New York ISO
Independent System Operator

2021-2030
Comprehensive Reliability Plan

A Report from the
New York Independent
System Operator

Draft Report
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Revised

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Executive Summary

This Comprehensive Reliability Plan (CRP) concludes that the New York State Bulk Power Transmission Facilities as planned will meet all currently applicable reliability criteria from 2021 through 2030 for forecasted system demand in normal weather. While the NYISO finds that there are no remaining long-term actionable reliability needs to be addressed in this cycle of the Reliability Planning Process, the margin to maintain reliability over the next ten years will narrow or could be eliminated based upon changes in forecasted system conditions. Risk factors such as delayed implementation of projects in this plan, additional generator deactivations, unplanned outages, and extreme weather could potentially lead to deficiencies in reliable electric service in the coming years.

The wholesale electricity markets administered by the NYISO are an important tool to mitigate these risks. These markets are designed, and continue to evolve and adapt, to send appropriate price signals for new market entry and retention of resources that assist in maintaining reliability. The potential risks and resource needs identified in the analyses may be resolved by new capacity resources coming into service, construction of additional transmission facilities, and/or increased energy efficiency, integration of distributed energy resources, and growth in demand response participation. The NYISO will continue to monitor these and other developments to determine whether changing system resources and conditions could impact the reliability of the New York bulk electric grid.

Reliability Violations Resolved

The 2020 Reliability Needs Assessment (RNA), published in November 2020, provided an evaluation and review of the reliability of the New York bulk electric system, considering forecasts of peak power demand, planned upgrades to the transmission system, and changes to the generation mix expected over the next ten years. Grid reliability is measured by assessing transmission security and resource adequacy criteria established by the Northeast Power Coordinating Council and the New York State Reliability Council. Transmission security is the ability of the electric system to withstand disturbances such as electric short circuits or unanticipated loss of system elements without involuntarily disconnecting firm load. Resource adequacy is the ability of the electric system to supply the aggregate electrical demand and energy requirements of their customers, taking into account scheduled and reasonably expected unscheduled outages of system elements.

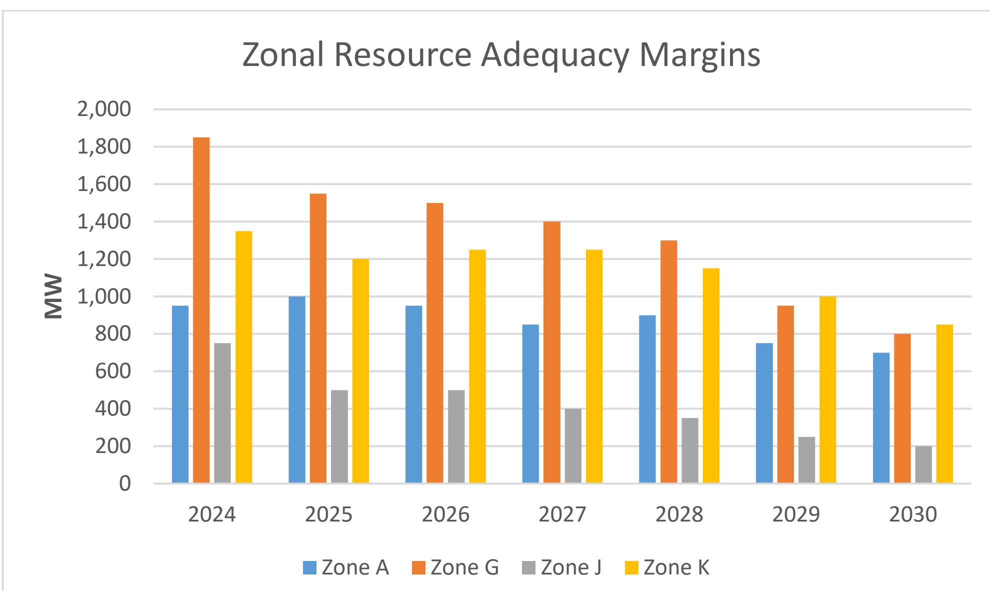
The RNA identified reliability criteria violations and system deficiencies constituting actionable reliability needs primarily driven by a combination of forecasted peak demand and the assumed unavailability of 1,500 MW of generation in New York City affected by the New York State Department of Environmental Conservation (DEC) “Peaker Rule.” The Peaker Rule will limit nitrogen oxides (NO_x)

emissions from simple-cycle combustion turbines in a phased implementation from 2023 to 2025. After the RNA was published and before pursuing a solicitation for solutions, the NYISO considered subsequent updates to system plans. These updates included a reduced demand forecast to account for economic and societal effects from the COVID-19 pandemic, and new local transmission plans and operating procedures by Con Edison for the New York City service territory. With these updates, there are no remaining violations of reliability design criteria.

