TAKING ADVANTAGE OF REAL-TIME PRICING PROGRAMS TO REDUCE ENERGY COSTS IN MANUFACTURING

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Increasingly, utilities are offering optional real-time pricing programs to their industrial customers. In many of these programs, the price of electricity changes on an hourly basis to reflect the projected cost of providing electricity to the consumer during that hour. Real-time pricing of electricity will become more prevalent in the future as competitive spot markets or power exchanges for electricity are developed.

Real-time pricing can provide industrial energy consumers with new opportunities to reduce energy costs. Under real-time pricing, it may prove cost-effective to reschedule operations from high-price periods to low-price periods, reschedule maintenance activities, or endure voluntary curtailments in electricity service during high price periods. Investments in standby generation, energy storage devices, and control systems may prove attractive. Successfully exploiting this option requires the development of an effective strategy for responding to changing electricity prices.

A number of reports and guides have been prepared under the sponsorship of the electric utility industry to assist utilities and regulators in designing effective real-time pricing tariffs. Yet, industrial energy consumers wishing to exploit real-time pricing have been provided little guidance. This paper examines the potential benefits and costs of real-time pricing programs from the perspective of industrial energy consumers in hopes of filling some of this gap.

This paper outlines how industrial energy consumers can develop effective energy cost reduction strategies to take advantage of real-time pricing programs. Typical pricing algorithms and program design features are first described. Common measures and operating strategies for energy cost reduction under real-time pricing are discussed. Practical advice is provided to assist energy managers in analyzing cost reduction opportunities from real-time pricing programs.

WHY ARE REAL-TIME PRICING PROGRAMS BEING INTRODUCED?

Real-time pricing seeks to match electricity prices to the changing marginal cost of meeting customers' power needs. A utility's marginal cost changes continuously as different utility system resources are placed on- and off-line to meet changing demand levels and system constraints.

Many utilities and regulatory agencies are keenly interested in promoting real-time pricing. Adherence to marginal cost pricing principles normally assists markets in allocating society's resources in an economically-efficient fashion. High hourly prices will tend to decrease or ration electricity during peak periods, while low prices can encourage electricity consumption when the electric power system is under-utilized.

A utility's overall cost of service can be lowered when electricity demand is shifted from peak to off-peak periods. By reducing demand on the utility's system during peak perdiods, capacity additions may be deferred. Average fuel costs may be lowered by reducing the utilization of less-efficient (higher cost) generating and increasing the utilization of baseload units. Cross-subsidization among customers is also minimized when customers are billed on the basis of the actual costs that they impose on the electric power system.

Today's real-time pricing programs can provide a vehicle to foster competition in the electric utility industry. Many electric power industry restructuring proposals envision the development of a competitive spot market for electricity where prices are set by the forces of supply and demand on an hourly basis. In California, for example, energy consumers will be permitted direct access to a spot market for electricity (the Power Exchange) beginning in 1998. Today's real-time pricing programs tend to mimic the behavior of prices in tomorrow's spot markets.

Many industrial energy consumers are demanding that utilities offer a real-time pricing option to provide them with new opportunities to lower energy costs. Consumers faced with quotes for different electricity prices for different time periods can manage their energy costs by shifting the operation of electricity-consuming equipment from high-price time periods to low-price periods or through other strategic means. At an industrial plant, production activities or maintenance activities might be rescheduled from high-price hours to low-price hours. Non-essential electricity consuming operations might be curtailed during high-price periods.

THE EVOLUTION OF REAL-TIME PRICING OF ELECTRICITY

While the concepts behind real-time pricing were formulated over 100 years ago, its application to electricity pricing has become practical only in recent years. Some of the factors that have fostered its introduction and maturation include:

- Advances in metering technology and a decline in metering costs. Relatively sophisticated metering devices are required for real-time pricing to monitor the customer's electricity demand in roughly real-time.
- Advances in communications technology. The internet, computer bulletin boards, fax machines, or some other media must be available to inform energy consumers of the applicable electricity prices.
- Experience gained through time-of-use rates. Beginning in the late 1970s, many electric tariffs have been designed with predetermined and predictable price differentials between electricity used in different seasons or times of the day. These tariffs have been a natural step in the evolution toward real-time pricing.
- The introduction and enhanced cost-effectiveness of new technologies enabling energy consumers to exploit price differentials. Such technologies include control systems and energy storage devices.
- The establishment of a spot market for "economy energy" transactions among utilities in wholesale markets for power. Such wholesale markets have provided utilities with valuable experience in developing cost-based bids to buy and sell power.
- Industry restructuring initiatives have further fostered the maturation of real-time pricing programs. Some market participants view participation in real-time pricing programs as an opportunity to hone competitive buying or selling strategies.
- Finally, utility efforts to expand their service and pricing options to industrial customers have led to the introduction of real-time pricing programs. Increased choices can foster higher customer satisfaction with the utility.

