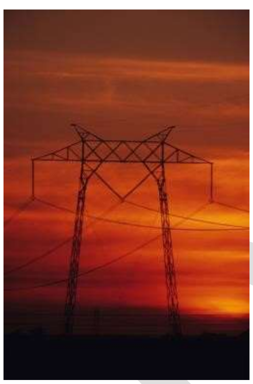
Technical Study Report

New York Control Area Installed Capacity Requirement



For the Period May 2022 to April 2023

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December 3, 2021

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 upcoming Capability Year[1] 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 1, 2022 through April 30, 2023 (2022 Capability Year). The IRM study described in this report for 2022 Capability Year is referred to as the "2022 IRM Study."

Results of the NYSRC technical study show that the required NYCA IRM for the 2022 Capability Year is xx.x% 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. The base case, along with other relevant factors, will be considered by the NYSRC Executive Committee on December 3, 2021 for its adoption of the Final NYCA IRM requirement for the 2022 Capability Year.

The NYSRC study procedure used to establish the NYCA IRM[2] also produces corresponding "initial" New York City and Long Island locational capacity requirements (LCRs) necessary to satisfy the NYCA resource adequacy criterion. The 2022 IRM Study determined initial LCRs of yy.y% and zz.z% for the New York City and Long Island localities, respectively. In accordance with its responsibility of setting the LCRs, the New York Independent System Operator, Inc. (NYISO) will calculate and approve *final LCRs* for all NYCA localities using a separate process that utilizes the NYSRC approved Final IRM and adheres to NYSRC Reliability Rules and policies.

The xx.x% IRM base case value for the 2022 Capability Year represents a *a.a% decrease* from the 2021 base case IRM of 20.7%. Table 6-1 shows the IRM impacts of individual updated study parameters that result in this change. In summary:

- There are *six parameter drivers* that in combination *increased* the 2022 IRM from the 2021 base case IRM by b.b%. Of these six drivers, the most significant are the addition of 180 MW of wind and solar units which increased the IRM by 0.4% and poorer performance of the subterranean cables surrounding NYC and LI which increased the

[1] A Capability Year begins on May 1 and ends on April 30 of the following year.

[2] This procedure is described in Section 3, IRM Study Procedures. This procedure for calculating IRM requirements and initial LCRs is sometimes referred in this report to as the "Tan-45 process."

IRM by 0.3%. Four other factors are show on table 6-1 and result in an additional 0.4% increase in the IRM.

- Seven parameter drivers in combination decreased the IRM from the 2021 base case by 3.2%. Of these seven drivers, the most significant are a lowering of several of the high load bins of the updated Load Forecast Uncertainty which resulted in a 1.3% reduction and an updated load forecast which resulted in a reduction of 0.7%. Five other factors are show on table 6-1 and result in a further combined reduction of 1.2%

The complete parametric analysis showing the above and other results can be found in Section 6 in this report.

This study also evaluated IRM impacts of several sensitivity cases. The results of these sensitivity cases are discussed in Section 7 and summarized in Table 7-1. The base case IRM and sensitivity case results, along with other relevant factors, will be considered by the NYSRC Executive Committee in adopting the Final NYCA IRM requirement for 2022. NYSRC Policy 5-15 describes the Executive Committee process for establishing the Final IRM.

In addition, a confidence interval analysis was conducted to demonstrate that there is a high confidence that the base case xx.x% IRM will fully meet NYSRC and NPCC resource adequacy criterion that require a Loss of Load Expectation (LOLE) of no greater than 0.1 days per year.

The 2022 IRM Study also evaluated Unforced Capacity (UCAP) trends. The NYISO values capacity sold and purchased in the market in a manner that considers the forced outage ratings of individual units, whereby generating unit capacity is derated to an unforced capacity basis recognizing the impact of forced outages. This derated capacity is referred to as "UCAP." This analysis shows that required UCAP margins, which steadily decreased over the 2006-2012 period to about 5%, have remained fairly steady since then (see Table 8-1).

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, 2022 through April 30, 2023 (2022 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:

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

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 2022 Capability Year.

The NYISO will implement the Final NYCA IRM as determined by the NYSRC, in accordance with the NYSRC Reliability Rules, NYSRC Policy 5-15, *Procedure for Establishing New York Control Area Installed Capacity Requirement and the Installed Reserve Margin (IRM)*;[3] the NYISO Market Administration and Control Area Services Tariff; and the NYISO Installed Capacity (ICAP) Manual.[4] The NYISO translates the required IRM to a UCAP basis. These values are also used in a Spot Market Auction based on FERC-approved Demand Curves. The schedule for conducting the 2022 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 2022 Capability Year (2022 IRM Study) are set forth in NYSRC Policy 5-15. The primary reliability criterion used in the IRM study requires an LOLE of no greater than 0.1 days per year for the NYCA. This NYSRC resource adequacy criterion is consistent with the Northeast Power Coordinating Council (NPCC) resource adequacy criterion. IRM study procedures include the use of two reliability study methodologies: The *Unified Methodology* and the *IRM Anchoring Methodology*. NYSRC reliability criteria and IRM study methodologies and models are described in Policy 5-15 and discussed in detail later in this report.

The NYSRC procedure for determining the IRM also identifies "initial" corresponding locational capacity requirements (LCRs) for the New York City and Long Island localities. The NYISO, using

[3] http://www.nysrc.org/policies.asp

[4] http://www.nyiso.com/public/markets_operations/market_data/icap/index.jsp

a separate process – in accordance with the NYISO tariffs and procedures, while adhering to NYSRC Reliability Rules and NYSRC Sections 3.2 and 3.5 of Policy 5-15 – is responsible for setting *final* LCRs for the New York City Long Island and Zones G-J Localities. For its determination of LCRs for the 2022 Capability Year, the NYISO will continue utilizing an economic optimization methodology approved by the Federal Energy Regulatory Commission.

The 2022 IRM Study was managed and conducted by the NYSRC ICS and supported by technical assistance from the NYSRC's technical consultants and the NYISO staff.

