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The impact of advanced metering infrastructure on energy conservation: A case study of two utilities

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ABSTRACT

An analysis of the potential of energy management tools enabled by advanced metering infrastructure to induce energy conservation behavior among customers of two utilities suggests that EMTs empower individual residential customers to have a more thorough understanding of their electricity consumption. This is encouraging news at a time that many U.S. states are developing climate action plans with aggressive targets for reducing greenhouse gas emissions.

1. Introduction

In this article we introduce an analysis of a comprehensive energy management tool (EMT) program which is enabled by the deployment of advanced metering infrastructure (AMI) and smart meters. The EMTs empower individual residential customers to have a more thorough understanding of their electricity consumption. Among various other ways of informing customers on smarter energy decisions as described further below, the EMT program includes detailed bill inserts, presenting details of a customer's consumption over the month, and a web portal, which offers user-friendly charts and tables to inform customers about their energy consumption habits and energy bills.

We present an econometric analysis of two service territories that have rolled out EMTs enabled by AMI to provide customers with granular information about their electricity consumption and encourage them to use this information to conserve energy. The service territories are Potomac Electric Power Company Maryland (Pepco MD) and Delmarva Power & Light Company Maryland (DPL MD), both operating companies of Pepco Holdings, Inc., now part of Exelon Utilities. Pepco MD serves approximately 500,000 residential and 50,000 non-residential customers in much of Prince George's and Montgomery counties.[1] DPL MD serves approximately 175,000 residential and 26,000 non-residential customers on the eastern side of the Chesapeake Bay.[2]

Both Pepco MD and DPL MD completed their AMI deployment by the end of 2014. Pepco Holdings also deployed AMI in two other of its service territories: Potomac Electric Power Company District of Columbia (Pepco DC) and Delmarva Power & Light Company Delaware (DPL DE). Pepco Holdings is also the parent company of another service territory, Atlantic City Electric Company New Jersey (ACE NJ). As of the time of writing this article, there were no approved utility plans for AMI deployment in the ACE NJ service

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[1] Statistics on Pepco Maryland customers reported in Pepco Maryland's FERC Form No. 1 filing, filed with the Maryland Public Service Commission in May, 2016. http://webapp.psc.state.md.us/newIntranet/CaseNum/NewIndex3_VOpenFile.cfm?filepath=%5C%5CColdfusion%5CUtility%20Company%20Annual%20Report%5C%5CPotomac%20Electric%20Power%20Company%5C2015%20-%20Potomac%20Electric%20Power%20Company.pdf

[2] Statistics on DPL Maryland customers reported in DPL Maryland's FERC Form No. 1 filing, filed with the Maryland Public Service Commission in June, 2016. http://webapp.psc.state.md.us/newIntranet/CaseNum/NewIndex3_VOpenFile.cfm?filepath=%5C%5CColdfusion%5CUtility%20Company%20Annual%20Report%5C%5CDelmarva%20-%20Connectiv%5C2015%20-%20Delmarva%20Power%20and%20Light%20Company.pdf

territory.

This article provides a description of the analysis of whether the residential customers in the Pepco MD and DPL MD territories have changed their electricity consumption in response to the information provided by EMTs introduced following the activation of AMI. Due to the nature of the AMI deployment and activation process, not all customers had access to the EMTs at the same time. Customer education was provided at a range of times based on each customer's individual installation and activation, while mass media information was available throughout the service territory at the same time. For Pepco MD customers, the AMI activations started in January 2012 and were completed by year-end 2013 with 90% of the activations being completed by May 2013. For DPL MD customers, the AMI activations started in January 2014 and were completed by year-end 2014 with 90% of the activations being completed by October 2014.

To assess the impact of EMTs on energy consumption, we carried out an econometric analysis using individual-customer-level data. We conducted separate analyses for Pepco MD and DPL MD service territories. This report is organized as follows. Section 2 provides an overview of AMI and EMT while Sections 3 and 4 describe the methodology and data used in this study. Section 5 presents the results of the analysis, and Section 6 presents our conclusions.

