	-1.40 percent
Top 11 percent saved more than:	-6.00 percent
Lowest 6.5 percent paid an increase of:	10.00 percent
17 percent were bill neutral (0 change):	0.00 percent
Percent drop-out rate *(i.e. non-participants)*:	11.00 percent

[16] April 1, 2011 report (page 15)

6.2.2 Smart Meter Customer Awareness Survey

Building upon the pilot results, and to get a wider understanding of the potential levels of interest in Smart Meter services, LG&E and KU conducted a web-based survey of a statistically valid sample of customers across the service territory, drawing from those for whom the Companies had email addresses and thus have Internet access. This survey provides additional important feedback regarding potential customer reactions to Smart Meter offerings among those who are already actively engaged in the Internet. Results of the survey are discussed in Section 7.

6.3 Experience Elsewhere

This section provides a summary of the AMI costs and operational benefits as reported by other utilities (details are provided in the Appendix D). The utilities surveyed were AEP Ohio, Duke Ohio, Ameren and NES. Results are also presented from the Smart Grid Consumer Collaborative (SGCC) report on Smart grid economic and environmental benefits which summarizes the results from a number of utilities.

6.3.1 AMI Costs

Utility	AMI Costs
AEP Ohio	$180 per customer plus yearly O&M costs
Ameren	$273 per customer over 20 years (additional costs of $376 for IT System and integration)
NES	$188 per customer plus additional yearly O&M costs
SGCC Study	$291.54 plus 4 percent yearly O&M costs

6.3.2 AMI Operational Benefits

The operational benefits presented here are primarily those related to AMI and do not include benefits due to Volt/VAR control and FLISR which would require additional investments.

Utility	AMI Operational Benefits (per customer per year)
AEP Ohio	$15.65 - $19.01
Duke Ohio	$11.05 - $14.73
Ameren	$36
NES	$35.92
SGCC	$24.50 - $46.48

6.3.3 Customer Engagement Comparative Results

Actual enrollment rates for smart meter services nationally track just above 80% for opt-out programs and just below 15% for opt-in programs. The national opt-in rate is generally in line when compared to LG&E and KU's experience with the RPP (13.5% enrollment for LG&E and KU versus 11% national average recruitment rate for opt-in smart meter programs).[17] Evidence shows, however that LG&E and KU customers have significantly lower levels of awareness and knowledge or understanding of benefits of smart meters as compared to a national survey of residential customers.

6.3.3.1 Federal Studies

There have been several Smart Meter pilot and early deployment programs that can be used as evidence of potential customer engagement. Two recent studies of projects funded by the federal government that summarize several programs are referenced here:

- US Department of Energy, Analysis of Customer Enrollment Patterns in Time-Based Rate Programs: Initial Results from the SGIG Consumer Behavior Studies (July 2013).[18]

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[17] Responsive Pricing and Smart Metering Pilot Program Annual Report for Louisville Gas and Electric Company; April 1, 2011

[18] The U.S. Department of Energy (DOE), Office of Electricity Delivery and Energy Reliability (OE), is implementing the Smart Grid Investment Grant (SGIG) program under the American Recovery and Reinvestment Act of 2009 (Recovery Act). The SGIG program involves 99 projects that are deploying smart grid technologies,

- US DOE, Voices of Experience: Insights on Smart Grid Customer Engagement (2013) [19]

The U.S. Department of Energy (DOE), Office of Electricity Delivery and Energy Reliability (OE), is implementing the Smart Grid Investment Grant (SGIG) program under the American Recovery and Reinvestment Act of 2009 (Recovery Act). The SGIG program involves 99 projects that are deploying smart grid technologies, tools, and techniques for electric transmission, distribution, advanced metering, and customer systems. DOE-OE is examining the progress, impacts, and benefits of these projects and is presenting the results on www.smartgrid.gov.

From the July 2013 report noted above, a wide range of enrollment results are in evidence: Of 19 solicitation efforts across the range of SGIG consumer behavior, sign up rates ranged from 5 percent to 28 percent for opt-in offers, and 78 percent to 87 percent retention from opt-out offers.[20] Average acceptance for opt-in programs is 11 percent.[21] These data show that actual enrollments often do not align with estimates of likely participation.

tools, and techniques for electric transmission, distribution, advanced metering, and customer systems. DOE-OE is examining the progress, impacts, and benefits of these projects and is presenting the results on www.smartgrid.gov.

[19] Prepared for the U.S. Department of Energy by National Renewable Energy laboratory under contract No. DE-AC36-08G028308, Subtask SG10.1011 in conjunction with Energetics Incorporated under contract No. GS-10F-0103J, Subtask J3806.0002.

[20] US DOE – SGIG report, page 18.

[21] US DOE - SGIG report, page iv.

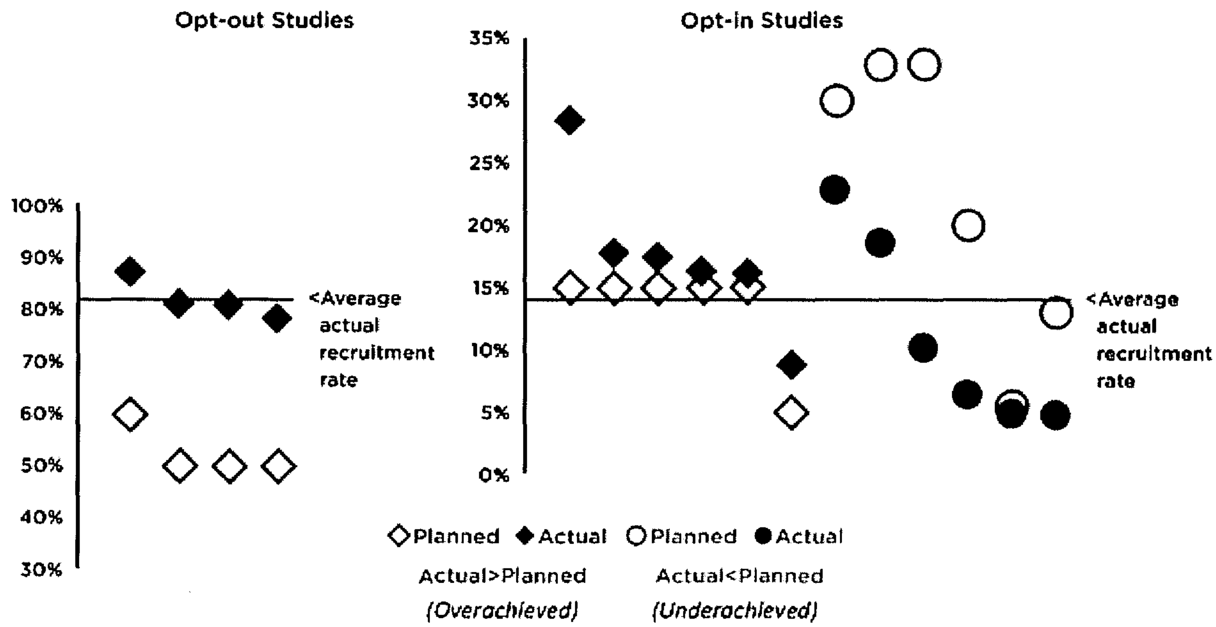


Figure 10: SGIG Enrollment Results

6.3.3.2 Utility Industry Studies

In parallel with the federal government, the utility industry has led several collaborations investigating smart grid and smart meter feasibility. Two significant ones that have involved researching customer reactions are the multi-utility Smart Grid Consumer Collaborative (SGCC) and the Electric Power Research Institute's (EPRI) Smart Grid Demonstration Initiative.[22] The website for SGCC indicates that the "Smart Grid Consumer Collaborative (SGCC), is a 501(c)(3) nonprofit with the mission of accelerating the adoption of a consumer-friendly, consumer-safe and consumer approved smart grid." It consists of membership from utilities, non-profit groups, governmental groups, technology providers, vendors and industry consultants.

DNV KEMA was interested in comparing the reactions of LG&E and KU customers on smart meter issues to customers from other areas of the country, to see how they differ. We identified a national survey on residential customer awareness of and reaction to smart meters that involved residential customer respondents from across the US, over 1000 in total.

[22] EPRI Smart Grid Demonstration Initiative, 5 Year Update (2013)

The following table compares LG&E and KU's Smart Meter survey results to those of a national survey of residential customers regarding Smart Grid awareness and interest conducted by the Smart Grid Consumer Collaborative.[23]

Table 8: SGCC Smart Grid Awareness Survey Results

SGCC National Survey Wave 3 (n=1089) (Aug – Sept 2012)	LG&E and KU Smart Meter Survey (n=496) (Dec 2011)
Consumer awareness of smart grid has remained relatively consistent over the last two years – 54% of respondents never having heard the term "smart grid", 52% never heard of "smart meters" While 52% have heard of smart meters, 19% don't know what it means	Awareness (unaided) of smart meters is very low - 73% have no knowledge of it Of the 27% who indicate awareness, 54% could not identify a benefit (no benefit or don't know)
54% of respondents who are aware of smart grid and its benefits are supportive, consistent with earlier "waves" of the survey	35% of those who are aware of smart meters could identify at least one potential benefit; Likelihood to participate, once a description was read, was 59% overall
• Both programs have lower interest in the most recent survey (Wave 4). CPP – from 63% down to 59% likely would participate TOU – from 49% down to 46% likely would participate	Likelihood to participate percentages in two rate programs comparable to the SGCC study are: CPP – 38% TOU – 43%
Conclusions from SGCC Wave 3 report: • So far, increased Smart Grid/Meter implementation nationwide has not made a meaningful difference in the Consumer Pulse findings on awareness. • These technologies continue to be off the public's radar screen to a surprising degree. • Although most of those who do know about Smart Grid tend to support it, too few understand the technology and its potential benefits.	Conclusions from LG&E and KU Smart Meter Survey: • Smart meter awareness (unaided) is low with less than one quarter of customers having heard of it. • Understanding of potential benefits is low with 65% unable to identify a benefit

[23] SGCC; Consumer Pulse and Segmentation Research, Wave 4, November 12, 2013

While the surveys for these two studies were not designed to be directly comparable, these data still reveal some very stark differences between national average attitudes and intentions regarding smart meters and those of LG&E and KU customers. Most revealing among these statistics is the difference in awareness – with a 20 percentage point difference in awareness among LG&E and KU customers (73% unaware versus 52% nationally); of those who have heard of smart meters, (27% LG&E and KU versus 43% nationally); 54% of LG&E and KU customers could not name a benefit (versus 19% nationally not understanding what it means). Finally, while Critical Peak Pricing offers are the most popular options both among the national sample and LG&E and KU customers, intended participation rates for the utility are significantly lower than nationally reported intentions – (38% LGE and KU versus 59% nationally). Intentions toward Time of Use rates are more closely aligned.

These findings illustrate the higher hurdle that LGE and KU would have to overcome to engage their residential customer sector in smart meter related programs. Indeed, the pilot RPP program spent considerably more in marketing and outreach to achieve lower actual enrollments than anticipated (28% had been planned for – 565 customers out of 2,015 with meters installed in the pilot program area; only 13.5% were actually enrolled – 274 customers out of 8,109 households were meters were installed).

6.3.3.3 Regional Utility Experience

Two companies in Kentucky received federal grant money to pursue Smart Grid projects, including pilot tests of AMI deployments. The US DOE website SmartGrid.gov provides results as of the date of this report from the various projects for which funding was received. However, neither of these companies has reports linked to the site as of the time of this report, nor were either of these two utilities highlighted in the US DOE report on enrollment patterns discussed above. We are therefore unable to obtain an update of actual enrollment status and performance results through publicly-available sources. The two projects are described below.

Duke Energy has a Smart Grid Deployment project that involves AMI and distribution automation systems in five states including Kentucky. They received federal funding for a part of this investment and have reported on results to the US DOE. The project tested customer response to time-of-use rates, peak-time rebates, and critical-peak pricing and have involved home area networks, web portals, and direct load control devices to evaluate their ability to reduce their electricity consumption and peak demand.[24] Data on Duke's program is not broken out by state, so we were unable to obtain publicly-available information as to progress in the Kentucky portion of the utility services territory.

[24] USDOE, Smart Grid Investment Grant Program, July 2012, Page b-18

The **South Kentucky Rural Electric Cooperative Corporation's** (SKRECC) opt-out project includes Smart Meters, enhanced communications infrastructure, in-home displays, and direct load control devices. The system allows customers to view their energy consumption through the customer web portal and in-home displays, among other services.[25] According to the DOE website SmartGrid.gov, the utility has 61,500 residential customers on the existing flat rate and has just over 1,500 customers in the Direct Load Control program. Time varying rates and in-home displays or other control devices are not being used at this time.[26]

[25] USDOE, Page b-46.

[26] http://www.smartgrid.gov/project/south_kentucky_rural_electric_cooperative_corporationadvanced_metering_infrastructure_deploy

7. Customer Engagement

7.1 Overview

DNV KEMA undertook a data mining analysis to uncover insights regarding customer engagement with LG&E and KU utility programs/offerings, by stitching together components from internal LG&E and KU billing/customer data, public domain ACS data, RASS data, and Residential Smart Meter data.

The objective of this analysis was to examine the variation in observed outcomes such as enrollment in opt-out programs, opt-in programs, and likelihood of participation in rate plans by potential explanatory factors such as demographics, attitudes, and other customer data such as energy usage, technology adoption etc.

In order to conduct such an analysis, we require and use disaggregated data. In lieu of individual level data, we use 5-digit zip code-level information provided to us by LG&E and KU and combine this with data from other sources such as the American Community Survey for an enriched understanding of the customer.

This section details the results of the following analyses:

- Propensity to Participate in Pricing Plan (based on Residential Smart Meter Survey data alone)
- Propensity to Participate in an Opt-in Program (based on LG&E and KU customer data and ACS data)
- Propensity to stay enrolled in an Opt-out Program (based on LG&E and KU customer data and ACS data)

Appendix B presents the detailed methodology for the background analysis. The conclusion of this analysis is that these data suggest that LG&E and KU will have a challenging chance of success in regard to customer engagement at three levels:

- Signing up for a program on an opt-in basis; or
- Staying in a program that is offered on an opt-out basis only; and
- (for either group) Actually responding to price and information signals by shifting or altering energy usage.

We describe the basis for our findings below.

Opt-In Program

The customer characteristics that most closely are associated with Opt-In behavior are:

- [Positive] education (prevalence of college education/bachelor's degree),
- [Positive] size of residence (number of bedrooms), and
- [Positive] home value (median home value of owner occupied housing units).

This means that the more educated the homeowner, the larger the number of bedrooms and the higher the home value, the more likely they are to participate in voluntary or Opt-in program offers associated with energy efficiency or demand response. It should be noted that the factors above may be confounded with other factors (also examined in our analysis) such as income, employment status, number of household members etc. The variables listed above are relatively better at capturing the variation in the outcome variable (participation in an opt-in program such as DLC) in a numeric model. They should be viewed as indicative of the types of variables that influence energy consumption and related behavior. For example, the number of bedrooms variable listed above is different from, but also related to, the square footage of the home, or the number of bathrooms, or the total number of rooms. These other variables were considered and discarded as they do not add anything more to the explanatory power of the model than the final set of variables listed above.

Opt-Out Program

The customer characteristics most closely associated with remaining in an Opt-Out program are:

- [Positive] Prevalence of owner occupied homes
- [Positive] Energy Consumption
- [Positive] Size of residence (number of bedrooms)
- [Negative] Prevalence of single member households
- [Negative] Prevalence of email (per LG&E and KU customer records)

This means that the propensity to stay enrolled in an opt-out program increases overall with an increase in the prevalence of owner occupied homes, increased energy consumption, and larger residences. On the other hand, prevalence of single member households and email are inversely related to the propensity to stay enrolled in an opt-out program.

It should be noted that these relationships are not necessarily causal. For example, perhaps email facilitates opting out easily or at any time of the day without reliance on a customer service representative during office hours. But, it could also be that one way LG&E and KU captures email addresses of customers is when they opt out of a program. It should also be noted that the relationship between the explanatory variables and the outcome is relatively weak in the analysis of opt out programs compared to the model above examining opt in programs (direct load control).

In summary, while neither the opt-in nor the opt-out model prove causation of the outcome, a predictive model for an opt-out program will require the addition of other variables to explain customer propensity to opt-out as LG&E and KU and ACS data do not suffice. We may hypothesize that other attitudinal motivators might be driving this behavior versus in the case of an opt-in like a DLC program where it might be a more straightforward desire to reduce consumption/size of bill and this is directly correlated with the size/value of the home and the amount of knowledge the consumer has about such programs..

Pricing Plan/Rate Program

From the survey research on the likelihood of participating in a rate program (like the four options presented in the Residential Smart Meter Survey) under a Smart Meter initiative, it appears that LG&E and KU could anticipate around 22 percent of customers to respond to an offering, if intentions as reported in the survey translate into enrollments. Since that is not typically the case, one could consider 22 percent to be an upper bound of potential. Almost 100 percent of those who indicate a high interest in all 4 of the rate programs (22 percent of the sample) state that they are highly motivated to make changes to their energy usage and save money with Smart Meter programs. Approximately 51 percent of this highly responsive group has smart phones (10 percent of the sample are highly responsive to rate programs and have a smart phone).

7.2 Propensity to Participate in Pricing Plans

The objective of this analysis is to explore customers' propensity to participate in pricing plans such as Time of Use (TOU), Critical Peak Pricing (CPP), Peak Time Rebates (PTR), and Inclined Block Base (IBB) as a function of explanatory variables such as customer usage, demographics, attitudes, technology adoption and other factors.

