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A Locational Analysis of Generation Benefits on Long Island, New York

Juan Wang, Jesse Cohen, Jennifer Edwards, and Chris Marnay

Environmental Energy Technologies Division

June 2005

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Table of Contents

Table of Contents i

List of Figures and Tables iii

Acknowledgments v

Acronyms and Abbreviations vii

1. Introduction 1

2. Berkeley Lab Electricity Markets and Policy (BLEMP) NYISO Database 3
   - 2.1 Locational Based Marginal Prices 3
   - 2.2 Load 3
   - 2.3 Transmission 4

3. Zonal Level Data Analysis for Long Island Summers 2000-2004 7
   - 3.1 LBMP Distributions 7
   - 3.2 Relationship Between LBMP and Load 8
   - 3.3 Profitable Hours for DG Units. 9
     - 3.3.1 Automated Mitigation Process 10
     - 3.3.2 Generating Capacity Expansion 10
     - 3.3.3 Demand Response Programs 12
     - 3.3.4 Transmission Line Expansion 13

4. Intra-Zonal Level Data Analysis for Long Island Summers 2000-2004 15
   - 4.1 The Role of Geographic Information Systems 15
   - 4.2 Long Island LBMP Spatial Analysis Method 15
   - 4.3 Assumptions 17
   - 4.4 Results 17
   - 4.5 Conclusion 17

List of Figures and Tables

Figure 1. The Web Interface of the BLEMP NYISO Database 4
Figure 2. An Example Query to the BLEMP NYISO Database 5
Figure 3. LBMP Distribution for Long Island During Summer 2004 7
Figure 4. LBMP Variation by Time of Day 7
Figure 5. Load and LBMP for Long Island During Summers 2001 - 2004. 8
Figure 6. Top 500 Hour Price Duration Curves 9
Figure 7. New York In State Reserve Margin 11
Figure 8. New York Generation Projects 12
Figure 9. Demand Response Program Growth 13
Figure 10. A Flow Diagram of GIS and Related Steps to Output the Final Map 16
Figure 11. Summer Peak Average LBMP Map 19
Figure 12. Top 500 Hours LBMP Map 20

Table 1. Profitable Hours for DG Units 9
Table 2. Long Island System Load and Generating Capacity 10

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Acronyms and Abbreviations

AMP	Automated Mitigation Procedure
ArcGIS	GIS software
ATC	Actual Transmission Capacity
BLEMP	Lawrence Berkeley National Laboratory Electricity Markets and Policy
DADRP	Day-Ahead Demand Response Program
DG	Distributed Generation
EDRP	Emergency Demand Response Program
GIS	Geographic Information Systems
HVDC	High Voltage Direct Current
ICAP	installed capacity
KV	Kilovolt
LBMP	Locational Based Marginal Price
LIPA	Long Island Power Authority
LIRTP	Long Island Real Time Purchasing Pilot Project
LSE	Load Serving Entities
MMM	Market Mitigation Measures
MW	Megawatt
MWh	Megawatt hour
NYISO	New York Independent System Operator
NYPE	New York Power Exchange
OASIS	Open Access Same-Time Information System
PJM	Pennslyvania – New Jersey – Maryland Interconnection
RFP	request for proposal
SCUC	Security Constrained Unit Commitment
TTC	Total Transmission Capacity

1. Introduction

Beginning in April of 2004, nine sites owned by Verizon began to participate in the Long Island Real Time Purchasing Pilot Project (LIRTP) as retail choice customers. LIRTP was designed to minimize electricity costs for retail customers who own on-site distributed generation (DG) units in the near-term, and to stabilize overall electricity costs in the long-term. The nine Verizon buildings have two types of DG units: gas turbines with an estimated generation cost of $156/MWh, and diesel units with an estimated cost of $120/MWh.[1] Due to total site emission limits, the operable hours of the DG units are limited. To estimate the economic value of running on-site DG units, an analysis of the New York Independent System Operator (NYISO) Locational Based Marginal Price (LBMP) data for Long Island was conducted, mainly covering the summer months from 2000 to 2004. Distributions of LBMP, relationship between LBMP and load, and estimates of profitable operating hours for the units were all analyzed. Since Long Island is a diverse and highly congested area, LBMP varies greatly. Looking at the data statistically offers a zone-wide viewpoint, while using spatial analysis shows the LBMP intrazonal differentiation.

LBMP is currently used by NYISO for pricing in the 11 NY control zones. Because geographic information systems (GIS) visualize the distribution of a phenomenon over space, it clarifies where load and generation nodes are located, and where load reduction would be most valuable. This study is based on the assumption that the control zone areas do not fully represent the diversity of pricing, and that intrazonal pricing can be analyzed to determine where and when electricity conservation or injection into the network is most valuable.

[1] Personal communication with Howard Freibus

2. Berkeley Lab Electricity Markets and Policy (BLEMP) NYISO Database

The NYISO Open Access Same-Time Information System (OASIS) market data are published daily on NYISO's website. The archived data are also available in zip files. However each file only contains one day's data, which makes yearly, even monthly analysis tedious. To facilitate analysis of the NYISO OASIS market data, the BLEMP NYISO database has been restarted. The database covers the entire period NYISO has been operating, i.e. November, 1999 to the present. The database is updated every day automatically as new daily data are published. There is a web interface to the database, which can be accessed at http://electricitymarketdata.lbl.gov/NYISO/index.html. Users can execute web-based queries for specific data and date ranges. The database server will return the query result as a downloadable .csv file, which can be easily imported to Excel. The web interface of the database is shown in Figure 1. Figure 2 shows the basic query window.

BLEMP NYISO Database has data in three categories:[2]

2.1 Locational Based Marginal Prices

Day-Ahead LBMP, Real-Time Market LBMP, and Time-Weighted/Integrated Real-Time LBMP, which is the average of real-time data over an hour, are available at the zonal and generator level. There is also Balancing Market (Hour-Ahead) Advisory Price, which is for evaluation only. All the prices have the LBMP ($/MWh), as well as Marginal Cost Losses and Marginal Cost Congestion components recorded. Marginal Cost Losses and Marginal Cost Congestion are measured relative to the reference bus, which is the New York Power Authority (NYPA) Marcy 345 KV transmission substation. Day-Ahead, Hour-Ahead, and Real-Time Integrated prices are available for the reference bus. Ancillary services prices are also available for the Day-Ahead and Hour-Ahead markets.

