The Economics of Real-Time and Time-of-Use Pricing For Residential Consumers

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Real-time and time-of-use prices for residential electricity customers have yet to gain widespread acceptance. This is in spite of their potential to save consumers over $1.2 billion per year -- in California alone, according to the Electric Power Research Institute. In an EPRI study, over half of the 123 investor owned utilities surveyed offered residential TOU tariffs, yet less than one percent of their customers subscribed to these rates. None offered real-time prices.[2] While the number of utilities now offering time-based pricing has increased, the percent of their customers receiving these prices has not changed much since the survey.

Results of time-based pricing continue to demonstrate the beneficial impact that innovative rate structures have on reducing residential peak load: historical analysis of residential TOU data at Connecticut Light & Power, Pacific Gas & Electric, Wisconsin Public Service, Narragansett Electric Company and Wisconsin Electric Power have shown significant consumption reductions during peak periods of approximately 23%, 18%, 15%, 7%, and 4% respectively.

Why haven't time-based prices become ubiquitous in the United States when the evidence indicates that customers are accepting and society receives sizable demand-side management benefits? First, residential electric meters don't record

[1] - This report is an updated version of a paper presented at the Third Annual International Distribution and Demand Side Management Conference.

[2] - "Time-of-use" prices have a peak, sometimes a mid-peak, and an off-peak price for a maximum of three prices per month. "Real-time prices" vary as frequently as every hour, though a prices for residential consumers are typically limited to four or five, adding a "super peak" and a "critical peak" to the normal TOU periods. The super peak and critical peak prices are dispatchable, meaning they can be turned on or off on a daily basis (the normal situation is that they are off, then turned on when wholesale prices rise significantly).

power use according to time of day, and advanced metering costs were high in the 1980s when TOU prices were introduced. Second, policymakers, unintentionally perhaps, have given electric utilities no or even negative incentives: more power plants and higher sales typically lead to higher profits. Today, however, higher value and lower technology costs now make the economics not only favorable, but compelling.

Time-Based Prices

The primary forces behind time-of-use rates or real-time prices are:

(1) to reflect the time variation in the wholesale costs to produce electricity, to more accurately match their costs with the service being provided to the customer, and

(2) to encourage customers to eliminate consumption during peak or to shift their energy usage to off-peak periods, allowing the utility or other power producers to operate facilities more efficiently

The resulting benefits of a successfully designed rate are twofold. First, the electric system load shifts over time, allowing society to defer capital expenditures. Secondly, end-use customers favor the new rates since their monthly bills are reduced.

The Evolution of Time-of Use

In the 1970's and early 1980's, the Federal Energy Administration sponsored utility trials to determine how to structure TOU rates and whether TOU rates made economic sense for the utility and the customer. Preliminary tests indicated that residential customers would accept TOU rates with encouraging results. Commercial and industrial customers were typically less responsive, since they have less elastic consumption patterns than residential customers. Even after the early studies, the demand-side management benefits to the utility remained unclear. Regardless of the utility industry's desire to offer residential

TOU tariffs, the technology required to record TOU energy consumption was too expensive to consider the introduction of these tariffs.

In the remainder of the 1980's many utilities continued to test time-of-use rates, using larger sample sizes and more sophisticated measurement equipment and techniques. These utility studies have shown an average reduction in peak consumption of about 20%, or 0.7 kW per residential customer, and an average reduction in total consumption of about 4.5%, or 450 kWh *(EPRI & EEI)*. In 1989, at a typical value of $60/kW-year for avoided capacity and $0.03 per kWh for avoided generation, the benefit to utilities was about $55 per customer-year for time-of-use rates. About 80% of this amount must be returned to time-of-use customers as the benefit of shifting their load, leaving about $11 per customer-year for metering. This amount, $11 per year, is equivalent to a total capital cost of $69. By 2000, wholesale capacity and peak energy prices had doubled, increasing the savings to consumers to nearly $100 per year, with $22 available for metering, or an equivalent capital cost of $138. Savings for real-time prices are even higher.

