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Phase 1 Report

Customized Energy Solutions
Seneca Compressed Air Energy Storage (CAES) Project
November 18, 2011

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1 Executive Summary

1.1 Overview of Phase 1 Study Results

Customized Energy Solutions was contracted to provide the review of the CAES operation in the NYISO Market. CES has developed a model to assess the net revenue opportunities for Energy Storage Systems in the organized Energy Market which include the NYISO. Due to the unique characteristics of the CAES Facility Configurations, CES developed a more advanced model system, which forecasts energy, regulation and operating services of an hourly basis for the life of the facility. A number of CAES configurations were reviewed in addition to changing parameters for the charging and discharging of the CAES Facility based on transmission constraints as well as Cavern storage capabilities related to the CAES Cycle designs.

A Base Case Scenario was developed and a number of alternate scenarios identified based on data from NYISO Planning Studies. These scenarios were run through the Model with the main result the identification of the annual net revenue projections for the operation of the two main CAES facility designs identified by the Worley Parsons cycle evaluation.

Based on the results of the NYSEG Net Present Value (NPV) model, it was determined that the total net revenue from either of the CAES 1A or CAES 2 configurations, that there was not enough revenue generated over the life of the facility to justify going forward with the project at this time.

1.2 Market Price Forecast Model

The Market Price Forecast Model was originally developed to support a NYSERDA Project. The model was then enhanced to include CAES Configurations which support the full Market revenue potential for the NYISO and Other organized market across the U.S. The model was calibrated to the NYISO Operating data for the years 2005 through 2010. Once calibrated the model was run using input data from NYISO reports and studies for the near years and extrapolations normalized for the out years, i.e., ten years and beyond.

1.3 Economic Dispatch Model for Market Price Forecast

The Dispatch portion of the model uses a complete data base of all the generating facilities in the NYISO Control Area as identified in the NYISO "Gold Book" report. This database includes the historic generating unit fleet and is used in the calibration to establish the marginal cost for each facility to calibrate the dispatch model. For the forward dispatch assumptions are made for the retirement of generating facilities and the additions of facilities based on the Interconnection Queue maintained by the NYISO and the Reserve Margin Requirements for the years beyond those identified in the queue.

1.4 CAES Dispatch Model

The model was run for each hour from the start of commercial operation of the facility in 2016 to 2045. By being able to predict the LBMP throughout the day using a weekly cycle for the operation of the CAES Facility, the arbitrage operation of the CAES plants was determined considering the energy ratio, power ratio and heat rate as well as the cavern size constraint.

1.5 Dispatch Model Results

The model showing that the CAES plant is not significantly impacted by the various scenarios as compared to the base case with the exception of the scenario for retirement of Indian Point by the start of the commercial operation of the facility. The key observation of the analysis in the out years shows that there is lower hours of arbitrage opportunity particularly in period beyond 2035 because of the majority of the generation supply comes from Natural Gas fired generation and with the exception of severe high and low load situations, the off peak and on peak pricing doesn't vary greatly for significant period.

The phased in approach to the cavern availability also had a significant impact on the revenues from the CAES Facility in the early years of operation.

1.6 Observations Regarding the NYISO Market

The modeling for the historic and the forward dispatch models were based on the NYISO's Day Ahead Market operation. The modeling did not include any additional operational benefits that may be available from the Real Time operation of the NYISO System. There are also some additional revenue opportunities excluded such as system benefits for reliability and operational constraints resulting from potential transmission investments that maybe avoided or delayed with the operation of the CAES Facility, In addition, the NYISO is considering changes to the Market design for the Regulation and Frequency and Voltage Support Services which could increase the revenue opportunity of the CAES Facility under a new Market design. The Environmental Protection Agency's Cross State Air Pollution Rule is currently under review and will have an impact on the cost of operation of certain generating facilities in the State along with a number of other regulations impacting the operation of the generating facilities in the 2015 time frame. Finally, the Renewable Energy Credits was not included in the evaluation which could benefit the NYSEG customers. Finally, no benefits attributed to the CAES facility for the direct relationships with Wind Generation providers where bilateral arranges can be made in ensure all of the Wind Generation available is delivered or stored allowing for a mutual benefit between the Wind Generator and the CAES Facility.

2 General Overview of NYISO Wholesale Market and Market Model

The NYISO facilitates and administers the markets for installed capacity, energy, ancillary services, and transmission congestion contracts. NYISO operates a multi-settlement wholesale market system consisting of financially-binding day-ahead markets and real-time markets for energy and ancillary services. Through these markets, the NYISO commits generating resources, dispatches generation, procures ancillary services, schedules external transactions, and sets market-clearing prices based on supply offers and demand bids. The Real Time Commitment model ("RTC") is primarily responsible balancing the Day-Ahead schedules to the real time supply and demand. RTC also schedules external transactions for the next hour based on bids and offers submitted by participants. RTC executes every 15 minutes, looking across a two-and-a-half hour time horizon to determine whether it will be economic to start-up or shut-down generation.

2.1 Installed Capacity Market

The Installed Capacity (ICAP) Market is established to ensure that there is sufficient generation capacity to cover the peak capacity requirements determined by the NYISO. An ICAP resource is a generator or load (demand response) facility with access to the New York State transmission system, and is) capable of supplying or reducing the demand in the New York Control Area) complies with the requirements of the NYISO reliability rules.

In order to provide this service, any new generating resource must determine through the NYISO interconnection process its deliverability through the NY Control Area (excluding Zone J -NYC and Zone K - Long Island which have their own deliverability requirements).

The ICAP market provides economic signals that supplement the signals provided by the NYISO's energy and operating reserve markets. If resources participate in the ICAP Market, they will receive revenue for making their resource available and as a result are required to offer the energy from the resource into the DAM. Energy storage systems capable of providing at least 4 hours of energy are eligible to receive ICAP payments as part of Energy Limited Resources (ELR).

All Load Serving Entities (LSEs) must acquire sufficient ICAP to cover their peak load plus a reserve by self-scheduling, bilateral purchasing, or through one of the NYISO's forward capacity procurement auctions. The NYISO has two Capability Periods to define the Peak Load requirements. There is the Summer Capability Period which covers the period from as May 1st, through October 31st, and the Winter Capability Period which extends from November 1st through April 30th. Any remaining obligations are settled against the NYISO's monthly spot auction where clearing prices are determined by a capacity demand curve.

