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Demand Response Providing Ancillary Services with Direct-to-NYISO Connectivity

Final Report

July 2015

Report Number 15-20

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Demand Response Providing Ancillary Services with Direct-to-NYISO Connectivity

Final Report

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Abstract

The purpose of this project was to develop and test technology and practices that would stimulate participation in the New York Independent System Operator's (NYISO) Demand-Side Ancillary Services Program (DSASP). DSASP was a relatively new Fast Demand Response program created in 2008 by the NYISO in response to directives from the Federal Energy Regulatory Commission. As of 2011, no demand-side ancillary services had successfully registered and performed in the program.

The project's main objective was to demonstrate successful participation of a large New York State industrial load providing DSASP 10-minute synchronized reserve in direct-to-ISO configuration. To accomplish that objective, it would be necessary to (a) implement secure, instantaneous communication between the NYISO's control center and the participating load resource at the customer's site and (b) create a methodology to assess risk and derive an optimal plan for resource participation in DSASP.

The objectives were realized with the registration and ongoing participation of the initial resource, Globe Metallurgical, since 2013. As pioneers in this program, the team encountered a number of unanticipated issues and indefinite procedures some of which were resolved in consultation with NYISO and others mentioned herein as recommendations and observations.

Keywords

Demand response, electrical grid, ancillary services, load shedding, smart grid, Fast DR, DSASP, NYISO

Acknowledgements

We would like to extend our gratitude to Globe Metallurgical, Inc. for their successful participation as the first demand response resource enrolled in the NYISO's Demand–Side Ancillary Services Program (DSASP). A special thank you to Globe Metallurgical's Russ Lang, Corporate Energy Manager, as well as the operators, engineers, and management team of their Niagara Falls, NY, plant for their support of this pioneering project.

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Executive Summary

The overall purpose of this project was to develop and test technology and practices that would stimulate participation in NYISO's Demand-Side Ancillary Services Program (DSASP), a "Fast Demand Response" program for which no participants had successfully registered and operated as of 2011.

Successful participation in DSASP would prove that a demand response resource could perform as well as a generator while adhering to the same stringent, real-time telemetry and infrastructural requirements. The project team, Demand Response Partners and SmartCloud, met that challenge and discovered in the process that equal performance did not guarantee market compensation equal with generators.

The project had three main objectives:

1. Ensure secure, direct communication between the NYISO control center and the participating load resource at the customer's site.
2. Establish a methodology to assess risk and derive an optimal plan for resource participation in DSASP.
3. Demonstrate successful participation of a large NYS industrial load providing DSASP 10-minute synchronized reserve in direct-to-ISO configuration.

The objectives were realized with the registration and successful participation of the initial resource, Globe Metallurgical for more than a year in the 2013-2014 demonstration stage of the project. As pioneers in this program, the team encountered a number of unanticipated issues and indefinite procedures some of which were resolved in consultation with NYISO and others proffered as recommendations or observations.

Major results of the project were:

1. Design, development, testing and validation of a low-cost remote transmission device (remote terminal unit [RTU]) that provides instantaneous, secure, 6-second telemetry from the meter to SmartCloud's servers.
2. Software modules configured to handle dispatch signals, integrate 6-second telemetry, calculate response, handle workflow, and other function in accordance with DSASP requirements.
3. User interfaces for Resource Owners (demand response customer) and Market Participants (demand response resource provider) to monitor performance and dispatches and receive event notifications.
4. Methodology to qualify customers as potential DSASP participants.
5. Methodology for analysis of risk, taking into account potential profit and loss according to types of dispatch, frequency of events, levels of compliance, and other relevant parameters.

The solutions and best practices that resulted from the first year of operation provide valuable guidance to new, potential DSASP participants and helpful strategies for their participation. Building on acquired experience, a second, large industrial customer was registered into DSASP by Demand Response Partners. In 2014, other resources were enrolled in DSASP, providing a total of 100 to 150 megawatts (MW) of demand response resources in the program.

1 Introduction and Background

Benefitting electricity consumers in New York State and serving the public interest are key aspects of the mission undertaken by the New York State Independent System Operator (NYISO).[1] Demand response plays an increasingly important role in accomplishing that mission.[2] The rationale underlying demand response (DR) is that the grid's reliability can be strengthened and the cost of electricity minimized by flattening or shifting load during peak times or others times when needed. Reducing demand can be less expensive and more efficient than securing more resources or constructing additional infrastructure (i.e., new transmission, distribution and generation facilities) to accommodate load surges.

In 2008, at Congress' behest, the Federal Energy Regulatory Commission (FERC) issued Order No. 719 outlining the major directions of its strategy to improve the reliability, performance, and cost of organized electric markets in the U.S.[3] An important element of the Order was the promotion of demand response resources as a source of energy and ancillary services. Even before 2008, NYISO, like the other regional organizations responsible for coordinating grid operations and the associated electricity market, had put in place DR programs to address, for example, capacity requirements and emergency situations. In 2008, the NYISO added a program enabling DR to also provide ancillary services called the Demand-Side Ancillary Services Program (DSASP).

A heat wave throughout the Northeast in July 2013 dramatically demonstrated the importance of demand response. "Heat Wave Drives Record Electricity Usage in New York" was the title of NYISO's press release on July 19,[4] and it stated:

> After six days of sweltering heat throughout the Northeast, New York state successfully met a new record peak demand for electricity of 33,956 megawatts (MW) on July 19, thanks to excellent performance by market participants' generation and transmission assets, demand response programs, inter-regional coordination and a large supply of available wind power.

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1 The NYISO Management Committee Meeting Minutes for September 29, 2010 explain NYISO's mission. Discussion about the mission statement makes it clear that minimizing cost to consumers and ensuring reliability are top concerns.

2 "Demand response" refers to consumers reducing or foregoing their electric usage in response to a signal from the grid operator.

3 Order No. 719, Wholesale Competition in Regions with Organized Electric Markets, 73 FR 61,400 (Oct. 28, 2008), FERC Stats. & Regs. (2008)

4 Heat Wave Drives Record Electricity Usage in New York, http://www.nyiso.com/public/webdocs/media_room/press_releases/2013/Heat_Wave_Drives_Record_Electricity_Usage_in_New_York_07192013.pdf

During this heat wave, the fast-DR resource registered with NYISO and brought online for this NYSERDA project was called on repeatedly during provide an ancillary service called 10-minute spinning reserves (also referred to as "10m spin").

1.1 Fast DR Implies Real-Time, Market-Driven Load Curtailment

Prior to 2008, the DR programs offered by NYISO were reliability-based; that is, they could be called up in the event of a deficiency in capacity reserves – either forecasted or actual. Those programs included the Emergency Demand Response Program (EDRP) and Installed Capacity (ICAP)-Special Case Resources (ICAP/SCR) to be activated at NYISO's discretion. The programs envisioned by FERC's Order 719 were of a different order entirely. They would require real-time response and they would be market-driven: [5]

> the Commission proposed to obligate each RTO or ISO to accept bids from demand response resources, on a basis comparable to any other resources, for ancillary services that are acquired in a competitive bidding process.

In 2009, the NYISO introduced the Demand-Side Ancillary Service Program (DSASP) to allow participation of demand-side resources in the wholesale market for ancillary services. Ancillary services historically have had a higher value compared to the capacity products that demand response had provided heretofore, making spinning reserves very attractive to capable curtailment resources. As a dispatchable service, DSASP required sophisticated real-time communication (i.e., telemetry) between the resources and ISO. Traditionally, ancillary services had been provided by generators receiving control signals from the NYISO and routed through the transmission owners' control room, typically the local utility.

[5] FERC, 2008.

1.2 DSASP Impeded by Technological and Economic Challenges

As of 2011, no DR resources had been registered and qualified into DSASP despite the program being available for three years. One significant obstacle was that the rules relating to ancillary resource communication obligated would-be participants to depend on the transmission owners (TO) to relay control signals. They had little incentive to extend those services and allow resources to be connected to their control rooms.

However, a change in NYISO's policy offered an alternative control and communication architecture that would allow curtailment resources participating in DSASP (or the network operations centers controlling these resources) to communicate directly with the ISO, bypassing the TOs while greatly simplifying integration and reducing costs. Allowing "direct-to-ISO" communication between demand-side suppliers and the NYISO obviated the requirement to rely on the TO's communications equipment and thereby removed a significant barrier to participation.

However, two other barriers to entry remained to be addressed in this project – one technological and the other economic. The technological challenge concerned the metering and measurement requirements for registering and operating the fast-DR resources for ancillary services. The requirement for 6-second, continuous telemetry and 20-second response are stipulated by NYISO. [6] In addition, the communication has to be implemented in a way that is secure, reliable, relatively inexpensive and compatible with the resource owner's existent metering. Moreover, having no predecessors in the program meant unknown and undefined details had yet to emerge and be resolved. This project used a bi-directional communication platform, provided by SmartCloud Inc., to support the required Inter-Control Center Communications Protocol (ICCP),[7] as well as being flexible and configurable to accommodate the addition of new participants' resources but also the evolution of communication requirements with NYISO.

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[6] This rate of responsiveness – a few seconds up to a minute – is sometimes referred to as "Fast DR" and the policy of treating a DR resource as biddable in the energy market ancillary to - and on a par with - generation has become known as "price-responsive demand."

