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Subcontractor Report

Aggregation of Distributed Generation Assets in New York State

Electrotek Concepts Inc.
Arlington, Virginia

New York State Energy Research and Development Authority
Albany, New York

National Renewable Energy Laboratory

1617 Cole Boulevard
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NREL Technical Monitor: Holly Thomas

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- "Aggregation of Distributed Generation Assets in New York State," NREL/SR-560-34779
- "Aggregation of Distributed Generation Assets in New York State: Appendix," NREL/SR-560-34780.

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Acronyms

ADC	Aggregation and Dispatch Center
DA	day-ahead
DAM	day-ahead market
DEC	Department of Environmental Conservation
DG	distributed generation
DMC	Data Collection and Management Center
EDRP	Emergency Demand Response Program
FO	Field Operation
ICAP	installed capacity
LIPA	Long Island Power Authority
LSE	load-serving entity
NYISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority
SCR	special case resource

Executive Summary

In a project jointly funded by the National Renewable Energy Laboratory of the United States Department of Energy and the New York State Energy Research and Development Authority (NYSERDA), Electrotek Concepts is demonstrating the technical and economic feasibility of aggregating distributed generating resources in New York State. This project demonstrates a system that allows distributed generation (DG) to participate in competitive markets in much the same way as large central-station power plants. This approach involves aggregating the distributed demand-side resources into a single transaction entity consistent with the requirements of the New York Independent System Operator (NYISO). This single entity then buys or sells capacity and energy (i.e., curtailment) in NYISO markets.

The objectives of this project are to develop and demonstrate the equipment and software necessary to aggregate, monitor, and dispatch multiple DG units. In this case, the DG units are local generators not interconnected with the bulk power system that provide curtailment to the NYISO markets. Under this scheme, Electrotek Concepts serves as a DG system aggregator and the agent for NYISO transactions.

The aggregation system collects operating data from field operations and the NYISO. In addition, the aggregation system is used to provide energy and capacity in NYISO electric markets. In other words, the proposed DG aggregation system will actually create a virtual generator that can be monitored and controlled over the Internet.

The project consists of tasks that develop the necessary system architecture and address and quantify the key technical and economic issues. Option Year One activities consisted of three project tasks.

1. In Task 6, the concept was tested via a pilot project on Long Island.
2. In Task 7, an evaluation of the available DG capacity in New York State was conducted, and 30 MW of DG capacity were recruited for commercial operation.
3. In Task 8, the DG aggregation system was designed and developed.

Each of these tasks is summarized below.

Task 6: Field Testing of Aggregated Backup Generator Control System

The objective of Task 6 was to confirm the technical viability of the concept that multiple DG units can be aggregated and dispatched to supply services in a competitive energy market. Several developments were pursued in this task.

The aggregated DG units were registered as a system resource with the NYISO. This designation allowed Electrotek to participate in the day-ahead market using the aggregated DG units as a single central generator. Ten facilities located on Long Island were recruited for participation in the field test. The total curtailable load of these sites was about 4.3 MW.

The system resource status required the installation of an interval meter and auxiliary monitoring equipment at each site and the development of a special protocol for the collection and transfer of these data to the NYISO. Electrotek worked closely with the NYISO to develop the metering and communications systems. Upon NYISO approval, the equipment was purchased and installed. The unit cost for the purchase and installation of the metering and communications systems is summarized below.

Item	Cost
InfoNode	$4,520
GE KV-2 meter (per generator)	$1,010
Code-activated switch	$500
ADAM module	$500
Relay	$250
KYZ Totalizer	$1,200
DSL telephone line	$300
Equipment installation	$4,650
Total average cost per site	$12,930

The total equipment and installation cost for the 10 sites was more than $130,000.

Because the sites were located in the Long Island Power Authority (LIPA) service territory, LIPA insisted that the sites be equipped with its own metering and communications systems. LIPA then sought cost recovery from Electrotek for expenses that would be incurred for the implementation of equipment supporting its preferred protocol. These costs were more than $149,000, and there were annual recurring costs of more than $95,000. The imposition of these significant costs doomed the schedule and economic viability of the proposed project and terminated the technical implementation. However, to test the viability of the market transactions of such an arrangement, a shadow market operation was developed to simulate the market transactions of the proposed system resource.

A control system—the DG aggregation system—for aggregation and centralized dispatch of distributed generators at 10 selected buildings was designed and implemented. The system included power-monitoring equipment installed on emergency generators and at the building service entrance at each site, data transmitting equipment, and a data collection and management center. To support operation of the DG aggregation system, a set of operating procedures for participation in the energy market was developed.

A field test was planned and executed during the NYISO summer 2002 capability period, May–September. Using actual hourly load data for the 10 participating sites, NYISO day-ahead prices for Long Island, NYISO real-time prices for Long Island, NYISO settlement procedures, and estimated LIPA delivery charges, Electrotek calculated the costs and revenues associated with being a direct customer bidding a price-capped load in the NYISO day-ahead market.

The shadow experiment demonstrated that the system resource concept on Long Island, although technically possible, was not an economically viable business model. However, the experiment did lead to the formulation of an engine management strategy that uses the aggregated DG units to modify the aggregate load of the system resource at the system coincident peak. Because the NYISO determines a customer's capacity requirement based on its load during the peak hour, this strategy allows a customer to eliminate or reduce its capacity requirement based on performance during the hour of the system peak. This is accomplished by dispatching the system resource generators during those hours that are likely to be the system peak hour.

In addition, the engine management strategy enables the aggregator to purchase low-cost energy in the energy market. The engines enable the strategy to work by eliminating the need to buy energy in NYISO Zone K (Long Island) during periods of high energy prices. The actual price at which the price cap is triggered is determined by algorithms developed to calculate the cost of energy produced by the aggregated DG units based on the temperature-humidity index and the forecasted site loads.

Task 7: Survey of Backup Generation in New York State

In Task 7, two activities were undertaken. Electrotek:

- Conducted an assessment of the potential for DG in New York State
- Recruited new customers with more than the 30 MW of curtailment needed for commercial demonstration of the concept.

To enable the evaluation of the opportunities for DG in New York, Electrotek engaged Power Systems Research of Eagan, Minnesota. Power Systems Research developed and provided to Electrotek a listing of DG resources in New York State. Using this listing, Electrotek formulated and conducted an analysis of the potential for DG in New York.

Analysis of the inventory shows that there is more than 3,582 MW of installed DG capacity across the state. Most of this capacity—2,896 MW, or 80%—is from reciprocating engines, with the balance from turbines. There were 10,542 generators of at least 100 kW of capacity in New York State listed in the database. Most of these generators were reciprocating engines, with turbines accounting for only 460 of the total. Across the state, the average capacity of a reciprocating engine was 285 kW, and the average turbine size was more than 1.5 MW.

The technical market potential for curtailment in New York consists of about 1,869 MW for participation in an emergency demand response program and special case resource market (reciprocating engines) and about 468 MW for participation in the energy and auxiliary services markets (turbines). A total technical potential of 2,338 MW of DG capacity can be bid into NYISO markets in New York State. This represents approximately 65% of the 3,582 MW of total DG capacity. Clearly, the stock of backup generators in New York is heavily weighted toward the NYISO emergency programs.

Thirty-eight buildings with a total installed backup generation capacity of 55.69 MW were selected for participation in the commercial operation. This installed capacity will be able to provide about 30 MW of curtailable load and is represented by three groups of buildings. The first group consists of buildings that participated in the pilot project (Task 6) and, thus, are fully equipped with the monitoring equipment. The second group includes buildings previously used by Electrotek in the Emergency Demand Response Program. These buildings are equipped with some monitoring equipment, usually electric meters at emergency generators. The third group does not have any monitoring equipment except for interval meters installed and read by a load-serving entity. To support the operation of backup generators in buildings from the second and the third groups with forecasting and historical data analysis capabilities imbedded in the aggregation Web site, building load and emergency generators output data will be modeled using interval meters data obtained from the load-serving entity.

Task 8: Design of Distributed Generation Aggregation System for Commercial Demonstration

The focus of Task 8 was to design a control center that could monitor the status of participating backup generators, conduct transactions with the NYISO, and dispatch distributed generators. It was found that rather than a single control center, an aggregation system should be developed to handle the multitude of functions required for commercial operation of the virtual power plant.

A DG aggregation system architecture was developed. The aggregation system includes three major elements: field operation (all participating generators with monitoring equipment), a data collection and management center, and an aggregation and dispatch center. All these parts are connected together through a DG aggregation Web page.

The DG aggregation Web page is the focal point of all information flows and contains a portfolio of computer tools, manuals, and procedures. These tools were designed to conduct and support the activities of the DG aggregation system. All of the elements and the entire DG aggregation system were tested using a pilot operation of 12 generators with a total capacity of 4.5 MW. The current system has 58 participants and a total capacity of 38 MW.

