Price-Based Demand Response

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WHITE PAPER

INTRODUCTION

Price-Based Demand Response Programs Offer an Affordable Solution for Managing Energy Consumption and Cost Improved Event Planning Input

Price-based demand response programs set different prices for electricity at different times of the day based on anticipated demand, available supply and the estimated cost of production. For example, energy consumed during peak hours, when demand on the electric grid is the highest, costs the customer more than that consumed during off-peak hours. Price-based demand response incentivizes customers to decrease their energy use during peak hours to reduce stress on the electric grid.

The only requirements to implement a price-based demand response program are a smart meter and two-way communications between the energy provider and consumer. Smart meters are being rapidly deployed nationwide, with the Institute of Electric Efficiency (IEE) estimating that by 2020 nearly all residential U.S. customers will have them.

With price-based demand response programs enabled by two-way communications and energy management devices, consumers can control almost all appliances, including air conditioners, heating systems, washers and dryers, pool pumps and water heaters, to take advantage of lower rates. Price-responsive consumer curtailment in turn reduces peak load, increases utilities' economic efficiency and asset utilization, and helps utilities avoid or defer resource costs, including adding additional generation.

Price-based demand response programs deliver an effective and affordable solution for managing energy consumption and costs, and they are receiving increased interest from state commissions and utilities.

This is driven in large part by an issue that the vast majority of utilities across the world have long faced — the fact that the cost of generating electricity does not always match the price the end user pays for that electricity.

This is highlighted in a recent Brattle Group study that demonstrates that costs are not always equally or fairly distributed. For example, the study found that consumers who use less energy during peak hours on a flat rate pricing plan—or one that is the same for all consumers at all times of the day—effectively subsidize heavy peak energy users in the amount of $3 billion a year. Collectively, consumers may be overpaying for electricity by about $7 billion a year (using the FERC staff estimate that 92 GW would be saved under universal price-based demand response plus demand response valued at $75 kW/year).

In other words, customers who consume energy modestly pay for the energy consumed by those customers who actually create the system peak and its associated higher costs.

Price-based demand response programs introduce a more equitable method of pricing energy wherein those who use the expensive energy pay the truer cost. They also support fairness in retail pricing by providing the means to charge those customers whose consumption patterns cause higher system costs according to their actual energy usage, and rewarding modest consumers with lower prices. Such programs also enhance the economic efficiency of energy usage by reducing peak demand, which in turn mitigates the need for expensive peaking capacity.

BENEFITS OF PRICE-BASED DEMAND RESPONSE

Price-based demand response programs benefit both consumers and energy providers. They reduce peak load, thereby helping utilities, businesses and residential consumers balance supply and demand; they support utilities in meeting federal regulations; and they can lessen environmental impact.

Benefits to the Utility

Improving the industry's load factor is the principal goal of price-based demand response. Load factor is a measure of how average usage relates to peak usage. **Load factor** is important because electricity cannot be stored in large quantities, so electrical services and generation must be designed to serve peak usage levels. When usage is less than peak, a portion of the facilities installed to meet peak load sits idle, decreasing the efficiency with which system assets are used.

Because a utility's load shape is parabolic, rather than flat, energy use varies during the day and year rather than remaining the same over time. For example, residential usage peaks in the morning as people get ready for work, falls during the day when they are not at home, and peaks again in the evening when they return home. Customers' electricity consumption also varies significantly by season, especially during the summer cooling months.

If a utility had a perfectly flat load shape—or used the same amount of energy every hour of the year— its load factor would be 100 percent. If instead it reflects varying peaks—or usage patterns that fluctuate at different times of the day or year— its peak load could be twice as high as its average load for a load factor of 50 percent. In fact, the load factor nationwide is between 50 and 60 percent. This means that there is a great deal of idle capacity. Price-based demand response improves this load factor by charging more for consumption during peak hours and charging less during non-peak periods.

