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**Pacific Northwest  
National Laboratory**

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## **Impact of Enabling Technologies on Customer Load Curtailment Performance**

Summer 2001 Results from NYSERDA's Program  
Opportunity Notices (PON) 585 and 577 Programs  
and New York Independent System Operator's (NYISO)  
Emergency Demand Response Program

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March 2002

Prepared for the Transmission Reliability  
Program Office of Power Technologies  
Prepared for the U.S. Department of Energy  
under Contract DE-AC06-76RL01830



(a) Lawrence Berkeley National Laboratory

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*under Contract DE-AC06-76RLO 1830*

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## Summary

This report describes a market and load research study on a small group of participants in the New York Independent System Operator (NYISO) Emergency Demand Response Program (EDRP) and the New York State Energy Development Authority (NYSERDA) Peak Load Reduction and Enabling Technology Program Opportunity Notices (PON).

In-depth interviews were conducted with 14 respondents (the sample group) that participated in the NYISO Emergency Demand Response Program (EDRP) through New York State Electric and Gas (NYSEG), and the firms of AES NewEnergy, and eBidenergy/ Consumer Powerline. These customers used funding from NYSERDA to apply enabling technologies that were hypothesized to improve customers' ability to curtail load. Both NYSEG and eBidenergy/Consumer Powerline offered the customers access to hourly load data on a day-after basis and, during curtailment events, on a near-real-time basis. Phone interviews were conducted with most customers; however, 25% of customers provided initial responses to the survey protocol via email. The market research information was then combined with load data during the curtailment events of August 7-10, 2001 to evaluate the impact of technology on curtailment responses.<sup>1</sup>

### Performance Indicators

Two indicators were developed to measure the sample group performance during curtailment events; the subscribed performance index (SPI) and the peak performance index (PPI). The SPI is a ratio of the customer's actual curtailed hourly load averaged over all hours of curtailment, divided by the customer's subscribed load, which is the target they set for themselves at the outset of the program. The PPI has the same numerator; however, the denominator is the customer's non-coincident facility peak demand, which provides an indicator of performance relative to the technical potential of load curtailment for that customer.

The average value and standard deviation for 14 respondents is identified below. Customers are identified by subgroups (a) seven customers with backup generation; (b) seven customers with out backup generation; (BUG) <sup>2</sup>; (c) eight customers participating only in the voluntary EDRP; and (d) six customers participating in the installed capacity program (ICAP) and EDRP.

**Customer Performance in EDRP: Impact of Backup Generation and ICAP Participation**

<i>Subgroups</i>	<i>No.</i>	<i>Curtailed Load/Subscribed Load (SPI)</i>		<i>Curtailed Load/Customer Peak Demand(PPI)</i>	
		Average	Std. Deviation	Average	Std. Deviation
<b>Customers w/ BUG</b>	7	1.04	0.55	0.46	0.37
<b>Customers w/o BUG</b>	7	0.32	0.30	0.05	0.04
<b>Customers in EDRP and ICAP</b>	8	0.92	0.61	0.41	0.37
<b>Customers in EDRP only</b>	6	0.35	0.31	0.05	0.05

<sup>1</sup> This study appears in Chapter 6 of the Neenan Associates 2002. *NYISO PRL Program Evaluation*.

<sup>2</sup> The NYISO allows Load Serving Entities (LSE) to claim curtailable special case resources (SCR) to fulfill their ICAP requirements. Qualifying customers can sell their ICAP/SCR capacity back to their load serving entities (LSE). The NYISO can exercise its call option on ICAP/SCR during periods of reserve shortfalls.

The seven customers that relied on load reductions only to curtail loads typically employed a variety of conservation and operational strategies (e.g., turning off lights, resetting thermostats, and reducing pump and compressor loads). Their pledged curtailment as a fraction of facility peak demand was low, averaging 5% over the sample. There was no evidence of customer performance “fatigue” found over the limited number of curtailment events in summer 2001. Customers in all subgroups performed as well or better on the second and third day of curtailment as on the first.

Based on the two performance indicators (SPI and PPI), it was determined that those customers with backup generators and those who participated in the ICAP program had much better performance compared to those customers that participated only in the voluntary EDRP or did not have backup generators. Study results suggest that differences in performance can be attributed thusly:

- customers with backup generators have much more discretion over how and how much they reduce their total load in response to curtailment events;
- as a result of possessing this strategic asset, these 7 customers were able to meet, and sometimes out-perform, their subscribed goals (i.e., SPI of 1.04); and
- actual curtailed load represented about 46% of non-coincident facility peak demand.

It should be noted that customers participating in the ICAP program faced a substantial performance penalty by NYISO demand reduction target were not met. For these customers, ICAP was not a “voluntary” program; the consequences of non-compliance had to be considered. Thus, these 8 customers, on average, performed near their subscribed load targets (i.e., an SPI of 0.92).

## **Implications for NYISO System Planners**

This case study of 14 respondents has one important implication for NYISO system planners: Results suggest that customer participation in an ICAP-type program are likely to significantly increase the probability that customers also enrolled in an emergency-type program (e.g., EDRP) will actually curtail their subscribed load during curtailment events. The finding that eight customers participating in both EDRP and ICAP had superior performance compared to the six customers that enrolled in EDRP only should be tested over the entire sample of 292 EDRP participants. Such analysis could improve the future ability of NYISO to predict customers’ actual load reductions during curtailment events compared to their subscribed load. The Neenan Associates evaluation of the 2001 EDRP notes that the Peak Load Reduction (PRL) program provided reliable and predictable resources to the NYISO from an hour-by-hour perspective over a several day period (e.g., within 5% of the average of 420 MW) and also found that maximum hourly curtailment in the EDRP was about 60% of total subscribed load (i.e., 425 versus 712 MW).<sup>1</sup> Study results suggest that there were potentially two subgroups of participants in the EDRP with very different performance characteristics: those in EDRP only, and those enrolled in EDRP and ICAP. Future changes in ICAP design could have major spillover effects on EDRP performance.

## **Impact of Enabling Technologies**

A major objective of the study was to assess the impact of enabling technologies on customers’ demand response capability and performance. Even in a small sample, some impacts were evident: web-based near-real time load monitoring was very useful for setting and tracking progress toward load reduction targets and for educating senior management, some customers quickly adopted the technology for other

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<sup>1</sup> Neenan et al., 2002. NYISO Price-Responsive Load Program Evaluation Final Report, New York Independent System Operator, January 8, 2002. Can be obtained at: [http://www.nyiso.com/services/documents/groups/bic\\_price\\_responsive\\_wg/demand\\_response\\_prog.html](http://www.nyiso.com/services/documents/groups/bic_price_responsive_wg/demand_response_prog.html).

energy management uses (e.g., turning off various processes to see impact on overall load), the installed base of backup generation provided an important load curtailment resource, and almost all of the customers surveyed relied on manual approaches, rather than automated response to respond to curtailment events, rather than automated response.

### **Primary Customer Motivations for EDRP Participation**

Customers indicated that the primary motivators for working with the contractors and participating in the EDRP were: (1) saving money on utility bills, (2) access to economic incentives offered by the program, and (3) the fact that program participation was voluntary and that control was retained regarding decisions on whether and how much load to curtail.

### **Suggestions for NYSERDA**

Given the fact that the NYISO programs are relatively new and that it takes users some period of time to realize the full benefits of adopting innovative demand-response technologies, it is recommended that NYSERDA consider additional evaluation/case studies to document other benefits (besides load curtailment capability) that customers receive from enabling technologies supported in the PRL Program. It is also recommended that NYSERDA develop a more robust understanding of relationships between adoption of enabling technologies, performance of customers individually in curtailing load, and the influence of other confounding factors (e.g., participation in other programs, such as ICAP/SCR).





## **Acknowledgements**

The work reported herein was conducted by the Consortium for Electric Reliability Technology Solutions (CERTS) and funded by the U. S. Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Power Technologies under Contract No. DE-AC03-76SF00098, the Pacific Northwest National Laboratory under Contract No. DE-AC06-76RL01830, and Lawrence Berkeley National Laboratory under Contract No. DE-AC03-76SF00098.