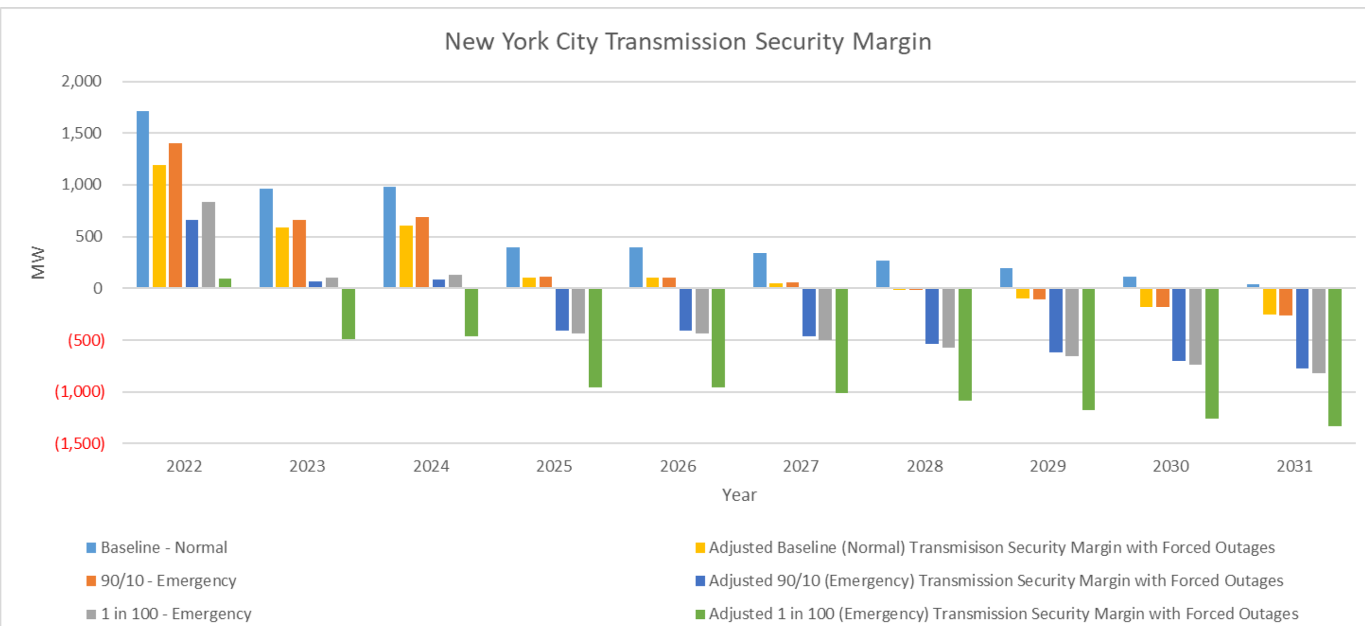
Risk Factors – Narrowing Reliability Margins

The finding of no reliability violations reflects the Reliability Planning Process assumptions, which are set in accordance with applicable reliability design criteria and NYISO's procedures. There are, however, risk factors that could adversely affect system reliability over the planning horizon. These risk factors may arise for several reasons including climate, economic, regulatory, and policy drivers.

Reliability margins will shrink in upcoming years due primarily to the planned unavailability of simple cycle combustion turbines that are impacted by the DEC's Peaker Rule. Over the next ten-year period, the NYISO is forecasting a decrease in energy usage due to energy efficiency initiatives and increasing amounts of behind the meter solar generation. However, significant load-increasing impacts are forecasted due to expected growth in electric vehicle usage, large cloud-computing data centers, and other electrification (*i.e.,* conversion of home heating, cooking, water heating and other end-uses from fossil-fuel based systems to electric systems). The following figure shows the tightening of zonal resource adequacy margins for western New York (Zone A), lower Hudson Valley (Zone G), New York City (Zone J), and Long Island (Zone K). New York may experience even smaller resource adequacy margins if additional power plants become unavailable or if demand is greater than forecasted.



The dangers of severe weather impacting the grid have been demonstrated around the country in the past year, with Texas experiencing a brutal polar vortex in February and California facing problems from extreme heat last summer. New York is not immune from such extreme weather, which could lead to greater electrical demand and more forced generator outages than currently accounted for in the baseline forecasts underpinning this CRP. In consideration of these climate-related risk factors, the New York grid may cross a "tipping point" in future years such that the transmission system and resources could not fully serve the demand. The following figure shows the transmission security margin in New York City for a variety of plausible conditions. The baseline analysis of normal weather and limited generation outages shows a positive but narrowing transmission security margin across the ten-year period. However, heatwave conditions combined with the impact of additional forced generation outages would result in deficiencies to serve demand in New York City in many of the years. A heatwave with a statewide average maximum temperature of 95 degrees Fahrenheit (1-in-10-year event, or 90/10) may result in very thin margins in 2023 and significant deficiencies beginning in 2025, while an extreme 98-degree Fahrenheit sustained heatwave (1-in-100-year event) would test the system limits today and exceed grid abilities beginning in 2023. This outlook could improve as more resources and transmission are added to New York City. Through the quarterly Short-Term Reliability Process and biennial Reliability Planning Process, the NYISO will continue to address reliability issues identified for the ten-year planning horizon.