7.2.1 Data Sources

The data sources available and considered for this analysis include:

- **LG&E and KU Customer data** - Customer information summarized at the 5 digit zip code level obtained from LG&E and KU
- **RASS data** - Individual level responses to the Residential Appliance Saturation Survey (RASS) conducted amongst a sample of LG&E and KU customers
- **ACS data** - Public domain information sourced from the American Community Survey and summarized by DNV KEMA for the 5 digit zip codes that fall within its service territory

- **Residential Smart Meter Survey data** -Individual level responses to a web-based survey amongst customers in LG&E and KU service territory with email addresses on file with the Companies.

We first analyze propensity to participate in any rate offerings of a Smart Meter program using the response data base from the Residential Smart Meter Survey conducted by Bellomy Research, Inc. in 2012. Table 9 presents a summary of utility customer likelihood of participating in a Smart Meter rate offering based on a "likelihood" score created by DNV KEMA, and then by specific rate type (taken directly from the survey results).

Table 9: Percent of customers responding to Smart Meter Rate Options

	Likelihood to participate in [4,3,2,1,0] rate offerings Constructed based on responses to 4 rate types					Rate Types - % 4 or 5 on a 1-5 scale				Sample size
	Highly Likely	Somewhat likely			Highly Unlikely	Time of Use	Critical Peak Pricing	Peak Time Rebate	Inclining Block	
	4	3	2	1	None	TOU	CPP	PTR	IB	
LG&E	24%	24%	19%	17%	16%	60%	55%	71%	38%	216
KU	21%	20%	20%	20%	20%	52%	44%	70%	38%	280
Total	22%	22%	19%	18%	18%	55%	49%	70%	38%	496

Source: Residential Smart Meter Survey, Bellomy Research, Inc., 2012

It must be noted that customer intent as reported in a survey does not directly translate into action. Studies show that among those who indicate interest in a rate offering, 5-10 percent will typically actively engage.[27]

7.2.2 Geographic Analysis

The Residential Smart Meter Survey captures responses from 496 customers residing across 122 distinct zip codes. This wide-ranging survey asks respondents about their attitudes towards energy efficiency, their motivations to conserve energy and save money, the perceived benefits and disadvantages of the Smart Meter etc. The survey data received by DNV KEMA also includes merged monthly and annual (November 2010 – October 2011) actual bill information regarding electricity and natural gas usage at the

[27] EPRI Smart Grid Demonstration Project Overview and Results & Lessons Learned, October 10, 2013 presentation. http://psc.ky.gov/PSCSCF/2012%20cases/2012-00428/20131009_PSC_Memo.pdf

respondent level and demographics such as income, age, household size, education level, appliances in the home and usage habits etc.

The survey also asks respondents to indicate on a 1-5 scale, where 5 means highly likely to participate and 1 means highly unlikely to participate, their likelihood to participate in TOU, CPP, PTR and IB pricing plans.

As the best acceptable proxy measure available in any of our data sources for propensity to adopt time-differentiated rate plans, we construct a compound indicator of likelihood to adopt rate plans based on responses to all four questions on participation in pricing rate plans as follows. If the respondent is highly likely (4 or 5) to participate in all four pricing plans then they are assigned a score of 4, else if they indicate high likelihood to participate in three of the four plans they are assigned a score of 3, and so on. Respondents who do not indicate likelihood to participate in any of the four plans are assigned a score of 0. This yields 5 groups/segments of respondents of near equal size ranging from 18 percent to 22 percent with vastly different propensity to participate.

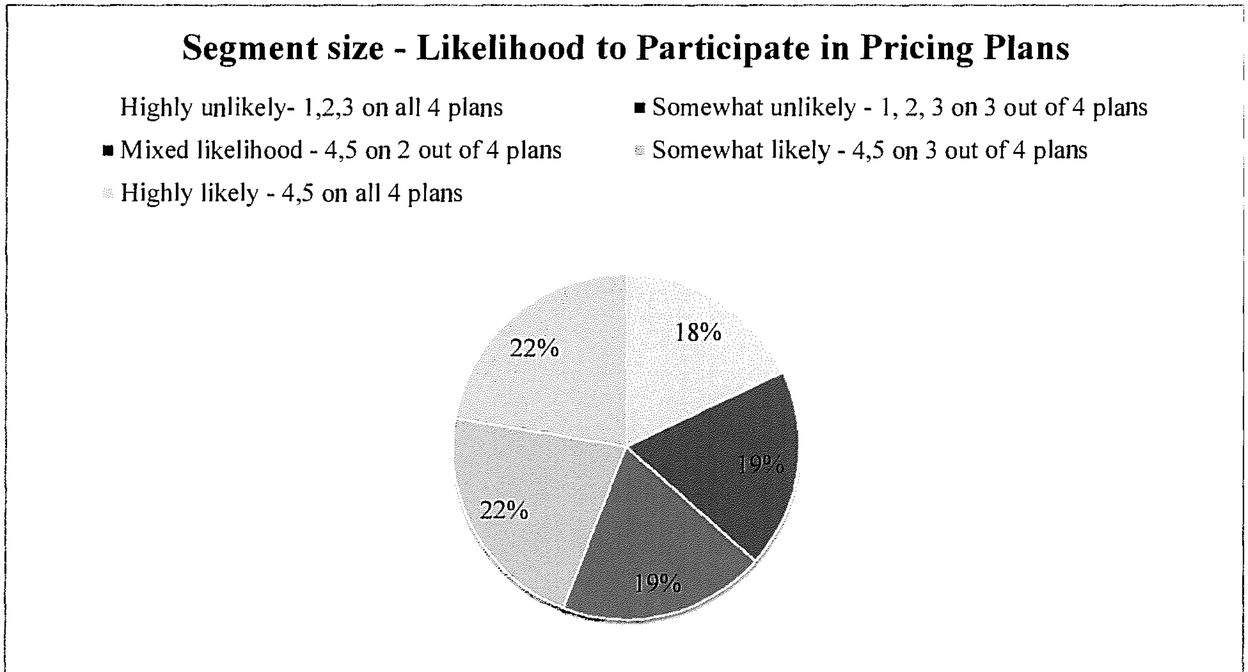


Figure 11: Likelihood to Participate in Pricing Plans - Segment size/share of total

The survey data used in this analysis has sparse data in some areas at the 5 digit zip level, with as low as a single observation from a zip code. In order to overcome this sparse data problem, we create larger geographical groupings based on the 1st 3 digits of the zip code called Sectional Center Facility or SCF, which is simply a definition we borrow from the USPS as a device in order to conduct an analysis on the geographic distribution of our propensity to participate in pricing plans segments. For example: The Louisville area is served by SCFs 400, 401, and 402. The 122 zip codes across the 496 Residential Smart Meter survey respondents may be collapsed into 17 SCFs (see Appendix C for table of groupings and the number of responses in each one). The figure below is a visual representation of the geographic distribution of propensity to participate in time-varying rate plans with Smart Meters, overlaid on the LG&E and KU territory.

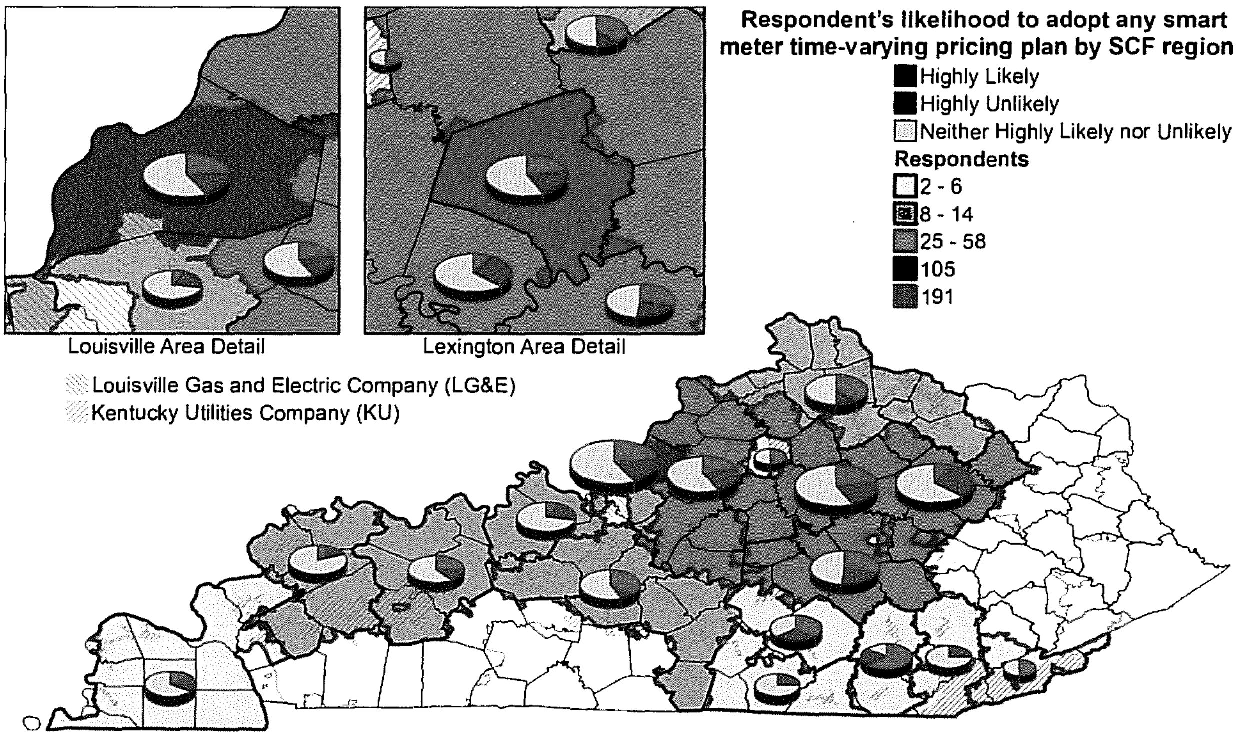


Figure 12: Geographic Distribution of Propensity to Participate in Pricing Plan Segments

While we still have low sample size for some SCFs, even after collapsing records to the SCF level, we note from the figure above that there might be some pockets of concentrated interest in these pricing plans (for example: the southeast corner on the map above).

A second map below shows the five top areas by their urban-versus-rural designation where customer participation – and therefore benefits – would be expected to be highest, according to the data. The areas generally follow I-64 and encompass the greater urban areas of Louisville, Frankfort and Lexington.

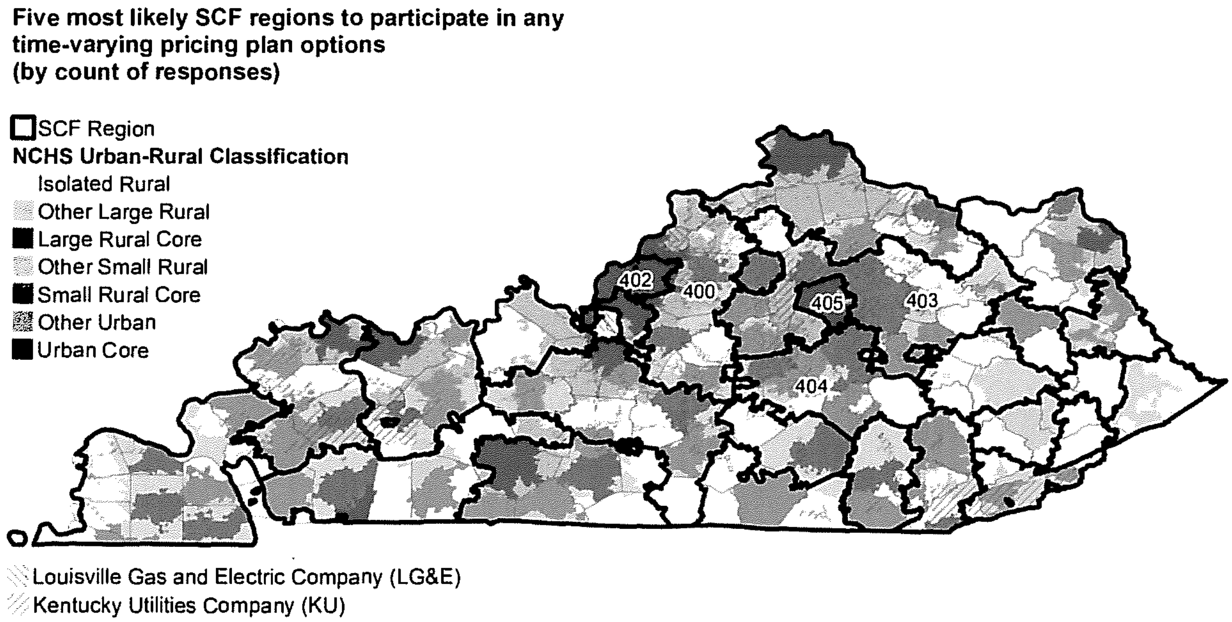


Figure 13: Top Five areas of Most Likely Customer Engagement in Time-Varying Rate programs

7.2.3 Customer Profiles

Each of these 5 segments is also profiled by utility, energy consumption, attitudes towards energy efficiency, income, age, perceived benefits and disadvantages, household size etc. We can examine these data to develop a profile or picture, if you will, of the typical customer in each likelihood group.

- **"Highly Likely" Customer Profile** – 22 percent of customers are highly likely to participate in all of the 4 pricing plans (TOU, CPP, PTR, IBB) under a Smart Meter program, as based on the survey results. The characteristics of the household that is most likely to respond favorably to a Smart Meter rate offering are relatively lower average electricity usage, higher prevalence of programmable thermostats, higher concurrence on considering themselves "green", higher agreement on having a low carbon footprint and moving towards a low carbon future. There is no (0 percent) prevalence in this segment of those who agree that Smart Meters have no benefits.
- **"Highly Unlikely" Customer Profile** - 18 percent of households surveyed are not likely to participate at all in any Smart Meter program. This household looks similar on the surface to the highly likely customers on aspects such as education with almost 60 percent of both groups possessing a college degree, cell phone ownership, smart phone ownership, and internet access but they have divergent attitudes on energy and technology. This household has relatively higher gas usage, is willing to pay for comfort, and thinks reducing usage is

unimportant in higher numbers than other segments. They consider checking devices a nuisance although they currently have the similar levels of phone and internet prevalence as other segments. Almost one in four (23 percent) agree that Smart Meters have no benefits or are not interested in Smart Meters.

- **"Somewhat likely" Customer Profile** - The majority (60 percent) of respondents to the survey indicated positive intentions toward one to three of the four rate offerings described as being part of a Smart Meter program. While these households vary considerably in terms of socio-demographics and attitudes, a composite profile can be described as follows: They lie in the middle between the "highly likely" and the "highly unlikely" with respect to their attitudes toward conserving energy, saving money, reducing their carbon footprint etc. They have the highest electricity and gas usage relative to the other two segments described above, the highest prevalence of those with income over $50,000 (66 percent for this segment versus 49 percent and 46 percent for the above two respectively), and relatively the lowest Smart Meter awareness.

7.2.4 Detailed Findings

Those who are highly likely to participate and the least likely to participate in time-varying rate plans may be described by the following characteristics:

- The highly likely segment constitutes 22 percent of those surveyed and this is approximately the size of the remaining segments along the likelihood spectrum as well. Size in descending order of likelihood is 22 percent, 22 percent, 19 percent, 19 percent, and 18 percent
- While, there is a relatively higher prevalence of KU customers (53 percent) than LG&E customers (47 percent) in the high likelihood to participate segment, their share of the highly unlikely segment is the highest of all 5 segments at 62 percent KU customers versus 38 percent LG&E customers.
- They have the lowest electricity usage (Total annual usage from November 2010 to October 2011) at 15,248 KWH versus the other segments that range from 16,620 KWH to 19,800 KWH
- They are the most likely to have a programmable thermostat (58 percent) along with the immediate next segment of likelihood (57 percent) versus the lowest likelihood segment (52 percent)
- Smart Meter awareness is relatively higher amongst the group with the lowest likelihood to adopt any of the 4 pricing plans (34 percent) than the group with the highest likelihood (27 percent)
- On average, the least likely to participate also score relatively lower (average on a 1-5 scale) on whether they consider themselves green (3.0) versus the most likely to participate (3.6).

- The least likely to participate has a high score (3.1) on willingness to pay for comfort versus the most likely to participate suggesting that this segment will not be as persuadable by the potential for savings from Smart Meter program pricing plans.
- The most likely to participate has a relatively higher score on wanting to reduce their carbon footprint (4.1) versus the least likely to participate(3.3) and moving to a low carbon future (4.1 versus 3.4 respectively)
- The least likely to participate also has a relatively higher agreement on the statement that reducing usage is unimportant than the most likely to participate (2.4 versus 1.6)
- The least likely to participate scores relatively higher than the most likely to participate on their belief that climate change is hype (2.7 versus 2.2 respectively).
- The most likely to participate concur to a higher degree that technology makes life easier (4.3) versus the least likely (3.9).
- The least likely to participate also has a relatively higher score than the most likely to participate (2.7 versus 2.1) on the statement "checking devices is a nuisance".
- Smart phone ownership, cell phone ownership and internet access have relatively comparable prevalence amongst the least likely and most likely groups (53 percent vs. 51 percent, 93 percent vs. 96 percent, 96 percent vs. 97 percent respectively) suggesting that while technology access is at the same level, attitude towards technology varies as noted in the preceding points.
- The ability to save money on Smart Meter programs motivates relatively more of those in the highly likely to participate segment (30 percent) versus those in the least likely segment (10 percent).
- A relatively higher number of the least likely to participate segment believe uncomfortable temperatures are a disadvantage due to some Smart Meter programs than those in the highly likely to participate segment (10 percent vs. 3 percent, respectively)
- Likelihood to participate in Smart Meter program pricing plans is highly correlated with the motivation to make changes and save money on Smart Meter program pricing plans. The most likely to participate segment scores relatively higher (3.9 on a compound indicator ranging from 0-4) than the least likely to participate segment which has near zero motivation (.3 average on a 0-4 scale).Propensity to participate in an Opt-in program

LG&E and KU has provided DNV KEMA with aggregated customer information at the 5 digit zip code level across 361 zip codes in its service territory on the total number of customers, total number of customers participating in a direct load control program who have demand conservation devices in their home, the total number of customers who are still enrolled in an opt-out comparative home energy report program (Smart Energy Profile), customers with email access, energy consumption in KWH, percent enrolled in bill pledge, and customers who are confirmed/likely owners versus renters.