We thank the following individuals for their support and assistance: Dave Coup and Peter Douglas, NYSERDA; Dave Lawrence, NYISO; John Zdimal, NYSEG; Ken Camera, eBidenergy; Steve Kass, AES NewEnergy; Mike Gordon, Consumer Powerline; and Bernie Neenan and Donna Pratt, Neenan Associates.

We also acknowledge major contributions to the customer survey by the following Pacific Northwest National Laboratory staff: David M. Brown, Donald Hadley, Ronald Underhill, Curtis Nichols, and James Nickolaus.



# Glossary

<b>BUG</b>	<b>backup generator</b>
<b>CBL</b>	<b>customer baseline</b>
<b>CSP</b>	<b>curtailment service provider</b>
<b>DADRP</b>	<b>Day-Ahead Demand Response Program</b>
<b>DR</b>	<b>distributed resources</b>
<b>EMCS</b>	<b>Energy Management Control Systems</b>
<b>EPO</b>	<b>Energy Profiler Online</b>
<b>EDRP</b>	<b>Emergency Demand Response Program</b>
<b>ICAP</b>	<b>Installed Capacity Program</b>
<b>LBMP</b>	<b>locational-based marginal price</b>
<b>LBNL</b>	<b>Lawrence Berkeley National Laboratory</b>
<b>LSE</b>	<b>load serving entity</b>
<b>NYISO</b>	<b>New York Independent System Operator</b>
<b>NYSEG</b>	<b>New York State Electric and Gas</b>
<b>NYSERDA</b>	<b>New York State Energy Research and Development Authority</b>
<b>PNNL</b>	<b>Pacific Northwest National Laboratory</b>
<b>PON</b>	<b>Program Opportunity Notice</b>
<b>PPI</b>	<b>peak performance index</b>
<b>PRL</b>	<b>peak load reduction</b>
<b>SCR</b>	<b>special case resources</b>
<b>SPI</b>	<b>subscribed performance index</b>
<b>VIP</b>	<b>Voluntary ISO Profit</b>



# Contents

<b>SUMMARY.....</b>	<b>iii</b>
<b>GLOSSARY.....</b>	<b>ix</b>
<b>FIGURES .....</b>	<b>xiii</b>
<b>TABLES .....</b>	<b>xiii</b>
<b>1. INTRODUCTION .....</b>	<b>1</b>
<b>2. APPROACH .....</b>	<b>5</b>
<b>3. CUSTOMER RESEARCH FRAMEWORK.....</b>	<b>9</b>
<b>4. RESULTS; ANALYSIS OF CUSTOMER SURVEYS AND LOAD CURTAILMENTS .....</b>	<b>13</b>
<b>5. CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>23</b>



## Figures

1... Subscribed Curtailment Versus Facility Peak Demand.....	16
2. Variation in Customer Performance in EDRP Only and EDRP/ICAP Actual Curtailed Load/Subscribed Load (SPI).....	17
3. Variation in Customer Performance With and Without Backup Generation: Actual Curtailed Load/Subscribed Load (SPI).....	18
4. Load Curtailment Potential and Persistence.....	19
5. Customer Performance and Persistence of Load Curtailments .....	19
6. Customer Motivation for Signing Up for EDRP.....	20

## Tables

1. Summary of Market Research Target Sample and Survey Results.....	11
2. Facility Characteristics of Survey Respondents.....	12
3. Customer Performance in ERDP: Impact of Backup Generation and ICAP Participation.....	15





# 1. Introduction

The restructuring of U.S. electricity markets has created new opportunities for load-serving entities, such as utilities or retail energy suppliers, or curtailment service providers (e.g., aggregators) to partner with customers in curtailing or altering electric demand in response to either electric system reliability needs or high prices in electricity markets. Although the benefits of allowing customers to manage their loads in response to system conditions or wholesale market prices are potentially large, there are numerous challenges to creating workable price-responsive load programs in wholesale markets. Success in facilitating customer participation in day-ahead or real-time markets for power hinges on both enabling technologies and market/institutional requirements. From a policy perspective, technologies that facilitate price-responsive loads are important because they introduce higher elasticity in the customer's demand curve, which can potentially reduce price volatility and average price levels in wholesale markets.

Enabling technologies for price-responsive load include, but are not limited to:

- widespread deployment of interval meters with two-way communications capability
- multiple, user-friendly communication pathways to notify customers of load curtailment events
- energy information tools that enable near-real-time access to interval load data
- demand reduction strategies that are optimized to meet differing high-price or electric system emergency scenarios
- building energy management control systems that facilitate automation of load curtailment strategies at the end use level; and
- onsite generation equipment, used either for emergency backup or to meet primary power needs of a facility.

With funding from the Department of Energy Office of Power Technologies, Lawrence Berkeley National Laboratory (LBNL) and the Pacific Northwest National Laboratory (PNNL) are conducting research on price-responsive load programs and technologies.<sup>1</sup> As part of that effort, the LBNL/PNNL team worked with stakeholders in two states (New York and California) to conduct market research on the impact and role of various technologies that enable customers to participate more effectively in price-responsive load programs.

In 2001, NYSEERDA made awards to five contractors under PON 585 (“Enabling Technology for Price Sensitive Load Management”). In this program, NYSEERDA provided up to \$150,000 for contractors to demonstrate technologies that would expand the capability of NYISO market participants (either load-serving entities or curtailment service providers) to reduce load in response to emergency and/or market-based price signals. Eligible technology solutions for customers included real-time communications and metering capability, two-way communication protocol, web-enabled technology, real-time price

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<sup>1</sup> The “Load As A Resource” project’s overall objective is to assess and support development and demonstration of key distributed resource (DR) enabling technologies; evaluate technical, market and institutional barriers that influence direct participation by customer loads in electricity markets; and identify and support dissemination of “best practices” among program administrators, contractors/aggregators, and end users.

forecasting capability, and technologies that automate load curtailment. NYSERDA also made awards totaling \$6 million under its Peak Load Reduction (PRL) program (PON-577). The PRL program had four components: permanent demand reduction efforts (e.g., Energy Management Control Systems (EMCS) upgrades, controls), short-duration load curtailment (SDLC) measures (e.g., radio-frequency-controlled strategies, telemetry controls), dispatchable emergency generator (DEG) initiatives (e.g., installation of transfer switchgear, catalytic reduction technologies, dual-fuel options); and interval meters. NYSERDA funding for installation of enabling technologies or infrastructure helped customers to participate in the NYISO price-responsive load programs: Emergency Demand Response Program (EDRP) and Day-Ahead Demand Response Program (DADRP). In addition, NYISO offered an installed capacity program (ICAP/SCR) [see NYISO Demand /Response Programs following]. Based on discussions with NYSERDA and the willingness of contractors to cooperate, three contractors agreed to participate in this study: New York State Electric and Gas (NYSEG), AES New Energy (AES), and eBidenergy/Consumer Powerline.

LBNL and PNNL worked closely with and attempted to coordinate this study with the comprehensive evaluation of the NYISO programs conducted by Neenan Associates (2002).<sup>1</sup> Specifically, customer survey protocols were shared to minimize duplication of topics, attempts were made to minimize overlap in surveying customers, and market research results were provided to Neenan Associates. Conceptually, the LBNL/PNNL study used a case study approach with a small sample of customers. The focus was on such topics as customer load curtailment strategies, customer's perception of the effectiveness of various technologies that facilitate load curtailment, and the relationships between contractors, customers, and NYISO programs.

This report is organized as follows: Section 2 describes the overall research approach and objectives and the customer market survey instrument. Section 3 summarizes the program and technology offerings of the three contractors and includes a description of customers that responded to the survey. Section 4 describes the performance indicators developed to assess customer performance and discusses the results of the analysis of customer load curtailment data and customer surveys. Section 5 summarizes conclusions from the case study of 14 participating customers.

## **NYISO Demand Response Programs**

NYISO offered two voluntary response programs (EDRP and DADRP) and one that required a load reduction commitment with a penalty clause for noncompliance (ICAP/SCR). None of the respondents subscribed to the DADRP. Thus, the brief summary of this program is omitted; the reader is referred to the DADRP manual<sup>2</sup> for information on this program.