Reliability Risk Factors: Key Takeaways

- Resource adequacy margins are tightening across the New York grid through time, from Buffalo to Long Island. New York would experience even smaller margins if additional power plants become unavailable or if demand is greater than forecasted. If the margins are totally depleted, the reliability of the grid would be at risk.
- While transmission security within New York City is maintained through the ten-year period in accordance with current design criteria, the margin would be very tight starting in 2025 and would be deficient beginning in 2028 if forced outages are experienced at the historical rate.
- The reliability plan is heavily reliant on the timely completion of planned transmission projects. If the planned projects were delayed for any reason, the grid's ability to reliably serve customer demand would be jeopardized.
- Extreme events such as heatwaves or storms could result in deficiencies to serve demand statewide, especially in New York City considering the plans included in this Comprehensive Reliability Plan. This outlook could improve as more resources and transmission are added to New York City.

Road to 2040 – Reliability and Resiliency Challenges

The electric system is undergoing significant and rapid change. Part of the change is climate related, which will drive more frequent extreme weather events and higher temperatures, thus impacting the ability of the grid to reliably serve electric demand. Part of the change is the result of public policies in response to climate change. The Climate Leadership and Community Protection Act (CLCPA), enacted in 2019, requires an economy-wide approach to addressing climate change and decarbonization. This includes sweeping mandates that 70% of New York electricity consumed shall be produced from renewable resources by 2030 ("70x30") and 100% emissions-free electricity supply by 2040 ("100x40") while promoting electrification in other sectors of the economy. Understanding the policy drivers and the impacts to the generation, transmission, and load components of the bulk electric system is critical to understanding the challenges to reliable electric service in the coming years.

Transmission will play a key role in moving power from the renewable resources to the load centers. In response to the declaration of Public Policy Transmission Needs by the New York Public Service Commission (PSC), the NYISO has already selected three major public policy transmission projects to enable the delivery of renewable energy to consumers across New York State. These projects are scheduled to enter service within the next few years. The PSC also approved NYPA's request to proceed with development of its proposed Northern New York Transmission Projects, which seek to increase the capacity of certain transmission lines to accommodate incremental delivery of renewable energy from northern New York. More recently, Governor Kathy Hochul announced two recommended contract awards for the Clean Path NY and Champlain Hudson Power Express projects to increase transmission capability to New York City. Even with the potential benefits provided by these projects, several renewable generation pockets across the whole state would persist that could constrain output from renewable resources, including offshore wind. In March 2021, the PSC issued an order declaring that offshore wind goals are driving the need for additional transmission facilities to deliver that renewable power from Long Island to the rest of New York State. The NYISO is evaluating transmission solutions to determine whether they are viable and sufficient to meet the PSC-identified need and whether to select the more cost-effective or efficient project to satisfy the need.

Most renewable generation is intermittent, and intermittent resources are not fully dispatchable due to the variability of their "fuel" source. To maximize efficiencies, the location of these resources is dictated by where the wind is most constant for wind resources or by where there is sufficient land for solar resources. This results in land-based wind locating in northern and western New York and solar resources locating upstate as well. Offshore wind would connect primarily into New York City and Long Island. The variability of meteorological conditions that govern the output from wind and solar resources presents a fundamental challenge to relying solely on those resources to meet electricity demand. Solar resources will have little to no output during the evening and nighttime hours and reduced output due to cloud cover, while wind resources can experience significant and sustained wind lulls. Periods of reduced renewable output will occur for short durations due to cloud cover or changes in wind speed and for prolonged periods across a daily/seasonal cycle. Sufficient resources to address all conditions will be necessary to provide continued reliability.

As the level of renewable resource generation increases, the grid will need sufficient flexible and dispatchable resources to balance variations in wind and solar output. The integration of batteries will help store renewable energy for later use on the grid and is poised to help with the short duration and daily cycles of reduced renewable output. Depending on the duration of need, enhancements to various market design aspects may be required including reserves, regulation, ramping, and load forecasting. Looking ahead to 2040, the policy for an emissions-free electricity supply will require the development of new technologies. Substantial zero-emission dispatchable resources will be required to fully replace fossil generation. Long-duration, dispatchable, and emission-free resources will be necessary to maintain reliability and meeting the objectives of the CLCPA. Resources with this combination of attributes are not commercially available at this time but will be critical to future grid reliability. Over the next several years, NYISO market projects will continue to address the changes needed in the energy and ancillary services as well as prepare the markets for new resource classes. These efforts will focus on improving signals to drive investment in resources with the characteristics and attributes needed for continued grid reliability.