2.2 Load

The Security Constrained Unit Commitment[3] (SCUC) Forecast Load, Zonal Load Commitment, Actual Real-Time Load, and Integrated Real-Time Actual Load are all available in the database. Except for the SCUC Forecast Load, the New York city zone and the Long Island zone are released aggregated. Separated data are available on the NYISO website only after a six month lag.

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[2] For more description of the data, please refer to the NYISO OASIS website: http://www.nyiso.com/oasis/index.html

[3] Security constrained Unit Commitment (SCUC): The process through which the NYISO prepares a generation schedule for the following day, after evaluating load forecasts, price and availability Bids of Generation Resources, information on Ancillary Services Bids and Bilateral Transactions furnished to it, minimizing the total bid production cost of energy while meeting Reliability Rules and Generator performance constraints consistent with the terms of the NYISO Tariff and the New York Power Exchange (NYPE) Tariff.

2.3 Transmission

Actual Transmission Capacity (ATC) and Total Transmission Capacity (TTC) are stored in the database for the Day-Ahead and Hour-Ahead settlements. Tie Line Flows for Import/Export are also available.

Data in the BLEMP NYISO Database

The following is a summary of the data which currently exists in the database.
Click on the links to search the data.
If you have any comments or question please email us.
Back to home page

LBMP		
Energy Market		
zones	Day Ahead	*starts 11/18/99*
	Hour Ahead	*starts 11/18/99*
	Real Time	*starts 11/18/99*
	Real Time Integrated	*starts 11/18/99*
generators	Day Ahead	*starts 11/18/99*
	Hour Ahead	*starts 11/18/99*
	Real Time Integrated	*starts 11/18/99*
reference bus	Day Ahead	*starts 5/1/00*
	Hour Ahead	*starts 5/1/00*
	Real Time Integrated	*starts 5/1/00*
Ancillary Services		
East/West region	Day Ahead	*starts 11/18/99*
	Hour Ahead	*starts 11/18/99*
LOAD		
zones	SCUC Forecast	*starts 11/18/99*
	Zonal Bid	*starts 6/28/01*
	Real Time	*starts 5/26/01*
	Real Time Integrated	*starts 6/21/01*
TRANSMISSION		
interfaces	Total Transmission Capacity/Actual Transmission Capacity	*starts 11/18/99*
interfaces	Tie Line Flows (Imports/Exports)	*starts 11/18/99*

Figure 1. The Web Interface of the BLEMP NYISO Database

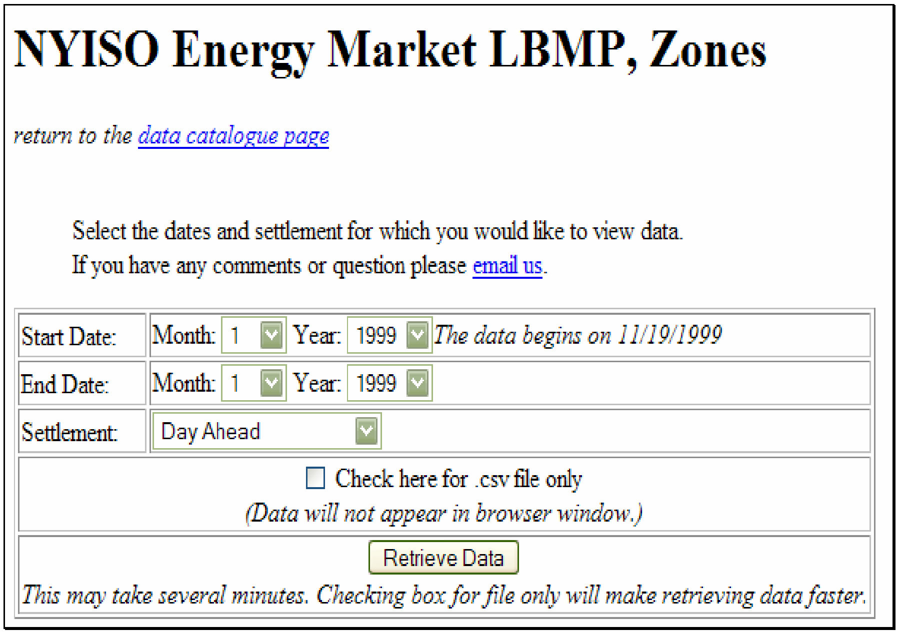

Figure 2. An Example Query to the BLEMP NYISO Database

3. Zonal Level Data Analysis for Long Island Summers 2000-2004

Using the BLEMP NYISO, price and load data for Long Island's summer months (June-September) from 2000 to 2004 were analyzed. The main findings are explained below:

3.1 LBMP Distributions

The distributions for Long Island summer 2004 peak hours and all hours are shown in Figure 3. The average LBMP for all summer hours is \$61.99/MWh and the average LBMP for peak hours is \$74.80/MWh. How LBMP varies with time of the day is shown in Figure 4.