7.3 Opt-in versus Opt-out Results

DNV KEMA modeled propensity to participate in Opt-in as well as Opt-out programs; the methodology and detailed results are provided in Appendix B. The top five variables that most closely explain Opt-in and Opt-out propensity are as follows.

Opt-in behavior is modeled from data on customers who elected to participate in the Direct Load Control program as indicative of potential Smart Meter participation. Table 10 presents the top five explanatory variables for Opt-in behavior as based on these data.

Table 10: Explanatory Variables for Opt-In Behavior as based on DLC Participation

Data Source	Label	Correlation with DLCPCT
ACS	percent Bachelor's degree	0.7
ACS	Median home value - owner occupied	0.7
ACS	percent Masters or higher	0.7
ACS	Median family income	0.6
LG&E and KU	percent with email	0.5

These results suggest that customers meeting the same profile as above would be potentially good candidates for Opt-in Smart Meter related programs.

A second analysis was done on Opt-out behavior as based on the Smart Energy Profile program participation, where all residential customers were initially enrolled, and customers wishing to be removed from the program could make that request. Table 10 presents those results with the top 5 explanatory variables and their correlations; Table 11 elaborates on those who elected to stay in the program (e.g., not opt-out). One can see that the correlation of variables is weaker here than in the analysis above.

Table 11: Top 5 Variables for Opt-In Behavior as based on SEP Participation

Data Source	Label	Correlation with percent still enrolled in an opt-out program
ACS	percent Owner occupied homes	0.3
LG&E and KU	Average electricity consumption	0.2
ACS	Median number of bedrooms (as a measure of house size)	0.2
ACS	percent Employed	0.2
ACS	Year home built	0.2

7.4 Conclusions

We hypothesize that there might be other behavioral factors related to motivation, attitudes towards/against energy efficiency etc. that might have an impact on the decision to opt-out. While we do have some of this data from the Residential Smart Meter Study and RASS surveys at the 5 digit zip level, even aggregating records up to the SCF level leaves us with sparse cells and some zips and/or SCFs with fewer than 10, and in some cases, as few as 1-5 households representing the whole zip.

We are unable to put information from all four sources of data together due to the sparse "n" that underlies the data at the 5 digit zip/SCF level for the surveys. This means that that while we can conduct inferential analysis at the total level based on survey data, analysis at a disaggregated zip or SCF level is not interpretable. For example, while the work presented in this document includes original research on the Residential Smart Meter Survey Data alone, any combined multivariate analysis has been using LG&E and KU and ACS data.

Additional primary research to gather survey data based on a representative sample of customers from each zip (or the majority of zips that LG&E and KU is interested in studying) and building upon the above work for more insight into drivers of participation in pricing plans, opt-out programs, opt-in programs might be beneficial.

8. Gap Analysis

A recent report by the Smart Meter Consumer Collaborative indicates that there are several factors that will heavily influence the potential for a successful business case for Smart Meter:

1. Customer participation levels in Time-Varying Rates, Prepayment and Customer Energy Management;
2. Utility operating characteristics pre- and post-investment, including electric energy and capacity costs;
3. The speed with which operating cost reductions can be translated into lower rates;
4. Utility regulation and governance issues and their impact on the realization of benefits, particularly treatment of lost revenues due to reduced sales volumes.

A high level gap analysis is provided in the graphic below, which indicates our conclusion of how LG&E and KU compare to these four areas of a business case strategy.

Table 12: Gap Analysis Highlights

	Current State	Gap	Fully Automated AMI/Smart Meters
Operational Conditions	At present most of the reading is done manually by a meter reader; most meter field service such as disconnect/reconnect, off cycle reads require a field visit by a technician; there is very little distribution automation or communication to the field devices.	Installation of AMI in locations of the service territory where operational conditions are such that the benefits outweigh the costs.	Use of AMI to enable meter reading automation and automation of meter field services; backend system using MDMS, OMS and DMS. Field devices enabled using distribution automation.
Customer Conditions	Customer participation in opt-in programs ranges from 1-5 percent for energy efficiency and 23 percent for DLC. Participation in opt-out programs is strong with 99 percent of original enrollees still participating	No gaps are apparent for opt-out behavior when using SEP as a proxy; however RPP pilot program results showed a drop-out rate of 60 percent (of 200 enrollees there were 80 remaining customers)[28]; Propensity to participate voluntarily shown as likely to be between 10 and 20 percent according to study results.	Achieve industry average of approximately 83 percent retention for opt-out program or 15 percent recruiting for opt-in program
Regulatory Conditions	Rules of engagement under consideration	Clarification of specific elements of cost recovery; agreement as to an evaluation plan for justifying claims results, achievement of key metrics	Cost recovery of Smart Meter investments including related ongoing maintenance, customer programs and services

[28] Responsive Pricing and Smart Meter Pilot Program Final Results for Louisville Gas and Electric Company, Case no. 2007-00117; July 1, 2011.

8.1 Operational Status and Requirements

Table 13: Operational Conditions Gap Analysis

Feature	Current State	AMI/Smart Grid
Meter reading	Current done manually and using AMR (93 percent of the meters are read manually and 7 percent using AMR)	Using AMI
Connection / Disconnection of services	Currently done manually	Using AMI
Distribution operations	SCADA at only 25 percent of the KU distribution substations but controlling 75% of load; no distribution automation or communication to field devices	SCADA to distribution substations; distribution automation and communication to field devices
Volt/VAR control	No communication to field devices	Communication to field devices; use of a DMS; Volt/VAR control to reduce energy use
Outage management	Based on customer calls	Information from outage messages from Smart Meters; sensors in the field and customer calls
Call center operations	Based on customer calls	AMI enables ping of the customer meter; knowledge of outage before customer call; ability to locate outages more quickly

9. Assessment of Costs and Benefits of AMI

This section provides an analysis of the costs and benefits of AMI. The discussion follows the three categories outlined below in Figure 16 as representative of the typical types of benefits considered in developing business cases for Smart Meter around the industry.

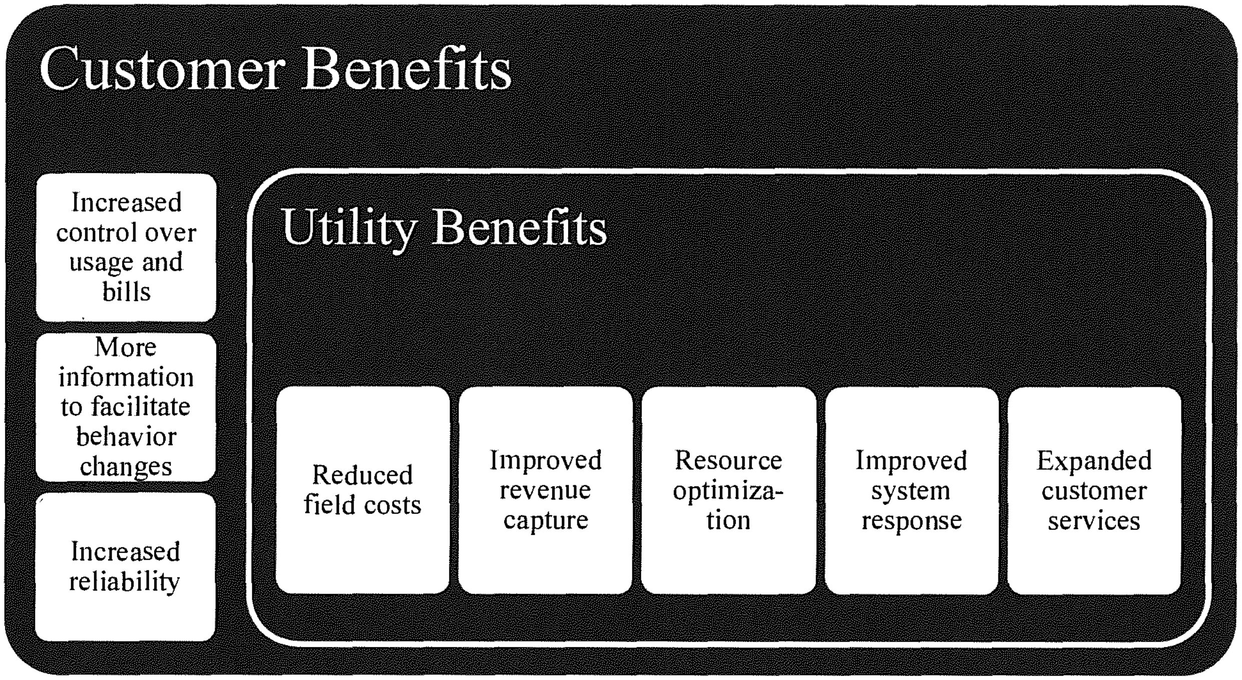


Figure 14: SG Benefit Categories

Customer benefits have not been quantified for this analysis, though several recent sources of information have been published regarding early experiences from federally funded and other pilot programs. Further, some of the customer benefits are not easily monetized (such as perceptions of increased reliability) and are the subject of ongoing research in the industry.

9.1 Utility Costs and Benefits

The AMI costs are a summary of the costs that DNV KEMA has seen in its involvement with AMI deployments and from publicly available information from other utilities on their AMI deployments. The costs we use are a summary of costs from AMI RF mesh deployments and AMI Point-to-multipoint deployments. The AMI benefits are based on discussion with different groups at LG&E and KU.

We provide a quantitative discussion of the benefits due to meter reading automation and other meter services (such as remote connect/disconnect and off-cycle reads). For the other benefits of AMI such as improved outage management, reduction in unaccounted for energy etc., we provide a qualitative discussion.

The cost-benefit analysis is based on Net Present Value (NPV) analysis. The time horizon for the business case is taken to be 20 years which is similar to the AMI business cases done by other utilities (most utilities have used either used 15 year NPV analysis or a 20 year NPV analysis – examples of several utilities are given in Appendix D). We use an escalation rate of 2.1 percent for labor and other costs (based on an average of the inflation rate for last 5 years). For the NPV analysis, a discount rate of 3.4 percent was used (based on the current 20-year Treasury bill rate).

9.2 Costs

The costs are based on deploying AMI to LG&E and KU's 945,000 electric customers. Deployment of AMI for gas meters is not considered in this report.

9.2.1 Initial Costs

The initial costs are for the deployment of meters, network infrastructure, backend systems along with associated integration and program management costs, estimated for a full deployment scenario across the LG&E and KU service areas.

Table 14: Initial Costs – Full Deployment

		Total Cost
AMI Meter	$100 - $120 per meter	$95M - $114M
Meter Installation	$20 - $35 per meter	$19M - $33M
Network Infrastructure	RF – mesh (assuming 2 repeaters and 1 collector per 1000 meters) - $7K - $12K for 1000 meters PMP – (assuming 1 base station per 4000 meters) - $10K - $15K per base station	$2.5M - $11M
Network Infrastructure installation	RF – mesh ($1500 - $2500 for 1000 meters) PMP – ($8K - $10K per base station; in addition there may be costs for leasing tower space etc.)	$1.5M - $2.5M
Head-end / MDMS	$2M – $5M	$2M - $5M
Project management / Integration / Implementation	Assuming implementation over 4 years with 15-20 FTE $3M - $6M per year	$12M - $24M
Other HW and SW costs (SAN, other backend systems etc.)	$2M - $10M	$2M - $10M
Total Initial Costs		$134M - $200M

9.2.2 Operations and Management Costs

The operations and management costs are the yearly costs for operating the system.

Table 15: Operations & Management Costs

	Cost
Backhaul Communications Cost	$0.5M - $1M per year
NOC (SaaS) and Field Maintenance of the Network	$2.5M - $5M per year
Annual SW/HW Maintenance	$1M - $2M per year
Total Per Year Cost	$4M - $8M per year

9.2.3 Total Cost

Based on a 20 year analysis, the NPV of the costs are estimated to be $204M - $340M. The NPV cost over 20 years per meter is $216 - $363.

9.3 Operational Benefits

The following operational benefits of AMI are discussed:

- Reduction in meter reading costs due to meter reading automation
- Reduction in costs from other field and metering services such as off cycle reads and meter connects and disconnects
- Reduction in unaccounted energy due to consumption on inactive meters, energy theft etc.
- Improved outage management
- Improved distribution system management
- Call center and Customer care efficiencies and improvements
- Improved support for PEVs and DERs

We provide a quantitative discussion of the benefits from meter reading automation and other meter related services. A qualitative discussion of the other operational benefits is provided.

9.3.1 Meter Reading Automation

The total expenses for meter reading per year is approximately $9.4 Million per year (this includes cost of reading electric meters, gas meters and overhead). The total reduction in meter reading costs by using AMI to read the electric meters is estimated to be $6.5M per year. Currently the meters are also physically inspected during the meter reading process. By regulation, LG&E and KU are required to physically inspect the meters every 2 years. In case AMI is implemented, this will still require a technician to visit and physically inspect the meters every 2 years. The cost of the physical inspections is estimated to be about $2M each year. Hence the net savings from AMI in reading and inspecting electric meters is estimated to be $4.5M per year. The NPV with AMI of the reduction in meter reading and inspection costs over 20 years is estimated to be $79M.

9.3.2 Field and Meter Services

AMI can be used to automate a number of currently manual field services such as off-cycle reads, meter re-reads, meter disconnects, reconnects etc.

LG&E and KU employ both company technicians and contractors to perform this work. KU has a total of 70 field technicians (42 company technicians and 28 contractor technicians). LG&E has 49 field technicians (19 company technicians and 30 contractor technicians).

The total yearly labor cost to LG&E and KU for field service technicians is $10.8M. We estimate that LG&E and KU may be able to eliminate up to 33 percent of the field and meter services costs from AMI automation (based on the assumption that manual intervention will be required for disconnections and reconnections). The NPV of this reduction in field and meter service costs may reach $62M over 20 years. In addition to these savings, there are expected to be additional cost savings from reduced vehicle maintenance and fuel charges that are not quantitatively accounted in this report.

9.3.3 Reduction in Unaccounted Energy

AMI potentially leads to a reduction in energy theft, improved tamper detection and detection of dead meters. At present LG&E and KU does not have an estimate of losses due to unaccounted energy. Last year LG&E and KU investigated about 15,000 cases of meter tampering events. About 10,000 of these meter tampering cases were eventually confirmed.

9.3.4 Improvement in Reliability

AMI meters can generate outage messages. The messages can be directed to the OMS and can lead to reduction in outage detection time. In addition, AMI can help in detecting nested outages. The dispatch center can also ping the customer's meter to determine if the power is back on.

9.3.5 Distribution System Management

AMI can provide time based loading information and voltage information from the meters. This can be used for Volt/VAR control, transformer load monitoring as well as to optimize the investments in the distribution infrastructure.

LG&E and KU is currently planning an AMI project of about 1,700 meters in the downtown Louisville area mainly to use the loading data from AMI for distribution modeling of the network.

9.3.6 Support for PHEVs, Demand Response, Distribution Automation and DERs

AMI can support PHEVs through the use of TOU rates. In addition AMI can be used to deduce loading information on distribution transformers which may be used for preventing overloading of distribution transformers.

The 2-way AMI communication network also enables communications for distribution automation devices, DERs and demand response. Additional investments in addition to AMI would be required for enabling distribution automation, demand response etc.

9.3.7 Summary of AMI Costs and Benefits

The following table summarizes the costs and the quantified operational benefits of AMI.

Table 16: High-Level Costs & Benefits

Costs and Benefits	20 year NPV	Per customer
AMI Capital and O&M costs	($204M to $340M)	$216 - $363 per customer
Meter Reading Automation benefits	$79M	$4.18 per customer per year
Field/Meter Services Automation benefits[29]	Up to $62M	Up to $3.28 per customer per year
Net Benefit	($199M) to ($63M)	

As noted previously, there are a number of other operational benefits which have been discussed qualitatively but which have not been quantified in this report. A comparison with the costs and benefits of AMI at other utilities is discussed in Appendix D.

9.4 Summary of AMI Costs and Benefits

DNV KEMA participates as a member of the Smart Meter Consumer Collaborative, a group of utilities, Smart Meter equipment vendors, energy service providers, regulatory and non-profit consumer advocates all interested in advancing research related to the impact of the Smart Meter on customers. A recent study was completed by the SGCC entitled Smart Meter Economic and Environmental Benefits: A Review and Synthesis of Research on Smart Meter Benefits and Costs (October 8, 2013). The conclusion of this study is that (page 7):

- *The Smart Meter is likely to offer economic benefits in excess of cost*
  - *Increasing electric distribution efficiency, primarily through a capability known as Integrated Volt/VAR Control*
  - *Facilitating changes in customer behavior, either by shifting usage away from high-demand periods or by reducing usage altogether. These capabilities include Time-Varying Rates, Prepayment Programs, and Customer Energy Management*

[29] Savings related to automated disconnect/reconnect for non-payment were not included in the Field/Meter Services Automation benefits because the requirements related to these activities are not fully defined.

- *Reducing operating costs from capabilities such as remote meter reading and remote service disconnect/reconnect.*
- *Improving revenue capture through improved Smart Meter accuracy and theft detection capabilities.*

- *The Smart Meter offers significant reduction in environmental impact.*
  - *Carbon Dioxide-equivalent reductions can be traced directly to Smart Meter capabilities offering a conservation effect.*
  - *To the extent customer-sited generation is predominantly renewable, Smart Meter capabilities designed to accommodate it offer even more significant environmental benefits.*[30]

[30] SGCC, Page 7.

