How Do Consumers Respond to Price Complexity?
Experimental Evidence from the Power Sector

Grant Jacobsen, University of Oregon
James Stewart, The Cadmus Group

Electric utilities are increasingly using dynamic pricing programs, in which households pay different prices depending on when electricity is consumed, to shape residential demand. Shifting demand is an important element in the transitional path toward further integrating low-carbon renewable resources into the electric system because it can help align consumer demand with the supply of intermittent renewable sources of power. For example, dynamic pricing programs can be used to shift consumption toward periods of elevated solar and wind generation and away from periods of elevated coal and natural gas-based generation. While dynamic pricing has historically been used sparingly, the installation of automatic metering infrastructure, the increased prevalence of intermittent renewables, and increased adoption of electric vehicles have sparked broad interest in recent years. The number of consumers on dynamic pricing globally is expected to rise from 4.5 million in 2018 to 75 million by 2025, in part because jurisdictions, such as California and New York, are requiring utilities to shift toward dynamic rates.

Dynamic prices can be implemented in a variety of ways. Real-time pricing, in which prices continuously reflect the costs of generation, would best align prices with the costs of generation, thereby creating large efficiency gains. However, due partly to fears about price volatility, utilities and consumers have been reluctant to embrace such programs. In contrast, time-of-use (TOU) pricing, in which consumers pay different prices for electricity depending on the time of day when electricity is used regardless of system conditions, have received relatively greater acceptance. TOU programs typically set a different per kWh price for electricity depending on whether the electricity is consumed during "peak" (e.g., 3:00 p.m.- 8:00 p.m.) or "off-peak" periods. A shortcoming of TOU pricing is that it is not responsive to idiosyncratic events that affect electricity supply or demand, such as unusual weather. Event-based pricing schemes, including critical peak prices (CPP) or critical peak rebates (CPR), are designed to address such events. Event-based programs provide a large per-kWh incentive for customers to conserve electricity during "critical" events, which utilities have traditionally called when demand is predicted to be unusually high. Under critical peak prices, consumers are charged a higher price for electricity consumed during critical events. Under critical peak rebates, consumers receive a rebate for each kWh they conserve during critical events relative to their reference usage.

TOU pricing and event-based pricing have been studied in isolation, but little research has examined how these two types of pricing programs interact when implemented simultaneously. This is an important shortcoming because there are potential benefits to implementing the programs simultaneously. TOU prices are oriented toward creating consistent shifts in daily demand patterns, whereas event-based programs are designed to shift demand in response to idiosyncratic events. Both types of demand changes are helpful for decreasing peak loads and reducing reliance on generators at the end of the dispatch curve,

which tend to be inefficient and powered by fossil fuels, and are potentially important tools as the supply of intermittent renewable generation expands. Recognizing the possible benefits of using TOU and event-based programs in tandem, utilities have begun implementing dynamic pricing programs that include both elements.

While there is theoretical appeal to using TOU and event-based pricing in combination, it is unclear how well the two pricing schemes will work in combination in practice, in part because consumers have been shown to respond in unpredictable ways in the face of multiple financial incentives. For example, Chetty et al. (2009) show that consumers do not fully account for sales taxes when purchasing goods for which the full price is both the posted price and the sales tax. As described in DellaVigna (2009), this behavior is consistent with consumers having limited attention and being forced to develop simplifying heuristics for decision-making.

This paper evaluates how consumers respond to dynamic pricing, focusing especially on the effectiveness of layering time-of-use pricing with event-based pricing. The specific types of dynamic pricing that are evaluated include TOU pricing (in isolation), critical peak rebates (in isolation), and TOU and critical peak rebates offered simultaneously ("hybrid pricing"). The analysis is based on data from a field experiment run by a vertically-integrated electric utility in the western U.S. The treatments were initiated in the summer of 2016 and included about 3,500 households. The key finding is that, during summer critical events, the use of rebates in isolation is highly effective and reduces consumption by 19 percent. In contrast, hybrid pricing schemes that create a nearly identical incentive to conserve electricity during events are much less effective, only reducing consumption by about 5 percent.

How should our findings—especially the reduced effectiveness of hybrid pricing--be interpreted? We posit that the key results are driven by the complexity of hybrid pricing and the response of consumers to this complexity. Hybrid pricing can be considered the most complex form of dynamic pricing we evaluate based on either of the two primary adjective definitions for "complex," which are "involving a lot of different but related parts" and "difficult to understand or find an answer to because of having many different parts" (Cambridge Dictionary, 2020). In the context of these definitions, hybrid pricing involves the most "parts" relative to TOU-only or event-only versions of dynamic pricing because it includes two dynamic pricing components, as opposed to one. Relatedly, as we discuss and show graphically, hybrid pricing creates the most changes in the marginal price of electricity across hours of the day. With respect to being "difficult to understand," we present survey evidence that customers on hybrid pricing had weaker comprehension of how dynamic prices operate than customers on either type of stand-alone pricing. If customers indeed found hybrid pricing to be more complex, then our findings, while initially surprising, are consistent with predictions from the literature on behavioral economics. Specifically, this literature has found that, when forced to make complex decisions, consumers sometime choose to simply maintain the status quo. In our context, the status quo would manifest as reduced effectiveness at changing consumption patterns.