Real-time pricing programs have developed in two "waves" to date. The first set of utility programs in the U.S. were established in the mid-1980s. Many of these programs were designed to discourage large industrial customers from installing cogeneration capacity to take advantage of the PURPA-related incentives for cogeneration established by the federal government in the late 1970s. Some utilities sought to discount prices to potential cogenerators as much as reasonable, and the logical "price floor" was the utility's short-run marginal operating cost (often calculated on an hourly basis). Many of these tariffs were for interruptible service. The customer would be assessed a minimal demand or capacity-related charge. The hourly electricity prices would reflect the utility's changing hourly fuel-related costs, with "adders" or "markups" for the recovery of other types of costs. In this first wave of programs, prices were often poorly communicated. Some of the pathbreaking real-time programs were offered by Houston Lighting and Power Company, Central Power and Light Company, Gulf States Utilities Company, Southern California Edison, Detroit Edison, San Diego Gas and Electric Company, and Pacific Gas and Electric Company.[3,4]

In the early 1990s, a second wave of real-time pricing programs were initiated. Many of these new tariffs were designed specifically for firm service customers, although an optional program for interruptible service customers was often made available, as well. For firm service customers, a "curtailment premium" or "marginal power supply cost" charge was typically added to fuel and O&M charges whenever generating system capacity constraints were approached to bring electricity demand into balance with available capacity. The concept of a "customer baseline" was introduced, in hopes of guaranteeing the utility and the customer revenue/cost

neutrality with respect to some historical usage pattern. Generally, these tariffs have been viewed as "experiments" and participation has been limited. Advances in communications technology were exploited to improve the price information provided to the customer, as well as the information pertaining to customer energy usage provided to the utility. Leading this second wave of real-time pricing programs were Georgia Power Company and Niagara Mohawk Corporation. Many other utilities have followed suit, and today, over 40 electric utilities in North America offer tariffs with real-time pricing features.

Tomorrow's real-time pricing initiatives will be shaped by electric utility industry restructuring activities. Many of the state-level industry restructuring initiatives envision the establishment of spot markets (or "poolcos") for electricity. Market clearing prices would be posted on an hourly basis. Customers electing direct access to this spot market would receive hourly price quotes, similar to the quotes from today's real-time pricing programs.

Tomorrow's true spot market pricing is likely to differ from today's real-time pricing in some significant respects. Today's price quotes are calculated by a single supplier. Tomorrow's spot market pricing will be dependent upon the costs and actions of numerous potential suppliers and consumers. To mimic prices in tomorrow's competitive energy markets, today's price quotes are designed to approximate the utility's costs based upon formulas and algorithms developed by utilities and approved by regulators. Tomorrow's spot market prices should provide a true reflection of actual costs and market conditions.

