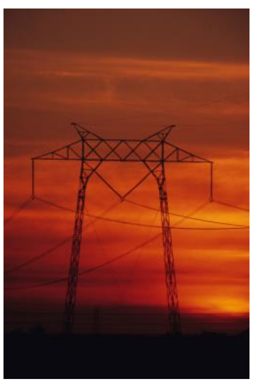
Technical Study Report

New York Control Area Installed Capacity Requirement



For the Period May 2016 to April 2017

December 4, 2015

New York State Reliability Council, LLC
Installed Capacity Subcommittee

About the New York State Reliability Council

The New York State Reliability Council (NYSRC) is a not-for-profit corporation responsible for promoting and preserving the reliability of the New York State power system by developing, maintaining and, from time to time, updating the reliability rules which must be complied with by the New York Independent System Operator and all entities engaging in electric power transactions on the New York State power system. One of the responsibilities of the NYSRC is the establishment of the annual statewide Installed Capacity Requirement for the New York Control Area.

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Note: Appendices A, B, C, and D are included in a separate document.

EXECUTIVE SUMMARY

A New York Control Area (NYCA) Installed Reserve Margin (IRM) Study is conducted annually by the New York State Reliability Council (NYSRC) Installed Capacity Subcommittee (ICS). ICS has the overall responsibility of managing studies for establishing NYCA IRM requirements for the following capability year, including the development and approval of all modeling and database assumptions to be used in the reliability calculation process. This year's report covers the period May 2016 through April 2017 (2016 Capability Year).

Results of the NYSRC technical study show that the required NYCA IRM for the 2016 Capability Year is 17.4% under base case conditions. This IRM satisfies the NYSRC and Northeast Power Coordinating Council (NPCC) reliability criterion of a Loss of Load Expectation (LOLE) of no greater than 0.1 days per year.

This study also determined corresponding preliminary Locational Capacity Requirements (LCRs) of 80.8% and 102.4% for New York City and Long Island, respectively. In accordance with its responsibility of setting the final LCRs, the New York Independent System Operator (NYISO) will later determine appropriate LCRs for the New York City and Long Island zones using a separate calculation process in accordance with NYISO tariff and procedures, while adhering to NYSRC Reliability Rules.

The 17.4% IRM base case value for the 2016 Capability Year represents a *0.1% increase* from the 2015 base case IRM of 17.3%. Table 6-1 shows the IRM impacts of individual updated study parameters that result in this change. There are five parameter drivers that in combination *increased* the 2016 IRM from the 2015 base case. Of these, the three most significant drivers are the modeling of all hours in a year (8,760 hours) in the reliability simulation in MARS instead of only peak hours, which increased the IRM by 0.4%; the retirement of the Huntley Generating Station and related transmission topology changes, which increased the IRM by 0.4%; and updated Ontario, New England, and Quebec interconnected area models, which increased the IRM by 0.3%.

Five other parameter drivers collectively *decreased* the IRM. Of these, the most significant drivers are an updated PJM load and capacity model with a corresponding change in the topology model, which decreased the IRM by approximately 0.5%, and updated NYCA generating unit EFORds, which decreased the IRM by 0.4%.

This study also evaluated IRM impacts of several sensitivity cases. The results of all sensitivity cases are summarized in Table 7-1 and in greater detail in Appendix B, Table B-1. In addition, a confidence interval analysis was conducted to demonstrate that there is a high confidence that the base case 17.4% IRM will fully meet NYSRC and NPCC resource adequacy criteria that require a Loss of Load Expectation (LOLE) of no greater than 0.1 days/year.

The base case and sensitivity case IRM results, along with other relevant factors, will be considered in a separate NYSRC Executive Committee process in which the Final NYCA IRM requirement for the 2016 Capability Year is adopted. The 2016 IRM Study also evaluated Unforced Capacity (UCAP) trends. UCAP is the manner the NYISO values installed capacity considering the forced outage ratings of individual generating units. This analysis shows that UCAP margins, which steadily decreased over the 2006-2010 period, have ranged between 5.5% and 7% since then.

1. Introduction

This report describes a technical study, conducted by the NYSRC Installed Capacity Subcommittee (ICS), for establishing the NYCA Installed Reserve Margin (IRM) for the period of May 1, 2016 through April 30, 2017 (2016 Capability Year). This study is conducted each year in compliance with Section 3.03 of the NYSRC Agreement which states that the NYSRC shall establish the annual statewide Installed Capacity Requirement (ICR) for the NYCA. The ICR relates to the IRM through the following equation:

$$\mathbf{ICR} = \left(\mathbf{1} + \frac{\text{IRM Requirement (\%)}}{\mathbf{100}}\right) * \textbf{Forecasted NYCA Peak Load}$$

The base case and sensitivity case study results, along with other relevant factors, will be considered by the NYSRC Executive Committee for its adoption of the Final NYCA IRM requirement for the 2016 Capability Year.

The NYISO will implement the Final NYCA IRM as determined by the NYSRC, in accordance with the NYSRC Reliability Rules[1], the NYISO Market Services Tariff, and the NYISO Installed Capacity (ICAP) Manual.[2] The NYISO translates the required IRM to an Unforced Capacity (UCAP) basis. These values are also used in a Spot Market Auction based on FERC-approved Demand Curves. The schedule for conducting the 2016 IRM Study was based on meeting the NYISO's timetable for conducting this auction.

The study criteria, procedures, and types of assumptions used for the study for establishing the NYCA IRM for the 2016 Capability Year (2016 IRM Study) are set forth in NYSRC Policy 5-9[3], *Procedure for Establishing New York Control Area Installed Capacity Requirement*. The primary reliability criterion used in the IRM study requires a LOLE of no greater than 0.1 days/year for the NYCA. This NYSRC resource adequacy criterion is consistent with Northeast Power Coordinating Council (NPCC) reliability criteria and National Electric Reliability Corporation (NERC) reliability standards. IRM study procedures include the use of two study methodologies: the *Unified Methodology* and the *IRM Anchoring Methodology.* The above reliability criterion and methodologies are described in Policy 5-9 and discussed in more detail later in this report.

[1] http://www.nysrc.org/NYSRCReliabilityRulesComplianceMonitoring.asp
[2] http://www.nyiso.com/public/markets_operations/market_data/icap/index.jsp
[3] http://www.nysrc.org/policies.asp

In addition to calculating the NYCA IRM requirement, the above methodologies identify corresponding preliminary LCRs for New York City (NYC) and Long Island (LI). In its role of setting the final LCRs, the NYISO will utilize the IRM value approved by the NYSRC. The LCR values determined in this NYSRC study are considered *preliminary* because the NYISO, using a separate calculation process in accordance with its tariff and procedures, sets the final LCRs.