Previous IRM Study reports, from year 2000 to year 2021, can be found on the NYSRC website.[5] Appendix C, Table C.1 provides a record of previous NYCA base case and final IRMs for the 2000 through 2021 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).

A different analysis, separate from the IRM study process covered in this report, is conducted by the NYISO and is called the Reliability Needs Assessment (RNA). This analysis assesses resource adequacy of the NYCA for ten years into the future. This assessment determines whether the NYSRC resource adequacy reliability criterion, as defined in Section 2 below, is maintained over the study period; and if not, identifies reliability needs or compensatory MW of capacity or other measures of solutions required to meet those needs.

2. NYSRC Resource Adequacy Reliability Criterion

The required reliability level used for establishing NYCA IRM Requirements is dictated by Requirement 1.1 of NYSRC Reliability Rule A.1, *Establishing NYCA Statewide Installed Reserve Margin Requirements,* which states that the NYSRC shall:

> *Probabilistically establish the IRM requirement for the NYCA 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 allowances for demand uncertainty, scheduled outages and de-ratings, forced outages and de-ratings, assistance over interconnections with neighboring control areas, NYS Transmission System emergency transfer capability, and capacity and/or load relief from available operating procedures*.

The above NYSRC Reliability Rule is consistent with NPCC's Resource Adequacy criterion in NPCC Directory 1, *Design and Operation of the Bulk Power System*. This criterion is interpreted to

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

mean that planning reserve margins, or the IRM, needs to be high enough that the probability of an involuntary load shedding due to inadequate resources is limited to only one day in ten years or 0.1 day per year. This criterion has been widely accepted by most electric power systems in North America for reserve capacity planning. In New York, use of the LOLE criterion of 0.1 day per year has provided an acceptable level of reliability for many years.

In accordance with NYSRC Reliability Rule A.2, *Establishing Load Serving Entity (LSE) Installed Capacity Requirements*, the NYISO is required to establish LSE installed capacity requirements, including LCRs, for meeting the statewide IRM requirement established by the NYSRC in compliance with NYSRC Reliability Rule A.1 above.

3. IRM Study Procedures

The study procedures used for the 2022 IRM Study are described in detail in NYSRC Policy 5-15, *Procedure for Establishing New York Control Area Installed Capacity Requirements and the Installed Reserve Margin (IRM)*. Policy 5-15 also describes the computer program used for reliability calculations and the types of input data and models used for the IRM Study.

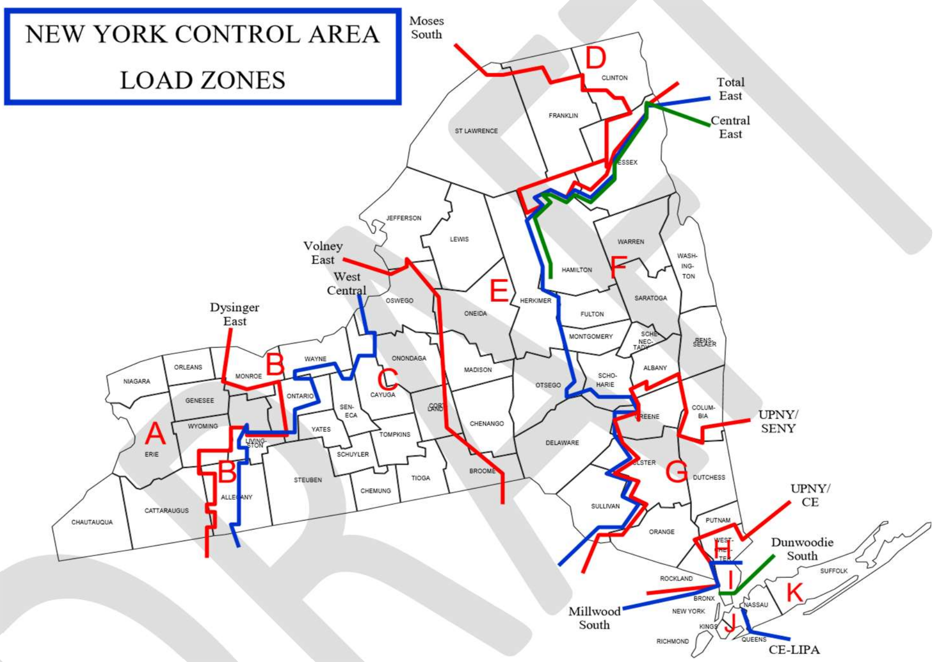
This study utilizes a *probabilistic approach* for determining NYCA IRM requirements. This technique calculates the probabilities of generator unit outages, in conjunction with load and transmission representations, to determine the days per year of expected resource capacity shortages.

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 Outside World Control Areas (Outside World Areas) directly interconnected to the NYCA. The Outside World Areas are as follows: Ontario, New England, Quebec, and the PJM Interconnection. The eleven NYCA zones are depicted in Figure 3-1. 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 A, Section A.1.

Prior to the 2016 IRM Study, the IRM base case and sensitivity analyses were simulated using only weekday peak loads rather than evaluating all 8,760 hours per year in order to reduce computational run times. However, the 2016 IRM Study determined that the difference between study results using the daily peak hour versus the 8,760-hour methodologies would be significant. Therefore, the base case and sensitivity cases in the 2016 IRM Study and all later studies, including this 2022 IRM Study, were simulated using all hours in the year.

