Demand Responsive Load Management: From Programs to a Demand Response Market

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ABSTRACT

This paper presents a discussion of demand response concepts and applications, the market for demand response, and examples of how demand response principles are being applied in innovative ways. This includes a description of a Sacramento Municipal Utility District (SMUD) demand response program which utilizes internet based communications and technologies and a series of case studies describing how demand response systems were installed in commercial establishments in California. A brief discussion on the future of demand response in electricity markets is also included. These quick reviews are intended to serve as springboards for a more comprehensive panel discussion of the issues surrounding the deployment of demand response by consultants and practitioners.

Background

Demand response (DR) is simply a mechanism to increase the elasticity of electricity demand by providing end use energy customers with the necessary tools for modifying their energy consumption in response to signals related to the cost and/or availability of energy. DR relies on the basic economic concept that aggregate demand should decrease as prices rise. Essentially, demand response allows the customer to participant in the "supply and demand" paradigm. Therefore, achieving DR capabilities is a critical element of a market driven electricity infrastructure – i.e. DR allows the consumer (retail market) to respond to the supplier (wholesale market).

DR programs sponsored by utilities, particularly the rate and involuntary control programs, have been around for a long time. Their objective is to provide emergency relief via mandated load reductions for capacity and/or transmission shortages in a regulated environment where the mandate to serve all loads at any cost is well ingrained in the system. However, with the advent of electric deregulation and very high power prices during peak hours of the year, interest in demand response mechanisms in the marketplace has grown. If there is no link between retail and wholesale prices—that is, if the customer sees a fixed retail price, irregardless of the actual wholesale price—then the customer has no incentive to even consider reducing use, causing the wholesale price to rise even further, ultimately leading to price spikes and possibly outages (Montague, 2000; Gromer, 2001). Conversely, if customers receive price signals and reduce load at times of high cost, prices for all customers will decline. One study found in California, a 2.5% reduction in demand statewide could have reduced wholesale prices by 24%, and a 10% reduction in demand would have cut them in half (Moore, 2001). In New York, a 4% demand reduction would have reduced the final settled price on May 8, 2002 by 70 percent (Moury, 2002).

In 2000 and 2001 the big boost in the number of programs offered in all of the country's active RTO and ISO markets—New York, California, New England, and PJM—was due to concerns about critical shortages of power and excessive prices for peak power (Gilligan, 2001). Policy makers and technical experts agreed that without a mechanism for the consumer to respond to pricing spikes and shortages there was a risk of extended periods of outages. In California, for example, this issue was particularly exacerbated because of fixed, regulated, retail prices that had no relationship to wholesale prices (which varied by market forces and were partially deregulated). This was because California's deregulation legislation and implementing regulations froze retail prices to ensure customers benefited from restructuring while utilities recover stranded costs. Similar situations occurred in other states where retail prices were not allowed to respond to wholesale price signals for the vast majority of consumers.

Simultaneously, in the deregulated wholesale markets, federal price cap controls were set at very high levels ($500-$1000/MWH) for wholesale prices, . Thus there were times when wholesales prices far exceeded retail prices. This reversed arbitrage created an opportunity for customers and ESPs to profit by not using electricity and selling it elsewhere. Economic dispatch became a new term for the demand side management industry. An explosion of programs and companies offering demand response options and technologies resulted.

However, this anomaly of wholesale prices above retail prices has ended, as it had to, and now the question becomes: "is there still a role for demand response programs or markets at a funding level that exceeds the levels existing during the *old days* of interruptible and TOU rates?" This is the question of this paper and it is explored through a review of the market for demand response and discussion of the experience with a new program. This program demonstrated new internet communication and control technologies that can lead to customer benefits beyond demand response. This topic is also explored through a review of the experience of six organizations with innovative approaches to voluntary demand response that resulted in other benefits as well.

Overview of Demand Response

It is important to note that demand response is not necessarily equivalent to investments in energy efficiency or even conservation of energy. Demand response programs are designed to result in customers either stopping or reducing power consumption at a particular time and potentially *moving* that energy consumption to another time period. Classic demand response approaches include shifting of energy intensive processes to off-peak period hours, introducing load shifting technologies (such as thermal storage), or simply shutting down an industrial production line or residential air-conditioner when power is curtailed or interrupted. Unlike energy efficiency programs, which encourage reduced energy consumption while maintaining the quality of service associated with the energy consumption, demand response programs or strategies, on their own, can result in diminished quality of service.

While there are no formal definitions of the types of demand response programs, it is possible to classify them in two broad categories:

- **Rate based price programs** that involve end-use customers paying for energy through real time pricing or time-of-use tariffs, and
- **Reliability programs** that involve end-use customers, on relatively short notice, being asked to or required to reduce load at particular times in return for a rate discount or incentive payment.

