Participation of Demand Response Resources in ISO New England's Ancillary Service Markets

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Abstract

The participation of demand response resources in Ancillary Service Markets (ASM) is a recent development. Proponents characterize this new opportunity as a win-win situation for both the Independent System Operators (ISO) and demand response (DR) resources. Others question whether smaller DR resources will choose to participate given technology requirements and whether they can successfully deliver on commitments to the ISO. This paper addresses these questions using data from the evaluation of the Demand Response Reserves Pilot Program (DRRP) at ISO New England. First, we provide a brief background on the Ancillary Service Market. We describe the roles of the market and of traditional generation. Second, we introduce the ISO New England's Demand Response Reserves Pilot. This includes: (a) a brief outline of the program structure including: data requirements, the Internet Based Communication System Open Solution (IBCS OS), and program incentives, and (b) summary descriptions about the assets enrolled in the DRRP. Third, we describe the evaluation tools that were designed for this program. These tools range form event-specific reports produced shortly after each event to customer logs and surveys. Last, we provide findings from the October 2006 – May 2007 performance period. These findings include a range of asset load relief performance metrics as well as metrics associated with delivery of the program. These findings motivate preliminary conclusions with regards to the potential for DR in the Ancillary Service Market.

Introduction

The peak load reduction afforded by a successful DR program is one way of maintaining healthy reserve margins under difficult system conditions. More recently, DR programs have been identified as potential contributors to another key aspect of system reliability, Ancillary Services. Ancillary Services provide the on-call, short-term relief that maintain system supply in the event of a loss of generation or transmission resources. If DR resources can be successfully utilized to provide Ancillary Services, the result will be a win-win situation for both the system operator and the providers of DR resources. The system operator will have increased flexibility maintaining reliability requirements, and DR providers will have additional opportunities to sell their services. That said, the inclusion of DR resources in the ASM involves a number of challenges.

As of 2004, the ongoing development of the ISO-NE ASM opened up the potential for DR program participation. However, like most market systems, the rules for the market are generally developed around the predominant technology. As a result, the market rules defining participation in ASM have been traditionally geared toward the classic generator. If a resource can effectively act like a generator, be dispatched like a generator, and be settled like a generator, then that resource is considered an acceptable participant in the ASM. DR and small generation resources under 5 MW, however, differ from traditional generation resources on many counts.

As DR resources are considered for the traditionally generator-only ASM a variety of issues arise:

- Are DR and small generation resources under 5 MW available at any time?

- Can they provide sufficient response?
- How quickly can they respond?
- Can the response be sustained?
- Can the resource be monitored in real-time in a cost effective manner?

The Demand Response Reserves Pilot Program

The DRRP was established with the primary goal of demonstrating the effectiveness of DR resources with respect to ASM. In its pilot form, the program allows DR resources to establish their value to the capacity and reserves market without fully participating in these markets. Ultimately, the DRRP program is a transitional tool to a pure market-based approach.

The DRRP program started with the winter session (October 2006-May 2007) and is scheduled to run for one year, divided in two sessions, each with approximately 21 scheduled pilot activations (“events”). Events take place between 7 AM and 6 PM and last 30 to 60 minutes. Less than half an hour of warning is generally given prior to the start of an event. Participants include convenience stores, big box stores, educational institutions and a range of industrial and manufacturing businesses.

The DRRP program had 48 active assets[1] during the winter of 2006/2007. Forty-seven of these assets provided resources to the program through some form of demand response and one was a small generator, under 5 MW. These 47 DR assets committed to supplying between 86 kW and 5 MW of demand response. Half of the assets committed to 100 kW or less of load reduction. During the winter session, total commitment was 19.9 MW.

The DRRP program started its summer session on June 1st 2007. A total of 92 assets are participating in the summer session; 88 DR resources, two generators and two demand aggregated residential air conditioning programs. Only four of the assets enrolled in the winter session opted out of the program. The range of committed response for the summer session is 100 kW to 5 MW with fully 73 percent committing at the 100 kW level. The summer session the total commitment is 49.3 MW.

As a necessary condition to evaluating the effectiveness of DR resources in the ASM context, the metering and communication process to provide real-time monitoring had to be established. This requires a telemetry alternative functionally equivalent to the near real-time SCADA (Supervisory Control And Data Acquisition)[2] connection with generators, that is: (a) cost-effective to small assets; (b) consistent with NERC (North American Electric Reliability Counsel)[3] regional reliability requirements; and (c) meeting the system operators’ needs. In the case of ISO-NE, the initial telemetry alternative for demand response resources is the IBCS OS (Internet Based Communication System Open Solution). The IBCS OS acts as a gateway that

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[1] An asset in Demand Response represents the registered resource. It can represent an educational facility with a combined heat and power facility whose output can be increased above normal operation to reduce the demand on the system or a manufacturing facility that has agreed to stop a specific operation (such as shredding metal). By contrast, an asset can be 3,000 individual residential central air conditioning units that are controlled by a Demand Response Provider upon ISO New England control instructions.

[2] The analog power system data shall be made available to the local communications network processor within ten (10) seconds of a change in data at a RTU (Remote Terminal Unit). This data requirement recognizes the change detect logic employed by some RTU’s in that the data is telemetered to the SCADA system only after a change is detected by the RTU, and that the amount of change may be different for each point in an RTU.