Price-based demand response programs accomplish this at no cost to the utility other than administration of the pricing rates. The programs can:

- Reduce peak load, provide environmental benefits through possible emissions reductions and help utilities comply with federal regulations.
- Increase utilities' economic efficiency and asset utilization and help utilities avoid or defer resource costs, including generation capacity.
- Help improve reliability and security of the system.
- Increase the economic attractiveness of distributed resources, such as local small-scale power production and other end-use technologies such as electric vehicles that can be recharged during off-peak hours.
- Reduce wholesale market prices by reducing demand during high-priced hours of operation, thereby benefitting all market participants.
- Facilitate fairness in retail pricing so that those customers whose consumption patterns cause higher system costs bear their proportionate responsibility for those costs.
- Benefit most low-income customers, even without changing their energy consumption patterns, because they tend to have flatter load shapes so are already using energy during offpeak hours.
- Provide value to utilities in both regulated and market-based environments.

Price-based demand response programs save money and defer or eliminate costly investments in new infrastructure. They treat consumers more fairly and support the adoption of local distributed generation. Price-based demand response increases the efficiency of the electricity system at every step of the value chain.

Benefits to the Consumer

With prices that are higher during peak hours and lower during off-peak hours, price-based demand response programs encourage customers to shift consumption away from peak hours and therefore reduce system peak demand.

Consumers can also use the pricing and personal consumption data they receive from the utility to proactively increase their energy efficiency.

Consumer benefits of price-based demand response programs include:

- Taking advantage of lower-cost, off-peak billing to actively curb their energy usage.
- Lower energy rates are in force much of the time, resulting in an overall reduction of consumers' energy costs.
- Environmental benefits through possible emissions reductions.
- High customer engagement, satisfaction and user experience with rich tools that deliver insight and control in an easy-to-use customer Web portal.
- C&I organizations can schedule energy cycling to better manage demand across the grid.

CHANGING CONSUMER BEHAVIOR

Many utilities are reinventing the way they interact with their customers. Two-way communications between the utility and its customers enables utilities to implement demand response and pricing programs and provides consumers with the real-time insight into their consumption patterns that they need to take control of their energy usage, save energy and decrease their energy costs.

Price-Based Demand Response

Price-based demand response rates enable consumers to take advantage of lower-cost, off-peak billing and proactively curb their energy use. More than 130 experiments with different forms of price-based demand response in the US, Canada, Europe and New Zealand in the last ten years solidly demonstrate that:

- Consumers definitely respond to the price of electricity.
- Consumer response varies with the price incentive. The higher the incentive, the greater their demand response.
- Consumer price response also increases with enabling technologies, such as programmable communicating thermostats (PCTs) and Web portals. Enabling technologies help consumers to understand their usage patterns, while facilitating their ability to automatically control the function of their major appliances.
- Consumer response persists over multiple years. In fact, analysis conducted after the Baltimore Gas and Electric pilot in 2008 and 2009 showed that consumers actually became more price-responsive in the second year.

In addition, consumers are accustomed to paying different rates during periods of peak demand in a wide variety of purchase categories, including travel and tourism, professional sports, broadcasting, concerts, manufacturing and cruise lines. They understand that they will pay more when demand is higher, such as staying at a hotel on the weekend. They also understand that they can plan trips during lower-cost periods in order to save money. Consumers are familiar with this pricing model and are comfortable applying it to the energy industry.

In fact, among consumers who have experienced price-based demand response pilot programs, customer satisfaction is exceptionally strong. In 2011, the Brattle Group cited multiple post-pilot surveys and focus group studies that reflected satisfaction rates of between 78 and 93 percent, with between 73.5 and 99 percent indicating they would participate in the program again.

PRICE-BASED DEMAND RESPONSE PROGRAMS

The most common types of price-based demand response programs employ time-of-use and critical-peak pricing rates, dynamic rates and use feedback to encourage energy curtailment by consumers.