Conclusions

The project accomplishments have been both broad and significant. In this effort, Electrotek has proved the technical and financial viability of DG aggregation in several NYISO programs. In achieving these objectives, Electrotek has designed and tested a DG aggregation system that has demonstrated the concept. As a part of this system demonstration, Electrotek has developed a portfolio of tools used in the bidding process, including a load-forecasting model, a generator cost model, and a dispatch optimization model. Using these tools, Electrotek has formulated an engine management strategy that ensures the cost-effective bidding and dispatch of curtailment resources.

Because of the problems posed by LIPA’s demand for metering and communications protocols not required by NYISO for a system resource, Electrotek conducted a shadow experiment to evaluate the economic merit of a 10-site, 4.3-MW aggregation. The economics of this shadow experiment were marginal. Although there were substantial savings on energy costs, the burdens imposed by delivery charges significantly compromised the financial incentives.

Based on a market study, Electrotek has estimated a technical potential of 2,338 MW of curtailment in New York State. Approximately 468 MW might be able to participate in NYISO energy and ancillary services markets. It should be noted that this technical potential does not consider the economics of their participation, only the technical potential to do so.

Table of Contents

Table of Figures

Table of Tables

1 Project Background

The New York Independent System Operator (NYISO) is responsible for the administration of the wholesale electric power markets in New York State and for the operation of New York State's bulk power system. In this role, the NYISO has segmented the state into 11 geographic zones. These zones are shown in Figure 1. All NYISO capacity and energy market prices are calculated by zone.

Figure 1. NYISO zones

New York State's bulk power system is facing serious capacity deficiencies, particularly in New York City and Long Island, zones J and K respectively. This is reflected in the capacity and energy prices of these zones.

According to NYISO in its "Power Alert III" report, "The future outlook for adequate, efficient, and environmentally friendly generation is bleak."[1] Also according to NYISO, New York State load is expected to increase from 31,450 MW to 33,800 MW between 2003 and 2008. Thus, to maintain current levels of reliability (i.e., to maintain an 18% reserve margin), an additional 2,360 MW of generation are needed.[2]

1 New York Independent System Operator. "Power Alert III." May 2003; p. 10.
2 New York Independent System Operator. "Power Alert III." May 2003; p. 24.

In response to this, the NYISO has developed three programs to allow demand-side resources the opportunity to participate in wholesale power markets. The first of these is the Day-Ahead Demand Response Program, the second is the Emergency Demand Response Program (EDRP), and the third is the NYISO Installed Capacity (ICAP) Special Case Resource (SCR). These programs allow load curtailment or local (behind the fence) generation to participate in wholesale power markets by providing load relief on a day-ahead basis (Day-Ahead Demand Response Program) or during system emergencies (SCR and EDRP). With New York State Energy Research and Development Authority (NYSERDA) support, these programs have proved remarkably successful in providing load relief to the NYISO during high load periods.[3]

The SCR program pays participating customers to provide curtailment for a specified contract period. Participants receive capacity payments in advance for agreeing to reduce consumption by the contract amount during periods in which system operating reserves are deficient.

The EDRP pays participants to reduce energy consumption upon notification from the NYISO. Participants are paid for verified load reductions at the real-time energy market settlement price if called. Hourly curtailments are determined using a baseline load, defined as the average hourly load of the customer of the five highest days over a 10-day period preceding the curtailment call. Curtailments are called based on bid prices and capacity requirements.

The Day-Ahead Demand Response Program allows customers to bid load reductions into the day-ahead market (DAM). Curtailment bids are evaluated along with generator bids in the NYISO Security Constrained Unit Commitment Program. If scheduled, curtailments are paid the day-ahead (DA) locational-based marginal price.

The demand response programs have proved to be very effective. In 2001 and 2002, the NYISO called on SCR and EDRP customers on eight occasions: August 7–10, 2001, and April 17 and 18, July 30, and August 14, 2002. In 2001, demand response programs reduced peak demand by an average of more than 1,000 MW; in 2002, peak load reductions averaged 650 MW. Clearly, these programs have had a significant positive effect.

Under contract to NYSERDA and the National Renewable Energy Laboratory, Electrotek has proposed to aggregate distributed demand-side resources and offer these resources in New York energy markets, conducted a demonstration project with 10 sites to test the validity and viability of a single aggregated resource on Long Island, and designed and implemented a distributed generation (DG) aggregation system.

In the development of this concept, Electrotek worked to ensure compliance with all pertinent NYISO and New York Department of Environmental Conservation (DEC) requirements. In addition, Electrotek worked closely with the NYISO to solicit recommendations regarding the system implementation. The NYISO was very supportive and cooperative in this process.

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[3] All these programs are discussed in detail in Section 3 and in the Task 7 report in Aggregation of Distributed Generation Assets in New York State: Appendix.

2 Field Testing of Aggregated Backup Generator Control System

These activities were conducted under Task 6, "Field Testing of Aggregated Backup Generator Control System," which consisted of conducting a field test of the DG aggregation system. The Task 6 report can be found in the companion document "Aggregation of Distributed Generation Assets in New York State: Appendix."

Under this task, Electrotek developed a system to monitor and dispatch DG units at 10 sites on Long Island. As part of the field test, Electrotek aggregated these sites and registered them with the NYISO as a single transaction entity. This entity, a system resource, was the first of its kind at the NYISO. A "system resource" is a portfolio of capacity (or curtailments) provided by resources in a single NYISO zone. These resources are controlled as a single entity.

The first step in Task 6 was to identify and solicit the participation of customers for the field test. Because of the severity of the capacity issues in New York City and Long Island, the search was confined to two areas: NYISO zones J and K. For the field test, 10 customers were enlisted, all of which were located on Long Island. Table 1 summarizes the sites.

Table 1. Participating Sites

Site	Peak Load (kW)[a]	Curtailment (kW)[b]	Installed DG Capacity (kW)[c]
1	800	800	1,500
2	880	880	1,500
3	500	500	750
4	500	500	1,000
5	100	100	200
6	500	500	1,000
7	230	230	435
8	100	100	200
9	100	100	200
10	500	500	750
Total		**4,210**	

[a] Peak load – maximum electrical demand of the building

[b] Curtailment – part of building load that can be curtailed by emergency generators

[c] Total installed capacity of emergency generators

As shown in the table, all the sites are able to provide complete curtailment (i.e., the backup generators are able to carry the full site load).

After successfully recruiting participants, Electrotek registered them as a system resource. NYISO rules require a system resource that has sold its capacity in the NYISO ICAP market to participate in either the energy or ancillary services markets. Electrotek was then prepared to offer these resources in the ICAP market and bid them in the DAM.

Electrotek worked closely with the NYISO to establish the first system resource and develop the metering and communications systems. Upon NYISO approval, the equipment was purchased and installed. The unit cost for the purchase and installation of the metering and communications systems is summarized below.

- InfoNode $4,520
- GE KV-2 meter (per generator) $1,010
- Code-activated switch $500
- ADAM module $500
- Relay $250
- KYZ Totalizer $1,200
- DSL telephone line $300
- Equipment installation $4,650
- Total average cost per site $12,930

Metering and communications equipment was procured and installed, and communications protocols were developed with the NYISO to satisfy all NYISO technical requirements. The total equipment and installation cost for the 10 sites was more than $130,000.

However, the Long Island Power Authority (LIPA) did not accept this protocol. LIPA did not support the metering and communications systems and protocols agreed on by the NYISO and Electrotek. LIPA insisted that only its own systems would be appropriate. LIPA's position made the establishment of the system resource impossible. LIPA sought cost recovery from Electrotek for expenses for installing equipment supporting its preferred metering and communications protocol and for providing the meter reading services to support the system resource. These costs were more than $149,000, with annual recurring costs of more than $95,000. These additional costs doomed the financial viability of the system resource. In addition, the scheduling of the installation of this equipment would not allow the project to be implemented during the summer 2002 capability period.

Because of this, Electrotek devised an alternative approach to test the viability of aggregated DG in NYISO market transactions. This approach was to establish a shadow experiment. Under this scheme, the 10 sites were aggregated and treated as a direct customer at the NYISO. As a direct customer, the10 aggregated sites purchase all capacity and energy directly from the NYISO when it makes economic sense to do so. LIPA only provides distribution services.

The idea behind this approach is to purchase energy from the NYISO when the locational-based marginal price is less than the generation cost of the sites. Thus, under the shadow experiment, when DA energy prices exceed generation cost, power at the sites is provided by self-generation.

Under this approach, Electrotek developed a portfolio of three planning models to manage and conduct the bidding process. These are:

- The load forecasting model
- The generator cost model
- The dispatch optimization model.

Each of these is detailed below.

2.1 Load Forecast Model

To determine the loads of the 10 sites, Electrotek developed a load forecast model for each location. This forecast tool is a linear regression model that uses the forecast of the hourly ambient temperature and humidity to estimate hourly loads for each site.

