Executive Summary
Optimization of Time-Varying Electricity Rates

Jacob Mays and Diego Klabjan
Northwestern University
Department of Industrial Engineering & Management Sciences

The cost of generating electricity can vary tremendously over the course of the day and the year, but end-use customers have traditionally seen prices that are flat or close to it. The mismatch between the cost of supplying electricity and the price of using it leads to inefficiency: customers use too much electricity when costs are high and too little when costs are low. The effect of this inefficiency is compounded by the capital-intensive nature of electricity generation. Capacity is built to meet the highest load of the year, leading to the construction of generating stations that operate only rarely. Recognizing this problem, many economists and policy makers over the past several decades have advocated a shift from fixed to time-varying electricity prices. Allowing prices to change can both reduce the deadweight loss arising from differences between wholesale and retail prices and lead to a reduction in required capacity. This proposal has gained popularity in recent years, with over 500 utilities in the U.S. having at least some customers enrolled in time-varying rates in 2014.

While momentum is gaining for time-varying rates, there is little agreement on what form such rate structures should take. Economists tend to advocate real-time pricing (RTP), in which retailers simply pass through wholesale prices. Most utilities to date have favored simpler two- or three-tier time of use rates, in which peak and off-peak time windows and prices are determined in advance. Several utilities have introduced critical peak pricing, which adds a much higher charge for usage on select high-demand days. Many small retailers have opted for a simple flat rate that changes on a monthly basis. In this environment, it is important to understand the potential impact of various rate structures.

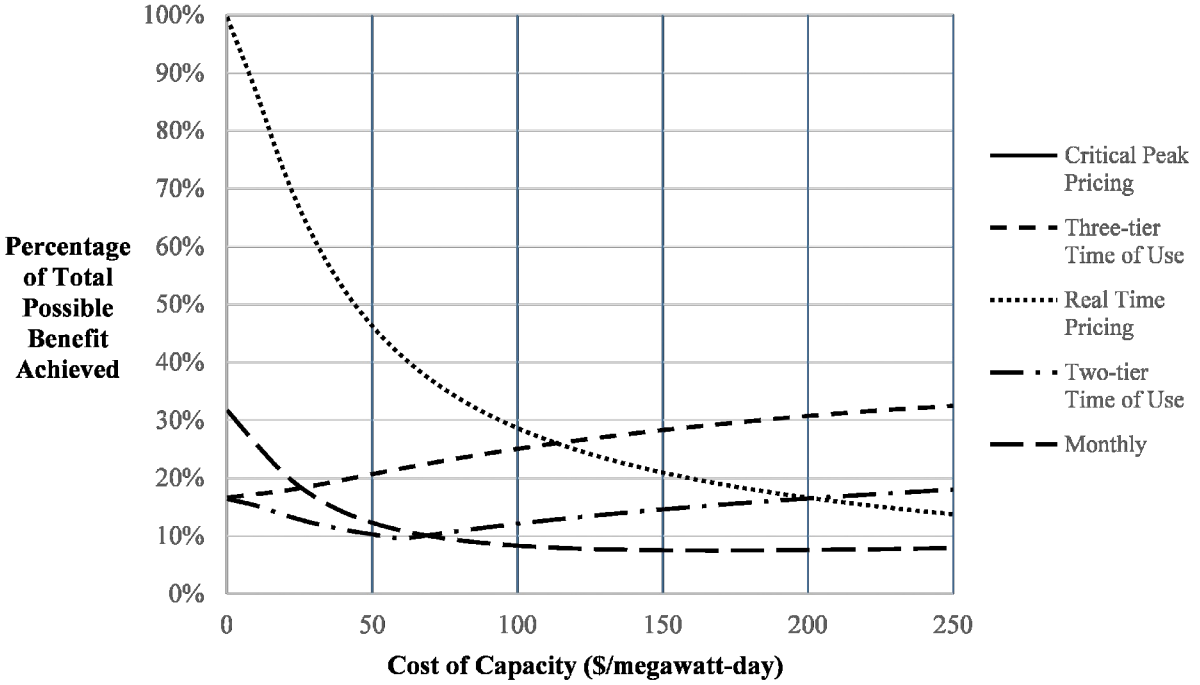
In parallel with this debate, many utilities have become interested in the use of demand charges to recover their capacity costs. These charges, however, are difficult to design well. Non-coincident peak demand charges encourage end users to limit their individual maximum load; given the diversity of electricity consumers, most of these individual peaks are unlikely to align with the system peak that actually drives cost. Coincident peak demand charges, on the other hand, may be difficult for customers to manage, since they require each consumer to predict when system peaks are likely to occur.

A potentially simpler and more effective strategy is to combine energy and capacity costs into a single rate. In this work, we develop a model that determines optimal prices and time windows for each of the rate structures described above, effectively choosing the best possible hours in which utilities should recover their capacity costs. We also propose a new rate structure that reflects optimal hourly prices. Since they represent the wholesale energy prices utilized in RTP plus optimal pass-through of capacity costs, we designate these prices RTP$^+$. We then use the model to evaluate each of the rate structures under a range of realistic assumptions.

Using data from PJM, Figure 1 compares the maximum potential benefits of each rate structure currently in use against RTP$^+$ under a range of capacity costs. By definition, RTP$^+$ achieves 100 percent of potential benefits in every case and is therefore not shown. The possible benefits of time-varying rates may go largely unrealized by current utility proposals. For instance, at a typical capacity cost of $120/MW-day, even an optimally chosen two-tier time of

use rate may achieve only 13 percent of the benefits possible from RTP+. In the absence of a well-designed demand charge, RTP achieves just 25 percent of possible benefits. By contrast, critical peak pricing enables retailers and their customers to achieve 65 percent of the total potential benefits.

Figure 1: Relative performance of Rate Structures by Capacity Cost



The choice of rate structure can have a significant effect on welfare: moving from a two-tier to a three-tier time of use scheme, for example, could double the resulting benefits. Within a given rate structure, making optimal choices has an equally significant impact: identifying the right time windows, calling the right number of critical peak pricing events, and setting the right hourly prices all strongly impact the effectiveness of these rates. While by no means the only consideration in setting time-varying rates, understanding the potential benefits is a crucial component in these decisions.

Many of the outcomes hold under a wide range of input assumptions and across many geographical areas, leading to several clear implications for retailers and regulators:

- Most of the benefits of time-varying rates come in the form of reduced capacity requirements.
- In markets with capacity costs typical in the U.S., retailers can benefit from capacity reductions in the short term and should prioritize this goal when designing time-varying rates.
- Passing through wholesale clearing prices (RTP) may be an ineffective way to reduce capacity requirements, missing most of the potential benefits of optimal hourly pricing (RTP+).
- Among rate structures currently in use, Critical Peak Pricing is a much more promising route than RTP.