2. AMI enabled energy management tools

Both Pepco MD and DPL MD relied on AMI to enable EMT programs in their service territories. The EMT programs cover a wide range of information outlets, such as:

1 **My Account web portal**: Customers can log on to My Account and see their hourly usage of electricity; view user-friendly charts comparing consumption to selected periods, i.e. same month last year; projected bills; tips on energy conservation, and several other useful analytics on their electricity consumption patterns.
2 **Detailed bill presentment**: After the activation of AMI meters, monthly electricity bills include more details about each customer's usage including monthly electricity usage charts and daily consumption charts. These details allow customers to relate their activities on certain days and months to the resulting level of electricity consumption.
3 **Educational campaigns** in multiple forms, including:

- Letters and fact sheets regarding the installation of smart meters;
- Postcards announcing the availability of new tools;
- Newsletters discussing the new tools, energy savings tips, and the benefits of AMI;
- Mass media advertising related to saving energy and availability of new tools to help consumers save energy;
- Customer education related to the announcement of the Peak Energy Savings Credit, including energy savings tips and ideas for reducing energy during the summer;
- Community meetings and events that involved presentations, individual discussions and demonstrations of My Account, and providing customer education handouts.
- **News coverage** including press releases, articles, and TV coverage of AMI activation and other energy management tools enabled by AMI.

The EMT programs we analyze in this study can be categorized under the behavioral energy conservation programs. For there to be a significant impact on residential energy usage, customers must take the information provided through the EMTs and change their electricity consumption habits. Our analysis investigates how energy consumption feedback via EMTs affects what Allcott and Rogers (2014), citing Becker and Murphy (1988), call "consumption capital," defined as "a stock of energy use habits." This is opposed to "physical capital," which in the context of a behavioral energy conservation program, would include customers enrolling in energy efficiency programs that result in customers purchasing energy efficient lightbulbs or appliances. These physical capital changes are accounted for separately in our econometric analysis.

Behavioral energy conservation programs have significant potential to conserve energy and are often cost-effective. Allcott and Mullainathan (2010) discuss that behavioral energy conservation programs are notably attractive methods for reducing carbon emissions because they are often more cost-effective than other methods (such as developing more renewable generation resources). The key is that the behavioral energy conservation program has to be well constructed and result in significant, legitimate reductions in energy consumption.

Behavioral energy conservation programs have been studied for decades, long before significant parts of the U.S. started to deploy AMI on a wide-scale basis. There is a wealth of literature dating back to the 1970s that reviews the effects of feedback on energy consumption. McClelland and Cook (1979) present a study of 25 homes being fitted with feedback devices that display electricity consumption in cents per hour. They found that such feedback can lead to electricity savings of 12%. Their findings are generally in line with other literature of the time, such as Seligman and Darley (1977) and Becker (1978). These studies helped set the stage for a robust literature on behavioral changes due to feedback on energy consumption. However, they were limited by small sample sizes and limited technology.

Abrahamse et al. (2005) review 38 different studies, which all include interventions which aim to encourage households to reduce energy consumption. They find that offering rewards can effectively encourage energy conservation; but that the effect is not long-term (i.e. consumers do not actually change baseline behavior in response to a financial incentive). The researchers find that feedback "has its merits" as long as it is given frequently. To that end, the EMTs we analyze in this study are frequent in that customers receive detailed bills every month and are also able to log in to their web portal at any time. A more recent meta-analysis provided by Delmas et al. (2013) reviews over 100 field trials published from 1975 to 2012, which analyze information-based energy conservation experiments. The authors find that individuals in experiments reduced consumption by 7.4%. Furthermore, the authors find that non-monetary, information-based strategies can be highly effective at promoting conservation and that monetary incentives (such as providing information on cost savings) are not generally effective in promotion energy conservation.

Hahn and Metcalfe (2016) present an informative review of literature pertaining to how information can improve outcomes and how the use of social norms can increase conservation. Much of the discussion on social norms focuses on Opower, which we discuss below. With respect to how information can lead to energy conservation, authors note that context and details are important. That is, not all behavioral programs are inherently successful. Customers should be provided a significant amount of information such that they can make a behavioral change.

The EMTs we analyze in this analysis are AMI-enabled, and are thus able to provide an unprecedented level of information to customers to encourage them to learn about their energy consumption habits. Early literature on AMI indicated aggressive reductions in energy consumption. A study by Gans et al. (2013) that analyzes customers in Northern Ireland, who received AMI as early as 2002, found that the AMI deployment resulted in an