The regression model was developed by Electrotek to provide a reasonable hourly load forecast for each of the 10 locations. Electrotek then planned to use this forecast along with other data to estimate generation costs. The regression equations were created using one year of historical hourly ambient temperature and humidity data as well as hourly load data for each location.

The regression equations were specifically targeted toward those hours when the DG resources would most likely be operating: between 8 a.m. and 6 p.m. It is during these hours that most load variation occurs. Hence, the regression equations were tuned to this period to more accurately capture the load variation more directly attributable to the temperature and humidity index.

2.2 Generator Cost Model

The generator cost model was developed to calculate the hourly cost of operating the generators at each site. This cost is the variable cost of generation (i.e., fuel and variable operation and maintenance costs). The generator cost model calculates the generator load as a percentage of generator capacity based on the load forecast model for each location. Two adjustment factors are then applied. These adjustment factors provide an improved basis for calculating the running costs of the generators.

The first adjustment factor is the load adjustment, which accounts for generator performance changes observed at various levels of output. The performance of generators changes based on the output level of the generator. This relationship between output level and efficiency is effectively the heat-rate curve, which correlates electrical output and fuel consumption levels.

The second adjustment factor reflects the relationship between the generator output and the ambient temperature. The load on gas turbines is especially sensitive to ambient temperature. As ambient temperature rises, the output of the gas turbine decreases.

Using the hourly generator performance data described above along with the operation and maintenance cost and the fuel cost, the generator cost model calculates the hourly variable cost of operating each generator. These hourly running costs are then used to develop the hourly bid costs in the dispatch schedule model described below.

2.3 Dispatch Optimization Model

Bidding in the DAM as a direct customer is conducted for the aggregated sites in three blocks. Each block is bid separately and must be at least 1 MW. Thus, three bid prices are calculated for each hour. The specific sites associated with each of the blocks are determined by the dispatch optimization model.

Once site loads and running costs are determined, the dispatch optimization model is used to determine how to combine the sites into three separate blocks for purposes of bidding their capacity (or curtailment) in the NYISO DAM. Because each site's loads and running costs vary by hour, determining how to combine them in the most efficient (i.e., least-cost) way becomes a daunting task. For each day, 720 potential combinations (10 sites x 24 hours x 3 blocks) need to be evaluated.

To streamline the calculation process for determining how to define the sites into the three blocks, Electrotek developed an optimization model that calculates the least-cost combination of resources. This is done to increase the likelihood of the DAM bids being accepted. A flowchart of the model is presented in Figure 2.

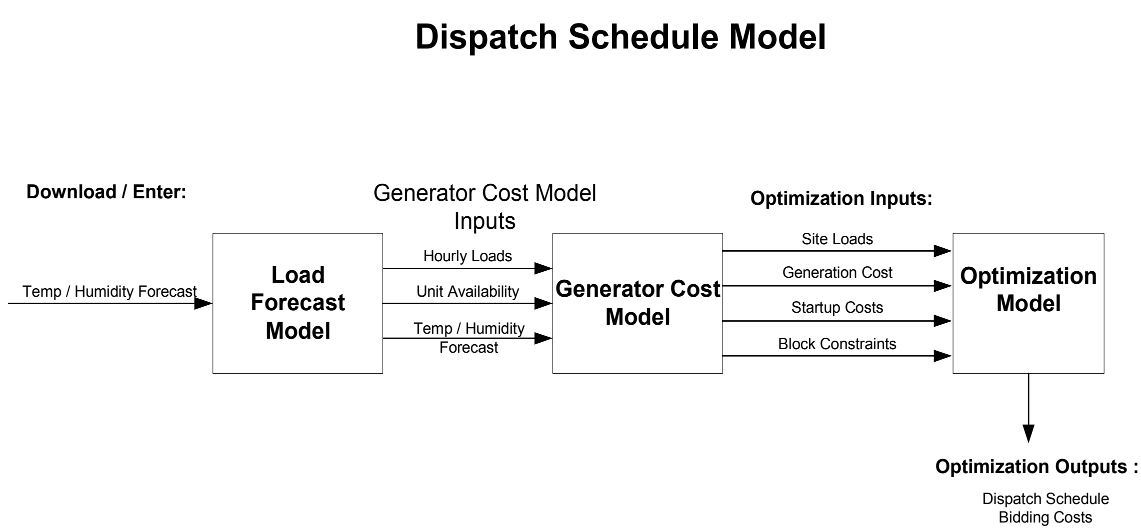

Figure 2. Dispatch optimization model

The DAM bidding procedure consists of a series of steps that must be undertaken in order each day. These steps include developing the bid costs and preliminary operating schedules, submitting the bids to the NYISO, and then, if the bids are accepted in the DAM, forwarding the dispatch schedules to the sites. Figure 3 shows the steps followed to develop and submit the hourly bid prices.

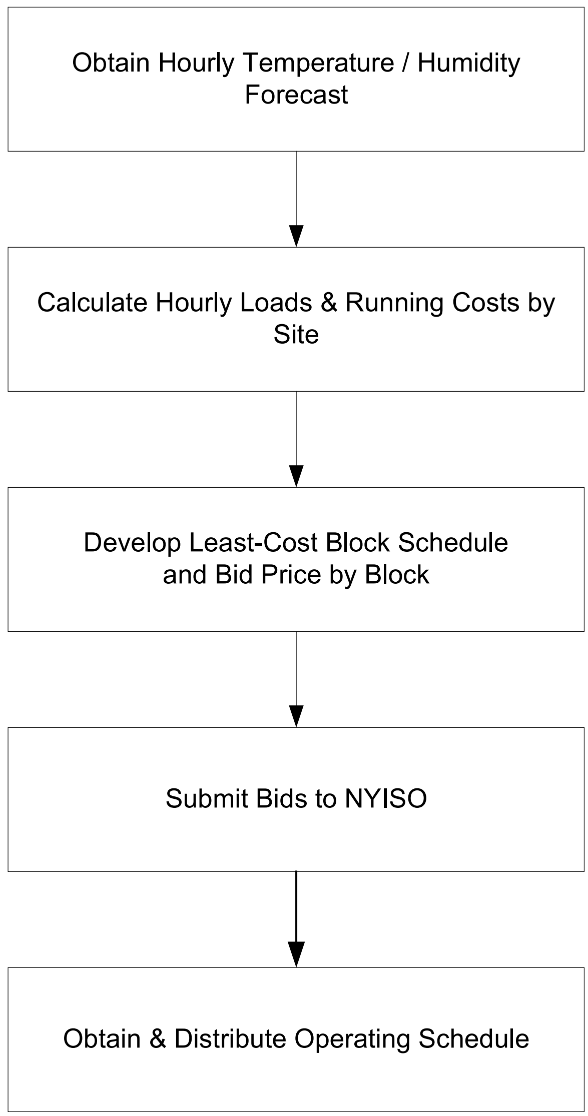

Figure 3. Bidding procedure

Under NYISO market procedures, DA bids must be received by 5 a.m. They are then evaluated in the NYISO Security Constrained Unit Commitment program. Under this program, the NYISO dispatch schedule is developed and forwarded to all market participants by 11 a.m.

2.4 Shadow Experiment Results

The results of the shadow experiment were evaluated for the period July–October 2002. Delays in the development of the system resource and its final demise did not allow for the inclusion of May and June in the shadow experiment.

The basis of the shadow experiment was to evaluate the hourly cost of self-generation at each of the 10 sites based on forecasted hourly temperature and humidity, to group these sites into three blocks to satisfy NYISO bidding requirements (1 MW minimum block size), and to place daily bids to purchase power from the NYISO based on the bid prices. When DAM prices are lower than a block's bid price, the energy for that block is purchased from the DAM. For those hours when the DAM price is greater than the block bid price, the energy for that block is self-generated.

Using hourly load forecasts for each of the 10 sites, NYISO DA prices for Long Island, NYISO real-time prices for Long Island, NYISO settlement procedures, and estimated LIPA delivery charges, Electrotek calculated the costs and revenues associated with being a direct customer bidding a price-capped load in the NYISO DAM. The Task 6 report, available in "Aggregation of Distributed Generation Assets in New York State: Appendix," details the market mechanics and bidding process.

The calculation of the total cost to provide the 10 sites with power under a price-capped load bid as a direct customer consists of several components. These include:

- The DA hourly price of electricity in the NYISO market for Zone K (Long Island)
- The hourly running costs of the generators at each of the sites based on hourly temperature, humidity, and load forecasts
- The LIPA delivery charge for the energy purchased from the NYISO
- The LIPA delivery charge for the energy curtailed through self-generation
- The real-time hourly price of electricity in the NYISO market for Zone K.

The real-time hourly electricity price is used to reconcile the energy contracted for versus the energy bought or sold. Variances between the values contracted for (either for purchase or sale) and the amount actually used or delivered are settled at the hourly real-time rate by the NYISO. This reconciliation is part of the NYISO settlement process. This reconciliation accounts for variances between the forecasted loads and actual loads.

