The Efficiency and Distributional Effects of Alternative Residential Electricity Rate Designs

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Residential electricity tariffs typically distort - and thus do not allow consumers to respond to - the marginal cost of energy consumption. Rates are typically constant across time and location, despite the fact that short-run marginal costs can vary dramatically. As of the end of 2016, less than one quarter of one percent of residential customers in the U.S. faced electricity prices that reflected the real-time marginal cost of energy production. Furthermore, the bulk of system costs are recovered through volumetric charges - that is, charges per-unit of energy consumed - despite the fact that a substantial fraction of these costs are fixed in the short term. More economically efficient rate designs - enabled in part by the proliferation of smart metering infrastructure - could substantially improve market efficiency. However, the potential distributional impacts across customer types and incomes of transitioning from today's tariffs to more efficient designs have historically impeded progress.

This paper examines the distributional and economical efficiency implications of residential electricity tariffs. Using interval metering data - measuring electricity consumption every 30 minutes -for more than 100,000 customers in the Chicago, Illinois area, we assess the economic benefits of efficient tariffs relative to alternative tariff designs. The rate designs explored are depicted in Figure 1. We then use census data to understand the demographics - i.e. income levels - of the customers in our sample. A regulator might seek to shift from the current tariff structure to a two-part tariff, because the two-part tariff has higher economic efficiency. If this two-part tariff has an equal fixed charge for all customers, we demonstrate that this shift is regressive; the change in monthly bills is larger, as a share of income, for lower income consumers. However, we show that a two-part tariff that bases the fixed charge on income or other measures that correlate strongly with income can improve distributional

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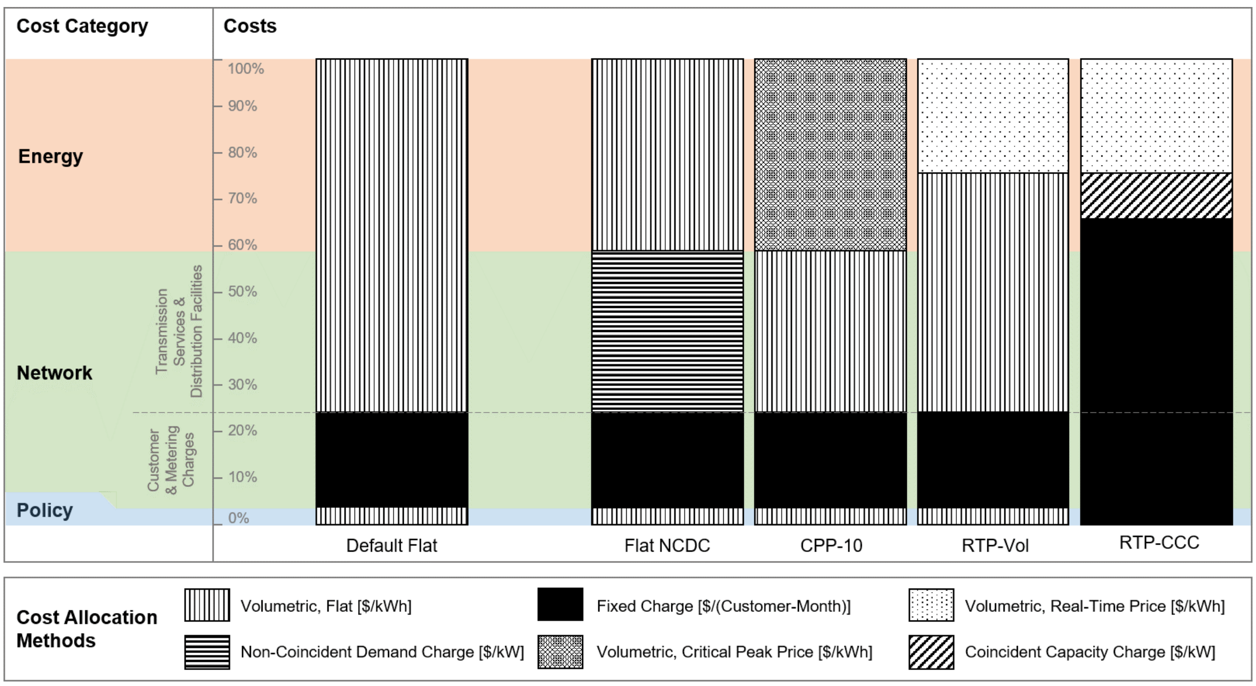

Figure 1: Breakdown of costs under the tariff designs in this study

outcomes without substantially sacrificing economic efficiency.