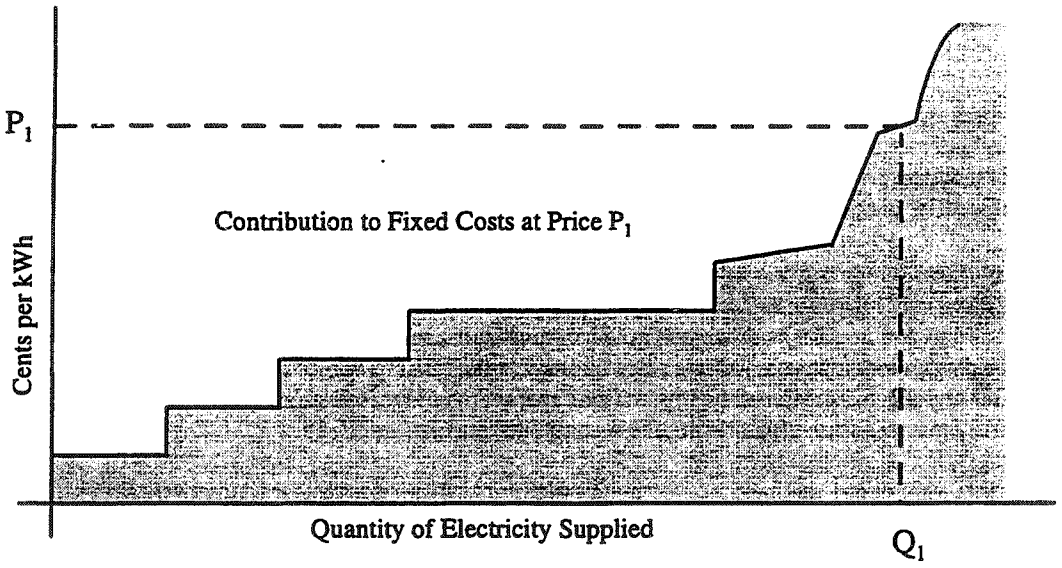
The number of factors affecting prices will also expand in the future. Under most of today's simple real-time pricing formulas, hourly prices change when marginal fuel costs change or expected demand levels change. In tomorrow's electricity markets, separate prices might be charged for real power and reactive power. Transmission congestion charges could be assessed to bring demand into balance with available supply in transmission-constrainted regions of the power network. Temporary surcharges could be assessed to control demand to address power quality problems. Temporary environmental price premiums could be charged to constrain demand and reduce power plant emissions in air sheds which may be temporarily out of compliance with ozone air quality standards. Each of these situations impose costs which could be reflected and addressed through price changes.[1]

REAL-TIME PRICING IN PRACTICE

In theory, the optimal real-time price for a specific customer at a specific time is the marginal cost associated with serving that customer at that time. In practice, this price is often calculated as the sum of the utility's marginal system operating cost (adjusted for losses), a curtailment premium (if generating capacity limits are approached), and a transmission congestion charge (if transmission or distribution system capacity constraints are approached in serving the customer). In practice, curtailment premiums are often based on the expected level of demand in relation to the annual system peak. If the tariffs are designed for interruptible service customers, curtailment premiums and congestion charges may be omitted, since service to the customer would be interrupted if capacity constraints were approached.

There is a common misconception that real-time pricing cannot provide a contribution to the utility's fixed costs. However, assuming an "upward-sloping" marginal cost curve, real-time pricing will indeed assist a utility in the collection of revenues to offset the utility's fixed cost burden. The lightly shaded area in Figure 1 represents this contribution.

Figure 1: The Contribution to a Utility's Fixed Costs under Real-Time Pricing



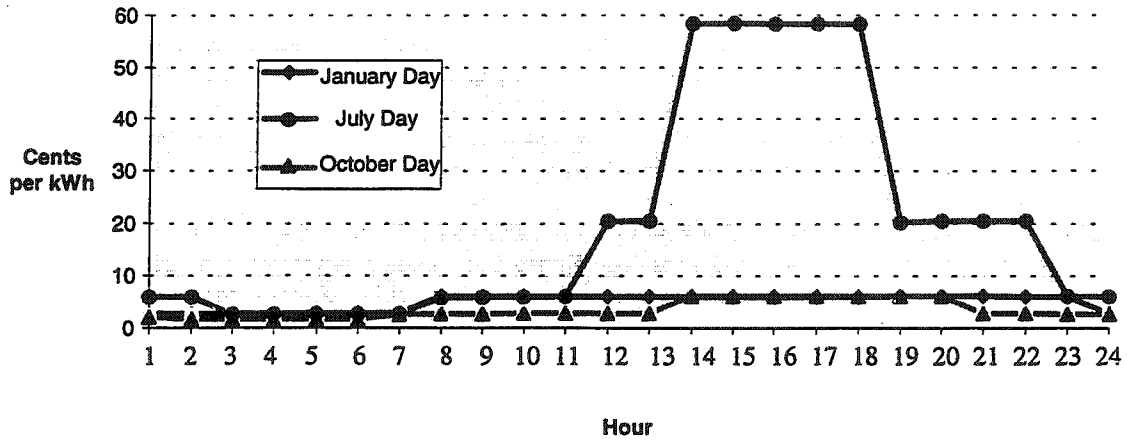
Nonetheless, there is no guarantee that the contribution to fixed costs under real-time pricing will prove sufficient to meet a revenue requirement established by a regulatory authority. Consequently, the utility's marginal cost estimates are often scaled up in setting prices. This mark-up is often achieved through "customer baseline" features, "price adders" (where is fixed charge is added to the price) or "price multipliers" (where prices are scaled up by some multiple).