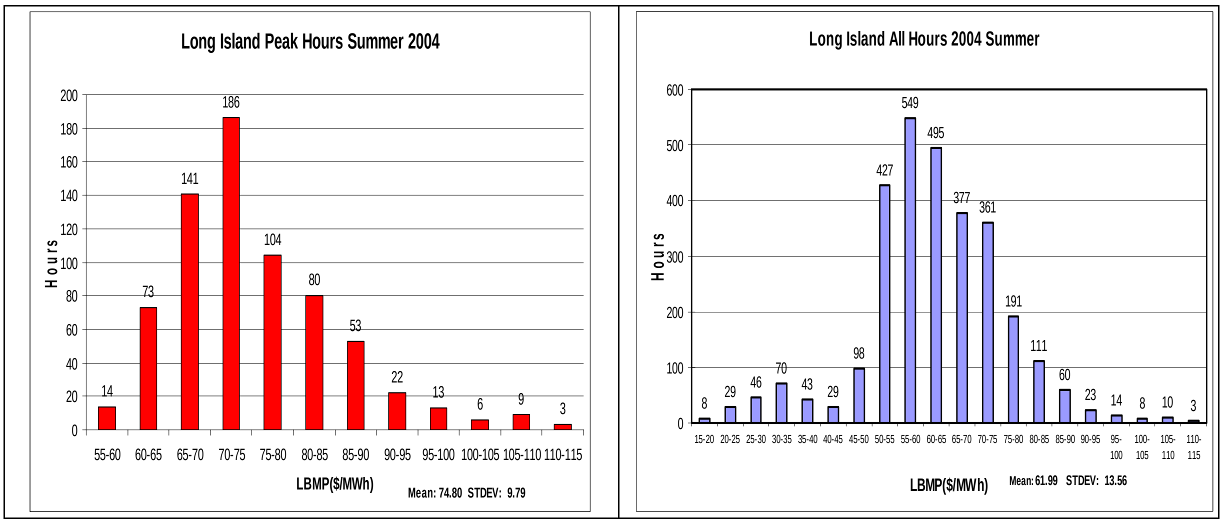

Figure 3. LBMP Distribution for Long Island During Summer 2004

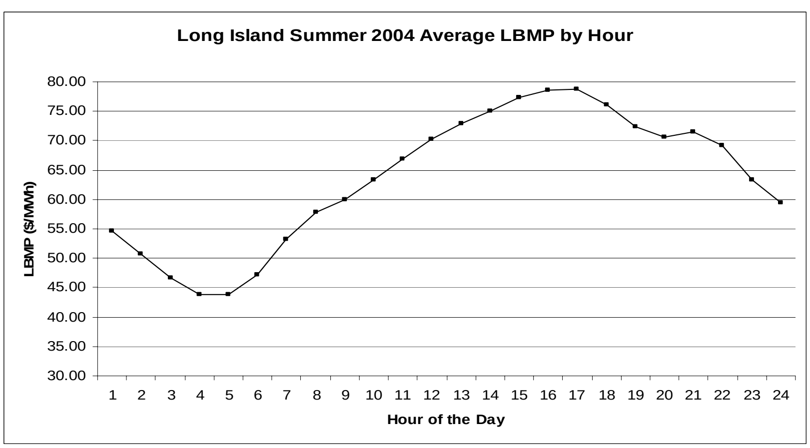

Figure 4. LBMP Variation by Time of Day

3.2 Relationship Between LBMP and Load

The panels in Figure 5 show LBMP plotted against load for all summers 2001-2004. The classic hockey stick shape is clearly evident, especially during the summers of 2001 and 2002. Even though the maximum price varies significantly among years, the maximum loads for all years are around 5000 MW, with the hockey stick curve appearing around 4500 MW. Even though price spikes usually coincide with high loads, high loads do not necessarily imply high prices.

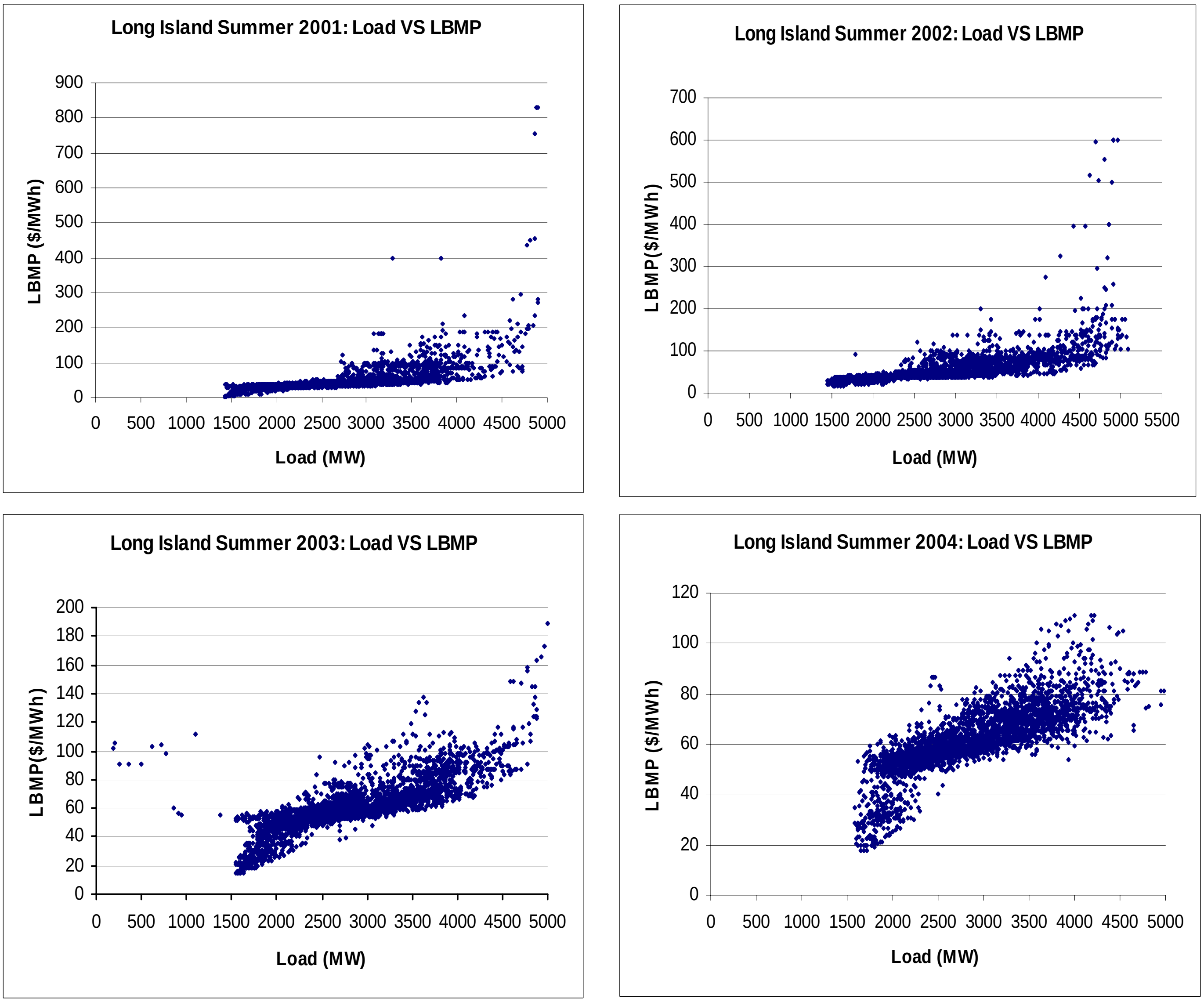

Figure 5. Load and LBMP for Long Island During Summers 2001 - 2004[4]

[4] The "irregular points" with very low load but high LBMP results from the 2003 blackout

3.3 Profitable Hours for DG Units

A summary of the number of hours above a certain price level is given by Table 1. Based on the cost of operation for Verizon's combustion turbines, which is $156/MWh, the last row shows the number of hours they can be profitably operated. Similarly, the penultimate row shows the number of hours a Verizon diesel unit can be profitably operated.