The 2016 IRM Study included a modeling change whereby all hours in the year (8760 hours) are considered in the IRM simulation rather than only daily peak hours as represented in previous IRM studies. This study also included parametric changes in the PJM model which led to a reduction in the PJM LOLE compared to the 2015 Study. This change permits increased emergency assistance to NYCA.

The 2016 IRM Study was managed and conducted by the NYSRC Installed Capacity Subcommittee (ICS) and supported by technical assistance from NYISO staff.

Previous IRM Study reports, from 2000 to 2015, can be found on the NYSRC website.[4] Appendix C, Table C-1 provides a record of previous NYCA base case and final IRMs for the 2000 through 2015 Capability Years. Figure 8-1 and Appendix C, Table C-2, show UCAP reserve margin trends over previous years. Definitions of certain terms in this report can be found in the Glossary (Appendix D).

2. NYSRC Resource Adequacy Reliability Criterion

The acceptable LOLE reliability level used for establishing NYCA IRM Requirements is dictated by the NYSRC Reliability Rule A.1, *Statewide Installed Reserve Margin Requirements,* which states:

> *The NYSRC shall establish the IRM requirement for the NYCA such that the probability (or risk) of disconnecting any firm load due to resource deficiencies shall be, on average, not more than once in ten years. Compliance with this criterion shall be evaluated probabilistically, such that the loss of load expectation (LOLE) of disconnecting firm load due to resource deficiencies shall be, on average, no more than 0.1 day per year. This evaluation shall make due allowance for demand uncertainty, scheduled outages and deratings, forced outages and deratings, assistance over*

[4] http://www.nysrc.org/reports3.asp

interconnections with neighboring control areas, NYS Transmission System emergency transfer capability, and capacity and/or load relief from available operating procedures.

This NYSRC Reliability Rule is consistent with NPCC Resource Adequacy Requirement 4 in Section 3.0 of NPCC Directory 1, *Design and Operation of the Bulk Power System*.

In accordance with NYSRC Reliability Rule A.2, *Load Serving Entity (LSE) Installed Capacity Requirements*, the NYISO is required to establish LSE installed capacity requirements, including locational capacity requirements, to meet the statewide IRM Requirement established by the NYSRC for maintaining NYSRC Reliability Rule A.1 above.

3. IRM Study Procedures

The study procedures used for the 2016 IRM Study are described in detail in NYSRC Policy 5-9, *Procedure for Establishing New York Control Area Installed Capacity Requirements*. Policy 5-9 also describes the computer program used for reliability calculations and the types of input data and models used for the IRM Study.

This study utilizes a *probabilistic approach* for determining NYCA IRM requirements. This technique calculates the probabilities of generator unit outages, in conjunction with load and transmission representations, to determine the days per year of expected resource capacity shortages.

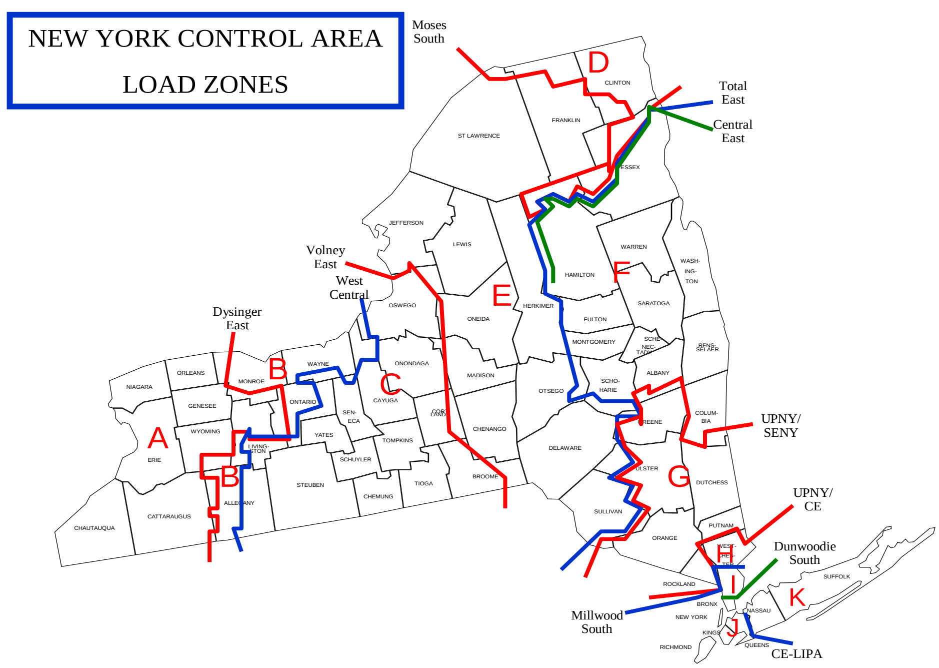
General Electric's Multi-Area Reliability Simulation (GE-MARS) is the primary computer program used for this probabilistic analysis. This program includes detailed load, generation, and transmission representation for eleven NYCA load zones — plus four external Control Areas (Outside World Areas) directly interconnected to the NYCA. The external Control Areas are: Ontario, New England, Quebec, and the PJM Interconnection. The eleven NYCA zones are depicted in Figure 3-1.[5] GE-MARS calculates LOLE, expressed in days per year, to provide a consistent measure of system reliability. The GE-MARS program is described in detail in Appendix Section A.1.

[5] The Federal Energy Regulatory Commission has ordered the creation of a new capacity zone (NCZ) within the NYISO's ICAP market encompassing Load Zones G, H, I, and J (the "G-J Locality"). The creation of the G-J Locality did not impact the current Unified and IRM Anchoring Methodologies and NYSRC's calculation of the NYCA IRM that is discussed in this report.

Past IRM base case and sensitivity analyses were simulated using only weekday peak loads rather than evaluating all 8,760 hours per year to reduce computational run times. In recent years the base case was run with all 8,760 hours to verify that there were no significant differences between study results produced by the two methodologies. However, for the 2016 IRM Study it was determined that the difference between study results using the daily peak hour versus the 8,760 hour methodologies would be significant. Therefore, in this 2016 IRM Study, the base case and sensitivity cases were simulated using all hours in the year (8760 hours).