10. Recommendations

This study indicates that full deployment of AMI at this time may not provide adequate returns or be economic for the Companies and their customers. Targeted deployments may provide benefits while limiting costs. AMI deployment can also serve as a foundation for energy efficiency, Direct Load Control and distribution improvements going forward. Based on the data available for this study, preliminary indications are that urban/suburban communities may best suited to targeted AMI conversion as they are likely to present a strong combination of operational and customer benefits.

10.1 Customer Segmentation

When planning for targeted deployments, a number of key considerations must be taken into account including the thorough testing of a discrete set of potential customer engagement strategies with additional quantitative and qualitative market research; additional surveys would improve the Companies' ability to quantify the likely levels of engagement and resulting impacts on revenues, energy savings and peak load reduction, to facilitate a more comprehensive cost-benefit analysis that includes customer components. Most importantly, such research would help identify the appropriate messages that would appeal to the high potential segments of the population.

This recommendation is consistent with this lesson learned from the US DOE SGIG study:

> "Many of the utilities found that focus groups, surveys, and other research on customer preferences were vital components for test marketing terms and concepts for convincing customers to participate in solicitation efforts. This was because the opinions of the utilities about what would be effective marketing terms frequently differed from what customers thought would be effective." (SGCC, page v).

Also, from a summary of five case studies, a meta-evaluation conducted by DEFG indicated that:

> "Utilities are investing very modestly in customer education, especially when viewed in the context of overall smart grid deployment costs. Yet the critical barrier to implementation and acceptance often appear in the courts of public opinion, which would be helped by greater media and customer understanding." [31]

[31] Wimberly, Jamie, DEFG EcoAlighn; DETech, Meta Analysis and Utility Case Studies on Smart Grid Communications; Smart Grid Communications Top Line Findings; (June 2012)

We further recommend that these market research results would allow for a customer segmentation analysis to develop more definitive estimate of the potential for customer engagement for the specific offerings selected. This research would be useful in the development of an outreach and marketing plan for proceeding with geographically targeted deployment, and a refined assessment of likely customer costs and benefits. A combination of surveys and focus groups are the likely methods that would be appropriate.

10.2 Geographic Targeting

The Companies' low cost and high reliability limit any deployments that are economic and do no justify system wide deployment at this time. From our high level review of LG&E and KU, however, it is most likely that LG&E and KU may be able to justify deployments in these areas first as the benefits are highest and the cost to deploy lowest. This study has pointed to several locations that would appear to be good candidates for Smart Meter deployment from a customer acceptance standpoint. A full geographic analysis would combine the customer acceptance results with a review of the physical features of the system where operational benefits might be highest, and conversion costs low. A combined assessment of all of these variables together would render a prioritized list of locations for consideration for staged Smart Meter deployment by the companies.

APPENDICES

Appendix A: Customer Demographics and Attitudes

The various data sources used for the residential sector analysis have different levels of granularity. For data from LG&E and KU we present data at the LG&E, KU and combined LG&E and KU levels. Data from LG&E and KU's Residential Appliance Saturation Survey includes a special section "RPP (Pilot)", which provides responses for those who participated in the Responsive Pricing Pilot.

For ACS, we have data down to the Kentucky level, while the RECS data only goes down to a regional level that includes Kentucky, Alabama and Mississippi.

High Usage Indicators

Direct monetary gains tend to be the most cited benefit in both LG&E and KU and industry studies. Fifty-one percent of respondents in the Residential Smart Meter Survey's study said they would want to see at least $25 in savings per month to be interested in implementing Smart Meter technology.[32] Actual savings were under $2 over a 4 month summer period under the RPP, indicating that the expectation as expressed in the survey would be unlikely to be realized.

The DOE's 2009 RECS data shows that single-family households use more energy on average than multi-family and mobile home households. When comparing LG&E and KU house-types to regional and national levels, LG&E and KU reported higher percentages of people living in single family homes, about 78 percent, compared with the national level of 66 percent or even the Kentucky state-level estimates of 69 percent. Five percent of respondents to LG&E and KU's Appliance Saturation Survey reported they lived in a mobile home, compared with 13 percent of Kentucky households living in a mobile home as reported in the 2011 American Community Survey.

In the United States, space heating, space cooling and water heating account for over half the household annual energy consumption.[33] However, these end uses do not always come from the same energy source.

[32] Question from Residential Smart Meters Study: "How much would you need to save on your monthly electric bill in order to change your behavior, such as adjusting your thermostat to sometimes less comfortable settings, changing the time of day you use appliances, etc.?

[33] 2009 Residential Energy Consumption Survey, US DOE, Energy Information Administration

LG&E and KU customers differ significantly in terms of energy source for space heating and water heating. The majority of LG&E customers use natural gas as their main heating fuel (74 percent), while the majority of KU customers use electricity as their main heating fuel (56 percent).

Table 17: Penetration of Electric Heating and Cooling

	Pilot (RPP)	KU	LG&E	LG&E and KU	National
	35	500	503	1038	
Electric heating, water heating & central AC	11.4 percent	**30.8 percent**	**13.5 percent**	21.8 percent	22.8 percent
Electric heat, electric water, no central AC	5.7 percent	18.2 percent	4.6 percent	11.2 percent	9.4 percent
Electric heat, central AC, no electric water	5.7 percent	2.6 percent	4.8 percent	3.8 percent	11.1 percent
Electric water, central AC, no electric heat	2.9 percent	13.6 percent	9.7 percent	11.4 percent	4.8 percent
Central AC only	71.4 percent	**24.4 percent**	**62.0 percent**	44.2 percent	22.6 percent
Electric Water heating only	0.0 percent	5.8 percent	0.4 percent	3.0 percent	4.5 percent
Electric heating only	2.9 percent	1.0 percent	0.6 percent	0.9 percent	7.7 percent
None	0.0 percent	3.6 percent	4.4 percent	3.9 percent	17.1 percent

Source: 2010 RASS, 2009 RECS

Table 17 shows about 31 percent of KU customers have electric space heating, electric water heating, and central air conditioning. The next highest proportion of customers has central air conditioning only. The majority of LG&E customers, around 62 percent, have only central air conditioning.

LG&E and KU's Direct Load Control (DLC) program allows the utility to shut off a household's central air conditioning, electric water, and/or pool pump remotely at times of system peak to help alleviate demand on the system.

Table 18 shows the percentage of households that have the listed devices. Most households had only one of the three, with KU customers being more likely to have two of the three items; this is largely due to the higher penetration of electric water heating in the KU service territory. While KU customers are more likely to have two items that can be controlled, a lower proportion of KU customers are enrolled in the DLC and/or other Demand Response Programs; fifteen percent of KU customers are enrolled in DLC or a demand response program, compared with 23 percent of LG&E customers. See Figure 15 below for a geographical display of DLC participation to date.

Table 18: Direct Load Control

	Pilot (RPP)	KU	LG&E	LG&E and KU
	35	500	503	1038
None	2.9 percent	4.4 percent	5.0 percent	4.6 percent
One of three	82.9 percent	48.4 percent	66.6 percent	58.4 percent
Two of three	11.4 percent	45.2 percent	26.2 percent	34.9 percent
All three	2.9 percent	2.0 percent	2.2 percent	2.1 percent

Source: 2009 Residential Energy Consumption Survey, DOE, Energy Information Administration

Between the two companies, LG&E customers have both a greater saturation of central AC systems (62 percent versus 24 percent for KU) and at least one of the three primary controllable appliances (66 percent), whereas KU customers are more likely to have two of the three controllable appliances than LG&E customers (45 percent versus 26 percent).

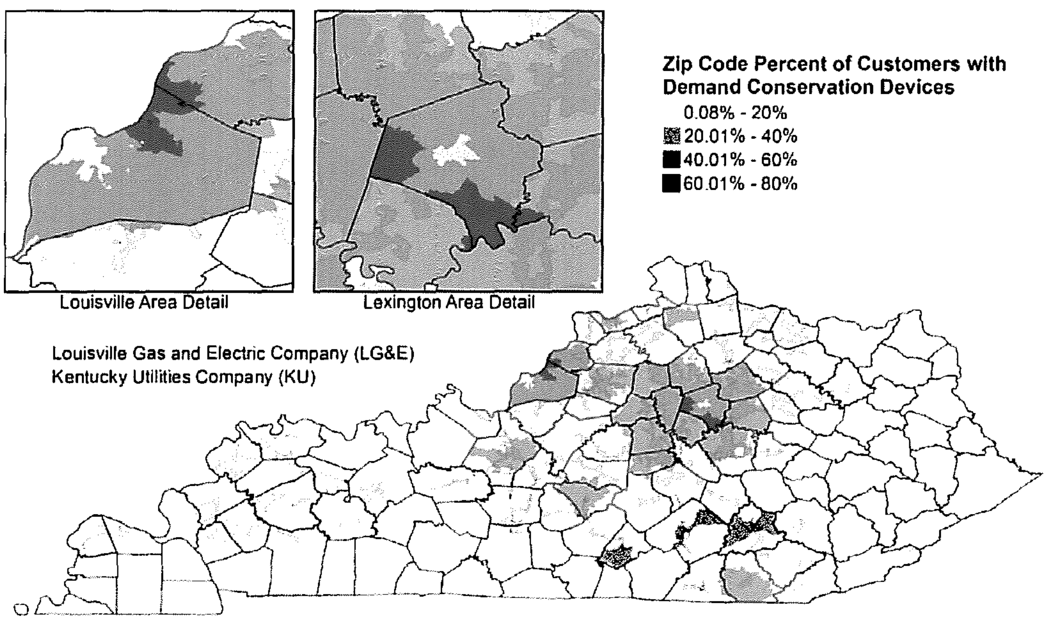


Figure 15: Direct Load Control Participation by Zip Code

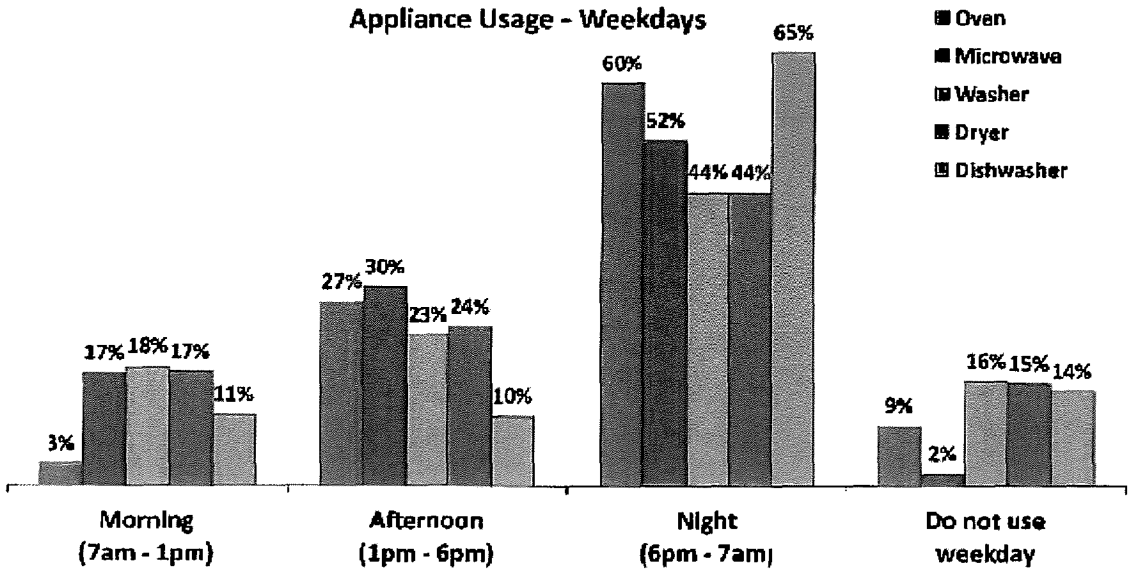
Other appliances with high energy usage include refrigerators, standalone freezers, clothes dryers, and dishwashers. Most homes have at least one refrigerator, but it is less common for homes to have a separate freezer, dishwasher and/or clothes dryer. However, these units can all be high energy users. Table 19 shows the frequency of households with one or more of these appliances. There is generally little difference between the saturation of most of these appliances in LG&E versus KU service territories.

Table 19: Energy Intensive Appliances

	Pilot (RPP)	KU	LG&E	LG&E and KU	National
All three	17.1 percent	27.2 percent	23.5 percent	25.1 percent	20.6 percent
Electric dryer and dishwasher	68.6 percent	35.0 percent	37.5 percent	37.3 percent	33.9 percent
Electric dryer and freezer	0.0 percent	11.9 percent	5.6 percent	8.5 percent	8.2 percent
Freezer and dishwasher	2.9 percent	1.1 percent	5.0 percent	3.1 percent	0.3 percent
Electric dyer only	0.0 percent	14.7 percent	9.7 percent	11.8 percent	16.7 percent
Dishwasher only	5.7 percent	4.0 percent	8.2 percent	6.1 percent	4.6 percent
Freezer only	0.0 percent	2.5 percent	2.9 percent	2.6 percent	1.3 percent
None	2.9 percent	2.9 percent	4.5 percent	3.6 percent	14.4 percent

Source: 2009 RECS, 2010 RASS

According to the survey conducted by Residential Smart Meter Survey, the majority of households most often use their appliances during the 6pm to 7am window, with the next highest usage section being during the 1pm to 6pm window. Peak usage generally occurs during the 1-6pm event window, but some may continue past 6pm. Therefore, future survey research might break these usage windows into smaller periods, especially in the evening since 6pm-9pm usage affects a utility's energy planning more than 9pm to 7am.



Source: Figure from Bellomy, Residential Smart Meter Survey; 2012 Presentation on Results

Figure 16: Appliance Usage

High penetration rates for energy-intensive appliances, combined with KU's high electric space and water heating penetration, show a slightly heavier reliance on electricity in the KU region.

Customer Relationship with Energy Usage

A potential barrier to a successful Smart Meter program is whether a customer cares enough about reducing energy or shifting usage based on TOU rates or other incentives to alter their behavior. This is especially true in regions with lower electricity rates. This section examines indicators of customer investment in modifying the cost of their energy bill.

Having electricity bills included in the rent reduces a household's investment in energy usage and makes it difficult for those who do want to alter their consumption patterns to know how they are doing. About five percent of US households have a portion of their entire electricity bill included in their rent. Only 1 percent of households in the Kentucky, Alabama and Mississippi region have electricity costs included in their rent. Table 20 shows that there is a lower percentage of households that rent in Kentucky compared to the national average. While renters often pay their own energy bills, renters still present a challenge for utility programs as they often need permission from landlords before enrolling in programs or purchasing new equipment.

Table 20: Home Ownership

	Kentucky	Regional	National
Own Home	68.9 percent	68.7 percent	64.6 percent
Rent Home	31.1 percent	31.3 percent	35.4 percent

Source: 2011 American Community Survey, Selected Housing Characteristics

Despite having lower rates of electricity than most other states, the average annual electricity bill in the Kentucky, Alabama and Mississippi region is higher than the national average due to higher usage levels. The average household in the Kentucky, Alabama and Mississippi region use almost 4,000 kWh more per year than the US average household. Even so, LG&E and KU customers have lower average annual electric bills than the average bills in either the region, the neighboring states or nationally as shown below in Table 21.

Table 21: Electric Usage and Bill - Distribution

					National	
					USD	kWh
Average	$1,257	15,488	$1,586	15,236	$1,340	11,320
Minimum	n/a	n/a	$57	685	$0	17
25 percent		n/a	$966	9,745	$733	5,812
50 percent (Median)		n/a	$1,461	14,656	$1,151	9,687
75 percent		n/a	$2,136	19,187	$1,719	14,895
Maximum		n/a	$5,214	48,926	$19,040	150,254

Source: Column 1 – LG&E and KU customer data; other Columns - 2009 Residential Energy Consumption Survey

Table 22 below shows the detail of average bills and consumption by separate Companies.

Table 22: Average Customer Bills and Usage

	Average of bills	Average of kWhs
KU	$ 1,277	15,776
LG&E	$ 1,154	13,895
LG&E and KU combined average	$ 1,257	15,488
Source: LG&E and KU customer data, un-weighted by # of customers in each zip		

Customer demographics related to Smart Meter engagement

Local research done after the pilot in 2011 indicates that the households most interested in Smart Meters tend to have higher levels of education, higher income, and are more technologically driven than the average household. [34] The Residential Smart Meter Survey found that customers who agree with the statement "Technology makes my life easier" had a higher likelihood of participating in a Smart Meter program.[35] This survey also suggested that among the respondent pool, younger people tend to be more interested in Smart Meter programs; however it must be noted that since the survey was limited to customers with known email accounts and who were able to complete the survey on-line, the results are most likely skewed to a younger respondent pool than the general customer population. Other research has indicated higher levels of interest in Smart Meter programs among the older population.[36]

The Kentucky, Alabama and Mississippi Region tend to have an older population compared with the National statistics. The percentage of people with at least a high school degree is on par with the regional and national stage, though Kentucky and the South Central Region do have a somewhat lower percentage of those with a Bachelor's Degree or higher (21 percent in Kentucky) compared with the National average of 29 percent.

Table 23: Head of Household - Age

	Kentucky, Alabama, Mississippi	National
16 to 44	29.5 percent	39.4 percent
45 to 64	43.6 percent	39.4 percent
65 and older	26.9 percent	21.2 percent

Source: 2009 Residential Energy Consumption Survey

[34] LG&E 2009 Smart Rate Program Assessment, Executive Summary Report; Bellomy Research, Residential Smart Meter Survey

[35] Other statements that correlated with higher likelihood of participating in a Smart Meter program across different segments of the LG&E and KU populations included "Reducing Carbon Footprint", "Low carbon energy is future", "Consider myself green", "Look for Energy Star Ratings".