[7] Inter-Control Center Communications Protocol also referred to as IEC 60870-6/TASE.2

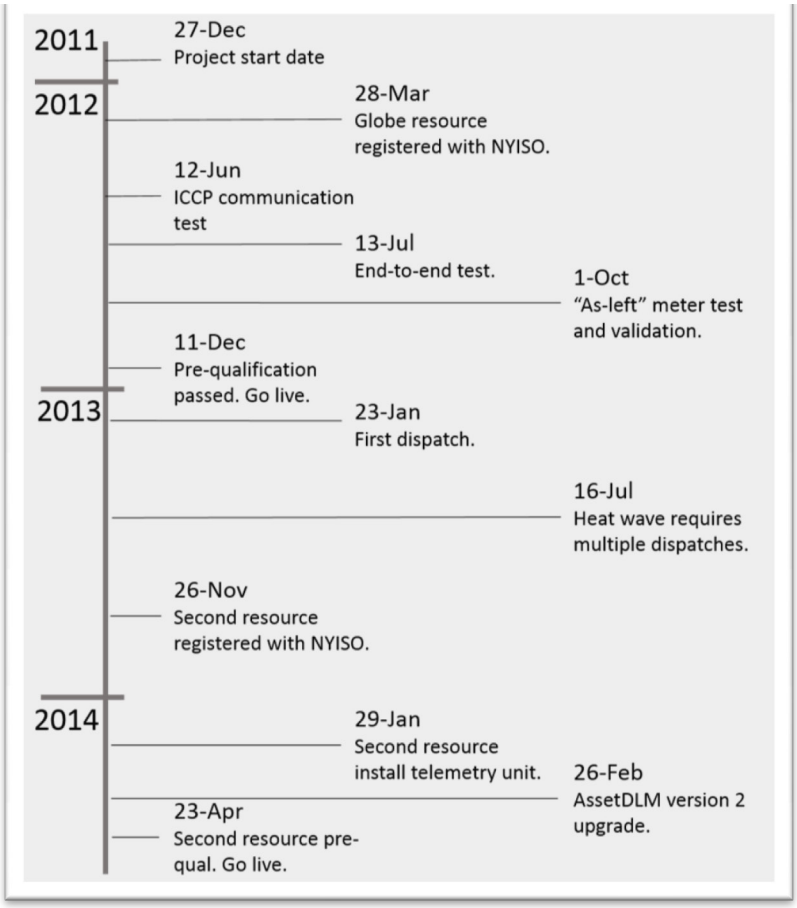
The second significant barrier was economic and concerned compensation and performance in the ancillary service and energy market. DSASP enables DR resource providers to bid as ancillary services into the day-ahead market for 10-minute and 30-minute spinning reserves just like a generator. However, demand response resources have very different internal calculations of revenues, opportunity cost, and business risk compared with generation. DSASP is a more complex dispatchable service, and commercial and industrial facilities need to make intelligent business and operational decisions about when to offer their curtailment as market prices change for ancillary service. Previously, there were no precedents to indicate, for example, how frequently the DSASP resource might be dispatched, nor what would be the pattern of dispatch signals. This lack of precedent held economic implications both in terms of interrupted productivity at the customer's plant and in terms of possible penalties for noncompliance. Without acquired operational experience, the exposure to profit and loss could only be guessed at and therefore the initial customer needed to be amenable to learning as DSASP participation progressed.

In summary, the project addressed these barriers for DSASP participation:

- Cost-effective, bi-directional communication of the data pertaining to ancillary services resources.
- Risk assessment of different combinations of program options that will enable the prospective market participant to explore and choose an optimal plan.

1.3 Project Timeline Spanned Deployment and DSASP Participation

Figure 1. DSASP Project Milestones Include Deployment of Two DSASP Resources



The project began on December 27, 2011, and the system was deployed into live operation almost one year later on December 11, 2012. The effort during 2012 was dedicated to: a) fulfilling NYISO qualification requirements and b) implementing and testing the software modules necessary for DSASP. Those two sets of activities were interdependent: NYISO requirements are ordered sequentially and specific software functionality was needed to accomplish those requirements.

The Globe Metallurgical resource was active in DSASP throughout 2013 and bid into the 10-minute spinning reserve market full time. Thus, there was ample opportunity to learn from real operational experience. A number of lessons were learned regarding dispatch signals, event patterns, and operational procedures that informed the plans and best practices going forward. In the second half of 2013, new features were implemented to build on SmartCloud's software platform and preparing to add a second resource to the program. That second resource went live on April 23, 2014.

1.3.1 Registering and Qualifying a DSASP Resource Required 15 Sequential Steps

Registering a resource in the DSASP program entails a number of steps. Because some tasks depend on others, they need to be accomplished sequentially. The steps carried out for this project are shown in Table 1 in the order in which they were accomplished.

Table 1. Steps to Register and Deploy the Resource in DSASP

	Step	Description
1	Intent to participate in DSASP	The Provider contacted the NYISO Customer Relations Department (CRD) expressing intent to participate in DSASP.
2	Ancillary service provider registration	Initial submission of the *NYISO Demand Side Ancillary Service Program (DSASP) Provider Registration Packet (December 2011).*
3	Identify resources to NYISO	Submit initial *NYISO Demand-Side Ancillary Services Program (DSASP) Registration Packet (June 2008).* The Provider shall submit to the CRD representative a list of Resources it proposes to directly communicate with the NYISO. The Provider will verify its ownership and/or control of those Resources for participation in the NYISO markets. Verification of ownership and/or control is subject to NYISO review.
4	AIEF form, data template, ICCP object.	SmartCloud completes the Association Information Exchange Forms (AIEF) containing the detailed information necessary for each node to establish an ICCP association with the other.
5	NYISO ICCP configuration and data model	NYISO data coordinator creates a Data Template to include all agreed-upon data objects. This constitutes the data model.
6	ICCP testing and certification	Upon completion of modeling, ICCP Test Procedure will be carried out in accordance with the *Initial Communications Test Procedure, Attachment C of NYISO's Direct Communications Procedure.* The testing procedure comprises several stages: (a) association testing of the connection, (b) data object and dataset, (c) dataset conditions, and (d) data quality flags. Additionally, the testing is carried out first using the test environments of SCI and NYISO and then with the production environments. Upon successful completion, NYISO certifies the ICCP communication and issues the point ID (PTID).
7	End-to-end production test	End-to-end: NYISO to Resource. Show heartbeat from NYISO, telemetry received, basepoints, calculated response, etc.
8	Resubmission of resource packet	Provider re-submits the *NYISO Demand-Side Ancillary Services Program (DSASP) Registration Packet (June 2008)* including any changes based on NYISO feedback.

Table 1 continued

	Step	Description
9	Identification of need for clarification	NYISO-initiated conference call to discuss the metering arrangement at the resource location, as well as the Meter Authority protocol for a DSASP resource.
10	Agreement of meter data validation test	NYISO and Provider reach an agreement of standards and protocols for the meter data validation test.
11	Meter validation	"As left" testing in accordance with meter testing facility requirements of *16 NYCRR Part 92 Operating Manual*
12	Enroll DSASP resources	Provider submits final *NYISO Demand-Side Ancillary Services Program (DSASP) Registration Packet (June 2008)* including any changes from initial submission.
13	Meter Validation Approval	NYISO grants approval of meter data validation test and the final *NYISO Demand-Side Ancillary Services Program (DSASP) Registration Packet (June 2008).*
14	MIS inclusion	Provider activated in NYISO's Market Information System
15	Pre-qualification test	Provider bids the Resource into the day-ahead market. NYISO schedules an audit dispatch within a 48-hour period for qualification in the DSASP. Dispatch occurred at 9:30AM on 11-Dec-12 and was successful.

It is worth noting that meter validation and approval were unanticipated activities that consumed several months in the fall of 2012 for two reasons. The first reason, which is described more fully in the next section, was that after evaluating commercially-available devices for telemetering, is that none would satisfy NYISO's requirements for secure, 6-second telemetry at our cost target of $2,000; therefore, the project team built one to its own specifications. This task then required explanation and validation of the custom-built Remote Transmission Unit (RTU) for NYISO's approval. The second reason was the question of whose telemetry for the resource load would be considered the history of record for market resettlement purposes. That decision involved discussions with NYISO and the resource's load serving entity, National Grid.

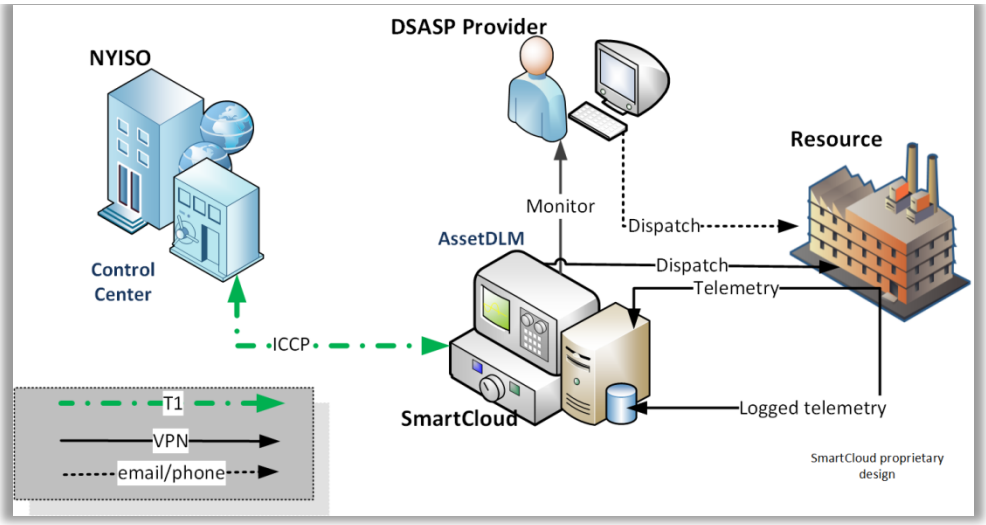
Important software functionality from SmartCloud was critical to accomplishing NYISO's qualification tests for ICCP communication, end-to-end production, meter validation and pre-qualification. That functionality included the agent system for ICCP, message data management agent system, event handling, the user notification system, operations monitoring, graphic user interface, knowledge base, and data historian.

2 Technology Development

2.1 Communication Architecture Contains 4 Actors

The information exchange for DSASP include four major components: NYISO's control center, the resource (Globe Metallurgical), the market participant (Demand Response Partners) and, for this system, a separate information service provider (SmartCloud). SmartCloud's AssetDLM platform[8] receives data simultaneously in real time from NYISO and from the DR resources then synchronizes and processes it and publishes it to the parties concerned. When the system detects dispatch events, it initiates notifications and other actions.

Figure 2. System Architecture Showing the Major Components



2.1.1 ICCP Communications with NYISO Deliver High Availability, Security, and Performance

The network, with AssetDLM at its center, contains two main segments: (a) NYISO to AssetDLM over dedicated T1 line and (b) Globe Metallurgical to AssetDLM over the internet. AssetDLM, which coordinates ICCP communications and telemetry, is hosted on SmartCloud's servers some of them located at a CIP-compliant,[9] secure data center and others in a private, cloud-computing environment. The entire network is designed to provide high availability, real-time performance and security. For

[8] AssetDLM is SmartCloud's agent-based platform for real-time, distributed software applications.

[9] CIP is Critical Infrastructure Protection procedures as defined by the North American Electricity Reliability Corporation.

security, access to all nodes is restricted through dedicated routers employing Security Socket Layer (SSL) protocol. In accordance with NYISO's communications specifications,[10] transmission rates were tested and proven to meet the 6-second telemetry requirement. To achieve high availability all components and circuits were configured for redundancy (that is, primary and backup for every device).