When customer baselines are a tariff feature, the customer's bill is first calculated based on the tariff that the customer was formerly served under. The customer's bill is then adjusted by multiplying the real-time price by any deviation from the baseline load pattern set for the customer. Thus, if the customer's load is higher than the baseline for a particular hour, the customer's bill is adjusted upward by an amount equal to the real-time price multiplied by the increase in load over the baseline. The customer can receive a bill credit for each hour that actual demand remains lower than the baseline load.

Typically, a set of hourly price quotes or projections for a day are communicated to electricity consumers on a prior day. Utilities often install load monitoring and communications equipment at the customer's site to receive the hourly price quotes and monitor the customer's hourly electricity consumption.

Price levels and patterns are at the mercy of the utility's changing costs and the price formulas which have been established. In general, prices will be lower than the prices quoted in the utility's traditional tariffs during "off-peak" periods, but can be significantly higher during peak hours. Under some utility real-time pricing formulas, prices can exceed 50 cents per kWh for 100 to 200 hours per year. Pacific Gas and Electric Company raises prices over $1 per kWh for select hours. Some typical price profiles are presented in Figure 2.

Figure 2: Typical Price Profiles Under Real-Time Pricing



CAN YOUR FACILITY BENEFIT FROM REAL-TIME PRICING?

The extent to which your facility may benefit from real-time pricing will depend upon the design of the real-time pricing program and your firm's ability to respond to electricity price changes.

Facilities that have very little flexibility in scheduling their operations (for example, department stores, offices, and cement manufacturers operating at full capacity) may see little benefit from real-time pricing, unless the price differentials are large enough to justify investment in standby-generation or energy storage devices. Yet, most industrial and commercial facilities can realize some energy cost savings by taking service under a real-time pricing tariff. An assessment of the potential benefits and costs requires an analysis of the following:

Relative prices. Given your expected load patterns, would your cost of electricity be higher or lower under a real-time pricing tariff, in the absence of taking any load management actions? This type of analysis requires either a forecast of hourly prices for a few years or a backcast of what the real-time might have been for some historical period.

Rescheduling operations. Can you reschedule some of your facility's operations within a day from hours of relatively high electricity prices (e.g., afternoon hours) to hours of lower prices (usually late night hours)? Can operations be rescheduled from high price months (e.g., summer and winter months) to low price months? Can operations be scheduled using electricity price information as one factor in the scheduling process so as to minimize overall production costs?

Maintenance. Can maintenance activities be rescheduled to coincide with hours of high electricity prices?

Curtailments. How much inconvenience or lost profit would your facility experience if it simply curtailed all or part of its operations during high price hours? Can non-critical electrical loads be identified at your facility? Controls can be installed to automatically reduce electricity purchases when prices rise above predetermined levels.

Standby Generation. A customer lacking flexibility in operations might still benefit from real-time pricing by installing and operating standby generation equipment during high price periods.

Energy storage devices. The installation of energy storage equipment (thermal energy storage devices, chemical batteries, and flywheels) may prove to be cost-effective in conjunction with real-time pricing, if the anticipated price differentials are sufficient.

Ability to switch among different energy resources. In some processes, fossil fuels can be substituted for electricity or a resource mix may otherwise be changed (e.g., oxygen injection might be used as a substitute for an energy resource) in response to the changing relative prices of resource inputs.

Subsidization. Due to the imperfections in traditional rate-making, many customers are presently subsidizing other customers in their rate classes. If your facility presently has a greater share of its consumption during low-cost off-peak periods than the typical customer in your class, you may be subsidizing other customers in that class. Moving onto a real-time pricing tariff could provide a means of eliminating your subsidy payment to other customers.

Facility automation. The state of technology at your facility can affect your ability to respond to changing energy prices. Some consumers have the capability to quickly analyze load information to isolate patterns and identify efficiency opportunities. Manufacturing operations which have adopted agile manufacturing concepts may be able to optimize operations using changing electricity prices as a factor in operations decisions.

