COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

| | | |
|---|---|---|
| JOINT APPLICATION OF LOUISVILLE GAS AND ELECTRIC COMPANY AND KENTUCKY UTILITIES COMPANY FOR REVIEW, MODIFICATION, AND CONTINUATION OF EXISTING, AND ADDITION OF NEW, DEMAND-SIDE MANAGEMENT AND ENERGY-EFFICIENCY PROGRAMS | ) ) ) ) ) ) ) | CASE NO. 2014-00003 |

# ADVANCED METERING SYSTEMS 2017 ANNUAL REPORT

On November 14, 2014, the Commission issued an Order in Case No. 2014-00003[1] 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 program does not include in-home devices.

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.[2]

## Customer Experience – Enrollment

Since inception of the AMS Opt-In Program in 2015 through December 31, 2017 there are 7,390 active customer enrollments and 5,878 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 network deployment planning.

[1] 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).
[2] Id. at 32.

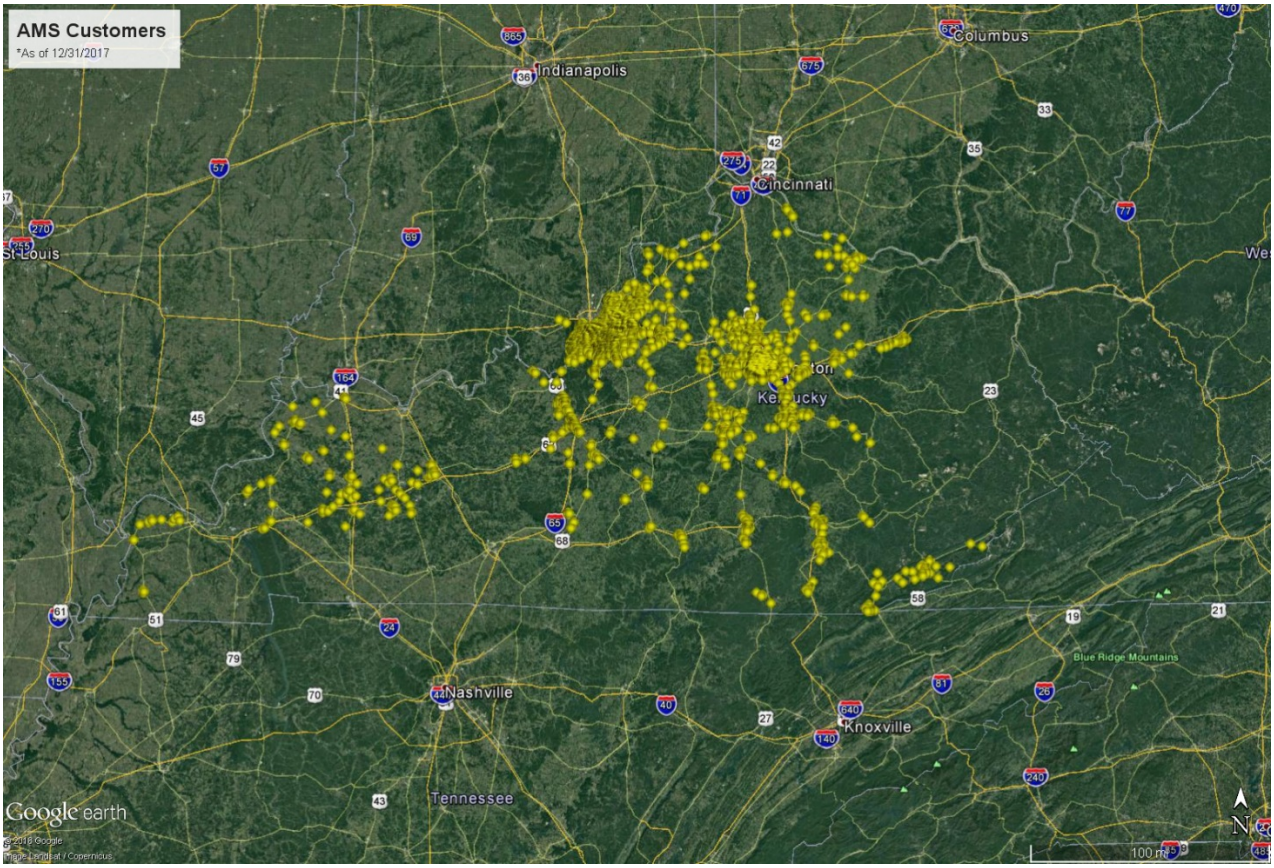



FIGURE 1 – ACTIVE CUSTOMER ENROLLMENTS IN AMS OPT-IN

Total customer enrollment between January 1 and December 31, 2017 is displayed in Figure 2 below. These counts represent total enrollments received in the month reported and are not net of any removals or cancelled requests.

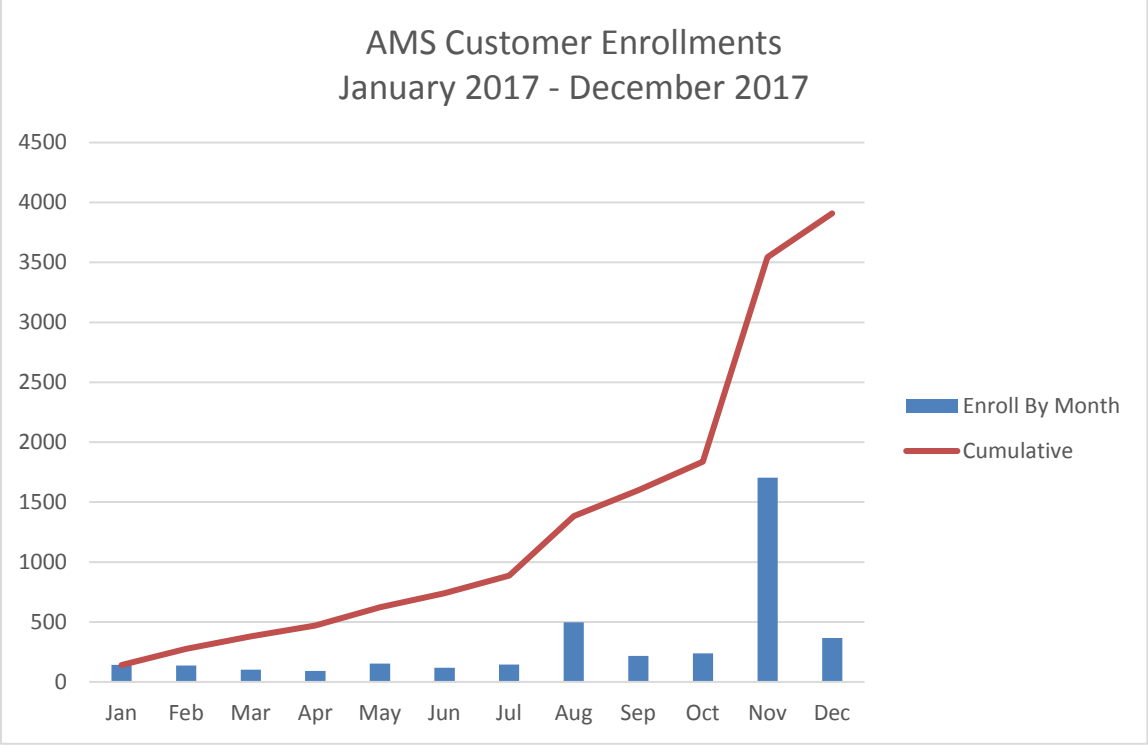



FIGURE 2 - CUSTOMER ENROLLMENTS IN AMS OPT-IN BY MONTH

Active enrollments in AMS Opt-In are distributed by company as seen in Figure 3 below.

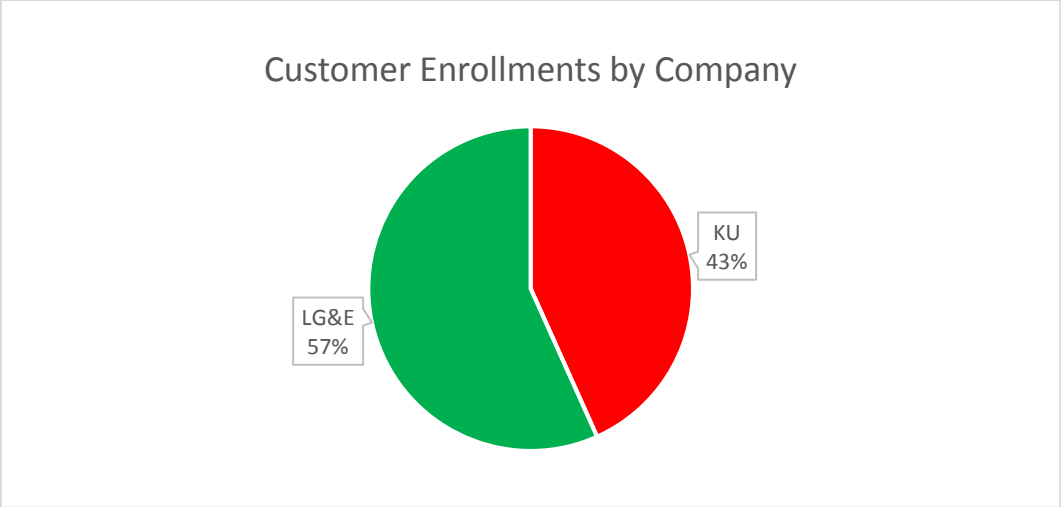



FIGURE 3 - AMS ENROLLMENT BY COMPANY

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 4 below.

| | **Active Program Enrollments as of December 31, 2017** | |
|---|---|---|
| **Rate** | **LG&E** | **KU** |
| Residential Electric Service | 4,065 | 3,049 |
| Residential Time-of-Day Energy | 9 | 2 |
| General Service Three Phase | 61 | 59 |
| General Service Single Phase | 56 | 89 |
| **Grand Total** | **4,191** | **3,199** |

FIGURE 4 - ENROLLMENTS BY RATE

As stated previously, 5,878 AMS meters are actively installed as of December 31, 2017. These meters are associated with 5,805 customers[3]. 36% of the current meter deployment utilizes cellular communications, while 64% are radio frequency (RF) mesh communicating meters.

Through 2017, 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 2017) | | |
|---|---|---|---|
| | Participation Goal | Actuals Enrollments | Installed |
| LG&E | 3,500 | 4,191 | 3,167 |
| KU | 3,500 | 3,199 | 2,638 |
| Total | 7,000 | 7,390 | 5,805 |

FIGURE 5 – AMS OPT-IN PARTICIPATION GOALS VS ACTUALS

[3] Some customers have more than one meter.

The participation numbers listed above are not inclusive of customers who move out (860 customers), resulting in an AMS meter removal if the move out occurs after the AMS meter was installed. Nor do they include customers (51 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 (195 customers) or opt out of the AMS offering after their meter is installed (23 customers).

Including the customers described above with the current enrollments results in over 8,500 customer enrollments received since program launch which provides a more reflective gauge of customer interest in AMS. This volume demonstrates customer excitement around AMS; outpacing the Companies' participation goal by over 21%. 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 6) reflects a sampling of the 2017 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.

| Page | Description | Pageviews | Unique Pageviews | Avg. Time on Page |
|---|---|---|---|---|
| **All page URLs begin: https://lge-ku.com/ *** | | 22,994 | 18,362 | 00:00:54 |
| saving-energy-money/advanced-meter-service/ | General awareness page that explains the service and how to sign up for it. | 17,696 | 14,573 | 00:01:02 |
| /advanced-meter/help | Help topics for AMS customers. | 2,741 | 1,630 | 00:01:04 |
| /advanced-meter | General awareness page that explains the service and how to sign up for it. URL introduced November 3, 2017. | 2,079 | 1,724 | 00:01:19 |
| /advanced-meter-service/ams/chart-view | AMS welcome site featuring helpful tips and video tutorials about how to use the MyMeter "Charts View". | 167 | 149 | 00:00:30 |
| /advanced-meter-service/ams/data-view | AMS welcome site featuring helpful tips and video tutorials about how to use the MyMeter "Data View". | 127 | 116 | 00:00:44 |
| /advanced-meter-service/ams/notifications | AMS welcome site featuring helpful tips and video tutorials about how to use the MyMeter "Notifications". | 99 | 92 | 00:00:31 |
| /advanced-meter-service/ams/profile | AMS welcome site featuring helpful tips and video tutorials about how to use the MyMeter "Profile". | 85 | 78 | 00:01:10 |

FIGURE 6 – GOOGLE ANALYTICS SNAPSHOT OF COMPANIES' AMS WEB TRAFFIC

The following table (Figure 7) 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[4] | 2016 | 2017 |
|---|---|---|---|
| Accounts registered (enrollments) | 908[5] | 3,281 | 2,179 |
| User Registrations (first time a user clicks into MyMeter) | 514 | 2,484 | 1,417 |
| Customer Energy Markers™ | 71 | 416 | 214 |
| Customer Notification: Mobile phone notification set-up | 34 | 73 | 36 |
| System Notifications[6] | 492 | 2,515 | 1,440 |
| Customer Notification: Threshold alert set-up | 54 | 173 | 103 |
| Threshold notifications sent by system | 653 | 12,663 | 21,318 |
| Total Sessions within MyMeter Site | 2,035 | 26,519 | 27,655 |
| Sessions by new users | 614 | 7,473 | 6,000 |
| Sessions by returning users | 1,421 | 19,046 | 21,655 |
| Average session duration (minutes:seconds) | 4:05 | 2:04 | 1:44 |
| Page visits/session | 2.96 | 1.8 | 1.69 |
| Average Number of times MyMeter visited per month | 508.8 | 2,209.92 | 2,304.58 |
| Unique pageviews to MyMeter site | 3,523 | 36,231 | 36,755 |
| Total MyMeter site pageviews | 6,027 | 47,742 | 46,788 |

FIGURE 7 – MYMETER WEB PORTAL ACTIVITY AND ANALYTICS

The chart below (Figure 8) illustrates the type of devices customers are using to access the MyMeter web portal.