2.1.2 Remote Telemetry Updates Every 6 Seconds Using Custom Remote Device

NYISO's DSASP has several requirements for direct communications. Among them are 6-second instantaneous metered load and a total latency for the round trip (base point signal sent to Resource, analog output received back at NYISO) not to exceed 20 seconds. On top of NYISO's requirements, a goal was set for this project that the hardware and software solution would be low-cost to reduce barriers to entry for DSASP. As a low-cost solution, the target was that the telemetry component of the solution should cost less than $2,000.[11]

When the project began, the Globe Metallurgical plant had in place two iTron Sentinel (R) SS3S2L revenue-grade meters enabling the utility, National Grid, to measure electricity usage. Both meters were already equipped with an under-the-cover Trilliant NCXR801 (CDMA/1xRTT) CellReader modem. The DSASP requirement for "instantaneous metered load" is intended to be equivalent to the metering of generators; the iTron Sentinel meters are capable of reading at the required rate and they are on the list of approved devices.[12]

Taking advantage of the existing metering had several advantages. One was that it would not disrupt what was already in place for the utility and approved by the regulatory authority. Replacing the meters would likely be more costly and certainly time-consuming due to the approval process. Having made that determination, the challenge then became what type of RTU equipment was needed to acquire the data from the existing meters and then transmit it accurately, reliably, and securely every 6 seconds or less.

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10 NYISO, Direct Communications Procedure (December, 2011)

11 By comparison, generators typically install a complete SCADA system with a server that handles the ICCP communication. The cost runs $100,000 or more.

12 Approved Meter List, New York State Department of Public Service, 11/21/2011.

Evaluation of what was commercially available showed two types of RTU products for capturing and transmitting telemetry: AMI/AMR[13] cards and data loggers. After identifying potential products in both categories and conferring with vendors, none met the requirements. Briefly, the AMI/AMR cards were found to be too expensive because they came bundled with service plans. The data loggers, which are external devices that tap into the meters using a KYZ card, could not transmit telemetry at less than 1-minute frequency.

Having determined that an off-the-shelf solution was unavailable at a low-cost, an instantaneous telemetry transmission device was designed using standard components.[14] The device includes the capability to acquire multiple meter readings (pulses) within a 6-second period and, through a programmable router, timestamp, and transmit the data over the Internet to a remote server. Transmission over an Internet connection uses digital cellular transmission as a backup. For security, both channels use secure shell (SSH) encryption protocol. At the server, the data is normalized to a 6-second reading, transformed to MW and formatted for ICCP transmission to the NYISO.

The RTU was tested in terms of validity, reliability and performance. *Validity* was evaluated by comparing RTU data history to log files produced by the plant's control system (programmable logic controller [PLC]). The filtered 6-second telemetry was compared against the 3-minute PLC data for 10 hours on May 29, 2012 for a period of time with during which occurred full operating load, load curtailment, and recovery. For this time period and other sampling times, the mean absolute percentage error (MAPE)[15] was less than 1%.

Comparing the values in Figure 3, the PLC readings can be seen to slightly lag the RTU readings because of the time intervals of the readings; for example, a load reduction at 00:00:03 will be detected by the 6-second telemetry at 00:00:06 whereas the same load reduction is not visible in the 3-minute PLC data until 00:03:00.

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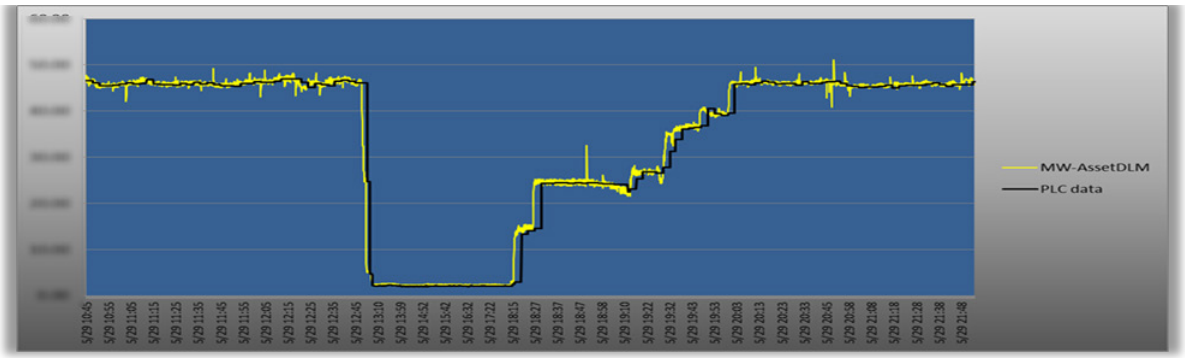
13 AMI/AMR = Advanced Metering Infrastructure, Automatic Meter Reading.

14 We believe this design is a novel invention and have therefore filed a Provisional Patent Application.

15 Also known as Mean Absolute Percentage Deviation, MAPE is the average of absolute difference between the test value (that is, our readings) and the reference values (the PLC values).

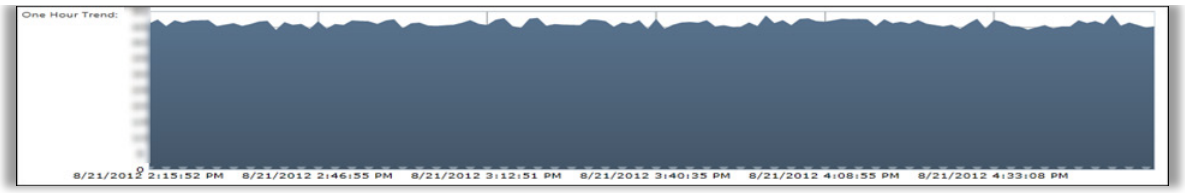
Figure 3. Validating RTU Telemetry Against the Plant's PLC Historian[16]



For *reliability* testing, the system, encompassing the RTU and AssetDLM, operated continuously for most of July and August 2012. More than 17 million telemetry messages were transmitted, processed, and logged during that time; none were dropped.

Performance was evaluated with a sample taken over 3 days (August 14 – 17, 2012; Figure 4). The transmission rate averaged 3,582 readings per hour which is 99.49% of the expected frequency of one message per second. Considering DSASP's requirement of 6-second telemetry, we are able to acquire multiple readings within the 6-second period, and thereby achieve more accurate readings.

Figure 4. Reliability of Telemetry Over 3 Days



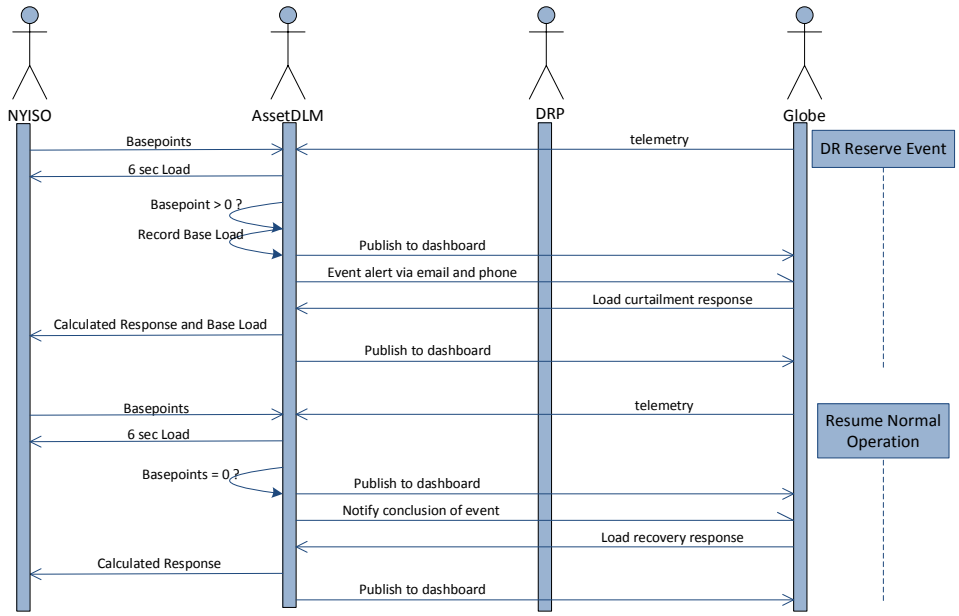
The testing procedures were authenticated by a licensed meter service provider. NYISO reviewed and approved the documentation of the testing procedures and results. Since the initial testing, additional RTU devices have been built and installed for backup replacements at the Globe Metallurgical site and for the second resource.

[16] The *x*-axis values in various figures have been blurred to conceal proprietary operational data.

2.2 AssetDLM Orchestrates Data Flow

As previously mentioned and shown in Figure 5, four actors are engaged in the data flow for DSASP: NYISO Control Center, SmartCloud's AssetDLM agent system, Demand Response Partners as the Responsible Interface Party (RIP) and Globe Metallurgical as the Resource Owner.

Figure 5. DSASP Flow of Telemetry and Instructions Between Actors



AssetDLM centralizes and orchestrates the flow of information. A stream of telemetry comes from Globe Metallurgical and a stream of basepoints comes from NYISO's control signal. AssetDLM joins those streams and publishes information at 6-second intervals to a dashboard on a secure web portal where it can be viewed in real time by operators and managers at DRP, Globe and SmartCloud. AssetDLM also relays the telemetry every 6 seconds to NYISO.

As it processes the data streams, AssetDLM checks for dispatch events that are signaled by NYISO sending non-zero basepoints for the Resource. When AssetDLM detects non-zero basepoints, it initiates several actions. First, it captures the coincident measured load and records that as the Base Load for the ensuing event. AssetDLM also begins to calculate (a) Target Load for every 6 seconds as the difference between Base Load and basepoint and (b) Performance based on the difference between the Target and actual Load. Second, AssetDLM posts current telemetry, event alert and target information to the

dashboard on a Web portal where it is visible to operators and managers from DRP and Globe Metallurgical. Third, AssetDLM composes and issues instructional messages that are delivered via a third-party notification system by phone, email, and text message to a distribution list of operators at Globe Metallurgical, DRP, and SmartCloud. Fourth, during the event, AssetDLM continues to calculate and monitor performance, transmit Resource response to NYISO and escalate notifications if necessary.