How are you planning to change your operations in the future? Facilities planning to expand or change operations in the future need to carefully study the utility's real-time pricing tariff. If a customer baseline feature is a part of the utility's tariff, can the baseline be modified for anticipated changes in facility operations? If it cannot, how will this affect the facility's energy cost? How will the load profile be affected by the change in operations?

Predictability and risk. Under traditional utility tariffs, there is little, if any, hourly volatility in electricity prices. Time-of-use price differentials are quite predictable under traditional tariffs. Under real-time pricing, prices can be quite volatile and sometimes unpredictable. How much electricity price risk can your facility tolerate? Financial instruments (e.g., swaps and futures) are available to hedge such risks, yet the acquisition of such instruments will involve some cost.

When such questions are posed to facility operations personnel, a typical response is "we are already doing all that we can to keep energy costs low." Yet a manufacturing operation set up to minimize energy costs under a system of fixed or predetermined electricity prices may not necessarily be capable of exploiting the opportunities presented by real-time pricing. Taking advantage of real-time pricing generally requires a higher degree of flexibility in operations and/or reliance upon energy storage or standby generation equipment. It also requires a re-examination of the capabilities of control systems, labor commitments, operations scheduling, and maintenance scheduling.

The development of an effective energy cost reduction strategy involving service under a real-time pricing tariff requires careful consider of each of these factors. The required analyses can become rather complicated, since hourly data and price forecasts are required.

SPECIFIC DESIGN CONSIDERATIONS

Industrial energy consumers often have an opportunity to influence the design of real-time pricing programs through negotiations with utility suppliers or through intervention in regulatory proceedings. Some of the design features that an industrial energy consumer may wish to influence include:

The existence of customer baselines. Some industrial customers appreciate the stability provided by customer baseline features. If their future load patterns follow historical patterns, then their bill will be the same as it would have been under traditional tariffs, so there is little to lose by accepting real-time pricing service. Flexible customers see opportunities to receive significant bill credits from the utility by dropping well below baseline load levels during peak periods. However, customers with low load factors and/or erratic load patterns typically dislike the concept of customer baselines. Meaningful baselines may be impossible to establish for such customers. Further, some customers consider historical load patterns to be irrelevant in the determination of current electricity costs. Customer

baseline features are generally more appropriate for firm service tariffs than for interruptible service tariffs.

The determination of customer baselines. If a customer baseline is to be a feature of the real-time pricing tariff, then how will it be established? Will the customer participate in its development or will it be set at the utility's discretion? Will adjustments be made to compensate for extraordinary events in historical load data? Will it be adjusted annually, or fixed for a set period of time? Will it be based on "typical day" profiles, the load during the same hour in the previous year, or some other scheme?

Calculation of curtailment premiums or capacity-related charges. Real-time pricing tariffs for firm service typically contain capacity-related charges which are imposed whenever capacity constraints may be approached. A large variety of approaches have been proposed to calculate such costs. How does the utility propose to calculated such charges? Will they reflect the utility's actual capacity-related costs?

Load monitoring and communications infrastructure. What type of hardware, software, and communications media will be used to monitor electricity consumption at the customer's site and notify the customer of price changes? Can the customer also use this equipment for load control at the site? Will the price information be communicated to the proper personnel and scheduling systems? Will submetering capabilities be available? Will the customer be able to access all of the same load and price information as the utility can access? Can load and price information be analyzed and manipulated by the customer?

Built-in risk management features. Late 1996 saw a doubling of prices in the spot market for natural gas. This, in turn, produced a significant (and unanticipated) increase in electricity prices to many industrial customers served under real-time pricing tariffs, thus highlighting the importance of managing electricity price risks. Does a customer have the option of purchasing under a fixed price contract the fuel that will be used by the utility to generate the electricity to be sold to the customer (thus fixing the fuel cost component of the real-time price)?

CONCLUSIONS

The number of utilities offering real-time pricing options is rapidly growing. Further, the establishment of competitive spot markets for electricity providing hourly prices is the cornerstone of many of the proposals to restructure the electric power industry. In the future, hourly pricing schemes may become the standard way that electricity is priced in the United States. Facilities prepared to respond to hourly pricing can begin to realize very significant savings on their electric bill.

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