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The distributional impacts of residential demand charges

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ABSTRACT

Demand charges have recently emerged as an important feature in many proposals to reform residential electricity rates. Relying on load and income data for more than 1,000 utility customers, the authors provide an assessment of the impact this rate design could have on residential customer bills and examine the potential for home energy storage to enhance bill savings. One encouraging finding: demand charges do not disproportionately impact low-income customers relative to the rest of the sample.

1. Introduction

Residential electricity rate structures have remained essentially unchanged for the past century. However, recent advancements in energy technologies such as smart metering, distributed generation, and the "connected home" have necessitated a new look at rate design. The existing rates, which typically consist of a modest fixed monthly charge and a volumetric (i.e., cents-per-kilowatt-hour) charge, are beginning to be replaced with more sophisticated options. These new options are intended to better reflect the cost of generating and delivering electricity and to provide customers with opportunities to reduce their bills through changes in electricity consumption patterns.

One rate design option that is receiving increasing interest in the industry is the introduction of a demand charge. Demand charges recover some portion of the utility's cost by charging the customer based on his/her maximum instantaneous demand for electricity (measured in kilowatts), rather on his/her total monthly consumption (measured in kilowatt-hours).[1] There are several potential benefits to this approach if the demand charge is well designed and carefully implemented. It could improve fairness and equity in cost recovery by more accurately charging customers for their use of the power grid. It would also provide an incentive for demand reductions and adoption of emerging energy management technologies, which could reduce system resource costs and customer bills. Demand charges have been offered to commercial and industrial customers for decades.

Given the industry's growing interest in this rate design concept, it is critical to understand the implications of the rate's widespread adoption. Two questions in particular are regularly asked. First, what will be the impact of demand charges on customer bills, particularly those of low-income customers? And second, to what extent will demand charges improve the economics of emerging home energy technologies, specifically those aimed at helping customers manage their peak demand, such as distributed energy storage?

In response to those questions, this study provides an initial assessment of the impact that demand charges could have on customer bills and on the economics of distributed energy storage. The article is not intended to comprehensively answer these questions. Rather, it frames the issues and provides initial insights using load data for a sample of utility customers in Vermont. The findings of this study should be considered a starting point for further, detailed analysis of these issues using an expanded dataset and regional case studies.

1.1 The trend toward residential demand charges

While demand charges are not a new concept – they have been a common feature of rates for commercial and industrial customers for decades – it has been relatively unusual to find them in residential rate offerings. A recent survey identified 19 U.S. utilities offering residential demand charges (Hledik, 2015). In some instances those offerings have significant enrollment. For example, Arizona Public Service (APS) has 117,000, or roughly 10% of its residential customer base, on a rate with a demand charge. In most cases, however, enrollment is limited.

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[1] Typically, a demand charge is not based on a truly instantaneous measure of demand, but rather an average over an interval of 15, 30, or 60 min. And, as discussed later, there are a variety of ways in which demand could be defined for the purposes of billing a demand charge, such as maximum demand during a period coincident with the system peak, maximum demand during a period coincident with the class peak, or maximum demand based on the customer's own peak over the course of the month. Other alternatives are also available.

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Recent developments suggest that there could soon be an increase in residential demand charge offerings. Several utilities have proposed demand charges in the past couple of years. Georgia Power, for instance, introduced a voluntary three-part rate in 2014 (Georgia Power, 2016).[2] Salt River Project introduced a demand charge as a standard feature of the rate for all residential customers with distributed generation in 2015 (Salt River Project, 2016). Residential demand charge proposals have also recently been made in Arizona, California, Illinois, Kansas, Nevada, Oklahoma, and Wisconsin.

What is driving this interest in demand charges? One driver is growth in capacity-related costs. Since demand charges are designed to recover costs driven by peak demand, namely generation, transmission and/or distribution capacity, high growth in these costs relative to other costs is emphasizing the need for a demand-driven rate component.

According to the U.S. Energy Information Administration (EIA), T&D costs, which are largely driven by peak demand, will represent a growing share of total electricity costs in coming years. Between 2012 and 2020, the EIA projects that transmission costs will grow at an average annual real growth rate of 2.4%, distribution costs will grow at 1.5%, and generation capacity costs will row at 0.1%. At the same time, the share of variable costs (primarily fuel) in the total is shrinking.

Technological developments are also contributing to the trend toward demand charge offerings. By allowing a customer's electricity consumption to be measured over short time intervals, smart meters are enabling, for the first time, widespread and low-cost deployment of demand charges. In the U.S., more than 50 million homes now have smart meters (FERC, 2015).