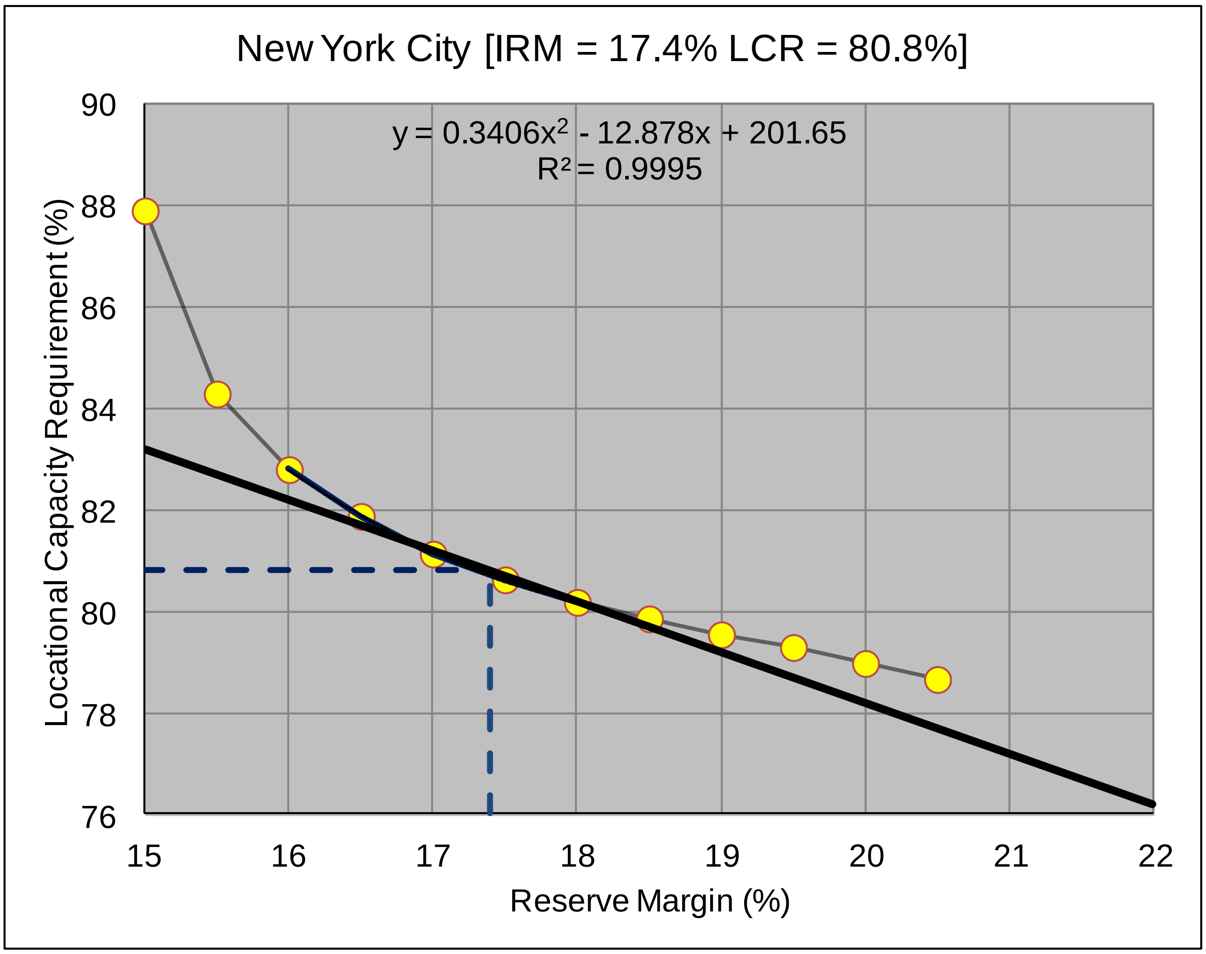
Using the GE-MARS program, a procedure is utilized for establishing NYCA IRM requirements (termed the *Unified Methodology)* which establishes a relationship between NYCA IRM and preliminary LCRs, as illustrated in Figure 3-2. All points on these curves meet the NYSRC 0.1 days/year LOLE reliability criterion described above. Note that the area above the curve is more reliable than criteria, and the area below the curve is less reliable. This methodology develops a pair of curves, one for NYC (Zone J) and one for LI (Zone K). Appendix A of Policy 5-9 provides a more detailed description of the Unified Methodology.