2.2 Energy Market

The energy market provides a mechanism for Market Participants to buy and sell energy at the Locational Based Marginal Price (LBMP).

The generators designated by Security Constrained Unit Commitment (SCUC) program to be available for the next day are dispatched against the Load Serving Entity (LSE) bid-in load including transmission losses. From the dispatch, LBMP's are computed, and day-ahead forward contracts are established for generation and load accordingly. Subsequently, during real-time operation, changes in operating conditions, the influence of additional real-time supply bids, and variations in actual load will cause the real-time schedules and prices to be different from the day-ahead schedules and prices. Differences between the day-ahead and real-time generation levels and load consumption values are settled at the second settlement, or at the real-time price.

There are eleven zones defined by NYISO across the New York Control Area. These regions are distinct in terms of geography and in energy price distribution. The major price differentials exist between the Upstate and Downstate Regions. This is generally viewed as the areas west of the Central East Interface and East of the Central East Interface. The Hudson Valley region, New York City and Long Island are in this eastern region.

For the NYISO's operations, the peak period is defined as the hours between 7 am and 11 pm inclusive, for the prevailing Eastern Time, Monday through Friday, except for North American Electric Reliability Council (NERC) defined holidays. The off-peak period is defined as the hours between 11 pm and 7 am, for the prevailing Eastern Time, Monday through Friday; all day Saturday and Sunday; and NERC defined holidays. NYISO has two Capability Periods to define the Peak Load requirements. There is the Summer Capability Period which covers the period from as May 1st, through October 31st, and the Winter Capability Period which extends from November 1st through April 30th.

2.3 Ancillary Services Market

Ancillary services support the transmission of energy and reactive power from supply resources to loads and are used to maintain the operational reliability of the NYS power system. The ancillary services include:

2.3.1 Regulation and Frequency Response Service

Regulation and frequency response services are necessary for the continuous balancing of resources (generation and NY Control Area interchange) with load, and to assist in maintaining the Interconnection frequency at 60 Hz. This service is accomplished by committing Generators, including Limited Energy Storage Resources (LESR's) and Demand Side Resources (Regulation Service Suppliers), whose output or demand is raised or lowered (predominately using Automatic Generation Control (AGC)) as necessary to follow moment-by-moment changes in the load.

The NYISO establishes the regulation and frequency response requirements consistent with criteria established by North American Electric Reliability Council (NERC), which will vary by hour and by season. The NYISO posts the hourly regulation and frequency response requirements.

Regulation Service is offered into the market by Regulation Service qualified suppliers that have AGC capability, which is the intention of all three CAES Cycles.

Regulation Service capacity is allocated to each Regulation Service resource that was selected to provide Regulation Service. The capacity allocated is based on the economics of the bid and the NYISO Regulation Service requirement, not to exceed the lesser of the regulation response rate times 5 minutes, or the regulation availability MWs bid.

Figure 1 shows the average daily price curves for the Regulation service in New York Western Region for 2005 through 2011 (partial year). The regulation service is applied across all Zones in the NYISO, so one price is established for the entire Control Area. Figure 2 shows the synchronous and non synchronous (non-spin) ancillary service price pattern.

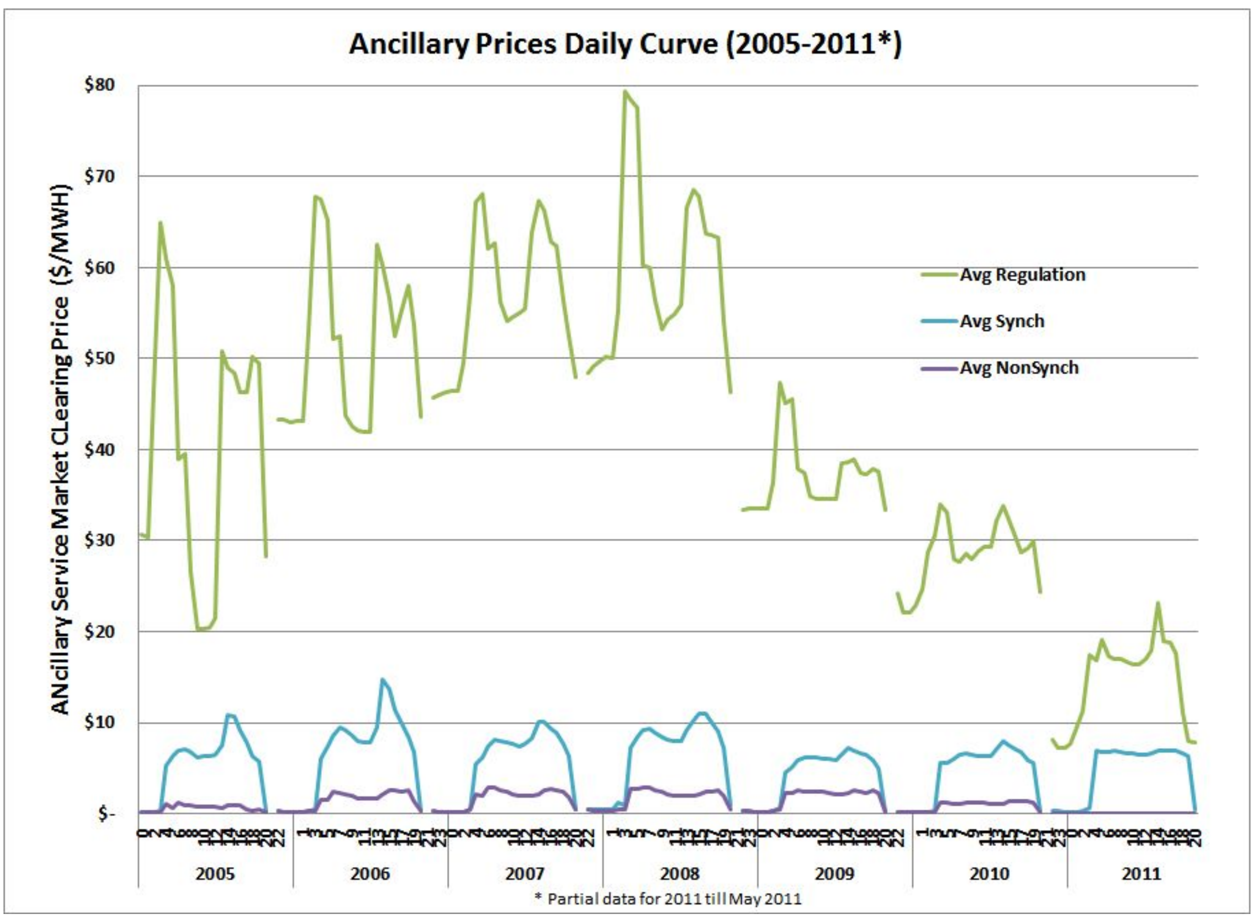


Figure 1: Average daily ancillary service market clearing price profiles for NYISO western region during 2005-20011*.