Most renewable generators will be connected to the grid asynchronously through power electronic devices (*i.e.,* inverter-based resources). The characteristics of inverter-based resources are different than conventional synchronous generation. Without significant mitigation measures, a shift to inverter-based resources may result in flickering lights and disruptions to industrial processes and consumer electronics. The ability of inverter-based resources to function properly often depends on the strength of the grid at or near the interconnection of the resources, and the stability of the grid could weaken as conventional synchronous generation retires. Grid strength is a commonly used term to describe how the system responds to system changes (*e.g.,* changes in load, and equipment switching). In a "strong" system, the voltage and frequency are relatively insensitive to changes in current injection from the inverter-based resource. Inverter-based resources connecting to a portion of the system rich in synchronous generation that is electrically close or relatively large are likely connecting to a strong portion of the system. Inverter-based resources connected to a "weak" portion of the grid may be subject to instability, adverse control interactions, and other issues. Through assessments of short-circuit ratios and voltage flicker described in this report, the NYISO has identified weak portions throughout the New York grid that are likely to experience system performance issues without mitigation measures such as the implementation of control systems, grid-forming inverters, and synchronous compensators.

Road to 2040: Key Takeaways

- Transmission expansion is necessary throughout New York State in order to maximize access to renewable resources.
- Climate change will impact meteorological conditions and events that introduce additional reliability risks.
- The variability of output from wind and solar resources presents a fundamental challenge to reliably meeting electricity demand.
- Battery storage resources help to fill in voids in renewable resources output, but extended periods rapidly deplete storage capabilities resulting in the need for longer running dispatchable emission-free resources.
- Significant amounts of dispatchable, emission-free resources are needed to balance renewable intermittency on the system. Resources with this combination of attributes are not commercially available at this time but will be critical to future grid reliability. By 2040, the amount of necessary dispatchable emission-free resources could be over 32,000 MW, approximately 6,000 MW more than the total fossil-fueled power plants on the New York grid in 2021.

Future NYISO Studies

Through the Short-Term Reliability Process, the NYISO will conduct quarterly Short-Term Assessments of Reliability (STARs) to assess reliability needs within a five-year horizon. If necessary, the NYISO will seek solutions to address any reliability needs identified through that process. The next cycle of the Reliability Planning Process will begin in 2022, for which preparations will begin late this year. The 2022 RNA will provide a new reliability assessment based on updated system models and assumptions, and will review the status of the risk factors discussed in this CRP, together with other reliability issues.

For the first time, the NYISO is currently undertaking a 20-year System & Resource Outlook, to be issued in 2022. The Outlook will provide a comprehensive overview of system resources and transmission constraints throughout New York, highlighting opportunities for transmission investment driven by economics and public policy. Together, the Comprehensive Reliability Plan and the System & Resource Outlook will be the marquee NYISO planning reports that will collectively provide a comprehensive power system outlook to stakeholders, developers, and policymakers.

Background

The 2021-2030 Comprehensive Reliability Plan (CRP) completes the NYISO's 2020-2021 cycle of the Reliability Planning Process. The 2020 Reliability Needs Assessment (RNA), approved by the NYISO Board of Directors in November 2020, was the first step of the NYISO's 2020-2021 Reliability Planning Process. This CRP follows the 2020 RNA and post-RNA updates and incorporates findings and solutions from the quarterly Short-Term Reliability Process. A description of the Reliability Planning Process is provided in Appendix G.

2020 Reliability Needs Assessment

The 2020 RNA provided an evaluation and review of the reliability of the New York Bulk Power Transmission Facilities (BPTF) for the study period (2024-2030), considering forecasts of peak power demand during normal weather, planned upgrades to the transmission system, and changes to the generation mix expected over the next ten years (2021-2030). System performance is measured against currently applicable reliability criteria established by the North American Reliability Corporation (NERC), the Northeast Power Coordinating Council (NPCC), and the New York State Reliability Council (NYSRC). The RNA assessed an actionable "base case" set of assumptions, as well as various scenarios that are provided for information. The 2020 RNA base case included projected impacts driven by limitations on generator emissions, while the scenarios included an in-depth look at certain policy goals from the Climate Leadership and Community Protection Act (CLCPA). The RNA also discussed the reliability risks associated with the cumulative impact of environmental laws and regulations, which may affect the availability and flexibility of power plant operation.