Rate Based Programs

The premise behind rate approaches to inducing demand response is that if a provider of energy indicates the actual cost of energy, particularly as it varies in time, the consumer can respond in a way that works best for both the customer and the market. Assuming that customers will reduce power consumption when prices are high—likely through a combination of shifting some use to another time and curtailing some altogether—would indicate that real time pricing would help balance supply and demand. Unlike reliability programs, the rate approach does not involve any particular technology approach, and the response of the customer, is up to the customer.

Interruptible and curtailable rates. These rates have been provided by many regulated utilities within their conventional rate structures for many years. Most of these rates involve providing customers a rate discount on all of their power consumption in return for the utility having the ability to stop (interruptible) or reduce (curtailable) the amount of power provided after a certain amount of notice, usually 30 to 60 minutes.[1] The intent of these schedules, which are applicable to large customers, is to provide a reserve in the event of short-term capacity or transmission constraints. The expected customer response to these rate schedules would be installation of back-up supplies (e.g., generators for power, LNG for natural gas). However, generally speaking these interruptible customers were rarely called on to reduce their energy use, unlikely customers such as hospitals and hotels ended up with these rates, and the rates were sometimes used as unofficial economic incentives for larger customers. After the spring of 2001 ("all Stage 3, all the time," according to one utility wag), in which some California customers were asked to curtail 32 days in a row, the popularity of interruptible rates has declined sharply. A small survey of E Source Corporate Energy Managers found that while over half of them had participated in interruptible rates, only half of those would do so again (Kolwey, 2002).

Time-of-use (TOU) rates. TOU rates have been used for decades as a mechanism for reducing on-peak electricity consumption. TOU rates, typically for large customers with demand over 500 or 1,000 kW, consist of demand and energy charges that vary by time of day, day of week, and/or season. The expected customer response to these rates would be load shifting with techniques such as thermal storage for air-conditioning or simply scheduling processes around the high peak prices. While TOU rates are relatively common, and do reduce average aggregate peak demand, many customers show no direct response (for example, commercial buildings still provide cooling during peak afternoon hours and most factories continue with the common 8am to 4pm day shift) and demand shapes for load consumption continue to show high energy consumption during peak period hours. One

[1] For the balance of this paper, the terms interruptible will be used to represent both interruptions and curtailments

market research study found that although about half of large commercial, industrial, and institutional customers have facilities on TOU rates, just over one-quarter of those on the TOU rates actually shift load (Hensler, 2001). To be more effective at shifting load away from peak times, information on pricing and use needs to be clearly communicated to customers, along with specific tactics to implement. Automating control, so that customers can either pre-program responses or implement them very easily, will also encourage greater load shifting, as discussed in the following enhanced automation case studies.

Real time pricing. RTP is a relatively new concept, compared to TOU rates, generally more of an experimental (as opposed to standardized) rate format, although there are exceptions.[2] With real time pricing, actual hourly costs are provided to the customer, and updated on perhaps an hourly basis with some programs providing day ahead or even two-day ahead projections of rates. The expected customer response is to establish procedures, whether manual or automated, to lower consumption during periods of very high power costs. Customers frequently make decisions on a daily basis, such as deciding to pre-cool a building in early morning hours and allowing it to coast through to higher than normal temperatures in the afternoon. Customers also have the choice to "buy through" and simply pay the higher costs. In addition, there are a number of financial packages that can work to hedge the price risk.

Coincident peak pricing. CP pricing is a simple rate structure, similar to TOU, with a super-peak period. The rate for the utility's peak 50-200 hours per year is very high, and is discounted from normal tariff for all other hours. Customers know what the high price will be, and are notified a day ahead that the next day will be a high price day. CP pricing is designed to be revenue neutral; that is, if the customer doesn't shift load, his total electricity cost will be the same under CP pricing or his previous rate. However, because the price is designed to be so much higher during the super peak period, "anyone on this rate is going to be getting off peak" (Uhr, 2000). CP pricing offers a compromise between the full transparency (but also unpredictability) of RTP and the simplicity (but not complete price reflectivity) of TOU. Another intriguing facet of CP pricing is that it can be applied to either energy or distribution.