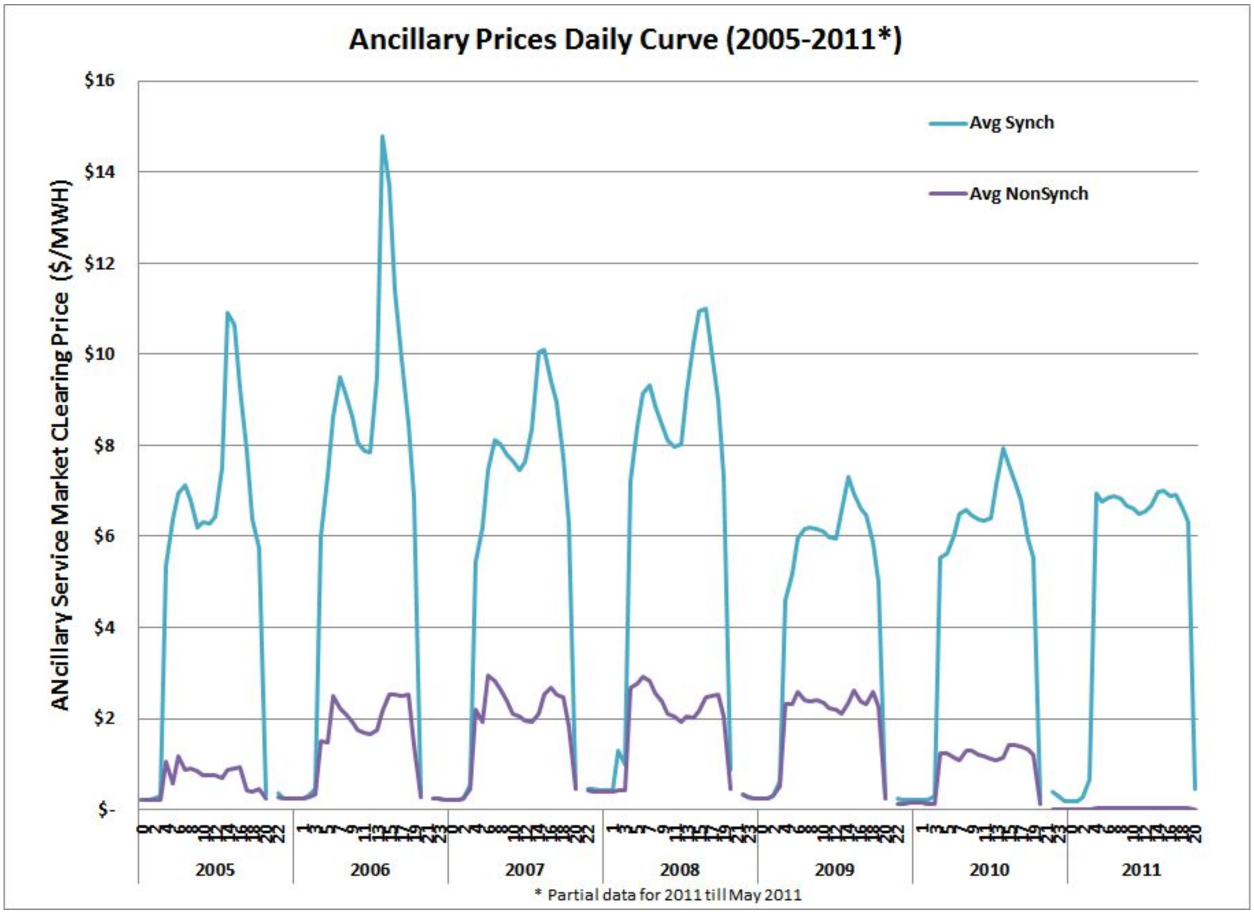


Figure 2: Synchronous Reserve and Non Synchronous Reserve Prices for NY West region (2005-2011*)

2.3.2 Operating Reserves Service

Operating Reserve Services provides backup generation when there is an unexpected change in generation or transmission due to reaching a power system contingency and/or an equipment failure. The NYISO Operating Reserves Service must be available in 10 minute spinning, 10 minute non-synchronous, and 30 minute reserves and are each a separate product.

In each hour, the NYISO purchases 1,800 MWs of operating reserves. From these 1800 MWs, at least 1,200 MWs must be 10 minute reserves and 600 MWs must be spinning reserves as shown in Figure 2.

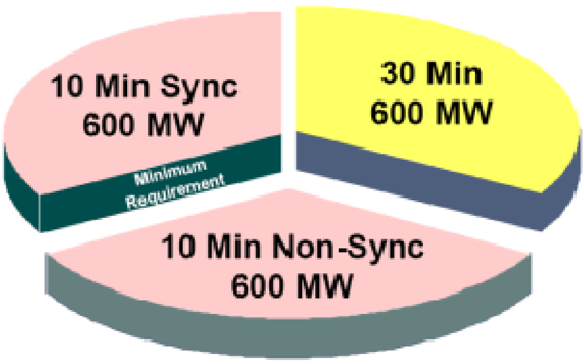
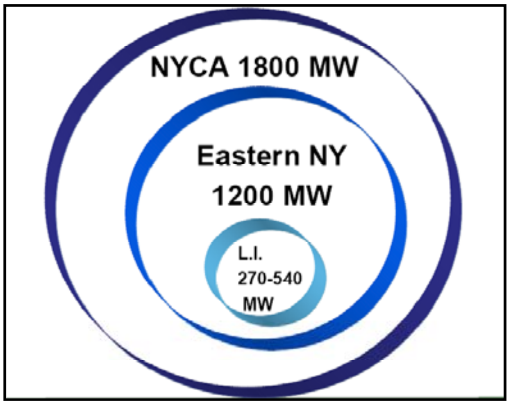


Figure 3: NYCA Operating Reserve Requirements (Source: NYISO)

The NYISO values Spinning Reserve to be the "highest quality" Operating Reserve, followed by 10-Minute Non-Synchronized Reserve and then by the 30-Minute Reserve (spinning and then non-synchronized).