The 2020 RNA identified violations or potential violations of applicable reliability criteria (Reliability Needs) in the actionable base case throughout the entire study period (2024-2030) due to dynamic instability, transmission overloads, and/or resource deficiencies.[1] The issues identified were primarily driven by a combination of forecasted peak demand and the assumed unavailability of certain generation in New York City affected by the "Peaker Rule."

In 2019, the New York State Department of Environmental Conservation adopted a regulation to limit nitrogen oxides (NOx) emissions from simple-cycle combustion turbines (referred to as the "Peaker Rule[2]"). Combustion turbines known as "peakers" typically operate to maintain bulk power system reliability during the most stressful operating conditions, such as periods of peak electricity demand. Many

[1] Effective May 1, 2020, the scope of the RNA is limited to years 4-10 of the planning horizon while the NYISO Short-Term Reliability Process is responsible for years 1-3 and also assesses years 4-5.

[2] https://www.dec.ny.gov/regulations/116131.html

of these units also maintain transmission security by supplying energy within certain constrained areas of New York City and Long Island — known as load pockets[3]. The Peaker Rule, which phases in compliance obligations between 2023 and 2025, will impact turbines located mainly in the lower Hudson Valley, New York City, and Long Island. The Peaker Rule required all impacted plant owners to file compliance plans by March 2, 2020. The plans filed in 2020 indicate approximately 1,500 MW of peaker capability would be unavailable during the summer by 2025 to comply with the emissions requirements. A subset of those generators would be unavailable starting in 2023.

The 2020 RNA also discussed the coronavirus outbreak and its significant impact on New York's economy due to reductions in commercial and industrial activity as New Yorkers adjusted their lives by working from home and limiting social interaction. Due to the rapidly evolving nature of the pandemic, the demand forecasts utilized in the study reflected the NYISO's perspective as of April 2020. The sudden departure from historical behavioral patterns caused by New York's response to COVID-19 is unprecedented and creates unique challenges to forecasting the state's energy needs. As the situation evolves and more data becomes available, the NYISO will continue to monitor these forecasts and adjust course accordingly. Following completion of the RNA and prior to any solicitation of solutions, the NYISO considered updates to the demand forecasts and determined to what extent the forecasts impacted any identified system needs.

The following is a summary of the 2020 RNA Base Case findings. These findings were later revised as described in the Post-RNA Updates sub-section.

- Dynamic stability Reliability Needs were observed for the entire study period. Following the initial phase of the Peaker Rule in 2023, instability of the grid may have occurred due to a lack of dynamic reactive power capability and inertia available to parts of the New York City grid. The criteria violations included transient voltage response violations, loss of generator synchronism, and undamped voltage oscillations.
- With full implementation of the Peaker Rule in 2025, several 345 kV circuits in the Con Edison service territory would have been overloaded, resulting in Reliability Needs equating to a deficiency of 700 MW and increasing to 1,075 MW by 2030. The duration of the deficiency ranges from nine hours in 2025 (3,853 MWh) to 12 hours in 2030 (7,672 MWh).
- Similar transmission deficiencies would have also occurred within pockets of Con Edison's non-bulk system (138 kV) ranging in duration from 10 to 14 hours.
- The studied system exceeded the LOLE criterion of one day in 10 years, or 0.1 days per year, starting in 2027, and increasing through 2030 resulting in a Reliability Need with a compensatory MW amount of 350 MW in 2030.

[3] The Con Edison criteria reference Transmission Load Areas, which are analogous to load pockets.

Short-Term Reliability Process

In parallel with the RNA and CRP process, the NYISO has implemented a new quarterly Short-Term Reliability Process (STRP), with its requirements prescribed in Attachments Y and FF of the NYISO's Open Access Transmission Tariff. The STRP evaluates the first five years of the planning horizon, with a focus on needs arising in the first three years of the study period. With this process in place, the biennial Reliability Planning Process focuses on solutions to longer term needs through the RNA and the CRP.

The first step in the STRP is the Short-Term Assessment of Reliability (STAR). STARs are performed quarterly to proactively address reliability needs that may arise within five years (Short-Term Reliability Needs)[4] due to various changes to the grid such as generator deactivations, revised transmission plans, and updated load forecasts. Transmission Owners (TO) also assess the impact of generator deactivations on their local systems. A Short-Term Reliability Need that is observed within the first three years of the study period constitutes a "Near-Term Reliability Need."[5] Should a Near-Term Reliability Need be identified in a STAR, the NYISO solicits and selects the solution to address the need. If a need arises beyond the first three years of the study period, the NYISO may choose to address the need within the STRP or, if time permits, through the long-term Reliability Planning Process.

The 2020 Quarter 3 STAR[6] found Short-Term Reliability Needs on the Bulk Power Transmission Facilities (BPTF) starting in 2023 and increasing in scope and scale through 2025. Through the STRP, the NYISO addressed the Near-Term Reliability Needs arising in 2023, with the needs arising in 2024 and 2025 being addressed through the Reliability Planning Process. No other BPTF reliability needs have been identified and addressed in the STARs completed to date.