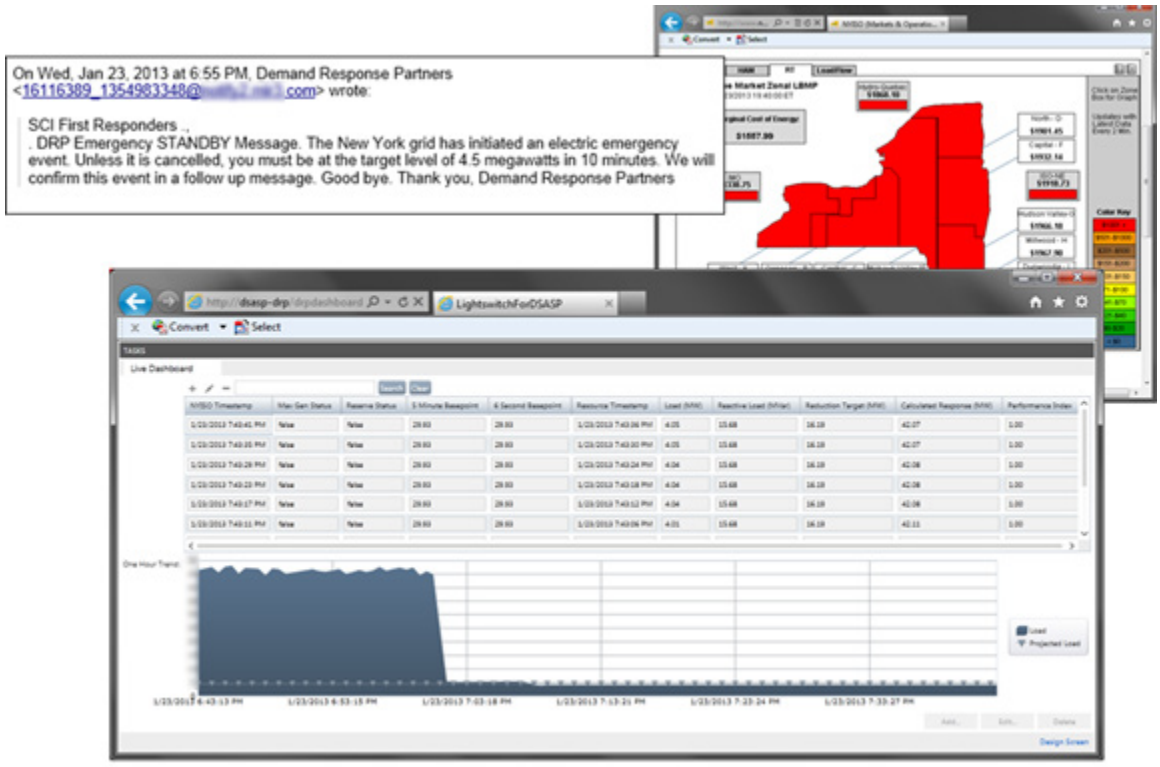
When the software agent detects that basepoint signals from NYISO have reverted to zero from non-zero values, it recognizes the end of the event and consequently issues notifications to resume normal operations and restore load. On the dashboard, the system publishes load recovery targets according to NYISO-issued basepoints and signals the termination of the event.

2.3 Human Interface Includes Web Portal Dashboard and Notifications by Phone

Communication with operators is carried out in two ways (Figure 6). One mechanism is a graphic dashboard that can be viewed by logging into a secure Web portal. The other mechanism is a third-party notification service that transmits instructional messages via phone, instant text messaging, and email. Those messages are composed by the DSASP application and issued to the notification service.

The composite images shown in Figure 6 relate to an actual dispatch event on January 23, 2013. The figures include the text of the email messages (also transmitted by phone using text-to-voice interpretation), the dashboard, and NYISO's on-line map of wholesale electricity prices (locational based marginal price) for different load zones in the New York region at the time of the event. This information is available to plant operators and managers. It informs them of the status of events in real time as well as curtailment targets, performance and degree of compliance.

Figure 6. Graphical User Interface (GUI) Components: Notifications and Dashboard



2.4 Experience in Operation Led to Important Lessons Learned

2.4.1 Dispatch Events and Basepoint Patterns

Designing the AssetDLM functionality to participate in DSASP relied on the information available from NYISO. The Direct Communications Procedures document, for example, provided specifications on the instructions as issued by NYISO's control center, the telemetry to be returned as well as measures to be computed by the custom AssetDLM module such as Base Load and Calculated Response.

In addition to the data definitions, an understanding of information flow was needed. The only information to describe the pattern and expected behavior of basepoints and response during a dispatch event was contained in a training document, Demand-Side Ancillary Services Training.[17] That document provided an example with U-shaped dispatch patterns made up of three stages: the initial ramp, the body of the event as a plateau, and then the recovery ramp. As shown in Figure 7, the pattern is delineated by the NYISO-issued basepoints in the table at the bottom of the figure.

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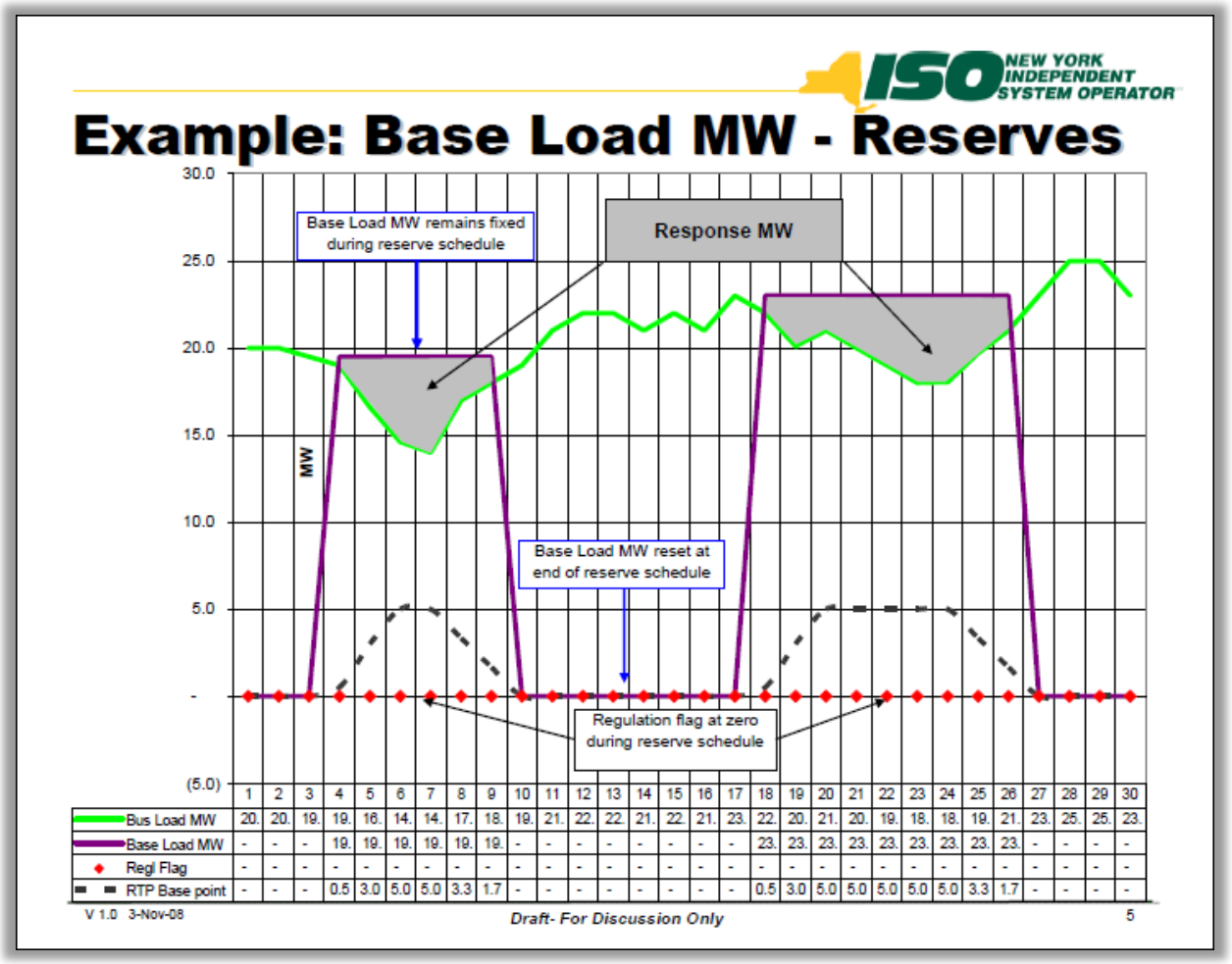
17 Demand Side Ancillary Services: DSASP Training Course, November 21, 2008, D. Pratt, New York Independent Service Operator, Albany, NY.

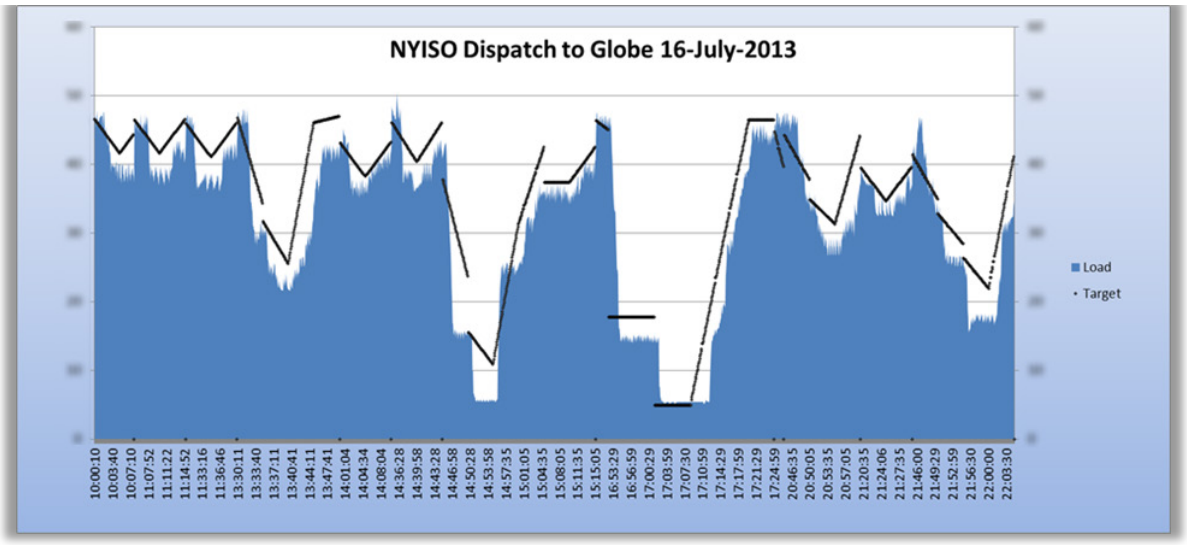
Figure 7. Dispatch Basepoints and Baseload Example from NYISO Training



Initially the reasoning embodied in the software agents was designed and built to manage events and match the anticipated U-shaped pattern. In operation, however, NYISO's dispatch signals were much more varied than the uniform pattern in the example.

For example, on July 16, 2013 there were 12 different dispatches and, as can be seen in Figure 8, the basepoint pattern varied considerably from one event to another. Beginning at 10:00 a.m., three V-shaped signals in which a ramp down were followed immediately by a ramp up without sustained curtailment in the middle. At other times, notably 15:15 and 17:00, dispatches called for abrupt curtailment without a ramp. None of the events conformed neatly to the U-shape.

