How and Why Customers Respond to Electricity Price Variability:

A Study of NYISO and NYSERDA 2002 PRL Program Performance

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CERTS

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Prepared for

New York Independent System Operator
and
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Executive Summary

How and Why Customers Respond to Electricity Price Variability: A Study of NYISO and NYSERDA 2002 PRL Program Performance

Overview

This summer was the second year of operation for the New York Independent System Operator's (NYISO) suite of Price Responsive Load (PRL) Programs: the Day-Ahead Demand Response Program (DADRP), the Emergency Demand Response Program (EDRP), and the third year of operation for the Installed Capacity Program/Special Case Resources (ICAP/SCR) program. It also marked the second year that the New York State Energy Research Authority (NYSERDA) provided funding to support participation in these programs. NYISO and NYSERDA commissioned Neenan Associates to conduct a comprehensive evaluation of the performance of these PRL programs, building on methods and protocols developed last year and augmented by significant professional staff resources provided by the Consortium for Electric Reliability Technology Solutions (CERTS) with U.S. Department of Energy (DOE) funding.

The PRL program evaluation was undertaken from three perspectives. The first, top-down, perspective looks at the overall impact of PRL programs on New York electricity market prices and system reliability. Quantifying price impacts involves simulating what prices would have been had the curtailments not been undertaken. A supply model developed last year was used to reconstruct this year's market supply curve and estimate the change in hourly prices due to PRL-induced curtailments. Reliability impacts were estimated by valuing the improvement in reliability associated with curtailments undertaken through the EDRP and ICAP/SCR programs, which were jointly administered during 2002.

The second perspective explores why some customers chose to participate while others did not and characterizes the strategies participants employed to curtail when the opportunity or obligation arose and quantifies their performance during events. A variety of statistical analyses and behavioral models were developed from data collected by a survey administered to both participants and non-participants. More in-depth interviews were conducted with a sub-set of

survey respondents to further characterize the decision process that customers undertook when evaluating PRL participation opportunities.

The third perspective examines demand response from the vantage of market entities that have incorporated or may incorporate these services into their business model by analyzing demand response as a business opportunity. A combination of survey data, collected from entities such as load-serving entities, curtailment service providers, control and information technology vendors and performance contractors, and financial models were used to characterize expectations for returns from subscribing customers to the NYISO's PRL programs.

EDRP Program Description and Performance

NYISO solicits curtailable load from its EDRP participants to be dispatched on two hours notice to meet anticipated reserve shortfalls. Customers pledge curtailable load through either one of the state's default or competitive load serving entities (LSE), a curtailment service provider (CSP), as a limited customer (to PRL programs), or as a direct-serve customer. Loads curtailed during EDRP events are paid the greater of $500/MWH or the prevailing real-time, locational-based marginal price (LBMP). For most curtailment events in 2002, as was the case in 2001, the floor price of $500/MWH prevailed.

Curtailment performance in each event hour is measured as the difference between the participant's baseline load (CBL), which is the average usage during that hour on the five highest of the ten most recent like days, and its metered use in that hour. Retail customers that offer their load curtailment capability in the Installed Capacity/Special Case Resources (ICAP/SCR) program through a Responsible Interface Party (RIP) were also allowed to subscribe to EDRP in 2002, thereby making them eligible for EDRP energy curtailment payments in addition to the amount they received from the sale of their ICAP/SCR capacity.

Enrollment in EDRP increased dramatically to 1,711 in 2002 compared to 292 in 2001. Moreover, EDRP participants in 2002 subscribed more load for curtailment, 1481 MW, which represents a two-fold increase from 2001 (Fig. E-1). Approximately 58% and

EDRP 2002 Experience

	Participants MW	Events	Load Curtailed	Payment
EDRP 2002	1711 1481 MW	22 hr Downstate 10 hr Upstate	668 MW 34% of CBL *(summer events)*	$3.3 mil
2001	292/712	23/18	425/38%	$4.2

Fig. E-1: EDRP 2002 Summary

69% of 2001 EDRP and ICAP/SCR participants, respectively, re-enrolled in the 2002 programs, an indication of high program satisfaction. Market entry by curtailment service providers (CSP) increased significantly from 12 in 2001 to over 20 in 2002. CSPs aggressively promoted participation in the EDRP program, especially among smaller customers, accounting for over 60% of participating customers and 20% of the load curtailments during summer events. Most of the remaining 40% of participants were enrolled through a regulated LSE and accounted for 56% of the subscribed load reduction capability.