Ten minute spinning (or synchronous) reserves are held on generating units that are on-line and can provide additional output within 10 minutes. The resource must provide a full response in 10 minutes and be able to perform at the committed response for 30 minutes. 10 Minute non spinning reserve can be used to supply 10-minute total resources, and are typically off-line gas turbines that can be turned on and generate within 10 minutes. These facilities must be able to synchronize with the network and provide a full response in 10 minutes. They also must be able to perform at the committed response for 30 minutes. 30-minute operating reserves may be supplied by any unit that can be ramped up in 30-minutes or that can be on-line and be producing within 30 minutes. All dispatchable (flexible) resources participate in the reserve market. The resource must provide a full response in 30 minutes and be able to perform at the committed response for at least 1 hour. The prices for the operating reserve service are set by the NYISO through the co-optimized Market providing the lowest cost service from the offer bids of each Supplier except for situation where scarcity exists and the price are set accordingly. The price of higher quality Operating Reserves will not be set at a price below the price of lower quality Operating Reserves in the same location. Thus, the price of Spinning Reserves will not be below the price for 10-Minute Non-Synchronized Reserves or 30- Minute Reserves; and the clearing price for 10-Minute Non-Synchronized Reserves will not be below the clearing price for 30-Minute Reserves.



Operating Reserves procurement is subject to locational requirements (Figure 19) that ensure the reserves are located where they can respond to system contingencies. Of the required 1200 MW of total 10-minute reserves, 1,000 MW must be purchased east of the Central-East Interface.

2.3.3 Voltage Support Service (VSS)

In order to maintain transmission voltages on the NYS Transmission System within acceptable limits, facilities offering VSS are operated to produce (or absorb) Reactive Power. The NYISO directs the Supplier's Resources to operate within their tested reactive capability limits. Supply resources that have Automatic Voltage Control (AVR) and have successfully met the testing requirements to determine the total reactive power capability (lagging and leading) can participate in the service and be paid a cost-based predetermined rate for the service. Suppliers are paid based on their capability whether they are called to provide the service or a portion of the service. Payments to synchronous generators and synchronous condensers eligible for VSS are based upon a fixed dollar amount per MVAR -year. This service is cost based and is currently set at $3419/MVAR-year

2.3.4 Black Start Service

Black Start capability is provided by key generators that, following a system-wide blackout, can start without the availability of an outside electric supply and are available to participate in system restoration activities that are under the control of the NYISO or, in some cases, under local Transmission Owner control.

The NYISO identifies the generating units that are in critical areas for New York State Power System restoration. Transmission Owners, such as NYSEG, can also identify key generating facilities to provide local Black Start capability which are compensated by the customers within the Transmission Owners service territory. During system restoration activities, the NYISO manages and deploys the Black Start capability, as needed, depending on the specific situation.

Compensation for providing Black Start Service is cost based and requires annual testing and review of updated embedded cost information associated with maintaining the Service capability.

It is not expected that the NYISO would change its system restoration plan; however, NYSEG may want to consider the addition of the Seneca CAES facility in its local restoration plan.

2.4 Future Market Developments

The Electric Markets are very dynamic with constantly changing pressures on Supply Resources, Demand requirements, Market design changes, the economy, environmental regulations, energy policy, new technology enhancements, and consumer interests.

The NYISO is and will be facing many challenges in the operation and market design in the coming years. These changes will have an impact on the contribution of the Seneca CAES built to the NYS Energy Market. Some examples of the influences include:

On October 20, 2011, FERC issued its final rule on Frequency Regulation Compensation in the organized Wholesale Power Markets. FERC has found that current compensation methods for Regulation Service fail to recognize the value provided by faster ramping resources such as flywheels and batteries. The NYISO currently pays one price to Regulation Service providers for Regulation. This FERC rule requires the NYISO to modify this into two payment streams: a capacity payment that includes the marginal unit's opportunity cost and a second payment for performance that reflects the quantity of Regulation Service provided by a Resource. The NYISO is currently reviewing these requirements. This new market design will allow the Seneca CAES Project to obtain greater regulation revenue due to the amount of regulation the Facility can provide and the increased response rate over traditional resources to respond to the requirements.

The NYISO is also experiencing voltage problems in the off peak periods and during high load periods. The NYISO has noted that there a key providers of the service due to their location in the system and if not properly incented, they could discontinue providing the service which could result in reliability concerns. The NYISO has committed to reviewing the overall service design.

There are a number of environmental regulations that are scheduled to be in place ahead of the startup of the Seneca CAES facility. The NYISO had identified that approx 49% of the Supply Fleet will be impacted by these regulations. Many of the Supply Resources impacted by these regulations will be candidates for retirements, while the remaining Supply Fleet will require significant investment to meet the regulations, thus putting upward pressure on the Capacity, Energy and Ancillary Service Markets.

The Renewable Portfolio Standard adopted in New York State sets the goal of providing 30% of the electric energy requirements from renewable resources. To meet this standard most of the renewable energy will come from Wind Generation. The Wind Generation tends to be intermittent, requiring supply resources to fill the voids for when the wind is not available. This puts significant pressure on the System as more wind generation is developed. The contribution of Wind Generation has been factored in the evaluation, however, extreme variability of the Wind Resources from the historic data may not reflected in this phase of the evaluation.

3 Forward Price Curve Model

3.1 Background

The Customized Energy Solutions and Lumina team developed an economic dispatch model to forecast future market prices to calculate the Location Based Marginal Price (LBMP), regulation, operating reserves, and capacity prices. The model is a fundamental economic dispatch model that attempts to keep track of the marginal units required to meet load for each hour and then provides additional adjustment to the marginal price to account for transmission congestion and marginal losses in order to predict prices for the NYISO Zone C, where the Seneca CAES plant will be located. The inputs to the forward model are based on published data and forecasts from the NYISO (the "Gold Book" being the source of most of the information along with other internal NYISO planning studies) and other reporting services. This data includes the projected generation retirements and additions as well as load growth projections. Most of this information is projected 5 and 10 years in the future. Since the planned life of the CAES facility is 30 years, data inputs beyond the 5 and 10 year horizon are projected based on extrapolating the trends. For fuel prices, the model uses the U.S. Energy Information Administrations' (EIA) Annual Energy Outlook 2010 (AEO) fuel price forecasts. for price forecasts through 2035. The trend from 2010 to 2035 was used to project fuel prices from 2035 until 2046. Escalation factors are applied to these "Real Prices" indexed to the projected GDP growth rate from the AEO 2010 data were used in bringing the real 2009 price forecast provided by AEO to nominal prices for 2016 through 2046.