[3] NERC’s mission is to improve the reliability and security of the bulk power system in North America. To achieve that, NERC develops and enforces reliability standards; monitors the bulk power system; assesses future adequacy; audits owners, operators, and users for preparedness; and educates and trains industry personnel. NERC is a self-regulatory organization that relies on the diverse and collective expertise of industry participants. As the Electric Reliability Organization, NERC is subject to audit by the U.S. Federal Energy Regulatory Commission and governmental authorities in Canada.

conveys transmissions of five-minute data back to the system operator. It is the lynchpin in the system designed to facilitate cost-effective monitoring of DR resources through a series of service providers.

The assets had to commit to a level of load reduction prior to the start of the program. They are measured against this benchmark for the purposes of settlement. The DRRP program rewards participation with a number of different payments. Capacity payments are based on performance during the most recent system reliability event. Availability payments are based on previous DRRP event performance and the forward reserve market-clearing price. Performance payment is an energy-based payment calculated using actual event performance and the maximum of the forward reserve strike price or real-time LMP in the load zone. In addition to the payments, the asset is penalized for failure to provide the committed level of load reduction. The penalty is also calculated at the same price as performance payment. That is, at 50 percent of commitment the performance payment is fully offset by the corresponding penalty.

The ISO-NE retained KEMA, Incorporated to provide technical support with various aspects of the DRRP.

Evaluation Tools

ISO-NE is utilizing a range of tools with which to monitor and evaluate the DRRP program. These include:

- Event Reports – Event day-specific results provided within a few days of each event
- Data quality monitoring – Monthly reports on the quality of the data provided by assets
- Data upload monitoring – Monthly reports on data updates through settlement
- Customer logs – Excel spreadsheets used by participating assets to report on event-specific conditions, such as time at which they were notified of the event and actions taken to respond to it
- Customer survey – Detailed survey administered online once during each session, designed to obtain detailed asset information on pilot participation
- Quarterly Reports – A summary of the results from the event and monthly reports along with a summary of logs provided by the participating assets and IBCS providers.

Of all the tools developed, the Event Report provides the most direct and accessible illustration of the program. An overview of the event report is provided in this section.

Event Reports

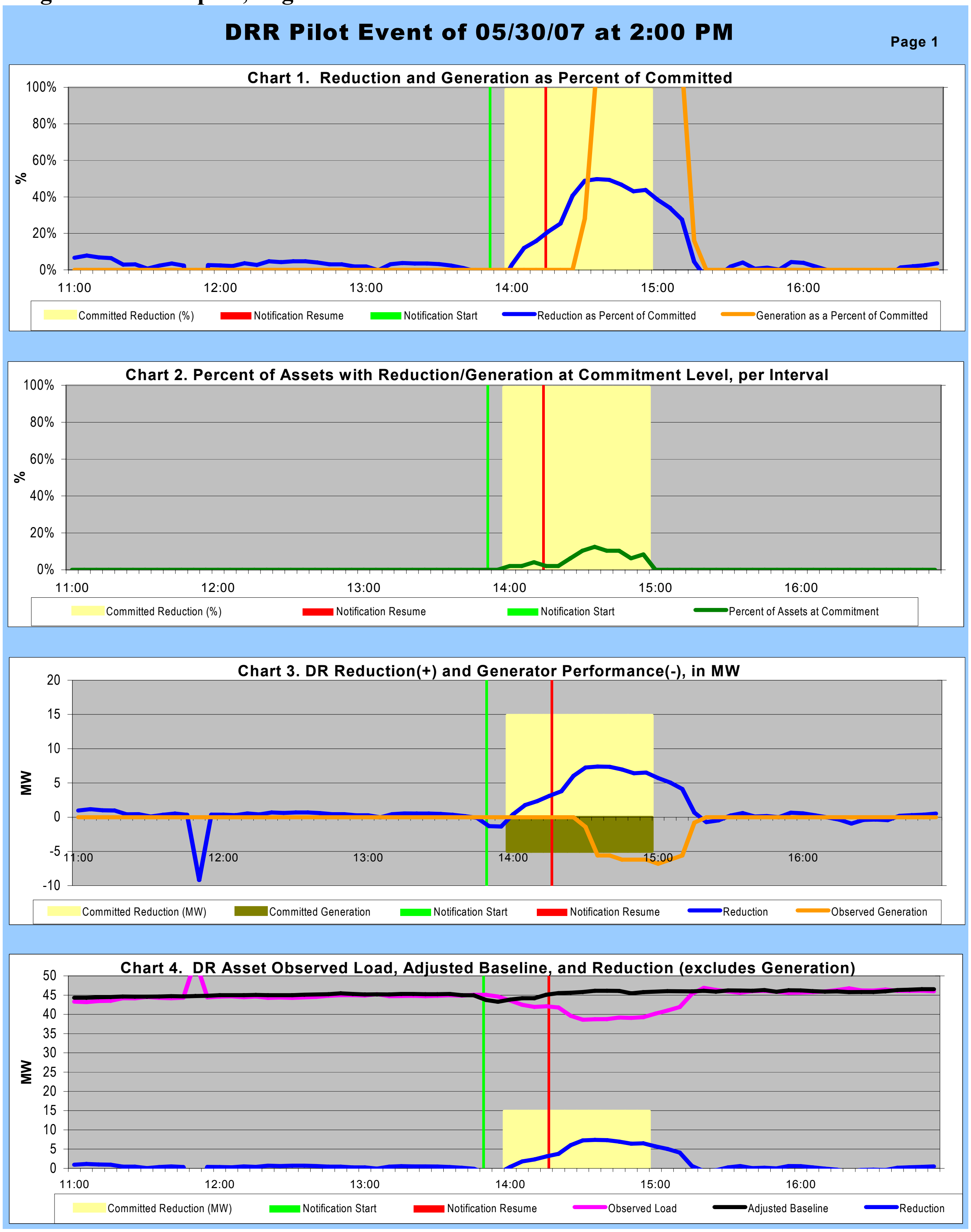
The Event Report was designed to provide ISO-NE staff timely and accessible feedback on event performance. The Event Report includes three facets:

- A summary of program performance for the event,
- A cumulative summary of average event performance through the current event, and
- Access to asset-level data, at both the aggregate event level and the five-minute data.

The event reports are in spreadsheet format. Below are descriptions and illustrations of three of the pages of these reports.

Figure 1 provides the graphical presentation from the first worksheet of the Event Report. The page presents four graphs each using program level, five-minute data to illustrate a different aspect of program performance for that event. Chart 1 in Figure 1 presents program level results, broken into load-reduction resources and generation resources, as a percentage of committed reduction. For each

Figure 1
ISO-New England Demand Response Reserves Pilot
Program Event Report, Page 1



five-minute interval the aggregate reduction or generation is reported as a percentage of the relevant committed reduction. A central column (yellow block) represents the event period. Narrow columns indicate the time of notification for the start of the event (green line) and time of the notification to resume normal functions (red line.)

From this first chart, the viewer can ascertain many details regarding the outcome of the event: the level of reduction/generation, the ability to sustain that level through the event, and the speed with which the program reaches the maximum levels of reduction/generation and returns to normal function. Plotting the load reduction assets side by side with the small generators facilitates a comparison with the performance of the two kinds of demand response.

Chart 1 for May 30th, 2007 shows the assets had less than 15 minutes warning before the start of the event. The DR resources started reducing load immediately during the event period while the generation resource only started providing supply almost half way through the event. With regard to maximum contribution, however, the generation resource supplied more than the committed level while the combined DR resources barely reached 50 percent of commitment. Despite approximately 45 minutes warning prior to the event finish, both DR and generation resources took 20 minutes to return to baseline levels. While the event report is particularly suited for comparing DR and small generator performance, in this case it is important to remember that only one generator participated in the winter session. The relative characteristics of the DR and generator performance levels are in part a function of aggregation or lack thereof.

Chart 2 in Figure 1 provides information on individual asset performance. It shows the percent of assets with reduction or generation at or above their individual level of commitment. It tracks the percent of assets at commitment at each five-minute interval through the event. Chart 2 for May 30th , 2007 shows that overall very few assets reached their commitment level. The chart also reveals that one asset is at its commitment level within five minutes of the start of the event and as many as six assets are at commitment level at the peak of the event.

Chart 3 mirrors Chart 1, presenting program level five-minute results in terms of reduction or generation magnitude. In addition to the event period and notification times, the magnitude of the commitment is visually indicated by the height of the large column. Chart 3 for May 30th , 2007 offers the same insights as Chart 1 with the additional benefit of seeing the two types of assets compared in the same scale. The single small generator, at or above its commitment, provides a similar level of resource as the aggregated DR resources.

The final graph on Figure 1 shows the aggregate DR assets' load and baseline through the event period. This chart gives an overall indication of how well the aggregate baseline matches pre-event load. It also gives an indication of the magnitude of commitment relative to baseline load. The winter session showed commitment levels approaching 50 percent of baseline load. Chart 4 for May 30th , 2007 provides an illustration of DR load commitment and reduction relative to customer baseline for that day. DR resources committed approximately 33 percent of baseline load and delivered on about half of that.

Figure 2 provides the charts from page three of the Event Report. These four charts parallel the charts on Figure 1 but report cumulative results through the date of the current event. Chart 5 gives the event level reduction and generation as a percent of resource commitment. The column indicates the magnitude of the commitment. The results, shown here for late in the winter session, illustrate the performance of DR assets and small generation through the full winter period. The DR asset reduction consistently falls between 25 and 50 percent of committed reduction. Small generation resources are more consistently above 75 percent of committed levels. Small generators appear to have more variability in load levels, but this is once again because there is only one generator resource. Regarding the apparent variability of small generator load Charts 1 and 5 combine to provide clues related to performance level.

Generator performance appears to be a function of timing. The relatively late start for the May 30th event dooms the average event generator load to a low percentage of commitment.