Table 2 shows the average bid prices by block for each month of the shadow experiment. It should be noted that the sites constituting each block changed daily based on the dispatch optimization program. This program was run daily to ensure that the block assignments were the lowest-cost combinations. As shown in Table 2, the bid prices were fairly uniform, with the lowest-cost block typically bid at about $230/MWh and the highest-cost block bid at about $250/MWh.

Table 2. Average Hourly Bid Prices
($/MWh)

Block	Jul	Aug	Sep	Oct
Block A	230.93	252.86	252.71	246.59
Block B	246.20	228.47	234.68	231.08
Block C	248.50	247.11	263.95	244.02

In Table 3 are the minimum, maximum, and average DA prices for Long Island for July–October. As shown in Table 3, the DA prices were significantly higher for July and August than for September and October. It should be noted that the generators operated only in July and August; during September and October, all energy for the direct customer was purchased from the NYISO.

Table 3. Day-Ahead Prices – Long Island
($/MWh)

Month	Min	Max	Avg
Jul	21.68	498.06	64.36
Aug	21.10	599.75	67.95
Sep	21.19	198.46	50.18
Oct	19.05	148.46	47.91

Table 4 shows the hours of self-generation for each of the blocks bid in the DA market. As shown in Table 4, August had the most curtailment hours, with each of the three blocks operated at least 16 hours. In July, there were 5 days when some or all of the sites provided self-generation: July 2, 3, 16, 18, and 23. In August, there were 6 days: August 2 and 13–16.

Table 4. Hours of Self-Generation

Block	Jul	Aug	Sep	Oct
Block A	6	16	0	0
Block B	5	19	0	0
Block C	10	18	0	0
Total	**21**	**53**	**0**	**0**

The amount of self-generation by month and block is presented in Table 5. As shown in the table, in the shadow experiment more than 95 MWh of electricity were provided through self-generation during the evaluation period.

Table 5. Megawatt-Hours of Self-Generation

Block	Jul	Aug	Sep	Oct
Block A	12	23	0	0
Block B	5	27.6	0	0
Block C	10	18.1	0	0
Total	**27.0**	**68.7**	**0**	**0**

When evaluating the cost-effectiveness of being a direct customer, a number of factors come into consideration. These include the energy cost, the capacity cost, the distribution delivery charges, the real-time reconciliation charges (accounting for any variance between what is bid and what is delivered), and revenue associated with the sale of curtailments.

Customers taking distribution service in the LIPA service territory must pay an energy delivery charge. This charge applies not only to energy delivered by LIPA but also to energy supplied through self-generation. All investor-owned utilities in New York State are required to post their delivery charges under tariff. However, because LIPA is a public authority and not under the purview of the New York State Department of Public Service, it is not required to post a tariff delivery charge.

During the summer 2002 capability period, this charge would be negotiated between LIPA and the customer. Attempts to obtain a value for this charge from LIPA were unsuccessful. Thus, for purposes of the shadow experiment, three distribution service charges were evaluated: a low, a medium, and a high. For the summary presented here, the medium charge is used, which is based on the distribution charges found at other New York utilities: $55/MWh.

Table 6 presents a summary of the total cost and revenue associated with the shadow experiment. The total energy is the sum of the loads for all 10 sites by month. The energy cost is the cost of purchasing energy in the DAM, the generating cost during those hours when the DA price is greater than the bid price, and the LIPA delivery charge for the total site load. The revenue numbers represent the sale of curtailments to the NYISO during those periods when the DA price was greater than the bid price. For those hours, the revenue is equal to the DA price for Long Island times the load for each block.

Table 6. Shadow Experiment Summary

	Jul	Aug	Sep	Oct	Total
Total energy (MWh)	3,144	3,111	2,844	2,683	11,781
Total DA energy cost ($)	172,130	174,343	144,506	142,600	633,580
Total DA revenue ($)	9,661	26,317	0	0	35,978
Real-time reconciliation ($)	979	-147	0	0	832
Total energy cost ($)	161,490	148,173	144,506	142,600	596,770
Avg. energy cost ($/MWh)	51.37	47.63	50.81	53.15	50.65
LIPA delivery charge ($55/MWh)	172,902	171,087	156,407	147,572	647,968
Avg. total cost ($/MWh)	106.36	102.62	105.81	108.15	105.66

As shown in Table 6, the average energy cost is $105.66/MWh. Clearly, the effect of the LIPA delivery charge is significant—roughly equal the cost of energy. The shadow experiment demonstrated that the concept, although technically possible, is not an economically viable business model.

3 Survey of Backup Generation in New York State and Recruitment of 30 MW Capacity for Commercial Demonstration

The objectives of Task 7 were to provide an assessment of the potential for DG in New York State and to recruit 30 MW of generation for participation in the commercial demonstration of DG. The use of DG to support the bulk power system holds promise. However, the specific roles for DG—whether it participates in emergency programs, DAMs, or ancillary services markets—depend on the type of generating asset, its location, and the fuel used.

For this assessment, Electrotek engaged Power Systems Research of Eagan, Minnesota, to develop and provide a database of DG resources in New York State. Using this database, Electrotek then conducted an analysis of the DG potential of New York. The full Task 7 report is provided in the companion document "Aggregation of Distributed Generation Assets in New York State: Appendix."

To evaluate the potential of DG capacity in New York, one must first consider the markets in which these resources would participate. In New York wholesale power markets, DG has been aggressively pursued. The deployment of DG resources for load curtailment has been successfully used in New York with the EDRP and the Day-Ahead Demand Response Program. The EDRP market was critical in maintaining system reliability in the summer of 2001 and 2002 and has been recognized as one of the most effective curtailment programs in the country. This has been driven by the capacity situation in New York and particularly in New York City. Although there is a large number of emergency and backup generators in New York, many are diesel fuel-fired internal combustion and turbine units with high emission levels. Compounding this problem is the fact that these resources are most likely to be called on during peak load periods characterized by high temperatures and humidity, thus exacerbating an already severe pollution problem.

Electrotek has developed an aggregation and dispatch system for DG that is well suited for the institutional and regulatory environment of New York State. This system can be used for nearly all qualified generating assets in any number of NYISO programs and markets. With this system, DG units are able to participate in the emergency programs, the ICAP market, the energy market, and the ancillary services market. This flexibility makes the aggregation system a key component of bringing DG to the marketplace and helping mitigate the reserve shortfalls in New York State's bulk power system.

3.1 Survey of Backup Generation in New York State

There are four markets in the NYISO in which DG resources can participate. These are the ICAP market, the energy market, the ancillary services market, and the emergency demand reduction program. These are all administered by the NYISO in accordance with rules detailed in the Open Access Transmission Tariff and numerous NYISO manuals. The markets are summarized below.

3.1.1 ICAP Market

The New York ICAP market has two 6-month planning cycles, or capability periods: the winter capability period from November through April and the summer capability period from May through October. Each capability period begins with a 6-month strip auction, which is followed by a series of six monthly capacity auctions and, if necessary, monthly deficiency auctions to provide a market for load serving entities (LSEs) that have not met their ICAP requirement.

Registered ICAP resources in New York State face a number of technical and regulatory requirements. First, all ICAP resources must be in full compliance with New York DEC registration and emissions regulations. These resources must be registered with DEC with a state facilities permit, a Title V registration, or an air facilities registration. Each of these classifications places a cap on total emissions for the facility. In addition, all ICAP resources that are sold in New York either bilaterally or in NYISO markets must be certified with the NYISO on a monthly basis. This certification is the process through which all transactions are registered with the NYISO and provides a basis for determining whether these ICAP resources have satisfied their transaction obligations. For most ICAP resources, there are also maintenance scheduling requirements and outage reports that must be filed with the NYISO. This ensures that all certified capacity that is not in service because of maintenance or outage is reported as unavailable to the NYISO. Finally, there are operating data reporting requirements for all resources.

There are six types of ICAP resources in the NYISO. These are:

- Generators and system resources
- Energy limited resources
- Interruptible load resources
- Municipally owned generation
- SCRs
- Intermittent power resources.

With the exception of SCRs, energy limited resources, and intermittent power resources, all ICAP is obligated to bid in the energy or ancillary services market on a daily basis.

One characteristic of the ICAP market that should be noted is that all ICAP resources have their capacity adjusted based on their performance. This adjusted capacity, or unforced capacity, is provided by the NYISO to suppliers based on the reported performance of the resource over the previous year. Thus, if an ICAP resource provides all the capacity it has bid in the ICAP market, its adjustment factor is 100%; if only half the bid capacity is provided, the unforced capacity value is 50%. When bidding resources, suppliers can only bid their unforced capacity values.

3.1.2 Energy Market

The energy market consists of the DAM and real-time market and the DA demand response program. In the DAMs, the NYISO schedules successful bidders with a program called Security Constrained Unit Commitment, which is an optimization program that minimizes the total production cost of serving load while satisfying all reliability and generator performance constraints such as ramp rates, minimum run times, and start-up costs.