Curtailments under EDRP were called on two consecutive days in the early spring and one day in each of the months of July and August. The EDRP events on April 17th and April 18th began at noon and ended at 6:00 p.m., but curtailments were called for only in the downstate pricing zones. EDRP curtailments on those days were modest, about 70 MW on average, due to the early date on which they occurred. Few of the previous summer's participants were prepared to curtail so early in the season and recruitment for the summer of 2002 had just begun.

The two summer events, on July 30 and August 14, were declared statewide for five hours on each day beginning at 1:00 p.m. and ending at 6:00 p.m. The average hourly curtailment performance over the 10 curtailment hours was about 668 MW, ranging from an hourly low of 550 MW to a high of over 800 MW (Fig. E-2). Curtailments in 2002 exhibited greater variation than those of summer 2001, when curtailments never varied more than 5% from the hourly average for the 18 hours of statewide curtailments.

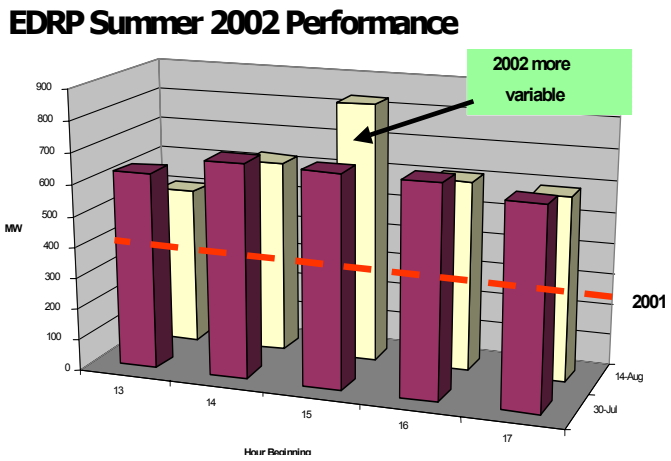

Fig. E-2: EDRP Performance – Summer 2002

In 2002, EDRP participants reduced their hourly electricity usage by an average of 34% compared to their customer baseline (CBL), slightly less than last year. EDRP payments to participants for the summer 2002 events totaled over $3.3 million, about two-thirds of which was for load curtailed in the upstate zones. However, participation and load curtailment activity in 2002 increased in the New York City/Long Island zones, accounting for almost 20% of the

statewide load curtailment response, up from 12% in 2001. Subscription of on-site generation in 2002 was about 270 MW, over twice that of last year.

EDRP Program Effects: Market Impacts and Benefits

The overall strategy for evaluating the 2002 EDRP events utilized protocols and methods developed primarily in Neenan (2002) to measure market impacts and to quantify provider and customer benefits (see Chapter 6).[1] Market impacts include: (1) program costs, which are payments to program participants for verified load reductions, (2) market price impacts, measured by the value of estimated changes in day ahead market (DAM) and real-time market (RTM) electricity prices resulting from load reduction events, and (3) reliability benefits. The market price impacts are comprised of two components: settlement transfers from generators to wholesalers and hedging benefits that reflect the longer run impacts of lower price variance resulting from program curtailments. One would expect that competition would ensure that these benefits eventually inure to retail customers. Another important benefit, the quantification of which was beyond this study's resources, is the reduction in deadweight losses that are associated with DADRP curtailments. Deadweight losses result from retail prices that fail to reflect the underlying marginal cost of supply.

Reliability benefits measure the effect of EDRP load reductions on system reliability as valued by the decrease in expected un-served energy; how an increase in reserves would reduce the likelihood of a forced outage and thereby reduce the costs that customers incur when service is interrupted. These benefits are enjoyed directly by all end-use customers. Fig. E-3 compares estimated collateral,