Table 1. Profitable Hours for DG Units

Year	2000	2001	2002	2003	2004
Maximum LBMP ($/MWh)	818	831	600	189	111
# of hours above $100/MWh	171	159	197	96	21
# of hours above $120/MWh	98	111	130	23	0
# of hours above $156/MWh	43	53	53	6	0

Complete price duration curves are shown in Figure 6.

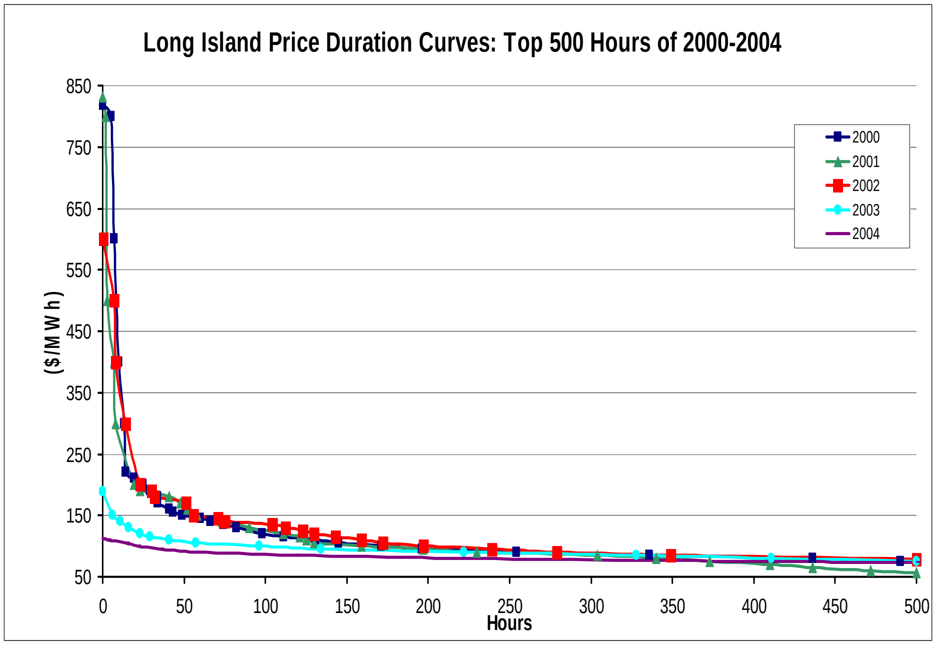

Figure 6. Top 500 Hour Price Duration Curves

From Figure 6 and Table 1, it can be seen that summer peak prices have had a descending tendency over the years. Remembering that the marginal operating cost of Verizon's diesel generators is approximately $120/MWh, there was an average of more than 100 operable hours during 2000-2002, but there were no operable hours for either type of Verizon DG units in 2004 and only 23 hours in 2003. As pointed out previously, the price falls do not correspond to big decreases in electricity consumption; in fact, according to NYISO's report, NYC and Long Island's demand continues to grow at a rate of 1.7 percent a year, but there are several possible explanations, four of which are described in the following sub-sections (New York Independent System Operator 2004a; New York Independent System Operator 2005).

3.3.1 Automated Mitigation Process

Electricity markets that are generally competitive may cease to be competitive for temporary periods when market participants have the ability to raise prices significantly by withholding capacity. Such instances generally occur under relatively tight market conditions that can be caused by high loads, generator outages, or binding transmission constraints. The NYISO implemented an Automated Mitigation Procedure (AMP) for the automatic detection and mitigation of day-ahead energy supply bids that exceed the thresholds for economic withholding established in the Market Mitigation Measures (MMM) of the AMP. It is activated when the Day Ahead Market zonal LBMP for any hour exceeds $150/MWh (New York Independent System Operator 2004b). Each hour is evaluated separately for purposes of implementing the AMP, and any resulting mitigation. In case of activation, suppliers' offers in the Day Ahead Market are automatically reviewed to determine if they are $100, or 300 percent higher than the emergency reference price or in the case of having start up cost bids, 200 percent higher than the start-up cost reference. AMP may have helped eliminating the price spikes caused by economical withholding.

3.3.2 Generating Capacity Expansion

For the past few years, the growth in peak demand in NY has been more than offset by an increase in generating capacity. NYISO's two reports, Power Alert I: New York's Energy Crossroads, and Power Alert II: New York's Persisting Energy Crisis, published in March 2001 and March 2002 respectively, concluded that New York was in serious need of new electric generating plants and significant additional generating capacity would enhance reliability, and put downward pressure on wholesale electricity prices. Of the 5,000 to 7,000 additional megawatts of generation originally recommended by NYISO to be in place by 2008, more than 3,000 MW had already been built by 2004. An additional 2,038 MW are under construction, and there are 3,120 MW approved by the State's Article X power plant sitting law (created in 1992 to streamline the permitting and approval process for power plants over 80 MW). Figure 7 shows New York's in-state reserve margin. From the figure we see that in year 2000 and 2001, the reserve margins were below the 18 percent target, but after 2002, reserve margins became comfortable and are forecasted to stay so through 2007. Table 2 shows Long Island's system load requirement and generating capacity in the summers of 2003-2005. These reserve margins helped reduce the peak wholesale electricity price. Figure 8 shows that many of the newly built generators are located on Long Island.

Table 2. Long Island System Load and Generating Capacity

Long Island Summer 2003-2005 System Load and Generating Capacity (MW)				
	Requirement (Load +Reserve or Locational Requirement)	Generation Available	New Generation and SCRs[5]	Projected Margin
Summer 2003	4607	4983	107	483

[5] SCR is a Demand Response Program that can reduce customer demand on peak load days. More details can be found in Section 3.3.3.