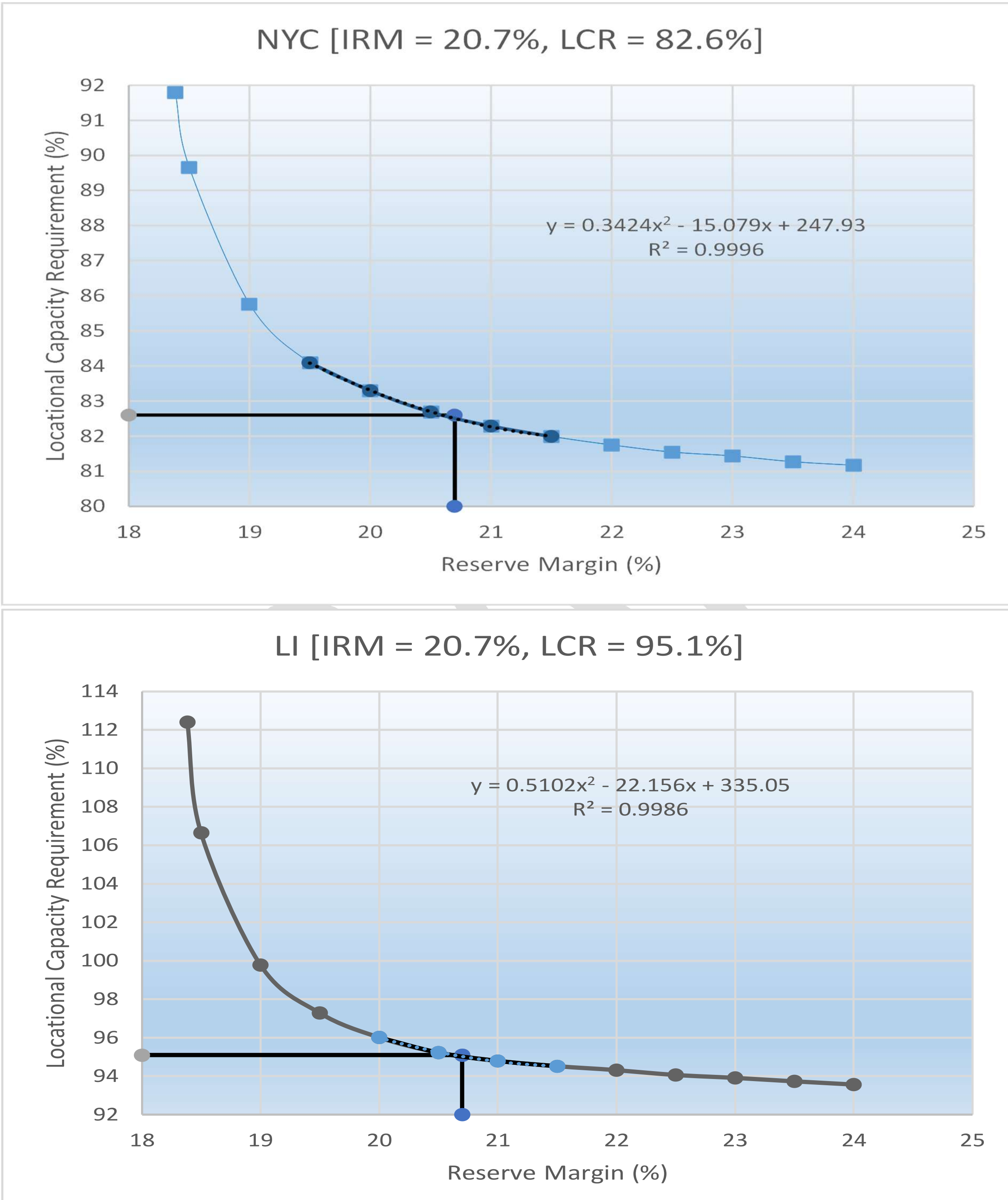
Using the GE-MARS program, a procedure is utilized for establishing NYCA IRM requirements (termed the *Unified Methodology*) which establishes a relationship between NYCA IRM and corresponding initial LCRs, as illustrated in Figure 3-2. All points on these curves meet the NYSRC 0.1 days/year LOLE reliability criterion described in Section 2. Note that the area above the curve is more reliable than the criterion, and the area below the curve is less reliable. This methodology develops a pair of curves for two zones with locational capacity requirements, New York City (NYC), Zone J; and Long Island (LI), Zone K. Appendix A of NYSRC Policy 5-15 provides a more detailed description of the Unified Methodology.

Figure 3-1 NYCA Load Zones



Base case NYCA IRM requirements and corresponding initial locality reserve margins for Zones J and K 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 NYSRC Policy 5-15 provides a more detailed description of the methodology for computing the Tan 45 inflection point.

TO BE UPDATED Figure 3-2 Relationship Between NYCA IRM and Corresponding Initial Locational Capacity Requirements



4. Study Results – Base Case

Results of the NYSRC technical study show that the required NYCA IRM is xx.x% for the 2022 Capability Year under base case conditions. Figure 3-2 on page 8 depicts the relationship between NYCA IRM requirements and corresponding initial LCRs for NYC and LI.

The tangent points on these curves were evaluated using the Tan 45 analysis described in Section 3. Accordingly, maintaining a NYCA IRM of xx.x% for the 2022 Capability Year, together with corresponding initial LCRs of yy.y% and zz.z% 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 corresponding initial LCRs in this 2022 IRM Study to 2021 IRM Study results (NYC LCR= 82.6%, LI LCR= 95.1%), the corresponding 2022 NYC initial LCR decreased by 2.0%, while the corresponding initial LI LCR increased by 1.0%.

In accordance with NYSRC Reliability Rule A.2, *Load Serving Entity ICAP Requirements,* the NYISO is responsible for separately calculating and establishing the final LCRs. The most recent NYISO LCR study,[6] dated January 14, 2021, determined that for the 2021 Capability Year, the final LCRs for NYC and LI were 80.3% and 102.9%, respectively. An LCR Study for the 2022 Capability Year is scheduled to be completed by the NYISO in January 2022. The NYISO utilizes an economic optimization algorithm for calculating LCRs that minimizes the total cost of NYCA capacity. This study utilizes the same base case database used by the NYSRC for calculating the NYCA IRM[7], while respecting the NYSRC-approved IRM and NYSRC's 0.1 days/year LOLE reliability criterion as well as required study procedures in NYSRC Policy 5-15.

A Monte Carlo simulation error analysis shows that there is a 95% probability that the above base case result is within a range of ff.f% and gg.g% (see Appendix A.1.1) when obtaining a standard error of 0.025 per unit or less at 2,750 simulated years. This analysis demonstrates that there is a high level of confidence that the base case IRM value of xx.x% is in full compliance with the one day in 10 years LOLE criterion in NYSRC Reliability Rule A.1.