Coincident peak pricing is being tried or considered in a handful of places:

- Orion (the New Zealand utility formerly known as Southpower) is a wires utility that has had mandatory coincident peak pricing distribution rates since 1990. Roughly 50% of the distribution costs are allocated to the system's top 80 hours per year, resulting in a very high cost during these top hours. Customers are given notice 15 minutes before a pricing signal is communicated by power-line carrier. Customer equipment can be automatically controlled by the same signal. Customers have responded so well that in eight years, Orion's load factor improved from 50 to 60 percent.
- In the U.S., Seattle City Light planned a small pilot program for summer 2001, targetting large downtown buildings. After the implementation of price caps, though, the pilot was put on hold. The price caps dampen prices, so prices during the 100-200

[2] For example, Georgia Power has one of the most successful programs (RTP-HA-2 and RTP-DA-2 Electric Service Tariffs), involving 1,700 customers and 5,000 MW (Peak Load Management Alliance, 2002).

peak hours aren't enough higher than those of other peak hours and so no longer justify a price significant to encourage commercial customers to curtail.

- Dominion Virginia Power has been offering a version of CP pricing, called Schedule 10, to large C/I customers since 1989. Schedule 10 classifies peak, normal, and super off-peak days, each with on- and off-peak periods. There are 25-28 peak days per year, 60 to 75 super off-peak days, and the rest are normal. On-peak prices on peak days are about 26¢/kWh, about 2.2¢/kWh on normal days, and about 1.4¢/kWh on super off-peak days. (For comparison, Dominion's GS-3 large customer rate charges about 2¢/kWh and $12/kW demand).There are more than 300 customers on Schedule 10. Most of the load reduction comes from industrial customers. Dominion does not help customers to identify discretionary loads or to develop load shedding plans. "We make sure they fully understand the rate and the implications of what it's going to cost them on the peak days, but then we really leave it up to them to respond to the peak-day price signal," says John Caskey, account manager for Dominion Virginia Power. Even so, the rate structure does shave load and it seems reasonable to assume that with some load-shedding guidance, the utility could see even larger results (Adams, 2001).

Reliability Programs

Reliability programs are designed so that, in return for an energy price break or direct incentive payment, customers allow their supply of power to be interrupted by their distribution utility. Similar to the interruptible rate options, the distinction with these programs is that there is a specific technology, or systematic approach, employed and controlled by the utility. The most common example is residential direct load control air conditioning programs. Typically with these programs[3] a customer is paid a fee and the utility is allowed to cycle off air conditioners for a set number of minutes per hour and for up to a fixed number of hours per year. Another example is load co-ops where a contractor solicits on behalf of a utility or ISO a large number of customers and the contractor is responsible for, utilizing all or some of the signed up customers, to provide the demand reduction when required to do so by the utility or ISO[4].

Programs are considered voluntary if the customer has the option to "opt-in" or "opt-out" (for example with an override switch) to a request for interruption. Some implementing technologies for voluntary programs are both web controlled residential thermostats and commercial/industrial energy management systems (both with overrides), and web based bidding programs (ABB Energy Interactive, Demand Exchange, Retx, and Silicon Energy)[5].

[3] See Xcel Energy Saver Switch Program at http://www.xcelenergy.com/ProductsServices/SaversSwitch/ResidentialCO.asp and SDG&E Smart Thermostat Program at http://www.sdge.com/efficiency/res_rebates.html#smart

[4] See Planeregy Load Control Programs, http://www.planergy.com/L4_2_energymgmt.html

[5] See Demand Exchange at http://www.demandexchange.com/; Silicon Energy at www.siliconenergy.com; ABB Energy Interactive at www.abb.com; and Retx at www.retx.com.

Market Assessment

Knowing what customers are willing to participate in demand response programs and at what prices they will curtail load are critical for successful demand response program design. E Source recently completed market research with 700 commercial, industrial, and institutional energy end-users across the U.S. and Canada (Hensler, 2001). Respondents were screened to ensure surveys were completed by the person who filled the role of the energy decision-maker for the company or organization. (Note: data presented here are based on field work done in 2000. The August presentation will include updated data from another 700-800 commercial, industrial and institutional energy end-users surveyed during June-July 2002.)

Time-of-use rates were fairly popular: nearly half of survey respondents had facilities on them. But the rates aren't very successful at eliciting demand response: only 28% of those on TOU rates reported actually shifting load. Perhaps some context will shed light on this initially rather startling finding. We screened survey respondents to include only those who negotiated energy contracts and dealt with local utility companies, but they had other responsibilities as well and didn't have a lot of time to focus on energy. The median time these people responsible for selecting utility pricing programs spent on energy management was 2-3 percent for industrial, commercial and institutional sectors. Energy management got a bit more attention in national accounts, more than doubling that figure to 7 percent—but still not much time. When asked to rank their familiarity with pricing terms, just over 70 percent said they were "very familiar" with the term "kilowatt" and "kilowatt-hour," just over half were "very familiar" with "demand charge," 39 percent were "very familiar" with "time-of-use rate" and even fewer for load management, curtailable or interruptible rate and real-time-pricing. It appears that many energy managers have facilities on rates they do not understand well (e.g.: 49 percent have facilities on TOU, but only 39 percent are very familiar with the term). Further, 34 percent of respondents did not know their facility's peak demand. This suggests that significant education will be required to achieve widespread participation in demand response programs.

