#### COMMONWEALTH OF KENTUCKY

#### BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

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)	
)	CASE NO.
)	2014-00003
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# Advanced Metering Systems 2018 Annual Report

On November 14, 2014, the Commission issued an Order in Case No. 2014-00003<sup>1</sup> approving an Advanced Metering System Opt-In service offering ("AMS Opt-In") for up to 5,000 Louisville Gas and Electric Company ("LG&E") and up to 5,000 Kentucky Utilities Company ("KU") (collectively "the Companies") residential and small commercial customers. The goal is to provide customers who desire to have consumption data more frequently than once a month an opportunity to request and receive an advanced meter, which will present individual daily consumption through a website. Advanced meters are installed for customers who elect to participate. A participating customer's consumption is captured, communicated and stored. Customers are able to monitor their hourly usage through the web within two business days.

The Commission ordered the Companies to prepare annual reports beginning on December 31, 2015, and due by January 31, 2016, and again annually through December 31, 2018, due by January 31, 2019. The Commission stated the reports should provide the number of participants by Company, measurable energy savings, the information learned, any problems and the resolution, and whether the information was accessible to the participants in a 24- to 48-hour period.<sup>2</sup>

# Customer Experience - Enrollment

Since inception of the AMS Opt-In Program in 2015 through December 31, 2018 there are 8,543 active customer enrollments and 8,333 meters currently installed in the AMS Opt-In service (see Figure 1).

The Companies use customer-provided address information to plot customer locations in Google Earth to aid in meter and network deployment planning.

<sup>&</sup>lt;sup>1</sup> Case No. 2014-00003, Joint Application of Louisville Gas and Electric Company and Kentucky Utilities Company for Review, Modification, and Continuation of New Demand-Side Management and Energy Efficiency Programs (Ky. PSC, Nov. 14, 2014).

<sup>&</sup>lt;sup>2</sup> Id. at 32.



FIGURE 1 – ACTIVE CUSTOMER ENROLLMENTS IN AMS OPT-IN

Total customer enrollment between January 1 and December 31, 2018 is displayed in Figure 2 below. Total customer enrollment from Program start to December 31, 2018 is displayed in Figure 3 below. These counts represent total enrollments received in the month reported and are not net of any removals or cancelled requests.



FIGURE 2 – 2018 CUSTOMER ENROLLMENTS IN AMS OPT-IN BY MONTH



FIGURE 3 – 2018 CUSTOMER ENROLLMENTS IN AMS OPT-IN BY MONTH

Active enrollments in AMS Opt-In are distributed by company as seen in Figure 4 below.



FIGURE 4 – AMS ENROLLMENT BY COMPANY

AMS Opt-In is available to customers in rate classes RS (Residential) and GS (Small Commercial), and the distribution by rate class is depicted in the Figure 5 below.

	Active Program Enrollments as of December 31, 2018		
Rate	LG&E	KU	
Residential Electric Service	4,588	3,651	
Residential Time-of-Day Energy	7	5	
General Service Three Phase	63	70	
General Service Single Phase	58	101	
Grand Total	4,716	3,827	

FIGURE 5 - ENROLLMENTS BY RATE

As stated previously, 8,333 AMS meters are actively installed as of December 31, 2018. These meters are associated with 8,235 customers<sup>3</sup>. 35% of the current meter deployment utilizes cellular communications, while 65% are radio frequency (RF) mesh communicating meters.

Through 2018, the Companies have closely managed the AMS Opt-In program delivering against the participation goals identified in Case No. 2014-00003:

	Cumulative Customer Counts (through 2018)					
	Participation	Actuals				
	Goal	Enrollments	Installed			
LG&E	5,000	4,716	4,510			
KU	5,000	3,827	3,725			
Total	10,000	8,543	8,235			

FIGURE 6 – AMS OPT-IN PARTICIPATION GOALS VS ACTUALS

The participation numbers listed above are not inclusive of customers who move out (1,706 customers), resulting in an AMS meter removal if the move out occurs after the AMS meter was installed. Nor do they include customers (61 customers) who request AMS service and reside in areas with existing AMS-capable meters (*e.g.*, customers in Wilmore, KY and the Downtown Louisville Network have AMS-capable meters; however, they are not included in AMS Opt-In metrics). The participation numbers also do not include customers who request to cancel their enrollment before their meter gets installed (319 customers) or opt out of the AMS offering after their meter is installed (37 customers).

Including the customers described above with the current enrollments results in over 10,600 customer enrollments received since program launch which provides a more reflective gauge of customer interest in AMS. This volume demonstrates customer excitement around AMS even though the Companies provided minimal education efforts during the rate case proceeding as described below; outpacing the Companies' participation goal by over 6%. Additional discussion around customer interest in AMS will follow in the Customer Education section of this report.