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

[7] This database may be updated for base case assumption changes that occur after the IRM study is completed.

5. Models and Key Input Assumptions

This section describes the models and related base case input assumptions for the 2022 IRM Study. The models represented in the GE-MARS analysis include a *Load Model, Capacity Model, Transmission Model, and Outside World Model*. A *Database Quality Assurance Review* of the 2022 base case assumptions is also addressed in this section. The input assumptions for the final base case were approved by the Executive Committee on October 15, 2021. Appendix A, Section A.3 provides more details of these models and assumptions and comparisons of several key assumptions with those used for this 2022 IRM Study.

5.1 The Load Model

5.1.1 Peak Load Forecast

The NYCA peak load forecast is based upon a model that incorporates forecasts of economic drivers, end use and technology trends, and normal weather conditions. A 2022 NYCA summer peak load forecast of 32,139 MW was assumed in the 2022 IRM Study, a decrease of 104 MW from the forecast used in the 2021 IRM Study. This "Fall 2022 Summer Load Forecast" was prepared for the 2022 IRM Study by the NYISO staff in collaboration with the NYISO Load Forecasting Task Force and presented to the ICS on October 6, 2021. The 2022 forecast considered actual 2021 summer load conditions.

The peak load forecast change shown on Table 5-1 below, indicate a reduction in peak loads in the heavily loaded zones (Zones J and K) while the peak loads for upstate zones (zones A-I) continue to grow. The decrease in Zones J and K load forecast is in part due to the COVID-19 pandemic.

Table 5-1: Comparison of 2021 and 2022 Actual and Forecast Coincident Peak Summer Loads (MW)

	Fall 2021 Forecast	2021 Actual	2021 Normalized[8]	Fall 2022 Forecast	Forecast Change
	a	b	c	d	=d-a
Zones A-I	16,008	15,120	15,614	16,037	29
Zones J&K	16,235	15,177	15,944	16,102	-133
NYCA	32,243	30297	31,558	32,139	-104

[8] The "normalized" 2021 peak load reflects an adjustment of the actual 2021 peak load to account for the load impact of actual weather conditions, demand response programs, and muni self-generation.

Use of the Fall 2022 Load Forecast resulted in an IRM decrease of 0.7% compared to the 2021 IRM Study (Table 6-1).

5.1.2 Load Forecast Uncertainty

As with all forecasting, 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 load forecast uncertainty (LFU) of individual NYCA areas, separate LFU models are prepared for five areas: New York City (Zone J), Long Island (Zone K), Westchester (Zones H and I), and two rest of New York State areas (Zones A-E and Zones F-G).

These LFU models are intended to measure the load response to weather at high peak producing temperatures, as well as other factors, such as the economy. However, economic uncertainty is relatively small compared to temperature uncertainty one year ahead. Thus, the LFU is largely based on the slope of load vs. temperature, or the weather response of load. If the weather response of load increases, the slope of load vs. temperature will increase, and the upper-bin LFU multipliers (Bins 1-3) will increase.

The new LFU multipliers included summer 2021 data, which was not included in prior LFU models. In general, the load response to weather in 2021 was less in magnitude than it was in previous hot summers. The slope of load vs. weather has recently decreased, resulting in smaller LFU multipliers in the upper bins. This change has resulted in lower LFU impacts on the IRM than in previous years.

In addition, a thorough review of the bin structure was conducted for the 2022 IRM Study. This review indicated that a change in the midpoint of each bin should be changed from a simple arithmetic average to a frequency weighted midpoint. This change was approved and implemented for this study. Further description can be found in the White Paper[9] written on this topic.

A sensitivity case shows that the modeling of LFU in the 2022 IRM Study has an effect of decreasing IRM requirements by 7.9% (Table 7-1, Case 3), as compared to a range of 7.2% to 9.1% in the previous five IRM studies.

[9] Need to find reference to the LFU white paper.

5.1.3 Load Shape Model

The GE-MARS model allows for the representation of multiple load shapes. This feature has been utilized since the 2014 IRM study and was again utilized for the 2022 IRM Study. This multiple load shape feature enables a different load shape to be assigned to each of seven load forecast uncertainty bins. ICS has established criteria for selecting the appropriate historical load shapes to use for each of these load forecast uncertainty bins. For this purpose, a combination of load shape years 2002, 2006, and 2007 were selected by ICS as representative years for the 2022 IRM Study. The load shape for the year 2007 was selected to represent a typical system load shape over the 1999 to 2017 period. The load shape for 2002 represents a flatter load shape, *i.e.*, 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 load duration curves were reviewed as part of the 2021 IRM Study. These curves were examined for the period 2002 through 2019. It was observed that the year 2012 was similar to the year 2007, the year 2013 was similar to 2006, and the year 2018 was similar to the year 2002. As a result of this review, the ICS decided to continue using the current three load shapes.

The load shape selection process is the third leg in a multiple year study that had included an extensive load forecast review and an extensive load forecast uncertainty review. The extensive load shape review is expected to be completed in time for the 2023 IRM study.

5.2 The Capacity Model

5.2.1 Conventional Resources: Planned New Capacity, Retirements, Deactivations, and Behind the Meter Generation

Planned conventional generation facilities that are represented in the 2022 IRM Study are shown in Appendix A, 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.

While there are no new conventional units planned, 111.2 MW of project related re-ratings are projected along with 19.1 MW of retirements.

A behind-the-meter-net-generation ("BTM:NG") program resource, for the purpose of this study, contributes its full capacity while its entire host load is exposed to the electric system. Several BTM:NG resources with a total resource capacity of at least 220 MW[10] and a total host load of 149.4 MW, are included in this 2022 IRM study. The full resource capacity of these BTM:NG facilities is included in the NYCA capacity model, while their host loads are included in the NYCA 2022 summer peak load forecast used for this study.

The NYISO has identified several state and federal environmental regulatory programs that could potentially impact operation of NYS Bulk Power System. The NYISO analysis concluded that these environmental initiatives would not result in NYCA capacity reductions or retirements that would impact IRM requirements during the summer of 2022. The analysis further identified those regulations that could potentially limit the availability of existing resources, and those that will require the addition of new non-emitting resources. For more details, see Appendix B, Section B.2.