We also developed several pricing scenarios and asked customers how likely they would be to curtail under different program and rate offers. Involuntary programs were presented with a 10 percent discount on annual energy bill with a penalty for non-compliance of either the "daily market rate" charge or a fixed dollar price for any load they could not shed. In both instances, a relatively small percentage of customers said they were very likely to participate (8 percent and 11 percent, respectively) or even somewhat likely to participate (37 percent and 26 percent).Voluntary programs were more appealing: 13 percent were very likely and 43 percent were very or somewhat likely to participate. (Note that in California, when customers perceived rolling blackouts to be imminent, response rates were even higher.)

The sample reported 20 percent of their load was non-essential load. Respondents of the whole sample were willing to shed about 18 percent of their total load at a price of \$1.00/kWh. Those who reported they were very likely to participate in the program were willing to shed 35 percent of their load. At \$2.50/kWh, customers reported they would shed up to 43% of load. They would be willing to reduce load for at least seven times for four hours. Portland General Electric's Demand Buy Back Program reported similar results:

customers required a minimum incentive of $70/MWh to respond and at $300/MWh curtailed over half of their summer peak demand (Goldman, 2002).

The time of day that a load reduction is called for (eg: from 2 to 6 pm) is the most important factor in whether or not customers will agree to shed or drop load. Next most important is the length of the reduction period, followed by the amount of notice given before reduction and the number of times per year reduction is requested. The method for calculating the reduction is the least important factor. The responses are only slightly different when viewed by individual customer segments. The commercial market mirrors the total sample breakdown. National accounts are quite similar, except that number of times asked is more important to them than the amount of warning before curtailments are required. For the institutional market sector, time of day is by far the most important, followed by amount of warning, length of interruption, and number of times asked, all close together. The industrial market sector is the only one to see length of interruption as the most important.

Larger users and industrial users are more likely to participate in voluntary curtailments than are smaller users. Reasons customers give for not participating are based on their “unique business situations” and being “unable to work without electricity.”

Note that aggregators would probably respond very differently. For example, ESCOs have been reluctant to participate in demand response programs, in large part because of the inherent uncertainty in how often the programs will be called, and what the payments will be. In the words of a NAESCO representative, “Successful ESCOs have spent the past decade figuring out how to squeeze all risk out of their operations. Demand response programs have too many unknowns to be attractive to ESCOs.”

2001 Experience of Six Commercial Scale Customers in California

The following are six examples of successful installations of enhanced automation systems—digital energy management and metering telemetry—that enable a facility to respond to emergency energy shortages with swift load curtailments. They are presented in order to demonstrate the variety of approaches that can be used for implementing demand response approaches, as well as some of the additional benefits. The problem facing the energy managers at all these installations was how to control their rapidly rising energy costs and avoid rolling blackouts. These facilities can shed impressive amounts of load, often for multiple locations from a single computer connected to the web. The benefits of enhanced automation extend beyond demand response: overall reduction in energy use, improved building operation, ability to monitor and control multiple buildings from a single point, and access to 15-minute interval energy information over the web, useful for building management as well as for verifying demand reduction. .

These installations were partly funded by the California Energy Commission's Peak Load Reduction Program. Funding for this program was provided for by state legislation that was passed in August of 2000 and April of 2001 in response to the state's energy crisis. The descriptions below are summaries of case studies that were developed as part of an outreach campaign intended to promote the benefits and uses of enhanced automation technologies. This campaign, funded by the CEC, also includes a brochure, guidebooks, flyers, and a web site.[6]The complete case studies, as well as these other items, are available from the CEC; the

[6] www.consumerenergycenter.org/enhancedautomation

complete case studies include more details about the facilities and the benefits and technical components of the installed systems.