### **Emergency Demand Response Program (EDRP)**

The EDRP provides a mechanism for load reduction during emergency conditions in the New York State bulk power system. The program is effective from May 1, 2001 through October 31, 2002. Retail end-users can participate through one of 4 curtailment service providers (CPS):

- load-serving entities
- through NYISO-approved curtailment customer aggregator
- as a direct customer of the NYISO
- as a NYISO-approved curtailment program end-use customer

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<sup>1</sup> This study appears in Chapter 6 of the Neenan Associates 2002. *NYISO PRL Program Evaluation*.

<sup>2</sup> NYISO Day-Ahead Demand Response Program Manual, New York Independent System Operator. Schenectady, New York. May 24, 2001.

CSP must provide load reduction of at least 100kW/zone and respond within 2 hours of emergency notification. Participation is voluntary and no penalties are attached if CSP fails to respond to a NYISO notice. Retail end users may also participate in the ICAP/SCR program. If the NYISO activates the program, each CSP will be paid the higher of \$500/MWh or the zonal real-time locational-based marginal price (LBMP) per MWh of load reduced. If NYISO activates the program for less than 4 hours, the CSP will receive payments for 4 hours. The load reduction will be determined on the basis of a customer baseline (CBL). There are several metering configuration requirements allowing customers to meter generation of backup generators separately or as embedded in the total facility load. More detail on the CBL and the metering configuration requirements can be found in the EDRP manual.<sup>1</sup>

## **Installed Capacity, Special Case Resources (ICAP/SCR)**

The New York State Reliability Council (NYSRC) sets the Installed Reserve Margin, and the ISO determines the NYCA Installed Capacity Requirement in accordance with the criteria and standards of the Northeast Power Coordinating Council and the New York Public Service Commission. In the summer of 2001, load could participate in the market and procurement process as special case resources (SCR). The required installed capacity is procured through a competitive auction, in which a participant submits a bid price for a dispatchable load amount. The bid price is nominated in \$/kW per 1 month. If accepted, the load receives a capacity reservation payment for making the resource available for a period of 1 month.

SCR is available to generators and load reduction providers that meet testing, metering requirements, and other requirements. The capacity reservation payments under SCR and the energy payments under EDRP are additive. While there are no penalties for nonperformance under EDRP, the SCR program will reduce future capacity payments if the SCR does not perform. The NYISO will activate both programs at the same time. For more information, see the Installed Capacity Manual.<sup>2</sup>

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<sup>1</sup> NYISO Emergency Demand Response Program Manual, New York Independent System Operator, Schenectady, New York. May 24, 2001.

<sup>2</sup> NYISO Installed Capacity Manual, New York Independent System Operator, Schenectady, New York. February 27, 2002.



## 2. Approach

This research on demand-response load programs and technologies is intended to provide insights on three general questions:

1. What end uses do customers target for load reduction (e.g., HVAC, lighting, elevators, process loads)?
2. How effective are enabling technologies on influencing absolute levels and persistence of load reductions that can be achieved in buildings?
3. What price and non-price attributes of contractor/program service offerings seem to contribute to customer/end user compliance, performance, and retention?

The specific objectives of this research project are to:

- elicit opinions from a sample of customers that participated in the NYISO Price-Responsive Load Programs and received demand response technologies, communication equipment, or information software from contractors that participated in the NYSERDA Program on:
  - the value of specific enabling technologies
  - motivations for participating in the contractor's program and the NYISO PRL programs
  - the contractor's program design and implementation
- increase our understanding of:
  - how customers assess their load management capabilities and what curtailment strategies they adopt
  - customer investments and preparations for curtailments
  - the role of automation in executing load curtailments
  - the role of backup generators in load curtailment goal-setting and performance
  - how facility operators and/or occupants are affected by curtailments
  - how enabling technologies affect customer satisfaction and willingness to continue participating

Given time and budget constraints, LBNL/PNNL informed NYSERDA/NYISO that phone interviews could be conducted with ~20 to 25 customers. In selecting the contractors, the goals were to work with both a load-serving entity (LSE) and a curtailment service provider (CSP) to get diversity in service providers, and work with contractors that were providing innovative demand response technologies or service offerings. The contractor's willingness to cooperate was ultimately critical because they provided customer contact information to LBNL/PNNL, and informed and urged customers to cooperate by being interviewed. Two contractors pre-screened customers enrolled in their program and provided

LBNL/PNNL with a subset of customers that were willing to be interviewed. This further reduced the potential sample. One contractor provided us with contact information for all of their customers.

LBNL/PNNL developed an interview protocol that was used by PNNL facility engineers to conduct phone interviews. Participating customers were assured that responses would be treated as confidential, and that results would be presented in aggregate so that customer-specific information would not be reported. Some customers requested the interview questions in writing prior to the phone interview. About 75% of the responding customers were ultimately interviewed by phone, while the remaining 25% of customers returned answers to the interview questions via email, and were then contacted by PNNL facility engineers to clarify answers to questions. Interviews were conducted during late November and early December 2001. It is worth noting many New York area facility operators were preoccupied and burdened with additional responsibilities in the aftermath of the destruction of the World Trade Center in September 2001.

The phone survey included questions on the following topics:

- facility description: type, ownership characteristics, vintage, operational schedule, and typical monthly summer electricity usage and peak demand
- basis for developing load curtailment goals (e.g., subscribed load in NYISO PRL program)
- load curtailment strategies: specific technologies or operational strategies, targeted end uses; set of questions on backup, emergency generators (e.g., fuel source, type of generator, size, vintage, parallel or stand-alone operation, estimated “running costs” of generator)
- customer views on extent to which they met load curtailment goals and suggested changes to improve results
- additional costs or investments made by customers to participate in PRL programs
- curtailment notification scheme (e.g., phone, fax, email, pager) and implementation procedures (e.g., manual schemes, semi-automated, fully-automated, other)
- estimated load reduction during August 2001 curtailments
- notification and/or involvement of facility occupants during load curtailments
- questions on specific enabling technologies offered by each LSE/CSP
- relative importance of reasons why customer participated in the contractor’s program (i.e., motivation)
- customer views on intentions to continue participating in load curtailment programs
- suggestions for improvement

Electricity usage data for the periods prior to and including the curtailment events (August 7-10) was provided by contractors or NYISO. In the analysis, for each customer, customer hourly load and load curtailment data was combined with market survey information to examine factors that might explain their load curtailment performance. Results from this study should be interpreted with caution, given the small sample size and the case study approach.





### 3. Customer Research Framework

All regulated load-serving entities in New York and numerous curtailment service providers offer programs under the broad umbrella of the NYISO's PRL programs. Several program developers applied for and won supplemental funding from NYSERDA's PONs 585 (Enabling Technology) and 577 (Peak Load Reduction). After discussions with both NYSERDA and individual LSEs and CSPs, three programs were chosen that offered particularly interesting technology features, such as advanced notification devices and meter data hosting technologies. The NYSERDA supplemental funding allowed the LSEs and CSPs to recruit customers, install, test and verify interval meter reading at the customer sites, and provide web-enabled data hosting capabilities, allowing customers to track their load on a day-after or near real-time basis. The following section describes the particular service and technology offerings by the three selected LSEs/CSPs. More detail on all of the NYSERDA funding participants can be found in Chapter 6 of the Neenan Associates evaluation, NYISO Price-Responsive Load Program Evaluation Final Report<sup>1</sup>.