Applied to all residential customers in the U.S., a 10% reduction in peak would translate to about 20,000 MW (this is about the same as the peak load for all of Pacific Gas & Electric, the nation's largest combined electric and gas utility). A 450 kWh reduction in consumption per customer translates to 40 billion kWh per year.

In an effort to participate in this potentially huge TOU market, meter manufacturers made major product advancements. In the 1980s, with the availability of low cost microprocessors, the first reasonably-priced, under-the-glass, solid-state TOU register was introduced. Throughout the 1980s, the selling price of TOU registers dropped substantially, bottoming out at about $125 in large quantities by the end of the decade. Even at this price, TOU programs did not expand as rapidly as the meter manufacturers had hoped.

Several utilities have proven that small scale time-of-use programs can be beneficial to both the customer and the utility. As an example, several years ago

Central Maine Power Company introduced a mandatory[3] TOU rate program for those residential customers exceeding 2,000kWh in any winter month, or 5% of their residential customer base. The program has had a significant impact on usage patterns, with customers reducing their overall consumption by 5% to 12% compared to previous years. The net effect has benefited the utility by reducing the residential customer's contribution during winter peak periods by 14%, while customer satisfaction is high.

Studies conducted by Central Maine indicate that, excluding "lost revenues"[4], even with the lower benefits and higher meter costs available during the 1980's, TOU rates were cost effective after only three years of operation, with a benefit /cost ratio of 1.15. The ratio improves to 2.08 after six years. When taking lost revenues into account, TOU rates became cost effective after 8 years. By putting a dollar value on capacity and energy savings, Central Maine calculated savings per TOU meter installed of $104 in 1989 and up to $240 in the year 2000.

A 1992 study conducted by the Electric Association in the U.K. showed the majority of customers favored a TOU rate tariff, and adjusted their use of electricity. As expected, usage was reallocated to the less expensive off-peak periods, while overall monthly consumption remained relatively constant.

Pacific Gas & Electric has been a leading proponent of residential TOU rates since their first voluntary residential TOU program was introduced in 1982. Since then, the number of participants has grown to over 86,000 residential customers. As of the early 1990's, 80% of these customers saved $240 per year by participating in the program, while PG&E recognized benefits from the resulting demand shift to the off-peak periods. According to Ken Rogers, TOU Program Manager at PG&E at the time, the major obstacle inhibiting more widespread deployment of TOU rates was resources. This included the cost of purchasing new meters, installing the meters, reading the meters, marketing the program, and managing the overall TOU program.

[3] - Many policymakers favor voluntary time-based pricing for residential consumers. PG&E had great success with the voluntary Residential Time-of-Use Program I managed in the 1980's, achieving peak load reductions of 20 percent for program participants.

[4] - Some analyses of TOU programs consider consumer savings to be "lost revenues." These savings reflect lower wholesale costs, and thus real savings, that are passed on to program participants.

Challenges with Time-Based Pricing Programs

There have been both technological and economic barriers to widespread time-of-use rates for residential customers. These rates require new metering solutions that are able to record consumption at peak and off-peak times. Historically, these meters were all inclusive, responsible for pulse accumulation, load profile recording, time-of-use bin switching, rate modifications, calendar management, and alarm handling. In order to safely store and later retrieve the data, batteries, optic ports, liquid crystal display, and large amounts of memory are required in each and every end meter device. This consolidation of metering functions resulted in the commercialization of multi-functional, stand-alone meters that sell today for between $100-$150 versus $25-$30 for standard electro-mechanical meters. In a first step to reduce costs, time-of-use register devices were either retrofitted to electro-mechanical meter bases, or integrated onto new meter bases. There are several suppliers of stand alone time-of-use meters or registers, including G.E., ABB, Siemens, and Schlumberger.