Summer 2004	5008	5091	89	172
Summer 2005	5179	5329	90	240

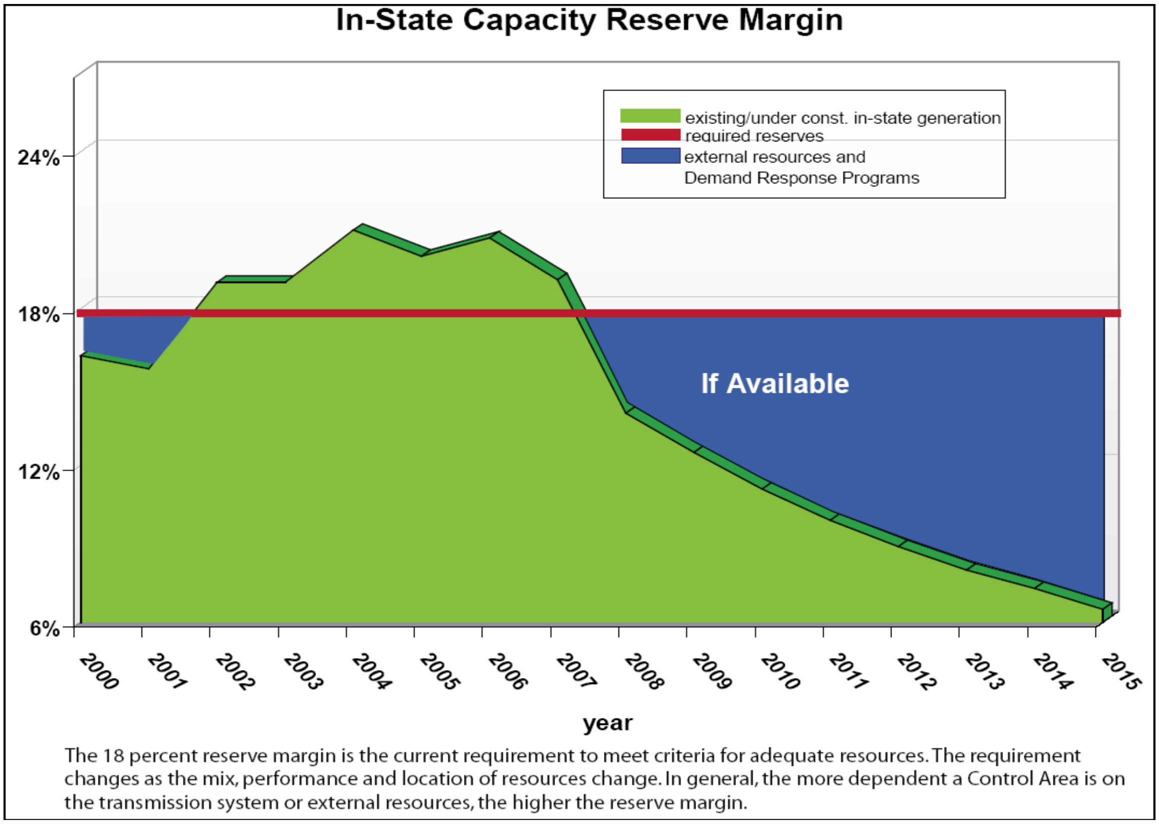

Figure 7. New York In State Reserve Margin

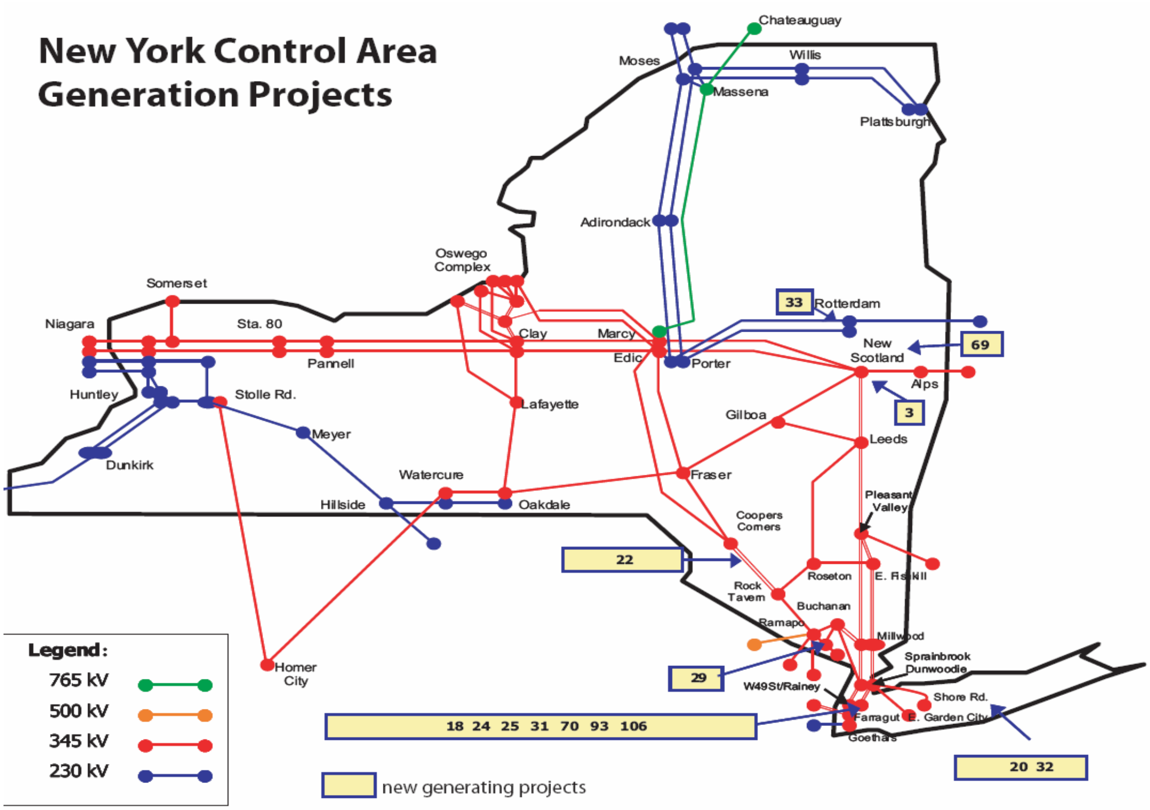

Figure 8. New York Generation Projects

More capacity is expected to be built over the next few years. The Long Island Power Authority (LIPA) issued a Request for Proposals (RFP) for additional generating and transmission resources in 2005. Three proposals were selected to meet Long Island's future needs: a 326 MW combined cycle generating plant, a 660 MW High Voltage Direct Current (HVDC) tie to Pennsylvania-New Jersey-Maryland (PJM) Interconnection in New Jersey and the construction of 100 offshore wind turbines with a nominal capacity value of roughly 150 MW. Target in-service date for these projects is 2007.