# Customers' Engagement with MyMeter Web Portal

The following table (Figure 7) reflects a sampling of the 2018 customer engagement with the websites the Companies have established to provide information on the Advanced Meter Service as well as educational materials on the MyMeter portal. Please note, Google Analytics defines "Pageviews" as the total number of pages viewed. Repeated views of a single page are counted. "Unique Pageviews" is the number of sessions during which the specified page was viewed at least once. A unique pageview is counted for each page URL + page Title combination.

<sup>&</sup>lt;sup>3</sup> Some customers have more than one meter.

Page	Description	Pageviews	Unique Pageviews	Avg. Time on Page
All page URLs begin: https://lge-ku.com/ *		13,877	11,710	00:01:28
/advanced-meter	General awareness page that explains the service and how to sign up for it.	9,057	7,478	0:01:00
/advanced-meters	General awareness site for the AMS CPCN and education on the technology.	1,147	947	0:01:44
/newsroom/press- releases/2018/01/03/lge- and-ku-request-approval- expand-benefits- advanced-meters-all	Press release announcing the AMS CPCN.	881	812	0:02:25
/advanced-meter/help	Help topics for AMS customers.	734	655	0:02:08
/advanced-meters/FAQ	Frequently asked questions site.	566	528	0:02:06
/newsroom/articles/201 8/07/06/myths-and- facts-about-advanced- meters	Myths and Facts about Advanced Meters	363	348	0:01:51
/newsroom/articles/201 8/07/11/advanced- meter-service-fact-sheet	Advanced Meter Service Fact Sheet	284	244	0:01:55
<u>/advanced-meter-</u> service/ams/chart-view	Welcome site for AMS customers featuring helpful tips and video tutorials about how to use the MyMeter "Charts View".	216	182	0:00:56
<u>/advanced-</u> meter/additional-views	Welcome site for AMS customers featuring helpful tips and video tutorials about how to use various functionality within MyMeter.	199	154	0:00:32
<u>/advanced-meter-</u> service/ams/data-view	Welcome site for AMS customers featuring helpful tips and video tutorials about how to use the MyMeter "Data View".	119	104	0:00:52
/advanced-meter- service/ams/profile	Welcome site for AMS customers featuring helpful tips and video tutorials about how to use the MyMeter "Profile".	116	83	0:01:05
/help/knowledge- base/what-advanced- meter	Knowledge base site describing what an advanced meter is.	100	95	0:01:03
/advanced-meter- service/ams/notifications	Welcome site for AMS customers featuring helpful tips and video tutorials about how to use the MyMeter "Notifications".	95	80	0:01:21

FIGURE 7 – GOOGLE ANALYTICS SNAPSHOT OF COMPANIES' AMS WEB TRAFFIC

The following table (Figure 8) depicts data on customer activity utilizing the MyMeter web portal as part of the AMS Opt-In service. For a brief definition of each metric please see Appendix 1.

MyMeter Analytics	2015 <sup>4</sup>	2016	2017	2018
Accounts registered (enrollments)	908 <sup>5</sup>	3,281	2,179	3,013
User Registrations (first time a user clicks into	514	2,484	1,417	1,745
MyMeter)				
Customer Energy Markers <sup>TM</sup>	71	416	214	204
Customer Notification: Mobile phone notification set-	34	73	36	32
up				
System Notifications <sup>6</sup>	492	2,515	1,440	1,757
Customer Notification: Threshold alert set-up	54	173	103	78
Threshold notifications sent by system	653	12,663	21,318	26,398
Total Sessions within MyMeter Site	2,035	26,519	27,655	29,883
Sessions by new users	614	7,473	6,000	6,958
Sessions by returning users	1,421	19,046	21,655	22,925
Average session duration (minutes:seconds)	4:05	2:04	1:44	1:53
Page visits/session	2.96	1.8	1.69	1.7
Average Number of times MyMeter visited per month	508.8	2,209.92	2,304.58	2,490.25
Unique pageviews to MyMeter site	3,523	36,231	36,755	39,803
Total MyMeter site pageviews	6,027	47,742	46,788	50,934

FIGURE 8 – MYMETER WEB PORTAL ACTIVITY AND ANALYTICS

The chart below (Figure 9) illustrates the type of devices customers are using to access the MyMeter web portal.



FIGURE 9 – MYMETER WEB PORTAL SESSIONS BY DEVICE TYPE. SOURCE: GOOGLE ANALYTICS

<sup>&</sup>lt;sup>4</sup> 2015 metrics are for September – December 31.

<sup>&</sup>lt;sup>5</sup> The difference between "Accounts registered" and "Meters installed" is that some accounts have multiple meters.