5.2.2 Renewable Resources

Intermittent types of renewable resources, including wind and solar resources, are becoming an increasing component of the NYCA generation mix. These intermittent resources are included in the GE-MARS capacity model as described below. These resources, plus the existing 4,750 MW of hydro facilities, will account for a total of 7,081 MW of NYCA renewable resources represented in the 2022 IRM Study.

It is projected that during the 2022 summer period there will be a total wind capacity of 2,017.5 MW participating in the capacity market in New York State. This represents a increase in available wind resources of 158.1 MW and reflects the addition of one new wind resource and the capacity market entrance of an existing wind resource. All wind farms are presently located in upstate New York in Zones A-E.

GE-MARS allows the input of multiple years of wind data. This multiple wind shape model randomly draws wind shapes from historical wind production data. The 2022 IRM Study used available wind production data covering the years 2016 through 2020. For any new wind facilities, zonal hourly wind shape averages or the wind shapes of nearby wind units will be modeled.

[10] T least one of the suppliers considers their out

Overall, inclusion of the projected 2017.5 MW of wind capacity in the 2022 IRM Study accounts for 5.6% of the 2022 IRM requirement (Table 7-1, Case 4). This relatively high IRM impact is a direct result of the relatively 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.

Land Fill Gas (LFG) units account for 99.3 MW and are included in the above total.

For the 2022, there were 182.9 MW of solar additions. The total NYS Bulk Power System (BPS) solar capacity in the IRM Study is 214.4 MW. Actual hourly solar plant output over the 2016-20 period is used to represent the solar shape for existing units, while new solar units are represented by zonal hourly averages or nearby units.

5.2.3 Energy Limited Resources

In 2019, the NYISO filed, and in 2020 FERC approved tariff changes that became effective May 1, 2021 enhancing the ability of duration limited resources to participate in the NYISO markets. These rules allow output limited resources to participate in the markets consistent with those limitations, and requires owners of those resources to inform the NYISO of their elected energy output duration limitations by August 1st for the upcoming capability year (i.e., August 1, 2021 for the Capability Year beginning on May 1, 2022).

To accommodate this new classification of resources, the NYISO and GE have been working to expand the capabilities of the GE-MARs program to model ELRs. The NYISO and GE work on the new functionality is still proceeding and therefore, previously developed simplified modeling techniques of these resources continue to be utilized for the 2022 IRM Study. The simplified modeling approach dispatches the ELR units at pre-determined output levels, consistent with the resources' operational capabilities. Resource output is aligned with the NYISO's peak load window, when most loss-of-load events are expected to occur.

While these pre-determined output shapes were aligned with the periods that typically experience the highest loss-of-load risk, the profiles were not dynamic nor optimized. Thus, a more flexible or optimal dispatch schedule for these resources, such as that being developed within the MARS program, will be reviewed by ICS for adoption in future IRM studies.

Due to the confidential nature of these output limitations, the elections made, and the identity of units participating, the hourly representation of each unit was developed by NYISO and several of the NYSRC consultants taking into consideration the elections and operating history, particularly over the peak load conditions.

The introduction of output duration limitations on resources (ELRs) caused a significant increase in the number of times the GE-MARS simulation ~~looked~~ utilized ~~for~~ emergency ~~assistance~~ operating procedures (EOP) to resolve a shortage. It is important to note that a "shortage" can be for a duration of an LOLE event as low as 15 minutes, or as little as a single MW necessary to bring the system back to criteria. Making an SCR call is the first step in the EOP process.

~~Given~~ The modeling of duration limited resources for 2021 IRM study, the need for SCR resources increased to 170.1 days (probabilistic expected value) from the 2020 value of 8.2 days. For the 2022 IRM study a revision to how operating reserves are distributed by Zone, resulted in a reduction of SCR calls to XX. Due to the number of calls limit, however, SCRs ~~where~~were used to relieve load only 5 times/month. (see appendix B, table B.2). Work continues on refining the ELR modeling which should further reduce the number of SCR calls needed to meet LOLE criteria.

The ~~new~~ ELR modeling update resulted in a~~n increase~~ decrease in the IRM of 0.~~9~~1% (Table 6-1) for 2022 VS. 2021.

5.2.4 Generating Unit Availability

Generating unit forced and partial outages are modeled in GE-MARS by inputting a multistate 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 2021 IRM Study covered the 2016-2020 period.

The weighted average five-year EFORd for NYCA thermal and large hydro generating units calculated for the 2016-20 period is slightly lower than the 2015-19 average value used for the 2021 IRM Study. This decrease in average forced outage rates, ~~however, was not sufficient to materially change the~~ decrease the IRM by 0,3% (Table 6-1). Appendix A, Figure A.4 depicts NYCA EFORd trends from 2005 to 2020.

5.2.5 Emergency Operating Procedures (EOPs)

(1) Special Case Resources (SCRs)

SCRs are loads capable of being interrupted and distributed generators that are rated at 100 kW or higher. SCRs are ICAP resources that provide load curtailment only when activated when as needed in accordance with NYISO emergency operating procedures. GE-MARS represents SCRs as an EOP step, which is activated to avoid or to minimize expected loss of load. SCRs are modeled with monthly values based on July 2021 registration. For the month of July, the forecast SCR value for the 2022 IRM Study base case assumes that 1,164 MW will be registered, with varying amounts during other months based on historical experience. This is ~~87~~ 31 MW lower than that assumed for the 2021 IRM Study.

As indicated above, the number of SCR calls in the 2021 Capability Year for the 2022 IRM base case was limited to five calls per month.

The SCR performance model is based on discounting registered SCR values to reflect historical availability. The SCR model used for the ~~2021~~ 2022 IRM Study is based on a recent analysis of performance data for the 2012-19? period. This analysis determined a SCR overall performance factor of 69.6%. This is 0.8 % higher than the performance factor used in the 2021 IRM Study (refer to Appendix A, Section A.3.9 for more details). Although overall SCR performance factor improved than assumed in the 2021 Study, a decline in downstate performance resulted in a net IRM increase of 0.1% compared to last year's study (Table 6-1).