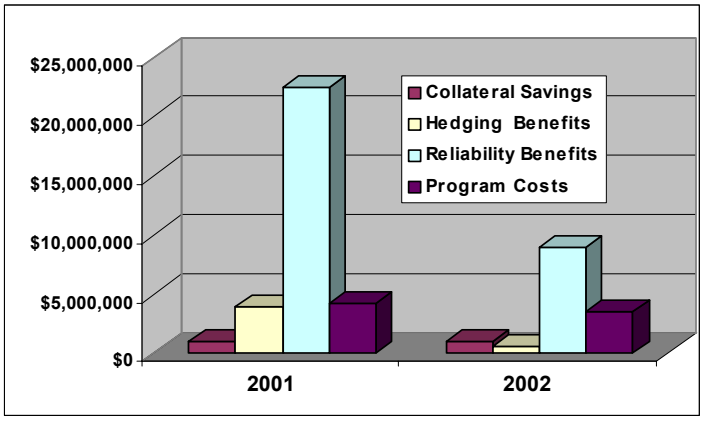

Fig. E-3: Comparison of EDRP Program Costs and Benefits – Summer 2001 vs. 2002

[1] The detailed methodology for estimating these effects is thoroughly documented in Neenan Associates (2002). *NYISO Price-Responsive Load Program Evaluation: Final Report*, Prepared for the New York Independent System Operator, Albany, NY, January 8, 2002.

hedging and reliability benefits for the 2001 and 2002 EDRP program, along with program costs. EDRP load curtailments in 2002 are estimated to have caused a reduction in real-time LBMPs ranging from 4.4% in the Hudson River region to just over 25% in the Western NY region. When applied to the load settled in the real-time market, these price reductions are estimated to have resulted in a transfer of settlement revenue (collateral benefits) from electricity suppliers (generators) to wholesale purchasers of electricity (LSEs) of just over $577,000.

Price reductions in the Real-Time Market also affect bilateral and forward markets, exerting downward pressure on prices as a result of reduced variability. The estimated average price reductions for weekdays for the summer 2002 EDRP events range between $0.04 –to 0.15/MW downstate and slightly higher upstate, $0.20/MW, which translates into total hedging benefits of about $370,000. These values are an order of magnitude lower than the corresponding impacts estimated for the 2001 EDRP program, mostly due to lower overall prices, both after and before the curtailments, during 2002 events compared to the events of 2001.

By restoring reserve margins, EDRP curtailments led to a reduction in the loss of load probability (LOLP), the consequences of which are a reduction in the value of expected un-served energy based on a customer's outage cost. System reliability benefits were analyzed using a range of values for outage costs and the reduction in LOLP to bracket the likely, but unobserved, actual values. Assuming an average outage cost of $5,000/MWh and that 5% of the load was at risk due to a reserve shortfall, the reliability benefits were estimated to range between $1.697 million and $16.9 million, depending on the assumed level of reduction in LOLP at the level of 0.05 and 0.50, respectively.

DADRP Program Description

Retail customers during 2002 were able to bid load curtailments into the NYISO Day-Ahead Market (DAM) by submitting a DADRP bid through a LSE. Curtailment bids were submitted on terms similar to those that apply to generators seeking scheduled commitments to produce for the next day, with two important exceptions. If the NYISO accepts the participant's bid and it curtails the amount scheduled, the participant receives payment equal to the day-ahead LMBP multiplied by the scheduled amount.[2] DADRP bids are subject to a floor price of

[2] Since participants subscribe to DADRP through a LSE, the payment for the curtailment goes to the LSE, which then pays the customer according to the arrangements they have made between themselves.

$50/MWH and the penalty rate for failure to meet the curtailment obligation in the real-time market is 110% of the greater of the prevailing RTM price or the scheduled DAM price. In contrast, generator supply bids in the DAM are not subject to a floor price and generator supply shortfalls in the RTM are settled at the real-time LBMP.

DADRP Program Effects: Market Impacts and Benefits

Customer bidding activity in the 2002 DADRP decreased compared to 2001, despite an increase in customer enrollment (from 16 to 24 customers-Fig. E-4). Payments for DADRP curtailments were about $110,000 in 2002, about half of the previous year's level. The collateral benefits, measured as the price decline associated with DADRP bids times the load scheduled in the DAM, were estimated to be about $236,000.