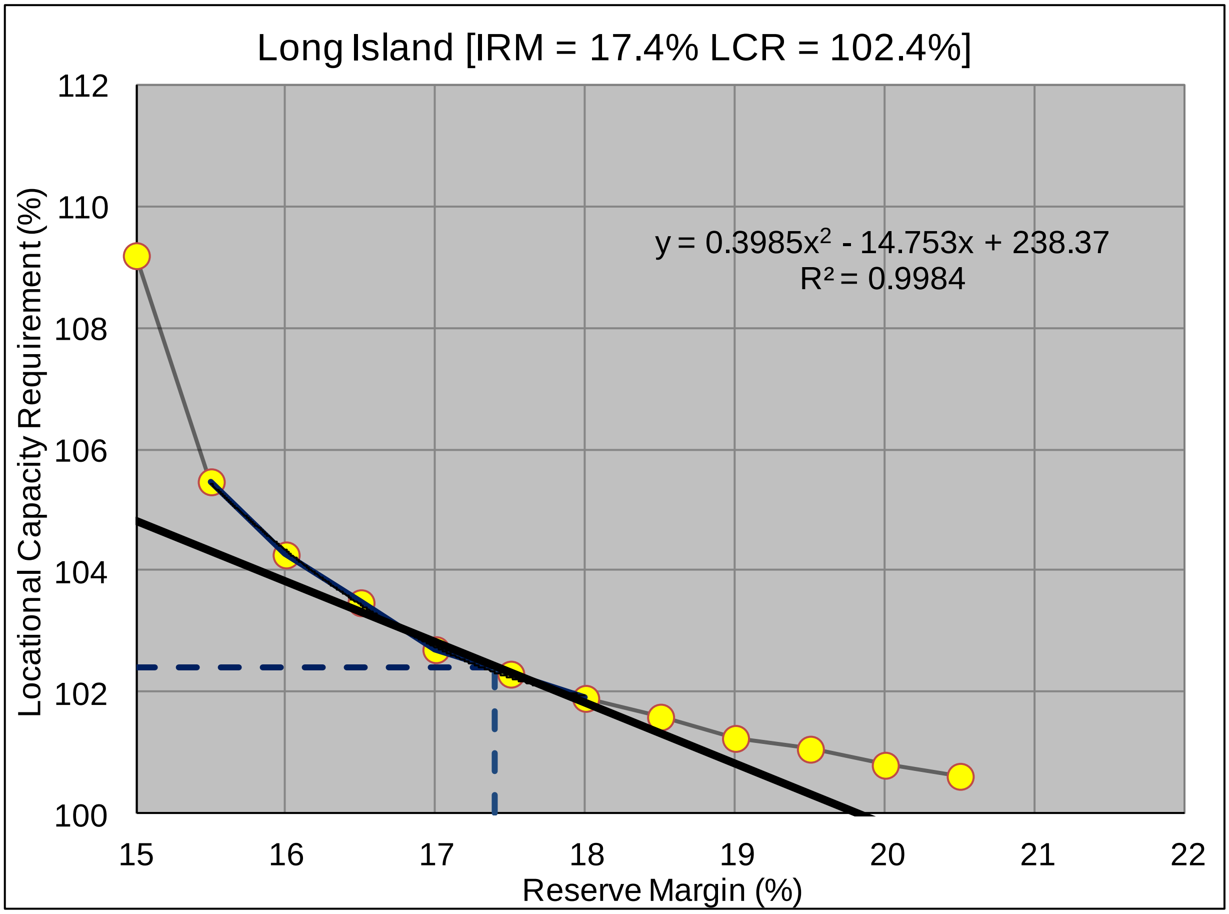
Figure 3-1 NYCA Load Zones



Base case NYCA IRM requirements and related preliminary LCRs are established by a supplemental procedure (termed the *IRM Anchoring Methodology*) which is used to define an *inflection point* on each of these curves. These inflection points are selected by applying a tangent of 45 degrees (Tan 45) analysis at the bend (or “knee”) of each curve. Mathematically, each curve is fitted using a second order polynomial regression analysis. Setting the derivative of the resulting set of equations to minus one yields the points at which the curves achieve the Tan 45 degree inflection point. Appendix B of Policy 5-9 provides a more detailed description of the methodology for computing the Tan 45 inflection point.

Figure 3-2 NYCA Locational Requirements vs. Statewide Requirements





4. Study Results – Base Case

Results of the NYSRC technical study show that the required NYCA IRM is 17.4% for the 2016 Capability Year under base case conditions. Figure 3-2 depicts the relationship between NYCA IRM requirements and resource capacity in NYC and LI.

The tangent points on these curves were evaluated using the Tan 45 analysis. Accordingly, it can be concluded that maintaining a NYCA installed reserve of 17.4% for the 2016 Capability Year, together with corresponding preliminary LCRs of 80.8% and 102.4% for NYC and LI, respectively, will achieve applicable NYSRC and NPCC reliability criteria for the base case study assumptions shown in Appendix A.3.

Comparing the preliminary LCRs in this 2016 IRM Study to the 2015 IRM Study results (NYC LCR=83.4%, LI LCR=103.7%), the preliminary NYC LCR decreased by 2.6%, while the preliminary LI LCR decreased by 1.3%.

In accordance with NYSRC Reliability Rule A.2, *Load Serving Entity ICAP Requirements,* the NYISO is required to separately calculate and establish final LCRs. The most recent NYISO study[6] determined that for the 2015 Capability Year, the required LCRs for NYC and LI were 83.5% and 103.5%, respectively. An LCR Study for the 2016 Capability Year is scheduled to be completed by the NYISO in January 2016.

A Monte Carlo simulation error analysis shows that there is a 95% probability that the above base case result is within a range of 17.2% and 17.6% (see Appendix A.1.1) when obtaining a standard error of 0.025 per unit at 1,500 simulated years. This analysis demonstrates that there is a high level of confidence that the base case IRM value of 17.4% is in full compliance with NYSRC Reliability Rule A.1 and resource adequacy criterion R4 in NPCC Directory 1.

5. Models and Key Input Assumptions

This section describes the models and related input assumptions for the 2016 IRM Study. The models represented in the GE-MARS analysis include a *Load Model, Capacity Model, Transmission System Model, and Outside World Model*. Potential IRM impacts of pending environmental initiatives are also addressed. The input assumptions for the base case were approved by the Executive Committee on November 6, 2015. Appendix Section A.3 provides more details of these models and assumptions and comparisons of several key assumptions with those used for the 2015 IRM Study.

5.1 Load Model

5.1.1 Peak Load Forecast

A 2016 NYCA summer peak load forecast of 33,378 MW was assumed in the 2016 IRM Study, a decrease of 209 MW from the 2015 summer peak forecast used in the 2015 IRM Study. The 2016 load forecast, completed by the NYISO staff in collaboration with the NYISO Load Forecasting Task Force and presented to ICS on September 29, 2015, considered actual 2015 summer load conditions. After accounting for the impacts of weather and energy efficiency programs, the weather/energy efficiency adjusted peak load during the 2015 summer was determined to be 33,199 MW.

Use of the 2016 peak load forecast in the 2016 IRM study increased the IRM by 0.1% compared to the 2015 Study due to the distribution of load growth

[6] *Locational Installed Capacity Requirements Study, http://www.nyiso.com/public/markets_operations/services/planning/planning_studies*

(Table 6-1); downstate load growth increased more than upstate. The NYISO will prepare a final 2016 summer forecast in early 2016 for use in the NYISO 2016 Locational Capacity Requirement Study. It is expected that the 2016 summer peak load forecast used for this study and the NYISO final summer 2016 forecast will be similar.

5.1.2 Load Forecast Uncertainty (LFU)

Some uncertainty exists relative to forecasting NYCA loads for any given year. This uncertainty is incorporated in the base case model by using a load forecast probability distribution that is sensitive to different weather conditions. Recognizing the unique LFU of individual NYCA areas, separate LFU models are prepared for four areas: New York City (Zone J), Long Island (Zone K), Westchester (Zones H and I), and the rest of New York State (Zones A-G).

A NYISO examination of the LFU models used for the 2015 IRM Study indicated that updates of these models were not required for the 2016 IRM Study. Appendix Section A.3.1 describes these models in more detail. Modeling of load forecast uncertainty in the 2016 IRM Study has an effect of increasing IRM requirements by 8.5% as demonstrated in a sensitivity case (Table 7-1).