Each of the price-based demand response options offers the consumer a different combination of risks and rewards, and customers can select the rate design that best meets their needs and risk preferences. For example, real-time pricing rates offer the highest potential reward at the highest risk and time-of-use rates offer the least potential reward at the lowest risk.

Time-of-Use Pricing

Time-of-use (TOU) pricing divides the day into distinct time periods and provides a static schedule of rates for each period. For example, a peak period might be defined as the hours between 11:00 a.m. and 5:00 p.m. on weekdays, with the remaining hours defined as off-peak. The price of electricity is higher during the peak period and lower during the off-peak period. Prices may also vary by season.

TOU rates are not widely considered dynamic because they are fixed and are not based on actual market conditions, so they do not address the extraordinary demand placed on the grid during times of extreme peak usage, such as a heat wave. This differentiates TOU from the other price-based demand response programs.

However, these programs are still tremendously effective in lowering peak loads and reducing the need for peaking capacity. They reliably flatten demand in typical periods of peak use throughout the year, and because the rates are known in advance, consumers can vary their usage in response to such prices, either shifting usage to a lower price period or reducing their consumption overall.

Critical Peak Pricing

Under a **critical-peak pricing** (CPP) rate, customers pay higher prices during the few days of the year when wholesale prices are the highest or when the power grid is severely stressed. This is typically up to 15 days per year. The higher peak price reflects both energy and capacity costs. In return, consumers receive a discount on the standard tariff price during the other hours of the season or year.

CPP provides an opportunity for customers to reduce their electricity bills by choosing to use less energy when it is most expensive, and the program has produced some of the highest peak reductions among the price-based demand response programs.

CPP is the only form of price-based demand response that does not require a smart meter, instead using day-ahead announcements of anticipated system peaks for either automated or manual curtailment by participants.

Real-Time Pricing

Real-time pricing (RTP) enables customers to pay for electricity at the wholesale price during a predetermined period of time, paying for energy at a rate that is linked to the hourly market price for electricity. It is usually targeted at commercial and industrial (C&I) customers that use large amounts of energy. These customers "curtail load" at the electric service provider's request: they reduce their consumption of high-priced energy based on an evaluation of the total load they can reasonably curtail.

In an RTP program, a utility provides prices in advance (usually a day or an hour ahead of the event) and a customer can either reduce an entire load or a portion of that load. This is often viewed as the purest form of price-based demand response, as the much smaller price-responsive interval periods lead to a closely linked cost/price ratio.

Peak-Time Rebate

Peak-time rebate (PTR) programs enable customers to earn a rebate by reducing energy use during peak demand hours. Instead of charging a higher rate during critical events, participants are paid for load reductions over a forecast of what the customer otherwise would have consumed.

Rebate payments are based on the amount of actual load reduction rather than to a calculated baseline usage level. The number of days when the program is available is typically capped for a calendar year.

PRICE-BASED DEMAND RESPONSE TECHNOLOGIES

Regardless of the particular price-based demand response programs employed, they all share a set of fundamental technologies and best practices that help utilities realize optimum results.

Demand Response Management System

At the core of any automated price-based demand response program is a demand response management system (DRMS). The DRMS enables utilities to send real-time or day-ahead price signals to a variety of end points, including Web portals, smart thermostats and mobile devices. Customers manage their energy use by programming their devices to automatically control when and how they consume energy and to take advantage of lower-cost, off-peak prices.

Enabled by two-way communications between the electricity provider and its consumers, the DRMS makes it possible for utilities to aggregate all adjustments to a participant's control schedules, offering advanced insight into the capacity made available by all program participants.

Automation

A study from The Brattle Group has shown that using technology to automate price-based demand response programs can deliver approximately a 40 percent increase in peak demand reduction over relying on the consumer to manually reduce demand.

Consumers can manage their energy usage by using a customer Web portal to set control schedules for all high-energy use appliances, including air conditioners, pool pumps and water heaters that use enabling technologies such as switches and smart thermostats to control the appliances. This “set it and forget it” capability makes it easy for consumers to participate and also provides a more predictable load drop for the utility.