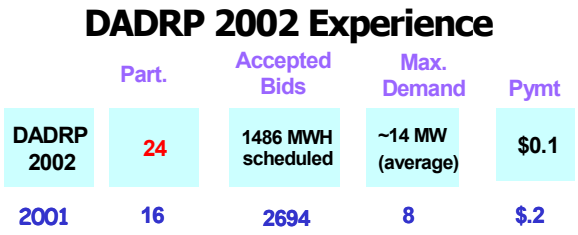

Fig. E-4 DADRP 2002 Experience

Customer Participation and Performance: Who Participates, Why, and How Well?

A primary objective of the 2002 evaluation was to better understand customers' decisions regarding participation and performance in the NYISO Demand Response programs (see Chapters 3, 4 and 5). For system dispatchers to view PRL programs as reliable resources during times of emergency, it is critical to identify and explain differences between subscription rates and actual performance. Moreover, because participant acquisition costs can be high, CSPs, LSEs, and policymakers would like to identify factors that contribute to higher performance yields. To characterize the drivers to participation in PRL programs, a survey was administered to 85 program participants and 59 informed non-participants, the latter comprised of customers that were exposed to the program opportunity, but chose not to participate. The data collected provide a means for comparing and contrasting participants with non-participants, both in terms of

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However, regulated LSE tariffs require that the customer be paid 90% of the payment the LSE receives from the NYISO.

observable characteristics and with regard to expressed preferences for program features and provisions.

Customers that participated in one or more of the NYISO's PRL programs are characterized by significantly higher summer peak demand than non-participants. The median maximum demand was 1.7 MW and 14.5 MW for EDRP and DADRP participants, respectively, compared to 750 kW for non-participants. Yet, many customers with relatively small loads, less than 500 kW, enrolled in EDRP and some curtailed proportionally as much or more load.

Among survey respondents, participants with prior experience in one or more utility load management programs were more likely to participate in NYISO PRL programs compared to those with no load management experience. PRL participants were more likely than non-participants (80% to 60%) to have an employee responsible for managing or procuring energy, although the differences are not as large as one might expect. When asked to name the primary impediment to shifting load during the summer day peak period (noon- 6 PM), commercial (80%), institutional (55%) and multi-family (85%) survey respondents overwhelmingly cited occupant comfort. Yet, over 25% of PRL program participants reported turning down lights to accomplish a curtailment and over 20% report that they altered HVAC system operation. One untested hypothesis is that the emergency nature of EDRP events makes relatively infrequent and relatively short (i.e., 2-6 hours) load curtailments tolerable, as they impart an element of public spirit, as is the case with curtailments undertaken for free as a result of public appeals by utilities.

An important focus of this year's survey was to characterize barriers to DADRP participation (see Chapter 4). DADRP offers customers the opportunity to bid against generators on their own price and curtailment terms, and the bids are resolved the day before, unlike EDRP events for which there is only two hours notice. Given customers' aversion to short notice outages, which was quantified by means of behavioral models estimated from survey data (see Chapter 5), one might expect that participation in DADRP would be even more attractive than EDRP, but that has not been the case so far.[3]

Why are customers currently unwilling to participate in DADRP? Analyses of the overall survey results, augmented by in-depth customer interviews conducted with a subset of 35 survey

[3] DADRP has many similarities to RTP programs that have enjoyed high levels of participation in many jurisdictions, for example Georgia Power which as over 1,600 participants, and that are the inspiration for many to propose that such service should be mandatory, at least to the largest customers.

respondents, indicate that a number of organizational, institutional, economic, technical and program-design barriers influence customers' willingness to participate. First, awareness level of the DADRP among survey respondents is low; only 45% of respondents indicated that they were aware of the DADRP program. Only 39% of EDRP and ICAP/SCR participants reported being aware of DADRP, even after two summers' experience. Apparently, LSEs and CSPs in marketing EDRP and ICAP/SCR are not exposing customers to the DADRP participation opportunity, perhaps because they have judged that opportunity to be inherently unattractive to the customer.

What about customers that were aware of DADRP but chose not to participate? Many of these (36%) cited the inability to shift or curtail usage as the primary reason for not participating, which confirms that DADRP is not for everyone (see Fig. E-5). Thirty-five percent indicated that either inadequate compensation or the perceived risks was the primary reason for not participating in DADRP. Paradoxically, many of the customers that rejected DADRP for these reasons participate in ICAP/SCR, which involves very short notice of a curtailment obligation that if not met results in a significant penalty, relative to the benefit. Part of the answer may be in the way customers perceive participation. In the case of EDRP and ICAP/SCR, participants may see themselves as foremost responding to a system emergency, which provides psychic income from acting as a good citizen. Moreover, reducing usage is a rational reaction to the possibility of a forced outage. Thus, it may be easier for an energy manager to sell their management on EDRP compared to bidding in DADRP, which involves market speculation, especially if the supplemental monetary benefits from EDRP are high.