A feature in GE-MARS that allows for the representation of multiple load shapes, adopted for the 2014 IRM Study, was utilized for the 2015 and 2016 IRM Studies. This multiple load shape feature enables a different load shape to be assigned to each of seven load forecast uncertainty bins. Part of the effort of implementing this model was to establish criteria for selecting the appropriate historical load shapes to use for each of these load forecast uncertainty bins. ICS concluded that an acceptable approach would be to select a combination of load shape years 2002, 2006, and 2007. The load shape for the year 2007 was selected to represent a typical system load shape over the 1999 to 2012 period. The load shape for 2002 represents a flatter load shape, a shape that has numerous daily peaks that are close to the annual peak. The load shape for 2006 represents a load shape with a small number of days with peaks that are significantly above the remaining daily peak loads. The combination of these load shapes on a weighted basis represents an expected probabilistic LOLE result.

The GE-MARS versions used for the 2015 and 2016 IRM Studies included a daily peak load feature that enhances the logic for calculating the daily LOLE index. As noted earlier in Section 3.0, previous GE-MARS versions the LOLE index was calculated using the base load shape's daily peak hours for all bins. The enhanced MARS version instead calculates the LOLE index using all 8760 hours in the year for each load shape in each bin. Previous IRM studies represented only daily peak hours in the simulation.

5.1.3 Planned Non-Wind Facilities, Retirements and Reratings

Planned non-wind facilities and retirements that are represented in the 2016 IRM Study are shown in Appendix Section A.3.2. The rating for each existing and planned resource facility in the capacity model is based on its Dependable Maximum Net Capability (DMNC). In circumstances where the ability to deliver power to the grid is restricted, the value of the resource is limited to its Capacity Resource Interconnection Service (CRIS) value. The source of DMNC ratings for existing facilities is seasonal tests required by procedures in the NYISO Installed Capacity Manual. Appendix Section A.3.2 shows the ratings of all resource facilities that are included in the 2016 IRM Study capacity model.

5.1.4 Wind Generation

It is projected that during the 2016 summer period there will be a total wind capacity of 1,455 MW participating in the capacity market in New York State. All wind farms are located in upstate New York in Zones A-E. The 2016 summer period wind capacity projection is two MW less than the wind capacity assumed for the 2015 IRM Study.

The present GE-MARS version allows only a single year wind shape to be input for this purpose. Over the last four years, the NYISO has collected hourly wind generation output. Although it had been the practice in the past two IRM studies to use the previous calendar year's hourly plant output as the basis for the wind shape model, an analysis indicated that during the peak hours the actual 2014 wind output exceeded the actual 2012 and 2013 wind output and actual 2015 summer wind output. It was therefore decided that use of the 2013 wind shape – the same used for the 2015 IRM Study – would serve as a better model for representing wind conditions over the 2012-2015 period;

and therefore should be used for the 2016 IRM Study base case. The average hourly wind generation by year is shown in Appendix A Figure A-4.

The 2016 IRM Study base case assumes that the projected 1,455 MW of wind capacity will operate at a 14% capacity factor during the summer peak period. This assumed capacity factor is based on an analysis of actual hourly wind generation data collected for wind facilities in New York State during the June through August 2013 period between the hours of 2:00 p.m. and 5:00 p.m. This test period was chosen because it covers the time during which virtually all of the annual NYCA LOLE occurrences are distributed.

Overall, inclusion of the projected 1,455 MW of wind capacity in the 2016 Study accounts for 3.6% of the 2016 IRM requirement (Table 7-1). This relatively high IRM impact is a direct result of the very low capacity factor of wind facilities during the summer peak period. The impact of wind capacity on *unforced capacity* is discussed in Appendix C.3, "Wind Resource Impact on the NYCA IRM and UCAP Markets." A detailed summary of existing and planned wind resources is shown in Appendix A, Table A-7.

A new GE-MARS version was recently made available that includes a feature that allows input of multiple years of wind data, an improvement over the present model. Although time did not permit this new model to be sufficiently tested and accepted for use in the 2016 IRM Study base case, the model was used for a sensitivity case (see Table 7-1). The model randomly draws daily wind shapes from historical wind production data. This sensitivity used wind production data for 2012 through 2015 (an estimate for the fourth quarter of 2015 was used). Results of the sensitivity study showed that use of this wind shape model would have the effect of lowering the IRM by 0.3%. After additional testing in early 2016, this new MARS feature will be considered for use in the 2017 IRM Study base case.

5.1.5 Generating Unit Availability

Generating unit forced and partial outages are modeled in GE-MARS by inputting a multi-state outage model that represents an equivalent forced outage rate during demand periods (EFORd) for each unit represented. Outage data used to determine the EFORd is received by the NYISO from generator owners based on outage data reporting requirements established by the NYISO. Capacity unavailability is modeled by considering the average forced and partial outages for each generating unit that have occurred over the most recent five-year time period – the time span considered for the 2016 IRM Study covered the 2010-2014 period. The average NYCA five-year EFORd calculated for this period is less than the 2009-2013 average value used for the 2015 IRM Study, causing the IRM to decrease by 0.4% (Table 6-1). Appendix A, Figure A-4 depicts NYCA 2005 to 2014 EFORd trends.

5.1.6 Emergency Operating Procedures (EOPs)

(1) Special Case Resources (SCRs)

SCRs are loads capable of being interrupted, and distributed generators, rated at 100 kW or higher. SCRs are ICAP resources that only provide load curtailment when activated as needed in accordance with NYISO emergency operating procedures. GE-MARS models SCRs as EOP steps which are activated to minimize expected loss of load. SCRs are modeled with monthly values based on the enrollment from August 2014-July 2015. For the month of July, the forecast SCR value for the 2016 IRM Study base case assumes that 1,254 MW will be registered, with varying amounts during other months based on historical experience.

The SCR performance model used for the 2016 IRM Study is based on 2014 performance data. SCR performance factors were determined from one-hour performance tests. This year's study used an Effective Capacity Value of 0.95 which resulted in a SCR model value of 960 MW with an overall effective performance of 76.6%. Refer to Appendix Section A.3.7 for more details.

The SCR model used for the 2016 IRM Study resulted in an IRM decrease of 0.1% from the 2015 IRM Study (Table 6-1). Incorporation of SCR resources in the NYCA capacity model has the effect of increasing IRM requirements by 2.2% (Table 7-1) because these resources' availability are lower than the average statewide resource fleet availability.

The 2016 IRM Study determined that for the 17.4% base case IRM, approximately nine SCR calls would be expected during the June-August 2016 period.