<sup>&</sup>lt;sup>6</sup> This metric label was "Customer Notification: E-mail address notification set-up" in the 2015 report and was updated for clarity. MyMeter updated their reporting structure in 2016 to include all system notifications rather than only customer generated email notifications so the values reported capture all system notifications created.

# **Customer Education**

Customer education efforts for the AMS Opt-In program were significantly impacted in 2018 by the certificates of public convenience and necessity (CPCN) to fully deploy AMS across the Companies' service territories requested in 2018<sup>7</sup>. Just as in 2017, the Companies' believed the potential for customer confusion between the AMS Opt-In program and the requested CPCNs was very high and thus elected to suspend or minimize AMS Opt-In education efforts for the duration of the case proceedings. On August 30, 2018 the Commission issued a ruling denying the Companies' request to fully deploy AMS across the Companies' service territories at which time customer education planning for AMS Opt-In was restarted.

The Companies deployed a number of customer education materials in 2018 in an effort to raise awareness of the AMS Opt-In program. These materials<sup>8</sup> included:

- Multiple email campaigns targeting GS customers in areas with RF Mesh coverage
- Postcard campaign targeting GS customers
- Bill messaging targeting residential customers
- Flyers and rack cards
- Yard signs at Company sponsored events like Homearama

# MyMeter Enhancements

The MyMeter web portal was updated throughout 2018 to enable limited system improvements, bug fixes, and feature requests either received from customers or recommended by MyMeter. Some of the key new functionality included:

- Enhanced data download functionality to give customers more control of the information included in the data extracts.
- Implemented support of the MyMeter smartphone app.

# Impact Assessment

In 2018 the Companies again partnered with Tetra Tech to quantify what, if any, measurable energy savings existed among AMS Opt-In participants. Tetra Tech reviewed participant billing data to investigate whether AMS Opt-In participants recognized energy savings during the time the advanced meters have been installed and operating.

To estimate energy savings resulting from the AMS Opt-in program, Tetra Tech used a PRISM model, calculating the weather normalized average consumption in the pre- and post-period for each household, with the difference in annual consumption representing the program impact. Tetra Tech estimated a separate model for treatment and contrast groups and interpret the difference in variances between the two groups as the overall program impact. The PRISM approach develops two weather normalized energy consumption models for each building in the sample based on regression models. Differences between the

<sup>&</sup>lt;sup>7</sup> Case No. 2018-00005, Application of Louisville Gas and Electric Company and Kentucky Utilities Company fora Certificate of Public Convenience and Necessity for Full Deployment of Advanced Meter Systems.

<sup>&</sup>lt;sup>8</sup> Samples of the various education materials that are new for 2018 may be found in Appendix 2.

weather normalized consumption between the pre- and post-periods show energy consumption increases or decreases, removing the effects of weather.

In October 2016, Tetra Tech provided a preliminary estimate of program impacts, based on limited participation data. Tetra Tech's 2016 analysis was based on pre- and post-installation PRISM-type models on households who had the advanced meter installed for at least 10 months during the post-installation period. For the current analysis, Tetra Tech analyzed an additional 12 months of billing data (i.e. 22 total months) and a larger number of program participants who had sufficient post installation data. Households that had at least 12 months of pre installation data and 12 months of post installation data were named, collectively, the treatment group. A contrast group was also developed for households enrolled in the AMS Opt-in program since the beginning of March 2017 and had at least 28 months of pre period consumption data that overlapped with the treatment group pre and post installation energy consumption data.

The 2018 analysis indicated average household energy savings of approximately 1.3 percent.

# Problems & Resolutions

There was one widespread delay related to loading customer usage data to the MyMeter portal outside of the two business day commitment in 2018. This event impacted approximately 150 customers with cellular meters, beginning around mid-December and was resolved on January 3, 2019. The root cause was that the meters were not loaded to their head-end system as expected by the meter manufacturer and as a result failed to communicate their usage. The meters themselves functioned without issue and once the head-end system was loaded with the meters the communications began as expected.

Isolated events impacting individual customers did occur and typically were related to usage file load schedule errors whereby the files were delayed in being transferred to the portal and resulted in the need to manually load the files after the fact.

As discussed in previous reports, the Companies have deployed roughly 2,000 3G meters for RS customers. In July 2017 the Companies received notice from Verizon that they plan to sunset support of 3G communications on December 31, 2019. As discussed in Case No. 2017-00441, the Companies plan to replace roughly 2,000 of the over 3,400 total number of cellular meters by that date to ensure customers will be able to continue their participation in the AMS offering.