[4] OATT Section 38.1 contains the tariff definition of a "Short-Term Reliability Process Need."

[5] OATT Section 38.1 contains the tariff definition of a "Near-Term Reliability Need." See also OATT Section 38.3.6.

[6] https://www.nyiso.com/documents/20142/16004172/2020-Q3-STAR-Report-vFinal.pdf/

Post-RNA Updates

After the 2020 RNA was approved and before a solicitation for solutions, the process considered subsequent base case updates that met the inclusion rules. The following updates were made:

- NYISO's load forecast update to account for the expected impact of COVID-19 and the associated economic and societal effects, as presented at the November 19, 2020 ESPWG/TPAS/LFTF meeting [link]
  - For example, the New York City peak load forecast decreased by 392 MW in 2030
- Local Transmission Owner Plans (LTPs) updates to address local reliability deficiencies as presented by Con Edison at the January 25, 2021, ESPWG/TPAS [link]:
  - A new 345/138 kV PAR controlled 138 kV Rainey – Corona feeder in 2023
  - A new 345/138 kV PAR controlled 138 kV Gowanus – Greenwood feeder in 2025
  - A new 345/138 kV PAR controlled 138 kV Goethals – Fox Hills feeder in 2025
- Short Term Reliability Process solution for addressing the 2023 short-term need identified in the 2020 Quarter 3 STAR [link]. The solution changed the planned operating status of existing series reactors, starting summer 2023 through 2030:
  - In-service: series reactors on the following 345 kV cables: 71, 72, M51, M52
  - Bypass: series reactors on the following 345 kV cables[7]: 41, 42, Y49
- The transient voltage response issues were observed on Con Edison's non-BPTF system during 2025 through 2030, while the BPTF violations were observed starting in 2029. Con Edison will address the non-BPTF violations with a Corrective Action Plan as required by NERC Standard TPL-001-4. When the non-BPTF violations are addressed, the BPTF violations are no longer observed. [link]

With these base case updates there is no remaining actionable Reliability Need throughout the 2024-2030 study period, and the NYISO did not solicit solutions in the 2020-2021 cycle of the Reliability Planning Process.

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[7] Additional LTPs were subsequently presented by the Transmission Owners, such as further changing the status of the series reactors on Con Edison's cables #41 and #42 from assumed bypassed in this CRP (starting 2023) to in-service, starting summer 2025 – details in the July 23, 2021 ESPWG Con Edison's presentation [link]. This change is reflected in the 2021 Q3 STAR [link].

Comprehensive Reliability Plan for 2021-2030

The Comprehensive Reliability Plan to reliably serve New York demand for the 2021-2030 timeframe incorporates forecasting the balance between generation, load, and transmission. A key part of the reliability process is to apply conservative inclusion rules so that only those projects that have a high level of certainty of being completed are planned for. This often results in only limited amounts of generation and transmission projects being included in the base case. It is important to note that the NYISO Interconnection Queue contains an unprecedented number of proposed projects in various stages of development. The NYISO's Gold Book Tables IV and VII contain proposed generation and transmission projects that are in a more advanced stages of the interconnection process, of which only a few have achieved sufficient milestones to be included in this CRP.

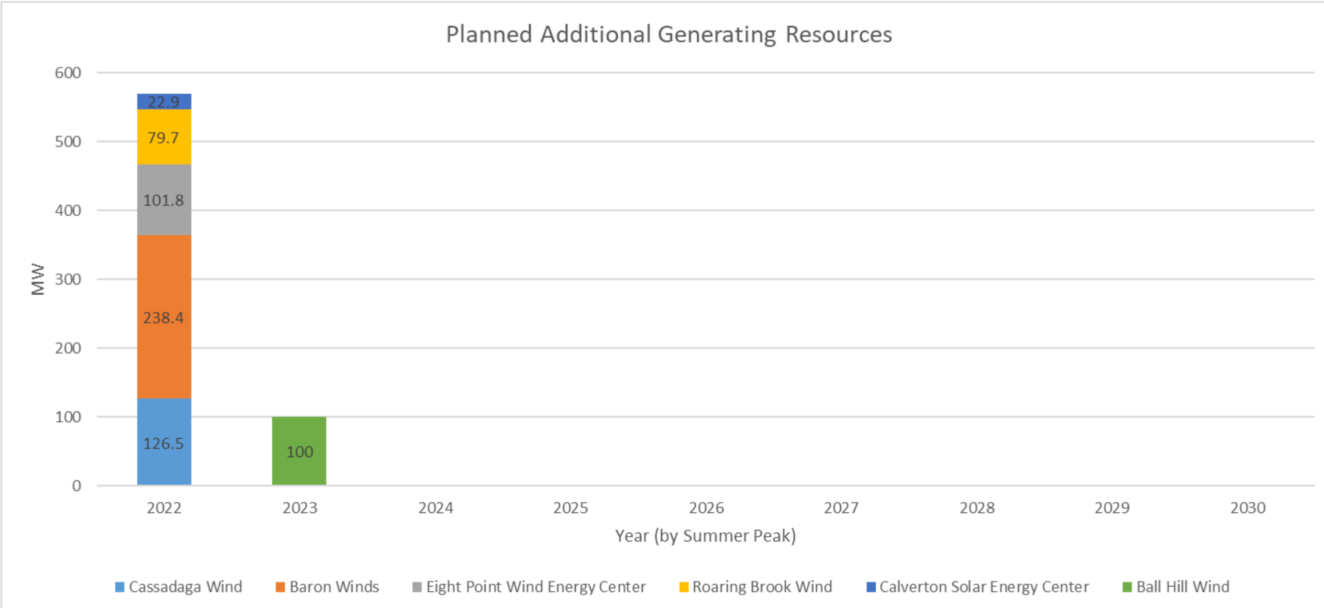
This section summarizes the key future projects and assumptions that have been included as part of the CRP, and the resultant reliability metrics for the system as planned. As discussed in the next major section of this report (Risk Factors to the Comprehensive Reliability Plan) there are numerous risk factors that could adversely affect the implementation of the plan and hence system reliability over the planning horizon.