3.3.3 Demand Response Programs

NYISO has been successful at using demand response programs for both reliability and market efficiency. Currently the NYISO offers three demand response programs: the Installed Capacity (ICAP) Special Case Resources (SCR); the Emergency Demand Response Program (EDRP); and the Day-Ahead Demand Response Program (DADRP). Figure 9 shows the growth in EDRP and SCR registration from May 2001 through February 2004. On Long Island, the available load reduction from SCR is estimated to be 90 MW in summer 2005.

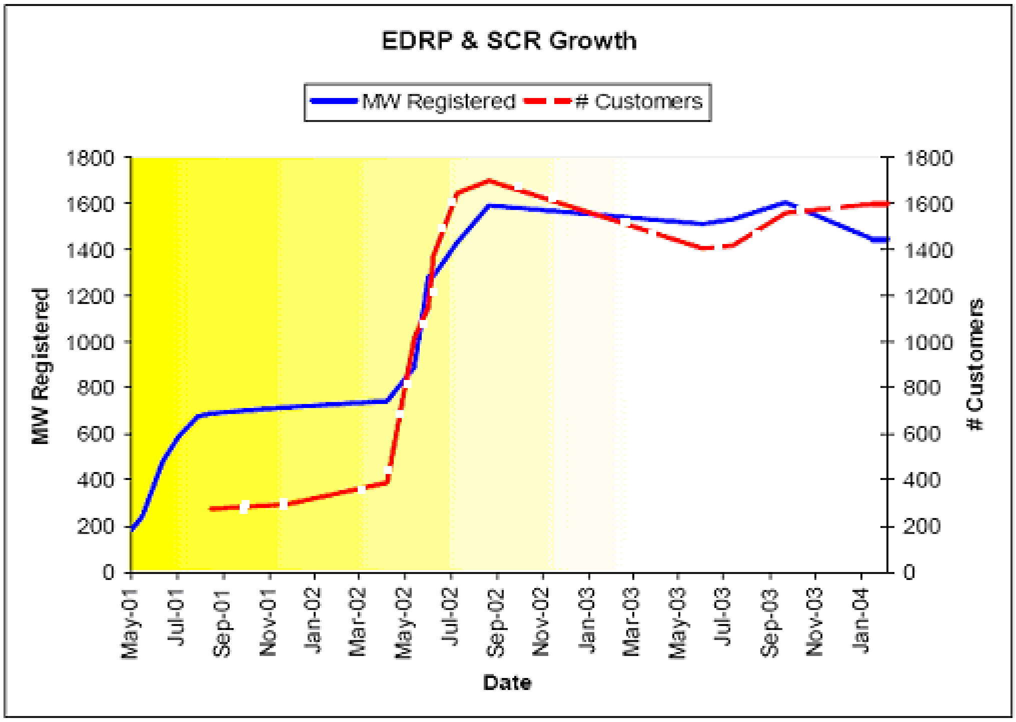

Figure 9. Demand Response Program Growth

3.3.4 Transmission Line Expansion

The Cross Sound Cable, a 330 MW HVDC facility connecting Connecticut with Long Island, has been constructed and began operating in August 2003. Because it connects the New England ISO and NYISO, the cable increases the state's import capacity by 4 percent, which constitutes about 7 percent of Long Island's peak demand.

4. Intra-Zonal Level Data Analysis for Long Island Summers 2000-2004

4.1 The Role of Geographic Information Systems

GIS visualizes the distribution of phenomena over space. The LBMP is currently used for pricing across the 11 NYISO control zones. GIS can clarify where the load and generation nodes are located, and show where load reductions would be most valuable relative to Verizon's generators. The study assumes that the zones are concealing considerable diversity of pricing within each zone, and that intrazonal pricing could be analyzed using hourly generator data compiled by the ISO. If the analysis proves useful it could be used in other ISO markets to perform spatial analysis beyond the visual analysis of the current study.

4.2 Long Island LBMP Spatial Analysis Method

An initial analysis of Long Island, NY was conducted using a GIS city point layer and the NYISO LBMP data, along with other data for reference and comparison. Combining these layers in a GIS offers a visual mosaic of the spatial patterns of LBMP pricing. The following section on completed tasks describes in detail the actual implementation used in this study.

The following tasks were completed to produce the final spatial analysis, shown in the Figure 10 flow diagram.

a) Compiled LBMP data for the years of study: Each individual generator hourly LBMP was downloaded from the BLEMP NYISO database. For ease of use and preprocessing they were combined into one file. Then the appropriate hours were selected using the commercial tariffs definition of "peak" hours.

b) Processed New York State Generator Location Table: The complete table of generators on the NYISO website is filled with redundancies, missing information, and multiple generators for each facility. These data problems were manually corrected, and generators with key information missing were discarded. There were also facilities with multiple generators i.e. areas of Niagara Falls had many generator units but only one location. A representative generator (and LBMP) was selected for each facility because a GIS can only represent one point at each location. Generators with a city name not available in the New York State cities point layer where located using the internet and then added to the New York State cities point layer using the editing feature of ArcGIS.

c) Reconcile city names: City names for generators and city points were manually matched to ensure a successful join. This required making spelling changes as well as looking up pseudonyms for towns with multiple spellings.

d) Create Verizon generator point layer: The city point names were recognized and matched to the location name of the generator. The result is a spatially accurate point layer of generators.

e) Join tables to create NYISO generator shapefile: This step requires two inputs, the generator city shapefile and the NYISO generator data. Within the arcGIS software, the "join" tool was used to join the table (.dbf) with the shapefile, effectively making them a single file.

f) Perform statistical analysis on LBMP data: The primary GIS analysis involved visualizing LBMP pricing data by generator. To achieve this, MS Excel was used to create a summary table of LBMPs which highlighted the average summer peak hours and Top 500 summer peak hour data for each generator.

g) Classify data for visualization: Once the data are in the GIS, it must be binned to show variation between the points. The generator points were represented with 3 quantiles, breaking the data into equally inhabited groups that are displayed using a color ramp (green to red). This method avoids making artificial categories solely for the purpose of visualization.

h) Collect secondary data: Secondary data was found and projected for reference and comparison. The secondary data consisted of transmission lines, Long Island counties, and a New York State reference map.

i) Create map product: The maps were created to highlight the LBMP variation across Long Island. The main features on the map include NYISO generators, Verizon generators, Long Island counties, and power lines. The generator color scheme avoided classifying the points but still used a red to green color ramp to accent the range of the LBMP values. Verizon generator sites were useful in comparing LBMP data with potential Load Reduction scenarios. These generators were labeled with the available data, i.e. capacity and load. An inset map was created to show the location of Long Island in reference to the state. Additional data included Long Island power lines, Long Island county lines, and New York State boundary lines. The power lines and county lines aided in giving context to the results on the main map. The state outline was for the overview map, showing the general location of Long Island.