[36] LG&E 2009 Smart Rate Program Assessment, Executive Summary Report

Table 24: Head of Household - Education

	Kentucky	Regional	National
Percent high school graduate or higher	83.1 percent	83.1 percent	85.9 percent
Percent Bachelor's degree or higher	21.1 percent	22.1 percent	28.5 percent

Source: 2011 American Community Survey, Selected Social Characteristics in the United States

Demographics that negatively affect Smart Meter engagement

Even if households have a desire to reduce energy and participate in a responsive pricing program, several factors negatively affect some households' ability to participate. Usually, this stems from the household not being able to shift energy use to other periods due to someone being home during the day (retirees, unemployed, young children) or people being sensitive to temperature changes (elderly and children), or those who require electricity for a medical reason.

Being home during the day both reduces desire to set back the thermostat and increases likelihood of appliance use during peak periods. Table 25 shows the percentage of households in the United States that have at least one child under 18, at least one person aged 60 or over, and single-resident households, where the person is 65 or over. The ten percent of households that have an elderly person living alone represent both people who are likely to be home during the day and those who are likely to be sensitive to temperature changes.

Table 25: Households and Families

	Kentucky	Regional (AL, KY, MS)	National
Children (under 18)	31.8 percent	32.0 percent	32.4 percent
Elderly (60 and over)	35.4 percent	36.1 percent	35.6 percent
Elderly (65+) living alone	10.2 percent	10.1 percent	9.9 percent

Source: 2012 American Community Survey, Households and Families

Kentucky, Alabama and Mississippi have a higher percentage of people who are unemployed and/or retired than other regions of the US. This could indicate more people are home during peak energy usage hours, potentially leading to increased difficulty in getting people to change their habits.

Table 26: Unemployment

	Regional (AL, KY, MS)	National
Not employed/retired	50.6 percent	39.5 percent
Works Part-time	6.8 percent	10.8 percent
Works Full-time	42.6 percent	49.7 percent

Source: 2009 Residential Energy Consumption Survey

Ability to get updates and change behavior quickly is another factor in responsiveness, especially for Smart Meter pricing that includes critical peak times. Having access to a cell phone, especially a smart phone which may be connected to a thermostat or even some smart appliances, could impact the ability for households to comply with critical peak reductions. Ninety-six percent of respondents to the Residential Smart Meter Survey owned a smart phone, with penetration at 99 percent for those 18-44 and 90 percent for those over 65. The differences in age are more apparent when it comes to smart phone ownership, with 80 percent of respondents ages 18-44 having a smart phone compared with 55 percent for those ages 45-64 and 36 percent for those 65 and older.

Current Knowledge and Opinions on Smart Meter

Research on the Smart Meter Pilot and the Residential Smart Meter Survey provide information on current knowledge and opinions about Smart Meter. While higher response rates from younger, more educated and technologically able populations may overstate the desire for Smart Meter, the information can still provide insight into what some of the main benefits and problems are with this new technology. Of those that responded to the Residential Smart Meter Survey:

- Twenty-seven percent reported being aware of Smart Meters. This varied both by age and income with younger and lower-income households being less likely to be aware of Smart Meters.
- When those who were aware of Smart Meters were asked about the advantages and disadvantages of Smart Meters, many people could not provide a response. Forty-six percent said they did not know of any advantages and fifty-nine percent said they did not know of any disadvantages.
- Advantages listed by at least five percent of the respondents included: ability to track electricity usage, conserve energy, save money, rate plans based on electricity usage. About eight percent said there were no benefits of Smart Meters.

- Disadvantages included loss of control, inaccurate/possibility of malfunction, uncomfortable temperature and lack of privacy. About 5 percent said there were no disadvantages of Smart Meters.

After being asked what they knew about Smart Meters, respondents received a definition of what a Smart Meter was and a description of what a Smart Meter program entailed. After hearing this description, 59 percent of respondents reported they would be likely to participate in a Smart Meter program, with 24 percent saying they would be unlikely to participate and 16 percent being neutral.

The survey then delved into specific types of Smart Meter programs: time of use, critical peak pricing, peak time rebate, and inclining block. The Residential Smart Meter Survey developed a 'take rate', which combined the ratings for the likelihood of participating, the ease of understanding, the ease of making usage changes and the motivation to lower usage/save money for each rate option (see Table 27).

Their analysis concluded that among the respondents, the peak time rebate was most favorable, followed by the time of use rate plan. However, other studies conducted on the effect of participation in Smart Meter programs found there was no statistically significant difference between the uptake on different pricing programs.[37]

Table 27: Residential Smart Meter Survey 'Take Rates'

	Time of Use (A)	Critical Peak (B)	Peak Time Rebate (C)	Inclining Block (D)
Likelihood to Participate (T2B)	55.2%^{BD}	48.6%^{D}	70.4%^{ABD}	37.9%
Ease of Understanding (T2B)	76.4%^{BD}	72.0%^{D}	74.2%^{D}	60.5%
Ease of Making Usage Changes (T2B)	52.8%^{BD}	48.2%^{D}	64.1%^{ABD}	36.5%
Motivation to Lower Usage/Save Money (T2B)	59.1%^{BD}	54.0%^{D}	72.4%^{ABD}	43.4%
Take Rate*	42.9%^{BD}	37.7%^{D}	55.0%^{ABD}	25.4%

Source: Bellomy Research, Residential Smart Meters Study (2012)

[37] Annika Todd, Peter Cappers, Charles Goldman. "Residential Customer Enrollment in Time-based Rate and Enabling Technology Programs". Smart Meter Investment Grant: Consumer Behavior Study Analysis. http://emp.lbl.gov/research-areas/demand-response-smart-grid

It must be noted that self-reported intentions to participate in programs does not equal actual action on the part of customers, thus these figures represent a top of range estimate of the potential population for program offerings.

Current Participation in Energy Efficiency and Energy Conservation Programs

LG&E and KU already have many energy efficiency and Energy Conservation Programs. This information provides evidence of the propensity of LG&E and KU customers to take advantage of services related to energy use and costs similar to what might be offered as part of a Smart Meter strategy. Table 28 shows the enrollment percentages across LG&E and KU for all programs. It also includes whether the program was opt-in (where customers voluntarily chose to participate) or opt-out (where customers are automatically enrolled but can elect to drop out if they wish). A recent study published by Lawrence Berkeley National Labs shows more customers enroll in a time-based rate program when the program is opt-out rather than opt-in.[38]

LG&E and KU did not have a similar opt-in versus opt-out approach during the Smart Meter pilot. However, one can examine the difference in rates LG&E and KU's energy programs to see in general how LG&E and KU customers respond to opt-in versus opt-out programs. The Smart Energy Profile, which was initially launched with an enrollment of 332,998 residential customers has only had 1,174 people opt-out to date (<0.5 percent). In comparison, the program with the next highest enrollment is the Demand Conservation Devices, which has 23 percent enrollment. As the Smart Energy Profile, run by OPower, only provides a report on the household's energy use and ways the household could reduce energy, it is not comparable to a Smart Meter program which incorporates changes in billing that could negatively affect households that do not change behavior.

[38] Annika Todd, Peter Cappers, Charles Goldman. "Residential Customer Enrollment in Time-based Rate and Enabling Technology Programs". Smart Meter Investment Grant: Consumer Behavior Study Analysis. http://emp.lbl.gov/research-areas/demand-response-smart-grid

Table 28: Enrollment in LG&E and KU Energy Programs

	No. of LG&E and KU customers participating as of 9/11/2013	percent of All residential customers	Opt-in/Opt-out
Smart Energy Profile	331,824	99 percent of original enrollees (42 percent of all residential)[39]	Opt-out
Demand Conservation Devices (Direct Load Control or DLC)	181,689	23 percent	Opt-in
Home Energy Rebates	37,450	5 percent	Opt-in
On-Site Home Energy Analysis	15,294	2 percent	Opt-in
Online Home Energy Analysis	13,382	2 percent	Opt-in
We Care	13,101	2 percent	Opt-in
Fridge & Freezer Recycling	9,709	1 percent	Opt-in
Energy Saving New Homes	4,161	1 percent	Opt-in
On-Site Home Energy Analysis Incentive (Tiers 2 & 3)	178	<1 percent	Opt-in

[39] The Smart Energy Profile targets the highest consuming residential customers.

Appendix B: Model Descriptions: Propensity to Participate

This section describes the modeling that was conducted as the basis for the propensity to participate findings.

Model – LG&E and KU data alone

Customers who have demand conservation devices for direct load control are participants who have opted-in to the program. The objective of this analysis is to model the propensity to participate in an opt-in program as a function of other customer information available to us at the zip code level. We compute the percent opted in to a direct load control program (DLCPCT) as the ratio of the total number of households with demand conservation devices to the total number of customers in that zip code. Figure 17 below shows the distribution of the dependent variable, DLCPCT.

While we use this ratio as the best available approximation of participation for our model, we acknowledge that the degree of participation at the 5 digit zip level could be over stated/under stated due the following reasons and may be refined by using the more precise number of eligible households in the denominator:

1. LG&E and KU does not serve every customer in every zip code
2. Not all LG&E and KU customers are eligible for DLC (among other criteria, participation in a DLC program requires households that have central air conditioners)

Figure 14 below displays the distribution of the dependent variable, DLCPCT, and reveals that over 70 percent of the 5 digit zips in LG&E and KU territory have less than 20 percent participation in DLC programs.

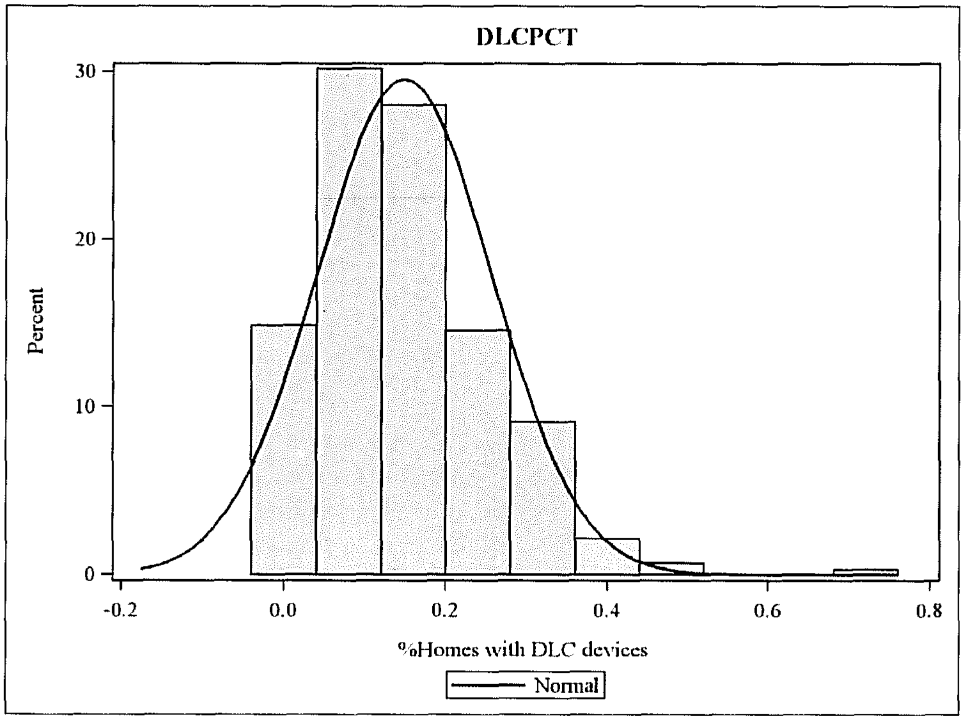


Figure 17: Percent of homes with DLC devices at the 5 digit zip level

Due to missing data on some variables, we are able to use data for 281 zip codes out of 361 records in total. The first step prior to model building is to examine the correlations of all potential explanatory variables with the dependent variable.

Table 29: Correlation of explanatory variables with DLCPCT (percent of homes with demand conservation devices/direct load control)

Data Source	Label	Correlation with DLCPCT
ACS	percent Bachelor's degree	0.7
ACS	Median home value - owner occupied	0.7
ACS	percent Masters or higher	0.7
ACS	Median family income	0.6
LG&E	percent with email	0.5
ACS	Median non-family income	0.5
LG&E	percent Confirmed owner	0.5
ACS	Median number of rooms	0.4
ACS	percent Some college	0.3
ACS	percent Employed	0.2
ACS	Median number of bedrooms	0.1
ACS	percent Household size =1	0.1
LG&E	Average electricity consumption	0.1
ACS	percent Household size =2	0.1
ACS	Year home built	-0.1
ACS	percent Household size >=4	-0.1
ACS	percent Household size =3	-0.1
ACS	percent Owner occupied homes	-0.1
LG&E	percent Bill Pledge	-0.3
ACS	percent Not in labor force	-0.5
ACS	percent High school or equivalent	-0.7

A basic model with LG&E and KU data alone and explanatory variables on home ownership, percent of customers with email (contact info per LG&E and KU), average electricity usage, percent bill pledge yields a model with an Adjusted R squared fit statistic of 0.30. While all the above explanatory variables are significant predictors of propensity to participate in an opt-in program (DLCPCT), the fit statistic of 0.30 indicates that the behavior of the dependent variable is not captured to a significant extent with just the above set of variables.

Model – LG&E and KU and ACS data combined

DNV KEMA compiled publicly available demographic data from the ACS at the 5 digit zip code level for the list of zip codes as in the customer data file obtained from LG&E and KU. Variables selected for inclusion in our ACS data are: household size as a prevalence percentage by various sizes, employment status, level of education as a prevalence percentage by various levels of attainment, number of rooms in the household, age of residential structure, number of bedrooms, and value of the home. We note here that the summary statistic available in the ACS data on family income, value of home, and age of structure is the median.

Our next model uses the same dependent (DLCPCT), but information from the ACS data used as the explanatory variables. Another version of this model merges the LG&E and KU provided customer information to ACS data to create an enriched record of explanatory variables. These two models (ACS data alone and ACS combined with LG&E and KU) are significant with an Adjusted R squared fit statistic of 0.60 and 0.62 respectively. This is an improvement compared to the model in Step 1 which relied solely on customer data available to LG&E and KU. While this is still not capturing all of the variation/behavior in the dependent variable, we are capturing a significant portion of it. The small difference in fit statistics (0.60 vs 0.62) from using ACS data alone in the 1st model to using both LG&E and KU and ACS data in the 2nd model could be due to the fact that some of the explanatory variables might be correlated and hence due to collinearity, the incremental lift going from a model based solely on ACS data to one based on both ACS and LG&E and KU data is small.

While we already have the actual percent enrolled in a DLC opt-in program, the objective of building a model based on zip level data is to understand the key drivers of this variable in terms of demographics and other energy usage characteristics. This model shows that we are able to do this with a fit of 0.6, indicating again that while we have captured the majority of the variation, it may be improved with the addition of additional variables on customer behavior, attitudes, and needs. In this form, DNV KEMA can share with LG&E and KU the model parameters (akin to a scoring function) to be applied to individual or some aggregated level of customers to assess their propensity to adopt. Given the data at hand, the fit of the model is at 0.6.

Some further refinements to the model building procedure such as excluding outliers (we have used all the data points in this model) and dropping variables that are collinear with other explanatory variables could contribute to an improved fit.

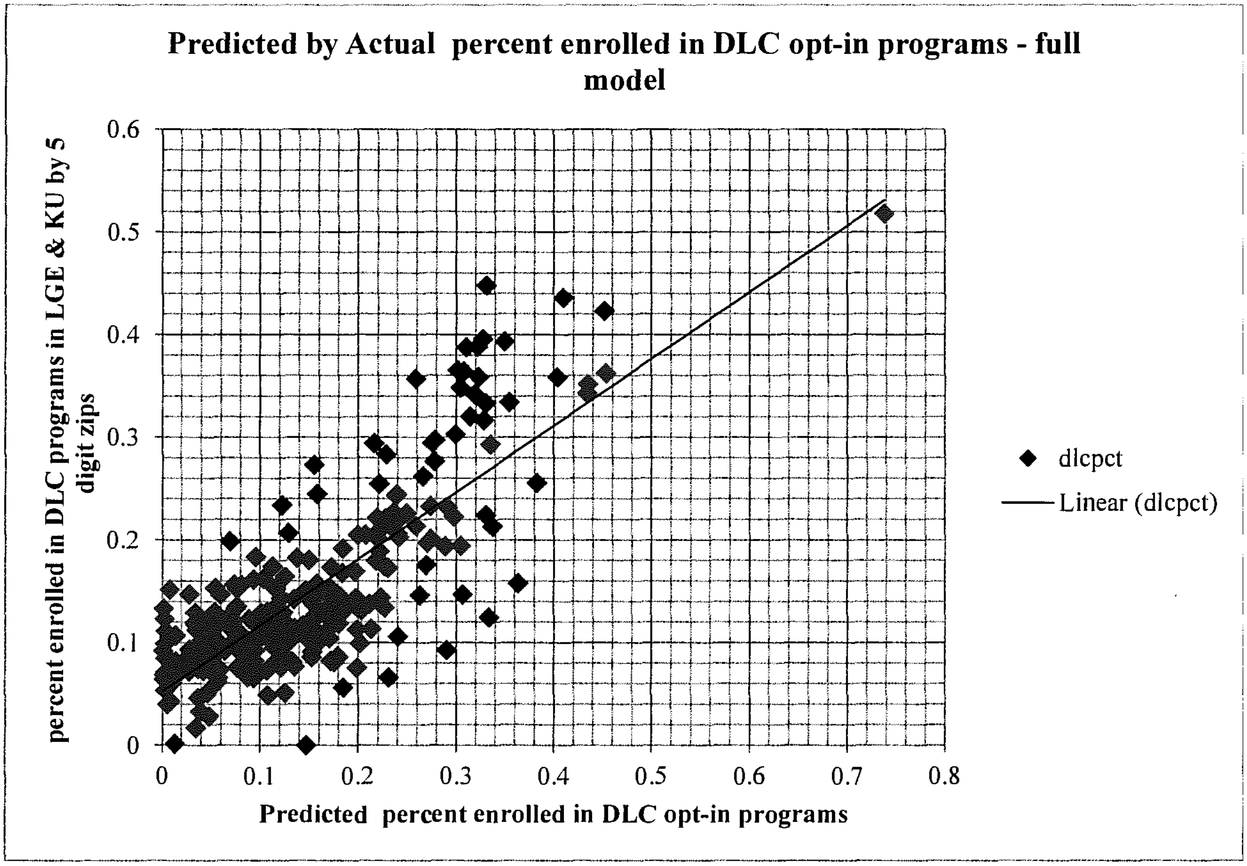


Figure 18: Plot of Predicted by Actual percent enrolled in DLC opt-in programs (model based on LG&E and KU and ACS data) – Adj Rsq=.62