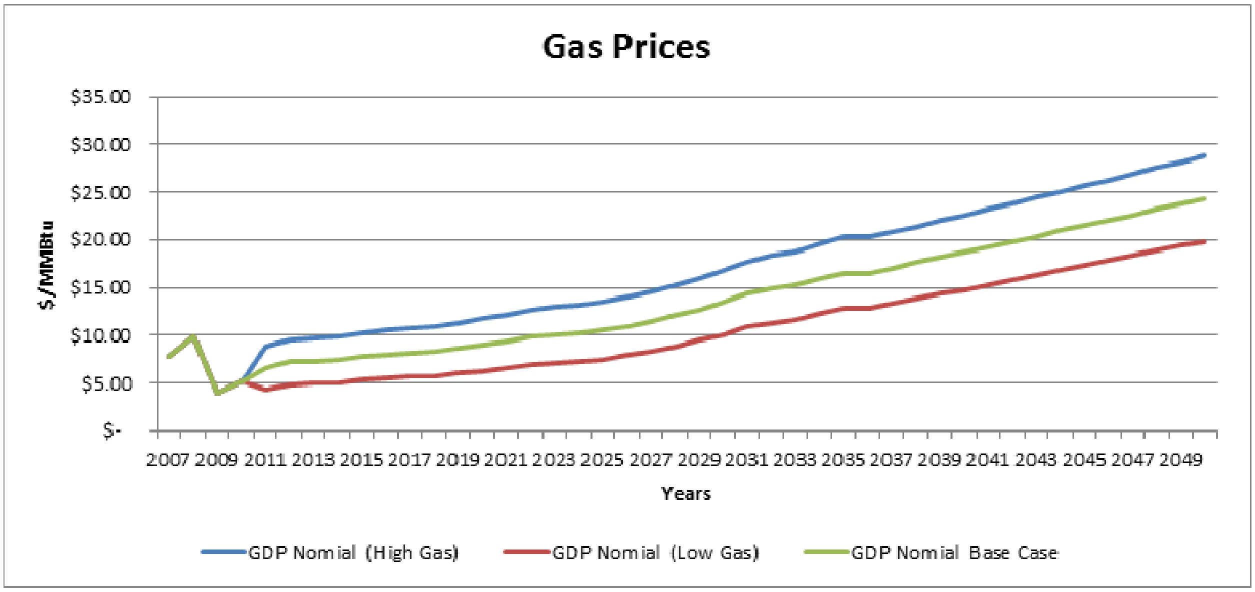
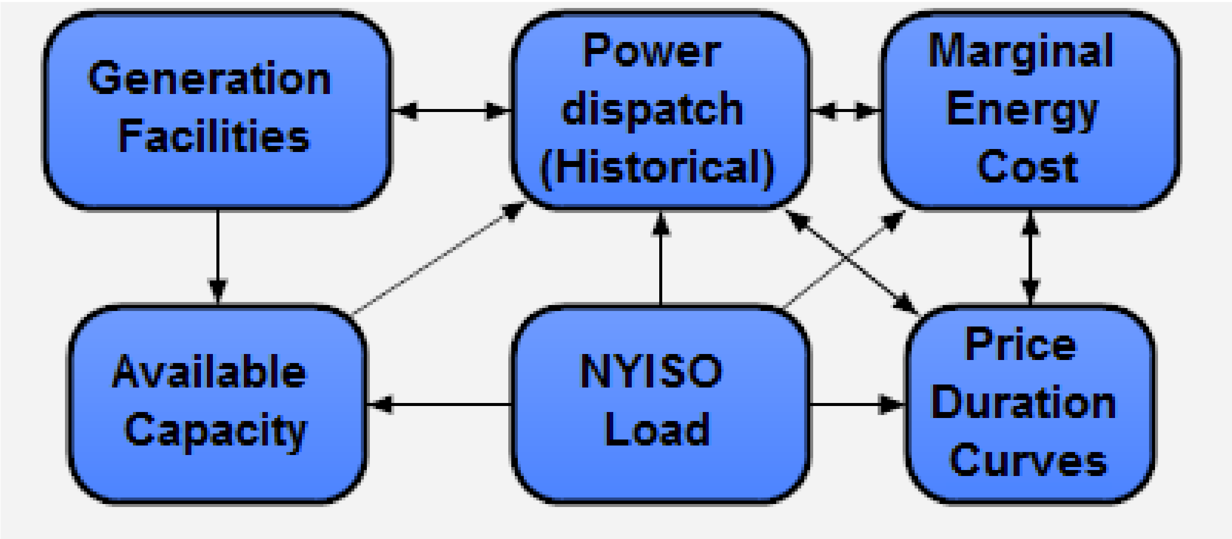


Figure 4: Natural gas price forecasts under 3 scenarios (base case, high price and low price) based on EIA's Annual Energy Outlook 2010 forecasts, adjusted for upstate NY prices based on NYISO CARIS methodology

The Model used was developed from previous evaluations conducted on Energy Storage Projects by Customized Energy Solutions and extended by the Lumina Decision Systems Analytica Software.

3.2 Energy Price Forecasting

The following section provides additional details on the model used to forecast future energy prices.



The model uses existing data on power plants to create a historical supply stack, which is then combined with assumptions on seasonal (summer and winter) capabilities and plant availability to generate available capacity (MW) estimates for each power plant in the supply stack.