Incorporation of SCRs in the NYCA capacity model has the effect of increasing the IRM by 2.7 % (Table 7-1, Case 5). This increase is because the overall availability of SCRs is lower than the average statewide resource fleet availability.

(2) Other Emergency Operating Procedures

In addition to SCRs, the NYISO will implement several other types of EOPs, such as voltage reductions, as required, to avoid or minimize customer disconnections. Projected 2022 EOP capacity values are based on recent actual data and NYISO forecasts. Refer to Appendix B, Table B.2 for projected EOP frequencies for the 2021 Capability Year assuming the XX.X% base case IRM.

5.2.6 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 provide locational capacity benefits. Non-locational capacity, when coupled with a UDR to deliver capacity to a Locality, can be used to satisfy locational capacity requirements. The owners of the UDRs elect whether they will utilize their capacity deliverability rights. This decision determines how this transfer capability will be represented in the MARS model. 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.

The following facilities are represented in the 2022 IRM Study as having UDR capacity rights: 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. 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 capacity requirements. The 2022 IRM Study incorporates the confidential elections that these facility owners made for the 2022 Capability Year.

5.3 The Transmission Model

A detailed NYCA transmission system model is represented in the GE-MARS topology. The transmission system topology includes eleven NYCA zones and four Outside World Areas, along with relevant transfer limits, is depicted in Appendix A, Figure A-11. The transfer limits employed for the 2021 2022 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 for this IRM Study topology.

The transmission model assumptions included in the 2022 IRM Study are listed in Table A.8 in the Appendix which reflects changes from the model used for the 2021 IRM Study. These topology changes are as follows:

Western NY Limits – Public Policy Impact

- Zone A export limit increases to 2650 from 1850
- Zone A to B limit increases to 2200 from 1700
- Zone B to C limit increases to 1500 from 1300

Cedars Import Limit

- Import Capability to Zone D from Chateguay increases to 1770 from 1690.

Derates to Central East

- Porter-Rotterdam (30 & 31) lines will be out of service.
- Derates applied to both individual and group limits
- See table A.8 in the Appendix A

Updates to Zone K Topology

- ConEd-LIPA Dynamic Rating table for Zone K to I and J increases - see table A.8.

Forced transmission outages based on historic performance are represented in the GE-MARS model 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 were calculated based on the probability of occurrence from the historic failure rates and the time to repair. Transition rates into the different operating states for each interface were calculated based on the circuits comprising each interface, including failure rates and repair times for the individual cables, and for any transformer and/or phase angle regulator associated with that cable.

The Transmission Owners (TOs) provided updated transition rates for their associated cable interfaces. Updated cable outage rates assumed in the 2022 IRM Study resulted in a 0.3 % increase in the IRM compared with the 2021 IRM Study (Table 6-1).

As in all previous IRM studies, forced outage rates for overhead transmission lines were not represented in the 2022 IRM Study. Historical overhead transmission availability was evaluated in 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 NYCA 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 NYC (Zone J) and LI (Zone K). To illustrate the impact of transmission constraints on the IRM, if internal NYCA transmission constraints were eliminated, the required 2022 IRM could decrease by 1.9% (Table 7-1, Case 2).

5.4 The Outside World Model

The Outside World Model consists of four interconnected Outside World Areas contiguous with NYCA: Ontario, Quebec, New England, and the PJM Interconnection

(PJM). NYCA reliability is improved and IRM requirements can be reduced by recognizing available emergency assistance (EA) from these neighboring interconnected control areas, in accordance with control area agreements governing emergency operating conditions.

For the 2022 IRM Study, two Outside World Areas, New England and PJM, are each represented as multi-area models—*i.e.,* 14 zones for New England and five zones for the PJM Interconnection. Another consideration for developing models for the four Outside World Areas is to recognize internal transmission constraints within those areas that may limit EA into the NYCA. This recognition is explicitly considered through direct multi-area modeling of well-defined Outside World Area "bubbles" and their internal interface constraints. The model's representation explicitly requires adequate data in order to accurately model transmission interfaces, load areas, resource and demand balances, load shapes, and coincidence of peaks, among the load zones within these Outside World Areas.

Representing Outside World Area interconnection support in IRM studies significantly reduces IRM requirements. For the previous ~~six~~ seven IRM studies, EA has reduced IRM requirements in the range of 6.9 to 8.7%.[11]

In 2019, the ICS conducted an analysis of the IRM study's Outside Area Model to review its compliance with a NYSRC Policy 5 objective that "interconnected Outside World Areas shall be modeled to avoid NYCA's overdependence on Outside World Areas for emergency assistance." This analysis resulted in a change in the methodology to scale loads proportional to excess capacities in each load zone of each Outside World Area to meet the LOLE criterion and the Control Area's minimum IRM requirement. The ICS used this new model in the current study (2022) as well as in the 2021 IRM Study.[12]

During the 2022 Capability Year, Hydro-Quebec is expected to wheel 300 MW of capacity through NYCA to New England (Is this still the case?). In addition, the 2022 IRM study continues to limit the EA assistance to a maximum of 3,500 MW as applied in the previous four IRM Studies[13].

[11] *See* 2015 to 2020 IRM Study reports at www.nysrc.org/reports3.html.

[12] *See Evaluation of External Area Modeling in NYCA IRM Studies*, for a description of this analysis, at http://www.nysrc.org/reports3.html

[13] The 2018 IRM Study report, pages 17-18, describes this EA limit and its derivation. See www.nysrc.org/reports3.html.

Utilizing the improved Outside Area Model, while including the Hydro-Quebec wheel to New England and continuing to represent the 3,500 MW EA limit described above, reduces the NYCA IRM by 8.6% (Table 7-1, Case 1). This is ~~0.6~~1.7% more than the impact determined in the 2021 IRM Study.

5.5 Database Quality Assurance Review (awaiting update)

It is critical that the database used for IRM studies undergo sufficient review in order to verify its accuracy. The NYISO, General Electric (GE), and two New York 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 two TOs for their review. Also, certain confidential data are reviewed by two of the NYSRC consultants as required.