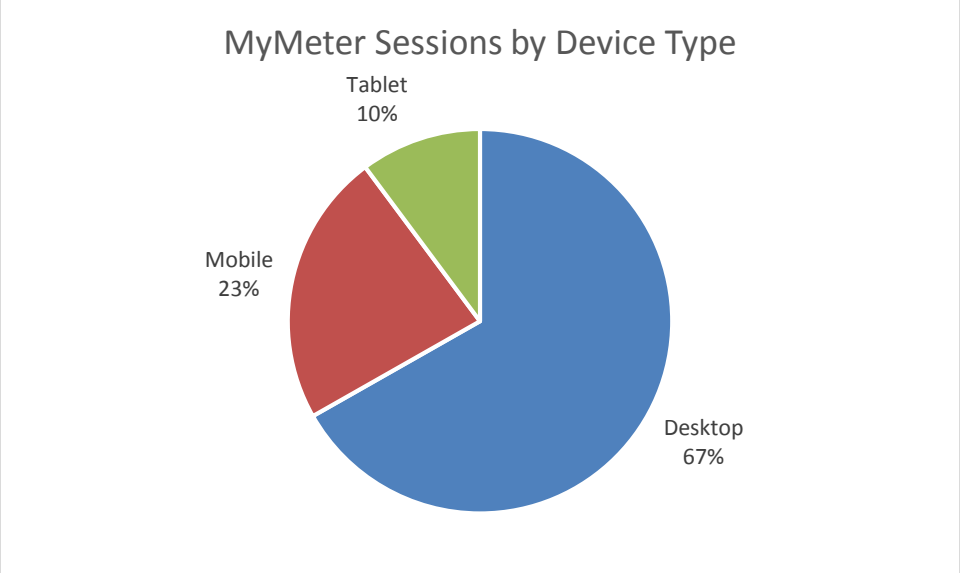



FIGURE 8 – MYMETER WEB PORTAL SESSIONS BY DEVICE TYPE. SOURCE: GOOGLE ANALYTICS

## System Design & Project Planning

The design process for the RF Mesh network infrastructure includes site surveys and field surveys of proposed substation, communication towers and distribution infrastructure locations. When suitable locations are finalized and approved, construction begins for the installation of communications

[4] 2015 metrics are for September – December 31.
[5] The difference between "Accounts registered" and "Meters installed" is that some accounts have multiple meters.
[6] 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 generated.

equipment. There are 31 substation and communication tower locations, and over 300 distribution infrastructure locations included in the Companies' RF Mesh design. The installation of RF Mesh network has been completed in the Louisville area (Jefferson County) and is 96% complete in the Lexington area (Fayette County). The balance of the Lexington area RF Mesh network is expected to be completed in 2018.

In August 2017, the Companies' upgraded the head-end software system, Command Center, which enables and controls the RF Mesh communicating meters and network infrastructure. This upgrade was needed to bring the software up to the latest release available at the time from the vendor and includes functionality that supports the Companies' efforts to provide the AMS Opt-In program to eligible customers across the state. One such piece of functionality is the ability to support cellular enabled meters from the same vendor that provides the RF Mesh meters which was not available in 2015 when the AMS Opt-In program was launched. The Companies' current cellular meter vendor uses the Verizon network for communications. While this is a highly robust network providing nearly 97% coverage of the Companies' service territory, there are still customers[7] who have requested AMS that fall outside this coverage area. Having additional meter vendors that use other cellular networks (like AT&T) will improve the ability of the Companies' to fulfil these requests.

The Command Center upgrade also enables the Companies' ability to implement Advanced Security protocols for the meter communications using the RF Mesh network. Under the previous configuration, meter communications were encrypted using what is classified as "Standard Security". Standard Security uses a single certificate to secure all network communications, meaning that a breach of this single certificate could place multiple meters at risk of a cyber-attack. The Company recognizes that industry best practices have evolved to mitigate the growing sophistication of cyber attackers and proceeded with the installation of Advanced Security to assure continued protection of the communications which transmits customer consumption information.

Advanced Security means that security certificates are created and assigned for each endpoint rather than a single certificate for all communications. This feature significantly reduces the risk of a successful cyber-attack gaining over-the-air control capabilities of all meters, therefore more effectively isolating the risk of a mass event. Advanced security protocols align with industry best practices as recommended by the National Institute of Standards and Technology Interagency Report (NISTIR) which states:

> *"Where meters contain cryptographic keys for authentication, encryption, or other cryptographic operations, a key management scheme must provide for adequate protection of cryptographic materials, as well as sufficient key diversity. That is, a meter, collector, or other power system device should not be subject to a break-once break-everywhere scenario, due to the use of one secret key or a common credential across the entire infrastructure. Each device should have unique credentials or key material such that compromise of one device does not impact other deployed devices."*[8]

Advanced Security was enabled on September 11, 2017.

[7] There are 17 customers that have requested AMS but are outside the Verizon coverage footprint as of December 31, 2017.
[8] Source: section 4.1.3, Pg. 219, NISTIR 7628.

# Customer Education

Customer education efforts for the AMS Opt-In program were significantly impacted in 2017 by the certificates of public convenience and necessity (CPCN) to fully deploy AMS across the Companies' service territories requested in the 2016 base rate cases[9]. 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. Additionally, to further reduce the potential for confusion, the Companies rebranded the AMS program offering from "Opt-In" to "Early Adopter". On April 19, 2017 a Stipulation and Recommendation agreement was entered by and between the Companies and the various intervening parties in which the Companies withdrew their requests to grant the CPCNs for the proposed full deployment of AMS. A ruling on the full rate review was issued on June 22, 2017 at which time customer education planning for AMS Opt-In was restarted.

The Companies deployed a number of customer education materials in 2017 in an effort to raise awareness of the AMS Opt-In program. These materials[10] included:

- Multiple email campaigns targeting areas with RF Mesh coverage
- Digital and social media campaign
- October LG&E and KU *Power Source* customer newsletters
- November LG&E and KU bill insert and envelope advertising
- Customer door hangers informing customers with meter access issues to participate in AMS
- Flyers and rack cards
- Yard signs at Company sponsored events like Homearama

# MyMeter Enhancements

The MyMeter web portal was updated throughout 2017 to enable a number of system improvements, bug fixes, and feature requests either received from customers or recommended by MyMeter. Some of the key new functionality included:

- Added dollar-based usage notifications for 15-minute and hourly data.
- Introduced a new feature for customers on time-of-day rates that shades customer energy consumption during on-peak hours; seeking to better enable the customer to quickly identify their usage patterns between on-peak and off-peak times.

Future enhancements will include a rate comparison tool that allows residential customers to quickly analyze what their bill would be if they were on the default energy rate, time-of-day energy, or time-of-day demand rates.

[9] Case No. 2016-00370, Application of Kentucky Utilities Company for an Adjustment of Its Electric Rates and For Certificates of Public Convenience and Necessity (Ky. PSC, Nov. 23, 2016). Case No. 2016-00371, Application of Louisville Gas & Electric Company for an Adjustment of Its Electric and Gas Rates and For Certificates of Public Convenience and Necessity (Ky. PSC, Nov. 23, 2016).

[10] Samples of the various education materials may be found in Appendix 2.

# Impact Assessment

In 2017 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 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 2017 analysis indicated average household energy savings of approximately 3.8 percent.

# Lessons Learned to Date

As Figure 1 displayed, customers across the Companies' service territories continue to show interest in the AMS Opt-In offering. Customers have 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 for additional functionality such as support for customer purchased in-home devices.

# Problems & Resolutions

Customers with time-of-day rates can also now not only view their usage but also, beginning in May 2017, can quickly differentiate from off-peak and on-peak hours within the presentment portal which implemented the additional benefit of shading during on-peak times. This feature is aimed to facilitate a better understanding of when usage is occurring.

There were two occurrences in 2017 that resulted in widespread delays in loading customer usage data to the MyMeter portal outside of the two business day commitment. The first occurred from May 26$^{th}$ to May 31$^{st}$ and was due to the Companies' planned SAP upgrade go-live. During the go-live period the AMS inbound and outbound file transfers were disabled until the impactful upgrade activities were complete. On May 31$^{st}$ the customer data was loaded and normal operations resumed. The second disruption occurred

during the previously discussed upgrade of Command Center from August 8th to August 18th. The delay was related to migrating all the meter communications from the previous system to the new. All systems operated as designed resulting in no usage data being lost during this time; rather it was delayed in being loaded to the MyMeter portal for customer review. Additional delays occurred in 2017 but were isolated to fewer customers 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.

The Companies also received a customer complaint, filed with the Commission on December 7th. A summary timeline of the event and actions taken to resolve is provided below:

- On the night of November 28th, the vendor that provides the MyMeter portal service deployed an update to their system that introduced a bug to the way solar data was displayed. Instead of accurately reflecting a negative value for the generated usage it was being added to the usage delivered by the Companies.
- The customer reported seeing this bug on November 29th around the same time the vendor reported the bug to the Companies. The meter was always accurately recording and reporting the consumption, both generated and delivered, but the error was in how the consumption was being presented in MyMeter. The customer was advised that the error would be corrected and that there was no impact to billing. The bug was resolved later on November 29th.
- On December 7th, the customer bill was mailed and the customer contacted us again that day with concerns that their bill was incorrect. The customer was advised that their bill was correct. Later the same day the customer contacted the Companies stating they were going to file a complaint to the Commission which they did. Ultimately the Companies made multiple unsuccessful attempts to follow up with the customer; eventually closing the complaint on December 12th.

Lastly, inventory delays with cellular meters reported in 2015 continued to impact deployment of all meter types in areas of 4G/LTE cellular network coverage in 2016. To minimize customer impact, the Companies secured 3G meter inventory for RS customers until the meter manufacturer resolved issues with the 4G/LTE products in October 2016. In July 2017 the Companies received notice from Verizon that they plan to sunset support of 3G communications on December 31, 2019. This will mean that roughly 2,000 of the over 2,800 cellular meters will need to be replaced by that date. The Companies have begun mitigation planning efforts and will seek to finalize plans in 2018.

## Subsequent Updates and Operations

The next AMS Opt-In report will be in January 2019.