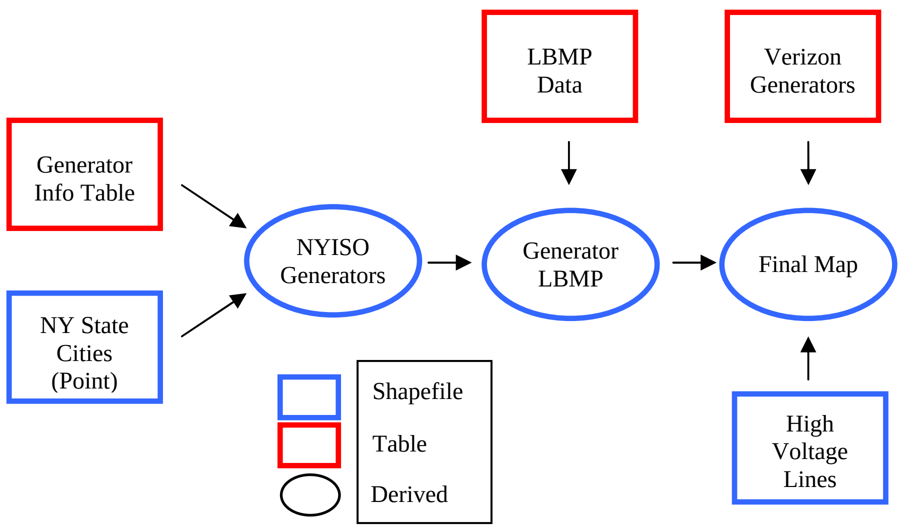

Figure 10. A Flow Diagram of GIS and Related Steps to Output the Final Map

4.3 Assumptions

The first assumption was that the selected generators were representative of the LBMP distribution in the surrounding area. The BLEMP database offered LBMP data by generator but did not specifically detail its relation to zonal LBMP figures. The second major assumption relates to the representative generator which was selected when there were multiple generators for a single facility (city). There were many cities that had multiple units with different LBMPs and capacities. Since a GIS can only represent one set of information for each point, the representative generator was a crucial input to the depiction of the city and its LBMP. The last assumption was that the hourly LBMP generator data could be compared to the zonal LBMP data. Since the generator data is not used for any of the zonal LBMP calculations, it is unknown whether or not it is reasonable to compare the LBMP figures.

4.4 Results

The mapped results of the Long Island LBMP study showed a common trend among the data. The southern and eastern portions of Long Island show higher pricing. This trend appears stronger in the Summer Peak Average LBMP map (Figure 11), and less so in the Top 500 Hours LBMP map (Figure 12). The latter would be useful in planning load reduction scenarios by using those Verizon generators in the vicinity of the high LBMP NYISO generators. This would be a logical first step to deciding which generators should be called.

Future work could include using more powerful statistical techniques on the complied data. The raw data is comprehensive and could potentially be used in analyses for understanding the fluctuations of the market since its inception. There is also the possibility of integrating GIS with powerflow models. This would add understanding of how capacity and electricity flow affect the LBMP pricing between zones. Lastly, performing more intensive spatial analysis such as surface modeling, scenario modeling, cluster analysis, and geostatistical analysis would add another dimension of understanding to future projects.

4.5 Conclusion

Our study of the LBMP was only possible with the use of the complete and accurate BLEMP database. Through statistical and spatial analysis a complete record of the NYISO OASIS database history was utilized to make a preliminary analysis of market functions. The method used in this study provides a way to estimate the economic benefits for participating in the LIRTP program. The GIS analysis can offer a look at the relationship between generator pricing and the Verizon generator locations to find best locations for running DG units.

This method can be extended to other zones or other ISO’s with suitable data. This information can be of use to both the ISO and the Load Serving Entities (LSE) to give insight into the designs of the various demand response programs.