The NYISO, GE, and TO reviews found a few 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 2021 IRM Study input data is shown in Appendix A, Section A.4.

6. Parametric Comparison with 2020 IRM Study Results

The results of this 2022 IRM Study show that the base case IRM result represents a 2.1% (PBC result) ~~increase~~ decrease from the 2021 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 last year's study. The estimated percentage 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 IRM impact of each parameter in this analysis was normalized such that the net sum of the -/+ % parameter changes total the ~~1.8~~2.1% IRM ~~increase~~ decrease from the 2021 IRM Study. Table 6-1 also provides the reason for the IRM change for each study parameter from the 2021 IRM Study.

There are ~~five~~ six parameter drivers that in combination increased the 2022 IRM from the 2021 base case by ~~3.1~~1.1%. Of these ~~five~~ six drivers, the most significant are capacity additions which increased the IRM by 0.4% and updated cable transition rates which increased the IRM by 0.3%.

~~Five~~ Seven parameter drivers in combination decreased the IRM from the 2021 base case by ~~1.3~~3.2%. Of these seven drivers, the most significant are a new summer LFU model which decreased the IRM by 1.3%, and a new load forecast reducing the IRM by ~~0.3~~0.7%.

The parameters in Table 6-1 are discussed under *Models and Key Input Assumptions.*

Table 6-1: Parametric IRM Impact Comparison – 2021 IRM Study vs. 2022 IRM Study

Parameter	Estimated IRM Change (%)	IRM (%)	Reasons for IRM Changes
2021 IRM Study – Final Base Case		**20.7**	
2022 IRM Study Parameters that increased the IRM			
Capacity Additions	0.40		Addition of 158 MW of wind and 183 MW of solar pushed IRM up.
Cable Transition Rates	0.30		Recent cable poor performance
Wind Shapes (2016-2020)	0.10		The added 2020 shape had a poorer performance than the deleted 2015.
New Reserve Allocation	0.10		Movement of Reserves from a bottled zone (Zone A) to Zones F and G
Maintenance	0.10		Planned maintenance increase
SCR Update	0.10		Slight drop in downstate performance
Total IRM Increase	**1.1**		
2022 IRM Study Parameters that decreased the IRM			
New Summer LFU	-1.30		Narrowing of high load bins
Gold Book Load Forecast for 2022	-0.70		Decrease in downstate load forecast
Gold Book 2021 DMNC Values	-0.40		Upstate to downstate decrease in total available MWs
Thermal Outage Rates (2016 - 2020)	-0.30		Downstate rates improved
Non-SCR EOPs	-0.30		Slightly more MWs available
ROR Shapes (2016-2020)	-0.10		2020 better saw better performance than the dropped 2015 shape
Update ELR Units	-0.10		Performance of underlying units improved.
Total IRM Decrease	**-3.2**		
2022 IRM Study Parameters that did not change the IRM			
New Winter LFU	0		
Solar and LFG Shapes (2016-2020)	0		
Deactivations	0		
Topology Changes	0		
Net Change from 2020 Study		**-2.1**	
2022 IRM Study – Preliminary Base Case		**18.6**	

7. Sensitivity Case Study

In addition to calculating the IRM using base case assumptions, sensitivity analyses are run as part of an IRM study to determine IRM outcomes using different assumptions than in the base case. Sensitivity studies provide a mechanism for illustrating "cause and effect" of how some performance and/or operating parameters and study assumptions can impact reliability. Certain sensitivity studies, termed "IRM impacts of base case assumption changes," serve to inform the NYSRC Executive Committee when determining the Final IRM regarding how the IRM may be affected by reasonable deviations from selected base cases assumptions. The methodology used to conduct sensitivity cases starts with the base case IRM results and adds or removes capacity from all NYCA zones until the NYCA LOLE approaches 0.1 days/year.

Table 7-1 shows the IRM requirements for ~~8~~ 9 sensitivity cases. Because of the lengthy computer run time and personnel needed to perform a full Tan 45 analysis in IRM studies[14], this method was applied for only select cases as noted in the table. It should be recognized that some accuracy is sacrificed when a Tan 45 analysis is not utilized.

Sensitivity Cases 1 through 5 in Table 7-1 are annually performed and illustrate how the IRM would be impacted if certain major IRM study parameters were not represented in the IRM base case. Four of these cases show reasonable results when compared to past results. The fifth, *'No Load Forecast Uncertainty'*, usually shows a continued rising trend or increase each time the data is renewed. ~~Because of this, the ICS has initiated a study to identify the causes of this trend~~For the 2022 IRM study, the introduction of new LFU model has reversed that trend. These parameters and their IRM impacts are discussed in Sections 5.1.2 and 5.4, respectively.

The next two sensitivity cases, Cases 6 and 7, illustrate the IRM impacts of changing certain base case assumptions. Case 6 shows the impact of advanced completion of the Zone D PAR repair. Case 7 utilizes the new MARS ELR software TC-4C option as the basis for testing the ELR functionality. SCR calls dropped from 45.3 to 34.8. The resources were modeled in the base case using a simplified representation of the limitations. This allowed a desired representation while a more detailed representation of the ELR limitations is studied over the course of the next six months.

The remaining cases, Case 8 and Case 9 look at the impact of extended partial outage of the Neptune UDR Case 8) and utilizing the same cable forced outage rates that were utilized in the 2021 IRM study. Appendix B, Table B-1 includes a more detailed description and explanation of each sensitivity case.

[14] The Tan 45 method is described in Section 3.

2022 IRM Study- Sensitivity Cases (based on PBC)

Note: The added LOLH[15] and EUE[16] statistics were extracted directly from GE MARS outputs and are reported for information only. These statistics should not be considered as having any impacts on the 2022 IRM or LCR outcomes and therefore caution should be taken when interpreting these results.