Fit is increased further to an Adj R-sq of 0.85 with a minimum model that excludes collinear variables and retains only the three predictors listed below:

- Education - percent Bachelor's degree
- Median number of bedrooms
- Median home value of owner occupied housing units

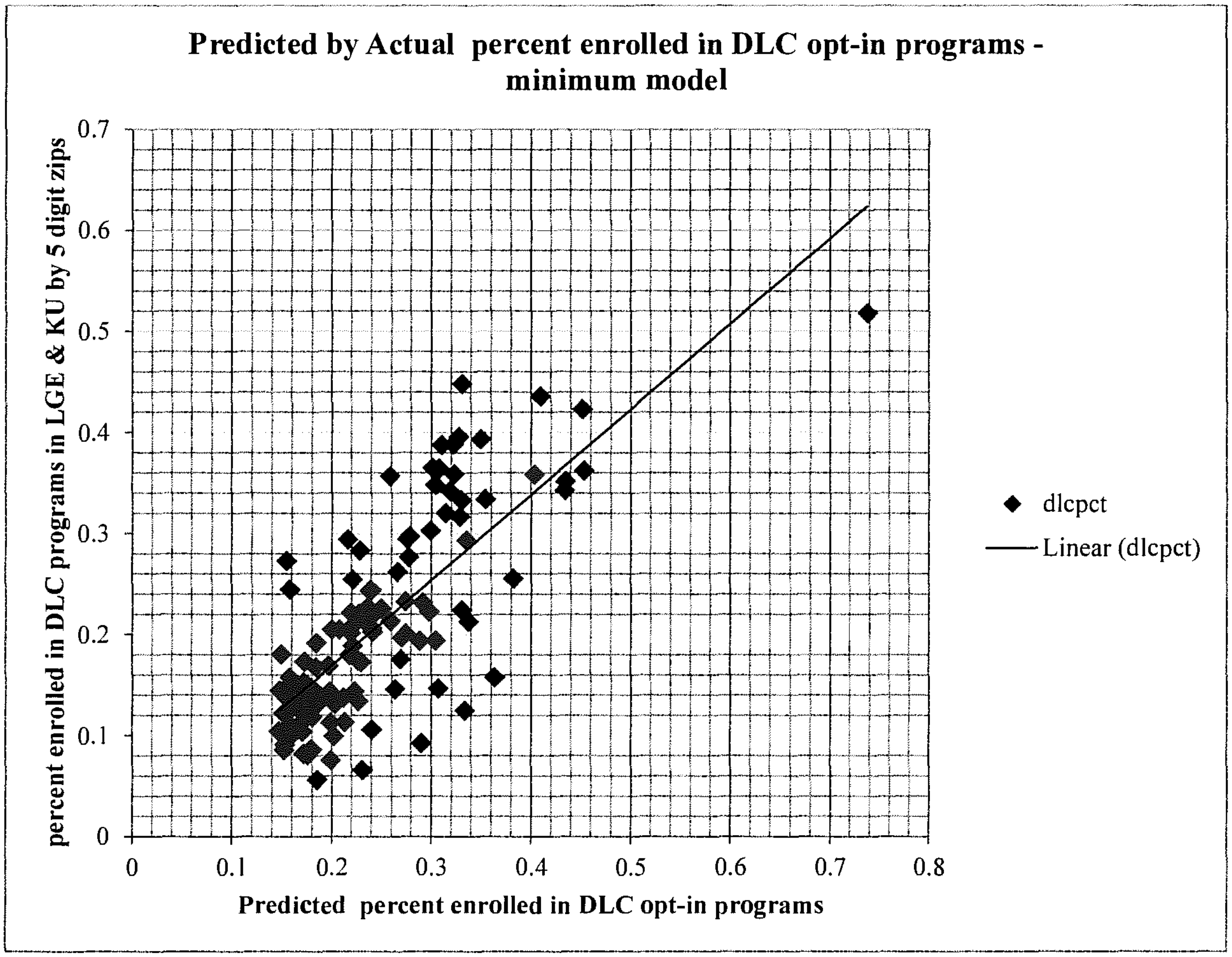


Figure 19: Plot of Predicted by Actual percent enrolled in DLC opt-in programs (model based on LG&E and KU and ACS data) – Adj Rsq=.85

Potential Participation (Stay Enrolled) in Opt Out Programs

LG&E and KU has provided DNV KEMA with aggregated customer information at the 5 digit zip code level across 361 zip codes in its service territory on the total number of customers, total number of customers participating in a direct load control program who have demand conservation devices in their home, the total number of customers who stay enrolled in an opt-out comparative home energy report program (Smart Energy Profile), customers with email access, energy consumption in KWH, percent enrolled in bill pledge, and customers who are confirmed/likely owners versus renters.

Model – LG&E and KU data alone

The objective of this analysis is to model the propensity to participate in an opt-out program as a function of other customer information available to us at the zip code level. We compute the percent who stay enrolled in an opt out program (OPTOUTSTILLIN) as the ratio of the total number of households currently enrolled/subscribed to Smart Energy Profile to the total number of customers in that zip code. Figure 3 below shows the distribution of the dependent variable, OPTOUTSTILLIN.

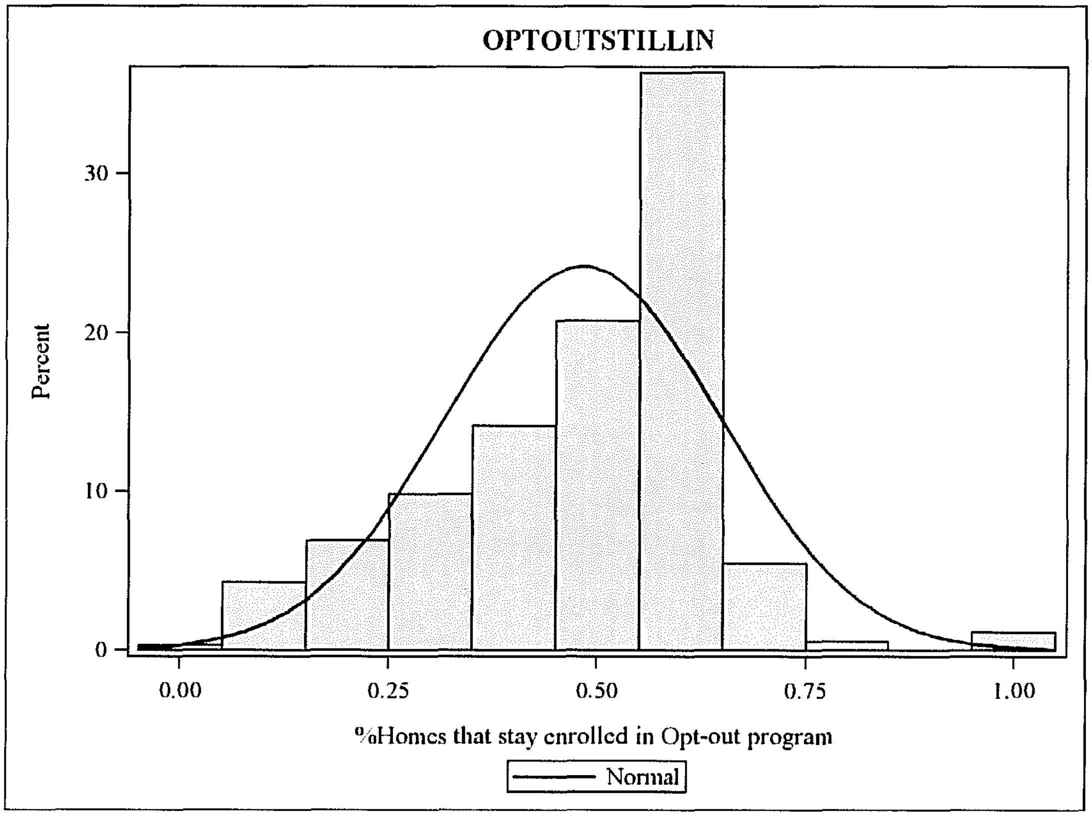


Figure 20: Distribution of percentage of homes that stay enrolled in an Opt-out Program

The table below displays correlations of all potential explanatory variables with the dependent variable OPTOUTSTILLIN (the percentage of homes, at the 5 digit zip code level, that are still enrolled in an opt-out program). While the explanatory variables had high correlations ranging from 0.7 to -0.7 in the case of DLCPCT (the percentage of homes with direct load control devices), we see that the relationship is much weaker in the case of OPTOUTSTILLIN (the percentage of homes that stay enrolled in an opt-out program) with correlations that range from 0.3 to -0.2.

Table 30: Correlation of explanatory variables with OPTOUTSTILLIN (percentage of homes still enrolled in an opt-out program)

Data Source	Label	Correlation with percent still enrolled in an opt-out program
ACS	percent Owner occupied homes	0.3
LG&E	Average electricity consumption	0.2
ACS	Median number of bedrooms	0.2
ACS	percent Employed	0.2
ACS	Year home built	0.2
ACS	Median number of rooms	0.1
ACS	percent Household size =2	0.1
ACS	percent High school or equivalent	0.1
ACS	percent Household size =3	0.1
ACS	Median family income	0.0
ACS	percent Some college	0.0
ACS	Median non-family income	0.0
ACS	percent Not in labor force	0.0
ACS	percent Household size >=4	0.0
LG&E	percent Confirmed owner	0.0
LG&E	percent Bill Pledge	-0.1
ACS	percent Masters or higher	-0.1
ACS	Median home value - owner occupied	-0.1
ACS	percent Bachelor's degree	-0.1
ACS	percent Household size =1	-0.2
LG&E	percent with email	-0.2

A basic model with LG&E and KU data alone and explanatory variables on home ownership, percent of customers with email (contact info per LG&E and KU), average electricity usage, percent bill pledge yields a model with an Adjusted R square fit statistic of 0.19. While all the above explanatory variables are significant predictors of propensity to participate in an opt-in program (DLCPCT), the fit statistic of 0.19 indicates that the behavior of the dependent variable is not captured to a significant extent with just the above set of variables.

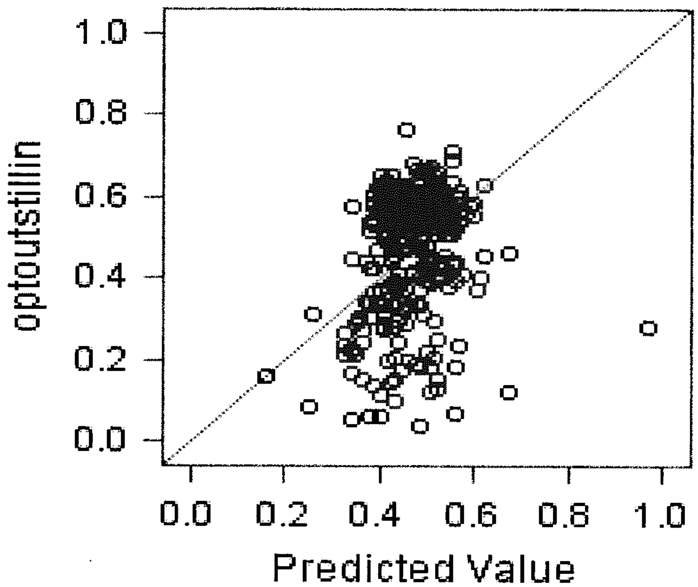


Figure 21: Plot of Actual versus Predicted (LG&E and KU data only) percent of homes still enrolled in opt-out programs, Adj R-sq=.19

Model – LG&E and KU and ACS data combined

Our next model uses the same dependent (OPTOUTSTILLIN), but information from the ACS data used as the explanatory variables. Another version of this model merges the LG&E and KU provided customer information to ACS data to create an enriched record of explanatory variables. These two models (ACS data alone and ACS combined with LG&E and KU) are significant with an Adjusted R square fit statistic of 0.17 and 0.21 respectively. While the combined model is a marginal improvement compared to the model in Step 1 which relied solely on customer data available to LG&E and KU, the model still does not capture all of the variation/behavior in the dependent variable.

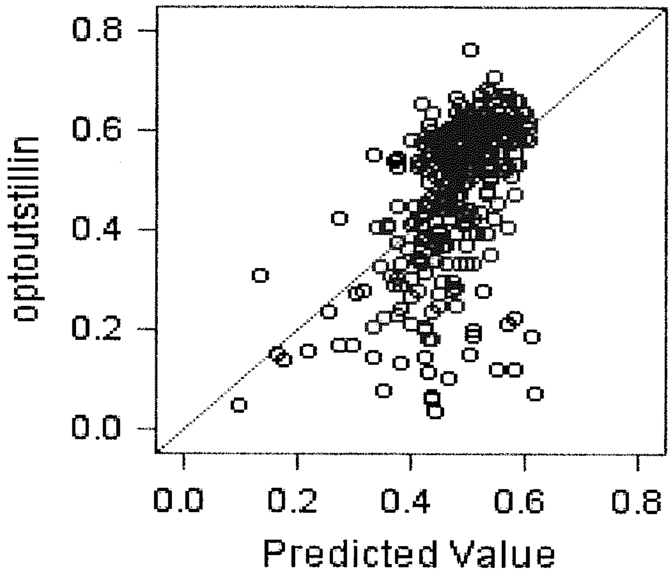


Figure 22: Plot of Actual versus Predicted (LG&E and KU and ACS data) percentage of homes still enrolled in opt-out programs, Adj R-sq=.21

Appendix C: Geographic Analysis

This section displays several maps created by DNV KEMA related to customer characteristics of importance to Smart Meter program acceptance and likelihood of participation and potential achievement of customer benefits. A reference map for identifying counties and cities can be found at: http://geology.com/county-map/kentucky.shtml.

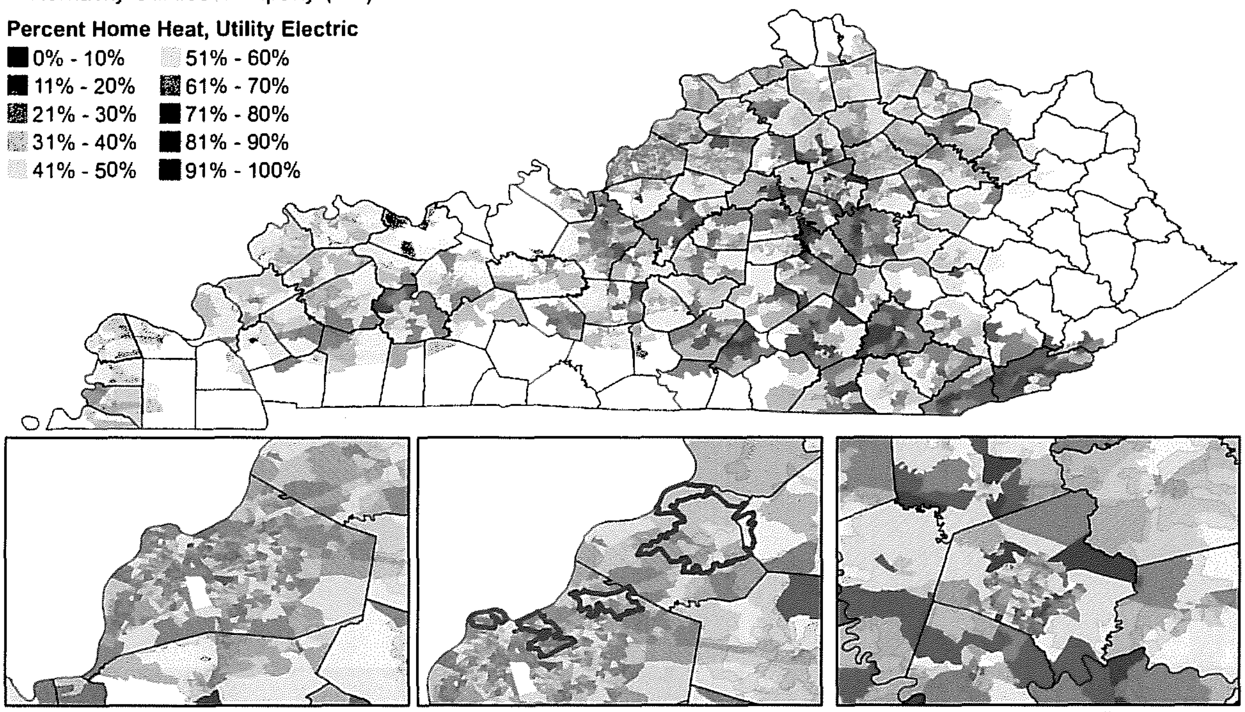
Most of the data reviewed by DNV KEMA was obtained at the zip code level. Survey statistics, however, were often inadequate at the zip code level to reveal meaningful results. In order to overcome this sparse data problem, we create larger geographical groupings based on the 1st 3 digits of the zip code called Sectional Center Facility or SCF, SCFs in order to display the data. The groupings are shown in the Table below.

