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The costs and benefits of real-time pricing: An empirical investigation into consumer bills using hourly energy data and prices

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ABSTRACT

This study analyzed smart meter data to compare how residential consumers would have fared in 2016 under traditional, flat-rate electricity pricing versus the 'real-time pricing' program offered by Illinois utility Commonwealth Edison. Although further study is needed with more customers and multiple years, 97% of households in the study would have saved with real-time pricing. The average savings would have been $86.63, or 13.2%, annually. Total savings would have been $29.8 million.

1. Introduction

The recent availability of extensive energy-use data allows a more accurate analysis of alternative electricity rate structures. This paper, what we hope will be the first in a series by the Citizens Utility Board (CUB) and Environmental Defense Fund (EDF), focuses on the impact of hourly prices on consumer bills.

Economists often argue for the system-wide benefits of dynamic electricity pricing, in which customers pay for power through time-variant rates. Brattle Group's Samuel Newell and Ahmad Faruqui make the standard case for dynamic pricing in comments to the New York Independent System Operator. They write:

> Dynamic rates would encourage consumers to adjust energy usage to take advantage of lower priced energy in low demand hours and to limit consumption in higher demand high priced hours. As a result, consumers … benefit from a more efficient electric system. Demand for electricity is uneven. Consumption in the top 1% of the hours of the year accounts for more than 10% of system peak demand. Actions taken to reduce electric demand during this relatively small number of peak hours can significantly reduce total annual electricity costs. Dynamic pricing targets these peak loads, reducing the need for expensive additional reserve generation and transmission capacity. (Newell and Faruqui, 2009)

Indeed, according to Faruqui et al. (2007), "even a 5% reduction in peak demand in the United States could lower consumer energy costs by at least $3 billion a year." Peak-load reductions also offer environmental benefits, most obviously in the form of reduced emissions from fossil-fueled peaker plants.

Currently, the vast majority of utility consumers pay an average price for electricity that changes little (if at all) over the course of the year. There are two main reasons for the predominance of flat rates. First, policymakers typically maintain that average-price rate designs create value by smoothing-out market volatility, providing certainty and stability, and avoiding potential bill shocks, particularly for low-income customers. Second, while dynamic pricing advocates talk about the importance of "price responsiveness" or "taking action to lower peak demand," what happens to a customer who doesn't respond to prices? True, if enough consumers act to lower peak demand, over time total systemic costs should decline and this would benefit everyone. However, if the benefits of dynamic pricing require action by the customer, the *costs* of this action may outweigh any potential benefits from moving to time-variant rates.

Average, flat-rate pricing, then, is akin to a form of insurance, where a premium is paid to hedge against market volatility and price spikes. Until recently, quantifying the cost of this premium for individual consumers has been challenging due to the limited number of studies involving hourly customer usage data. As a result, it has been difficult to make analytical progress, and the debate over dynamic pricing often relies on theories rather than empirical evidence. This is unfortunate for many reasons, not the least of which is that lowering peak demand becomes even more important with transportation electrification on the horizon, as system costs may increase significantly unless electric vehicles charge at the right times. Price signals are likely the simplest and lowest-cost way to accomplish this end (Cohen, 2017).

Now, the availability of anonymous energy-usage data from hundreds of thousands of advanced meters allows for new research that can more thoroughly investigate the costs and benefits of average, flat-rate

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pricing versus dynamic-pricing models, such as real-time pricing. This article does so by focusing on Illinois, the only state in the nation where the two largest utilities — Ameren Illinois and Commonwealth Edison (ComEd), which serve about 90% of the state's customers — offer comprehensive, opt-in dynamic "real-time pricing" programs for residential customers. Under real-time pricing, electricity rates vary by the hour, according to wholesale electricity markets.

In 2017, Illinois also approved an innovative tariff[1] allowing access to sets of anonymous usage data, which protects customer privacy while allowing researchers access to scrubbed, 30-min household energy usage data at the ZIP + 4 level. The existence of both a real-time pricing program and a formal channel for sharing anonymous energy-usage data have made Illinois a promising frontier for new research. This article offers one example: By comparing how residential customers of ComEd, the electric utility for much of northern Illinois, would have fared in 2016 on real-time pricing vs. traditional flat rates, *without making any behavior changes*, the paper begins to quantify the costs of the insurance provided for by flat rates.

Our analysis shows that roughly 97% of ComEd customers would have saved money through real-time pricing in 2016 without changing behavior, with a net average savings of $86.63 annually. In percentage terms, ComEd customers would have saved an average of 13.2% through the real-time pricing program. Focusing on the top 5% of savers produces more dramatic results: These customers would have saved an average of $104 per year, or 31% on their overall bills. Flatter load shape, as one might expect, turns out to be the main differentiator between the top 5% (mean savings: 31%) and the bottom 5% (mean savings: 0%). Generally, the flatter the load shape, the higher the savings. The data show no significant differences between low-income and other customers.