Figure 8. DSASP Dispatch Events for Globe on July 16, 2013



Classifying different dispatch patterns and correlating those with scheduling and dispatch history from NYISO's Market Information System (MIS) showed two triggers for dispatches: (a) in response to real time energy prices that exceeded energy market offer and (b) reserve pickups triggered by reliability events. Energy dispatches typically commence with an initial ramp. That ramp is defined by the basepoint signals that are assigned by the NYISO Real-Time Dispatch system (RTD) after an energy bid has been cleared by the Real-Time Commitment scheduler. Because the RTD re-runs approximately every 5 minutes, the V-shape results when the resource is not cleared in the subsequent 5-minute cycle and therefore ramps back up. In contrast, the reserve pickup pattern is an abrupt curtailment with no initial ramp. A telltale correlate is that in NYISO's ICCP instructions, the 6-second Unit Desired Generation (UDG) basepoint is the same as the 5-minute Security Constrained Dispatch (SCD). Because the dispatch corresponds to a grid reliability event as opposed to economic optimization, the target is intended to be achieved as quickly as possible.

The pertinent response time is unclear. NYISO's 10-Minute Spinning Reserve is defined as "Operating Reserves provided by qualified Generators and qualified Demand Side Resources located within the NYCA that are already synchronized to the NYS Power System and can respond to instructions from the NYISO to change output level within 10 minutes."[18] However, the performance evaluation and compensation for these 10-minute resources is based on a performance index that is calculated at time intervals shorter than 10 minutes. Basepoints are issued for both 5-minute and 6-second intervals and the NYISO advised to follow the 6-second signals, the most conservative procedure.

Not all dispatches fall neatly into the two patterns described; the irregularity of the signal apparently underlies the advice of NYISO staff that resource operators should "follow the basepoints." The implication for participants in the DSASP program is that they should be attentive to track and adhere to the basepoints no matter what the pattern.

The system put in place to issue alerts and monitor performance has performed as designed, and Globe's ability to follow a basepoint signal has unquestionably been proved. To date, load curtailment at Globe has been executed in real-time, but manually, by the plant operators guided by the notification system and dashboard provided by SmartCloud. This arrangement has been necessary and effective during learning about dispatch patterns and signals. In the long term, it is expected that the system will evolve to become more efficient, automated, and even more precisely match NYISO's dispatch patterns. Responsiveness also depends on the nature of the industrial process and capacity of the plant's control system as discussed in the following section.

The distinction between dispatches triggered by an Energy Bid and Reserve Pickups has important market and financial implications. For example, the dispatch profile is related to customers' ability to perform, financial penalties and, consequently, the RIP's strategy for qualifying customers' curtailment and degree of load control and allocating them within the aggregated resource. The next section expands on these implications.

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[18] NYISO, Ancillary Services Manual, November 2010, p. 6-5.

3 Market Development

3.1 Business Considerations are Just as Important as Technical Issues

The business management concerns for facilitating participation in DSASP are equally as important as the technical and operational considerations. With respect to profit and loss, there are two interested parties on the participants' side: the DR resource owner (initially Globe Metallurgical with others to follow) and the RIP (Demand Response Partners). Formulating a strategy for bidding and managing ancillary services in NYISO's Day-Ahead Market entails selecting qualified resources and then managing the resource's placement in the market profitably without unacceptable risk of loss.

This section describes the general considerations and methodology followed in developing a strategy without recommending or disclosing a particular strategy.

3.1.1 Previous Studies on Load Resources for DR Call Attention to Various Business Issues

The characterization and categorization of customer loads appropriate for demand response has been a considerable body of research, most notably studies carried out by Lawrence Berkeley National Labs.[19] The research topics fall into a few categories:

- Opportunities presented by the coincidence of curtailable load with peak demand on the grid.
- Prediction of load variance (hourly over the day, daily over the week) for the purpose of (a) designing load-shifting programs by the ISO or utility, and (b) baseline prediction to calculate load shed for financial settlement.
- Typology of DR loads with respect to curtailment response and following of ramp setpoints, for example (a) optimal setpoint patterns for commercial load (e.g., HVAC, lighting, data centers) and (b) industrial and commercial equipment amenable to instantaneous curtailment.
- Analysis of the cost-effectiveness of DR-enabling technologies many of which conclude that industrial loads are most effective compared to commercial and residential loads.
- Identification of the ideal industrial loads for DR based on amount of curtailable load and the presence of control equipment capable of receiving AutoDR signals.

[19] http://drrc.lbl.gov/publications

Some of this research is pertinent to other DR programs that differ from DSASP's Fast DR. For the purposes of this project, the important considerations for evaluating candidates were the size of the load, the load control capabilities at the plant, the capacity to follow precipitous or ramped dispatch in accordance with NYISO dispatch patterns, the vulnerability of the production process and equipment, and the opportunity costs of lost production.

Moreover, the initial pool of candidates was limited to industrial plants that generally operate 24/7 at a fairly constant load. The rationale for this constraint was to simplify the management of the resource during the learning stage. This constraint may be relaxed in the future, allowing for plants with more variable load and assigning varying amounts of DR load for different hours and days of the week.

3.1.2 Selection Criteria Include Size of the Load, Plant Control Capabilities, and Process Vulnerability

The criteria derived for qualifying suitable resources included the magnitude of the load, the ability of the plant's control system to respond to basepoints and the tolerance of the manufacturing process to sudden electricity reductions. Dispatch patterns can vary significantly as shown previously in Figure 8, and particular attention was paid to the consequences of Energy Bid dispatches versus Reserve Pickups.

In light of the authors' experience with different dispatch patterns, particular attention was paid to the ability (a) to curtail load quickly and (b) to recover from one event in time to be prepared for a subsequent event. For example, a sudden curtailment called for by a Reserve Pickup (i.e., no ramp) could be damaging for some processes and equipment suggesting that a candidate with those characteristics might not be suitable. Similarly, some processes and equipment require a deliberate and lengthy procedure for coming on line. If they were to be dispatched for 2 or 3 events in rapid succession, they would be unable to comply.

Table 2 can be thought of as a scorecard for participation in DSASP. Seven prospective candidates were scored for the DSASP. Some qualified, but others were unsuitable for the program.

Table 2. Parameters to Qualify Candidates for DSASP

	Candidates						
Characteristics	**A**	**B**	**C**	**D**	**E1**	**E2**	**F**
Load (MW)	confidential	7	13	16	80	80	36
Curtailable Load (MW)	confidential	6	4	11	20	60	36
Control system	PLC	Manual	PLC	Manual	PLC	PLC	PLC
Ramp following	Slow or fast	Slow	Slow or fast	Fast only	Slow or fast	Slow or fast	Slow or fast
Recovery rate	Variable	Slow	Variable	2 hours	30 minutes	1 hour	Variable
Equipment risk	low	low	low	low	high	low	minimal
Product risk	low	low	low	low	low	low	high

3.1.2.1 Candidate A

Candidate A is Globe Metallurgical, and its characteristics easily satisfy the selection criteria. The curtailable load surpasses the 1-MW minimum required for DSASP registration of a resource, simplifying the pilot stage of this project. Globe's process control allows for fast curtailment and variable recovery rates, moreover, they can perform this range of load management with minimal risk of equipment damage and product loss.

3.1.2.2 Candidate B

Like Candidate A, Candidate B is an industrial producer of raw materials used for manufacturing. They do have high curtailment capacity coupled with low risk of loss to their processes. However, Candidate B is relatively inflexible in their ability to respond to dispatch signals. Although this plant site is superficially similar to Candidate A in that they are a producer of raw materials, the multi-step nature of their materials processing means that there are many segregated equipment controls, which are not linked under a centralized PLC load control system. Upgrades to the facility, which would integrate PLC controls to enable Fast Ramp response, are extremely costly and so far unjustified by potential earnings from DSASP. The manual nature of Candidate B's load shed effectively rules it out of the DSASP market.

3.1.2.3 Candidates C and D

It is sometimes possible to isolate parts of an industrial process that are capable of conforming to the basepoint signals, but only to either the Slow Ramp energy bid dispatch or the Fast Ramp reserve bid dispatch. Candidates C and D are industrial gas processing plants. The industrial gas plants tend to have the vast majority of their load in the liquefiers, which have only a fast drop capable in the initial ramp as indicative of Reserve bid dispatches. The caveat remains that the recovery time, which can differ between different industrial gas plants, but typically is a lengthy 30 minutes to 2 hours.

Candidate C has a slow but variable recovery time and could participate with other complementary resources. However, Candidate D has a 2-hour recovery ramp for the liquefiers, which is an unacceptable recovery time. The remaining compressors are able to perform to both Fast Ramp dispatches as well as Slow Ramp dispatches; however, the compressors are only a fraction of the total load. For Candidate D, the compressors were equivalent to only 1.5 MW which is not cost effective to install the enabling technology.

3.1.2.4 Candidate E

One subset of customers are able to respond to the range of basepoints but the nature of their process or equipment requires lengthy recovery. Candidate E is a large industrial chemical processing site of which E1 and E2 are subsites.

The chemical processing plant, E1, has a large 20-MW block with Fast and Slow Ramp capabilities. Recovery may be as much as 30 minutes, but this characteristic in itself is not a disqualifier because NYISO still finds a Fast Ramp with long recovery to be useful. A partial site enrollment of 20 MW makes this customer cost-effective to enable but with the constraint that its assignment might need to be managed in aggregation with other loads elsewhere if the time interval between dispatches is insufficient for the recovery ramp.

3.1.2.5 Candidate F

A smaller set of chemical producers have industrial plants with extremely flexible ramping abilities as well as full load control and no risk to equipment damage. These locations would appear to be ideal candidates; however, a complicating factor is that their products are sensitive to power disruption.

Candidate F is a producer of industrial chemicals, whose power consumption is primarily based on a single product type of high sensitivity.

Product sensitivity alone was not the determining factor; an additional consideration was the long time required to produce each batch, with a short electric disruption resulting in the loss of an entire batch. If this facility had sufficient time to make additional batches, perhaps a role for DSASP participation could be considered. Yet this particular chemical producer is high volume with a continuous order backlog. A single lost batch results in a delay for all product orders. Therefore, Candidate F is technologically equipped but economically unsuitable for participation in DSASP.

3.1.3 Qualification Results of Example DSASP Candidates

Table 3 locates the example customers above in terms of how they could participate in the DSASP. They were classified as capable of responding to Energy and Reserve Pickup dispatches, or both, as explained previously.

Table 3. Market Qualification of DSASP Candidates

	Market			Rejected
Risk	**Reserve**	**Both**	**Energy**	
Low		A,C	E2	**B,D**
High	E1			**F**

Candidates A, C, and E are suitable candidates for DSASP. Site E1 is only able to perform the Fast Ramp load sheds with a 30-minute recovery time and therefore its participation is contingent on finding a way to balance their participation with other sites.