The majority of time-of -use meters are manually interrogated by a meter reader. The meter reader either records the bin information as it appears on the meter's display, or uploads the consumption information through an optic port on the meter. Both of these techniques are time consuming and costly for the utility. The costs associated with manually reading TOU meters are upwards of 30% greater than reading total consumption off of the meter dials.

Other challenges facing utilities with regard to stand-alone meters is maintenance and upkeep. Each stand alone metering device has a battery that must be replaced on a fixed cycle. These battery replacement programs, combined with the replacement of failed units, and the disposal of batteries can be a timely and costly undertaking for the utility. Since stand alone meters are only interrogated monthly, there is the possibility that the register failed to record consumption for part of the month. When a unit fails, a new unit, programmed with the correct rate information needs to be installed. If the customer wishes to subscribe to a different rate or the utility modifies a rate, the meter may need to be reprogrammed or replaced. In either case, a site visit is required. In addition, with a rate programmed into the meter, there is always the possibility of operator error, and incorrect programming.

Other costs associated with stand alone TOU metering include meter shop programming, meter shop training, and the administrative costs of tracking new rates and maintaining an inventory of several meter types.

The Future of Time-Based Metering

Thus far into 2001, the price of standalone TOU registers, the associated maintenance, and meter reading costs have remained relatively constant, forcing utilities to charge residential customers a substantial monthly fee to subscribe to most TOU tariffs.

It has become apparent to those closely involved in advanced metering concepts, that a paradigm shift is required; standalone meters are not the ultimate solution being sought by utilities for supporting TOU rate programs. The new variable that has entered into the utility metering environment is low cost wireless communications. In the past ten years, communication technologies have made major impacts on all aspects of corporate America: distributed computing to replace mainframe applications, local area networking to allow information and resource sharing, internetworking to create the global office, and wireless voice and data services for ubiquitous communications. Now is the time for the utility industry to evolve into the age of communications by applying these new technologies to the business of supplying energy services. Communications afford utilities the flexibility to offer innovative pricing and implement new demand-side management programs.

Applying advanced communication technologies to metering will be the driving force behind rapid deployment of TOU programs at U.S. utilities. With communicating TOU meters connected to cost-effective communication systems, favorable economics can finally be achieved. Through remote communications, a less complex and therefore more reliable TOU metering solution can be developed to address the equipment, reading, and maintenance costs associated with standalone TOU metering solutions.

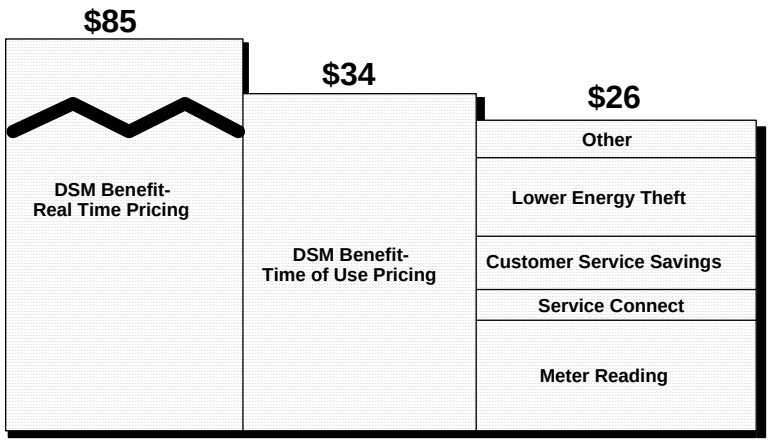
Time-Based Program Obstacles Standalone Meter	*Time-Based Program Solutions Communicating Meter*
High device cost	Lower cost, less complex
High maintenance costs	Lives longer, fewer parts
Battery replacement costs	No batteries required
High meter reading costs	Read over the network
Rate programming costs	Configured over the network