This two-way automated information exchange also enables utilities to aggregate all adjustments to participants’ control schedules for advanced insight into the capacity made available by all program participants.

Flexible Communications Deployment

Since price-based demand response programs require two-way communications, it was previously thought that an advanced metering infrastructure (AMI) communications network was required to deploy a program. If supported by a vendor’s devices, utilities can also take advantage of a customer’s broadband network and cellular networks. These networks provide the bandwidth to provide fast, reliable, two-way communications between the customer and the utility.

Measurement & Verification (M&V)

Once a utility has active participants in a price-based demand response program, measuring load reduction during an event ensures that the program will be as effective as possible. Analysis of M&V data enables utilities to monitor event performance, including evaluating device usage, forecasting futures based on historical event participation and ensuring ongoing performance. Additional tools for assessing system and network performance—such as load and event analysis, class/type segmentation and end-to-end system verification—provide the necessary analysis for further system optimization.

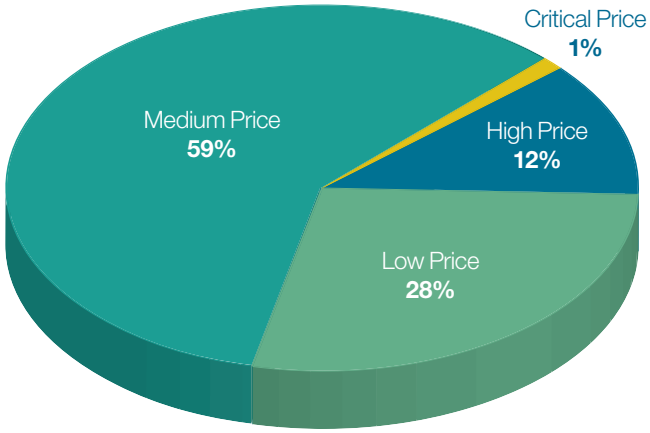
Marketing

Utilities can maximize the benefits of price-based demand response programs by continuously increasing participation. Because price-based demand response programs are relatively new to energy consumers, utilities are still developing the best marketing approach to drive program enrollment, ensure timely installation of devices in the field and provide call center support to participants. To ensure maximum program participation, the marketing function must include prospect analysis, segmentation, marketing implementation, recruitment, qualification and enrollment. Mass-scale adoption also depends upon ongoing support for program management, administration, field service and installation/inventory management.

CUSTOMER SUCCESSES

It is clear that price-based demand response programs have the potential to increase customer engagement and develop stronger customer relationships. Below are two real-world examples from Itron customers who have implemented price-based demand response programs and realized ongoing lower peak demand and improved customer satisfaction.

Lower Electricity 87% of the Time



Residential Service Variable Pricing Rate

Percent of Annual Hours in Effect

Customers at both Gulf Power and Tampa Electric can control energy pricing with the Itron dynamic pricing solution, earning lower rates 87% of the time.

Gulf Power

Based in Pensacola, Florida, Gulf Power Company is an investor-owned utility that provides services to more than 447,000 customers in Northwest Florida. Gulf Power's commitment to providing its customers with reliable and affordable energy, while minimizing environmental impacts, has earned the company national recognition as a leader in energy efficiency. For the last 15 years, the pioneering Gulf Power Energy Select TOU/CPP program, with more than 18,000 participants, has generated customer satisfaction rates as high as 95 percent and delivered environmental benefits by reducing the need for generation.

The Gulf Power Energy Select program gives customers greater control over their energy usage by allowing them to pre-program their central cooling and heating system, electric water heaters and pool pumps to automatically respond to pricing tiers and price signals. This "set it and forget it" capability makes it easy for customers to participate and also provides a more predictable load drop. The system bypasses the traditional AMI used for price-based demand response programs to instead use the customer's existing broadband network to enable a two-way exchange of information. The program has provided Gulf Power with a highly reliable source of capacity while enabling participants to pay a lower price for electricity approximately 87 percent of the time.