# 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™**
The number of Energy Markers™ created in a given timeframe. Energy Markers™ 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™ 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

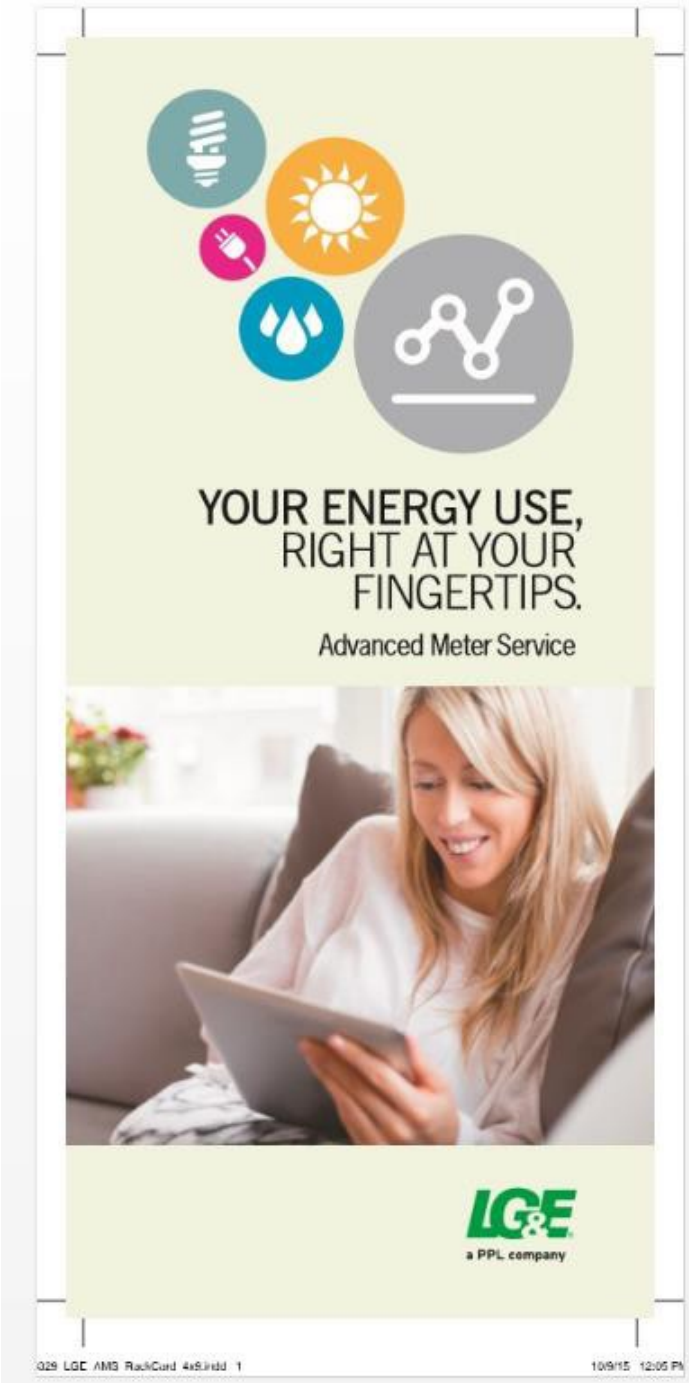
**Total MyMeter site pageviews**
Pageviews is the total number of pages viewed. Repeated views of a single page are counted. Source: Google Analytics

# APPENDIX 2 – AMS EDUCATION MATERIALS

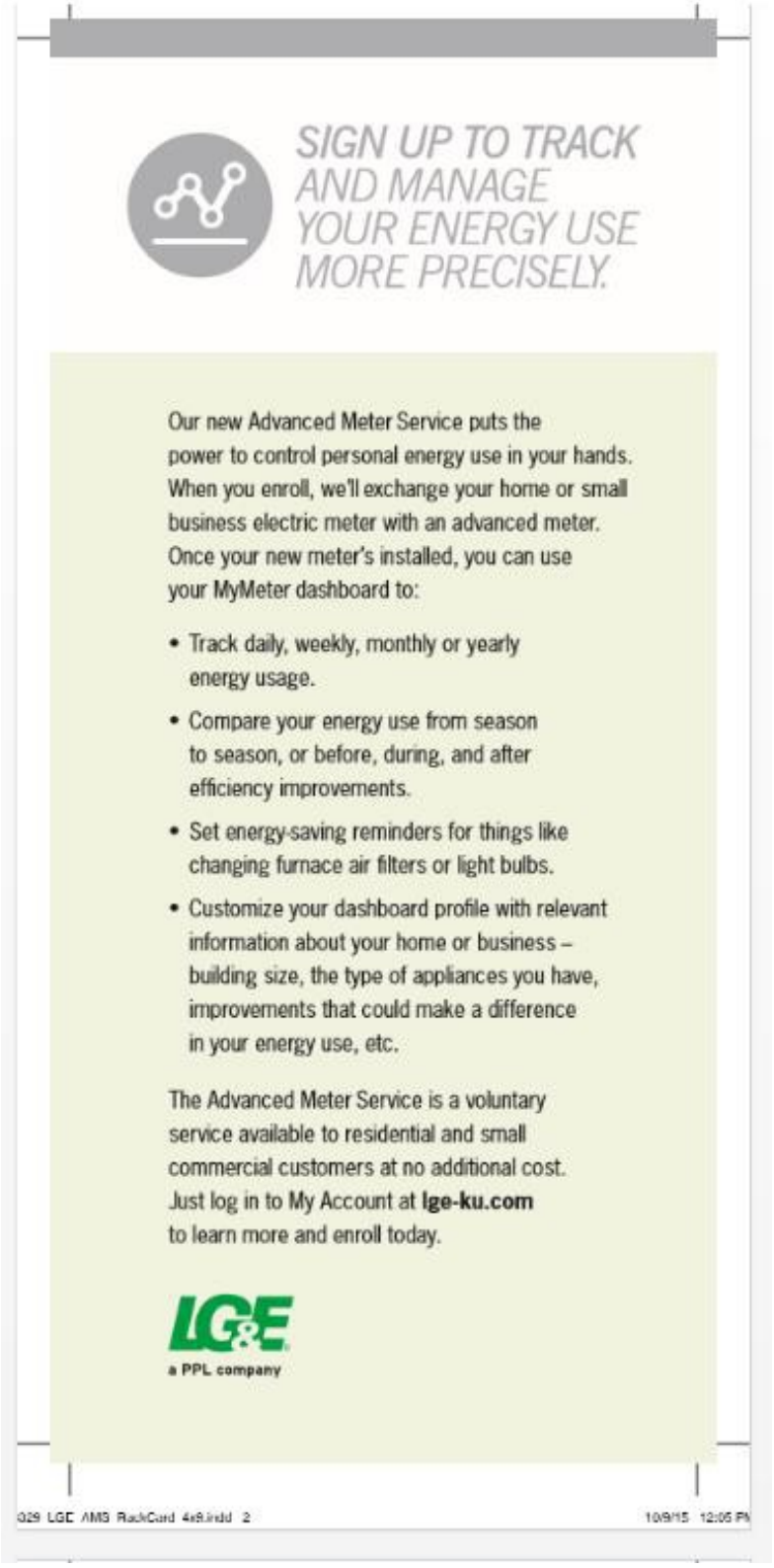
**RACK CARDS**

**Front – LG&E**

Microsoft Word Web App



**Back – LG&E**



SIGN UP TO TRACK AND MANAGE YOUR ENERGY USE MORE PRECISELY.

Our new Advanced Meter Service puts the power to control personal energy use in your hands. When you enroll, we'll exchange your home or small business electric meter with an advanced meter. Once your new meter's installed, you can use your MyMeter dashboard to:

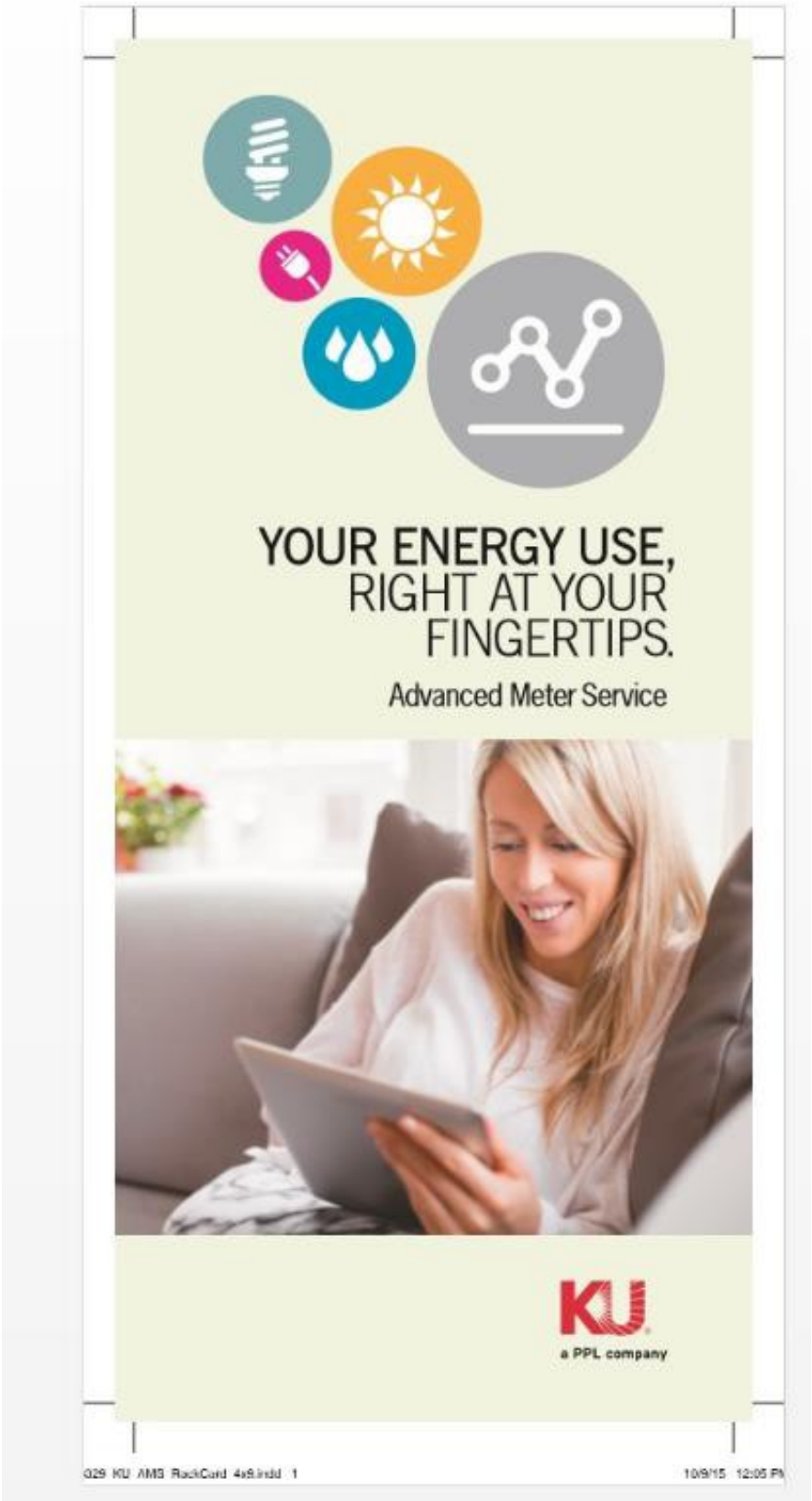
- Track daily, weekly, monthly or yearly energy usage.
- Compare your energy use from season to season, or before, during, and after efficiency improvements.
- Set energy-saving reminders for things like changing furnace air filters or light bulbs.
- Customize your dashboard profile with relevant information about your home or business – building size, the type of appliances you have, improvements that could make a difference in your energy use, etc.

The Advanced Meter Service is a voluntary service available to residential and small commercial customers at no additional cost. Just log in to My Account at **lge-ku.com** to learn more and enroll today.