Figure 2.
ISO-New England Demand Response Reserves Pilot
DRRP Program Event Report, Page 3

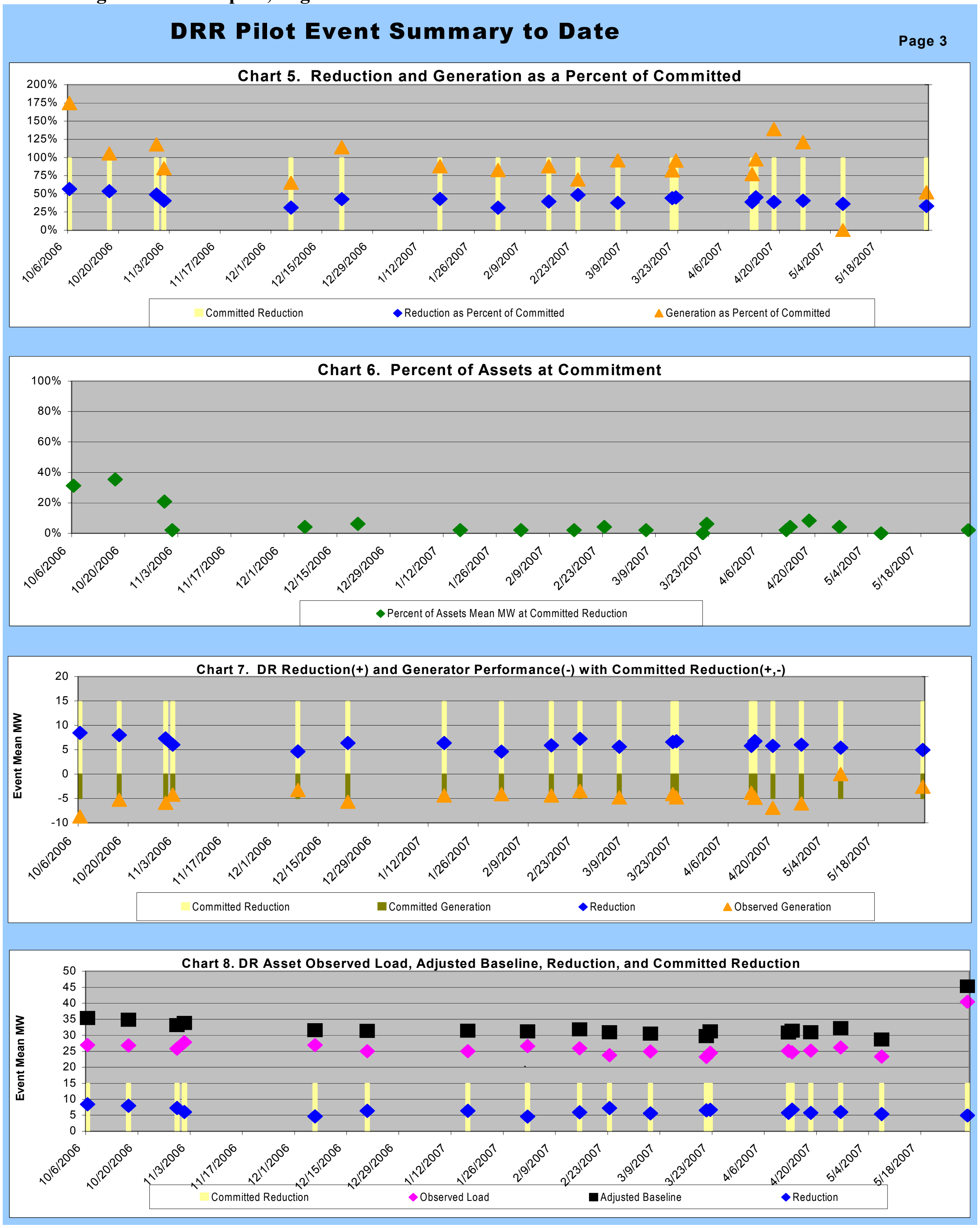
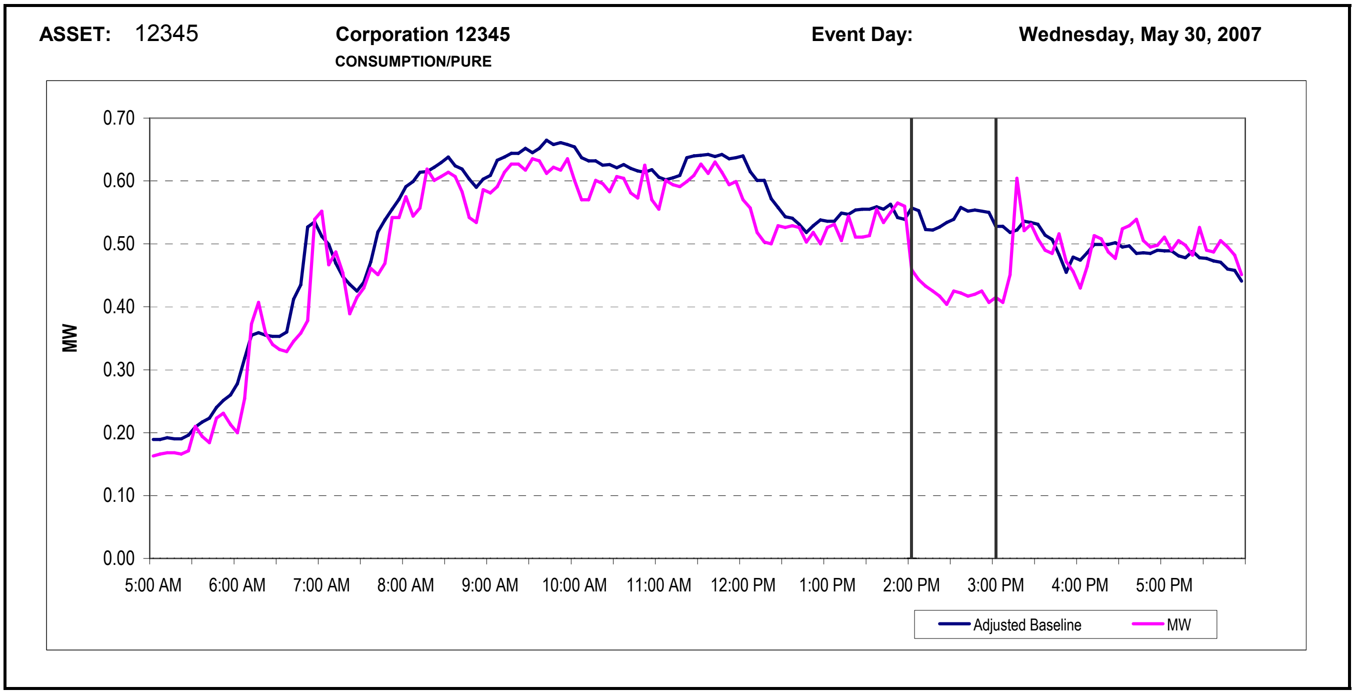