Several clarifications are useful. While the 2016 data set is large and includes a higher percentage of low-income customers than the overall service territory, it is not necessarily representative of the rural areas in the ComEd service territory. Running the analysis over multiple years – and with a larger number of utilities – is also necessary to further inform policy development (Fig. 1).

Nevertheless, the fact that ComEd customers would have benefited nearly universally from real-time pricing during 2016 indicates that this program can be a consumer asset on a much larger scale and across a far larger territory than it has been deployed to date. To reinforce that point, consider the following:

- The cost of average, flat-rate supply service for individual consumers was significantly higher than the hourly market price in 2016. ComEd customers on the utility's default, flat-rate supply price as a whole paid, on average, over 13% more than they would have on real-time pricing.
- Given what we know from numerous pilots and programs that price signals induce customer response, the systemic costs of average, flat-rate pricing over time are higher still, even before the environmental benefits of reducing peak demand are considered (Faruqui and Palmer, 2011).
- On average, low-income customers showed little variation from the rest of the population, with the only statistically significant difference being an additional 1% savings on average.

[1] Final Order at 9, 17. ICC Docket No. 13-0506 (Jan. 28, 2014) [A] "15/15 Rule" whereby utilities would provide 12 months of customer usage data of at least 15 customers organized by groups of customers within the same ZIP +4 area after stripping any identifiable information (name, address, account number, etc.). (Id.). A single customer's load must not comprise more than 15% of the customer group. If the number of customers in the dataset is below 15, or if a single customer's load is more than 15% of the total data, utilities must expand the geographic area, moving to a ZIP+2 level for example. CUB explains that if expanding the geographic area reaches the 15-customer threshold, but a customer still comprises 15% or more of the usage data, that customer is simply dropped from the dataset. (Id.). If the 15-customer requirement is not met after the first expansion of the zip code, the sample size is expanded to the ZIP level.

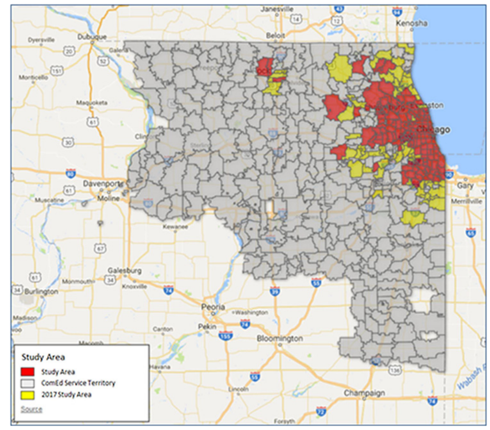

Fig. 1. Study area. ComEd's AMI deployment began in Chicago's Maywood area and has extended outward. This study includes customers who had smart meters as of Jan. 1, 2016. The next iteration will include customers with smart meters as of Jan. 2017.

The genesis for these findings was Illinois' seminal decision to share anonymous energy-use data with researchers, which unleashed new analytical capabilities that will continue to bear fruit in subsequent studies our organizations will conduct. We urge all states to adopt similar data access protocols that will promote the public interest.

Beyond that pivotal reform, the Conclusion section outlines a series of policy recommendations that collectively form a blueprint for broadening access to, and participation in, the cost-savings opportunities inherent in dynamic pricing.

2. Theory/calculation

Using actual energy-usage data, this study analyzes how customers who are currently under a traditional, average electricity pricing structure would have fared under ComEd's existing Hourly Pricing program, a residential real-time pricing initiative. Rather than rely on estimates or small samples, this analysis compares the bills of 344,717 ComEd customers—roughly 10% of the company's residential customers—in every month of 2016, which is the largest data set ever for a study of this kind. Each monthly data set contains half-hourly interval volumes for each anonymous customer.

The data include customers' 9-digit ZIP + 4 codes, allowing for fine-grained geographical analysis. For this iteration of the study, ZIP codes were tagged according to income (low- and moderate-income areas) and location (suburban and within Chicago). Low- and moderate-income areas were determined using Census data; areas tagged as low income had 50% or more residents with annual incomes of $12,300 (50% of the federal poverty level for a family of four) or less, and moderate income areas had 50% or more residents with annual incomes of $19,680 (80% of the federal poverty level for a family of four) or less.

In addition, individual customers' subclass is identified in the data. ComEd assigns subclasses to residential customer based on single-family versus multi-family status, and whether or not customers heat their homes with gas or electric space heating. This leads to four separate residential subclasses (listed in order of prevalence in the study group): single family non-electric space heat (SFNH), multi-family non-electric space heat (MFNH), multi-family electric space heat (MFH), and single-family space heat (SFH).

Both flat and hourly rate designs include multiple line-item rates, many of which vary on a monthly basis. The first step to estimating annual savings is to find the savings for each month. Annual savings are the sum of a customer's monthly savings.

Monthly savings are then estimated by calculating a customer's monthly charges, based on her actual energy usage, arising from each component of the flat rate and hourly pricing structures.