#### **New York State Electric & Gas Corporation (NYSEG)**

NYSEG is a regulated investor-owned load serving entity that markets a subsidiary program called the C.A.\$H. BACK Program. The program targets commercial and industrial customers interested in gaining access to the NYISO programs. The C.A.\$H. BACK Program provides participating customers with the following services and equipment:

- consultation by NYSEG staff to identify load curtailment opportunities and to discuss curtailment strategies
- installation of electronic pulse interval meter and connection to a phone line for automated meter reading
- subscription to the Energy Profiler Online (EPO) website, including training literature.<sup>2</sup> The EPO website provides the following features:
  - tracking of load data on a day-after basis during non-curtailment days. During curtailment periods, the meter was interrogated every 15 minutes to provide rapid feedback to the customer on effectiveness of the curtailment, allowing customers to adjust or refine their curtailment strategy to improve curtailment performance.
  - customer baseline information, where the calculated baseline load shape can be viewed as a graph superimposed into load data graphs. This feature provides an instant overview of their curtailment performance.
  - for participants of the DADR Program, the EPO website provided a nomination screen for entering the demand bids for NYISO's day-ahead market

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<sup>1</sup> Neenan et al., 2002. NYISO Price-Responsive Load Program Evaluation Final Report, New York Independent System Operator, January 8, 2002. On the internet at [http://www.nyiso.com/services/documents/groups/bic\\_price\\_responsive\\_wg/demand\\_response\\_prog.html](http://www.nyiso.com/services/documents/groups/bic_price_responsive_wg/demand_response_prog.html).

<sup>2</sup> Energy Profiler Online is a commercial product offered by ABB Energy Interactive.

- billing information to quantify payments for each curtailment selection of notification means, such as email or pager
- Alpha-numeric pager for emergency event notification.

The NYSEG Program was well-subscribed, and NYSEG program managers signed up over 35 customers with the anticipation of a cumulative load reduction of 93 MW for the EDRP and 49 MW for the DADRP.

## **AES NewEnergy**

AES NewEnergy is a curtailment service provider operating in retail and wholesale markets around the country. AES NewEnergy marketed the NYISO PRL programs as the Voluntary ISO Profit (VIP) Program to their existing energy customers, as well as an independent service offering to non-energy customers.

AES NewEnergy notified participating customers via pager and e-mail, following up receipt of electronic notification with a confirming telephone call (AES NewEnergy did not provide alpha-numeric pagers). Plans are underway to introduce a curtailment module within AES NewEnergy's WebJoules website for the summer of 2002. The website will provide access to load data, including the graphing of the customer baseline and billing data for performed curtailments. This web-based service was not available for the summer of 2001.

## **Bidenergy.com, Inc., and Consumer Powerline**

The teaming of eBidenergy.com and ConsumerPowerline brought together technology and energy services, with eBidenergy.com as the technology provider and ConsumerPowerline as the energy service provider. eBidenergy.com offered web-enabled software for data hosting and a metering platform, while ConsumerPowerline was responsible for the recruitment of commercial and industrial customers for the NYISO PRL programs.

Each program participant was provided access to eBidEnergy.com's PowerTrak website, which included the following features and functions:

- scheduling and nominating demand bids for NYISO's DADRP.
- access to customers' 15-minute load data, providing graphing features of individual and aggregated loads. On curtailment days, load data are updated every 15 minutes to enable customers to adjust and refine curtailment strategies to improve performance. On non-curtailment days, load data were updated once per day.
- determining customer baseline with graphing features to superimpose over load data to indicate curtailment performance.
- analysis of demand reduction to determine customers' performance with respect to their load reduction targets.
- curtailment billing features to estimate curtailment credits
- Notification selection allowing the customer to select the preferred means of notification and contact addresses.

In addition, customers received electric meters where metering technology was insufficient for interfacing with the PowerTrak web technology.

## Target Sample and Respondent Results

The LSE and two CSPs contacted their EDRP and DADRP customers to determine their willingness to participate in the LBNL/PNNL customer market survey. We received a self-selected sample of customers willing to be interviewed. Table 1 summarizes the LBNL/PNNL respondent selection and survey results, including initial respondent pool, number of respondents, and response rate. The survey achieved an overall response rate of 61%.

**TABLE 1. Summary of Market Research Target Sample and Survey Results**

	<b>Number of Participants</b>	<b>Number of Participants Responded</b>	<b>Response Rate</b>
AES NewEnergy	12	6	50%
Ebidenergy.com/ Consumer Powerline	4	2	50%
NYSEG	7	6	86%
<b>Total</b>	<b>23</b>	<b>14</b>	<b>61%</b>

Table 2 shows that the total subscribed load reduction the our respondents was 14.05 MW, with the majority (10.55 MW) enrolled in both the EDRP and the ICAP programs. None of the respondents enrolled in the DADRP. All EDRP/ICAP participants had sufficient generation capacity to meet the subscribed ICAP requirements, except for one office building, which entirely relied on load reduction to meet the ICAP load reduction target.

**TABLE 2. Facility Characteristics of Survey Respondents**

No.	Program Enrolled	Peak Demand [kW]	Curtailment Target [kW]	Subscribed Generation Capacity [kW]
1	EDRP	21,000	2,000	0
2	EDRP	8,500	500	0
3	EDRP	2,300	500	0
4	EDRP	400	100	0
5	EDRP	1,400	200	0
6	EDRP	1,350	200	0
<b>EDRP Only subtotal</b>		<b>34,950</b>	<b>3,500</b>	
7	EDRP/ICAP	1,500	900	>1,000
8	EDRP/ICAP	1,900	750	0
9	EDRP/ICAP	27,000	2,000	2,000
10	EDRP/ICAP	1,200	1,200	1,200
11	EDRP/ICAP	5,000	4,500	4,500
12	EDRP/ICAP	500	500	500
13	EDRP/ICAP	1,200	500	600 to 900
14	EDRP/ICAP	4,400	200	200
<i>EDRP/ICAP subtotal</i>		<b>42,600</b>	<b>10,550</b>	
<b>Total</b>		<b>77,550</b>	<b>14,050</b>	

**Note:** The column labeled “Subscribed Generation Capacity [kW]” represents generator capacity committed to the program(s). There are facilities (e.g., health facilities), which have backup generators, but may not commit them to the program. In that case, the on-site generation capacity is indicated as zero.

## 4. Results: Analysis of Customer Surveys and Load Curtailments

Results of the analysis of the customer survey and load curtailments follow.

### Load Curtailment Data Analysis

Performance in curtailing loads may be evaluated on an aggregate or program total basis and on an individual customer basis. This study focused on the individual customer level, and performance results were sorted by program type or customer characteristics (e.g., size, backup generation) to identify trends in performance as a function of customer attributes.

Load curtailment performance at the individual customer level is conventionally measured by a comparison of hourly actual customer loads against an assumed or calculated baseline load for a given hour. The baseline load may include adjustments for actual conditions, such as weather or customer work/production schedules. Such a detailed performance analysis at the customer and hourly level is necessary for settlement purposes but difficult to generalize for comparison purposes. Therefore, two related performance indicators were established that broadly represent customer performance and allow for easy comparison of performance across customers or customer groupings.

The two performance parameters calculated for each event are the subscribed performance index (SPI), and the peak performance index (PPI). The SPI is the ratio of the customer's curtailed hourly load averaged over all hours of curtailment divided by the customer's subscribed load. It describes how well a customer performed on average relative to the performance goal or target they set for themselves at the outset (i.e., their subscribed load in the NYISO EDRP). Therefore, an SPI of unity (i.e., 1.0) indicates the customer is performing "on target". SPI values of less than one indicate under performance, while values greater than one reflect a customer who is "over performing" relative to his load reduction target. The PPI has the same  $P_{avg}$  numerator as the SPI, but the denominator is the customer's maximum demand or peak non-coincident demand. Therefore, PPI reflects a different kind of performance measure relative to the technical potential of load curtailment for that customer. Thus, a PPI of 1.0 would be achievable only by a customer who can shed 100% of their peak demand over the entire curtailment period.

Formally, the SPI is defined as:

$$SPI = P_{avg} / P_{sub}$$

where 
$$P_{avg} = \frac{1}{N} \sum_{t=1}^{t=N} (CBL_t - P_{actual,t})$$

with  $N$  : number of hours per curtailment event

$P_{actual,t}$  : facility demand in hour  $t$ , [kW]

$CBL_t$  : customer baseline , [kW]<sup>1</sup>.

and  $P_{sub}$  : subscribed load curtailment as provided for each participating customer by NYISO.

The peak performance index (PPI) is defined as:

$$PPI = P_{avg} / P_{peak}$$

where

$P_{peak}$  : non-coincident facility peak demand.