Chart 6 in Figure 2, parallels with Chart 2 in Figure 1, and tracks the percentage of assets at commitment level through the winter session. The graph shows that after early events when more than 20 percent of assets were at commitment level for the event, the percent dropped below ten percent consistently for the remainder of the session.

Charts 7 and 8 provide the cumulative results paralleling charts 3 and 4. Chart 7 provides reduction and generation magnitudes through the winter session. Chart 8 shows baseline and observed load through the winter session. This chart shows a substantial increase in baseline load for the May 30th event. Despite this, the load reduction remained, consistent with previous events, well below commitment levels.

Figure 3 shows page five of the event report, which provides asset-level data in graphical form. The page includes a toggle that allows the viewer to scroll through the assets, looking at individual asset baseline and observed loads.

Figure 3. DRRP Event Report, Page 5



DRRP Winter Session Preliminary Results

The DRRP Winter session ran from October 2006 through May 2007. Highlights of this session include the following:

- Enrolled assets committed 19.9 MW of load relief (14.9 MW of load reduction and 5 MW of generation). Figures 4 and 5 illustrate the composition of achieved load relief as a percentage of committed load relief: Load relief ranged from a high of 17.2 MW (86% of commitment, in the first event of the Pilot) to a low of 5.4 MW (27% of commitment, in an event in May[4]). Average performance was 55% of commitment.

[4] When this paper was written, DRRP data for April and May was not final yet. As such, these results may not reflect final DRRP event results for some of the days included in this publication.