Table 7-1: Parametric IRM Impact Comparison – 2021 IRM Study vs. 2022 IRM Study

Case	Description	IRM (%)	IRM% Change from Base Case	LOLH (at criteria)	EUE (at criteria)	EUE Change from Base
0	**2022 IRM Preliminary Base Case**	18.6	-	0.348	223.0	-
	These are the Base Case technical results derived from knee of the IRM-LCR curve.					
1	**NYCA Isolated**	27.2	+8.6	0.304	175.8	-47.2
	Track Total NYCA Emergency Assistance – NYCA system is isolated and receives no emergency assistance from neighboring control areas (New England, Ontario, Quebec, and PJM). UDRs are allowed.					
2	**No Internal NYCA transmission constraints**	16.7	-1.9	0.373	326.0	+103.0
	Track level of NYCA congestion with respect to the IRM model – internal transmission constraints are eliminated and the impact of transmission constraints on statewide IRM requirements is measured.					
3	**No Load forecast uncertainty**	10.7	-7.9	0.256	65.6	-157.4
	Shows sensitivity of IRM to load uncertainty, assuming that the forecast peak loads for NYCA have a 100% probability of occurring.					
4	**No wind capacity**	13.0	-5.6	0.353	231.6	+8.6
	Shows wind impact; performed by freezing J & K at base levels and adjusting capacity in the upstate zones.					
5	**No SCRs**	15.9	-2.7	0.331	191.9	-31.1
	Shows sensitivity of IRM to SCR resources.					
6	**Zone D PAR sensitivity**	18.5	-0.1	0.352	226.6	+3.7
	Determines IRM if the zone D PAR repair is completed in advance of next summer; performed by freezing J & K at base levels and adjusting capacity in the upstate zones.					

[15] Loss of Load Hours (LOLH) is expressed as hours per year of expected loss of load.
[16] Expected Unforced Energy (EUE) is expressed as megawatt hours (MWh) per year of expected unserved energy.

7	**Enhanced Energy Limited Resource (ELR) sensitivity.**	17.8	-0.8	0.368	264.1	+41.1
	Selects the TC-4C option from the ELR whitepaper as the basis for testing a functionality of the new MARS ELR software. Includes results on the number of EOPs called. **(Tan 45)**					
8	**Extended partial outage of Neptune UDR**	19.8	+1.2	0.349	187.3	-35.7
	Sensitivity on line remaining partially unavailable (50%) (Shifting performed across Zones G-K)					
9	**Revert to 2021 IRM Study Cable Forced Outage Rates**	18.5	-0.1	0.350	227.8	+4.8
	Shows the **(Tan45)** Impact of Updated Cable Forced Outage Rates.					

8. NYISO Implementation of the NYCA Capacity Requirement

(still needs updating)

The NYISO values capacity sold and purchased in the market in a manner that considers the forced outage ratings of individual units, whereby generating unit capacity is derated to an unforced capacity basis recognizing the impact of forced outages. This derated capacity is referred to as "UCAP." 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.

Additionally, LCRs are translated into 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 raises the IRM because wind capacity has a relatively 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 shows that required UCAP margins, which steadily decreased over the 2006-2012 period to about 5%, and then have remained fairly steady since.

Appendix C provides details of the ICAP to UCAP conversion process used for this analysis

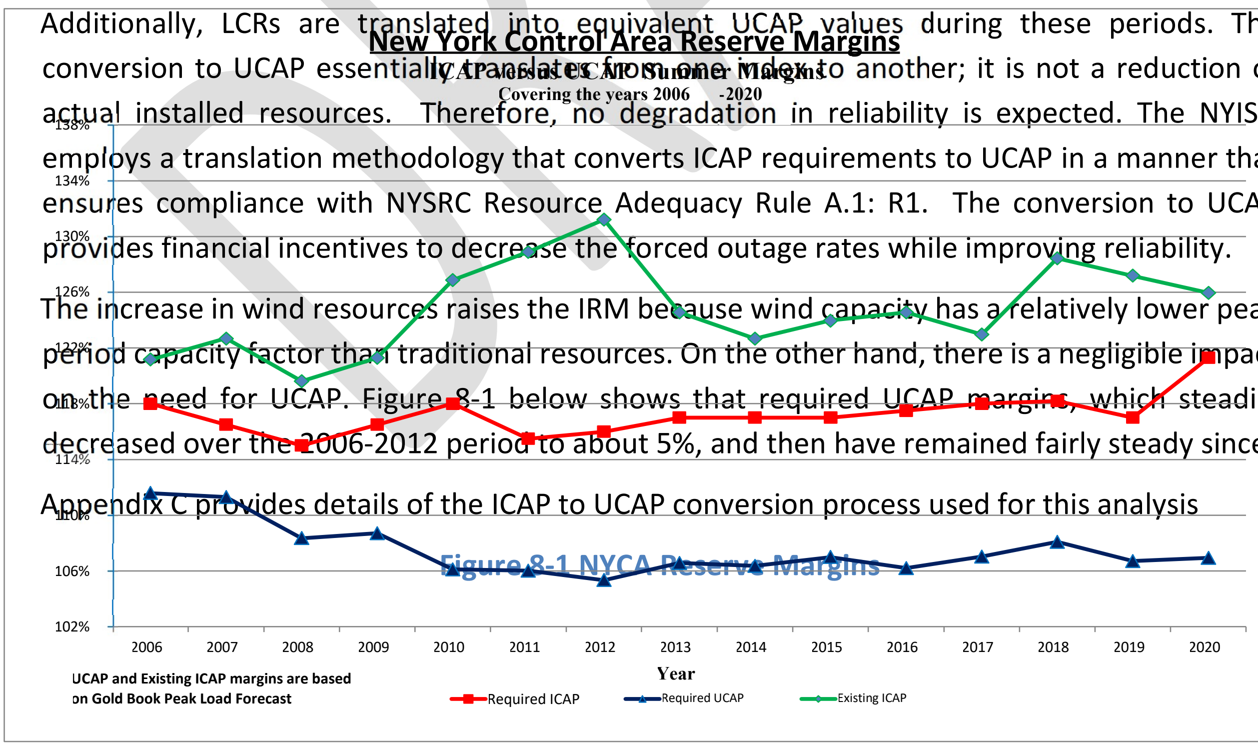


Figure 8-1 NYCA Reserve Margins