$P_{peak}$  was determined using the customer load data, which was received from the LSEs/CSPs. For those cases where only generation data were provided to the NYISO, or incomplete facility load data was provided by the LSE/CSP, self-reported facility peak demand, as obtained from the customer survey, was used.

These two performance indicators are useful in differentiating among customers that adopted different participation strategies. Participants that enrolled in the program and took a conservative approach were more likely to meet their subscribed load reduction targets than those who were more aggressive. However, both an aggressive and a conservative participant could contribute the same kW of load curtailment to the reliability of the power system, but achieve different SPIs if their curtailment commitment differs.

We recognize that the choice of these performance indicators is a departure from the implicit price elasticity concept traditionally used to denote a scale or measure of demand responsiveness. An elasticity framework was deliberately discarded because of an assumed lack of price diversity among the customer sample. Assuming a prevailing time-of-use (TOU) rate schedule for most commercial and industrial customers throughout New York State, with a summer peak energy charge of about 9 to 10¢/kWh (or \$90 to 100/MWh), the remaining price differential between the avoided energy cost (assumed \$100/MWh) and the EDRP energy payment in the amount of \$500/MWh would not provide an appreciable price differentiation to attribute different levels of customer curtailment capabilities. In addition, energy costs for customers served by competitive retail energy suppliers was not readily available or likely to be provided.

## Key Findings

Customer performance is primarily driven by EDRP customer participation in the ICAP and by whether they own and use backup generators.

A major objective of our work was to assess the impact of enabling technologies on customers' demand response capability and performance. In the New York ISO PRL programs, it was determined that an individual customer's incentive to perform was most impacted by two factors: (1) their participation in other existing load management programs offered by the NY ISO (i.e., ICAP/SCR); and (2) their ability to utilize backup generation in response to load curtailments. A particularly dominating feature in terms of customer performance and responsiveness seemed to be dual participation in the EDRP and the ICAP/SCR programs, which allowed customers to receive capacity payments in addition to their EDRP

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<sup>1</sup> The computation of the CBL is defined in the NYISO: Emergency Demand Response Program Manual. NYISO, revised 5/24/2001.

payments, if they qualified their load capability. ICAP/SCR participants face substantial penalties for non-compliance; therefore, they tend to outperform those that only participated in the EDRP.

Table 3 shows the average values and standard deviation of SPI and PPI for the 14 customers segmented by whether they participated in the ICAP and whether they possessed and were able to use backup generation in response to load curtailments. In the 14 customer sample, customers with backup generation (BUG) accounted for 2/3 or more of the total load reduction, which is much higher than the total sample of 292 EDRP participants, in which customers with BUG accounted for ~15% of the total subscribed load.

**TABLE 3. Customer Performance in EDRP: Impact of Backup Generation (BUG) and ICAP Participation**

Customer Group	No.	Curtailed Load/Subscribed Load (SPI)		Curtailed Load/Customer Peak Demand (PPI)	
		Average	Std. Deviation	Average	Std. Deviation
Customers w/ BUG	7	1.04	0.55	0.46	0.37
Customers w/o BUG	7	0.32	0.30	0.05	0.04
Customers in EDRP and ICAP	8	0.92	0.61	0.41	0.37
Customers in EDRP only	6	0.35	0.31	0.05	0.05

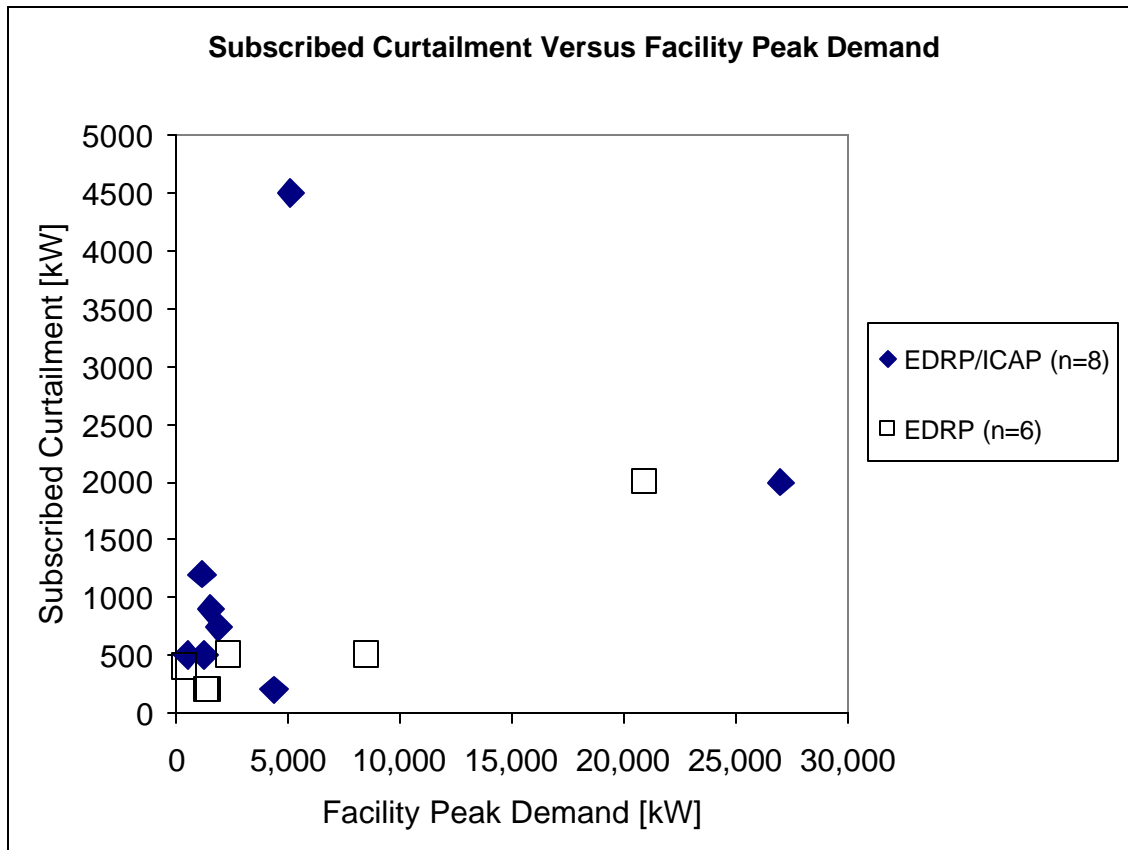
Using the two simple performance measures adopted for this analysis – SPI and PPI – we found that the customers with backup generators and who participated in the ICAP had superior performance. These two sets of customers in fact routinely over-performed, delivering more than their subscribed curtailment when called upon.

The set of respondents with backup generators and the set of customers participating in both the EDRP and the ICAP were identical, except for one customer who participated in the ICAP that did not possess a BUG. This finding emerged from our customer market research with 14 respondents and the load data analysis confirmed the result that customer size mattered less in terms of curtailment pledge and performance than participation in ICAP programs or possession of a backup generator. Specifically, we found that:

- Most customers without backup generators set relatively conservative demand reduction. Their pledged curtailment as a fraction of peak demand was very low – perhaps 5 %;
- Larger customers did not necessarily set higher demand reduction goals unless they possessed backup generators. For example, a customer with 7,000 kW of peak demand, but no BUG, set a load curtailment goal of 100 kW, whereas a 400-kW customer with a BUG set a load curtailment goal of 200 kW.
- Smaller customers can set ambitious demand reduction goals (as a % of total maximum demand) if they have backup generation.