(2) Emergency Demand Response Program (EDRP)

The EDRP is a separate program from the SCR Program that allows registered interruptible loads and standby generators to participate on a voluntary basis – and be paid for their ability to restore operating reserves after major emergencies have been declared. The 2016 IRM Study assumes 75 MW of EDRP resources will be registered in 2016, an 11 MW reduction from 2015. The 2016 EDRP capacity was discounted to a base case value of 12 MW reflecting past performance. This value is implemented in the study in July and proportional to monthly peaks loads in other months, while being limited to a maximum of five EDRP calls per month. Both SCRs and EDRP are included in the Emergency Operating Procedure (EOP) model. Unlike SCRs, EDRP resources are not ICAP suppliers and therefore are not required to respond when called upon to operate.

(3) Other Emergency Operating Procedures

In accordance with NYSRC criteria, the NYISO will implement EOPs as required to minimize customer disconnections. Projected 2016 EOP capacity values are based on recent actual data and NYISO forecasts. Refer to Appendix A, Table A-13 for projected EOP values.

5.1.7 Unforced Capacity Deliverability Rights (UDRs)

The capacity model includes UDRs which are capacity rights that allow the owner of an incremental controllable transmission project to extract the locational capacity benefit derived by the NYCA from the project. Non-locational capacity, when coupled with a UDR, can be used to satisfy locational capacity requirements. The owner of UDR facility rights designates how they will be treated by the NYSRC and NYISO for resource adequacy studies. The IRM modeling accounts for both the availability of the resource that is identified for each UDR line as well as the availability of the UDR facility itself.

LIPA's 330 MW High Voltage Direct Current (HVDC) Cross Sound Cable, LIPA's 660 MW HVDC Neptune Cable, Hudson Transmission Partners 660 MW HVDC Cable, and the 315 MW Linden Variable Frequency Transformer are facilities that are represented in the 2016 IRM Study as having UDR capacity rights. The owners of these facilities have the option, on an annual basis, of selecting the

MW quantity of UDRs they plan on utilizing for capacity contracts over these facilities. Any remaining capability on the cable can be used to support emergency assistance which may reduce locational and IRM requirements. The 2016 IRM Study incorporates the confidential elections that these facility owners made for the 2016 Capability Year.

5.2 Transmission Model

5.2.1 Internal Transmission Model

A detailed transmission system model is represented in the GE-MARS topology. The transmission system topology, which includes eleven NYCA zones and four Outside World Areas, along with transfer limits, is shown in Appendix A, Figures A-12, 13, and 14. The transfer limits employed for the 2016 IRM Study were developed from emergency transfer limit analysis included in various studies performed by the NYISO, and from input from Transmission Owners and neighboring regions. The transfer limits are further refined by additional assessments conducted specifically for this cycle of the development of the topology. The assumptions for the transmission model included in the 2016 IRM Study are listed in the Appendix A, Tables A-8 and A-9, and described in detail in Appendix Section A.3.3.

Forced outages based on historic performance are represented in the GE-MARS model for the IRM study for the underground cables that connect New York City and Long Island to surrounding zones. The GE-MARS model uses transition rates between operating states for each interface, which are calculated based on the probability of occurrence from the failure rate and the time to repair. Transition rates into the different operating states for each interface are calculated based on the circuits comprising each interface, which includes failure rates and repair times for the individual cables, and for any transformer and/or phase angle regulator associated with that particular cable. Updated cable outage rates in the 2016 IRM Study had no impact on the IRM compared to the 2015 IRM Study (Table 6-1).

As in all previous IRM studies, forced outage rates for overhead transmission lines were not represented in the 2016 IRM Study. This was confirmed by a study conducted by ICS in 2015, *Evaluation of the Representation of Overhead Transmission Outages in IRM Studies*, which concluded that representing overhead transmission outages in IRM studies would have no material impact on the IRM (see www.nysrc.org/reports).

The impact of transmission constraints on NYCA IRM requirements depends on the level of resource capacity in any of the downstream zones from a constraining interface, especially in the NYC and LI zones J and K. To illustrate the impact of transmission constraints, if there were no transmission constraints, the required IRM in 2016 would decrease by 2.9% (Table 7-1).

Interface transfer limits were updated for the 2016 IRM Study based on results of transfer limit analysis performed for the NYISO. The Dysinger East and Zone A Group transfer limits increased compared to the transfer limit used in the 2015 IRM. The thermal limitations on the 230 kV transmission path between Packard and Gardenville in Zone A became less constraining due to the reduced load forecast.

Central East, Central East Group, and UPNY-SENY interface transfer limits were updated to reflect the additional transmission facilities. Portions of the Transmission Owner Transmission Solutions (TOTS) are expected to be in-service before the 2016 summer, i.e., Marcy South Series Compensation and the additional 345 kV circuit between Rock Tavern and Ramapo and a 345/138 kV tap connecting to the existing Sugarloaf 138 kV station. Appendix A, Table A-9 summarizes the differences in transfer limits from the 2016 IRM Study.

Refer to topology details in Appendix Section A.3.3.

5.2.2 Outside World Model

The Outside World Model consists of those interconnected external control areas contiguous with NYCA: Ontario, Quebec, New England, and the PJM Interconnection (PJM). NYCA reliability is improved and IRM requirements reduced by recognizing available emergency capacity assistance support from these neighboring interconnected control areas, in accordance with control area agreements governing emergency operating conditions. Representing all such external interconnection support arrangements in the 2016 IRM Study base case reduces the NYCA IRM requirements by 8.5% (Table 7-1). This compares to 8.7% in the 2015 IRM Study. A model for representing neighboring control areas, similar to previous IRM studies, was utilized in this study. The assumptions for the Outside World Model included in the 2016 IRM Study are listed in Appendix A, Table A-10.

The primary consideration for developing the base case load and capacity assumptions for the Outside World Areas is to avoid overdependence on these Areas for emergency assistance support. For this purpose, from Policy 5-9, a rule is applied whereby an Outside World Area's LOLE cannot be lower than its own LOLE criterion. Therefore, for each of the Ontario, Quebec and New England control areas, a minimum LOLE of 0.1 days/year is modeled in accordance with NPCC requirements and the Areas' own individual resource adequacy criteria. For PJM, the 2016 IRM Study assumed a minimum LOLE of 0.14 day/year, which PJM uses for its planning studies. This is based on PJM's LOLE or resource adequacy criterion of 0.10 days/year, plus a PJM internal transmission constraint risk adder of 0.04 days/year. Also, each of these control areas' isolated LOLE cannot be lower than that of the NYCA, and its IRM can be no higher than that Area's minimum requirement.

