Utilities Policy 37 (2015) 58–68

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

Time-based electricity pricing for large-volume customers: A comparison of two buildings under tariff alternatives

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ARTICLE INFO

Article history:
Received 15 February 2015
Received in revised form
2 October 2015
Accepted 2 October 2015

Keywords:
Uniform-rate & time-based pricing
Demand shift strategies
Energy conservation

ABSTRACT

This study investigates a variety of pricing policies for commercial and industrial customer sectors. Two building examples were used to analyze energy usage by buildings under the uniform-rate and time-based pricing schedules of three electricity utilities. Critical-peak and real-time price signals encourage building managers to implement the greatest number of measures to reduce their electricity costs. Consumption-shifting and curtailment measures that take into account time-based electricity prices do not appear to reduce energy usage and costs as much as regular energy-efficiency measures. Nonetheless, expanding the focus of energy management to include measures based on time-based pricing can help reduce electricity costs for commercial and industrial buildings.

1. Introduction

Due to the fluctuating demand for electricity throughout the day and the fact that there are presently no economically viable energy storage systems for electricity, the cost of generation fluctuates continuously throughout the day. While the cost to generate electricity throughout the day varies based on both demand and supply availability (Borenstein et al., 2002), most residential, commercial, and industrial customers pay a uniform rate per unit of electricity used throughout the day. The historic reason for the adoption of uniform rates by electricity utilities, despite varying costs of production, was because it was not technologically feasible or cost effective to implement time-based pricing for most users. However, the development of smart-grid technologies, specifically Advanced Metering Infrastructure (AMI, also known as smart meters), allows electricity utility customers to monitor real-time electricity usage while also allowing utilities to charge different rates at different times of the day based on differences in the cost of service (Joskow and Wolfram, 2012).

Even though penetration of AMI technologies in the United States increased from 0.7% in 2006 to 22.9% in 2012, as of 2012, only 2.1 million residential customers (1–2% of all residential customers) were on time-based electricity rates (Federal Energy Regulatory Commission, 2012). As AMI penetration increases in the United States, implementation of time-based pricing for all utility customers will become more feasible.

In some service areas of the United States, electricity utilities are adopting time-based electricity pricing schedules for large-volume (commercial and industrial) customers, both on an opt-in and a mandatory basis. Time-based pricing structures are adopted for two related reasons. The first is that time-based pricing can be used to help manage peak demand. The second is that time-based pricing and enabling technologies will price electricity at the time it is consumed (based on marginal cost) and help them reduce their energy usage at times when costs are higher.

To compare large-volume customer costs under uniform-rate and time-based pricing structures, this study investigates both types of rate schedules for utilities throughout the United States. The time-based pricing practices of several investor-owned utilities are provided. The utilities were selected because they presently implement differing pricing structures.

We also present two case examples based on actual commercial and industrial buildings located in Hawaii. For both buildings, energy-efficiency audits resulted in recommendations to reduce each building's aggregate energy consumption. For the purposes of this study, these are referred to as regular "energy-efficiency measures".

Under a time-based electricity pricing structure, a building manager can install additional measures that would not necessarily yield an economic benefit under a uniform-rate structure. This would include measures to shift the energy load of a building from on-peak to off-peak time periods. For the purposes of this study,

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http://dx.doi.org/10.1016/j.jup.2015.10.001
0957-1787/

these are referred to as “consumption-shifting measures”.

Additionally, under some pricing structures the price of electricity can be much higher than normal based on system conditions (such as congestion). When this happens, it may be economically beneficial for a building manager to reduce energy usage drastically for brief periods of time. For the purposes of this study, these measures are referred to as “curtailment measures”. Incentives for consumption shifting and curtailment can be considered by utilities as part of their demand-response programs.

For the two case examples, daily load profiles were devised for the baseline usage case and after energy-efficiency measures were adopted. Subsequently, daily load management strategies for the buildings were devised to minimize electricity costs based on various time-based pricing structures. This included consumption shifting measures (such as installation of thermal energy storage) and curtailment measures (such as turning off air conditioning or interior lighting). In this study, in other words, consumption shifting and curtailment were considered in addition to energy-efficiency measures.

The annual costs of electricity to customers under both uniform-rate and time-based pricing structures under multiple potential daily load profiles in multiple service areas in the United States were calculated. This is meant to inform the evaluation of pricing structures in conjunction with energy-efficiency auditing for commercial buildings.