Distribution of Survey Responses by SCF

SCF	Number of survey responses
400	32
401	11
402	191
403	58
404	25
405	105
406	2
407	6
408	2
409	4
410	14
420	6
423	8
424	10
425	6
426	4
427	12
Grand Total	**496**

Map of Electric Heat

Louisville Gas and Electric Company (LG&E)
Kentucky Utilities Company (KU)

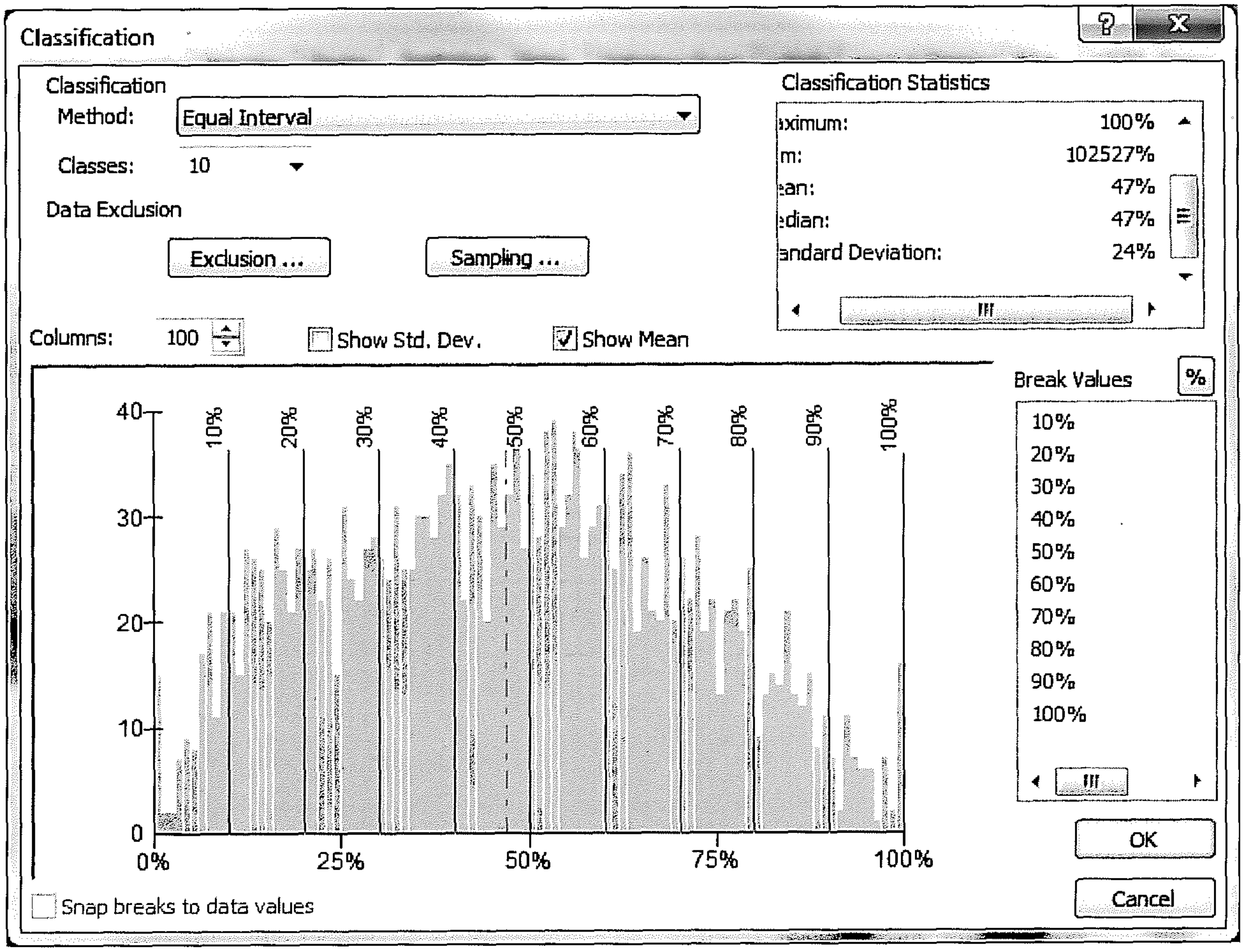


Louisville Area Detail | Pilot Area Detail | Lexington Area Detail

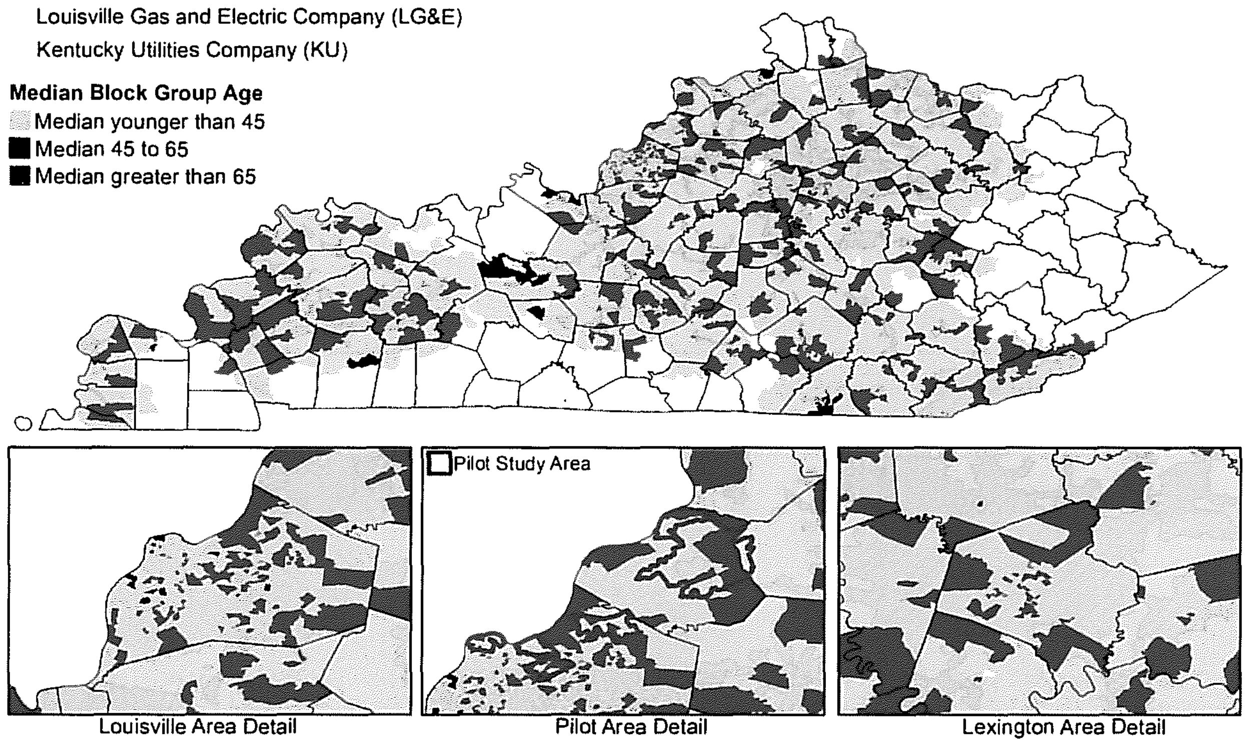
Percent of homes heating with electricity was derived from the 2007 – 2011 ACS. The number of occupied housing units with electricity as a primary fuel was divided by the total number of housing units for each of the ACS block groups. To generate the above map, the utility service territories were used to select only the ACS block grounds that we serviced in part or whole by one of the utility clients.

Key Points:

1. The pilot study area appeared to contain low percentages of homes that used electricity as a heating fuel. This may have impacted consumer expectations and satisfaction of how much electricity Smart Meters would save them, given their lower overall electric burden.
2. KU's southeast service area has a higher proportion of home using electricity as a heating fuel, this bears closer examination.
3. LG&E may be able to capitalize with targeted marketing on the smaller number of census block groups with a large proportion of homes using electricity as a heating fuel.


Classification
Classification
Method: Equal Interval
Classes: 10
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
ximum: 100%
m: 102527%
an: 47%
dian: 47%
andard Deviation: 24%
Columns: 100
Show Std. Dev.
Show Mean
Break Values
%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
0
10
20
30
40
0%
25%
50%
75%
100%
OK
Cancel
Snap breaks to data values

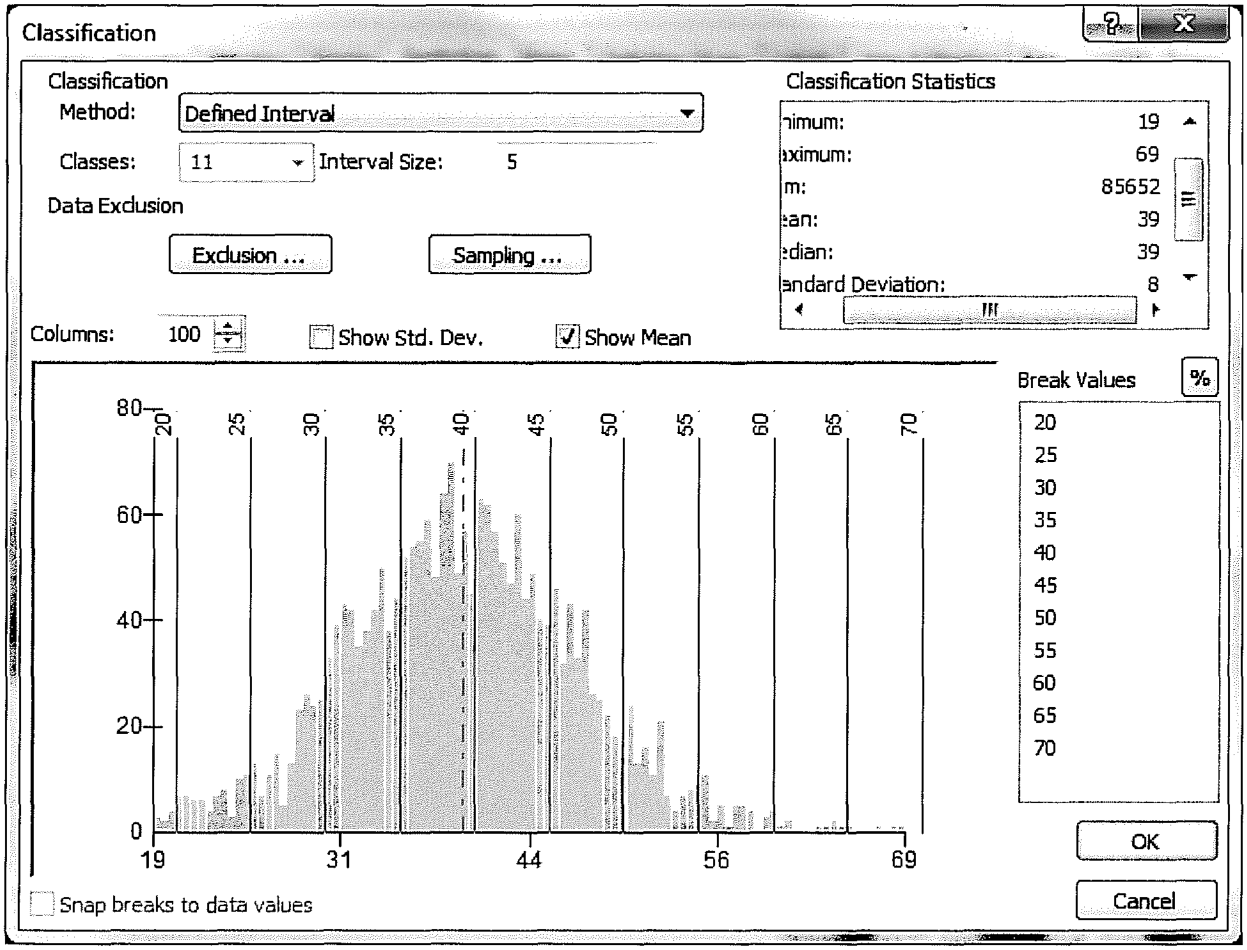
Map of Median Age



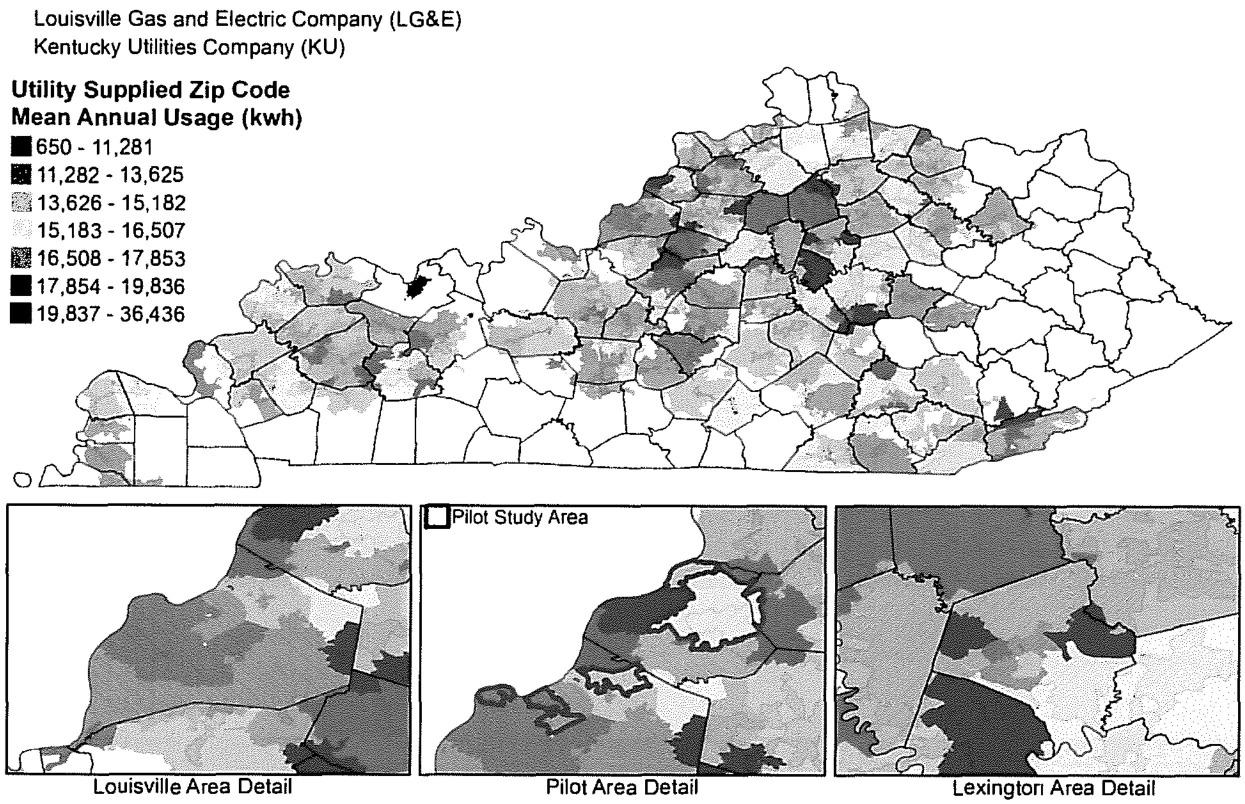
Median block group age was taken directly from the 2007 – 2011 ACS. To generate the above map, the utility service territories were used to select only the ACS block grounds that we serviced in part or whole by one of the utility clients.

Key Points:

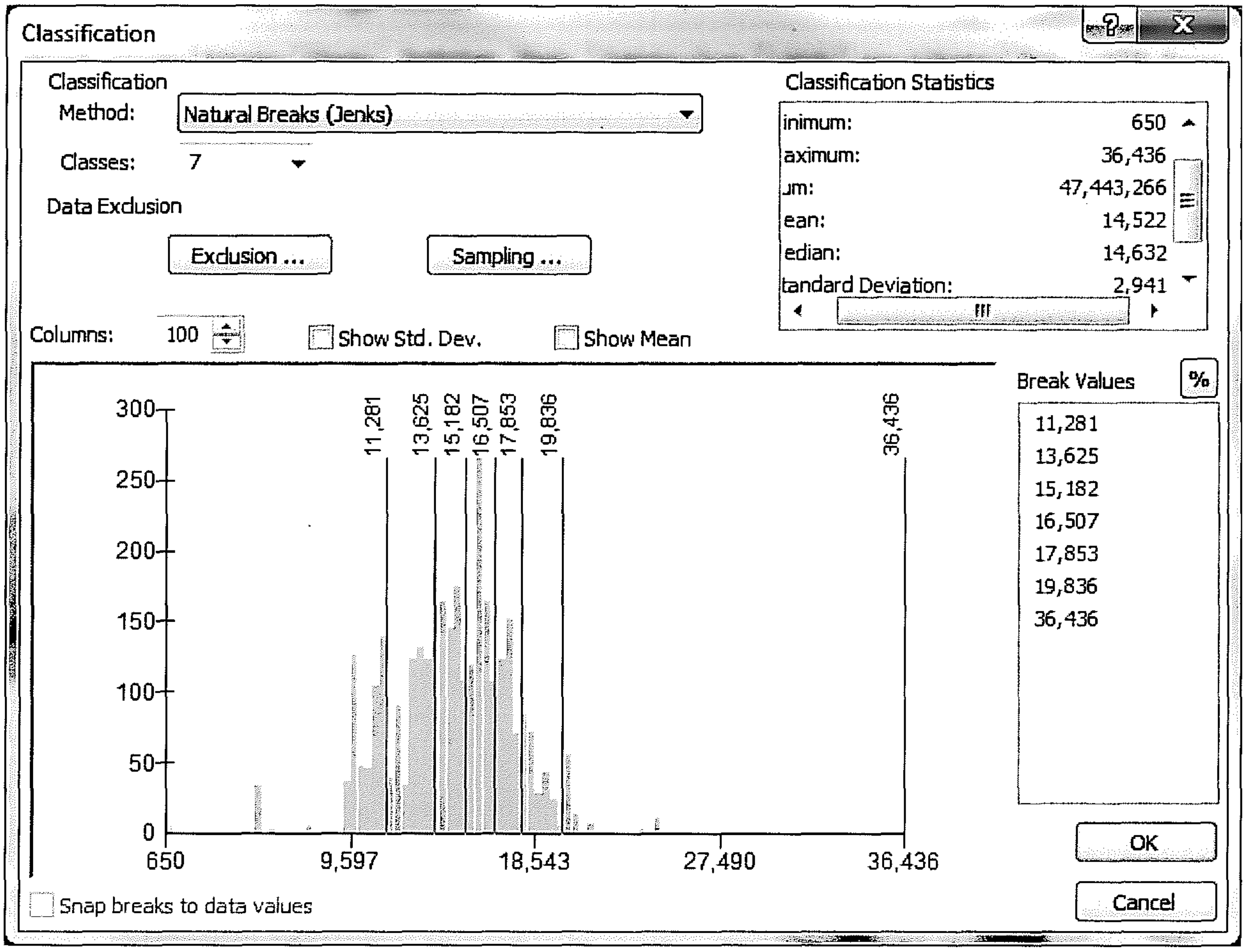
1. The three breaks were used to match the team and client breaks in the analysis of age. That said, if you look at the histogram, the breaks are not ideal based on the data. This does not impact the data, just the visualization on the map.