3.2 A Market Participation Plan is Critical for DSASP Success

Once qualified candidates have been identified, developing an economic plan becomes important. The plan serves two purposes. One is to set expectations with the asset owner about likely revenues, performance requirements and the consequences of underperformance. The second is to position the asset in terms of a market strategy, such as how much energy[20] (i.e., load curtailment capacity) should be bid into the Day-Ahead Market, for what hours and which days of the week. Critical to the economic plan is understanding the potential upside and downside of participation in DSASP.

3.2.1 Estimated Profit and Loss Depend on Market Factors, DR Events, and Participant Performance

The DSASP Market Participant receives an hourly reserve standby payment for the resources bid into the Day-Ahead market. The reserve standby payment is based on the hourly clearing price in the Day-Ahead market. In the past year, the hourly average for the clearing price for 10-minute spinning reserve in NYISO's Day-Ahead market has averaged between $4.00 and $7.50 per MW for Zone A.

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[20] It might appear incongruous that a 10-minute spinning reserve ancillary service is engaged in the energy market but, in fact, DSASP resources are required to bid into the same market as generators and can be dispatched on the basis of the price bid as well as for reserve events. That, in fact, is the distinction perceived between Energy Bid dispatches and Reserve Event.

For example, the average market clearing price for 10-minute spinning reserve in the Day-Ahead market for June 2013 was $4.46/MW. Assuming for explanatory purposes that 50 MW of a resource's capacity was bid into the 10-minute spin market for the entire month,[21] the reserve standby payment was estimated at $160,560 (Table 4).

Table 4. Hypothetical Calculation of Reserve Standby Payment

Parameter	June 2013
Day-ahead market clearing price for 10-minute spinning reserve (per MW)	$ 4.46
Hours per day	24
Days per month	30
Reserve standby payment (per month per MW)	$ 3,211
MW bid into the market	50
Reserve standby payment (per month)	$ 160,560

The reserve standby payment sets the upper limit for potential profit; from that amount, certain charges might be deducted. Those charges include penalties for noncompliance and estimated cost of lost production during curtailment. To get an idea of best cases, worst cases, and points in between, different levels of compliance and cost were modeled.

The analysis summarized in Table 5 shows payment, costs, and gain or loss for different hypothetical scenarios. Line 1, for example, pertains to February 2014. For that month, the actual clearing price for 10-minute sync in the Day-Ahead market averaged $7.32 and consequently reserve standby payment could have been $245,952. Also there were no dispatch events during that month, therefore no lost production costs were incurred and no penalties for non-compliance. As a result, the net return is 100% of reserve standby payment. The analysis for June 2013 in Line 2 also shows 100% gain because the assumption was made for analysis purposes (contrary to fact) that there were no dispatches during that month. The average market clearing price for that month was $4.46/MW, yielding net return of $160,560.

[21] This assumption simplifies the analysis. Bidding different amounts at different hours and different days of the week is possible, but that degree of complexity is unnecessary for the present analysis.

Table 5. Profit and Loss for Hypothetical Simulations

						Energy Dispatch			Reserve Dispatch				
Line	Scenarios	Month	Avg DAM 10 min sync MCP	Reserve Standby Payment	% Compliance	# dispatches	Penalties	Curtailment Cost	# dispatches	Penalties	Curtailment Cost	Net Return	% Gain or Loss
1	No events in February.	Feb-14	$ 7.32	$ 245,952	100%	0	$ -	$ -	0	$ -	$ -	$ 245,952	100%
2	Assume June 2013 had no events.	Jun-13	$ 4.46	$ 160,560	100%	0	$ -	$ -	0	$ -	$ -	$ 160,560	100%
3	Medium events, near perfect performance	Jun-13	$ 4.46	$ 160,560	90%	1	$ (450)	$ (946)	2	$ (598)	$ (1,243)	$ 157,323	98%
4	Medium events, mediocre performance	Jun-13	$ 4.46	$ 160,560	50%	1	$ (2,249)	$ (526)	2	$ (2,992)	$ (691)	$ 154,102	96%
5	Many events, near perfect performance	Nov-13	$ 4.37	$ 157,320	90%	8	$ (3,598)	$ (7,570)	3	$ (4,788)	$ (9,942)	$ 131,422	84%
6	Many events, mediocre performance	Nov-13	$ 4.37	$ 157,320	50%	8	$ (17,992)	$ (4,206)	3	$ (23,939)	$ (5,524)	$ 105,659	67%
7	Many events, near perfect performance	Jul-13	$ 4.06	$ 146,160	90%	12	$ (5,397)	$ (11,355)	6	$ (7,182)	$ (14,912)	$ 107,313	73%
8	Many events, mediocore performance	Jul-13	$ 4.06	$ 146,160	50%	12	$ (26,987)	$ (6,309)	6	$ (35,908)	$ (8,286)	$ 68,669	47%
9	Many events, awful performance	Jul-13	$ 4.06	$ 146,160	2%	12	$ (52,895)	$ (254)	6	$ (70,380)	$ (335)	$ 22,296	15%

Lines 3 and 4 again show June 2013 but include the cost of 1 Energy Dispatch and 2 Reserve Pickup Dispatches. In Line 3 compliance is "near perfect" (90%) and in Line 4 it is "mediocre" (50%), and the result that % gain is 98% and 96% for Line 3 and Line 4, respectively. To the degree to which the resource is out of compliance with a dispatch, NYISO covers the unfulfilled amount from other sources and penalizes the Resource Provider by that amount at the prevailing market price. To model that penalty, an Average Real-Time Market Clearing Price was used for 10-minute Synchronous Reserve of $450 per MWh during the dispatch interval. Penalties for Reserve dispatches tend to be higher than Energy dispatches because, given the absence of a ramp in the dispatch signal, the degree of noncompliance is greater for Reserve events.

Lines 5 and 6 refer to November 2013 when the average price was $4.37. Here a fairly large number of dispatches were hypothesized – 8 Energy Dispatches and 3 Reserve Dispatches – and contrasted near perfect performance with mediocre performance. The result was % Gain of 84% and 67% for Lines 5 and 6, respectively.

Finally, in Lines 7, 8 and 9, many events were modeled at three levels of compliance: near perfect, mediocre, and awful (2%). The % Gain or Loss varied from 73% to 15% among the three lines.

The analysis is instructive for DSASP participants with regard to what they can expect from the program. Risk of loss is greatest when many dispatch events occur in a month and the participant's compliance is well below 50%. Because dispatches are infrequent (most months have less than 2), there is little possibility of incurring significant penalty most of the year. On the other hand, when the occasional

torrent of dispatches does occur, the participant needs to be ready for it. Furthermore, even 50% compliance is better than non-compliance because the penalty is less severe but also because NYISO could at their discretion withdraw the certification of the resource for failure to perform.[22]

[22] Additionally, some non-compliance penalties may be partially offset through the Day Ahead Marginal Assurance Payment (DAMAP) which is a supplemental payment made to an eligible Supplier that buys out of scheduled Day-Ahead Energy, Regulation Service, or Operating Reserves such that an hourly balancing payment obligation offsets its Day-Ahead Margin.

It is worth noting that the Curtailment Costs modeled in this analysis are estimated to be $100/MWh. For other resources the opportunity costs of lost production might be much higher and, that being so, could significantly affect the Net Return and profitability. Conducting this type of risk/profit analysis for prospective participants, based on their own operating characteristics, can provide reasonable insight into what they should expect from DSASP participation.

3.2.2 Compensation for Energy vs. Reserve Dispatches Warrants Consideration

Being pioneers in the DSASP program, the authors encountered some differences between how market assignment and compensation worked compared to what was expected. Of particular consequence is how DSASP resources are treated differently from generators in the market. From the operational perspective DSASP resources are scheduled and dispatched like other energy sources including generators. But in terms of market settlement, there are some substantial differences. Namely, demand side resources are not paid any energy market compensation while generation resources are.

The difference comes down to the distinction of what the underlying reason was for the 10-minute synchronous reserve dispatch. As previously detailed, all 10-minute synchronous reserve offers consist of a reserve price as well as an energy market offer price. All resources that are scheduled into the market to provide 10-minute synchronous reserve are co-optimized by the Real Time Dispatch system for both real-time energy and operating reserve. Resources that have been scheduled and committed to provide this operating reserve can be converted to energy (or dispatched to reduce load in the case of a DSASP resource) by the Real Time Dispatch system based on either (a) an energy price that exceeds the resources energy offer or (b) a reliability event that requires the activation of the operating reserve. Demand-side resource are not paid energy market compensation if dispatched based on the resources energy market bid.

The initial and unfortunately incorrect assumption entering the project was that DSASP resources are providing 10-minute synchronous reserve. The expectation was that they would be dispatched due to reliability events that triggered reserve pickups, and not dispatched on the basis of energy price because unlike a generator, a demand-side resource receives no energy market compensation for providing this service.[23] An optimizing business algorithm could apply that fact to good advantage – both to the grid and

[23] Apparently this requirement resulted from the way that DSASP was adapted into the existing Real Time Dispatch system which depends, in turn, on the Real Time Commitment and Real-Time Automated Mitigation Process. Those systems co-optimize selection and assignment from a pool of available resources. The usual way for a resource to get into that pool for consideration is to have bid certain amounts of energy at certain time slots into the Market

to the resource – except that there is no provision in the rules to compensate the DSASP resource at the market clearing price for energy; it is paid only on ancillary service. [24]

During some periods of intense grid demand and high energy prices, like the week of July 16, 2013, the Globe Metallurgical resource was dispatched many times, sometimes coinciding with a reliability triggered reserve event and sometimes based on real-time energy market prices. Demand Response Partners, in an effort to maximize availability for reserve dispatches and minimize exposure to energy dispatches (and thus lessen customer fatigue), had intentionally set a sufficiently high price for Globe to minimize economic assignment by the NYISO. That tactic was not entirely successful because during this week in July, the Locational Based Marginal Price (LBMP) frequently surpassed $2,000/MW.[25]

A further twist is that the penalties for under-performance appear to apply differently for generators and DSASP resources. For a generator that can receive both real-time energy and ancillary payments, nonzero basepoints means simply producing energy in real time. The generator will be paid for the scheduled ancillary service as well as for any energy bids which were scheduled in the Day Ahead or Real Time Dispatch. As a result, generators can follow their basepoints in real time without regard to which bid triggered the conversion to energy; the financial settlement process will ensure full market compensation.

Under the current market rules the same does not apply to DSASP. The 10-minute sync product is an ancillary service offered through DSASP, and is defined as the ability to shed load within 10 minutes of dispatch. The added complexity begins when this 10-minute product is added into the dispatching software which generates a schedule every 5 minutes and then issues dispatch signals at 6-second intervals. The automated performance calculation runs concurrently using the same 6-second basepoints.[26]

Information System (MIS). Evidently the most convenient way to make demand-side resources visible to the Real Time Dispatch system was for them to be bid into the MIS so they would be included in the pool. Not incidentally, this way of doing things was also compatible with FERC's Order 719.