LG&E
a PPL company

029 LGE AMS RackCard 4x9.indd 2 10/9/15 12:05 PM

**Front - KU**


YOUR ENERGY USE,
RIGHT AT YOUR
FINGERTIPS.
Advanced Meter Service
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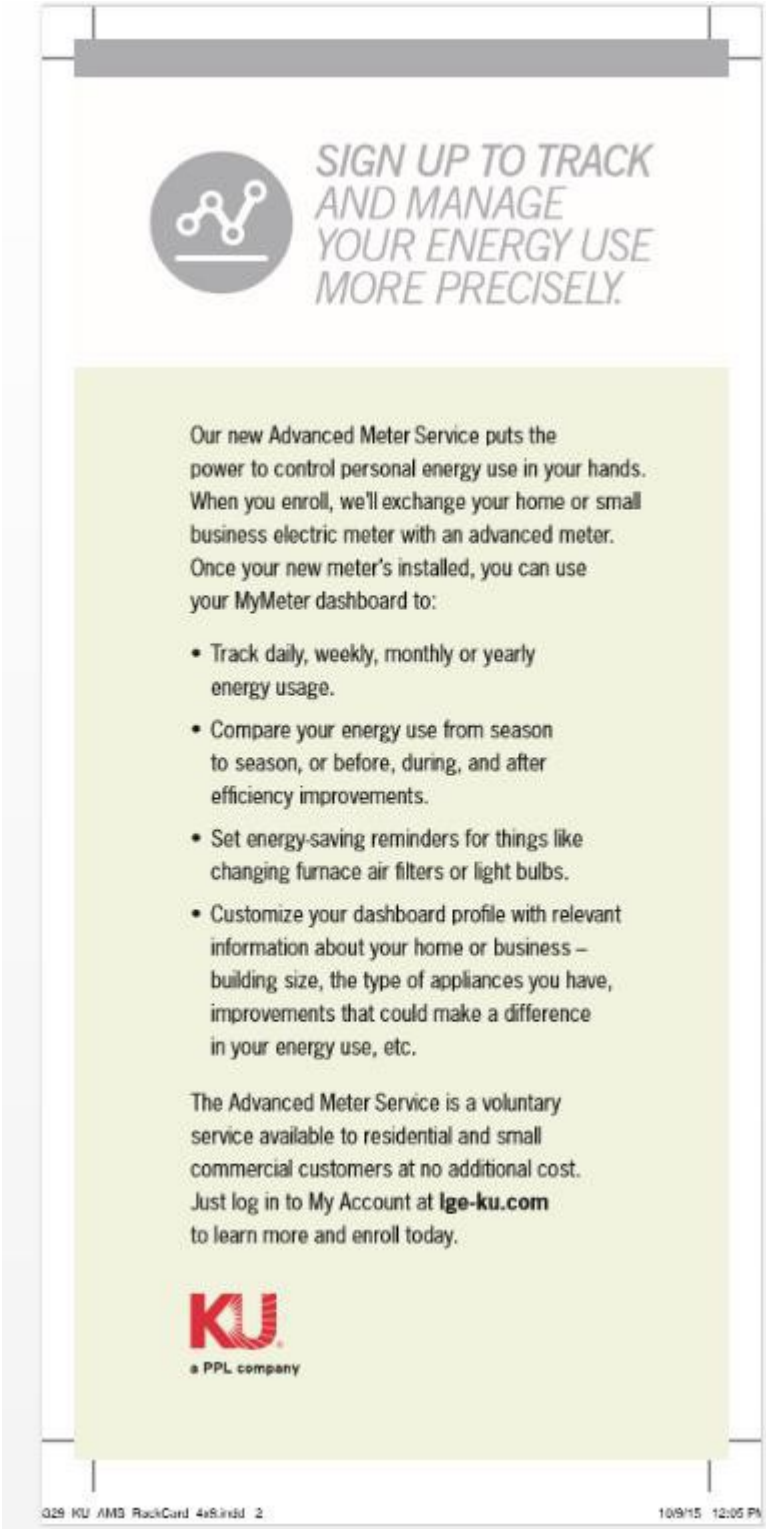
**Back - KU**



SIGN UP TO TRACK AND MANAGE YOUR ENERGY USE MORE PRECISELY.

Our new Advanced Meter Service puts the power to control personal energy use in your hands. When you enroll, we'll exchange your home or small business electric meter with an advanced meter. Once your new meter's installed, you can use your MyMeter dashboard to:

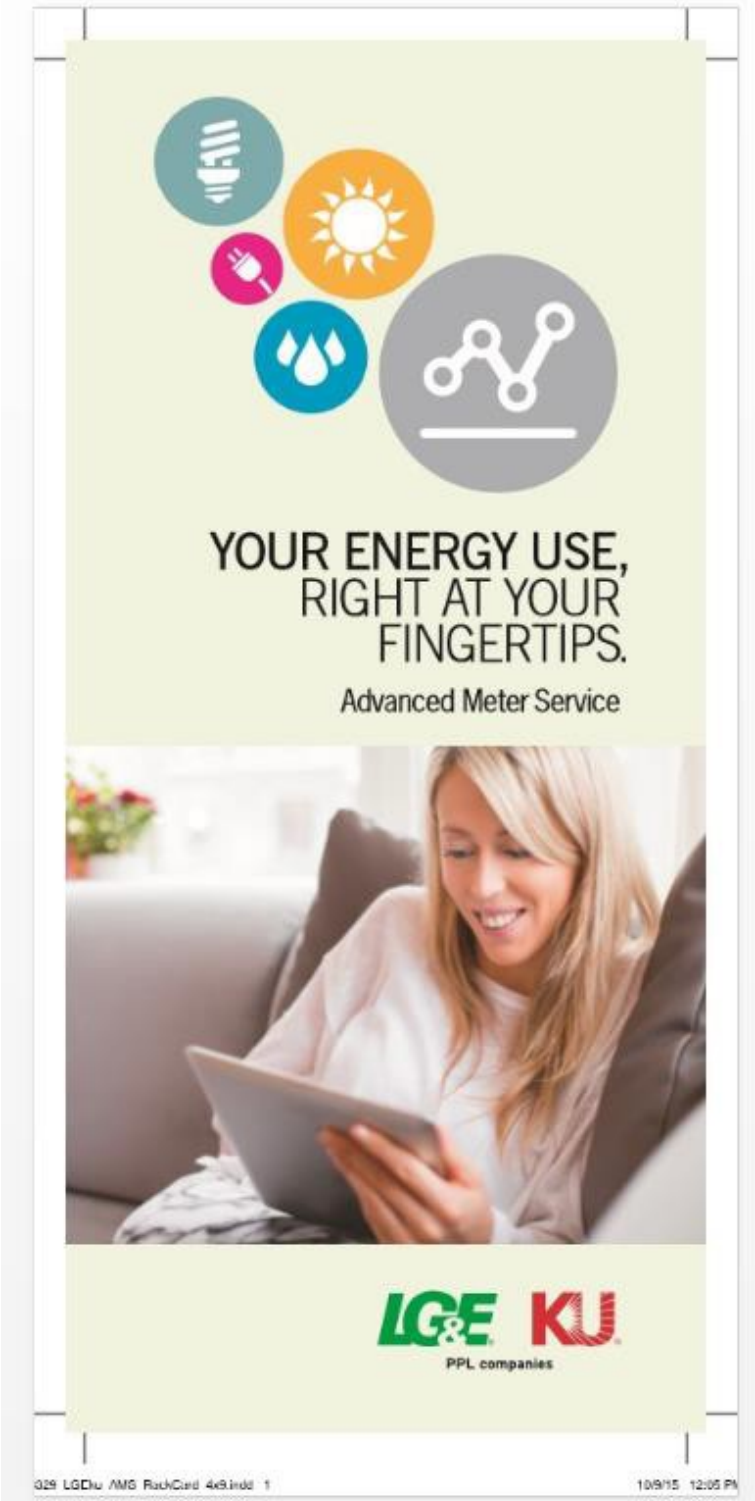
- Track daily, weekly, monthly or yearly energy usage.
- Compare your energy use from season to season, or before, during, and after efficiency improvements.
- Set energy-saving reminders for things like changing furnace air filters or light bulbs.
- Customize your dashboard profile with relevant information about your home or business – building size, the type of appliances you have, improvements that could make a difference in your energy use, etc.

The Advanced Meter Service is a voluntary service available to residential and small commercial customers at no additional cost. Just log in to My Account at **lge-ku.com** to learn more and enroll today.