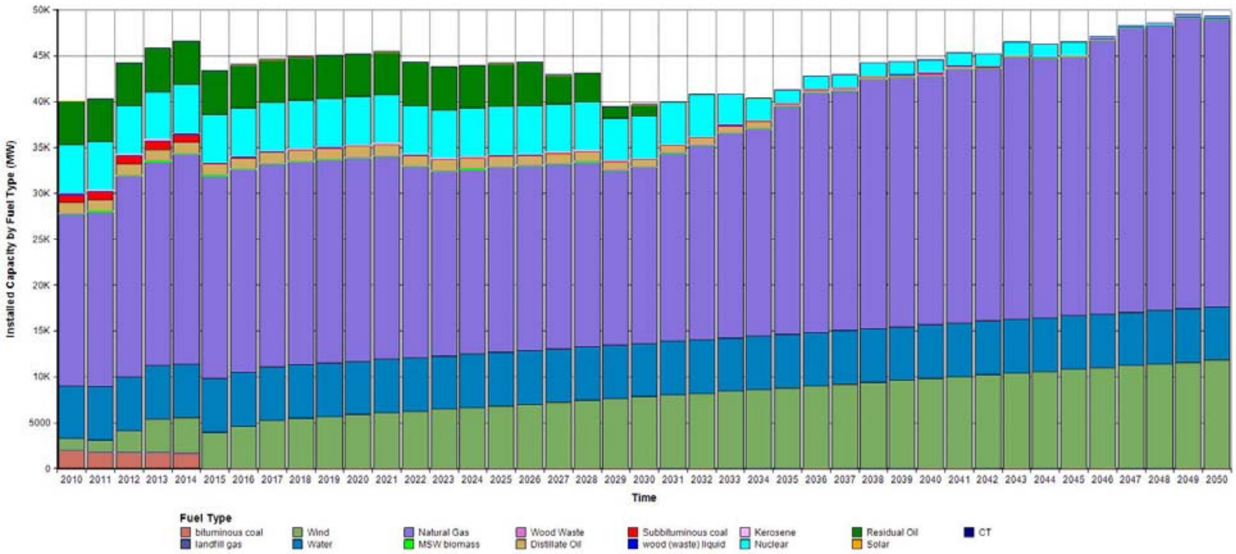


Figure 5: NYISO Installed Capacity from 2010-2050 based on base case scenario assumptions and NYISO generation queue data

Historical fuel price and heat rate data is used to estimate the Marginal Energy Cost (MEC), which serves as an input in the dispatch model. The dispatch algorithm then allocates capacity from the power generating units to satisfy NYISO hourly demand (load) on a merit order basis by dispatching plants with lowest marginal energy cost first. We used the 2010 load data for NYISO as base case. The total system load was adjusted to account for the imports from Ontario and PJM. Based on NYISO projections, it was assumed that the future imports will be similar to imports observed in 2010 due to limitations on the transmission capacity for such imports. A regression analysis was also done to estimate loss and congestion costs when computing marginal prices (LBMP's). The resulting LBMP's are then sorted and arranged as price duration curves before being calibrated against actual historical day-ahead LMPs) from the NYISO.

Using power plant data from eGRID database of Environmental protection Agency and the NYISO Gold Book, the historical supply mix of the NYISO was used to create a supply stack from 2005-2010. The purpose for developing the historical supply mix was twofold. First, the supply mix was used to dispatch the generators to meet the Load requirements providing an hourly LBMP, which was compared to actual DAM LBMPs resulted in a calibrated dispatch model. Second, the historical supply mix was adjusted going forward to generation additions as identified in the NYISO Interconnection Queue and projected for the years beyond 2018. This data includes Nominal Heat Rate (BTU/KWH)) and

Nameplate Capacity (MW) information, which is used in doing the power dispatch modeling. The NYISO hourly load data from 2005-2010 was imported into Lumina's Analytica model Historical fuel price data for all fuel types was obtained at varying levels of granularity from different sources. Daily historical natural gas prices were obtained from the NYISO, Monthly historical average kerosene prices, and annual historical coal prices were obtained from the Energy Informaiton Administration's (EIA's) State Energy Price Database. Generic Variable O&M cost data based on different generation sources was also obtained from EIA for use in the Marginal Energy Cost (MEC) cost calculations.

The model then simulates, on an hourly basis, which generators to dispatch to meet hourly load , selected on a merit order basis of lowest Marginal Energy Cost (MEC), where

MEC ($/MWH):= Fuel Cost ($/Btu)*Heat Rate (BTU/MWH) + Variable O&M Cost ($/MWH) + Emission Cost ($/MWH)

A regression analysis was performed to predict the Marginal Loss Cost (MLC) and Marginal Congestion Cost (MCC) using hourly day-ahead price data from NYISO. Basis terms include hourly load, daily gas prices, hour of the year, heating degree days, weekdays and seasons. Regression results were incorporated into historical analysis to get the zonal prices for Zone C by incorporating the congestion and marginal loss component in the MEC.

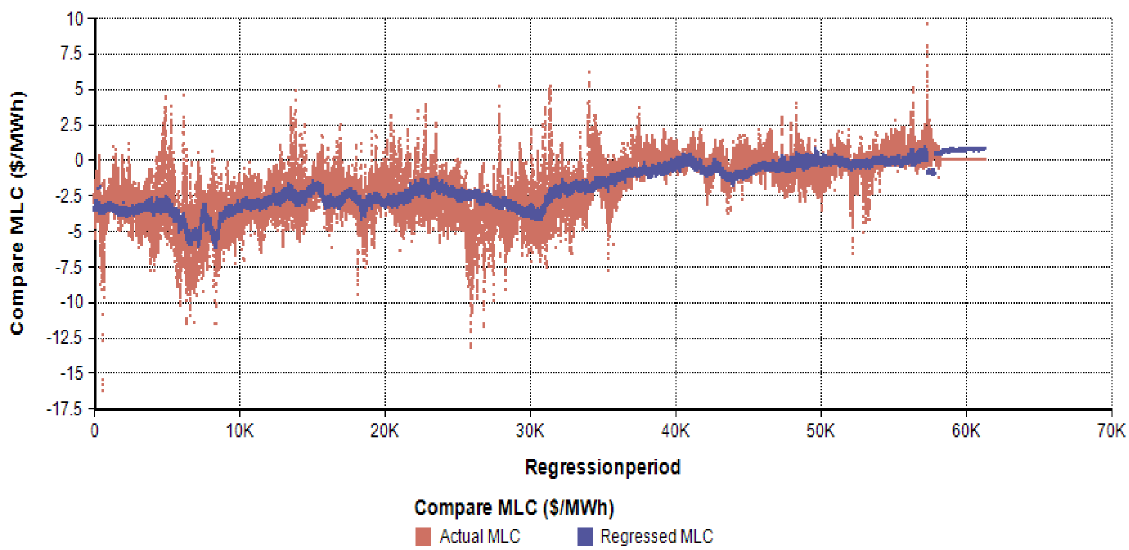


Figure 6: Results of the regression analysis for the Marginal Loss Component using 2005-10 actual data

During the initial runs of the model, it was observed that the fundamental model forecasts of LBMP's in Zone C never go below $40 in years beyond 2015. Although the results were consistent with the assumptions of the supply retirements, and fuel price scenarios, it was realized that the fundamental model does not capture the impact of all the parameters such as generator minimum run time, start up time, unforced outages and the costs associated with determining run or not to run decisions for off peak periods. Also transmission emergencies and extreme low load conditions can result in market clearing prices going below the marginal energy price. The low market clearing prices are expected increase as the anticipated wind generation penetration level increases. To account for this, hourly forecast data was used from the National Renewable Energy Laboratory (NREL) and assumed that during hours when more than 80% wind generation was available, there could be lower than marginal prices during low load hours (up to 17GW i.e. < 50% of the peak load). Based on the NREL data there were less than 750 hours (<8%) when the wind availability was anticipated to be above 80%. For such scenarios, the model assumes resultant LBMP to be in the range of $15 - $35 / MWH based on different load levels between <13 GW, 13-15 GW and 15-17 GW. The minimum price is escalated in future years using the same GDP index used for adjusting the fuel prices.