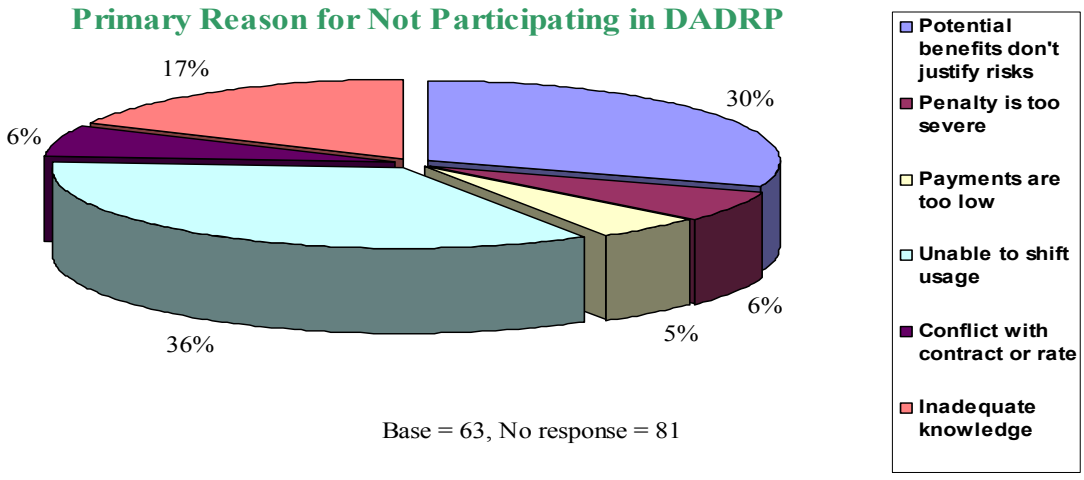

Fig. E-5: Reasons for Not Participating in DADRP

As was the case last year, the survey results indicate that lack of understanding of the benefits and risks of DADRP participation is a very important deterrent to participation. A significant group of non-participants (17%) cited various types of information and education barriers as their primary reason for not joining DADRP. To explore this further, some survey respondents were asked to rate their comfort level in performing the following activities on a 1 (low) to 5 (high) scale: (a) developing a curtailment implementation plan compatible with DADRP bidding, (b) monitoring day-ahead energy prices to determine whether to bid, and (c) developing a bidding strategy based on NYISO DAM and RTM prices. Not surprisingly, 90% of DADRP participants indicated that they were comfortable performing these threeactivities.

In contrast, while 70% of DADRP non-participants reported that they were comfortable creating a load curtailment plan, only 15% indicated that they were comfortable determining at what price to bid. This suggests that many customers that can see themselves curtailing at least some usage do not understand sufficiently the character of NYISO prices to develop a bidding strategy that takes advantage of that capability. These findings highlight the need for additional information, education, and training on how the market works and how prices are tied to observable and predictable market situations.

Customers reported high payback thresholds for investments in enabling control and information technologies (Fig. E-6). In addition, customers indicated that they saw little value for such technologies outside of the existing PRL programs, overlooking that some of these technologies could be used to facilitate participation in other dynamic rate programs, such as TOU, or to minimize demand charges. PRL programs on their own seem unlikely to spur significant investments in control technologies, at least under existing program designs.