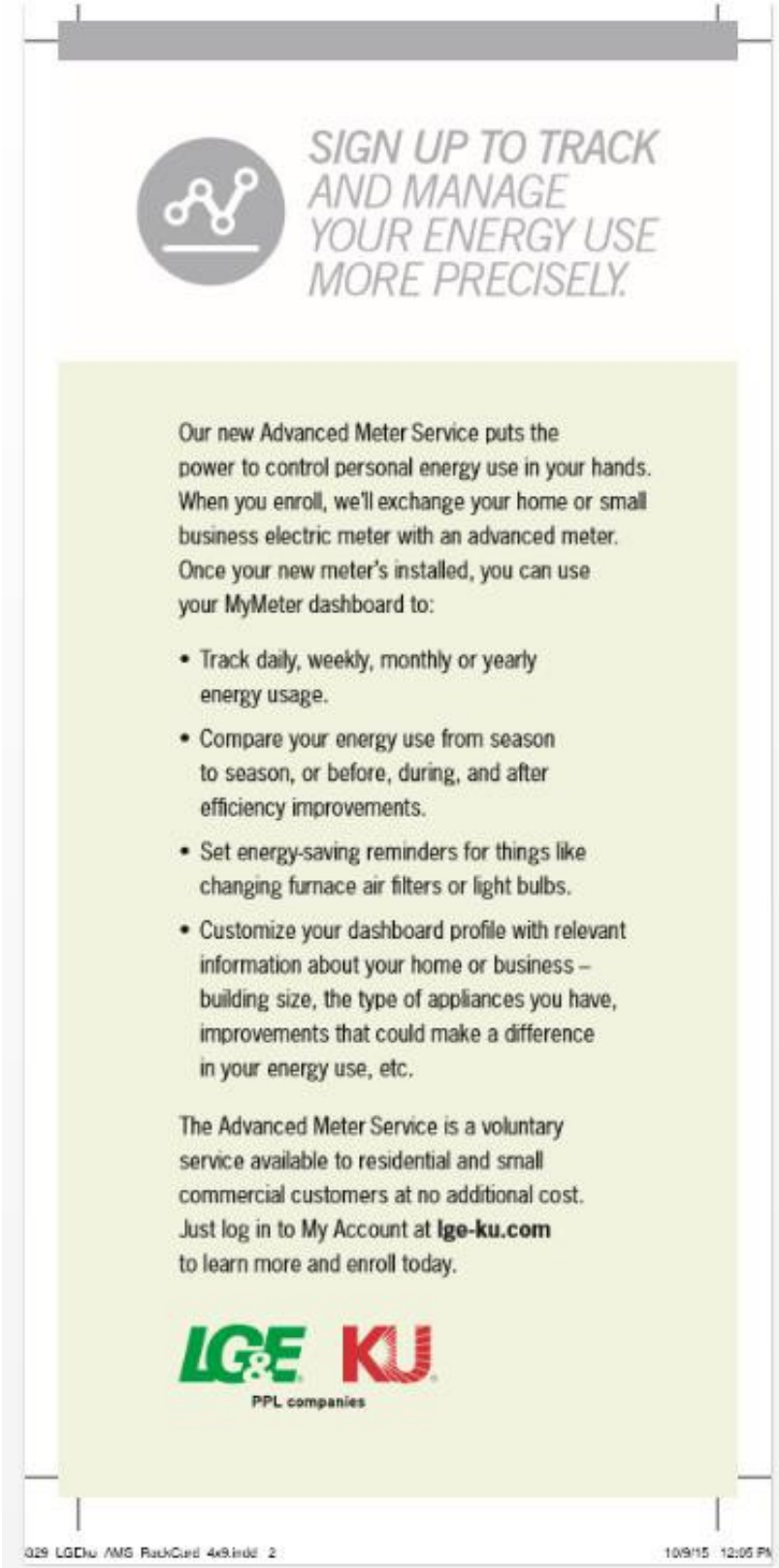
KU
a PPL company

029 KU AMS RackCard 4x8.indd 2 10/9/15 12:05 PM

**Front – LG&E and KU Version**

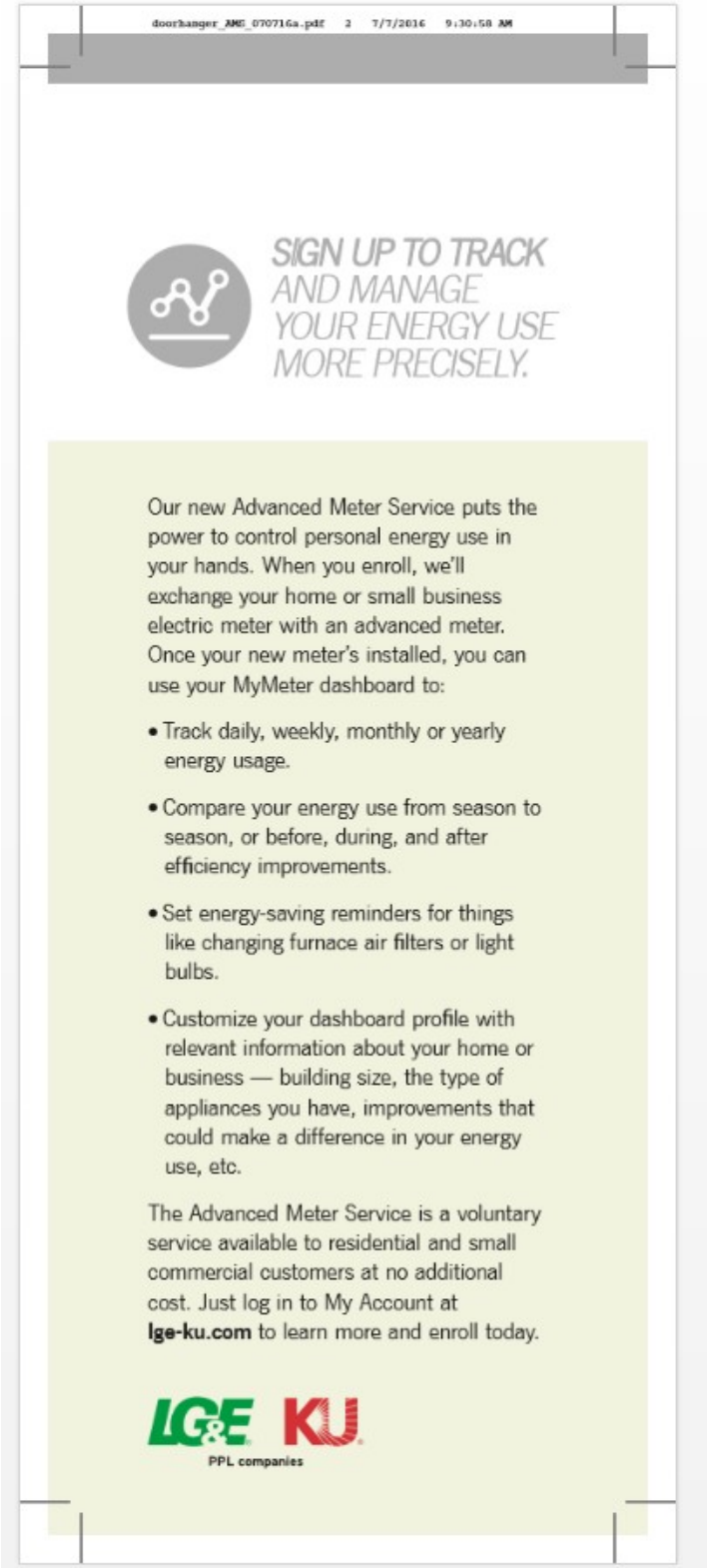


**Back – LG&E and KU Version**



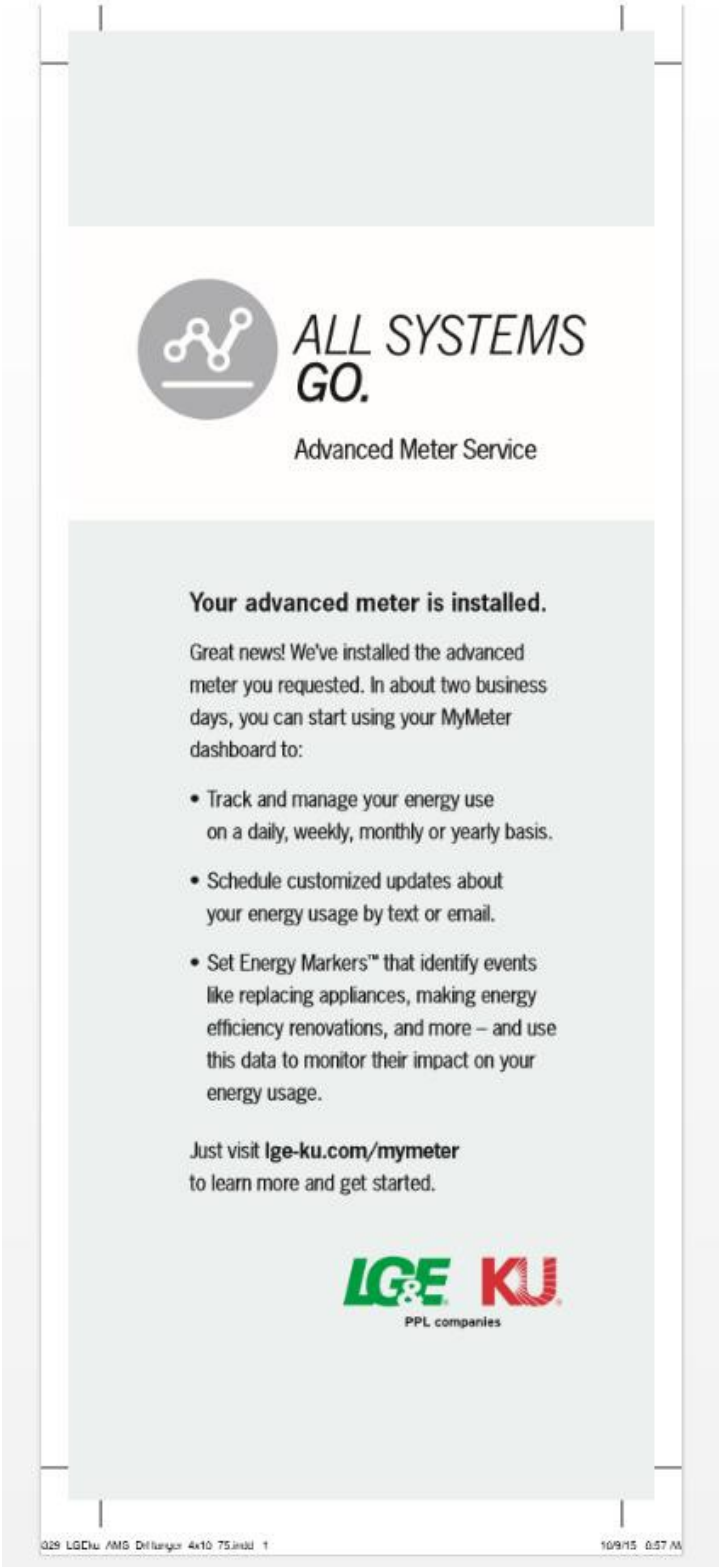
**RACK CARDS - FRONT**

**RACK CARDS - BACK**



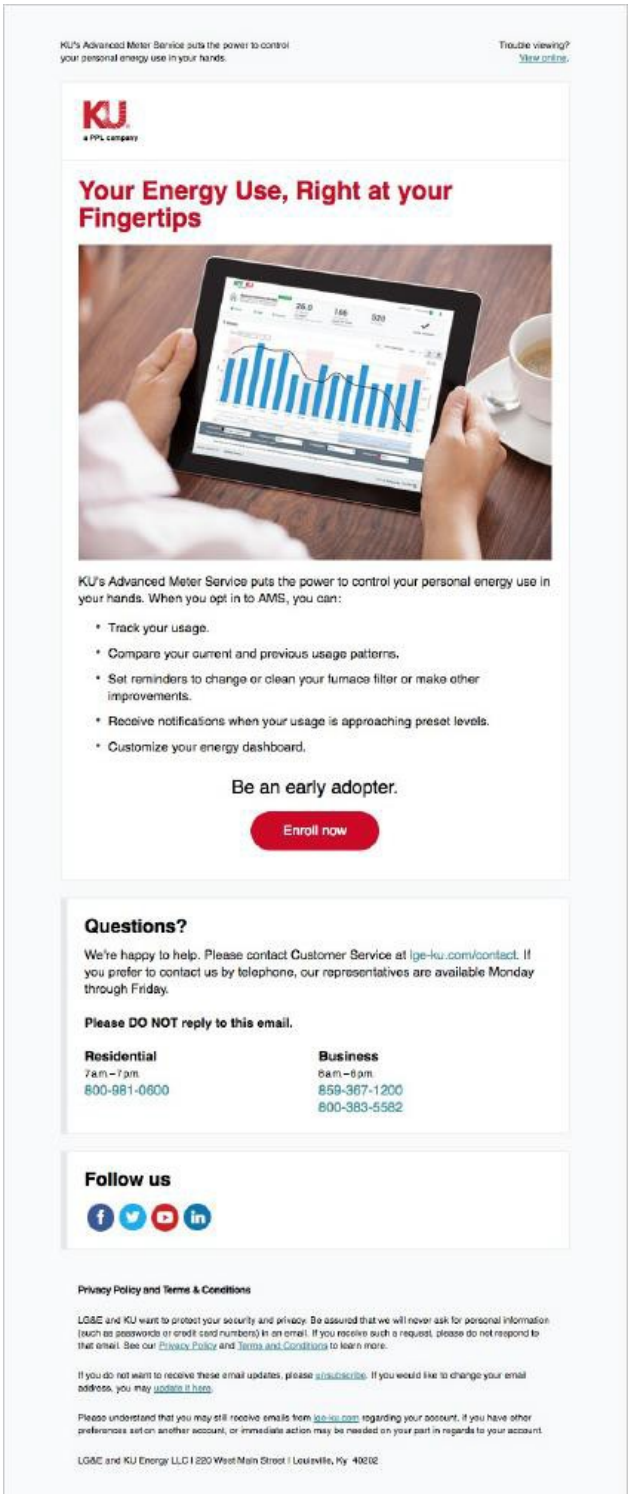
## DOOR HANGER

Microsoft Word Web App



## EMAIL BLASTS

### July 2017



KU's Advanced Meter Service puts the power to control your personal energy use in your hands.

Trouble viewing? View online.

KU
a PPL company

# Your Energy Use, Right at your Fingertips

KU's Advanced Meter Service puts the power to control your personal energy use in your hands. When you opt in to AMS, you can:

- Track your usage.
- Compare your current and previous usage patterns.
- Set reminders to change or clean your furnace filter or make other improvements.
- Receive notifications when your usage is approaching preset levels.
- Customize your energy dashboard.

Be an early adopter.

Enroll now

## Questions?

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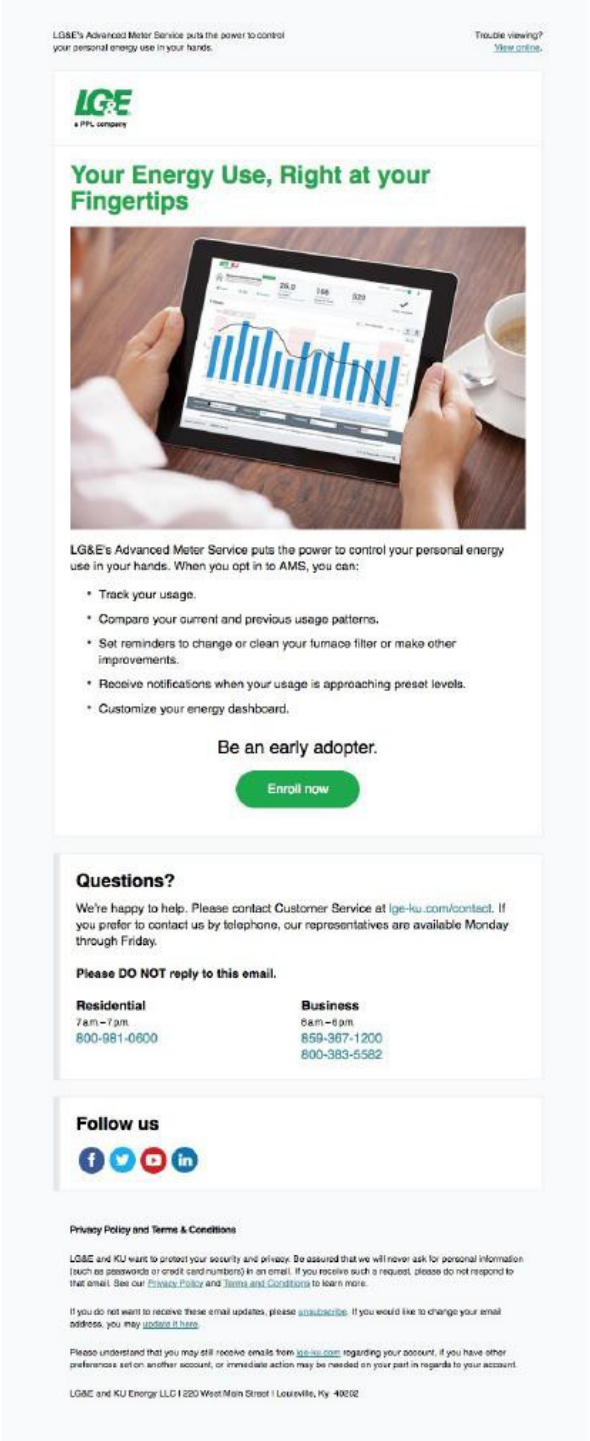

LG&E's Advanced Meter Service puts the power to control your personal energy use in your hands.

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## Your Energy Use, Right at your Fingertips

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- Track your usage.
- Compare your current and previous usage patterns.
- Set reminders to change or clean your furnace filter or make other improvements.
- Receive notifications when your usage is approaching preset levels.
- Customize your energy dashboard.