[24] NYISO is in process of creating market rules which would resolve this inconsistency by allowing load side resources, such as DSASP, to receive additional compensation for energy schedules. Although the market rules are in the early stages of drafting, equal treatment of generators versus DSASP could be realized by compensating resources for all bids cleared or picked up by RTC/RTD Scheduling in real time.

[25] Subsequent analysis showed that even when a reserve event was in progress, Globe sometimes received an energy dispatch rather than reserve dispatch. The apparent reason is that the scheduling progression of settling bids, committing resources and then dispatching resources meant that the bid price was struck and the resource committed even before the reserve event was called.

[26] The same basepoints are issued to generators and referred to as Unit Desired Generation.

3.3 Resource Aggregation Will Require a Balanced Strategy

With a large amount of load enrolled in the DSASP, Globe Metallurgical is somewhat unusual in comfortably fulfilling the mininum size requirements (1 MW) for a registered Resource in the DSASP by itself; there is no need to combine it with other load sources. For our introductory foray in the Program, this simplified resource management and proved helpful. However, it is to be expected that the more common arrangement for DSASP Resources will be aggregation of smaller, individual loads.

Aggregation offers some potential benefits such as reducing participant fatigue and using the unassigned capacity of one load to compensate for the shortfall of another. Finding an optimal strategy for managing aggregation is not simple, however. Various characteristics and factors can affect an asset's ability to perform – some pertaining to the asset and others to the nature of the dispatch.

Characteristics that pertain to the asset can be used as parameters in composing the bidding and/or dispatch strategy. For industrial loads the list of potentially relevant characteristics includes:

- The nature of the manufacturing process especially recovery time
- Seasonal and diurnal patterns of energy consumption.
- Control system and degree of precision.
- Company policy with regard to product quality and safety.
- Known performance record.
- Transient conditions like equipment unavailability.
- Circumstantial conditions such as event response fatigue.

For any resource and its component assets, the DR Provider needs to ascertain which characteristics are relevant to take into account in disaggregating the dispatch signal and assigning basepoints to the individual assets.

Characteristics that pertain to the nature of the dispatch include the magnitude of the load, the ramp rate of the signals and the interval between dispatches. Unsurprisingly, the most demanding dispatch profile is many large dispatches with no ramp and very brief intervals between dispatches.

This analysis took into account two variables that had emerged as especially salient during interviews with prospective participants: recovery capacity and response fatigue. Building on the classification of prospective customers described in Selection Criteria Include Size of the Load, Plant Control Capabilities, and Process Vulnerability, a hypothetical aggregated resource was constructed. The resource was composed of 4 assets: A1, C1, E1, and E2 (Table 6). For the sake of simplicity, each asset was considered

to have 10 MW registered capacity. This assumption enabled easy comparison of the differences in each load's responsiveness and its impact on the compliance of the whole resource.

Table 6. Four Assets Modeled in the Aggregated Resource

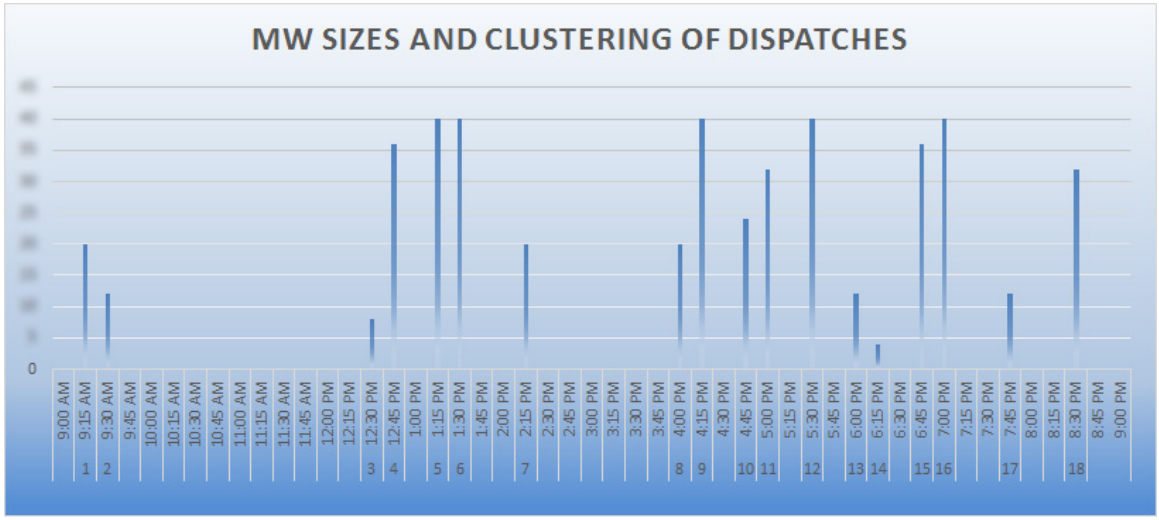
Registered Capacity	
Asset	**MW**
A1	10
C1	10
E1	10
E2	10
Total	40

Assets E1 and E2 require slow recovery due to the nature of their production processes. Therefore, if dispatches occur in rapid succession, their ability to respond is diminished. For modeling purposes we considered that type E assets required at least 15 minutes between the end of one dispatch and the beginning of the next. If the interval was less than 15 minutes, then assets E1 and E2 were noncompliant for the second dispatch.

Participant fatigue was also based on the interval between dispatches in conjunction with the magnitude of the curtailment. For assets of types A and C, 50% of their unused capacity was calculated to be available for curtailment when one dispatch immediately followed another.

The scenario we modeled was based on the dispatch pattern for July 16, 2013 – an extremely demanding day in the DSASP. Figure 9 shows the series of events through the modeled day, and the total MW curtailment requested of the resource for each dispatch. The standard duration used for the dispatch events was 15 minutes.

Figure 9. Hypothetical Dispatches Derived From the July 16, 2013 Pattern



Dispatches are clustered during certain periods during the day. The intervals between dispatches are brief especially between 4:00 p.m. and 7:00 p.m.

The analysis compared three different strategies for apportioning aggregation load, and outcomes were evaluated in terms of both financial and performance objectives.

3.3.1 Results of Analysis

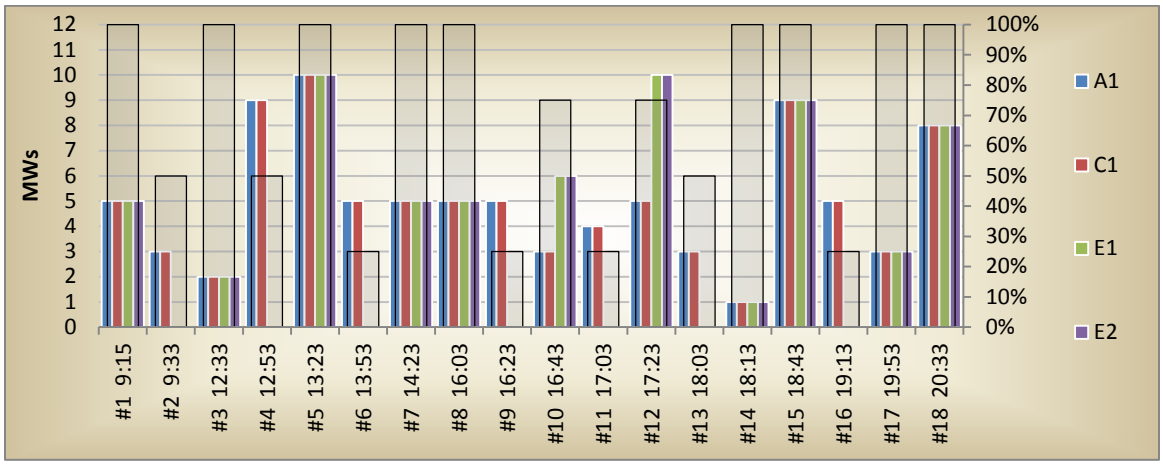
The model examined how aggregation management during basepoint dispatch will impact the compliance and financial outcomes for DSASP. The following scenarios are delineated by the different approaches utilized.

3.3.1.1 Strategy 1: Proportional Load Assignment

The most straightforward approach is to split the basepoint signal equally between all assets within an aggregation. Because the total registered capacity for the resource in this example is 40 MW and each asset has capacity of 10 MW, then each asset represents 25% of the whole. If a basepoint signal is received for 20 MW, then each asset would be assigned 5 MW. Figure 10 shows a hypothetical example demonstrating the equal MWs of load curtailment requested from assets A1, C1, E1, and E2.

Figure 10. Strategy 1: MW Delivered Per Asset and % Compliance

Note: The grey shaded bar shows the % compliance for the entire aggregation.



Behind the four colored bars in the bar chart is a shaded bar showing the % compliance for the entire aggregation. Compliance is measured for the whole resource and is used in the settlement process. The effects of the recovery constraint for E-type assets is apparent in dispatches 2, 4, and others. The effects of the response fatigue constraint are visible, for example, in dispatches 10 and 11.

For this scenario, the Proportional Load Assignment strategy resulted in a compliance score of 75%.

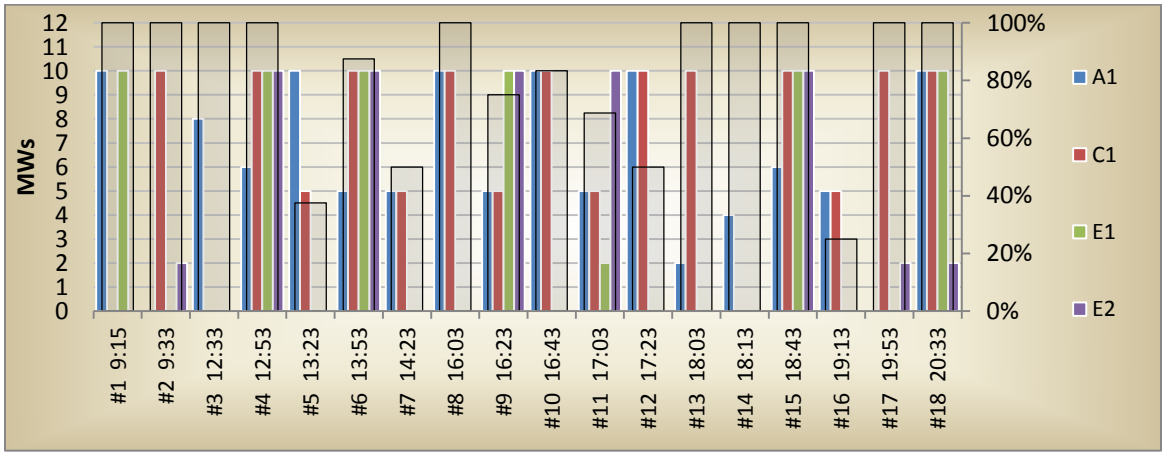
3.3.1.2 Strategy 2: Rotating Load Assignment

Another approach for allocating assets would be to have assets take turns with the objective of minimizing fatigue. To model this, the rules of assignment were (a) assign up to full capacity for each asset until the target is met, (b) assign first the asset with the oldest assigned-to time (the asset whose interval since their last dispatch was longest), and (c) give preference to A and C over E, while still

alternating between A1 or C1 and E1 or E2. For example, the dispatch amount in Event 1 was 20 MW so A1 and E1 were assigned for 10 MW each; in Event 2 with a dispatch of 12 MW, C1 was assigned 10 MW, and E2 2 MW.