# Lessons Learned to Date

As Figure 1 displayed, customers across the Companies' service territories continue to show interest in the AMS Opt-In offering. The Companies have learned that having ample inventory on hand to facilitate timely installation of advanced meters is critical to maintaining positive customer experience as well as engagement with the advanced meter data. Customers that enrolled and received a meter in 2018 experienced an average wait time of 114 days between enrollment and meter installation. Moving forward the Companies intend to reduce this waiting time to two weeks.

Customers have also been actively providing feedback since approval was received in November 2014. Questions have ranged from how to use the features available within the presentment portal to requests additional functionality such as support for customer purchased in-home devices as well as requests for gas usage information. These inquiries have continued to encourage the Companies to pursue full deployment of AMS as demonstrated in the requests for CPCNs in the 2016 base rate cases as well as the 2018 AMS case. The cases have provided valuable feedback for the Companies from the participants as well as the Commission itself pertaining not only to the full deployment requests but also to the Opt-In offering as well.

# AMS Opt-In Expansion and Forward Planning

The Commission ordered in Case No. 2017-00441 to expand the AMS program to 10,000 LG&E and 10,000 KU residential and small commercial customers. The Commission's provided further guidance in its conclusion in Case No. 2018-00005 stating that "The increased investment in AMS will not result in wasteful duplication because the pilot program meters can be used going forward if the Companies refile an application for AMS that satisfies the evidentiary requirements for a CPCN." The Companies' are providing the budget estimates for acquiring and serving these additional 10,000 customers below. The Companies plan to address the recovery of these expenses under DSM in its next DSM related filing which is the DSM Balancing Adjustment (DBA). The DBA will be filed in February with rates taking affect April 1. While the DBA has traditionally been an expenditure true-up for the preceding year the Companies plan to submit tariffs recognizing the recovery of the 2019 expenses depicted below which are expected to cover the DSM AMS Opt-In program in total (not incremental to what has already been approved).

#### <u>Budget</u>

	(\$1,000)	2019	2020	2021	2022	Total
Administration		\$ 291	\$ 300	\$ 309	\$ 318	\$ 1,218
Implementation CAPX		\$ 3,100	\$ 122	\$ 126	\$ 130	\$ 3,478
Implementation OPEX		\$ 1,183	\$ 208	\$ 204	\$ 206	\$ 1,801
Miscellaneous		\$ -	\$ 46	\$ -	\$ 48	\$ 94
Total		\$ 4,574	\$ 676	\$ 639	\$ 702	\$ 6,591

The Companies are estimating the following budget to accomplish the mentioned activities.

# Subsequent Updates and Operations

This is the final AMS Opt-In report per the order the Commission issued in Case No. 2014-00003.

# APPENDIX 1 – MYMETER METRIC DEFINITIONS

#### Accounts registered (Completed enrollments)

Number of unique customer accounts with AMS meters installed. Note, some accounts have more than one meter.

#### User Registrations (first time a user clicks into MyMeter)

The number of accounts registered. As noted, a user is considered registered after they first click into the MyMeter dashboard.

#### Customer Energy Markers<sup>TM</sup>

The number of Energy Markers<sup>TM</sup> created in a given timeframe. Energy Markers<sup>TM</sup> are a feature within the MyMeter dashboard where a customer can add activities that they would like to track the correlating impact said activity has on their energy consumption. For example, if a customer were to replace an appliance with a new Energy Star appliance, they can add an Energy Marker<sup>TM</sup> on the date the new appliance was installed.

#### Customer Notification: Mobile phone notification set-up

The number of unique accounts registered (definition above) in a given timeframe that have added mobile phone numbers to their MyMeter accounts via the Communication Options page. Some accounts have elected to receive notifications on multiple mobile numbers but these are only counted once here.

#### Customer Notification: E-mail address notification set-up

The number of unique accounts registered (definition above) in a given timeframe that have added email addresses to their MyMeter accounts via the Communication Options page. Some accounts have elected to receive notifications on multiple addresses but these are only counted once here.

#### **Customer Notification: Threshold alert set-up**

The number of threshold notifications set up in a given timeframe.

#### Threshold notifications sent by system

The number of notifications actually sent in a given timeframe.