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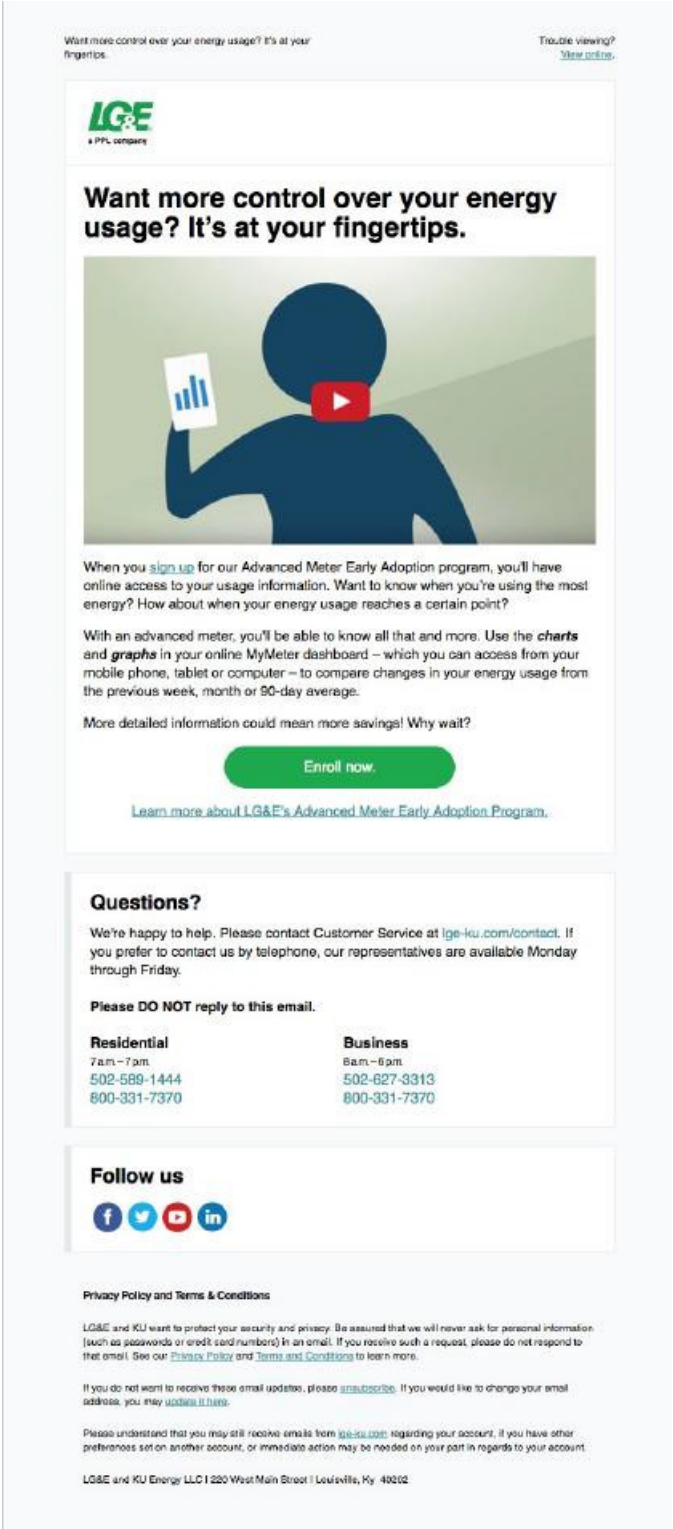

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With an advanced meter, you'll be able to know all that and more. Use the ***charts*** and ***graphs*** in your online MyMeter dashboard – which you can access from your mobile phone, tablet or computer – to compare changes in your energy usage from the previous week, month or 90-day average.

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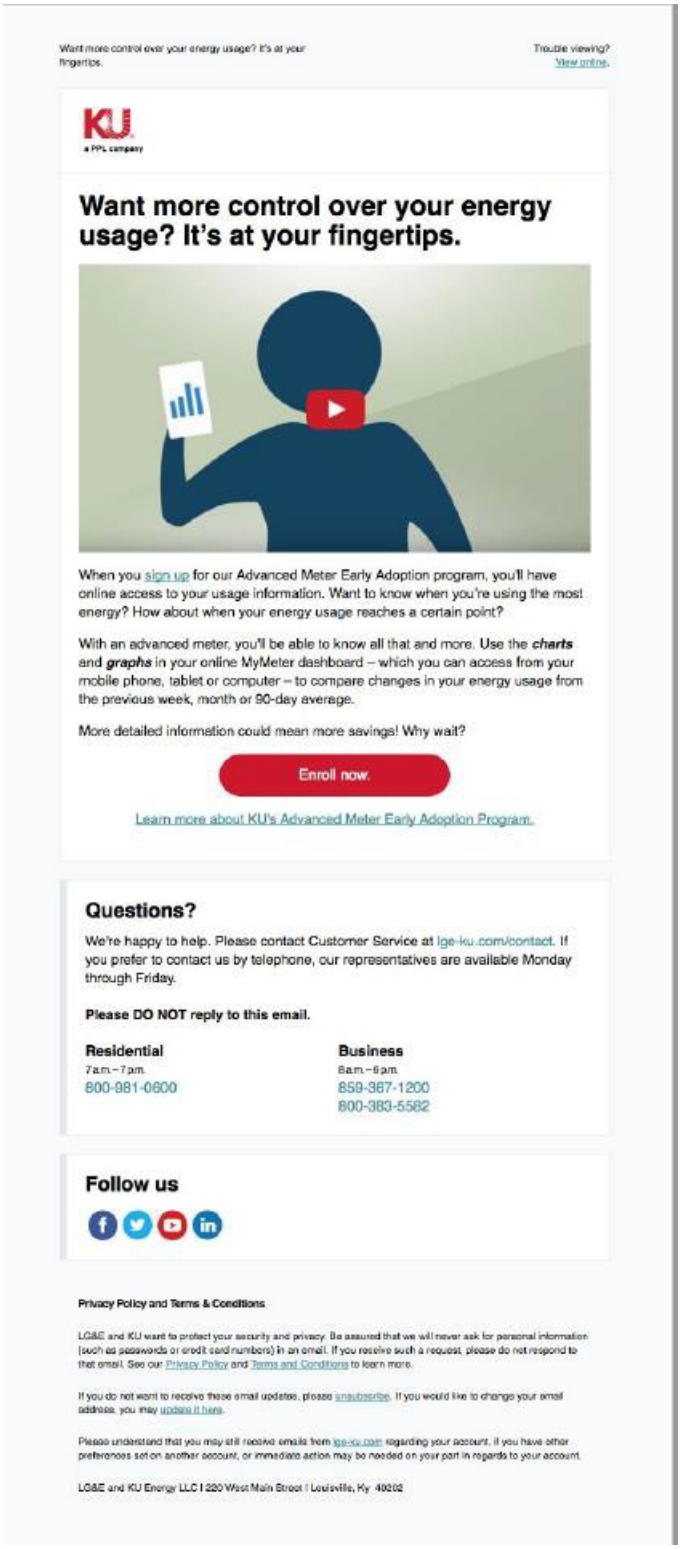
**November 2017 (Residential – KU)**



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With an advanced meter, you'll be able to know all that and more.

Use the ***charts*** and ***graphs*** in your online MyMeter dashboard – which you can access any time day or night – to compare changes in your energy usage from the previous week, month or 90-day average.

It doesn't matter if your business is open weekdays from 9 to 5 or 24/7/365. You can take steps to save energy. More detailed information could mean more savings! Why wait?

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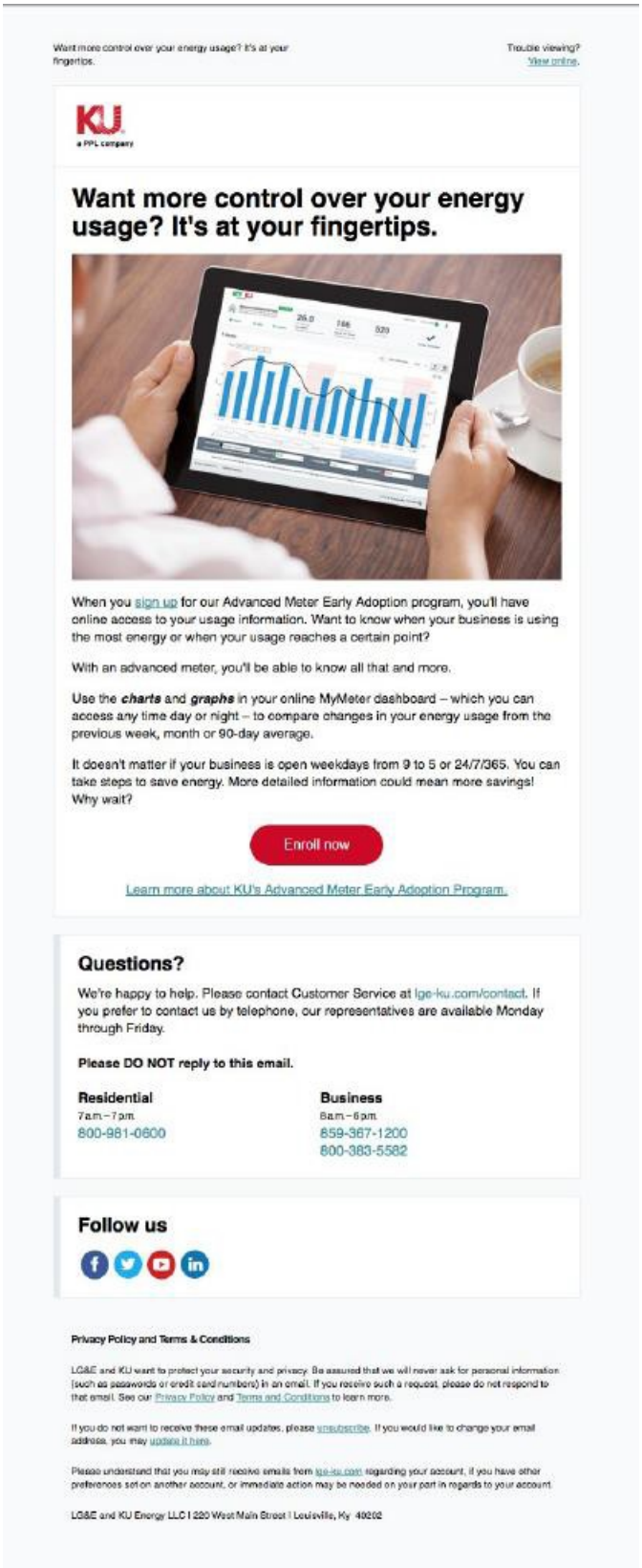

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**Bill Insert (Front – KU)**

# Advanced Thinking:
## More detailed info could mean more savings!

**KU's Early Adoption Advanced Meter Service** provides more information about your energy usage, including when you're using the most energy. This detailed information can help you better understand the factors that impact your energy bill.


## What is an advanced meter?

Advanced meters give you **more timely information** on your energy use. After installation, you can access a customized online dashboard that can help **track and compare your energy usage** by day, week, month or year.

KU
a PPL company

**BILL INSERT (KU – BACK)**

While most meters record a running total of the amount of energy used, **an advanced meter can record energy usage data in 15-minute increments**. The meter will communicate the usage information to KU's data network system several times a day. And customers can set thresholds to be **notified when their energy usage reaches a certain point**.

That knowledge lets customers know more specifically when they are using energy, which can help them enact energy-efficiency measures to reduce usage and lower costs.

With an advanced meter, **all customer information is confidential**.

## Be an early adopter

**There is no additional cost to upgrade to an advanced meter**. The Advanced Meter Early Adoption Program is only available to the first combined 5,000 KU residential electric and small commercial customers who sign up. **To enroll**, sign in to your online account today, or create one, at **my.lge-ku.com**.