Qualitative results were supported by load analysis, which shows the distribution by size of the 14 respondents [see Figure 1]. Most respondents (with the exception of three) were relatively medium to large commercial/industrial customers with facility peak demand less than 5 MW. The EDRP/ICAP participants generally subscribed to considerably larger amounts of curtailable load than ERDP-only customers of similar size, with only one exception: Customers that enrolled in both EDRP and ICAP, as

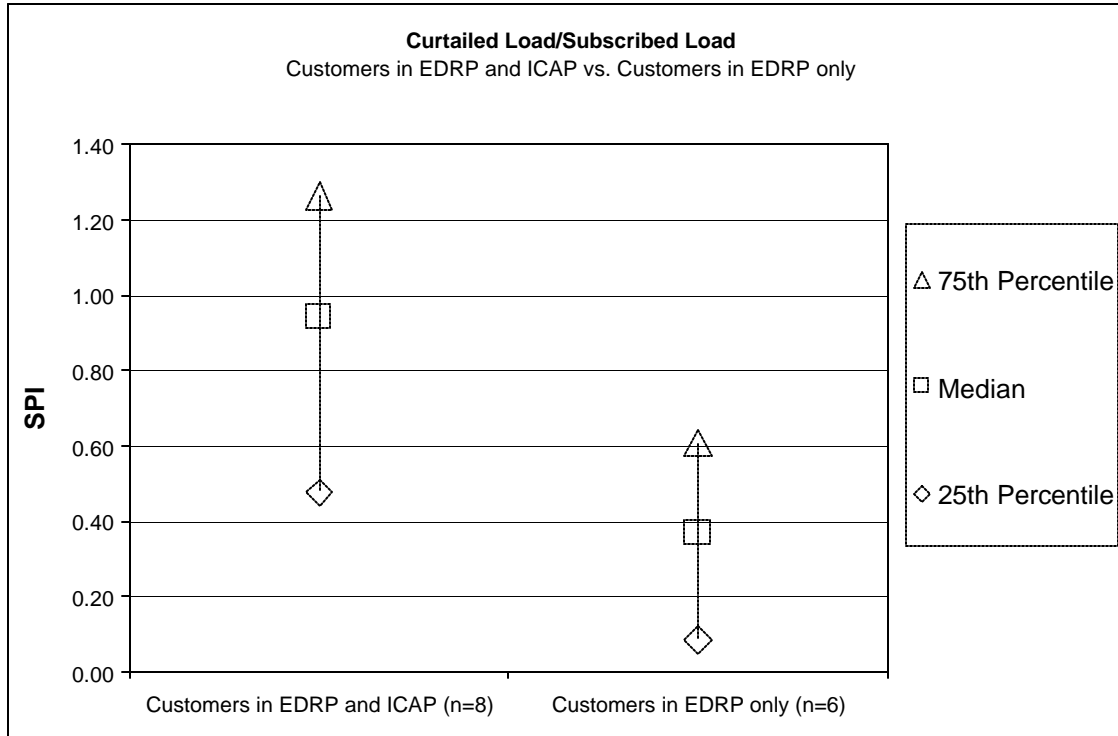
well as customers with backup generation generally met and, in some cases, exceeded their curtailment commitments



**Figure 1: Subscribed Load Curtailment Versus Facility Peak Demand**

The salutary effect that reservation payment and performance penalties have on customer performance can be seen in Figure 2. Here the results from the size 3 to 4 respondents' (depending on the customer) curtailment days were sorted by whether they participated in the ICAP. The range of performance results was plotted across these customers and curtailment, and the median and  $\pm 25^{\text{th}}$  percentile points are identified for each group as seen in Figure 2.





**Figure 2. Variation in Customer Performance in EDRP Only and EDRP/ICAP Actual Curtailed Load/Subscribed Load (SPI)**

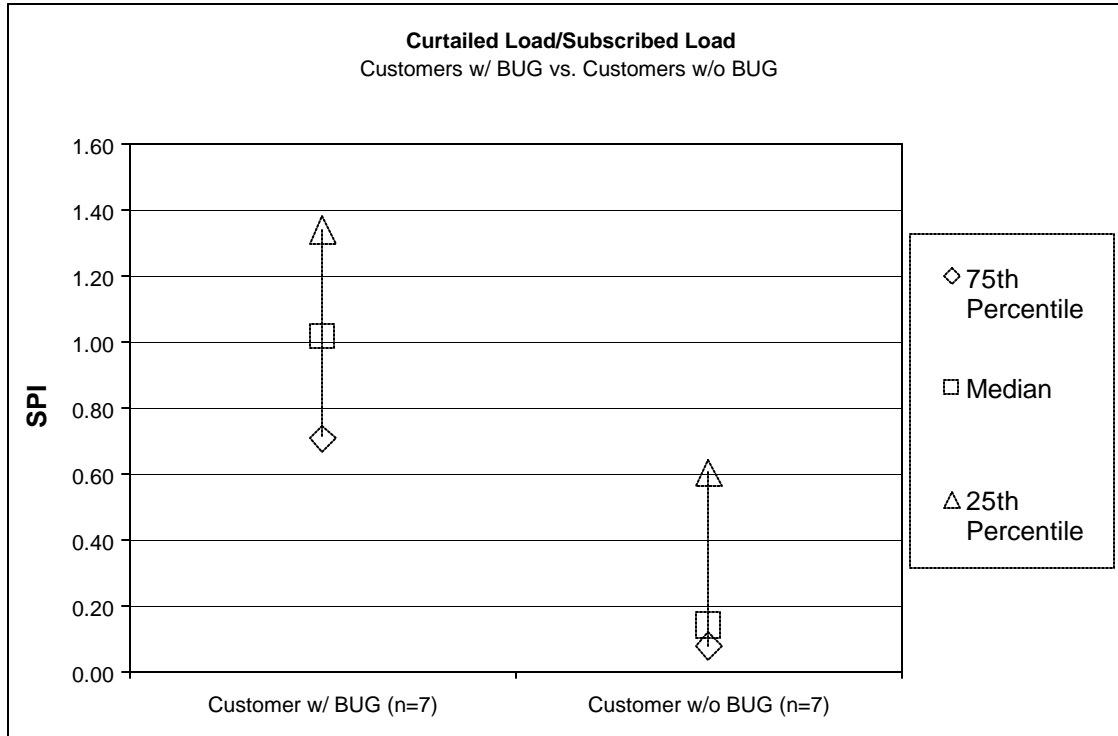
The superior performance of customers facing penalties is apparent in Figure 2. The median performance over eight respondents and four curtailment days was approximately 1.0 – their performance goal. There were some under-performers who faced penalties, but there were equally as many over-performers who curtailed with room to spare. On the other hand, median performance index values in the purely voluntary EDRP were only 35% of the curtailment goal.

Figure 3 shows a similar range of performance results for respondents with backup generators compared to those without backup generators. A similar pattern is found: customers with no backup generation fell short of their curtailment goals and, in some cases, performed very poorly. The customers with backup generators were more typically on target in terms of making their performance goals and in several cases significantly outperformed their targets.

No evidence of Customer Performance “fatigue” was found over the limited number of curtailment events in summer 2001

Some load curtailment programs (e.g., interruptible rate programs in California) have encountered problems with “customer fatigue,” when frequent or successive curtailment events have been called. In some of these programs, “customer fatigue” has deteriorated the level of aggregate load curtailment available as a function of frequency or cumulative number of events.

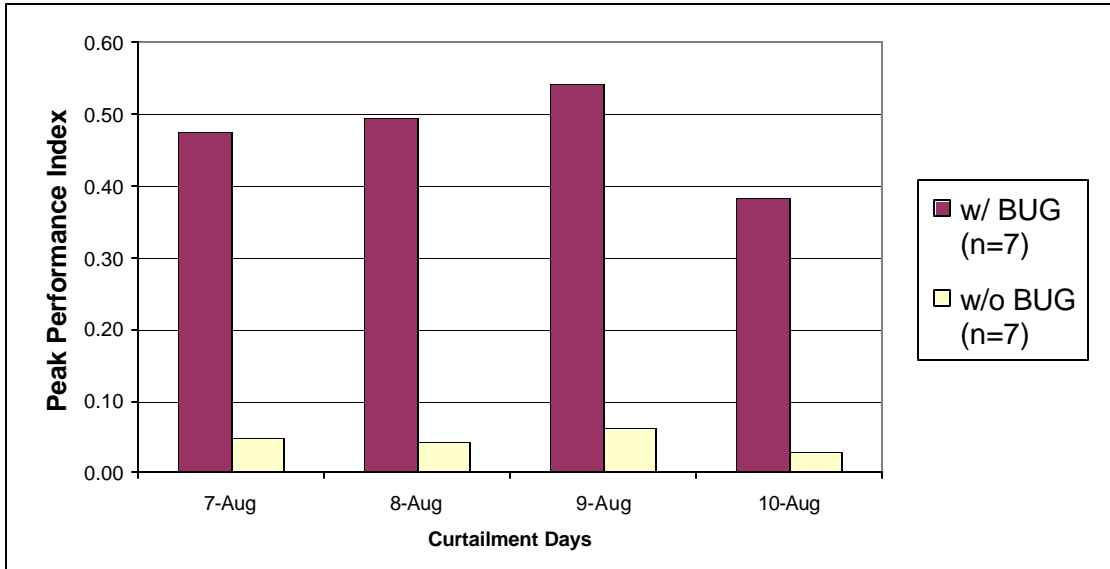
No evidence of customer fatigue was found over the period August 7-10 within the ranks of the four key subgroups in this analysis. Even though the average performance level was different in each group, that level did not appear to deteriorate during the four consecutive event days.