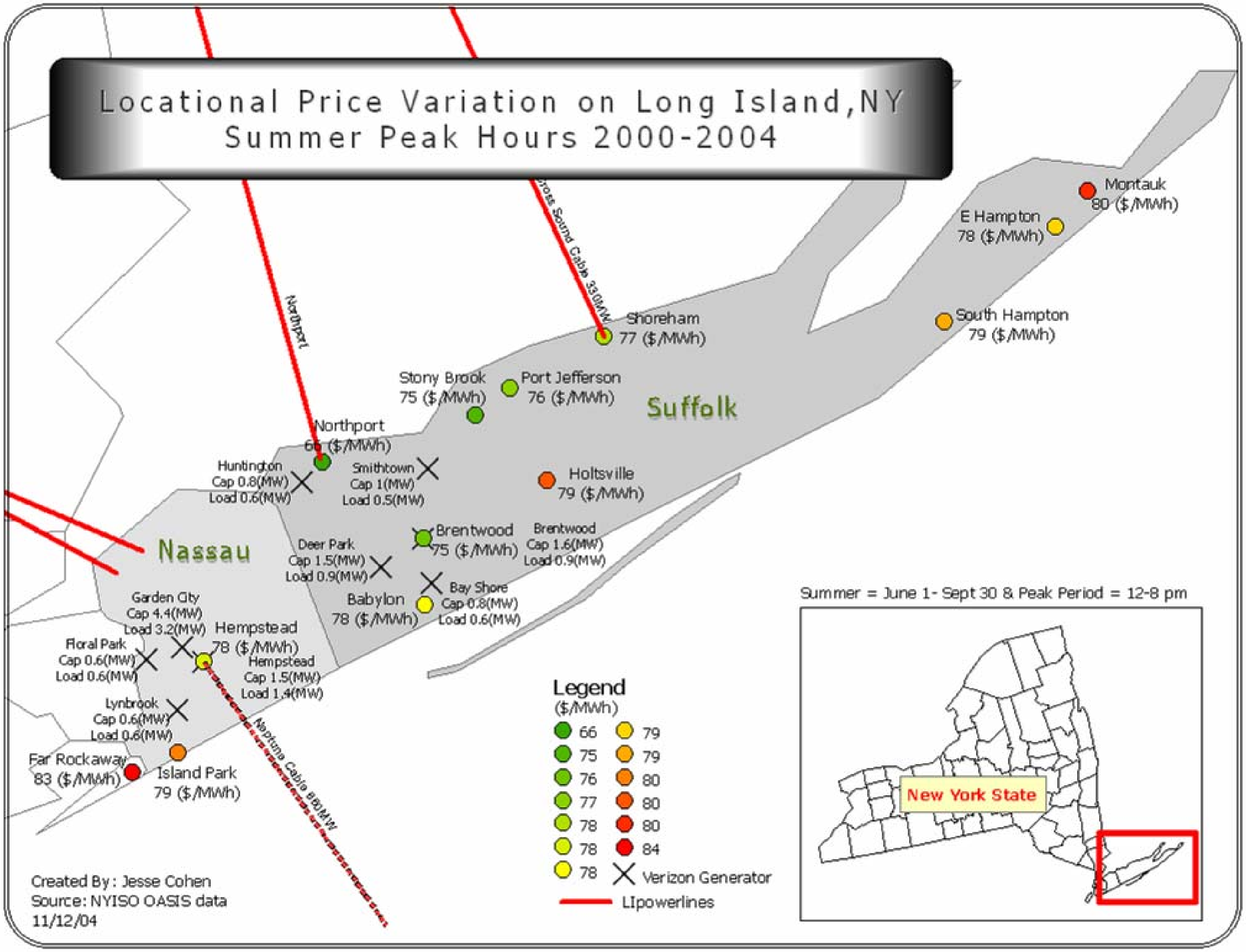

Figure 11. Summer Peak Average LBMP Map

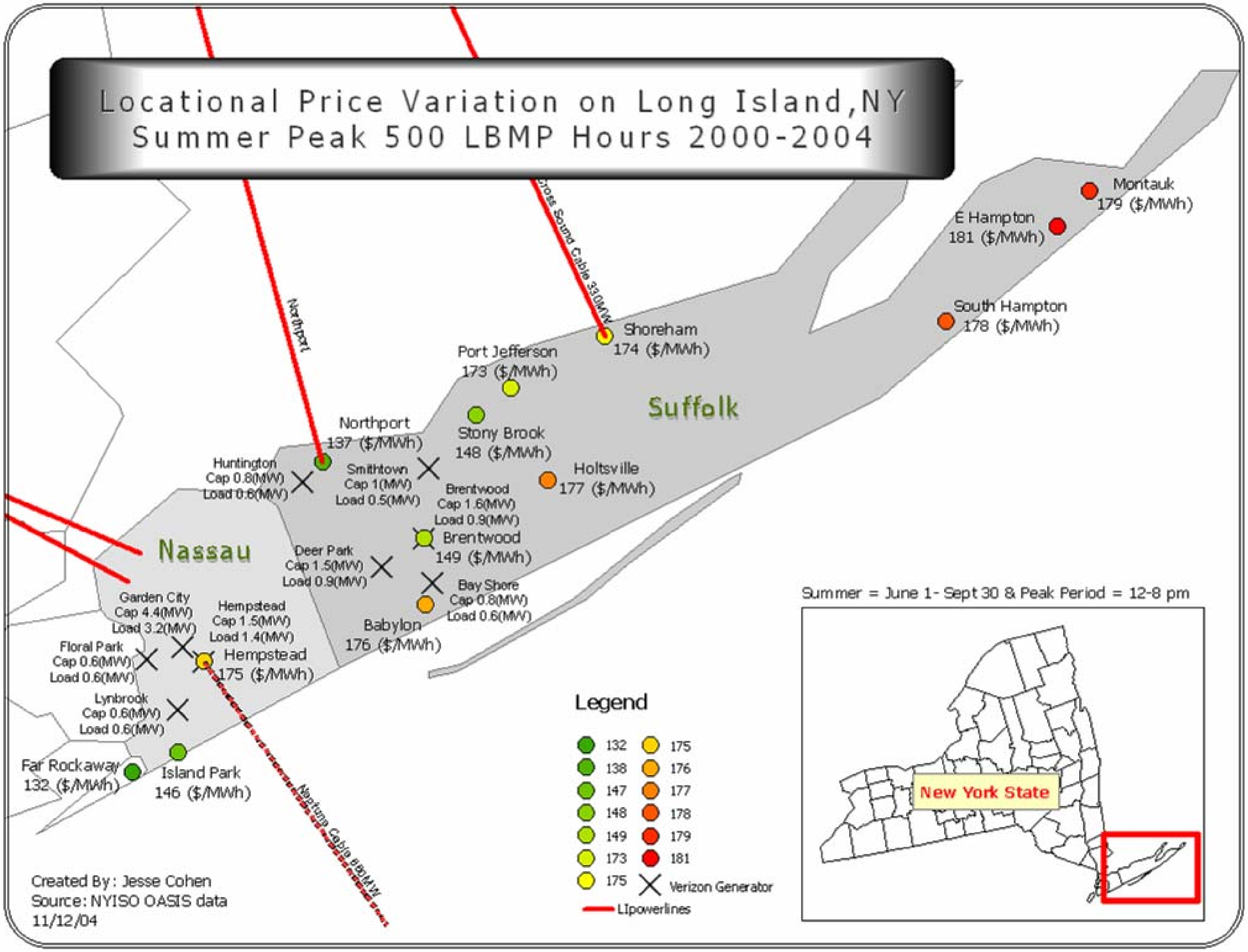

Figure 12. Top 500 Hours LBMP Map

References

New York Independent System Operator. 2004a. "Power Trends 2004."

New York Independent System Operator. 2004b. *Technical Bulletin 067 - Automated Mitigation Procedure*. New York Independent System Operator. December 30.

New York Independent System Operator. 2005. "Power Trends 2005."