> "Over the last 15 years, we have worked very closely with Itron on our Energy Select TOU/CPP program. The program has been incredibly successful, helping us achieve customer satisfaction rates of greater than 90 percent as well as environmental benefits by lowering peak demand and deferring the need to build additional generating facilities. Today, we have more than 15,000 participants, which is not only a testament to the program's success, but also makes it the largest automated residential price-based demand response program in the country."
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> *– Dave Eggart, Energy Efficiency Supervisor, Gulf Power*

Tampa Electric

Based in Tampa, Florida, Tampa Electric provides service to more than 725,000 residential and C&I customers over 2,000 square miles of the state. Inspired by the success of the Gulf Power Energy Select program, Tampa Electric implemented the **Energy Planner℠** program, a TOU/CPP program with more than 4,900 enrolled participants. One of the most sophisticated residential price-based demand response programs in the country, Energy Planner enables residential customers to automate control of their energy usage in order to reduce consumption during times of peak demand.

Tampa Electric deployed a cost-effective TOU and CPP program that bypasses both AMI and Meter Data Management (MDM) technologies to use an existing broadband network to collect and analyze data from energy management devices, smart meters and residential gateways. The Energy Planner program uses smart thermostats and control switches to help residential customers manage the operation of their central heating and cooling systems, electric water heaters and pool pumps based on dynamic rates. This automated price-responsive program enables Tampa Electric to offer four pricing rates for electricity (low, medium, high and critical) that provide lower rates approximately 87 percent of the time. The critical peak rate can be executed within minutes, and since 2008 the utility has reliably shed 3.1 kW during winter peak and 2.0 kW during summer peak per customer.

> *"Our average customer saves 8 to 10% annually, paying 87% less than the average residential energy rate. And 98% of our customers say the program exceeds their expectations. Tampa Electric credits the Energy Planner Program with enabling the utility to accomplish its residential goals. The program—which is powered by Itron—will continue to be a critical component of Tampa Electric's conservation efforts over the coming decade."*
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> *– Drema Hughes, Program Manager/Energy Planner, Tampa Electric*

CONCLUSION

The United States is forecast to realize total system peak demand savings from all forms of demand response in the range of 7.5 to 15 percent by 2022, with direct load control programs expected to reach 10 to 15 percent of all residential consumers. Price-based demand response programs, however—which currently reach less than one percent of residential consumers—are projected to gain between 7.5 and 20 percent of residential consumers in the U.S. as a whole, potentially soaring to 12.5 to 45 percent in the East North Central Census region of the country. In addition, participation rates for commercial and industrial consumers will exceed those for the residential markets, ranging from 10 to 30 percent overall.

Nationally, within ten years, more residential customers could be engaged with price-based demand response (20 percent high estimate) than with direct load control (15 percent high estimate). Furthermore, an assessment carried out by FERC in 2009 showed that price-based demand response deployed nationwide has the potential to quintuple the amount of U.S. peak demand that can be lowered through demand response, while another evaluation indicated that a conservative 5 percent reduction in U.S. peak demand could lower energy costs by $3 billion a year.

Price-based demand response programs align the cost of generating electricity with what users pay for it. Customers have demonstrated that they are interested in participating in price-based demand response programs. Their response has continued to be strong over time and increases with enabling technologies, leading to noticeable and significant behavioral changes in energy consumption that result in meaningful and sustainable load drop.

With the widespread deployment of smart meters, utilities can include price-based demand response programs as a low-cost part of their overall energy efficiency mix to improve the way in which energy is delivered and consumed around the world.

CORPORATE HQ
2111 North Molter Road
Liberty Lake, WA 99019 USA
Phone: 1.800.635.5461
Fax: 1.509.891.3355