#### **Total Sessions within MyMeter Site**

Total number of Sessions within the date range. A session is the period time a user is actively engaged with the MyMeter portal. Total is equal to the sum of sessions by first-time visitors and repeat visitors. Source: Google Analytics

#### Sessions by new users

The number of first-time users during the selected date range. Source: Google Analytics

#### Sessions by returning users

The number of repeat users during the selected date range. Source: Google Analytics

#### Average session duration (minutes:seconds)

The average length of time a user spends on the MyMeter site. Source: Google Analytics **Page visits/session** 

The average number of pages viewed during a session. Repeated views of a single page are counted. Source: Google Analytics

#### Average Number of times MyMeter visited per month

The average number of sessions per month. A session is the period time a user is actively engaged with the MyMeter portal. Source: Google Analytics

#### Unique pageviews to MyMeter site

Unique Pageviews is the number of sessions during which the specified page was viewed at least once. A unique pageview is counted for each page URL + page Title combination. Source: Google Analytics

#### **Total MyMeter site pageviews**

Pageviews is the total number of pages viewed. Repeated views of a single page are counted. Source: Google Analytics

# APPENDIX 2 – AMS EDUCATION MATERIALS

#### **POSTCARDS**

#### March 2018

Front







#### March 2018

#### <u>Front</u>



<u>Back</u>



#### **EMAIL BLASTS**

```
June 2018
```



#### July 2018



**Bill Message** 

# LEARN ABOUT YOUR ENERGY USAGE



# Understand when you use electricity most. Enroll in the Advanced Meter Program TODAY!

lge-ku.com/mymeter

# APPENDIX 3 – TETRA TECH IMPACT EVALUATION MEMO



To:	Greg Lawson, Jonathan Whitehouse, and John Hayden, LG&E and KU
Cc:	Carrie Koenig, Tetra Tech
From:	Jonathan Hoechst and Sue Hanson, Tetra Tech
Date:	January 28, 2019
Subject:	AMS Opt-In Program Impact Evaluation – 2018 Update

This memo presents savings estimates for Louisville Gas and Electric Company and Kentucky Utilities Company's (LG&E and KU's) Advanced Metering Systems (AMS) Opt-In program, using consumption and participation data spanning from January 2014 to November 2018. This is the third annual memo provided to LG&E and KU for the AMS Opt-In program. Findings are presented in the following main topic areas:

- Program description and background
- Executive summary
- Savings estimation methodology
- Findings.

## **PROGRAM DESCRIPTION AND BACKGROUND**

In January 2014, LG&E and KU proposed a voluntary AMS Opt-In program.<sup>1</sup> The initial deployment was limited to 5,000 LG&E and 5,000 KU residential and general service customers on a first-comefirst-served basis and included a website portal to display consumption data to customers. The primary purposes for proposing the AMS Opt-In program was to put in place the communications and control infrastructure necessary for possible future advanced-meter deployments, as well as to provide participating customers more detailed information about their consumption. The filing noted that "[n]ext generation residential utility meters that can provide residents with amount of current utility usage, its cost, and can be capable of being read by the utility either remotely or from the exterior of the home." The advanced meters LG&E and KU has deployed as part of the AMS Opt-In program meet these requirements. Additionally, the AMS Opt-In program served as a means to begin collecting data from participants in order to assess the potential for energy savings.

Based on a review of the 2013 Smart Grid Consumer Collaborative (SGCC) "Smart Grid Economic and Environmental Benefits" report, LG&E and KU expects that more detailed and timelier energy consumption information available to AMS device recipients through a web portal will lead to aggregate energy savings from these participants.

In November 2016, LG&E and KU proposed a full deployment of AMS across their service territory. As part of the business case for deploying AMS to customers LG&E and KU had originally estimated an energy savings of 0.5 percent across all residential electric customers who receive advanced meter equipment.

<sup>&</sup>lt;sup>1</sup> Case No. 2014-00003

In January 2018, LG&E and KU again proposed a full deployment of AMS across their service territory.<sup>2</sup> That business case again maintained an estimate of energy savings of 0.5 percent across all residential electric customers who receive advanced meter equipment.

# **EXECUTIVE SUMMARY**

Based on our analysis of consumption and participation data spanning January 2014 through November 2018, Tetra Tech recommends the impact of the AMS Opt-In program be estimated at 190 kWh per household, or 1.3 percent of annual consumption.

Tetra Tech implemented essentially the same methodology to estimate savings as the past two years<sup>3</sup>. Even so, it is challenging to discern household-level savings that are small in magnitude compared to total consumption. In similar studies, some treatment households reduce consumption a lot, some only a little, and some actually increase consumption between the pre and post periods. The aggregate savings signal is easily lost in the variability in consumption from one household to another. There are two additional key confounding factors in assessing estimated savings for the Opt-In program. First, the "treatment" program participants have received only a new meter and access to a web portal to review their usage. In this way, it is unlike a behavior-based program, where program participants typically receive email or mailed reports on a regular schedule that helps identify potential energy savings opportunities. And second, the degree to which Opt-In program participants may have already participated in energy efficiency programs offered by LG&E and KU. This piece adds a layer of complexity in assessing estimated savings, as energy efficiency program participation likely already reduced overall energy consumption.