Figure 4. DRRP Achieved Load Relief as a Percentage of Committed Load Relief

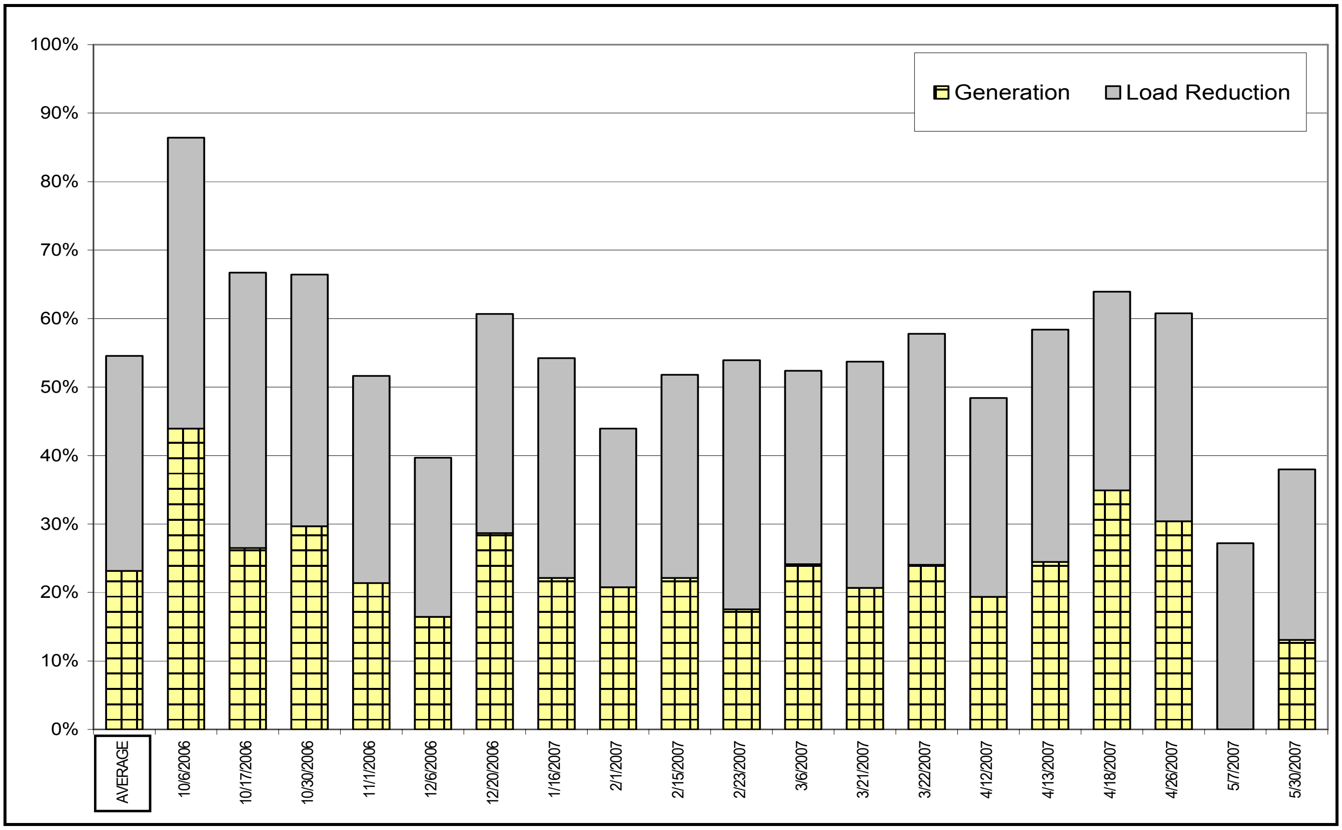
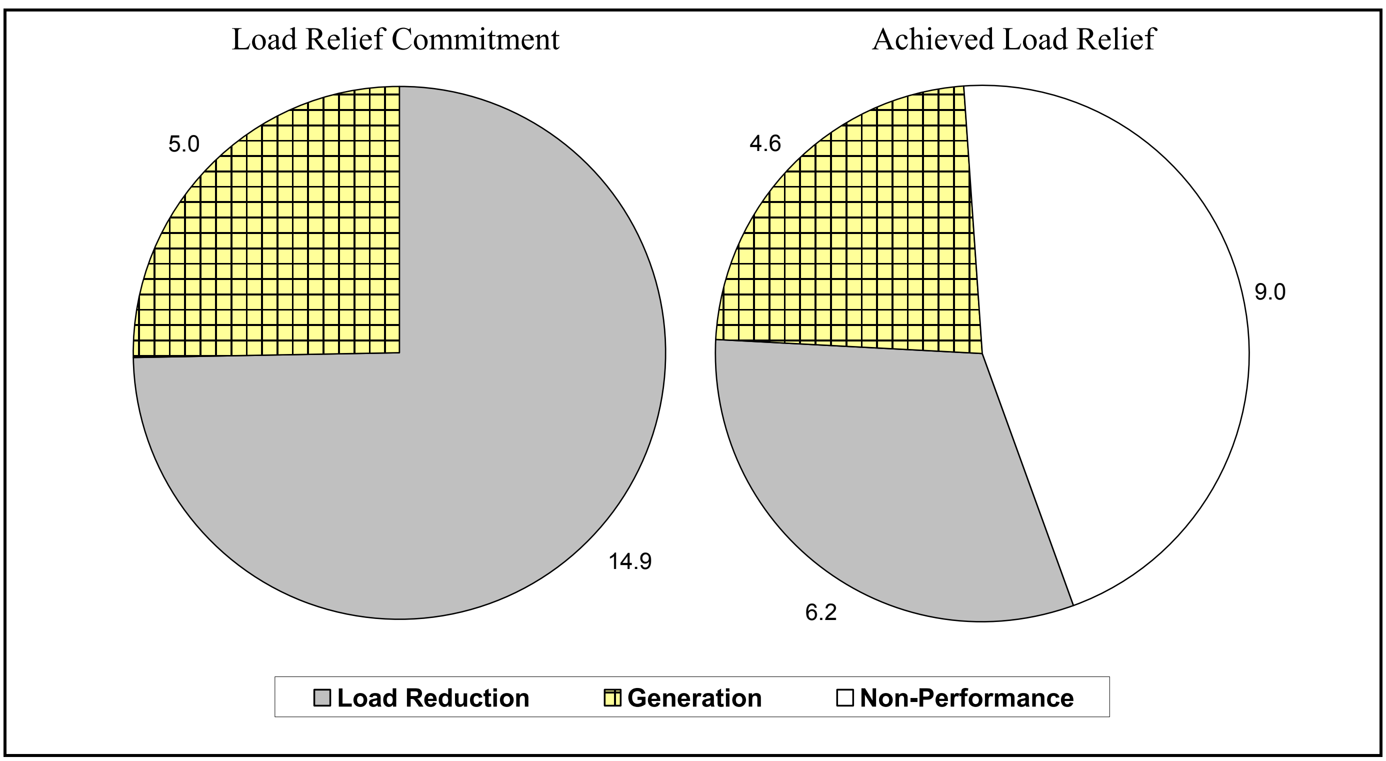


Figure 5. DRRP Load Relief Commitment Vs Achieved Load Relief (MW) Oct 2006 to May 2007



- Observed load reduction was statistically significant in all events[5]
- Actual performance compared to committed load reduction is difficult to forecast over a long winter season (eight calendar months).
    - Winter season weather ranges from days as hot as any summer day to a January cold snap.
    - Estimating performance based on a different measure may account for some of the variance

Statistical Significance of DRRP Load Reductions

A statistical significance test was designed to assess whether measured load reductions were different from what is expected from natural load variability of the participating assets.