The issues addressed in this paper are likely to increase in importance as distributed energy resources (DERs), such as rooftop solar, become more prevalent. When located and operated appropriately, DERs can deliver substantial benefits. However, if investment and operation decisions are not aligned with system objectives, DERs can substantially increase system costs. The lack of spatial variation in retail prices distorts where DERs are placed within a network and how they are operated. In addition, remunerating transmission and distribution costs through volumetric charges over-incentivizes solar adoption by driving a wedge between the private and social returns to solar adoption. Adopters of some DERs, for example, rooftop solar, are able to reduce, or eliminate, their payments for transmission, distribution, and other regulated costs, despite the fact that these DER owners remain connected to and continue to use the network. Given utility revenue sufficiency constraints, this leads to increases in the transmission and distribution volumetric charges faced by other customers.

This can also have large distributional consequences. Because solar adoption tends to be positively correlated with income, high-income consumers are effectively passing on their contributions to transmission and distribution costs to lower-income consumers. Finally, widespread adoption of renewables can lead to larger diurnal price swings, exacerbating the difference between time invariant rates and the social marginal cost of consumption.

These converging challenges have led many regulators, policy makers, consumer advocates, and utilities to call for improved tariff designs. For example, the New York Department of Public Service recently called for “more precise price signals...that will, over time, convey increasingly granular system value.” New York is not an anomaly. In 2017, regulators in 45 of 50 U.S. states and the District of Columbia opened dockets related to tariff design or made changes to tariff design. Similarly, in November 2016, the European Commission issued a sweeping set of rulings, with tariff design as a centerpiece.

The economic pressure to redesign electricity rates is countered in part by concerns among policy makers and regulators of how more efficient rate structures might impact different socio-economic groups in terms of both average bills and bill volatility. For example, the Massachusetts Department of Public Utilities, the New York Department of Public Service, and the California Public Utilities Commission all list concerns about the distributional impacts of rates in their principles for rate design. Distributional concerns are not unfounded. For example, the U.S. Energy Information Administration recently found that 31% of U.S. households struggled to pay the costs of meeting energy needs. In practice, regulatory decisions highlight these concerns: in the U.S. in the second quarter of 2018, state electricity regulators rejected over 80% of utility requests to increase fixed charges, frequently citing the potential impacts on low-income customers.

Our work leads us to a number of novel findings. First, we find that, holding the proportion of fixed and volumetric charges in the tariff constant, annual electricity expenditures tend to decrease for low-income customers from movements towards more time-varying rates. However, increases in customer fixed charges tend to increase expenditures for low-income customers who, on average, consume less electricity than their more affluent counterparts. The net effect of a rate design with real-time energy prices and uniform fixed charges for residual cost recovery is a near monotonic negative relationship between income and changes in expenditures. Second, in our sample, the economic distortions of recovering residual network and policy costs through volumetric tariffs likely outweigh the distortions that emerge from charging an energy price that does not reflect the underlying time- and location-varying cost of energy. Finally, we find that changes to fixed charge designs can preserve the efficiency gains of transitioning to efficient residual cost recovery while mitigating undesirable distributional impacts. We highlight three methods for designing fixed-charges for residual cost recovery - based on customer demand characteristics, income, or geography - that mitigate the regressiveness of fixed charges. Figure 2 shows the difference in distributional impact between a uniform fixed charge and one based on a customer’s historical peak demand.

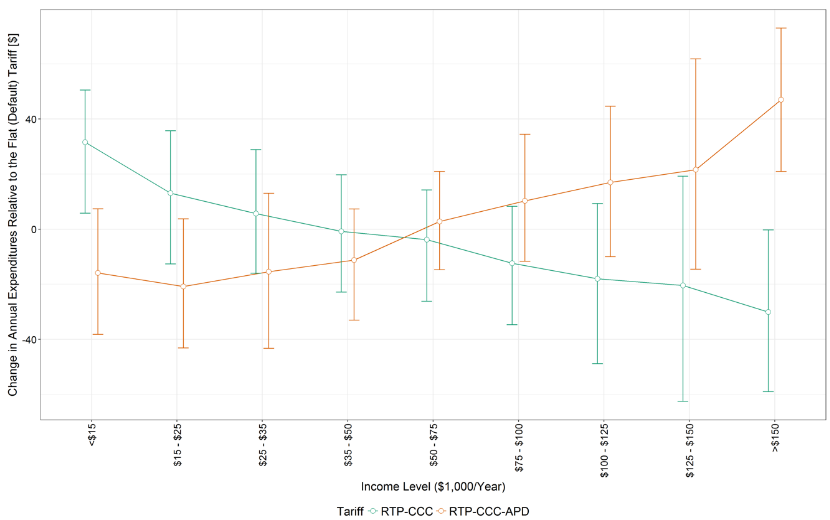

Figure 2: Change in annual expenditures under the RTP-CCC and the RTP-CCC-APD tariffs, zero-elasticity case