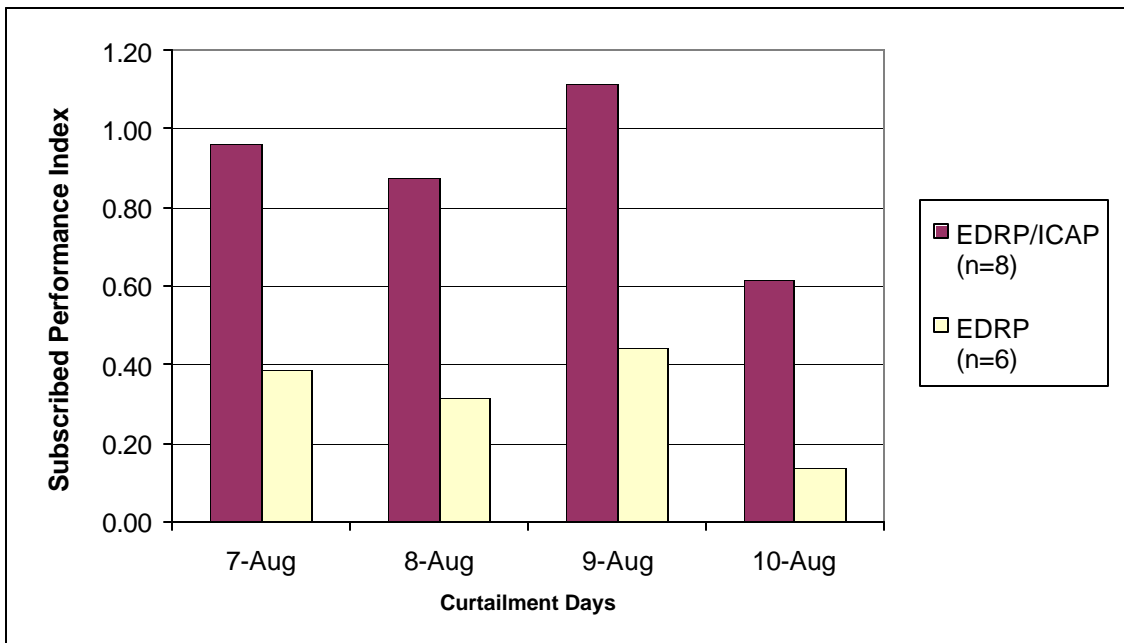
**Figure 3. Variation in Customer Performance With and Without Backup Generation: Actual Curtailed Load/Subscribed Load (SPI)**

Figures 4 and 5 depict the average performance levels of these four groups during the week of August 7-10, 2001. In Figure 4, the PPI performance parameter is used and compared the two groups of respondents (with and without backup generators). In addition to the large difference in overall performance levels, performance actually improved over the first 3 days with a small drop-off on the fourth day. Although the level of performance was much higher for the group possessing backup generators, the consistency of performance across curtailment days was similar.

Figure 5 uses the SPI performance indicator and compares the group of respondents participating in both EDRP and ICAP versus those participating only in EDRP. Given the similarity in the composition of these two groups, a similar pattern was identified. Customers that only participated in the EDRP generally performed at 30 to 40% of their curtailment goal, whereas customers on EDRP and ICAP delivered loads much closer to – and sometimes above – their curtailment goal. Within each group, however, the curtailment performance was reasonably consistent across the curtailment events, except for a drop-off on August 10. Results for August 10 cannot be directly compared to the previous 3 days, because customers in western New York were not included in the curtailment call on that particular day. We found no difference in performance based on customer motivations for joining the program.

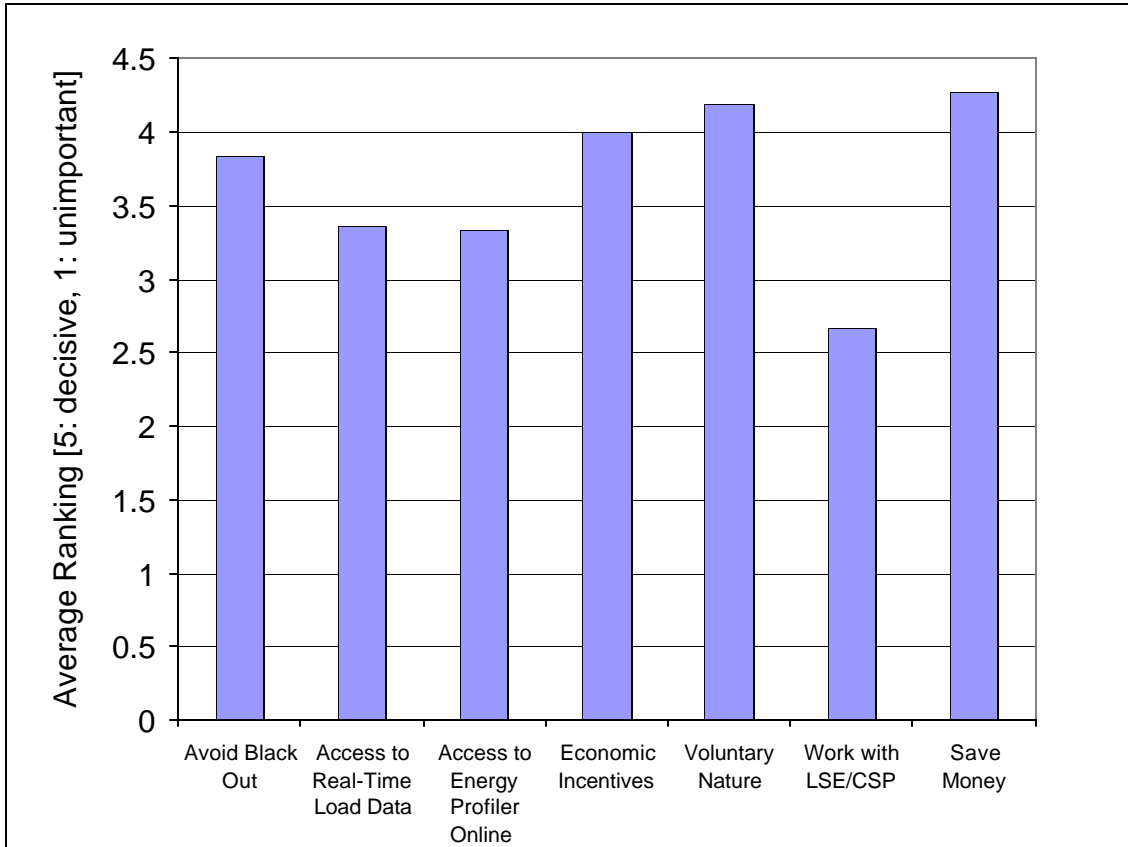


**Figure 4. Load Curtailment Potential and Persistence**



**Figure 5. Customer Performance and Persistence of Load Curtailments**

In our efforts to understand what customers valued about curtailment program design and features, several survey questions were asked regarding what motivated customers to participate in the EDRP. The average “scores” of these potential motivators, on a 1 to 5 increasing scale of importance to their decision, is shown in Figure 6 below. Not surprisingly, the overwhelming motivator to participate was “to save money.” The voluntary nature of the program was the second-most-important motivator, at least for those in the EDRP only.