Comerica Office Building

Macanan Investments, developers and owners of the 213,500 square-foot Comerica building in San Jose, used CEC program funds to cover part of the cost of installing technologies that enable the building to quickly curtail load during an emergency shortage. The project involved adding wireless controls to the building's dimmable lighting system and adding an energy information system (EIS) by connecting the meter to an internet gateway. . A dedicated relay is connected to the wireless load control devices so that the lighting system can be powered down quickly from the Internet. The building's new wireless lighting control devices can be activated remotely in less than a half an hour by paging signals that are initiated from a Web site. This technology, along with the new EIS, allows the building owner to participate in demand-responsive programs that offer per-kW incentives for peak load reductions during electricity shortages. A test of this system resulted in the successful curtailment of 65kW of peak demand. The system enhancements also helped reduce energy use in 2001 by an average of 34 percent during the peak demand period compared to the previous year. The new EIS, which enables owners to closely monitor and adjust energy use, has contributed significantly to these savings. Energy managers can access the previous day's energy use interval data and a variety of statistics and graphs over the web.

Foothill-DeAnza Community College District

The Foothill-DeAnza Community College District—two college campuses with a total of about 991,000 square feet of conditioned space—received a grant from the CEC that funded the installation of equipment that enables participation in demand-responsive programs. The District purchased and installed EnFlex internet gateways and controllers and CMS Viron's CurtailmentVision™ This Web-enabled, integrated metering and control technology allows for centralized, remote curtailment of loads, as well as immediate access to incremental meter data. The project included the installation of new hardware and wiring, as well as the re-programming of the existing digital energy management system (EMS). The District is now able to curtail up to 1.7 MW of peak load within minutes from a single password-protected Web site. At the same site, the District can also monitor instantaneous demand levels and view historical usage data, which are being collected at each campus in 15-minute increments and uploaded to the Internet. Access to such data has been useful for verifying that actual loads reflect intended use and for profiling and analyzing energy use. Improvements in operational efficiency have saved the District $30,000 in annual energy costs. The District is also prepared for the advent of real-time pricing, as their enhanced automation enables them to respond effectively to unexpected changes in prices.

Hewlett-Packard Company

Hewlett-Packard facility engineers had been optimizing their 10-building, 1.4 million square foot campus in Roseville, California, for many years, but their energy management system had limited automation. Reducing HVAC and lighting loads was labor- and time-intensive, involving manual adjustment of several controls in various locations around campus. HP used funding from the CEC to install enhanced automation technologies. HP added automated demand control ventilation and lighting controls. The existing Siemens EMS, LAN, and other controls and power monitors were linked and programmed for demand limiting.

As a result of these changes, HP is now able to shed up to 1.5 MW of peak load, without disrupting occupants' productivity or comfort. Originally intending to operate their new load-shedding strategies under emergency situations only, HP found that they could actually benefit from using them on a day-to-day basis. Enhanced automation allows HP to program a not-to-exceed setpoint for electrical demand and instruct the EMS to initiate pre-programmed load shedding strategies when that setpoint is approached. The system is able to monitor the effects of these strategies on overall demand throughout the day and to make continual adjustments so that the demand is kept just below the setpoint. Due to their conservation efforts over the past eight years, HP Roseville is currently saving $1.5 million annually.

Alameda County

To make their building automation system (BAS) more flexible in the face of energy shortages and to help mitigate the chance of rolling blackouts, the County of Alameda upgraded the existing BAS in five of their largest facilities using CMS Viron's Curtailment Vision™, an Internet-based load curtailment program. The upgrades, funded mostly through the CEC, involved (1) enabling the County to set controls to incrementally power down its chillers and (2) connecting the facilities' utility meters to the Internet so that the effect of the chiller load reductions on facility-wide loads could be verified in near-real time from any computer with an Internet connection and standard Web browser. The County now has the ability, through a single Web site, to shed a total of about 1.4 MW of load within minutes in the event of an emergency. However, the primary benefit that the County realized as a result of the new system was one that they had not anticipated: from a password-protected Web site, the new system provides the County continual, remote access to 15-minute energy use information for the facilities that received upgrades. According to the County's energy program manager, access to this data has been "tremendously useful" for verifying that actual building loads reflect intended use.

Staples, Inc.

With funding from the CEC, Staples devised and implemented an energy management plan that would help insulate its 119 California Staples stores from high demand charges and rolling blackouts. The plan involved the installation of wireless control technology that allows Staples personnel to send electronic pages from the Internet to automatically reduce the lighting and HVAC loads at selected California stores. Because the system is based on wireless Internet paging technology, the lighting and HVAC equipment at the stores can be controlled from Staples' headquarters in Massachusetts. The paging-activated relay system by Cannon Technologies instructs the Novar EMS to shed load. To verify the load reductions, Staples also installed interval meters equipped with modems at each of the stores. The Datapult Energy Information System allows Staples personnel to access and view previous-day 15-minute meter data from a password-protected Web site. Staples now has the ability to curtail up to 2.8 MW of demand within minutes without affecting customer comfort. This not only leads to significant savings in demand charges during peak periods, but also strengthens the reliability of regional electricity supplies in the event of a shortage. The ability to curtail, along with the load-verification metering system, also enables Staples to participate in a California Independent System Operator program that pays incentives for each kW reduced during peak demand times. .