Figure 11. Strategy 2: MW Delivered, Per Asset and % Compliance

Note: The grey shaded bar shows the % compliance for the entire aggregation.



The rotating load approach did improve compliance as intended. For the large MW events in rapid succession, events 5-6 and 15-16, the Proportional strategy resulted in 25% compliance for dispatch 6 whereas with the Rotating strategy the aggregation's compliance increased to 88%, for example.

By rotating load assignment, average compliance for all events was 83%, which compared favorably to 75% compliance of the proportional approach.

3.3.1.3 Strategy 3: Holding a Reserve

The Rotating Load strategy yielded a higher degree of compliance than the proportional approach, yet with compliance at 83% there is still some exposure to penalty. Granted we are analyzing performance under extreme circumstances, but those occurrences exemplified by the July 2013 heat wave are precisely what the demand-side ancillary services are intended to address. To that end, minimizing noncompliance is important.

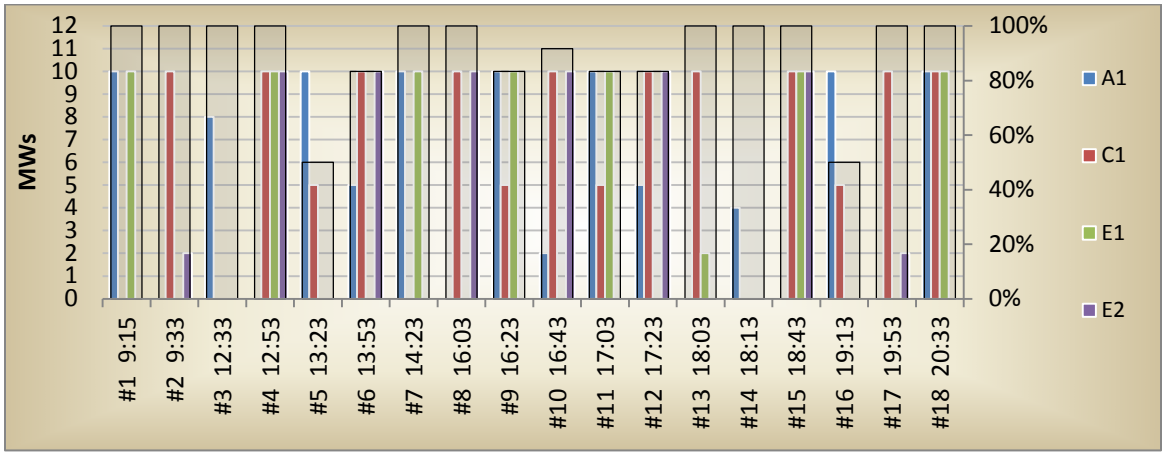
As a next step to further reducing the 17% noncompliance, we tried holding back a certain amount of capacity to have a reserve for an immediate subsequent dispatch, adding this to the Rotating Load strategy. Instead of bidding full curtailment capacity of the resource (40 MW) into the Day-Ahead Market

the effects of bidding only 30 MW were analyzed. With that bid amount the most that could be expected in basepoints from the NYISO would be 30 MW; at least one of the 10 MW loads would be held in reserve and ready to respond to the next event, even in the aftermath of a maximum dispatch.

This technique does have a positive impact on compliance as shown in Figure 12. For example, for event 5, rotating load combined with a 30-MW Day Ahead Market (DAM) bid cap, improved compliance from 38% to 50%.

Figure 12. Strategy 3: MWs Delivered, Per Asset and % Compliance

Note: The grey shaded bar shows the % compliance for the entire aggregation.



Fatigue is evident in the 90 minutes that encompass dispatches 8-12, the effect being partially alleviated by the use of a rotating load assignment. The additional impact of lowering the bid cap to 30 MW did improve aggregate compliance scores and reduced financial penalties for the last four dispatches in the series.[27]

Overall, the implementation of a 30 MW bid cap to utilize a 10 MW load reserve resulted in improved performance for seven events, no change in 10 events, and a worse compliance score in one event. Adding load backup to the strategy of rotating load assignment improved compliance from 83% to 92%.

[27] The improvement was also reflected in the financial penalties associated with this series of events: the creation of a 10 MW load reserve and the capped dispatch amount (30 MW bid cap) led to a reduction in the penalties from $4,950 to $1,913 for these five events.

3.3.1.4 Financial Outcomes Differ Between Strategies

Consideration of the best strategy for assigning load curtailment to the assets in an aggregation raises the question, "best" for what? So far this analysis has examined best in terms of optimizing compliance to NYISO's basepoints. It could easily be argued, however, that from the perspective of the asset owner and the resource provider, financial return is the most relevant objective.

As explained previously, the reserve standby payment makes up most of the benefit, from which are subtracted any penalties and a reduced make-whole arising from performance during events.

The financial outcomes for the three strategies are shown in Table 7. Average Real-Time Market Closing Price for 10-minute sync during dispatches are $450 per MWh, which resulted in $113 for each 15-minute event. A DAM clearing price of $4.06 per MW was used, resulting in reserve standby payment of $3,021 per MW per month.

Table 7. Financial Outcomes for Three Aggregation Strategies

	Strategy #1	Strategy #2	Strategy #3
Description	Proportional share for all assets. Bid full capacity.	Rotate assets over events. Bid full capacity.	Rotate assets over events. Bid 75% capacity.
# Assets	4	4	4
Capacity per Asset	10	10	10
Resource Capacity	40	40	40
Bid Amount	40	40	30
Reserve Standby Payment	$ 120,826	$ 120,826	$ 90,619
Compliance	75%	83%	92%
Penalty	$ (16,200)	$ (12,825)	$ (5,850)
Net for Month	$ 104,626	$ 108,001	$ 84,769

Rotating load assignment (Strategy 2) not only improved compliance – 83% vs. 75% – but also gave a better return – $108,001 vs. $104,626 – compared to proportional assignment (Strategy 1). The $3,375 savings in reduced penalties resulted from a single high constraint day.[28]

[28] Projecting the dispatch time in the analytical model to the actual dispatch time during 2013, the potential annual savings would be $9,887.

Strategy 3, which augmented Strategy 2 by holding a 10MW in reserve, did improve compliance from 83% to 92%. However, from a financial perspective, Strategy 3 signified a loss rather than a gain. Even reducing performance penalties by $6,975 did not offset the reduction in the reserve standby payment for 30 MW, which was $30,206 less than what it would have been for 40 MW.

In short, holding a reserve in Strategy 3 does improve the Rotating strategy (Strategy2) in terms of compliance, but it actually diminishes financial reward for the asset owner and resource provider.

3.3.1.5 Optimizing Compliance Competes with Financial Reward

In summary, any consideration for managed dispatch of an aggregation must include many considerations that are only evident upon modeling of the timelines of MW amounts of actual basepoint dispatches arising from constraint situations. The interplay between the abilities of each load, the recovery times, fatigue, and previous responsiveness will all play a role in the aggregation optimization that a DR Provider designs.

Interestingly, this analysis has disclosed that the best performing strategy is not the same as the one that yields most financial gain. In the future, DR programs that employ price responsive demand might achieve a closer alignment between reward and performance but until that time, the resource provider needs to balance those objectives.

4 Results and Conclusions

First, the project has augmented participation in DSASP and paved the way for the future. As intended, this project has substantially improved participation in NYISO's Demand-Side Ancillary Services program. Most concretely, one DR resource, Globe Metallurgical, was enabled to participate successfully in the project for well over a year. They have performed proficiently and have profited from their involvement in DSASP. The experience acquired in this first year has enabled us to refine procedures and methodology that can benefit future participants in DSASP. A second resource has now been registered by Demand Resource Partners and, as new resources are added by other market participants, NYISO's current cap of 150 MW for the DSASP program might soon be reached.

Second, the project has delivered communications innovations and business methods that promote DSASP participation. In addition to enrolling and managing an initial customer in DSASP, the project's other objectives were accomplished: (a) implementing direct, secure communication between NYISO control center and the customer's site and (b) creating a methodology to analyze risk for potential customers and a strategy for market participation.

Tangible results included:

1. Design, development, testing and validation of a low-cost RTU device that provides instantaneous, secure, 6-second telemetry from the customer meter to SmartCloud's servers at a price point below $2,000 and much less costly than telemetering used by generators which can cost more than $100,000.
2. Demonstrated a software solution that adheres to NYSIO-specified protocols as well as reliability and security stipulated by communications standards such as ICCP.
3. Software modules configured to handle dispatch signals, integrate 6-second telemetry, calculate response, handle workflow, and other functions that fulfill DSASP requirements.
4. User interfaces for Resource Owners and Market Participants to monitor performance, dispatches and receive event notifications.
5. Methodology to qualify resources as potential DSASP participants.
6. Methodology for analysis of risk that takes into account potential profit and loss according to types of dispatch, frequency of events, levels of compliance and other relevant parameters.
7. Demonstrated that real-time telemetry can be reliably and securely transported between demand-side resources and grid operators even for the most demanding of dispatch signals and transactions.

Nationally, demand response programs, driven by government policy, market forces and enabling technology, are trending Fast DR. DSASP exemplifies that trend and, in some ways, stands in the vanguard.

In particular, many of the rules and practices related to registration and participation of DSASP resources have been adopted verbatim from generation. That approach may have the advantage of expediting progress toward the vision of a restructured grid that includes distributed energy resources. However, the authors' experience reveals some loose ends. On one hand, not all of generation policies have been duplicated for demand-side ancillary services – absence of compensation for energy is a case in point. At the same time, it is worth questioning whether curtailment of load differs in some important ways from generation and those differences should be reflected in grid policies. For example, load has been shown to be curtailed quickly without the need to ramp up generation. By automatically managing smaller, aggregated loads, it should be possible to respond quickly and with flexibility to energy price spikes that reflect critical demand on the grid.

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