**Figure 6. Customer Motivation for Signing up for EDRP (n = 12)**

An exploratory analysis was conducted to assess whether motivation correlated at all with performance levels, and no significant differences in the average scores on motivation between the four subgroups were found. Results from this small sample suggest that none of the “motivating factors to participate” deemed decisive by individual respondents seemed to be particularly correlated with either good or bad performance. Customers’ use of enabling technologies was not particularly correlated with good or bad performance or with any of the subgroups.

In addition to examining motivations for enrolling in the PRL program, respondents were asked questions about the technology features offered by their contractor and whether they used them. In particular, customers were asked how frequently they monitored their load data (for those respondents who had this feature), what type of notification they preferred, and what type of automation of load control they used.

The survey was combined with the load data and correlations between “early adoption” of technology features and customer performance were examined. Once again, no significant association between the definition of early technology adoption and individual customer performance was found. In addition, no differences in technology adoption levels across the four key subgroups were identified.

Results from our small sample suggest that other technology features (e.g., access to near-real time data, extent of automated load control strategy) were less important in impacting customer performance compared to the importance of participation in ICAP or possession of backup generation.

## Customer Surveys: Specific Findings

This section discusses specific findings based on comparative analysis of customer survey responses. The findings are discussed in the form of questions and answers, patterned after the design of the survey.

- What kind of investment did customers incur to join the programs? Did investment lead to better performance?
  - The majority of survey respondents reported overtime of staff for implementing load reduction methods and procedures.
  - Most respondents reported that it didn't take much time to familiarize themselves with the use of web-enabled tracking tools.
  - Backup generators represented a significant in-place investment because they were a central load curtailment strategy for 7 of 14 respondents. Respondents with backup generators did not report additional capital investment or costs for switchgear.
  - One customer that currently uses semi-automated energy management strategies with their building automation system reported incurring additional costs for program curtailment procedures. This customer performed fairly poorly, with a SPI of 0.07, suggesting that, at least in the first year, automated demand response strategies did not allow the customer to accurately predict their load curtailment (compared to their subscribed load).
  - Based on the small sample, it was difficult to discern much of a relationship between incremental customer investments in distributed resource (DR)-enabling technologies (over and above the funding provided by NYSERDA) and overall performance in the ERDP pilot program.
- **How did customers like certain specific design features of the program, such as web-based near-real time (e.g., day-after) access to load data?**
  - Web-based near real-time load monitoring was very useful for achieving load reduction targets and educating management.
  - Majority of respondents valued ABB's Energy Profiler Online (EPO) as a useful tool to learn load management strategies. Several facility managers reported that they experimented with various load curtailment strategies by analyzing their impact, as shown on EPO graphs. Several customers reported that the EPO graphing features provided useful visual tools for discussion of load curtailment results with upper management.
  - Customers quickly adopted the EPO technology for other uses, such as studying systems' response by turning off processes and estimating the bottom-line impact on the load.
- **Alarming and notification using alpha-numeric pagers:**
  - Pagers were valued as a useful and reliable notification means. However, several respondents indicated that redundant means of notification were valuable to ensure timely

notification (e.g., a confirming phone call by the LSE or CSP).

- Day-of-curtailment near real-time access to their load data
  - Several respondents monitored the near real-time load data and adjusted their curtailment strategies based on whether they were meeting their contractual subscribed load.
  - Extent of automated load curtailment response
  - Majority of customers curtailed load using manual approaches. Only two customers pre-programmed load reduction methods into the EMCS to be invoked when curtailment calls were received.
- **What were the major demand reduction strategies as stated by customers? What end uses were most commonly targeted?**
    - Based on customer responses, load curtailment measures were grouped into three broad strategies: backup generation only; load reduction; and load reduction and backup generation.
    - Five customers used only backup generators, while two others used both backup generators and load reduction measures. For those customers with BUG, they represented most, if not all, of the curtailment strategy. Seven customers used load reduction strategies exclusively. The most commonly reported load reduction measures were reduced lighting load by turning of banks of lights, and reduce cooling load by resetting thermostats (e.g., one participant used absorption cooling switching from electricity to steam). Other load reduction strategies focused on facility specific large individual loads, such as air compressors and large pumps.
    - Customer satisfaction with the program? Participation plans for next year? Were the occupants an impediment to load curtailment or a part of the solution?
    - Customers reported high enthusiasm for participating in next year's PRL programs. Customers with backup generators impacted their facility occupants minimally.
    - For customers that relied on load reductions only, occupants did not complain about thermal comfort and loss of productivity as long as there was appropriate notification. Several facilities requested active participation by occupants to improve curtailment performance (e.g., occupants turn off lights and shut off non-essential equipment). Several customers reported that they incentivized occupants to participate in curtailments.

## 5. Conclusions and Recommendations

The following conclusions and recommendations are offered based on our case study of 14 customers that worked with three contractors participating in the NYISO EDRP.

- Two indicators were developed: the subscribed performance index (SPI) and the peak performance index (PPI), in order to facilitate comparison of performance among customers or between customer groupings. The SPI is a ratio of the customer's actual curtailed load averaged over all hours of curtailment events divided by the customer's subscribed load. The PPI is the same ratio of actual curtailed load averaged over all hours of curtailment divided by the customer's non-coincident facility peak demand and provides an indicator of performance relative to the customer's technical potential for load curtailment.
- For those customers with backup generators, use of BUG represented their primary curtailment strategy. The seven customers with backup generators seemed confident in setting demand reduction goals at or around the size of their generators, and their actual curtailed load represented about 46% of their non-coincident facility peak demand [see Table 3]. Moreover, customers with BUG often over-performed during curtailments, consistently cutting their load by more than their initial contracted goals (as indicated by an average SPI of 1.04; see Table 3).
- The seven customers that relied on load reductions only to curtail load typically used a variety of conservation and operational strategies (e.g., turning off lights, resetting thermostats, reducing pump and compressor loads). Their pledged curtailment as a fraction of facility peak demand was low, averaging 5% over our sample.
- Performance of individual customers in the EDRP also appears to be driven by their participation in the existing load management program (ICAP/SCR). The combination of another incentive stream, in the form of capacity reservation payments, coupled with substantial penalties for non-compliance led the eight customers that participated in both the EDRP and ICAP programs to meet their subscribed load goals during the four curtailment events (e.g., SPI of 0.92).
- From the perspective of a NYISO system planner that is concerned about the predictability and reliability of emergency demand response programs, our results suggest that customer participation in an ICAP-type program is likely to increase the probability that customers enrolled in an emergency-type program will actually curtail their subscribed load during curtailment events. Our finding that 8 customers that participated in both EDRP and ICAP had superior performance compared to the 6 customers that enrolled in EDRP only should be tested over the entire sample of 292 EDRP participants. Such analysis could improve the ability of NYISO to accurately forecast customer's actual load reductions during curtailment events compared to their subscribed load.
- A major objective of this work was to assess the impact of enabling technologies on customer's demand response capability and performance. In our small sample, we found that web-based near real-time load monitoring was very useful for achieving load reduction targets and educating management; some customers have quickly adopted the technology for other energy management uses (e.g., turning off various processes to see the impact on overall load); the installed base of backup generation provides an important load curtailment resource; and almost all customers relied on manual approaches to respond to curtailment events, rather than automated response.

- Customers indicated that the primary motivators for working with the contractors and participating in the EDRP were: saving money on their utility bill; access to economic incentives offered by the program; the fact that program participation was voluntary; and that they retained control regarding decisions on whether and how much load to curtail.
- Given the fact that the NYISO programs are relatively new and that it takes users some period of time to realize the full benefits of adopting innovative demand-response technologies, we recommend that NYSERDA consider additional evaluation/case studies to document other benefits (besides load curtailment capability) that customers receive from enabling technologies supported in the Peak Load Reduction Program, and develop a more robust understanding of relationships between adoption of enabling technologies, performance of customers individually in curtailing load, and the influence of other confounding factors (e.g., participation in other programs, such as ICAP/SCR).