Declining electricity sales, coupled with growth in peak demand, are also contributing to this trend. In particular, industry concerns about a "cost shift" associated with net energy metering are causing regulators to consider reforming rates that are largely flat and volumetric in nature.

The degree to which demand charges will ultimately be adopted is, of course, uncertain. A number of strong drivers are pushing rate design in that direction. Other considerations, whether technical, political, or economic in nature, will also prominently influence this trajectory. Among the many issues currently being debated about the merits of demand charges, one that commonly rises to the top of the list is the impact on customer bills.

2. The bill impacts of residential demand charges

Customer bills will be impacted whenever revenue-neutral[3] changes are made to a rate's design. Some bills will go up as a result of the change and others will go down. It is therefore important to understand the extent to which customer bills will be affected when introducing a demand charge. From a policy perspective, the bill impacts for low-income or otherwise "vulnerable" customers are often of particular interest, out of concern that electricity remains affordable for this customer segment. To understand how demand charges might impact customer bills, we estimated bills for a sample of customers under two revenue-neutral rates, one with a demand charge and one without, while distinguishing between low-income and non-low income customers in the sample.

[2] Throughout this article, "three-part rate" is used to refer to a rate that includes a demand charge. Typically, rates with a demand charge will also include two other "parts," a fixed monthly customer charge and a volumetric (cents/kWh) charge.

[3] Two rates are considered to be "revenue neutral" when they produce the same revenue for the rate class, absent any changes in electricity consumption patterns.

Table 1
Illustrative Two-Part and Three-Part Rates.

	Two-part rate	Three-part rate
Demand charge ($/kW-month)	None	$7.00
Volumetric charge ($/kWh)	$0.110	$0.068
Fixed charge ($/month)	$10.00	$10.00

Note: Rates shown are illustrative. Many alternative designs are possible.

2.1. Data and methodology

To analyze the impact of demand charges on residential electricity bills, we obtained load data for a sample of more than 2000 customers in Vermont.[4] The load is measured over 15-min increments and covers a full year, from Oct. 1, 2014, through Sept. 30, 2015. That time period was selected because it represented the most recent data available at the time of our analysis. After examining the data and dropping customers for whom we had incomplete information (e.g. missing load observations), 1107 customers remained in the dataset.[5]

The dataset also included an estimate of household income for each customer in the sample. Income estimates were presented in incremental ranges (e.g., $40,000 to $50,000 per year). We considered households below 150% of the federal poverty line to be "low-income customers" and those above this threshold to be "non-low-income customers."[6] With this definition, 122 customers, or 11% of the total sample, were considered to be low-income customers.

We established a "before and after" comparison using two revenue-neutral rates. The "before" case is an illustrative two-part rate consisting of a fixed monthly charge and a volumetric charge. The "after" case is a revenue-neutral three-part rate that includes a demand charge in addition to a fixed charge and a volumetric charge.[7] The rates are shown in Table 1. Bills were then calculated for each customer in the sample under both the two-part rate and the three-part rate, with the change in bill representing the impact of the demand charge on each customer.

Note that the demand charge in this illustrative rate is based on the customer's highest hour of average demand between the hours of 2 p.m. and 6 p.m. each month. We chose that window of time because it closely coincides with the timing of system peak demand in Vermont. As discussed above, system peak demand drives a significant portion of the investment in generation capacity and power grid infrastructure. In other words, the rate is

[4] The data was provided by Efficiency Vermont. To maintain confidentiality of customer data, all customer account numbers were replaced with random identifiers; other information that might be used to identify individual customers was stripped out of the dataset before it was provided to the authors.

[5] Specifically, there were customers for whom a significant portion of load observations registered as 0 kWh. It is possible that some customers have very low load or perhaps own vacation homes that remain unoccupied for a portion of the year. It is also possible that the 0 kWh observations represent the transition in a change of occupancy or are possibly reported in error. Given the uncertainty and to minimize the impact on the sample, we chose to restrict our dataset to accounts with no more than 5% of observations registered as 0 kWh. We also dropped customers for which we did not have data for all days of the year, income data, or household size data.

[6] The U.S. Census Bureau's formula for determining the poverty line is a function of income, household size and age of occupants. A description can be found here: https://www.census.gov/hhes/www/poverty/about/overview/measure.html.

[7] To establish the revenue-neutral three-part rate, we set the fixed monthly charge equal to that of the two-part rate and the demand charge was set at $7/kW-month, which is within the range of residential demand charges being offered by utilities around the U.S. (for a recent survey, see Hledik, 2015). We then set the volumetric rate such that it produced the same revenue as the two part rate for the sample of residential customers (including both low-income and non-low-income customers).