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**859-367-1200** (Business Service Center)
**800-383-5582** (outside Lexington area)

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**BILL INSERT (LG&E – FRONT)**

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**502-627-3313** (Business Service Center)
**800-331-7370** (outside Louisville area)

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## Envelope Messages

**Advanced Thinking –** More detailed info could mean more savings.

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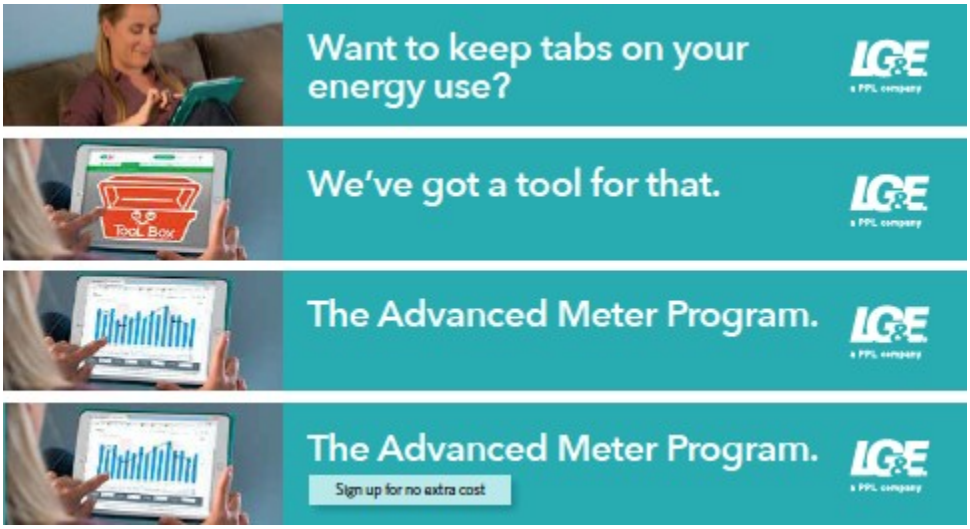
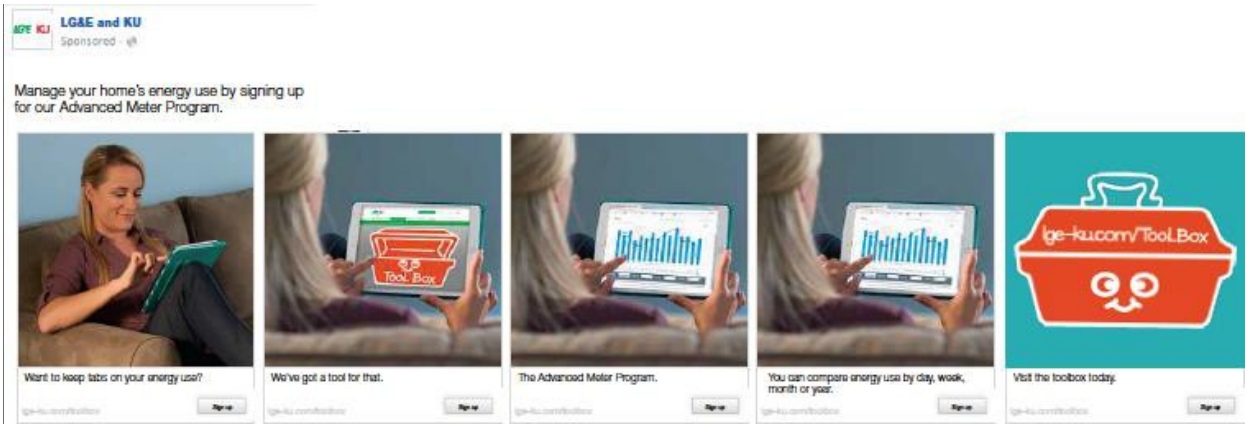
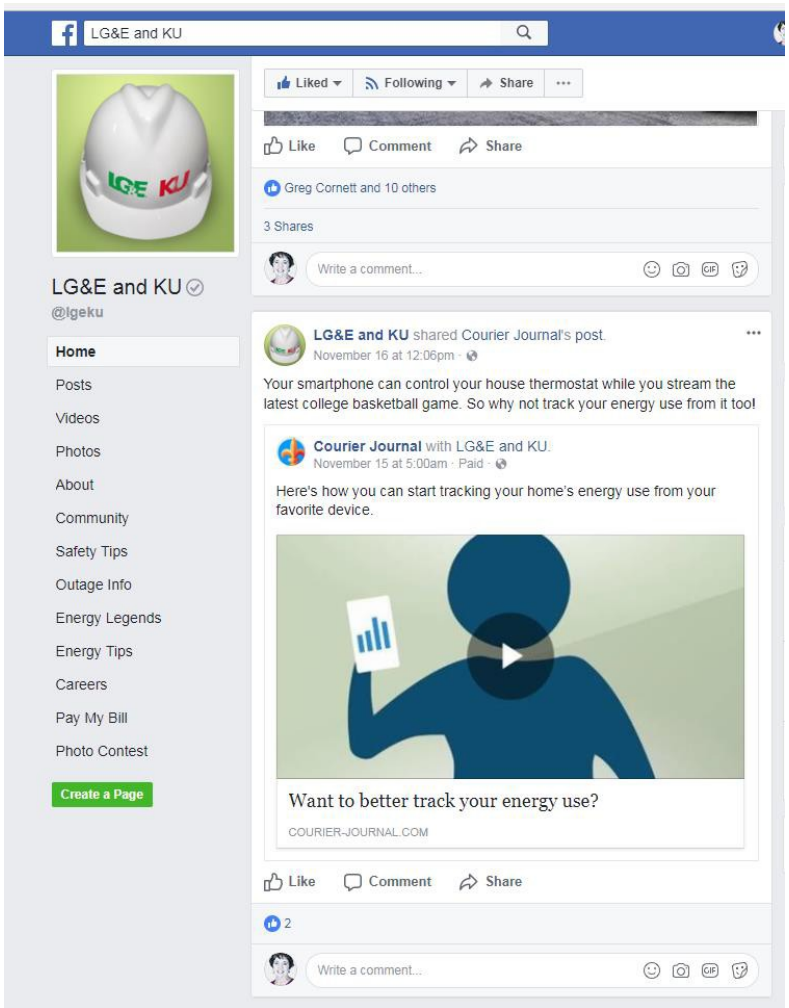


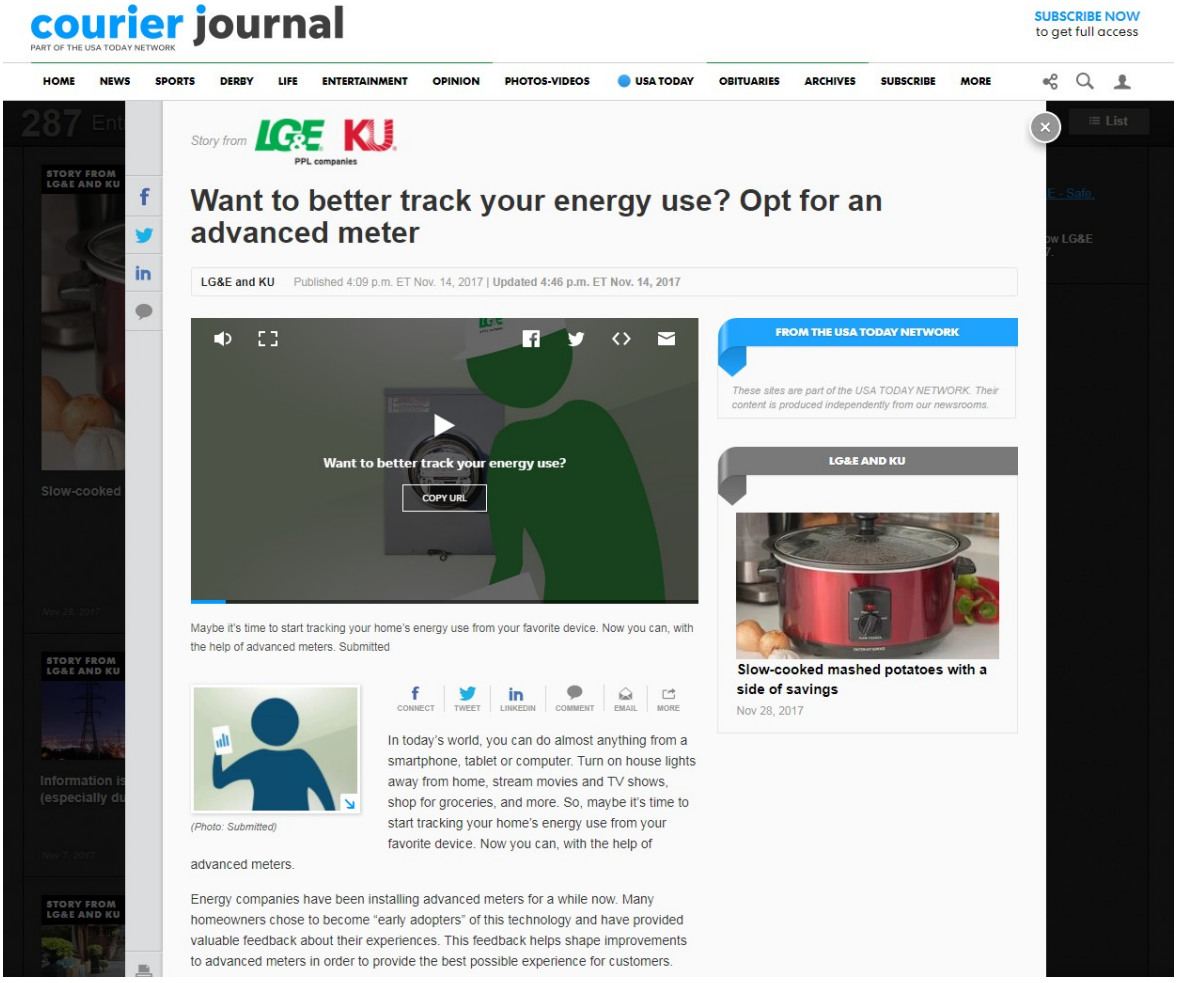
## Facebook Ads




## Social Media Posts



## Courier-Journal Energy Matters (Native Advertising)



## Videos

LG&E 15-second: https://www.youtube.com/watch?v=QUaE3xfV_7w

LG&E with FAQs: https://www.youtube.com/watch?v=bMZug13VlpA

KU 15-second: https://youtu.be/NmdL1YXYjD8

KU with FAQs: https://youtu.be/hzrLpXD_oIs

TETRA TECH

| | |
|---|---|
| ***To:*** | Greg Lawson, Kevin Craft, Jeff Myers, and Jonathan Whitehouse, LG&E and KU |
| ***Cc:*** | Rich Hasselman and Carrie Koenig, Tetra Tech |
| ***From:*** | Sue Hanson and Jonathan Hoechst |
| ***Date:*** | January 3, 2018 |
| ***Subject:*** | AMS Opt-In Program Impact Evaluation - FINAL |

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. Consumption and participation data spanning the January 1, 2015 to August 31, 2017 timeframe was analyzed, while MyMeter user data spanned from September 7, 2015 to December 5, 2017. Findings are presented in the following main topic areas:

- Introduction and program description
- Executive summary
- Savings estimation methodology
- Findings.

## INTRODUCTION AND PROGRAM DESCRIPTION

In January 2014, LG&E and KU proposed a voluntary AMS Opt-In program[1]. The initial deployment was limited to 5,000 LG&E and 5,000 KU residential and general service customers on a first-come-first-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[2], 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[3]. 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. This percentage was based on an estimate that 17 percent of

[1] Case No. 2014-00003
[2] https://smartenergycc.org/wp-content/uploads/2013/10/SGCC-Econ-and-Environ-Benefits-Full-Report.pdf, Page 30
[3] KU Case No. 2016-00370 and LG&E Case No. 2016-00371

customers will engage with the equipment and the web portal in a meaningful way and that these customers will save, on average, three percent of their energy consumption. LG&E and KU had observed preliminary results from the AMS Opt-in program participants that supported the engagement estimate and based the three percent energy savings estimate to be conservatively below the 2013 SGCC report's findings. For the purposes of estimating an overall benefit of the equipment, this logic was applied only to residential electric customers' consumption. Thus, while it was planned for both residential and commercial customers to receive advanced meters, the aggregate consumption benefit was limited to 0.5 percent of residential consumption. Any possible additional energy consumption reduction by small commercial customers was not counted in LG&E and KU's analysis.

## EXECUTIVE SUMMARY

Based on our analysis of consumption and participation data spanning January 1, 2015 through August 31, 2017, Tetra Tech recommends the impact of the AMS Opt-In program be estimated at 580 kWh per household, or 3.8 percent of annual consumption. Analysis presented in this memo also provides additional estimates of the potential savings achievable if AMS were deployed across all residential customers in LG&E and KU's service territory.

Using Google Analytics and other data files from the MyMeter web portal documenting user engagement, Tetra Tech's analysis resulted in average energy savings of 0.99 percent per AMS device. Based on Google Analytics MyMeter participant data, Tetra Tech found that 70.3 percent of AMS Opt-in program participants successful registered an account through the MyMeter ePortal, and of those, 37.2 percent became actively engaged users. Using these percentages, we estimated the aggregate savings of all residential advanced meter recipients to be:

$$0.703 \times 0.372 \times 0.038 = 0.0099$$

It is difficult 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.

The AMS Opt-in program had a reasonably large treatment group from which to determine program effects; however the contrast group, made up of later program enrollees, was by default, smaller. Hence, looking only at the treatment group, one readily concludes that normalized consumption declined following opting into the program. The size of this decline, more than four percent of consumption, was eight times larger than the 0.5 percent reduction that LG&E and KU program planning had originally anticipated.

Consumption among the contrast group also declined during the pre/post period of this study. The reduction was small—small enough that we could not eliminate the statistical possibility that no reduction occurred. However, it is statistically more likely that some reduction among the contrast group occurred. The reasons for this reduction are unrelated to weather—which has been controlled for—but we cannot provide a definitive explanation for why they occurred. For example, participants may have purchased energy efficient equipment either as a course of normal equipment replacement or through LG&E and KU's energy efficiency programs.

# SAVINGS ESTIMATION METHODOLOGY

## OVERVIEW

In October 2016, Tetra Tech provided a preliminary estimate of program impacts, based on limited participation data. Tetra Tech conducted billing analysis on opt-in customers, including both a treatment and a contrast group. At that time, Tetra Tech identified 164 customers who had participated in the AMS Opt-in program long enough to have at least 10 months of post-AMS installation data, as well as 199 contrast group participants. For the current analysis, we 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. Similar to the October 2016 analysis, Tetra Tech conducted a statistical billing analysis to estimate energy savings among households participating in the voluntary AMS Opt-In program. We analyzed data during two periods:

1. The period 1, from January 2015 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 August 29, 2017. 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*.