Doubletree® Hotel Sacramento

About six years ago, the Doubletree Hotel Sacramento began an aggressive energy management strategy that utilizes enhanced automation technologies. The hotel installed an energy management system (EMS) and partnered with the local utility, the Sacramento Municipal Utility District (SMUD), to participate in a demand curtailment program. Since then, the hotel has been an annual partner in this program, installed a real-time energy information system (EIS), and made concerted efforts to reduce loads and improve the efficiency of energy-using equipment. For example, the Doubletree can now monitor real-time energy use through EnerLink, a software interface that is linked to the hotel's interval meter. From a PC, facility operators watch the hotel's overall demand level throughout the day. As demand reaches peak levels, they can start shedding load and avoid excessive demand charges. The Doubletree uses their EMS to target numerous HVAC systems from a central location, and their EIS to immediately see the effects on overall demand. With the enhanced automation system and regular reductions in lighting loads, the Doubletree reduced annual energy use by 11 percent in 2001. As a result, they were able to hold electricity cost increases to 2.5 percent, despite a 15 percent average increase in the electricity rates. The hotel's EIS has become a valuable tool for analyzing operation of HVAC and lighting systems. Immediate access to usage data, on the order of minutes or years, has led to the discovery of potentially costly problems.

SMUD's PowerDirect Program – An Example of Using the Internet to build a Demand Response Market

In 2001, with $1.3 million in funding from the California Energy Commission, Sacramento Municipal Utility District (SMUD) developed two Internet-based, voluntary, price-responsive load management programs for commercial and industrial customers. *PowerNet,* a demand-bid program and *PowerDirect,* a commercial direct load control pilot program. This section will focus on *PowerDirect* and the experience SMUD has gained in the implementation of Internet-based, voluntary, direct load control of commercial buildings.

Objectives

The overall objective of the Commercial Direct Load Control Pilot program is to design, implement, and evaluate a pilot program that tests the viability of an Internet-based direct load-control system in five to seven commercial buildings. In addition, the program is designed to:

- Offer programs that are customer friendly and offer opportunities for both SMUD and the customer to participate in the market for load management SMUD may notify customers of curtailment opportunities from one hour ahead to two or more days ahead, depending on any of the following conditions:

Economic:

- SMUD avoided power purchase when a market opportunity exists (typically when market price is above $300/MWh, which SMUD splits 50/50 with customer)
- Market opportunity, such as a prescheduled sale of energy

Reliability

- Local SMUD emergency
- Response to a regional or statewide emergency

- Offer new program concepts with innovative, price – responsive programs that provide customer choice and operational flexibility;
- Provide improved information on customer pricing, performance, and program participation through the use of Internet-based load management systems.
- Install the technologies to enable the building(s) to be operated in response to price signals from the market and SMUD, and calls for load curtailment;
- Test the ability of the load management software and building interfaces to control the load and monitor the building performance;
- Test the response of the building, building management, and occupants to the load management event;
- Determine the effectiveness of the tools, types of applications, and best opportunities for direct load management control;
- Determine the cost-effectiveness and appropriateness of a wider scale direct load management control program based on the concepts tested in the pilot.

Description

The *PowerDirect* program addresses primarily medium size commercial customers and allows SMUD to capture load reductions from customers who are interested in a load management program where they have a more "hands off" role. Direct load control allows SMUD to automatically curtail load in response to price signals or emergency conditions and will provide the customer with the ability to choose to participate or override the curtailment signal.

The Internet-based load management system controls building loads, provides price signals, notification of curtailment events, bidding, and settlement and verification through the same stem. Customers also have the ability to program in load shaving control strategies using the equipment and software provided by the program. The system interfaces with a participating building's energy-management system (EMS), or lighting- and HVAC-control systems. Option include a remotely controlled thermostat or system temperature control, remotely dimmable or switched lighting, and potentially controls for other building loads.

SMUD Program Highlights

- The programs are voluntary; with the exception of requiring customers to participate once a year by submitting a responsive pledge to a curtailment notification. When a curtailment notification is sent out, a customer pledge to deliver a specific amount of load reduction is submitted, and the pledge is accepted by SMUD system operations, the customer and SMUD now have a binding agreement and the customer is bound to the performance criteria in the contract.