During the initial runs of the model, it was observed that during some years at the very low load (and very high loads) the marginal clearing prices do not compare well with the marginal energy prices. The bid behavior at very low load conditions need to consider generator minimum run time, start up time, unforced outages and the costs associated with determining run or not to run decisions for off peak periods. This situation becomes more critical as more Wind Generation is added to the system and provides low cost (if not negative costs) bids into the off peak periods. To accommodate this situation of low load generator bid strategy, the model has been adjusted to factor in the contribution the Wind Generation (as it increases in the future) for the hourly Wind Velocity projects from historical regional weather data.

The model was tested against the actual load and LMP data for Zone C. For historical analysis the wind related adjustment was not applied because, as of 2010 the wind penetration in NY was less than 1GW.

The charts below show the annual price duration curve of the NYISO Zone C LBMPs using Economic Dispatch Model developed by Customized Energy Solutions and the Analytica team, and compares the same with the actual LBMP price duration curve for each of the years. As noted earlier, the model was calibrated and validated to the historic NYISO data from 2005 through 2010. The following graphs illustrate the ability of the model using the Generation Supply Fleet, Primary fuel pricing, system load, etc. to predict the Day Ahead LBMPs with reasonable accuracy. Note the general disparity high price and low price regions of the curve. Also, the actual data may be influence by abnormal situations, transmission outages, generator outages, economic situations, etc., which are not fully recognized in the model design