Generation

Figure 1 shows the planned additional generation resources included as part of the CRP. A new generation resource is included in the CRP if the project has reached an advanced stage in the NYISO interconnection process and is making significant progress in construction, project financing, and/or regulatory approvals.[8] These resources include a total of 546.4 MW of land-based wind generation and 22.9 MW of solar generation planned to be in-service by summer 2022, with an additional 100 MW of land-based wind generation by summer 2023. The NYISO continues to track numerous additional generation projects active in the interconnection process.

[8] NYISO Reliability Planning Process Manual, Section 3.2, dated December 12, 2019.

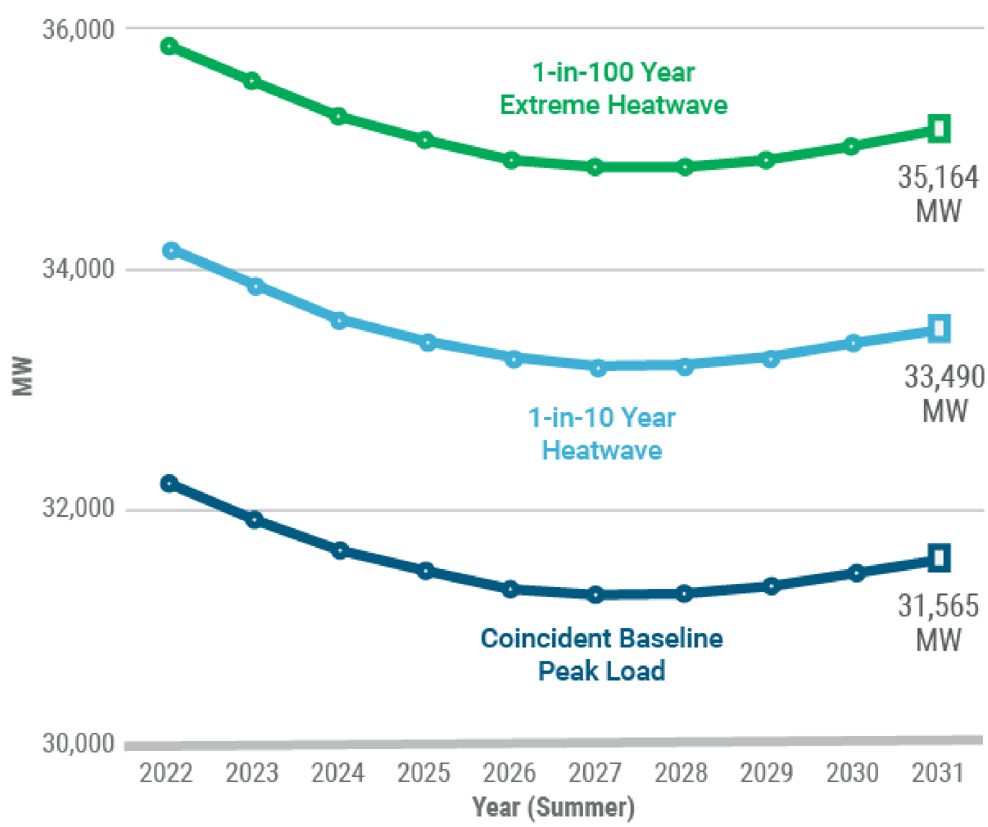
Figure 1: Planned Additional Generating Resources (Nameplate MW)