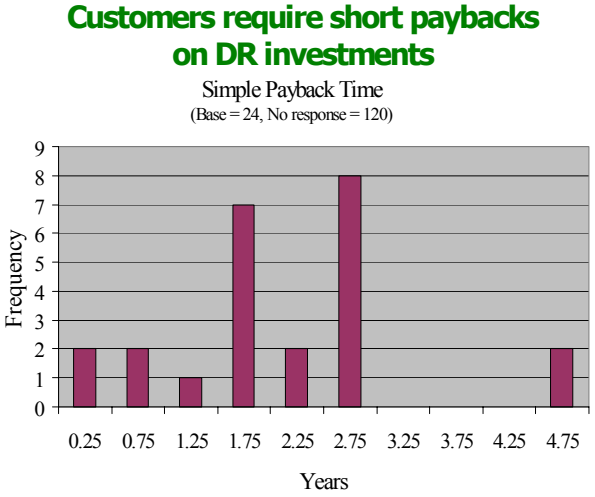

Fig. E-6: Payback for Demand Response Investments

To analyze the factors that influence customers' EDRP subscription levels and actual event curtailments, a performance metric, called the Subscribed Performance Index (SPI), was developed to compare customers' actual performance during the summer 2002 events relative to what they indicated they could achieve when they subscribed (see Chapter 5). The SPI metric facilitates the comparison of curtailment yield among groups of customers and serves to characterize the impact of dispatching EDRP resources during system emergencies. Table E-1 below summarizes the average performance of different groups of EDRP customers segmented by load curtailment strategy (e.g., load reduction only, on-site generation), program participation choices (e.g., EDRP only vs. EDRP and ICAP/SCR), market segment, and participation in a NYSERDA program. NYSERDA offered funding in 2001 and 2002 under two programs specifically to promote participation in the NYISO's PRL programs.

Table E-1: Performance Results of Selected Customer Groups

	N	Total Subscribed Load (MW)	Mean Customer-specific Subscribed Performance Index (SPI_C)
All Customers	**1,711**	**1,477**	
Curtailment Strategy			
Load Reduction Only	**1,292**	**1,147**	**32%**
On-Site Generation	**373**	**262**	**46%**
Program Choices			
EDRP Only	**1,105**	**429**	**42%**
EDRP and ICAP/SCR	**113**	**455**	**96%**
Market Segment			
Manufacturing	**99**	**558**	**65%**
Government/Utilities	**84**	**123**	**80%**
Education	**33**	**30**	**103%**
Trade	**29**	**26**	**80%**
Health	**16**	**28**	**45%**
Multi-Family/Apartment	**10**	**9**	**37%**
Office Building	**7**	**8**	**123%**
NYSERDA Peak Demand Program			
NYSERDA Program Participant	**111**	**154**	**64%**
Non-NYSERDA Participant	**1107**	**730**	**46%**

The 113 jointly subscribed active EDRP and ICAP/SCR participants curtailed 92% of their subscribed load reduction during the EDRP summer events, which accounted for 52% of the delivered load curtailment during EDRP events. In contrast, on average, the 1,105 active EDRP-

only customers delivered 42% of their subscribed load reduction commitment when called. Overall, actual curtailment performance compared to what was subscribed was more variable for those customers that relied on load reduction strategies relative to those that deployed on-site generation to effect a curtailment.

Participants in the government/utilities, education, and retail/wholesale trade sectors performed quite well during EDRP events, exhibiting mean SPI values ranging from 80-103%. Health care facilities and multi-family buildings had lower mean SPI values of 45% and 37%, respectively. On average, the 111 customers that received funding from NYSERDA and actively participated in EDRP events out-performed the non-NYSERDA participants, as evidenced by SPI values of 64% and 46%, respectively, which indicates the value and contribution of NYSERDA's technical and financial assistance programs.

Demand Response as a Business Case

A major objective of the 2002 evaluation for NYSERDA was to characterize the needs of business entities that are currently serving, or could serve, as retailers of price-responsive load services (see Chapter 7). These include regulated and competitive LSEs that offer electric commodity service, utilities that provide wires services to end-use customers, and other firms that provide related services to customers such as control and information technology vendors, ESCOs offering performance contracting, and curtailment service providers (CSPs) that specialize in facilitating participation in PRL programs.

Two initiatives were undertaken to characterize demand response as a business: a survey of firms to ascertain their criteria for involvement in PRL programs and pro forma financial analyses to characterize the potential bottom line contribution from doing so. These analyses provide policymakers and public benefit fund administrators (e.g., NYSERDA) with insights into the margin contributions that might be expected by various types of entities that recruit customers to DR programs and the potential sustainability of alternative business models under different scenarios.