For load reduction resources, demand response provided by program assets is measured as a load reduction with respect to a baseline. This baseline is calculated based on past load and serves as an estimate of what the load would have been at the time of the event if the demand response event had not been called. In simple terms, the customer baseline (CB) is an ongoing weighted average, for each five-minute interval, of non-event, business day loads. The CB is adjusted, if necessary, using the previous two hours of data. The calculated adjusted CB diverges from observed load according to the natural variability of load in the absence of an event. The statistical significance test measures the probability that observed load reductions happened as a result of the DRRP event, and not due to baseline error – the difference between the baseline and the actual load.

For generation assets, demand response is simply the positive generation during the event. Because we assume that these assets do not run in the absence of an event, the baseline condition for generation assets is known with certainty to be zero. There is therefore no question but that whatever positive generation is observed is in response to the event. For this reason, we exclude the generator from our tests.

The statistical significance of the load reduction provided by pilot assets was tested in the following manner:

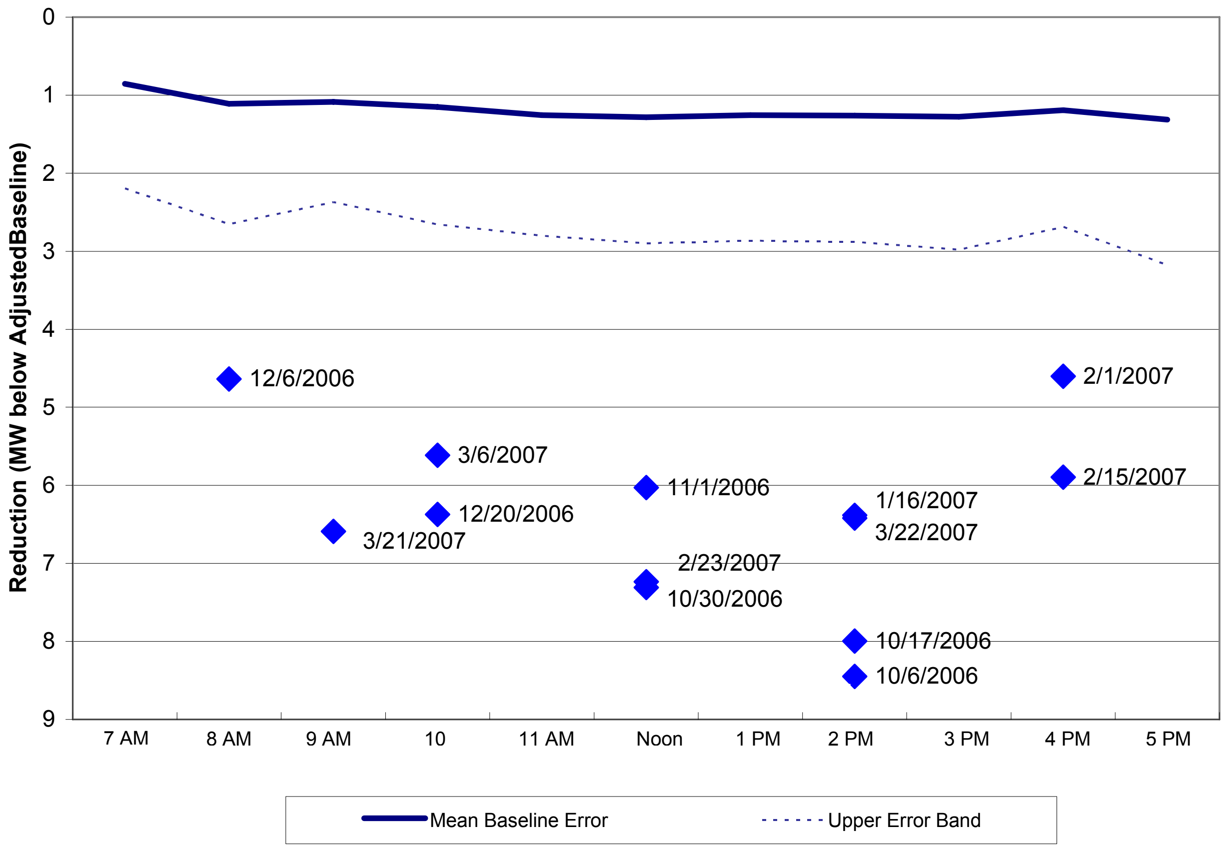
- For each DR resource and all actual or potential event hours, use the ISO-NE baseline and baseline adjustment formula to calculate the adjusted CB_{dh}, where d is day and h is hour.
- Use this calculated adjusted CB_{dh} and observed load L_{dh} to calculate ΔL_{dh}.
- Use only non-Event days to calculate the mean and variance of ΔL_{dh} across days d.
- Using this calculated variance, calculate the 95% confidence lower bound for ΔL_{dh} in the absence of an Event. This is a measure of the natural range of variation in the difference between the adjusted CB and the observed load.
- For each Event period, the observed load reduction is considered statistically significant at the 95% confidence (5% significance) level if the event ΔL_h is outside the 95% confidence bound, ΔL_{LO}.

Figure 6 illustrates the mean baseline error, $\Delta L_{.h}$, the corresponding uncertainty bound ΔL_{LO}, and DRRP event performance in the first and second quarters. All load reductions fall outside of the uncertainty band. This result leads us to conclude that asset loads during Pilot events were statistically significantly lower than the baseline. That is, the reductions were statistically significantly greater than zero[6].

[5] Generation is not subject to a statistical significance test. See the following section for more information.