Examining the treatment group's consumption prior to enrollment and comparing against energy usage after receiving AMS equipment resulted in a decline in normalized consumption following opting into the program of approximately 1.3 percent. Consumption among the contrast group also declined during the pre/post period of this study, though decrease in energy usage was much less than among the treatment group. Overall, contrast group members decreased energy usage by less than 0.1 percent (approximately 6 kWh). While this reduction is small enough that we could not eliminate the statistical possibility that no reduction occurred, it is statistically more probable that a reduction among the contrast group occurred.

<sup>&</sup>lt;sup>2</sup> Case No. 2018-00005

<sup>&</sup>lt;sup>3</sup> In the past two years, Tetra Tech has used a variety of sources to help estimate savings including annual monthly consumption data, Smart Energy Profile program participation data, Google Analytics, and other data files from the MyMeter web portal documenting user engagement. For this third annual update, two data sources were used—monthly consumption data and participant information from the Smart Energy Profile program.

# SAVINGS ESTIMATION METHODOLOGY

#### **OVERVIEW**

To estimate changes in consumption among participants of LG&E and KU's Opt-In program, Tetra Tech conducted a billing analysis that included both a treatment and contrast group. Information and findings presented in this memo contains a second update to the original 2016 analysis, using yet another 12 months of consumption data for program participants. As we did in previous years, we analyzed data during two periods:

- 1. The period 1, from January 2014 through the billing month at each household *prior to* opting into the program. This represents the pre installation period, which we refer to simply as the *"pre"* period; and
- 2. The period beginning the billing month *following* the opt-in month at each household, through November 2018. This represents the post installation period, or simply "post" period.

Households that had at least 12 months of pre installation data and 12 months of post installation data were named, collectively, the *treatment group*.

Tetra Tech created a *contrast group* against which to compare program savings.<sup>4</sup> In this group were customers who enrolled in the AMS Opt-In program since the beginning of March 2018 and had at least 28 months of pre period consumption data that overlapped with the treatment group pre and post installation energy consumption data. For the contrast group, the pre and post installation period cutoff was defined as the median month between January 1, 2015, and the AMS device installation date (no earlier than March 2018). The pre installation period corresponds with the months prior to the household's median month of the billing period date range prior to AMS device installation, with the post installation period extending from the month following the median month to the month prior to AMS device installation. As a group, using the individual median months allows the contrast group to reflect post periods that overlap with the treatment group's range of post installation dates. For example, a household in the contrast group with an AMS device installation date of July 30, 2018 would be assigned a median month of April 2017. The pre-installation period would correspond to January 2015-April 2017, and the post installation period would be May 2017-June 2018<sup>5</sup>. Changes in consumption by the contrast group are then able to be compared to the changes in consumption of the treatment group.

The value of using program participants who enrolled after the end of the treatment group's post period as a contrast group is that, collectively, they are presumed to be more similar in the unmeasured attributes of participants—energy use, demographics, lifestyle—than would a general population sample, reducing the potential for selection bias to skew results. The limitation of using this group is that it is relatively small, so the estimates of change are expected to have greater uncertainty than a larger sample.

Figure 1 illustrates the relationship between the pre and post periods for the treatment and contrast groups. The treatment group is represented by the green bars above the timeline. For them, the pre period extends up to, but not including, the billing months during which an AMS device was installed. The post period excludes the installation months, and extends to the end of 2016. Participants in 2015 who closed their accounts before 12 months had passed following treatment, or who opened their accounts fewer than 12 months prior to treatment, were removed from the

<sup>&</sup>lt;sup>4</sup> The term "control group" is avoided because households were not randomly assigned.

<sup>&</sup>lt;sup>5</sup> In this example, the AMS device was installed for the participant on July 30, 2018, so the "pre" consists of the earlier half of the period July 2015 through the month prior to install, and the "post" is the second half of this period.

analysis. Thus, a minimum of 12 calendar months of data exists for all treatment customers in both the pre and post periods.

The contrast group, represented in Figure 1 by the orange bars below the timeline, includes customers who received their AMS device in 2017 but had at least 12 months of untreated data following the median installation date among the treatment group. Thus, 2017 participants who received AMS devices early in the year were excluded from the contrast group.



Figure 1. Pre and Post Periods for the Treatment and Contrast Groups

To estimate energy savings resulting from the AMS Opt-In program, Tetra Tech used a PRISM model, calculating the weather normalized average consumption in the pre and post period for each household, with the difference in annual consumption representing the program impact. A separate model was estimated for treatment and contrast groups, with the difference in variances between the two groups interpreted as the overall program impact. Estimated impacts in the aggregate, across all households, were estimated through a panel fixed effects regression model.