Classification
Classification
Method:
Defined Interval
Classes:
11
Interval Size:
5
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
nimum: 19
aximum: 69
m: 85652
ean: 39
edian: 39
andard Deviation: 8
Columns:
100
Show Std. Dev.
Show Mean
Break Values
%
20
25
30
35
40
45
50
55
60
65
70
OK
Cancel
Snap breaks to data values

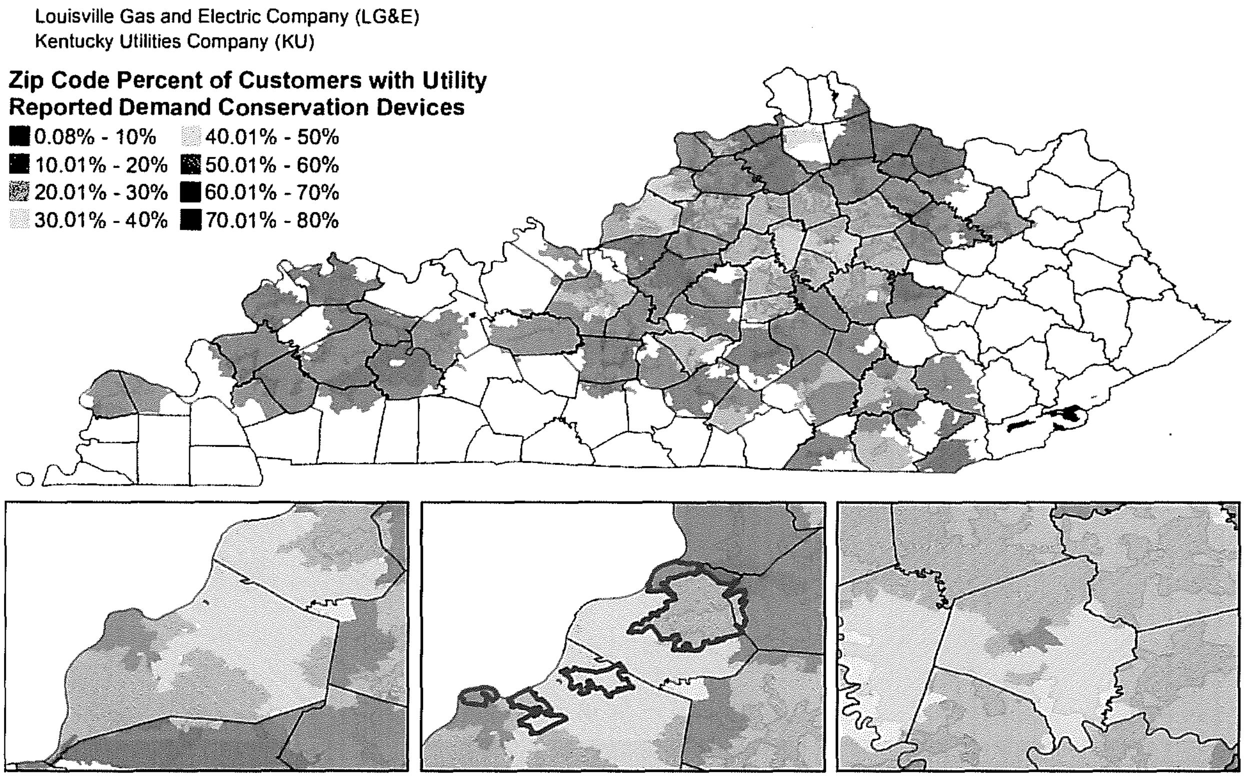
Map of Annual Energy Usage



Average annual energy use was taken directly from utility supplied average zip code level annual energy consumption and joining it to the US Census Bureau's 2010 zip code tabulation area files to generate the map above. No additional analysis was performed.


Classification
Classification
Method: Natural Breaks (Jenks)
Classes: 7
Data Exclusion
Exclusion ...
Sampling ...
Columns: 100
Show Std. Dev.
Show Mean
Classification Statistics
inimum: 650
aximum: 36,436
um: 47,443,266
ean: 14,522
edian: 14,632
tandard Deviation: 2,941
Break Values
11,281
13,625
15,182
16,507
17,853
19,836
36,436
300
250
200
150
100
50
0
650
9,597
18,543
27,490
36,436
Snap breaks to data values
OK
Cancel

Map of Customers with Demand Conservation Devices

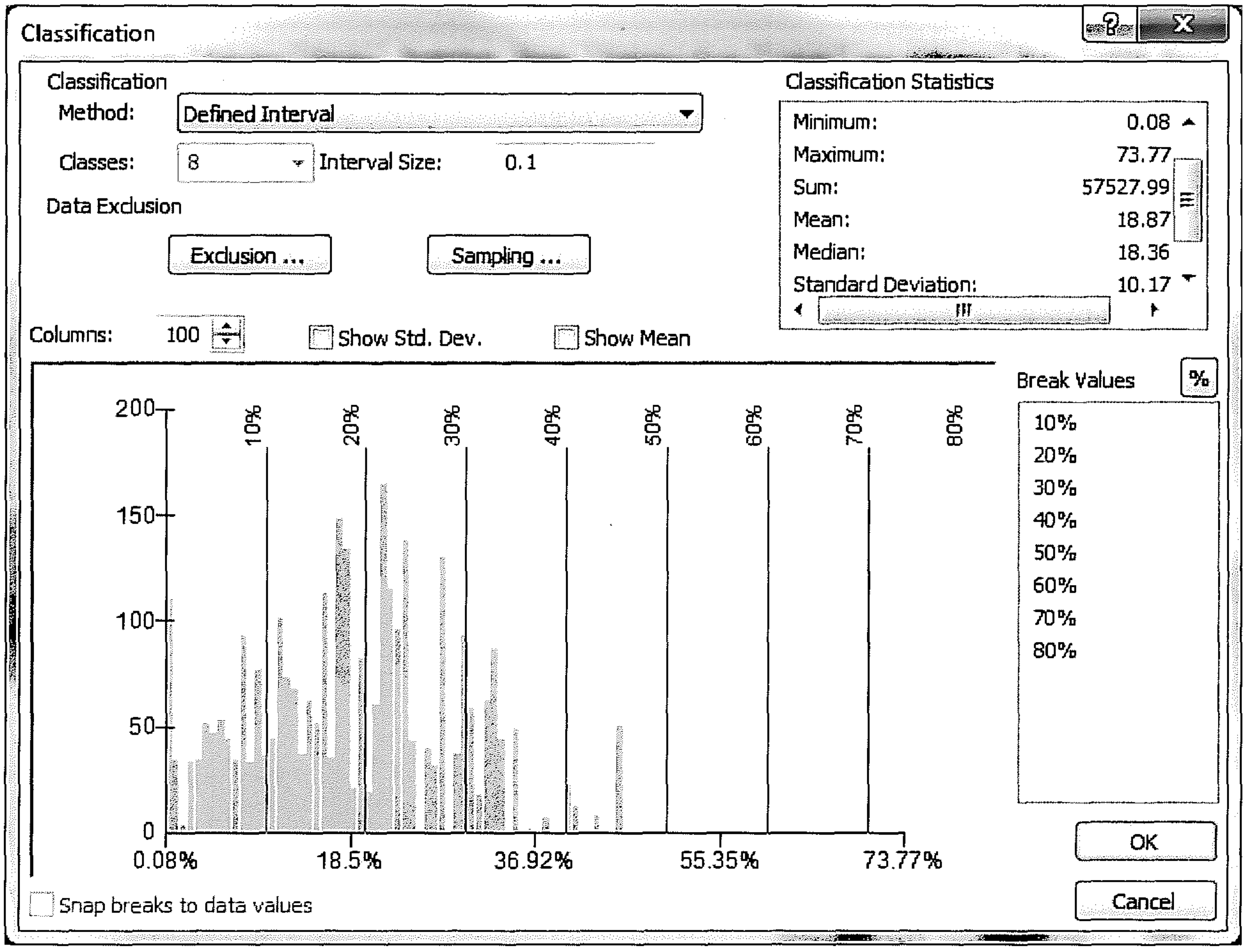


Louisville Area Detail | Pilot Area Detail | Lexington Area Detail

Proportion of accounts with demand conservation devices was calculated by taking the client supplied zip code counts of customer accounts and dividing it by the utility reported number of demand conservation devices for that zip code. The results were then joined to the US Census Bureau's 2010 zip code tabulation area files to generate the map above. For several zip codes, data quality issues meant that the zip code impacted was dropped from the analysis – for example, for KU in western Kentucky.

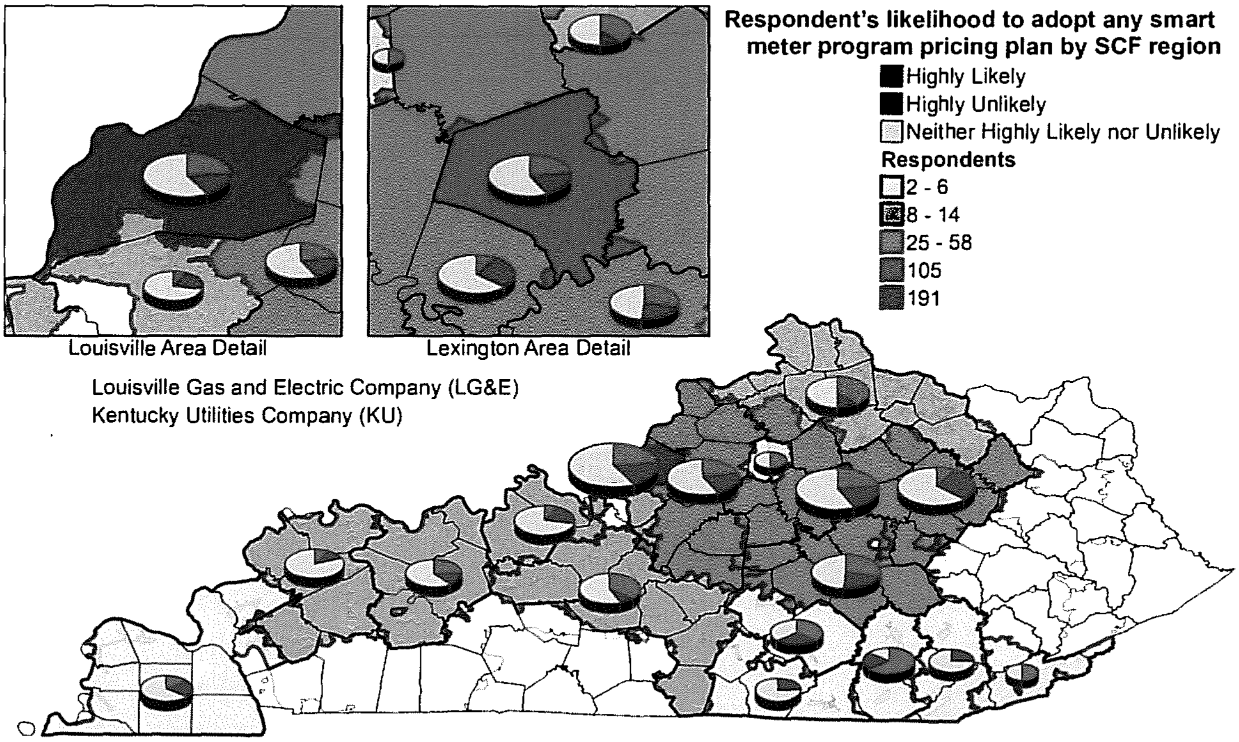
Key Points:

1. Per the histogram – bins 50 percent-60 percent and 60 percent-70 percent are empty. Bin 70-80 percent contains only 1 value.



Classification
Classification Method: Defined Interval
Classes: 8
Interval Size: 0.1
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Minimum: 0.08
Maximum: 73.77
Sum: 57527.99
Mean: 18.87
Median: 18.36
Standard Deviation: 10.17
Columns: 100
Show Std. Dev.
Show Mean
200
150
100
50
0
10%
20%
30%
40%
50%
60%
70%
80%
0.08%
18.5%
36.92%
55.35%
73.77%
Break Values
10%
20%
30%
40%
50%
60%
70%
80%
OK
Cancel
Snap breaks to data values

Map of Likelihood of Adoption



The map was generated by taking the 3 digit level model results and attaching them to 3 digit zip code tabulation areas where they utilities had a service presence.

<u>Key Points:</u>

1. This map would be improved if it could be restricted to just the utility service territory rather than the whole SCF. However, this would require individual customer records rather than aggregated records to the zip code and SCF level.

Appendix D: Costs and Operational Benefits as Reported by Other Utilities

This appendix describes the AMI costs and operational benefits as described in business cases of other utilities. The utilities covered are AEP Ohio, Duke Ohio, Ameren and NES. We also provide a summary of costs and benefits from the Smart Grid Collaborative which reflects the experience of utilities throughout the United States.

I. AEP Ohio

The AEP Ohio business plans extends AMI to approximately 894,000 customers, FLISR on approximately 250 priority circuits and Volt/VAR optimization on approximately 80 circuits.

The primary benefits which were part of the cost/benefit analysis in the business case are as follows:

	15 year cash value	Per Customer Per Year	
AMI financial benefits (meter reading, remote connect/disconnect)	$83M	$6.71 - $7.83 per meter per year	
Credit, collections and revenue enhancements through earlier theft detection, lower consumption on inactive meters and greater billing accuracy	$111M	$8.94 - $11.18 per meter per year	
Volt Var Optimization	$115M		Requires additional investment in addition to AMI and not quantitatively discussed in this report
Distribution automation circuit reconfiguration outage reduction (FLISR)	$1.06B		Requires additional investment in addition to AMI and not quantitatively discussed in this report

The AMI costs are estimated to be $180 per installed meter plus yearly O&M costs. There are additional costs for implementation of FLISR and Volt/VAR control.

The business case is primarily made through the benefits to customers of the FLISR technology.

II. Duke Ohio

The results in this section are from a mid-deployment audit of the Duke Energy Ohio grid modernization project by the Public Utilities Commission of Ohio. The program includes deployment of AMI to about 620,000 customers over a period of 7-8 years.

The primary operational benefits due to AMI are:

	Benefits (20 year NPV – based on an deployment over 7-8 years)	Per customer per year
Off-Cycle / Off-Season Meter Reads	$54M	$4.35 - $5.80
Regular meter reads	$50M	$4.03 - $5.37
Remote meter diagnostics	$6.5M	$0.52 - $0.70
Power theft – Recovery costs	$7.9M	$0.64 - $0.85
Meter accuracy improvement	$8.5M	$0.69 - $0.91
Vehicle Management	$10.2M	$0.82 - $1.10

Significant benefits were also found from Integrated Volt/VAR Control.

III. Ameren

Ameren plans to deploy AMI to 780,000 customers over 8 years. Numerous benefits and costs were computed for a NPV cost/benefit analysis over 20 years.

The costs of the AMI system are as follows:

	Costs based on a 20 year NPV	Cost Per customer
AMI equipment and installation	$129M	$165
AMI Operations (over 20 years)	$69M	$88

Project management	$16M	$20
IT System and Integration	$294M	$376

The IT System and Integration costs in the Ameren business plan are significantly higher than reported by other utilities.

The primary operational benefits were listed as follows:

	Benefits each year based on a 20 year NPV	Per Customer per year
Reduction in meter reading costs	$238M	$15.25
Reduction in field and meter services	$209M	$13.39
Reduction in Unaccounted for energy	$41M	$2.62
Outage management efficiency	$32M	$2.05
Improved distribution system spend efficiency	$42M	$2.69

In addition, other customer and societal benefits were also included in the Ameren business case. The largest customer and societal benefits in the Ameren business case were improved support for demand response and PEVs. The business case for AMI at Ameren was made by considering both the operational and the societal benefits.

IV. NES

NES developed the business case for deploying AMI to its 323,000 customers. It estimated the cost of deploying AMI to be $188 per customer plus additional O&M costs each year.

NES has partially deployed AMI in its territory. The operational benefits were identified as follows:

	Benefits each year based on a 15 year NPV	Per customer per year
Field Services	$6.8M	$21.05
Meter Services	$2.0M	$6.19
Billing and Collection	$1.8M	$5.57
Call Center	$0.5M	$1.54

Distribution Operation	$0.5M	$1.54

V. SGCC Study

The Smart Grid Consumer Collaborative (SGCC) recently released a report on Smart Grid Economic and Environmental Benefits. The results in the report are based on the research done by the members of the collaborative.

The primary operational benefits reported are listed below.

	Benefits per meter per year
Remote meter reading	$13.68 - $23.92
Pre-payment and Remote Disconnect/re-connect	$7.82 - $19.56
Revenue assurance	$3.0

There are other benefits discussed in the SGCC study including benefits due to Volt/VAR control and time-varying rates. These are not quantitatively discussed in this report.

The cost of the AMI system is estimated by SGCC to be $291.54 per customer plus 4 percent yearly O&M costs.