[6] Mean baseline error is positive because the baseline adjustment formula is not symmetrical. The baseline is only adjusted if the average pre-event baseline is less than the average pre-event observed load.

Figure 6
ISO-New England Demand Response Reserves Pilot
Statistical Significance of Observed Load Reductions (October 2006 to March 2007)



DRRP Performance Comparison to Generation Resources

As the ASM is traditionally a generator market, an important benchmark for the DRRP program is the equivalent of generator performance. NERC reports generator performance statistics in its Generating Availability Data System (GADS) that can be used to benchmark DRRP performance. For the purposes of this comparison, ISO-New England uses the following indicators:

•Net Output Factor (NOF) -- Net Output Factor is program level load reduction as a percentage of committed reduction, calculated as follows:

$$\sum_{a\in A}\sum_{h\in E}\Delta L_{ah} \Big/ n_E C_A$$

where A is all assets, E is Event hours, n_E is the number of event hours and C_A is the commited load reduction for assets A.

•Starting Reliability (SR) -- Starting Reliability is the percentage of asset/events where reduction is "started", defined as an event where the percentage of committed reduction was greater than 10%

Table 1 compares these indicators for DRRP Assets and NERC generator data for diesel generators, and small gas turbines, and all gas turbines. DRRP Assets performed at levels similar to small gas turbines during the first quarter. During the second quarter, DRRP assets experienced a reduction in performance as measured by these factors.

Table 1
ISO-New England Demand Response Reserves Pilot
Comparison to Generation Resources

Unit Statistic	DRRP Assets			NERC Generating Availability Data		
				Diesel	Gas Turbine	
	Q1	Q2	YTD	All Sizes	1-19 MW	All Sizes
Starting Reliability	91%	86%	88%	98%	91%	97%
Net Output Factor	59%	46%	52%	67%	60%	70%

NERC data source: Generating Unit Statistical Brochure – 2005 Only. November, 2006. http://www.nerc.com/~filez/gus.html

Preliminary Findings

The introduction raised a number of issues that need to be considered as small DR resources are considered for the ASM. The data collected during the first winter session of the DRRP allows us to make some preliminary conclusions with respect to these questions.

- **Are DR resources available at any time?** Availability is a function of many variables. This pilot is focusing on time of day and weather as drivers in asset availability. The analysis of drivers of event performance, including weather and time of day, has not yet been completed. It is possible, however, to draw some tentative conclusions from the data we have. Through the winter session, ISO-NE initiated events between 8 AM and 5 PM. DR assets responded consistently across the range of event start times. There is no obvious pattern in the variation in performance across events. During the winter session, the majority of DR actions consisted of lighting-related curtailments. This suggests that limitations to the ability to respond during business hours could be related to darkness or overcast weather. During the summer session it is expected some load response will be provided through air conditioning control. We will test for a correlation between load response and weather variables.
- **Can they provide sufficient response?** DRRP assets provided a reasonably consistent level of response through the winter session. With experience in gauging potential response levels, it is reasonable to expect assets to be able to reach a predictable fraction of their committed levels of load reduction. From the system perspective, aggregation is the solution to the question of "sufficient response," though there is a practical lower limit to per-unit contributions. Similarly, there is the question whether assets can provide sufficient response to make it cost-effective for them to participate in the program.

- **How quickly can they respond?** In theory, DR resources have the potential to respond to an event announcement as quickly as any generator could be activated. The DRRP program is testing the actual performance of a large group of assets activated through the IBCS OS. Timely response to an event includes event notification (a process that starts at the IBCS OS and goes through the assets' IBCS service provider), initiation of response (receipt of notification and commencement of response activities) and full expression of response activities. The winter session illustrated that the majority of assets were able to respond within 30 minutes. Furthermore, perusal of individual asset load responses illustrates that many assets can provide almost immediate response.
- **Can the response be maintained?** The ASM requires a consistent response level for a specific period of time. The DRRP assets, in aggregate, maintained a consistent level of response from the point of maximum response to the end of the event period. Given the length of events (one hour or less) and the time to maximum response (up to 30 minutes), the response level was only maintained for approximately 30 minutes or less.
- **Can the resource be monitored in real-time in a cost effective manner?** This question has only been assessed qualitatively. It must be answered separately from the perspective of participating assets and ISO-NE. The participation of assets in the program is an indication that the present program design offers potential benefits from the asset perspective. Furthermore, substantially more assets are signed up for the summer session than participated in the winter session while only a few assets opted to leave the program after the winter session. Ultimately, only long-range experience will determine the level of participation of small DR resources in this kind of program. It would appear, however, that the metering and communications structure that has been developed by ISO-NE is not a major barrier to the participation of these kinds of assets in the ASM.

  From the perspective of ISO-NE, the metering and communication system must allow system operators the ability to monitor program performance in near real-time and provide settlement quality data. The system has successfully maintained the program for over six months. The monitoring of data quality and data upload practices is essential for better understanding of the practical workings of the communication system. The final implementation must incorporate the dispatch mechanism into the ISO-NE existing dispatching software. Presently, the IBCS OS is a stand-alone system, which requires the system operator to activate DR resources separately from the normal dispatch process.

The first year of the DRRP program concludes in October, 2007. ISO-NE has the option to continue the program in it present form for another year, or terminate the program ending the experiment with DR loads in the ASM. This decision to continue the experiment for a second year must be made by August, 2007.

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