The real-time energy market is used to reconcile the DA dispatch schedules, which are based on forecasted loads, with the actual loads. In New York State, the real-time market accounts for roughly 5% of the total energy of the system. It serves as a balancing market.

3.1.3 Ancillary Services Market

Ancillary services are those services that support the transmission of energy from generators to loads. In the NYISO, there are six ancillary services. Three of these (regulation and frequency response, operating reserves, and energy imbalance) are market-based, and the other three (scheduling and system control, voltage support, and black start) are provided by the NYISO and paid for through embedded costs.

The DG resources considered here are not interconnected with the grid. Hence, the only ancillary service they are able to provide is operating reserves. Operating reserves provide backup generation in the event of equipment failure, when there would otherwise be insufficient capacity to serve load. Three types of reserves are sold in the NYISO ancillary services market. These are:

- 10-minute spinning reserves – operating reserves provided by generators and interruptible/dispatchable load resources located within the New York Control Area that are already synchronized to the New York State power system and can respond to instructions to change output level within 10 minutes
- 10-minute non-synchronized reserves – operating reserves provided by generators that can be started, synchronized, and loaded within 10 minutes. These reserves are carried on quick-start units such as gas turbines
- 30-minute spinning reserves – 30-minute spinning reserves provided by generators and interruptible/dispatchable load resources located within the New York Control Area that are already synchronized to the New York State power system.

Curtailable loads that are not SCRs, energy limited resources, or intermittent power resources are able to participate in the ancillary service reserve markets. As is the case with generators, they must be registered and certified in the ICAP market before participating in the ancillary services market.

3.2 Generator Database

Using a database of backup generators provided by Power Systems Research, Electrotek conducted an analysis to determine the potential for DG in New York State. The Power Systems Research database included the county, capacity of the unit, type of generator, fuel type, vintage, and type of business the owner of the generator is engaged in.

A careful review of the database revealed some omissions of generators known to Electrotek. Although these omissions cannot be dismissed, it is not believed that they materially diminish the value of the data obtained. Although not all-inclusive, the database is the most comprehensive accounting of DG resources in New York State that could be found.

The original database listed DG resources of all sizes, including units as small as 10 kW. For the purposes of this study, any units less than 100 kW of capacity were excluded. This is because the minimum size of units allowed to participate in the NYISO programs, EDRP and SCR, is 100 kW.

Tables 7 and 8 show the total generating capacity and number of DG units with capacity of 100 kW or more by generator type and county, respectively. A compilation of the data found more than 3,582 MW of capacity across the state. Most of this capacity—2,896 MW, or 80%—is from reciprocating engines, with the balance from turbines. There were 10,542 generators of at least 100 kW of capacity listed in the database. Of these, most were reciprocating engines. Turbines accounted for only 460 of the total. Across the state, the average capacity of a reciprocating engine was 285 kW, and the average turbine size was more than 1.5 MW.

Nine counties in New York had a total DG capacity of more than 100 MW. These counties were Dutchess, Erie, Kings, Monroe, Nassau, New York, Queens, Suffolk, and Westchester. Erie County in upstate New York had the most capacity with 124 MW. The remaining counties are located in the New York City and Long Island areas—areas that have capacity deficiencies.

Table 7. New York State DG Resources Installed Capacity (MW)

New York State DG Resources - MW											
County	**Recip**	**Turbine**	**Total**	**County**	**Recip**	**Turbine**	**Total**	**County**	**Recip**	**Turbine**	**Total**
Albany	50.2	16.3	66.5	Herkimer	29.7	8.7	38.4	Richmond	42.9	12.1	55.0
Allegany	29.5	4.9	34.3	Jefferson	31.6	9.6	41.2	Rockland	55.2	9.2	64.3
Bronx	76.9	18.1	95.0	Kings	83.5	21.2	104.7	Saratoga	39.4	6.8	46.2
Broome	52.3	11.1	63.4	Lewis	35.3	8.6	43.9	Schenectady	59.6	15.5	75.0
Cattaraugus	70.9	18.4	89.3	Livingston	41.4	8.9	50.3	Schoharie	30.0	4.8	34.8
Cayuga	36.7	8.5	45.3	Madison	38.0	9.7	47.8	Schuyler	21.6	7.3	28.9
Chautauqua	73.4	24.9	98.3	Monroe	84.4	24.2	108.6	Seneca	19.7	8.0	27.7
Chemung	37.7	4.7	42.4	Montgomery	35.5	5.0	40.5	St. Lawrence	49.0	13.6	62.7
Chenango	34.5	7.0	41.5	Nassau	89.2	22.1	111.3	Steuben	27.9	14.7	42.6
Clinton	33.1	9.0	42.1	New York	87.9	21.3	109.2	Suffolk	89.7	28.0	117.7
Columbia	31.4	4.4	35.8	Niagara	69.2	15.2	84.4	Sullivan	56.8	13.1	69.9
Cortland	35.3	6.0	41.3	Oneida	56.8	14.5	71.2	Tioga	29.5	2.5	32.0
Delaware	35.1	7.1	42.2	Onondaga	77.6	20.4	98.0	Tompkins	31.2	10.5	41.7
Dutchess	85.2	23.1	108.3	Ontario	41.5	5.9	47.4	Ulster	37.6	12.8	50.4
Erie	90.4	33.5	124.0	Orange	62.4	13.6	76.0	Warren	35.8	6.0	41.8
Essex	34.3	8.3	42.5	Orleans	32.9	3.0	35.9	Washington	20.3	6.2	26.5
Franklin	34.6	9.4	43.9	Oswego	39.4	6.8	46.2	Wayne	24.8	5.5	30.3
Fulton	30.6	9.4	40.0	Otsego	35.3	7.5	42.7	Westchester	89.0	27.1	116.1
Genesee	31.7	7.1	38.8	Putnam	32.1	6.0	38.1	Wyoming	25.9	6.4	32.4
Greene	22.0	4.9	26.9	Queens	85.9	24.2	110.1	Yates	6.1	0.0	6.1
Hamilton	22.2	4.9	27.1	Rensselaer	40.2	5.7	45.9	**Total**	**2,869.8**	**712.9**	**3,582.7**

Table 8. New York State DG Resources - Number of Generators

New York State DG Resources - Generators											
County	**Recip**	**Turbine**	**Total**	**County**	**Recip**	**Turbine**	**Total**	**County**	**Recip**	**Turbine**	**Total**
Albany	160	11	171	Herkimer	107	5	112	Richmond	151	7	158
Allegany	110	3	113	Jefferson	115	6	121	Rockland	199	7	206
Bronx	271	12	283	Kings	293	15	308	Saratoga	140	5	145
Broome	185	8	193	Lewis	121	5	126	Schenectady	204	10	214
Cattaraugus	245	14	259	Livingston	146	6	152	Schoharie	107	3	110
Cayuga	131	6	137	Madison	135	5	140	Schuyler	72	5	77
Chautauqua	253	16	269	Monroe	299	15	314	Seneca	64	6	70
Chemung	135	3	138	Montgomery	125	4	129	St. Lawrence	179	8	187
Chenango	122	5	127	Nassau	315	14	329	Steuben	96	7	103
Clinton	117	5	122	New York	309	14	323	Suffolk	316	15	331
Columbia	111	4	115	Niagara	245	9	254	Sullivan	200	10	210
Cortland	132	4	136	Oneida	201	9	210	Tioga	108	2	110
Delaware	123	5	128	Onondaga	277	14	291	Tompkins	110	7	117
Dutchess	288	14	302	Ontario	145	5	150	Ulster	128	8	136
Erie	318	16	334	Orange	220	10	230	Warren	129	4	133
Essex	122	6	128	Orleans	116	2	118	Washington	78	4	82
Franklin	120	6	126	Oswego	141	4	145	Wayne	89	4	93
Fulton	104	6	110	Otsego	119	6	125	Westchester	311	17	328
Genesee	113	5	118	Putnam	114	3	117	Wyoming	91	5	96
Greene	83	3	86	Queens	299	14	313	Yates	13	0	13
Hamilton	70	4	74	Rensselaer	142	5	147	**Total**	**10,082**	**460**	**10,542**

The extent of DG participation in these markets is dependent on a number of factors. These include the installed DG capacity, the actual load served by the DG capacity, the economic incentives for DG in the marketplace, and the environmental characteristics of the DG resources. In New York, diesel-fired generation is not allowed to participate in the DAMs.

To estimate the generating capacity available in New York for participation in NYISO markets, several factors must be considered. Under current NYISO rules, reciprocating engine generators are not eligible to participate in energy or ancillary services markets. Thus, reciprocating engine generators will only be eligible to participate in the NYISO EDRP and in the ICAP market as SCRs and only after they have been registered with DEC.