We also created a *contrast group* against which to compare program savings.[4] In this group were customers who 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. 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 2017). 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, 2017 would be assigned a median month of April 2016. The pre installation period would correspond to January 2015-April 2016, and the post installation period would be May 2016-June 2017. 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.

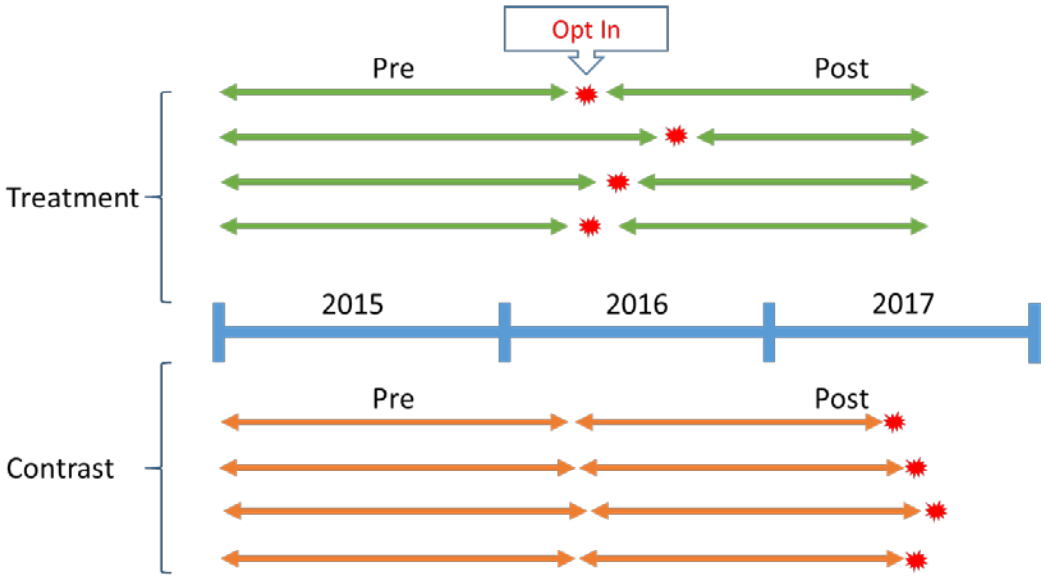
Figure 1 illustrates the relationship between the pre and post periods for the treatment and contrast groups. The treatment group is represented by the green bars above the timeline. For them, the pre period extends up to, but not including, the billing months during which an AMS device was

[4] We avoid the term "control group" because households were not randomly assigned.

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 analysis. Thus, we have a minimum of 12 calendar months of data 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 2016 but had at least 12 months of untreated data following the median installation date among the treatment group. Thus, 2016 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. We estimated a separate model for treatment and contrast groups and interpret the difference in variances between the two groups as the overall program impact. We also estimated a panel fixed effects regression model, which estimated impacts in the aggregate, across all households.

## DATA COLLECTION

Tetra Tech received data[5] from LG&E and KU indicating account numbers for all residential customers participating in the AMS Opt-in program, 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 5,875 customers across both LG&E and KU service territories. Records included the billing periods ending between January 1, 2015 and August 31, 2017 (see Table 1).

Tetra Tech downloaded hourly temperature data from the National Oceanic and Atmospheric Administration's National Climatic Data Center[6] for the entire study period. We targeted two

[5] AMS Opt-in usage Jan 2015 – Aug 2017.xlsx.
[6] https://www.ncdc.noaa.gov/

weather stations, one at Louisville International Airport and one at Lexington Blue Grass Airport. From the 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[7]. 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

We applied the following screening procedures to billing data to remove monthly data and entire households that might distort the findings.

- **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.
- **Extreme monthly consumption.** We removed commercial customers (those receiving electricity under GS rate categories), and subsequently removed the one percent highest and lowest energy consumers of the monthly consumption data. We retained households that had an adequate number of months of data after this screening.
- **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. We 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. With a relatively small sample, the extremes can bias the average results. Eliminating both high energy savers and high energy consumption increasers avoided the extreme changes from biasing the results in either direction.

Table 1 shows the effect on total sample size of each screening activity.

**Table 1. Data Screening**

| Analysis Group | Number in Sample |
|---|---|
| Initial Sample | 5,108 |
| (Treatment Group) Have 12 months consumption data post opt-in and at least 24 months total | 2,569 |
| (Contrast Group) Have no more than 4 month data post opt-in and at least 28 months total | 428 |
| (Treatment Group) Extreme Change in Estimated Annual Pre/Post Consumption | 116 |
| (Contrast Group) Extreme Change in Estimated Annual Pre/Post Consumption | 57 |
| **Total Treatment Group in Analysis** | **2,453** |
| **Total Contrast Group in Analysis** | **371** |

[7] http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3

## 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 our model, which estimated average daily consumption, we calculated the average daily HDD and CDD for each billing period.

To determine the appropriate reference temperature for LG&E and KU customers, we estimated separate heating and cooling regression models for each household in both the pre and post periods. 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—we 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

We estimated heating and cooling PRISM models 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.

$AVGCDD_{it}$ = 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, we calculated normalized annual consumption (NAC), 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—we 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.

## FIXED EFFECTS PANEL REGRESSION MODELS

As is our standard practice, we also ran fixed-effects panel regression models as a second approach to the estimation of program impacts. These models performed poorly, with our typical model specifications indicating no consumption reductions between the pre and post periods and only very simple models indicating any savings. We attribute this performance level to the relatively small size of savings per household as a percent of consumption and to the relatively weak relationship between weather and consumption in a substantial number of households. As is our normal practice, we reported savings for the type of model with the highest precision around the estimate, which is the PRISM model.

## GOOGLE ANALYTICS AND MYMETER REPORTING

Tetra Tech received and reviewed AMS Opt-in program Google Analytics data and MyMeter user activity reporting from LG&E and KU. The dataset containing MyMeter account activity[8], which included all user activity (e.g. MyMeter account registration, successful logins, etc.) within the MyMeter ePortal between September 7, 2015 and December 5, 2017. For those program participants with AMS devices but who had not registered for a MyMeter account, no MyMeter activity was recorded. In addition, records without valid account numbers were removed from the analysis file, as they were attached to names of LG&E and KU staff or administrative accounts used to monitor the ePortal website and perform maintenance (i.e. not actual users of the MyMeter ePortal).

Tetra Tech defined eligible account activity as either of two activities—successful registration or successful logins, based on the logic that any user must first create an account to use the site, and after that, anytime the user wishes to use *any* of the features within the MyMeter website, he/she must first successfully login before navigating to specific sub-sites. Users that accessed the MyMeter ePortal at least six times were defined as actively engaged customers.

[8] LKE Portal Activity w Account Number 12_5_17.xlsx.

# FINDINGS

This section documents the details in our approach to estimating savings using three determining factors: 1) the rate of enrollment in the program (i.e., the percentage who sign up for the ePortal); 2) the percentage of enrollees who actively engaged; and 3) the average savings of actively engaged customers. A discussion of each of these three factors follows.

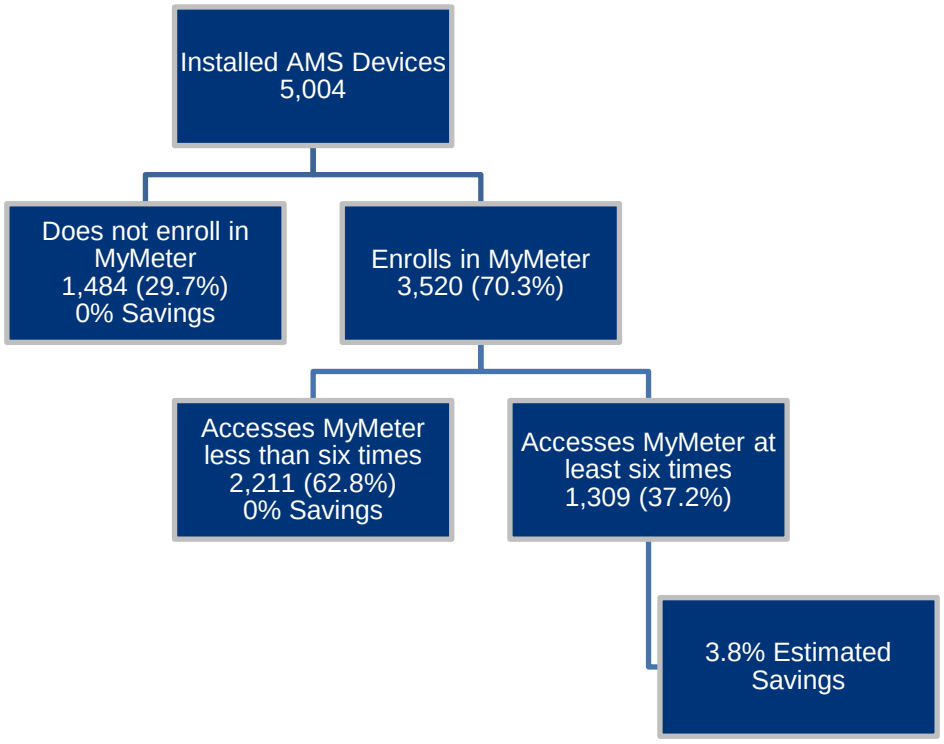
## RATE OF ENROLLMENT AND ACTIVE ENGAGEMENT

Compared with previous estimates provided in October 2016, the percentage of AMS Opt-in participants that successfully registered a MyMeter account has grown from less than half (48 percent) to 70.3 percent, while the percent of registered users with at least six logins remained stable (36.0 percent in 2016, 37.2 percent in 2017). The increased enrollment in MyMeter results in a savings estimate that is almost twice as large as the previous savings estimate—0.99 percent compared to 0.52 percent. The rate of MyMeter enrollment among AMS Opt-in participants, the percentage of actively engaged users, and the previously estimated average energy savings among program participants are summarized in Table 2. In addition, Figure 2 provides a tree diagram to visually show the decision points in the savings estimation methodology.

**Table 2. AMS Opt-In Participation and MyMeter Summary Statistics**

| AMS Opt-In Participant Subset | Number / Percent |
|---|---|
| Accounts with installed AMS device (through Sept. 15, 2017) | 5,004 |
| Registered MyMeter users | 3,520 |
| **Percent of AMS participants that created a MyMeter account** | **70.3%** |
| | |
| Registered MyMeter users with at least six logins | 1,309 |
| **Percent of MyMeter users with at least six logins** | **37.2%** |
| | |
| **Average Energy Savings of AMS Opt-In Participants** | **3.8%** |

**Figure 2. AMS Opt-In Participant Savings Tree Diagram**




## BILLING DATA ANALYSIS

The PRISM analysis indicated average household energy savings of approximately 4.5 percent compared with the pre-installation period among households in the treatment group. Consumption among households in the contrast group fell about 0.7 percent compared to pre-installation levels during the same period. The results for each analysis group are shown in Table 3.

**Table 3. PRISM Analysis Normalized Annual Consumption**

| Analysis Group | n | NAC (kWh) |
|---|---|---|
| Treatment – pre period | 1,353 | 15,233 |
| Treatment – post period | 1,353 | 14,451 |
| Contrast – pre period | 357 | 15,683 |
| Contrast – post period | 357 | 15,568 |

The treatment group reduced its NAC between the pre and post periods by an average of 692 kWh, or about 4.5 percent. The contrast group, however, reduced its NAC during this time by 115 kWh, or about 0.7 percent of a slightly higher baseline consumption. Thus, we estimated the average impact of the AMS Opt-In program to be 3.8% x 15,233 kWh = 580 kWh.

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

$$3.8\% = \frac{15{,}233 - 14{,}451}{15{,}233} - \frac{15{,}683 - 15{,}568}{15{,}683}$$

We estimated the 90 percent confidence interval around treatment group savings to be +/- 12 percent of the estimated value. Thus, the lower limit to the NAC for the treatment group is 609 kWh, or 4.0 percent of pre period NAC. Relative uncertainty around the contrast group impact was higher because the sample size was smaller and the impact was close to zero. We estimated the 90 percent confidence interval around the contrast group to be +/- 20 percent of 115 kWh.

To estimate uncertainty around the adjusted impact from the treatment and contrast samples we used a resampling approach. We drew 1,000 random participants, with replacement, from each group and estimated 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 we estimated that the 90 percent confidence interval around the adjusted impact is +/- 0.9 percentage points, for a relative precision of +/-22 percent.