In addition, Policy 5-9 does not allow EOPs to be represented in Outside World Area models for providing emergency assistance to NYCA because of the uncertainties associated with the performance and availability of these resources.

Another consideration for developing models for the Outside World Areas is to recognize internal transmission constraints within those Areas that may limit emergency assistance into the NYCA. This recognition can be explicitly considered through direct multi-area modeling of well-defined external area bubbles and their internal interface constraints. The model representation explicitly requires adequate data to accurately model transmission interfaces, load areas, resource and demand balances, load shape, and coincidence of peaks among the load zones within these Outside World Areas. If adequate data is unavailable, the area can also be modeled implicitly either by aggregating bubbles and associated interfaces and reflecting the constraint limits at the interfaces between aggregated bubbles and at the NYCA border, or by increasing the LOLE of the Outside World Areas.

For this study, two Outside World Areas – New England and the PJM Interconnection – are each represented as multi-area models, i.e., 13 zones for New England and four zones for the PJM Interconnection.[7] The 13 zones for New England (a member of NPCC Working Group CP-8) is an explicit representation that is reviewed by the ISONE staff and aligns with their official models for reserve margin studies. The PJM representation is provided to NPCC for use in its reliability studies by the PJM staff on a voluntary basis and is a mixture of explicit and implicit modeling. PJM uses a single bubble model for its own resource adequacy analysis. They do not use either the four bubble model that the NYISO has reviewed, or the new five bubble model, which is still under review by the NYISO.

The existing PJM-SENY group transfer limit is imposed to reflect internal constraints in both the PJM and NYCA systems. For the 2016 IRM Study, this limit was restored to the topology and transfer limits similar to the transmission representation in the 2014 IRM Study to reflect: (1) maintaining a balance of the contractual Con Edison-PSEG wheel,[8] and (2) the delay of the previously assumed Northern New Jersey transmission upgrades and Phase II (additional cooling) of Staten Island Unbottling project to beyond the 2016 summer period.[9] Refer to Appendix Section A.3.3.

5.3 Environmental Initiatives

The 2014 RNA identified new environmental regulatory programs that could impact the operation of NYS Bulk Power System facilities. These state and federal regulatory initiatives cumulatively have required considerable investment by the owners of New York's existing thermal power plants in order to comply. The programs are as follows:

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[7] Preliminary results of an NYISO analysis of a PJM five bubble model using parameters provided by PJM staff were inconclusive and not included in this report. The NYISO will continue to work with PJM in 2016 to improve the five bubble model for consideration by the NYSRC for possible use in the 2017 IRM Study.

[8] The transmission model in the 2016 IRM Study allows for delivery of 1000 MW at Waldwick and PJM re-delivery of 1000 MW at the Hudson and Linden interface. The balancing of the wheel does not reflect the actual thermal capability of the Hudson and Linden interface.

[9] The enforcement of PJM-SENY group transfer limit may not necessarily represent the operating model. This modeling was adopted for the 2016 IRM Study as an interim measure before a fully revised PJM-SENY transfer limit is adopted for the 2017 IRM study.

NOx RACT: Reasonably Available Control Technology (Effective July 2014).

BART: Best Available Retrofit Technology for regional haze (Effective January 2014).

MATS: Mercury and Air Toxics Standard for hazardous air pollutants (Effective April 2015, 2016, or 2017 depending on approved requests for extensions).

MRP: Mercury Reduction Program for Coal-Fired Electric Utility Steam Generating Units – Phase II reduces Mercury emissions from coal fired power plants in New York (Effective January 2015).

CSAPR: Cross State Air Pollution Rule for the reduction of SO_2 and NOx emissions in 28 Eastern States. The U.S. Supreme Court has upheld the CSAPR as promulgated by USEPA. The Supreme Court remanded the rule to the District Circuit Court of Appeals for further proceedings. Phase I became effective January 2015.

RGGI: Regional Greenhouse Gas Initiative Phase II cap reductions started January 2014. The Program design will be reviewed by the RGGI states in 2016.

CO_2 Emission Standards: NSPS effective June 2014, Existing Source Performance Standards become effective in 2022.

RICE: NSPS and NESHAP – New Source Performance Standards and Maximum Achievable Control Technology for Reciprocating Internal Combustion Engines (Effective July 2016, however, the exemption for use of non-compliant engines in energy markets has been remanded back to USEPA).

BTA**:** Best Technology Available for cooling water intake structures (Effective upon Permit Renewal).

The NYISO has determined that as much as 33,200 MW in the existing fleet (88% of 2014 Summer Capacity) will have some level of exposure to the new regulations. However, these initiatives are not expected to result in NYCA capacity reductions or retirements that would increase LOLE or IRM requirements during the 2016 Capability Year. Refer to Appendix Section B.2 for more details.

5.4 Database Quality Assurance Reviews

It is critical that the data base used for IRM studies undergo sufficient review in order to verify its accuracy. The NYISO, General Electric (GE), and two New York Transmission Owners (TOs) conducted independent data quality assurance reviews after the preliminary base case assumptions were developed and prior to preparation of the final base case. Masked and encrypted input data was provided by the NYISO to the transmission owners for their reviews. Also, certain confidential data were reviewed by two independent NYSRC consultants.

The NYISO, GE, and TO reviews found several minor data errors, none of which affected IRM requirements in the preliminary base case. The data found to be in error by these reviews were corrected before being used in the final base case studies. A summary of these quality assurance reviews for the 2016 IRM Study input data is shown in Appendix Section A.4.

6. Comparison with 2015 IRM Study Results

The results of this 2016 IRM Study show that the base case IRM result represents a 0.1% increase from the 2015 IRM Study base case value. Table 6-1 compares the estimated IRM impacts of updating several key study assumptions and revising models from those used in the 2015 Study. The estimated percent IRM change for each parameter was calculated from the results of a parametric analysis in which a series of IRM studies were conducted to test the IRM impact of individual parameters. The results of this analysis were normalized such that the net sum of the -/+ % parameter changes total the 0.1% IRM increase from the 2015 Study. Table 6-1 also provides the reason for the IRM change for each study parameter from the 2015 Study.