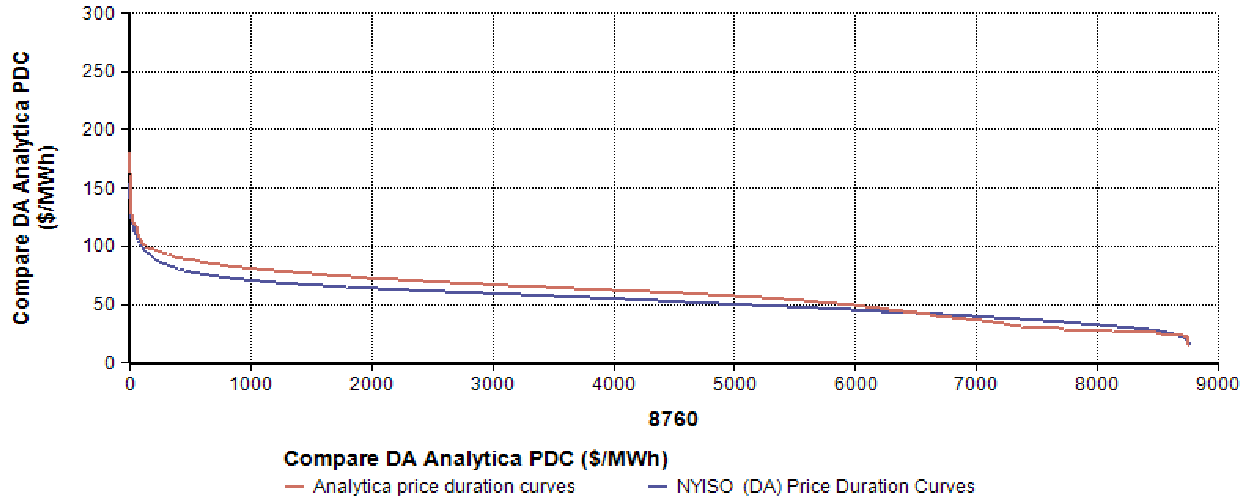


Figure 7: Comparing LMP Price Duration Curves for Year 2006

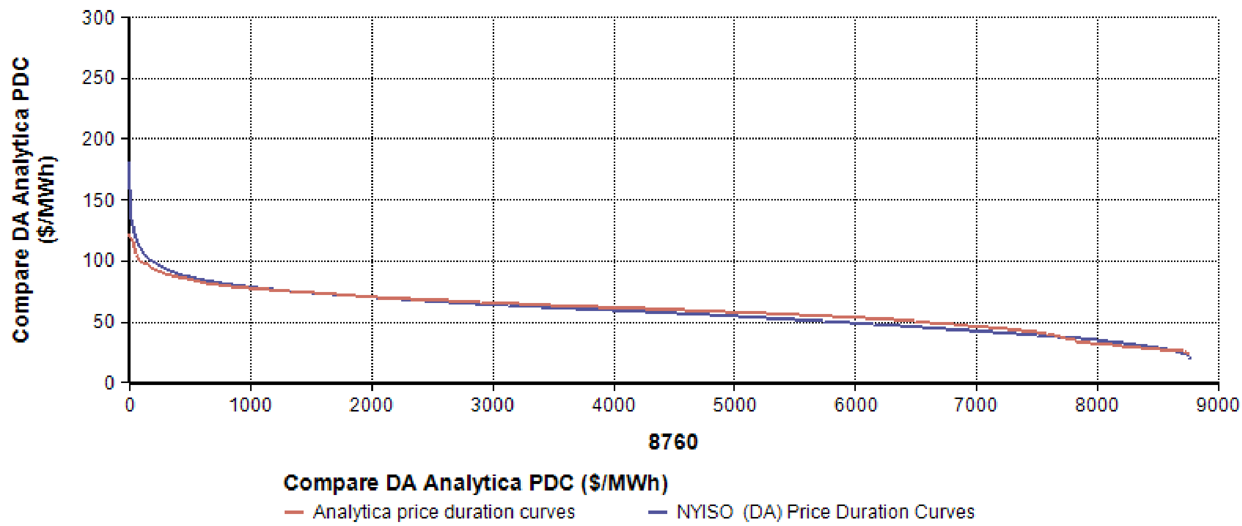


Figure 8: Comparing LMP Price Duration Curves for Year 2007

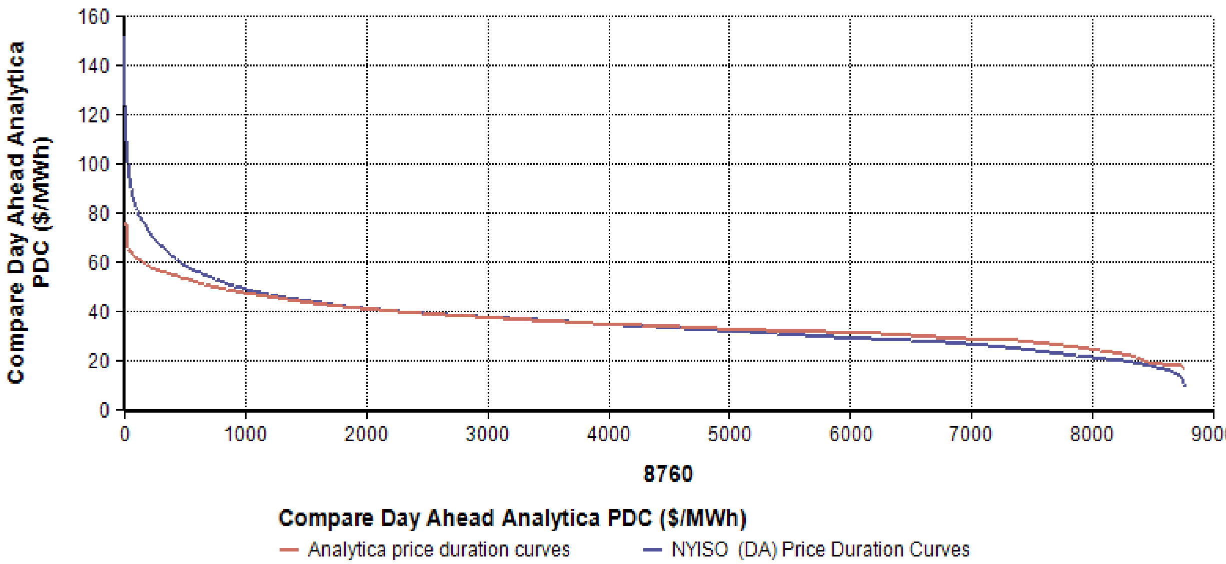


Figure9: Comparing LMP Price Duration Curves for Year 2009

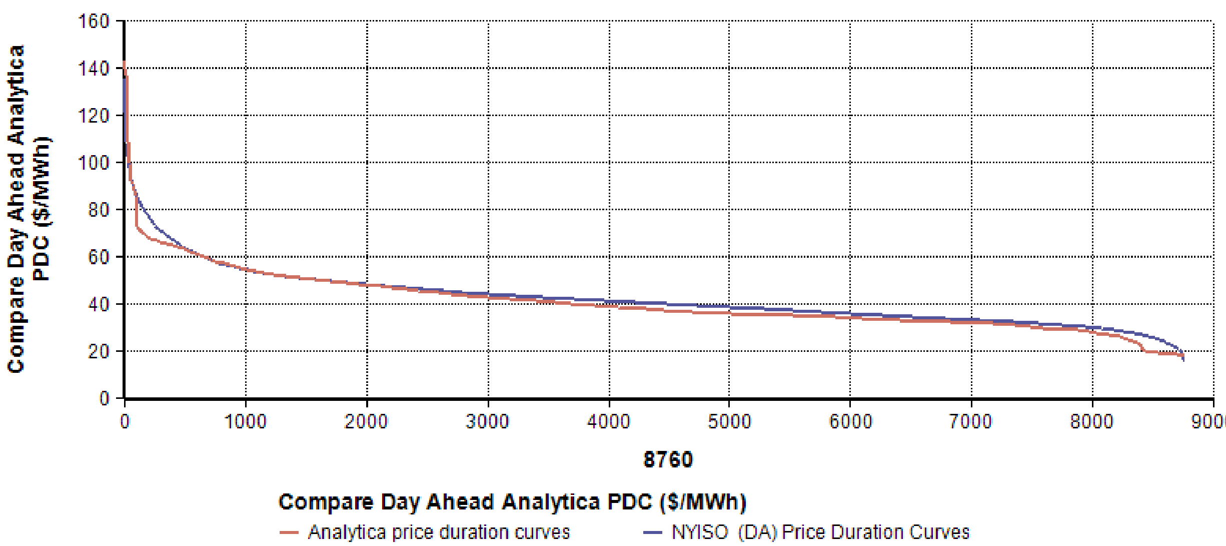


Figure10: Comparing LMP Price Duration Curves for Year 2010

3.3 Ancillary Price Forecasting

The model was also used to develop ancillary service price forecasts for Synchronous and Non Synchronous Operating Reserves. The historical analysis showed that these ancillary service prices were not significantly impacted by the varying inputs conditions that were observed in 2005 through 2010. As a result, a simple methodology of using the average of the previous 5 years prices was used to set the baseline prices, which were then adjusted for nominal value using the same GDP index used to adjust the fuel prices for future years.

3.4 Frequency Regulation Pricing

For frequency regulation prices, there are a number of factors that influence the market clearing prices. These include energy prices, regulation requirement (which changes from hour to hour and seasonally), as well as availability of regulation supply. Given the small size of the regulation market, the market has seen wide fluctuations in these prices over the past 5 years since introduction of the NYISO's SMD 2 Market Design. As a result, it was decided to use a Neural Network modeling technique to predict the forward regulation prices using the forecasted energy prices and anticipated regulation requirements based on wind penetration. Neural Network is an artificial intelligence process takes input and output through a decision process to train the software. Once trained the software can predict the output from the input data.

The NYISO also has carried out extensive analysis of potential impact of wind generation on regulation requirement (NYISO Growing Wind Final Report of the 2010 Wind Generation Study). The following tables show the proposed changes in regulation requirements in coming years as certain levels of Wind Generation penetration occurs in the NYISO grid. Cells in blue indicate hours when the regulation requirement is higher than the original NYISO requirements, and cells in orange indicate hours when the regulation requirement was reduced as it was expected that wind will contribute in reducing regulation requirements for those hours.