Turbine generators can participate in energy and ancillary services markets if they satisfy all appropriate DEC and local permitting requirements. For DEC, this would most likely involve a state facilities permit, which would cap nitrogen oxide emissions at 12.5 tons per year. Larger facilities would require a Title V permit, though the turbines included in this study—the largest of which is 2.6 MW—would not warrant such a permit. In this analysis, the turbine generators are considered only for the energy and ancillary services markets because these offer the greatest financial incentives.

The generator database provided the company SIC code for each unit. Using this, Electrotek examined these resources by industry-specific characteristics. Different industries have different requirements for the amount of backup generation needed. For example, certain facilities—such as financial institutions, telecommunication centers, and data processing centers—typically need redundancy of backup generation. The criticality of their loads might mean that a facility with a 1-MW load could have 2 MW of backup generation to ensure reliability. Other sectors with less critical loads would typically not have redundant backup generation. In fact, their backup generation may not support the entire load but only the portion deemed critical.

To account for these sectoral differences, Electrotek developed curtailment ratios for each two-digit SIC code. This ratio represents the amount of load actually curtailed with the generating capacity. These ratios were estimated based on Electrotek's experience across a range of clients with DG resources. Although not definitive, these ratios are based on professional judgment and experience and represent a reasonable first-order estimate of the amount of actual curtailment that could be realized by each generator in a sector. Table 9 lists the two-digit SIC codes and the curtailment ratios developed by Electrotek.

To estimate the technical potential for DG, total DG capacity was summed by sector and then multiplied by the curtailment ratios provided in Table 9. It should be noted that there are two distinct classifications for capacity. The first is for reciprocating engines. These generators would only participate in the NYISO EDRP or in the NYISO ICAP market as SCRs. The second classification is for turbines, which could be eligible to participate in the energy and ancillary services markets.

Table 9. Curtailment Ratios

SIC Code	Description	Curt Load/ Gen Cap
01	Agricultural Production Crops	1.00
07	Agricultural Services	1.00
08	Forestry	0.50
09	Fishing, Hunting, and Trapping	0.70
13	Oil and Gas Extraction	0.50
15	Building Construction General Contractors and Operative Builders	1.00
16	Heavy Construction Other Than Building Construction Contractors	1.00
17	Construction Special Trade Contractors	0.50
20	Food and Kindred Products	0.77
21	Tobacco Products	0.70
22	Textile Mill Products	0.70
23	Apparel and Other Finished Products Made From Fabrics and Similar Materials	0.70
24	Lumber and Wood Products, Except Furniture	0.50
25	Furniture and Fixtures	0.50
26	Paper and Allied Products	0.80
27	Printing, Publishing, and Allied Industries	0.50
28	Chemicals and Allied Products	0.56
29	Petroleum Refining and Related Industries	0.50
30	Rubber and Miscellaneous Plastics Products	0.50
31	Leather and Leather Products	0.70
32	Stone, Clay, Glass, and Concrete Products	0.60
33	Primary Metal Industries	0.50
34	Fabricated Metal Products, Except Machinery and Transportation Equipment	0.90
35	Industrial and Commercial Machinery and Computer Equipment	0.50
36	Electronic and Other Electrical Equipment and Components, Except Computer Equipment	0.67

SIC Code	Description	Curt Load/ Gen Cap
37	Transportation Equipment	0.60
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, and Optical Goods; Watches and Clocks	0.70
39	Miscellaneous Manufacturing Industries	0.80
40	Railroad Transportation	0.50
41	Local and Suburban Transit and Interurban Highway Passenger Transportation	0.75
42	Motor Freight Transportation and Warehousing	0.80
43	United States Postal Service	0.50
44	Water Transportation	0.80
45	Transportation by Air	0.50
47	Transportation Services	0.50
48	Communications	0.40
49	Electric, Gas, and Sanitary Services	0.40
50	Wholesale Trade-Durable Goods	0.80
51	Wholesale Trade-Nondurable Goods	0.50
52	Building Materials, Hardware, Garden Supply, and Mobile Home Dealers	0.80
53	General Merchandise Stores	0.80
54	Food Stores	0.60
55	Automotive Dealers and Gasoline Service Stations	0.60
56	Apparel and Accessory Stores	0.80
57	Home Furniture, Furnishings, and Equipment Stores	0.80
58	Eating and Drinking Places	0.50
59	Miscellaneous Retail	0.80
60	Depository Institutions	0.40
61	Non-Depository Credit Institutions	0.40
62	Security and Commodity Brokers, Dealers, Exchanges, and Services	0.40
63	Insurance Carriers	0.40
64	Insurance Agents, Brokers, and Service	0.90
65	Real Estate	0.36

SIC Code	Description	Curt Load/ Gen Cap
67	Holding and Other Investment Offices	0.40
70	Hotels, Rooming Houses, Camps, and Other Lodging Places	0.50
72	Personal Services	1.00
73	Business Services	0.51
75	Automotive Repair, Services, and Parking	0.80
76	Miscellaneous Repair Services	0.80
78	Motion Pictures	1.00
79	Amusement and Recreation Services	0.70
80	Health Services	0.56
81	Legal Services	0.80
82	Educational Services	1.00
83	Social Services	0.60
84	Museums, Art Galleries, and Botanical and Zoological Gardens	0.70
86	Membership Organizations	0.80
87	Engineering, Accounting, Research, Management, and Related Services	0.70
89	Actuaries	0.80
91	Executive, Legislative, and General Government	0.50
92	Justice, Public Order, and Safety	0.50
93	Public Finance, Taxation, and Monetary Policy	0.50
94	Administration of Human Resource Programs	0.80
95	Administration of Environmental Quality and Housing Programs	0.80
96	Administration of Economic Programs	0.80
97	National Security and International Affairs	0.50
99	Non-Classifiable Establishments	0.70

The evaluation of the technical potential for DG in New York is an estimate of the total capacity that is technically capable of participating in NYISO markets. As mentioned previously, two market categories have been evaluated: (1) EDRP and SCRs and (2) energy and ancillary services markets. Table 10 shows the technical market potential for curtailment in New York by SIC code and for the entire state.

Table 10. Technical Market Potential by Sector

SIC Code	Description	EDRP/ SCR Capacity (MW)	Energy/ AS Capacity (MW)	Total (MW)
01	Agricultural Production Crops	2.4	0.0	2.4
07	Agricultural Services	2.9	1.2	4.1
08	Forestry	0.1	0.0	0.1
09	Fishing, Hunting, and Trapping	0.1	0.0	0.1
13	Oil and Gas Extraction	0.7	0.0	0.7
15	Building Construction General Contractors and Operative Builders	20.5	1.5	22.0
16	Heavy Construction Other Than Building Construction Contractors	3.5	0.0	3.5
17	Construction Special Trade Contractors	15.1	2.9	18.0
20	Food and Kindred Products	17.3	18.7	35.9
21	Tobacco Products	0.5	0.0	0.5
22	Textile Mill Products	13.3	3.0	16.2
23	Apparel and Other Finished Products Made From Fabrics and Similar Materials	45.1	5.4	50.5
24	Lumber and Wood Products, Except Furniture	0.6	0.0	0.6
25	Furniture and Fixtures	4.2	0.0	4.2
26	Paper and Allied Products	9.6	9.5	19.2
27	Printing, Publishing, and Allied Industries	55.7	19.6	75.3
28	Chemicals and Allied Products	6.2	1.2	7.4
29	Petroleum Refining and Related Industries	0.2	0.0	0.2
30	Rubber and Miscellaneous Plastics Products	5.5	0.5	6.0
31	Leather and Leather Products	1.4	0.0	1.4
32	Stone, Clay, Glass, and Concrete Products	1.8	0.0	1.8
33	Primary Metal Industries	2.9	0.0	2.9

SIC Code	Description	EDRP/ SCR Capacity (MW)	Energy/ AS Capacity (MW)	Total (MW)
34	Fabricated Metal Products, Except Machinery and Transportation Equipment	17.0	8.2	25.2
35	Industrial and Commercial Machinery and Computer Equipment	4.9	1.1	6.1
36	Electronic and Other Electrical Equipment and Components, Except Computer Equipment	16.9	0.0	16.9
37	Transportation Equipment	4.4	2.2	6.6
38	Measuring, Analyzing, and Controlling Instruments; Photographic, Medical, and Optical Goods; Watches and Clocks	11.1	3.4	14.5
39	Miscellaneous Manufacturing Industries	21.6	0.8	22.4
40	Railroad Transportation	1.0	0.0	1.0
41	Local and Suburban Transit and Interurban Highway Passenger Transportation	37.3	5.6	42.9
42	Motor Freight Transportation and Warehousing	18.4	4.6	23.0
43	United States Postal Service	6.3	0.0	6.3
44	Water Transportation	0.4	2.0	2.4
45	Transportation by Air	7.7	0.0	7.7
47	Transportation Services	10.0	0.0	10.0
48	Communications	19.7	4.2	23.9
49	Electric, Gas, and Sanitary Services	3.0	1.3	4.3
50	Wholesale Trade-Durable Goods	79.0	17.5	96.4
51	Wholesale Trade-Nondurable Goods	26.4	10.9	37.3
52	Building Materials, Hardware, Garden Supply, and Mobile Home Dealers	6.0	4.9	10.9
53	General Merchandise Stores	17.0	8.2	25.2
54	Food Stores	25.6	4.0	29.6
55	Automotive Dealers and Gasoline Service Stations	16.2	1.1	17.3
56	Apparel and Accessory Stores	30.2	2.4	32.6
57	Home Furniture, Furnishings, and Equipment Stores	29.9	5.5	35.4
58	Eating and Drinking Places	66.3	10.6	76.9
59	Miscellaneous Retail	29.2	8.5	37.7