The principal drivers shown in Table 6-1 that *increased* the required IRM from the 2016 IRM base case are the representation of all hours in the MARS simulation, instead of only peak hours, the retirement of the Huntley Generating Station and related transmission topology changes, and updated models for Quebec, Ontario, and New England. These parameter changes increased the IRM by 0.4%, 0.4%, and 0.3%, respectively. The principal drivers that *decreased* the required IRM from the 2016 IRM base case are an updated PJM model and updated EFORd values. These parameter changes decreased the IRM by 0.5% and 0.4%, respectively. The parameters in Table 6-1 are discussed under *Models and Key Input Assumptions*.

Table 6-1: Parametric IRM Impact Comparison – 2015 vs. 2016 IRM Study

Parameter	Estimated IRM Change (%)	IRM (%)	Reasons for IRM Changes
2015 IRM Study – Final Base Case		**17.3**	
2016 IRM Study Parameters that Increased the IRM			
All 8760 hours in simulation instead of only daily peak hours	+0.4		Increase in 'off peak' LOLE events
Huntley retirement with related topology changes	+0.4%		Decreased transfer limits in western New York
Updated IESO, NE and Quebec models	+0.3		Less assistance from the new external models
Updated load forecast (Gold Book)	+0.1		Downstate load growth higher than upstate
Non-SCR EOPs	+0.1		Slightly lower voltage response
Total IRM Increase	**+1.3**		
2016 IRM Study Parameters that Decreased the IRM			
Updated PJM load and capacity (4-zone model)	-0.5		Increased planned PJM installed reserve
Updated generating unit EFORd's	-0.4		Five-year average performance improved
Updated SCRs	-0.1		Performance improvement
Updated large hydro model	-0.1		Improved hydro availability
Updated NYCA topology & generation additions	-0.1		Slight improvement of transmission and resource capability downstate
Total IRM Decrease	**-1.2**		
2016 IRM Study Parameters that do not change the IRM			
Updated Solar Shape	0		
Updated Sales	0		
Updated Cable Outage Rates	0		
Change Study Year	0		
Updated DMNC	0		
2013 Wind Shape Model* (Same as for 2015 IRM Study)	0		
Net Change from 2015 Study		**+0.1**	
2016 IRM Study – Final Base Case		**17.4**	

7.0 Sensitivity Case Study Results

Determining the appropriate IRM requirement to meet NYSRC reliability criteria depends upon many factors. Variations from the base case will, of course, yield different results. Table 7-1 shows IRM requirement results for selected sensitivity cases.

Sensitivity Cases 1 through 5 illustrate how the IRM would be impacted if certain major IRM study parameters were not represented in the IRM base case. The remaining group of cases – Cases 6 through 12 – show IRM impacts assuming selected base case assumptions are changed to reasonable alternative levels. NYSRC Executive Committee members may consider one or more of the latter group of sensitivity case results, in addition to the base case IRM, when the Committee develops the Final NYCA IRM for 2016. A summary of the twelve sensitivity case results is shown in Table 7-1. Appendix B, Table B-1 includes a more detailed description and explanation of each sensitivity case.

The methodology used to conduct the sensitivity cases starts with the preliminary base case IRM results, and adds or removes capacity from all NYCA zones[10] until the NYCA LOLE approaches criteria. Because of the lengthy computer run time and manpower needed to utilize a Tan 45 analysis in IRM studies,[11] this method was applied for only Cases 9 and 11 in Table 7-1.

Sensitivity Cases 1-11 determined the IRM required for meeting the 0.1 days/year LOLE criterion for the sensitivity condition assumed. However, for Case 12, Indian Point 2 and 3 were assumed to shut down in 2016 – without being replaced – when the NYCA IRM is 17.4% (the base case IRM for the 2016 Capability Year). The LOLE for this sensitivity increased from 0.1 days/year with both Indian Point both units in service, to 0.62 days/year with both units shut down. Therefore, if Indian Point was to close, New York customers would be expected to experience service interruptions at a rate about six times that permitted by the NYSRC Resource Adequacy Reliability Criterion.

[10] With the exception of the "No Wind Capacity" sensitivity in which replacement capacity only occurs in Zones A-F.
[11] See Section 3 for a description of a Tan 45 analysis.

Table 7-1: Sensitivity Cases – 2016 IRM Study

Case	Description	IRM (%)	% Change from Base Case
0	Base Case	17.4	0
1	NYCA isolated	25.9	+8.5
2	No internal NYCA transmission constraints	14.5	-2.9
3	No load forecast uncertainty	8.9	-8.5
4	No wind capacity	13.8	-3.6
5	No SCRs	15.2	-2.2
6	Assume 0.765 SCR adjustment factor	17.5	+0.1
7a	Forward Capacity Market Sales to NE of 135 MW	17.3	-0.1
7b	Forward Capacity Market Sales to NE of 405 MW	17.2	-0.2
8	Multiple-year wind shape model (new MARS feature)	17.1	-0.3
9	Use 2014 wind shape model[12]	16.3	-1.1
10	Model Marble River Wind (assumes CRIS rights awarded)	17.9	+0.5
11	No Huntley Station retirement [12]	17.0	-0.4
12	Retire Indian Point 2 and 3, w/o replacing capacity[13]	N.A.	N.A.

8. NYISO Implementation of the NYCA Capacity Requirement

The NYISO values capacity sold and purchased in the market in a manner that considers the forced outage ratings (UCAP) of individual units. To maintain consistency between the DMNC rating of a unit translated to UCAP and the statewide ICR, the ICR must also be translated to an unforced capacity basis. In the NYCA, these translations occur twice during the course of each capability year, prior to the start of the summer and winter capability periods.

[12] Results based on a Tan 45 analysis.

[13] Section 7 provides details of study results.

Additionally, any LCRs in place are also translated to equivalent UCAP values during these periods. The conversion to UCAP essentially translates from one index to another; it is not a reduction of actual installed resources. Therefore, no degradation in reliability is expected. The NYISO employs a translation methodology that converts ICAP requirements to UCAP in a manner that ensures compliance with NYSRC Resource Adequacy Rule A.1 (R1). The conversion to UCAP provides financial incentives to decrease the forced outage rates while improving reliability.

The increase in wind resources increases the IRM because wind capacity has a much lower peak period capacity factor than traditional resources. On the other hand, there is a negligible impact on the need for UCAP. Figure 8-1 below illustrates that UCAP reserve margins, which trended downward during the 2006-2010 period, have ranged between 5.5 and 7% since then. This indicates a generally lower burden on New York loads over the 2006 to 2015 time period. Appendix C provides details of the ICAP to UCAP conversion process used for this analysis.

Figure 8-1 NYCA Reserve Margins