- Customers incur a $15.50 per month meter channel charge for the operations and maintenance of the recording interval meter and data channel. (as applicable)
- Customers see a posted price signal that will generally be based on at least 50% of the market opportunity or 50% of the avoided cost of power.
- Customers qualify for *PowerDirect* if they can reduce 100 kW of load for at least two hours, June through September, between the hours of 2 pm to 6 pm weekdays. The minimum load reduction pledge for both *PowerNet* and *PowerDirect* participants is 75 kW for a two-hour block during the hours curtailment is requested by SMUD.
- *PowerDirect* customers are paid up to 130% of their pledge for exceeding their pledged load reduction, however, they do not incur liquidated damages for under performing. If they opt-out or override a curtailment after it has been accepted by SMUD, SMUD may view the override or opt-out as a breach of contract. *PowerNet* customers incur liquidated damages if performance falls below 80% of pledged load reduction.
- Participants are required to provide a high-speed Internet service (DSL or equivalent) for the Internet gateway, an e-mail text addressable pager, Internet access and an e-mail account.
- SMUD provides metering and energy use data, both daily and in near real time (meters are polled every 15 minutes and the data are displayed within 20 minutes) during curtailments.
- SMUD provides the system software, Internet gateway, and setup.
- SMUD provides up to $50,000 per site for installing demand responsive systems and equipment in customer facilities.
- SMUD provides facility analysis and recommendations. (Provided by SMUD staff and Nexant).

Load Reduction Potential and Participation

PowerNet and PowerDirect can provide SMUD with up to 27 MW of load reduction potential, depending on the time of year, temperature, and other factors. There are 15 customers and 19 accounts on PowerNet, with one customer on PowerDirect. Two other PowerDirect customers are reviewing their contracts and are expected to join the program and customer recruitment continues.

The programs have not been used under actual economic or reliability conditions. Customers participated in test days to verify their load reduction, with a price signal of $250/MWh. Customers responded by typically exceeding their pledged load reductions, some by as much as 130% of their pledge. Additionally, customers and SMUD staff found the program very easy to use.

No effects on market prices were directly attributable to implementing the program. SMUD program management staff does believe that the program may have helped stabilize the market by publicly demonstrating a price-responsive load management program that offers an alternative to purchasing peak power.

Short and Long Range Plans for the Program

The energy information and program infrastructure forms a foundation that SMUD will build on for the foreseeable future. The *PowerNet* program was designed to be an integral part of SMUD's commercial and industrial load management program offerings, replacing the previous curtailment program and program infrastructure. *PowerDirect,* as a pilot program, will be evaluated and refined, as the value proposition for both the customer and SMUD is determined. The Internet-based infrastructure facilitates the program design, implementation, and operation by automating many functions that were previously performed manually by many staff. Additionally, the *PowerDirect* infrastructure can be applied to many different types of programs since the Internet Gateways and associated software allow for controlling everything from a commercial building to remote operation of emergency generators.

By being voluntary and price responsive, the program structure is designed to take full advantage of customer price and electric demand elasticity . There is no guarantee of an event being called, a pledge being accepted, or a specific price being posted. As a benefit of participating in the program, *Energy Profiler Online* is provided free of charge, and the customer energy use data, including baseline energy use, is displayed daily. Loads can also be sub-metered, and using the Internet gateway, display the data in near real time.

The CEC will continue to fund the program development through September 2002. SMUD is actively marketing the programs and is working diligently to fulfill the objectives of the pilot. The PowerNet and PowerDirect programs are integrated into SMUD's overall load management program strategy for 2002 and are designed to be utilized as one of the first lines of demand response. For the summer of 2002, it is not anticipated that the programs will be used frequently or that a market opportunity will exist unless supplies are tight and market prices rise or load curtailments are required to maintain system reliability.

Summary of findings

Participation in the program requires the installation of demand responsive equipment and facility system modifications, in addition to the metering and Internet gateway device.

SMUD allocated a target of $50,000 per site for facility modifications. The innovator, a large commercial building, received modifications to the energy management system and the lighting on the 4th floor. The equipment and modifications are detailed in Table 1.

Similar to SMUD's experience in fall of 2000 on our own facility, the *PowerDirect* customer encountered potential problems with their firewalls at their data center and decided to use a DSL line through an independent Internet service provider.

Marketing and customer recruitment continues to be a challenge in identifying the right customers for the program and getting them to participate. Initially, SMUD had 5 parties interested in participating, one "innovator", and four "early adoptors". As of March 2002, the only *PowerDirect* participant that is operational is the "innovator". Some key findings from the pilot thus far are:

Table 1. Equipment and Modifications

Equipment or Modification	Description	Cost
4th floor lighting	Installation of dimmable ballasts, controls, and wiring.	$45,178
Energy Management System	Programming for two supply air temperature changes - 2 degree setup and 4 degree setup	$ 5,000
Sub- Total		$50,178
Internet Gateway	Stonewater gateway, shipping and setup	$ 2,000
Internet Router	Connect to DSL line for proper communication with gateway	$ 100
TOTAL*		$52,100

Labor for SMUD analysis of the facility is not included in this table.