SIC Code	Description	EDRP/ SCR Capacity (MW)	Energy/ AS Capacity (MW)	Total (MW)
60	Depository Institutions	18.2	16.9	35.1
61	Non-Depository Credit Institutions	5.8	1.7	7.5
62	Security and Commodity Brokers, Dealers, Exchanges, and Services	40.9	7.1	48.0
63	Insurance Carriers	4.4	0.0	4.4
64	Insurance Agents, Brokers, and Service	32.2	6.8	38.9
65	Real Estate	21.6	4.7	26.3
67	Holding and Other Investment Offices	6.9	0.7	7.6
70	Hotels, Rooming Houses, Camps, and Other Lodging Places	22.4	3.3	25.7
72	Personal Services	12.7	5.0	17.7
73	Business Services	104.8	21.1	125.9
75	Automotive Repair, Services, and Parking	3.5	1.0	4.5
76	Miscellaneous Repair Services	0.9	0.0	0.9
78	Motion Pictures	6.8	2.6	9.4
79	Amusement and Recreation Services	25.9	4.9	30.7
80	Health Services	175.3	57.0	232.3
81	Legal Services	70.3	37.4	107.7
82	Educational Services	322.9	75.6	398.5
83	Social Services	62.3	14.8	77.1
84	Museums, Art Galleries, and Botanical and Zoological Gardens	3.3	5.1	8.4
86	Membership Organizations	21.6	7.9	29.5
87	Engineering, Accounting, Research, Management, and Related Services	56.3	10.7	67.0
89	Actuaries	1.1	0.0	1.1
91	Executive, Legislative, and General Government	12.2	2.8	15.0
92	Justice, Public Order, and Safety	38.8	2.4	41.2
93	Public Finance, Taxation, and Monetary Policy	0.5	0.0	0.5
94	Administration of Human Resource Programs	5.0	1.8	6.8
95	Administration of Environmental Quality and Housing Programs	9.8	1.9	11.8

SIC Code	Description	EDRP/ SCR Capacity (MW)	Energy/ AS Capacity (MW)	Total (MW)
96	Administration of Economic Programs	6.8	1.1	7.8
97	National Security and International Affairs	1.1	0.0	1.1
99	Non-Classifiable Establishments	60.4	3.8	64.2
	TOTAL	**1,869**	**468**	**2,338**

Based on the assumptions detailed above, there is an estimated technical potential of 2,338 MW of curtailment in New York State. This represents approximately 65% of the 3,582 MW of total DG capacity. Most of this (1,869 MW) is eligible for the NYISO EDRP and SCR programs. The balance, 468 MW, would be eligible for the energy and ancillary services markets. Clearly, the stock of backup generators in New York is heavily weighted toward the NYISO emergency programs.

It should be noted that this technical potential does not represent the capacity that can be economically developed. NYISO market prices will drive this. For example, the energy and ICAP market prices in New York City and Long Island are significantly higher than those in the rest of the state. When one considers the full cost of participating in these markets—including metering, environmental permitting, and opportunity costs (diversion of staff time to the operation of generators and not site process, reduced reliability of generators, shorter service life of generators)—the incentives in areas other than zones J (New York City) and K (Long Island) may not be sufficient to bring these resources into the marketplace.

3.3 Recruitment of 30 MW Capacity for Commercial Operation

As a preparation for demonstration of the technical and economic feasibility of aggregated DG resources, planned for Option Year 2, Electrotek recruited 38 customers with 55.69 MW of installed capacity in New York City, Long Island, and Westchester County to participate in a commercial demonstration of an aggregated DG program. More than 38 MW of curtailment have been collectively committed to the curtailment programs of the NYISO, the New York Power Authority, and the LIPA. These 38 participating facilities have been equipped with the required metering systems and, in many cases, with additional metering, communications, and control systems to allow for their integration into Electrotek's DG aggregation system, which allows for near real-time monitoring and control of each facility's generators and loads.

4 Design of Distributed Generation Aggregation System For Commercial Demonstration

Task 8 was to develop the structure and components of the DG aggregation system to combine and operate numerous distributed generators as a single power plant. The Task 8 report can be found in the companion document "Aggregation of Distributed Generation Assets in New York State: Appendix." It provides a detailed description of the system, its design, and its development.

In support of this initiative, Electrotek's previously developed portfolio of tools—including load forecasting, peak hunting, and bidding programs—has also been integrated into the DG aggregation system. In addition, Electrotek is now evaluating a new strategy for a number of Verizon facilities that would allow them to purchase energy in the NYISO DAM when the DA price is lower than the facility generating cost and to self-supply when the DA price is greater than the cost of local generation.

In the original design, a single control center handled all the activities associated with the operation of DG units. However, during system development, it was decided to separate the aggregated power plant activities into three functional parts and develop a DG aggregation system instead of a single DG control center. This system includes three entities: the Data Collection and Management Center (DMC) located in Knoxville, Tennessee; the Aggregation and Dispatch Center (ADC) located in Edison, New Jersey; and Field Operation (FO), consisting of participating buildings/generators in New York City, Long Island, and Westchester County. Each entity includes several operation modules with specific duties interconnected via the Internet and with other communications media.

The decision to distribute management and operation activities between two locations was based on the following:

- The operation of the DG aggregation system requires powerful servers and computer stations to collect, store, and manage large amounts of data. Electrotek has this equipment already available at its Knoxville office. In addition, the manpower experienced in data management, software development, and system operations is also located in Knoxville.
- The proximity of the World Power Technology headquarters in Edison, New Jersey, to New York City and Long Island and World Power Technology's staff of experienced electronic/computer engineers and technicians to support field operations made it the logical choice for the ADC.
- The Web-based application AggregationWeb provides a single point of access to system information for all users (clients, the NYISO, ADC staff). Thus, the physical location of system components is immaterial.

DG Aggregation System Architecture

The DG aggregation system consists of three elements: (1) FO, (2) the DMC, and (3) the ADC. Figure 4 shows the system architecture and functional responsibilities.

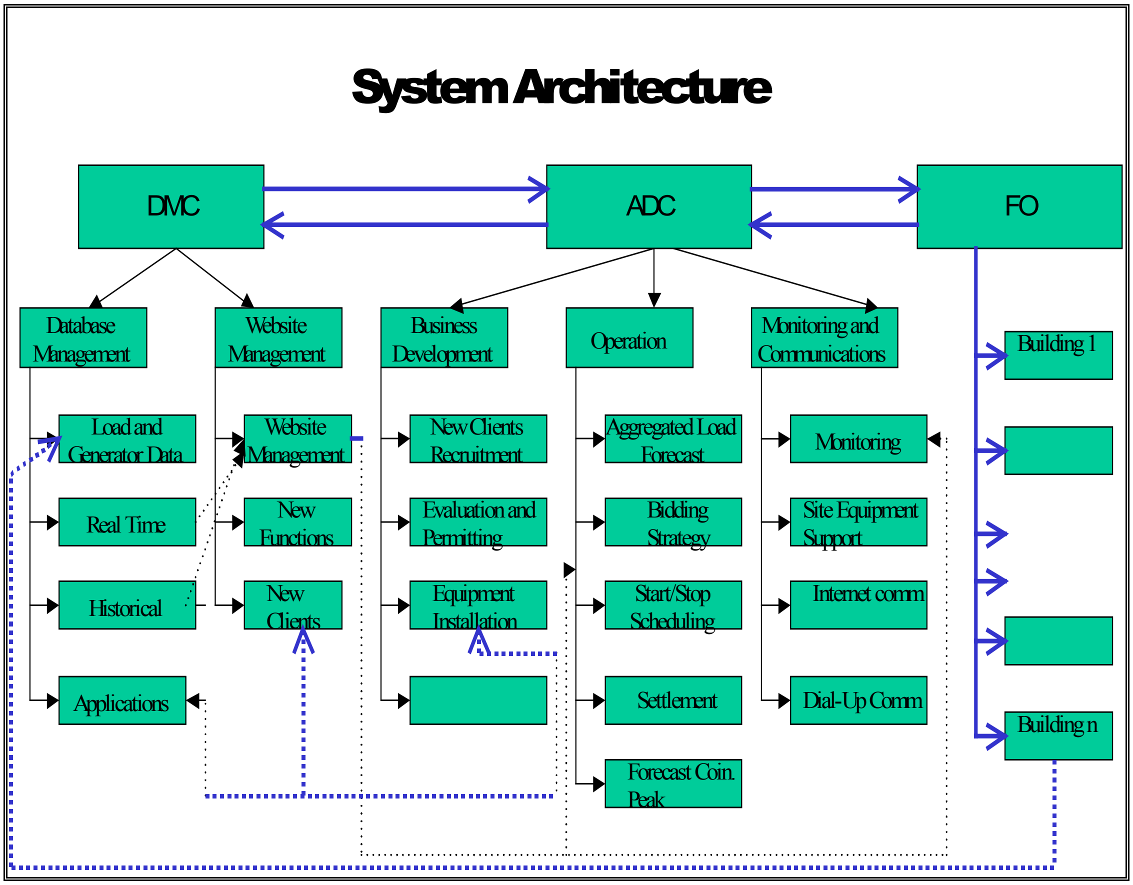

Figure 4. DG system architecture

Each of the three elements is described below.