Automation Beyond Meter Reading

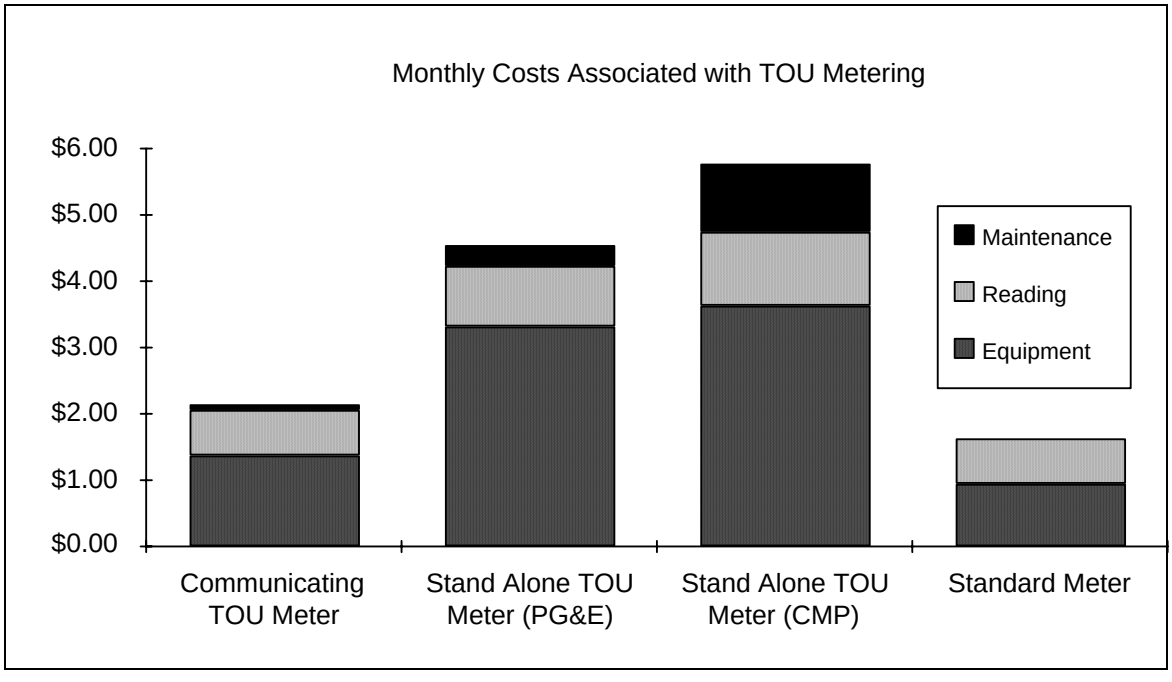
Many automatic meter reading systems installed at utilities today are limited in scope and function; either providing comprehensive support for a limited number of the utility's largest commercial and industrial customers, or offering only basic monthly reads for a subset of residential customers. Without low cost communication services for electric, gas and water metering, utilities were limited in the types of data that could be acquired from end device and the rate at which the data could be acquired. These restrictions eliminated the possibility of widespread time-based pricing programs.

When evaluating the economics of an automatic meter reading solution, utilities are now considering all of the potential applications that could be made available, including the ability to accommodate time-of-use and real-time pricing. According to an EPRI and New York Public Service Commission study, automatic meter reading offers only a small percentage of potential cost savings to a utility, whereas other more advanced applications such as time-of-use rates and real time pricing, can offer substantial monetary benefits to the utility.

Economic Payoff - Annual Cost Savings per Electric Customer



A systems-based approach both increases the benefits and reduces the cost. For example, an on-line communications link to the utility allows for far more than meter reading: implementation of time-based prices, immediate theft notification, power outage detection, detailed usage recording, and even appliance monitoring and control. At the same time, as shown, costs are reduced:



Summary

Effective economies, including the U.S. economy, have relied on price response to match supply and demand. In electricity, a long history of testing and implementation has shown the benefits of time-based pricing. With higher wholesale prices and lower technology costs, policymakers have the opportunity to provide consumers with billions of dollars in savings.

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