- Lighting systems offer reliable load reduction but are very expensive to retrofit with controls to allow demand response capability. One proof of concept lighting modification involved 260 fixtures retrofit with dimming ballasts and lighting controllers, interfaced with the energy management system (EMS) at a cost of just over $45,000. The lighting modifications were done on one floor of a multi-story building with over 1200 KW of peak demand and required significant changes to control wiring. The floor delivered approximately 12 kW of average demand reduction, proving a potential of over 200 kW price responsive load reduction if a complete lighting retrofit was performed. Another multi-story facility was analyzed to put in lighting contactors and wiring modifications at an estimated $120,000. These modifications are not cost-effective for the program for these particular facilities. SMUD is presently working with a major retailer and it appears that the lighting controls needed are already installed and linked to the EMS, making it possible to cost-effectively control the lighting for this building at a cost of $3,000 to $5,000 and the HVAC at a cost estimated at $6,000. Including auditing, analysis, recommendations, and $2,000 for the Internet gateway device and set up, the project should achieve approximately 200 kW of load reduction potential for approximately $20,000 or $100/kW.
- Existing EMS with good control points and capability currently installed can be easily programmed with strategies for control of HVAC and other functions. The EMS can be interfaced with the Internet gateway for approximately $5,000, in addition to the $2,000 cost of the gateway and setup.
- One Internet gateway and high-speed Internet connection can be leveraged through a facility EMS to provide multiple control strategies at the customer site.
- The high-speed Internet connection for the Internet gateway results in extremely rapid response of the gateway (<1 minute) and building to control signals. A telephone modem, used in the initial pilot tests on SMUD's facilities, resulted in a 15 to 20 minute delay from the time of scheduled curtailment to actual facility response.
- Indirect control of the energy using components, such as HVAC temperature reset, can have a widely varying effect depending on controlled parameter, type of equipment, time of day, occupancy and temperature. For example, tests of zone temperature reset on three package units showed two with good to fair response, with

another unit that was already running above setpoint and unable to meet the load in the building that did not respond until 2.5 hours into the 4 hour curtailment.

- PowerDirect customers were giving the ability to "pledge" their load reduction. This enables EnergyDirect customers to tailor their curtailment pledge to reflect changes in temperature and occupancy, and also allows them to take, and get credit for, additional manual actions in excess of the automatic actions to deliver more load reduction and earn additional money.

Discussion

The long-term prospects for DR as a sustainable energy market option will depend on the status of electric market deregulation, energy prices, customer attitudes, and technologies. Electric market regulatory decisions may be the driving factor for all these variables. This is because of the continued role of FERC, RTOs and state commissions in the setting of energy prices (at least caps) and the implementation of tariffs. Pricing will be driven by the regulatory policies and both technology and sustained customer participation will follow only if there are consistent and sustained regulations that enforce the value of demand response in the market place.

Stability in policy with respect to market design will be crucial in determining the success of DR programs. If there are policies and pricing that makes demand response viable one year, but not the next year, suppliers, contractors and customers will not consistently participate in the market. Without a sustained market for demand response, companies will not be able to develop products and services that require at least a several year implementation period for them to be profitable, and customers will not participate in programs that vary on an irregular basis.

To implement consistent and sustained DR regulations it will be important to recognize and account for the following benefits of DR in addition to market clearing prices:

- Reductions in peak wholesale clearing prices by displacing the most expensive generation associated with short periods of very high demand,
- Replacement of generation capacity reserve value with dispatchable demand,
- Locational distribution and transmission congestion relief value and reductions in line loading,
- Environmental benefits associated with displaced generation, and
- Enhanced competition by providing more alternatives to generator market power.

However, sustained regulatory policy has not been the hallmark of certain regulatory bodies (such as the California PUC and FERC) during 2001 as they implemented policies in a crisis mode. Thus, it is probably inappropriate to count on consistent and supportive policies as the sole source of support for DR although FERC now includes demand response in all its rulemaking as it views demand response as a key component in ensuring just and reasonable wholesale prices (Massey, 2002). Demand response technologies must also show that they can cost-effectively serve other functions when there are no curtailments or high peaking energy prices. For example, secondary benefits from enhanced building automation and subsequent better energy management derived from these systems may help DR systems become sustainable and economically viable over the long run.

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