#### DATA COLLECTION

Tetra Tech received data<sup>6</sup> from LG&E and KU indicating account numbers for all customers participating in the AMS Opt-In program since the program's inception, including the date of enrollment and the date that AMS equipment had been installed. The equipment installation date was considered the participation date. The AMS Opt-In program participant file included information for 9,394 customers across both LG&E and KU service territories. Tetra Tech also received six files<sup>7</sup> containing monthly consumption data for program participants, consisting of billing periods between January 2014 and November 2018 (see Table 1).

Tetra Tech downloaded hourly temperature data from the National Oceanic and Atmospheric Administration's National Climatic Data Center<sup>8</sup> for the entire study period. We targeted two weather stations, one at Louisville International Airport and one at Lexington Blue Grass Airport. From the

<sup>&</sup>lt;sup>6</sup> AMS Customers 11\_8\_18.xlsx.

<sup>&</sup>lt;sup>7</sup> EANALYSIS\_PATTERN\_1.xlsx - EANALYSIS\_PATTERN\_6.xlsx.

<sup>&</sup>lt;sup>8</sup> https://www.ncdc.noaa.gov/

hourly data we calculated a median daily temperature. Based on these data we calculated heating and cooling degree days by billing period. Tetra Tech also downloaded Typical Meteorological Year (TMY3) data from the National Renewable Energy Labs.<sup>9</sup> These data, representing hourly average temperature conditions for each weather station, were used to normalize changes in consumption between the pre and post installation periods and to provide a weather normalized result that would be applicable to typical annual weather conditions.

#### DATA SCREENING

The following screening procedures were applied to billing data to remove monthly data and entire households that might distort the findings<sup>10</sup>.

- **Nonresidential customers.** Removed commercial customers (those receiving electricity under GS rate categories).
- Extreme monthly consumption. Removed the one percent highest and lowest energy using customers, retaining households that had an adequate number of months of data after this screening.
- **Multiple program enrollments.** Two accounts in the data enrolled in the program, then opted out of the program, only to re-enroll in the program again at later dates. The accounts were removed, as their consumption data do not follow the typical pre/post pattern required for analysis.
- **Insufficient data.** Households with less than 12 months of pre or post period data were removed from the analysis because a full year of consumption data is highly preferred to accurately predict savings. Two accounts in the data enrolled, then opted out of the program, only to reenroll in the program again at later dates. Tetra Tech removed these accounts as their consumption data do not follow the typical pre/post pattern required for analysis.
- Extreme consumption change between pre and post periods. In the analysis, some households exhibited very high changes in consumption, indicating either increases in consumption or reductions in consumption. Tetra Tech eliminated the upper and lower one percent of the distribution of estimated annual changes in energy consumption. The households at the extremes were unlikely to reflect performance that would be generalizable to the population. Eliminating both high energy savers and high energy consumption increasers avoided the extreme changes from biasing the results in either direction.

<sup>&</sup>lt;sup>9</sup> http://rredc.nrel.gov/solar/old\_data/nsrdb/1991-2005/tmy3

<sup>&</sup>lt;sup>10</sup> Additional screening procedures were used for this annual update including removal of nonresidential customers and multiple program enrollments. Nonresidential customers were removed in order to ensure a more homogenous analysis group, and thus, a better prediction of savings estimates. Multiple program enrollments were removed this year, which was the first year we saw this type of enrollment.

Table 1 shows the effect on total sample size of each screening activity, while Table 2 provides details on the number of customers placed into each analysis group, as well as the number of customers removed from the analysis due to insufficienct billing data or extreme variability between pre- and post-installation.

Group	Number in Sample	Number Removed
Initial Population	9,394	-
Remove non-residential accounts	9,086	308
Remove records with extreme consumption	9,081	5
Remove accounts with multiple enrollments	9,079	2
Eligible Sample	9,079	315

#### Table 1. Data Screening

Table	2.	Analysis	Groups
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Analysis Group	Number in Sample	Number Removed
Eligible Sample	9,079	-
Treatment Group: 12 months consumption data post opt-in and at least 24 months total	3,756	4 226
Contrast Group: No more than 4 months data post opt-in and at least 28 months total	1,097	4,220
Treatment Group: Extreme Change in Estimated Annual Pre/Post Consumption	2,635	1,121
Contrast Group: Extreme Change in Estimated Annual Pre/Post Consumption	1,094	3
Total Treatment Group in Analysis	2,635	E 250
Total Contrast Group in Analysis	1,094	5,350

#### **HEATING AND COOLING DEGREE DAYS**

Heating degree days (HDD) are the difference between a reference temperature and the average daily temperature on a given day. The reference temperature represents the point at which heating equipment begins to operate. Cooling degree days (CDD) are the difference between the average daily temperature on a given day and a reference temperature that represents the point at which cooling equipment begins to operate.