The survey suggests that while most firms acknowledge that there might be value to incorporating demand response programs into their business offerings, few are willing to use it as a loss leader. In other words, these programs must contribute to the bottom line in order to be worth promoting, and that contribution requires returns of 10% or greater. Virtually all of the

firms contacted favor the use of public benefits funds to accelerate the growth of program participation. Some firms would restrict such expenditures to underwriting investments in enabling technologies or marketing costs. Others would like to see program benefits (for example, the EDRP $/MWH curtailed) supplemented over what the NYISO offers to increase margins from promoting such participation.

Financial analyses were conducted to quantify the potential benefits to serving as a demand response program provider. Pro forma income statements were developed to characterize the costs associated with promoting participation and to quantify the expected revenues, first using the program provisions applicable in 2002 and then under the revised provisions approved for2003. In 2003, participants must choose between ICAP/SCR and EDRP participation, which increases the expected benefits from ICAP/SCR participation and reduces those associated with EDRP participation relative to 2002. DADRP was modeled as a strip option to establish expected benefits of submitting a standing-offer strike price. In all cases, the firm sponsoring participation underwrites the equipment and administrative costs and shares in the payments that the customer earns for curtailing.

Acting as a CSP appears to be a highly speculative business. EDRP does not appear to provide sufficient revenues, assuming that the customers share 40% of the payments from the NYISO, to justify recruiting customers as a stand-alone business, unless customers can be acquired at very low costs or support funding is provided by some entity such as NYSERDA. Expected margins from sponsoring joint EDRP and ICAP/SCR participation downstate were encouraging when viewed from a Spring 2002 perspective based on 2001 EDRP events (i.e., 23 hours) and ICAP prices of around $50/kW. The Net Present Value (NPV) for three years of participation under those conditions was $1.3 –1.6 million.

However, in upstate NY, the low ICAP values generated from the same perspective produced negative expectations for margins. Nevertheless, actual ICAP/SCR and EDRP subscriptions expanded both upstate and downstate in 2002. In some cases that expansion was likely driven by NYSERDA public benefit funding, especially for CSPs, which offset the costs of recruiting and servicing participation. In all cases, actual revenues did not meet expectations since there were only 10 curtailment hours in the summer of 2002 and upstate ICAP values were lower.

Going forward to 2003, curtailable load can be subscribed to either ICAP/SCR or EDRP, but not both. In addition, ICAP/SCR resources will be called on first, which in some cases may preclude the declaration of an EDRP curtailment event, and ICAP/SCR resources will be

dispatched according to the strike price they declare; in some instances, not all of those resources will be paid for curtailing. As a result, ICAP/SCR revenues are expected to decline, and those from EDRP will become more speculative. In upstate NY, the consequencesare that expected returns for recruiting new customers for the next three years are negative. Downstate, promoting and sponsoring ICAP appears to continue to be an attractive business proposition, largely due to the higher ICAP market prices. However, customers that previously participated represent profitable opportunities as most of the transaction costs are sunk.

Participation in DADRP was evaluated to ascertain whether it could be bundled with ICAP/SCR to improve margin prospects. Whether it does or does not depends on the bidding strategy of the participants and DAM market prices over the next 3-5 years. Under optimistic conditions, from a business case perspective, the NPV of such an endeavor is $120/kW downstate and $46/kW upstate. Such conditions include ICAP values persisting at their summer 2002 values and DAM prices that result in extensive curtailments scheduled at a $100/MW strike price. Under the worst-case conditions, where ICAP prices are lower and few curtailments are scheduled, margins downstate are reduced to $13/kW and become highly negative ($34/kW) upstate. However, profitability is very sensitive to customer load acquisition costs.

Summary

The NYISO's PRL programs continue to grow and evolve through experience, and as a result become more effective. Participation in capacity and emergency programs has provided resources that have proven valuable in system emergencies, and laid the foundation for attracting customers to bid curtailments in the day ahead market to further improve market performance. In addition, the exposure to dynamic market prices will make participants more amenable to time-of-use and other pricing options that provide enduring benefits to all stakeholders. NYSERDA's programs have been especially useful in demonstrating the value of enabling technologies and attracting participation from underrepresented sectors. The comprehensive program evaluations these entities have sponsored have served as the basis for refining and adapting these PRL programs. Moreover, the methods and protocols developed provide an important contribution to a more complete understanding of how customers use and value electricity that will benefit many other initiatives to make electricity markets more efficient and effective.