4.0.1 Field Operation

The FO consists of multiple backup generators in locations around New York City, Long Island, and Westchester County. The system is designed to incorporate as many generators as necessary. Major principal responsibilities of the FO are to:

- Manage and maintain power generation resources
- Monitor generator performance
- Collect data.

For a more detailed description, please refer to Section 4 of the Task 8 report.

4.0.2 Data Collection and Management Center

The DMC is the center for the collection and management of data necessary for operation of the DG aggregation system. The primary duties of the DMC include:

- The collection and storage of information about the activities of FO, energy market pricing and load forecasts, and forecasted and historical weather data
- The development and maintenance of the DG aggregation Web site
- The development and maintenance of software necessary for the operation and expansion of the DG aggregation system.

An additional component of the DMC is AggregationWeb, which is the user interface to all DMC data and support functions. AggregationWeb supports DG operations tools such as client management (e.g., adding new customers and modifying existing account information), generator dispatch, and client access to data (e.g., loads, generation, and revenue).

DMC operations include the daily downloading and management of information from each of the sites (e.g., loads and generator output), from the NYISO (e.g., DA prices), and from the National Weather Service (e.g., hourly temperature and humidity forecasts). In addition, system checks and diagnostics are performed.

For a more detailed description of the DMC, please refer to Section 5 of the Task 8 report.

4.0.3 Aggregation and Dispatch Center

The ADC is responsible for the management and operation of the DG aggregation system. It is located in Edison, New Jersey, and will include three major divisions: Operations, Business Development, and Monitoring and Communication. Each division is summarized below.

The Business Development division is responsible for client recruitment, economic and technical site evaluation, permitting, and field equipment installation and startup. After a potential client is solicited, a series of activities is performed. This includes (a) an initial site visit to assess the technical requirements; (b) an economic and financial evaluation to determine the economic viability of the potential client's participation; (c) environmental permitting; (d) site design; (e) equipment procurement, installation, and startup; and (f) certification of installed equipment. Some facilities may require additional activities such as the installation of fuel flow meters and the implementation of emission reduction technologies.

The Operations division is responsible for adding new customers to the system, developing operations strategies, preparing and executing NYISO bids, dispatching and monitoring generators, and settlement and accounting procedures. All these activities are performed through the DG aggregation Web site, which contains several tools to support dispatchers in decision making and operating the DG aggregation system.

The Monitoring and Communication Division is responsible for the reliability of monitoring and communication equipment in the ADC and FO. This division's responsibilities include preventive and emergency maintenance of telecommunication equipment in the ADC and routine and emergency maintenance of on-site monitoring and telecommunication equipment.

5 Conclusions and Recommendations

The scope of activities under this contract has been broad. In addition, the project accomplishments have been significant. By targeting a serious power supply deficiency in New York State with an innovative and technically complex approach that provides needed curtailment capacity, Electrotek has demonstrated the technical and economic viability of DG aggregation in several NYISO markets, including the DAM, the ICAP market, and the EDRP.

Under the three tasks detailed in this report, a number of conclusions have been developed.

- Electrotek designed a field test of a DG aggregation system for 10 sites on Long Island. To support this test, Electrotek developed a metering system and a portfolio of tools to manage and conduct the bidding process. These included (1) a load forecasting model, (2) a generator cost model, and (3) a dispatch optimization model. Collectively, these tools allowed Electrotek to develop a strategy for engine management that resulted in the most economic approach based on site loads, generation cost, and the definition of bidding blocks.
- Electrotek developed and confirmed the metering and communications protocols with the NYISO and installed the necessary systems. Electrotek spent more than $130,000 for equipment and installation. But after the installation was accomplished, LIPA imposed additional metering and communications requirements that would have cost more than $149,000, with recurring costs of $95,000 a year. Because of this, the original objective of developing New York State's first system resource was not possible.
- Building on the development of the DG aggregation system, Electrotek conducted a shadow experiment designed to test the economic viability of operating the 10 aggregated sites as a 4.3-MW, price-capped load in the NYISO DAM.
- Technically, the concept proved to be feasible. The economic viability of the shadow experiment was marginal and undermined primarily by delivery charges that LIPA would have collected for power it would not have needed to deliver. Absent that, the strategy was quite cost-effective.
- The DG market assessment conducted by Electrotek estimated that there is a technical potential of 2,338 MW of curtailment in New York State. Of this, approximately 468 MW might be able to participate in the NYISO energy and ancillary services markets, with the balance eligible only for the NYISO emergency programs (EDRP and SCR).
- The Electrotek demonstration project for commercial operation recruited 58 customers in New York State and more than 38 MW of curtailment capacity. For each of these sites, necessary environmental permits should be obtained, metering and communications systems should be installed, and NYISO registrations should be secured.

With the technical success realized under this NYSERDA- and National Renewable Energy Laboratory-sponsored project, the viability of this approach on a commercial basis must be considered. Although Electrotek has clearly demonstrated the validity of the technical approach and the system design, implementation, and operation, the commercial success of this approach must also be addressed.

A number of recommendations can be made.

- For DG resources participating in the NYISO emergency programs (EDRP and SCR), the concept is viable by any measure, technical or economic. Particular credit for this should go to the NYISO for emergency programs that are well designed and targeted toward those locations (New York City and Long Island) that most are in need. Clearly, the market design of these emergency programs is a critical element of their success. The market design of the NYISO programs has proved to be an excellent model for other power pools to consider, particularly for the access to capacity markets for emergency resources.

- The NYISO should also be cited for its progressive approach to the emergency program development process, as evidenced by the Price Responsive Load Working Group, which brought all of the parties (generators, LSEs, customers, regulators, environmentalists, etc.) together to forge a consensus on program development. This process was especially valuable in the continued evolution of these programs. Again, this approach is a good model for others.

- The imposition of delivery charges on curtailments—i.e., for energy that is not delivered—places a significant impediment on the development of curtailment resources. The costs of developing these resources is high because one is typically dealing with a multitude of relatively small sites—each of which must secure environmental permits, metering equipment and services, and communications equipment and services—as well as relatively high operating costs when compared with central site generators. Given the value of these resources to the bulk power system during system stress and high-cost periods, it is counter-productive to impose these burdens on resources that operate for a limited number of hours a year and that contribute significantly to system reliability.

- The concept of a system resource in the NYISO is sound. However, as this experience has shown, the unfortunate reality is that delivery companies retain the ability to thwart their development through the imposition of costly technical requirements that do little except increase the burdens on an aggregation concept. If the requirements were set by the NYISO, there would be significantly more development of system resources. Delivery companies retain the right to impose burdens through practices of questionable technical merit on what are, in effect, their competitors.

- Much of the success of the NYISO emergency programs can be attributed to the direct support provided by NYSERDA. This support is critical to the successful development of curtailment resources. In the interests of continuing the development of these resources, NYSERDA should continue its strong support.

- Finally, the experience gained by Electrotek in conducting the shadow experiment leads to the development of other aggregated DG management strategies. For example, an engine management strategy can represent an expansion of the scope of services that the use of multiple DG units can supply. In addition to load curtailment to replace the need for system reserve, the onsite DG units may be used to cap the cost of energy during periods of congestion in the transmission systems. The engine management strategy enables aggregated onsite DG units to provide all of the value a system resource can provide *without* requiring approval or installation of unnecessary additional metering equipment. The 30-MW commercial demonstration planned in the final year of this effort will confirm this.

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13. ABSTRACT *(Maximum 200 words)*

This report describes a project to demonstrate the technical and economic feasibility of aggregating distributed generating resources in New York State. This project demonstrates a system that allows distributed generation (DG) to participate in competitive markets in much the same way as large central-station power plants. This approach involves aggregating the distributed demand-side resources into a single transaction entity consistent with the requirements of the New York Independent System Operator (NYISO). This single entity then buys or sells capacity and energy (i.e., curtailment) in NYISO markets.

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