*HDD* = *ReferenceTemp* - *AverageDailyTemp* 

CDD = AverageDailyTemp - ReferenceTemp

HDD and CDD can be summed across days for a monthly or annual value. For the model, which estimated average daily consumption, the average daily HDD and CDD were calculated for each billing period.

Separate heating and cooling regression models were estimated for each household in both the pre and post periods to determine the appropriate reference temperature for LG&E and KU customers. Each model allowed the heating or cooling reference temperature to range from 40°F to 90°F for each household in both the pre and post periods. The base temperature resulting in the best model fit  $(R^2)$  was assigned to the household.

For customers whose consumption was relatively insensitive to HDD or CDD—that is, for whom either the heating or the cooling models fit the data poorly—Tetra Tech assigned HDD = 0 or CDD = 0, or both, rendering the model a cooling only, heating only, or an intercept only model. The intercept only model in effect compares the mean average daily consumption in the pre and post periods, without adjusting for weather differences and reflects households without statistically significant changes in consumption due to weather.

#### **PRISM MODEL**

Heating and cooling PRISM models were estimated in both the pre and post period for each customer in the treatment and contrast groups using the following specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer '*i* and day '*t*':

- $ADC_{it}$  = Average daily kWh consumption in the pre or post program period.
- $\alpha_i$  = The participant intercept, representing the average daily kWh baseload.
- $\beta_1$  = The model space heating parameter, used in the heating only, and heating/cooling models. This represents the average change in daily usage resulting from an increase of one daily HDD.
- $AVGHDD_{it}$  = The base 40°F to 90°F average daily HDD for each location, used in the heating only and heating/cooling models
- $\beta_2$  = The model space cooling parameter, used in the heating only, and heating/cooling models. This represents the average change in daily usage resulting from an increase of one daily CDD.
- AVGCDD<sub>it</sub> = The base 40°F to 90°F average daily cooling degree days for each location, used in the cooling only and heating/cooling models.

$$\varepsilon_{it}$$
 = The error term.

Using this model, normalized annual consumption (NAC) was calculated, solving for typical annual HDD and CDD based on daily TMY3 data and summing across the 365 days in the year. For each of the analysis groups—treatment pre, treatment post, contrast pre, contrast post—Tetra Tech calculated an average NAC. The program impact, as a percentage of the treatment pre-NAC is:

$$percent \ savings = \frac{preNAC_t - postNAC_t}{preNAC_t} - \frac{preNAC_c - postNAC_c}{preNAC_c}$$

Where the subscript "*t*" represents the treatment group and the subscript "*c*" represents the contrast group.

### **FINDINGS**

This section documents the details in the approach to estimating savings using the consumption data of customers in the treatment and contrast groups.

#### **BILLING DATA ANALYSIS**

The PRISM analysis indicated average household energy savings of approximately 1.3 percent compared with the pre-installation period among households in the treatment group. Consumption among households in the contrast group fell less than 0.1 percent compared to pre-installation levels during the same period. The results for each analysis group are shown in Table 3.

Analysis Group	n	NAC (kWh)
Treatment – pre period	2,635	15,063
Treatment – post period	2,635	14,866
Contrast – pre period	1,094	14,322
Contrast – post period	1,094	14,315

Table 3. PRISM Analysis Normalized Annual Consumption

The treatment group reduced its NAC between the pre and post periods by an average of 197 kWh, or about 1.30 percent. The contrast group, however, reduced its NAC during this time by 6 kWh, or about 0.04 percent of baseline consumption. Thus, the estimated average impact of the AMS Opt-In program is  $1.3\% \times 15,063$  kWh = 190 kWh.

Based on these findings, the program impact as a percentage of pre treatment consumption, is:

$$1.3\% = \frac{15,063 - 14,866}{15,063} - \frac{14,322 - 14,315}{14,322}$$

The 90 percent confidence interval around treatment group savings is +/- 5 percent of the estimated value. Thus, the lower limit to the NAC for the treatment group is 187 kWh, and the upper limit is 207 kWh. Relative uncertainty around the contrast group impact was higher because the impact was essentially zero, resulting in a 90 percent confidence interval around the contrast group having bounds -9 kWh and 21 kWh, with a mean of 6 kWh.

To estimate uncertainty around the adjusted impact from the treatment and contrast samples, Tetra Tech used a resampling approach, drawing 1,000 random participants, with replacement, from each group and estimating the combined impact. The distribution of this impact is an approximation of the uncertainty around the point estimate of the program impact as a percentage of pre treatment consumption. From this activity, the 90 percent confidence interval around the adjusted impact is estimated to be +/- 0.1 percentage point. Put another way, if the exercise was repeated 100 times, with 100 random samples of 1,000 participants each, the savings result would be expected to be within 1.2 and 1.4 percent in 90 of 100 random samples.