2. Methods

Some large-volume electricity customers pay for electricity according to a uniform-rate structure under which all electricity is priced the same regardless of time it is used. While the energy (commodity) costs are priced at a uniform rate, there is also usually a demand charge based on the customer's peak usage during a specified period. Since a building usually reaches peak usage at the same time each day, the demand charge acts as a practical (but imprecise) proxy for a time-based electricity price. However, if the customer's peak does not coincide with the times when electricity is most expensive for the utility to produce, the demand charge will not act as an effective efficiency incentive at these times.

Instead of a uniform pricing structure in which all electricity has the same price regardless of the time that it is used, time-based pricing can be utilized to reflect costs in terms of the wholesale electricity price at the time it is produced. There are several time-based pricing structures in use by investor-owned utilities throughout the United States.

The utilities considered in this study that have or will soon have mandatory time-based electricity pricing structures for large-volume customers are Pacific Gas and Electric (PGE), which serves the San Francisco Bay Area, and Southern California Edison (SCE), which serves the Los Angeles metropolitan area. The third utility in this study, which has an opt-in (optional) time-based electricity pricing structure for commercial and industrial customers is the Hawaiian Electric Company (HECO), serving the Island of Oahu in the State of Hawaii. These utilities were chosen because they provide a variety of contemporary pricing structures for commercial and industrial buildings, a short description of which follows.

2.1. Time-based electricity pricing

A basic form of time-based electricity pricing is time-of-use (TOU) pricing, under which the price of electricity varies for two or three time periods throughout the day. Periods that have higher costs are usually known as peak periods and time periods with lower costs are called off-peak periods. TOU pricing is typically done so that there is some price fluctuation without the pricing structure becoming too complicated for customers.

Another form of electricity pricing is critical peak pricing (CPP), under which customers pay a premium (usually much higher than the typical price of electricity) during critical-peak periods. Critical peak days are days when demand is anticipated to be higher than normal, usually due to high outside temperatures. The utility company notifies a customer either within a few hours or a day in advance that there will be a critical-peak pricing day. The customer can then avoid costs by reducing their electricity usage during the critical peak. While this method captures more cost and price fluctuation, it may be difficult for some customers to reduce their electricity usage at a specific time. Thus, some customers will be exposed to much higher bills if they cannot reduce their electricity usage during the CPP period.

Dynamic or real-time pricing (RTP) allows the cost of electricity to fluctuate continuously based on the wholesale price of electricity. A variation estimates electricity costs based on the temperature of the service area. Price fluctuations can be from hour to hour or as short as 15-min intervals. While RTP may be considered efficient and equitable, it can also be challenging for end-use electricity customers to adjust their energy usage constantly in response to wholesale prices. Customers may be exposed to high prices under RTP to a greater degree than under other time-based pricing structures.

All of these types of retail electricity rate structures are explained in further detail in a report by the Electric Power Research Institute (EPRI) (Electric Power Research Institute, 2011).

2.2. Time-based pricing structures of various electricity utilities

In this section, the time-based electricity pricing structures of three investor-owned utilities is presented. These utilities were chosen for their comparative value.

2.2.1. Southern California Edison (SCE)

In the SCE service area, CPP rates are mandated for commercial and industrial customers, but they can opt out into a regular TOU rate. In addition to the CPP and TOU pricing schedules, there also are optional RTP schedules for all large-volume customers in the SCE service area. The real-time price of electricity is determined by the maximum ambient temperature in the service area, season of the year, and day of the week. These determinants come from historical records and are not directly tied to the wholesale price of electricity. SCE's rate schedules and prices were all taken from the utility's website (Southern California Edison, 2014).

2.2.2. Pacific Gas and Electric (PGE)

For large-volume customers, PGE has been transitioning the commercial and industrial sectors to CPP rates beginning with larger-volume customers in May of 2010 and smaller-volume customers in November of 2012. Mandatory adoption of CPP began in November of 2014 for consumers whose monthly demand exceeds 200 kW. For comparison purposes, we provide both the original uniform rates and the time-based rates. The utility's rate schedules and prices were all taken from the PGE website (Pacific Gas and Electric, 2014).

2.2.3. Hawaiian Electric Company (HECO)

For both residential and large-volume customers, HECO offers several optional TOU rate structures on an opt-in basis. There are no CPP rates or RTP rates presently available within the HECO service area. While there are no immediate plans to implement mandatory time-based pricing policies, HECO may adopt CPP policies in 2019, when implementation of AMI is complete. The utility's rate