Load

The 2020 Load and Capacity Data Report ("Gold Book") provides an in-depth review of the load forecast and changing resource mix. In general, the baseline forecast published in the 2021 Gold Book is lower than the level published in the 2020 Gold Book. The lower forecasted growth in energy usage can be attributed primarily to increased projected load reductions due to energy efficiency programs, increased load reductions due to stronger projected growth in behind-the-meter solar PV, and continuing economic impacts caused by the recession brought on by the COVID-19 pandemic. Figure 2 shows the forecasted statewide summer peak load under baseline normal weather conditions (maximum temperature of 91 degrees Fahrenheit) as well as a 95 degree Fahrenheit heatwave expected once every ten years (90/10) and an extreme 1-in-100 year heatwave with a maximum temperature of 98 degrees Fahrenheit.

Figure 2: Statewide Summer Peak Load Forecasts



Transmission

Transmission projects are considered firm plans in the CRP if (1) the project was selected by the NYISO as a regulated transmission solution, or (2) the project has completed necessary interconnection studies and siting applications, and is making significant progress in construction, project financing, and/or regulatory approvals.[9] Planned additions to the New York transmission system include the following:

- **June 2022:** The NextEra Empire State Line Project that was selected by the NYISO Board of Directors in October 2017 to address the Western New York Public Policy Transmission Need.
- **December 2023:** The Segment A joint project by LS Power and New York Power Authority (NYPA) that was selected by the NYISO Board of Directors in April 2019 to address the AC Transmission Public Policy Transmission Needs.
- **December 2023:** The New York Transco Segment B project also was selected by the NYISO Board of Directors in April 2019 to address the AC Transmission Public Policy Transmission Needs.

[9] NYISO Reliability Planning Process Manual, Section 3.2, dated December 12, 2019.

- Transmission Owner Local Transmission Plans (LTP) that meet the inclusion rules which includes:
    - **Summer 2021:** National Grid Clay #3 115 kV line uprate (in service).
    - **Summer 2021:** National Grid Clay #10 115 kV line uprate (in service).
    - **Summer 2023:** Orange & Rockland Lovett 345/138 kV substation.
        - **Summer 2023:** Con Edison new 345/138 kV PAR controlled 138 kV Rainey – Corona feeder.
        - **Summer 2025:** Con Edison new 345/138 kV PAR controlled 138 kV Gowanus – Greenwood feeder.
        - **Summer 2025:** Con Edison new 345/138 kV PAR controlled 138 kV Goethals – Fox Hills feeder.
- In-service, starting summer 2025: series reactors on the following Con Edison 345 kV cables: 71, 72, M51, M52.
- Bypass, starting summer 2025: series reactors on the following Con Edison 345 kV cables: 41, 42, Y49.

The NYISO continues to track other various transmission projects that are in conceptual and engineering stages of development, some of which are discussed further in the Transmission portion of the Road to 2040 section.

Reliability Metrics

With the plans and assumptions described above, and in the Appendix B, the system as planned meets all currently applicable reliability criteria from 2021 through 2030 for forecasted system demand in normal weather. Grid reliability is determined by transmission security and resource adequacy. Transmission security is the ability of the electric system to withstand disturbances such as electric short circuits or unanticipated loss of system elements without involuntarily disconnecting firm load. Resource adequacy is the ability of the electric systems to supply the aggregate electrical demand and energy requirements of their customers, taking into account scheduled and reasonably expected unscheduled outages of system elements. The NYISO assesses grid reliability with metrics including transmission security margins, loss of load expectation, zonal resource adequacy margins, and binding interfaces.

Transmission Security Margins

With the CRP base case assumptions, all dynamic stability and steady state thermal loading criteria violations previously identified in the 2020 RNA are resolved. The impacts of the updates on transmission security are described below.

- The first update involved the reduction of the load forecast to account for the expected impact of COVID-19 and associated economic and societal effects. The total statewide reduction in forecast for the summer 2025 peak load is 240 MW, and for the 2030 peak load the reduction is 383 MW. Specifically, the New York City peak load forecast decreased by 323 MW in 2025 and 392 MW in 2030. This decreases the thermal load and transient voltage response issues.
- The second update involved the Con Edison LTP updates to address local thermal deficiencies in their Astoria East/Corona 138 kV and Greenwood/Fox Hills 138 kV Transmission Load Areas. The Con Edison LTP update included three new 345/138 kV PAR-controlled feeders at Rainey – Corona, Gowanus – Greenwood, and Goethals – Fox Hills. These projects reduce the transient voltage response issue, as well as unbottle Staten Island resources.
- The third update was the Con Edison series reactor status change that balanced the flows on the bulk system and also resulted in a reduction of the transient voltage response issue.

Including these projects resulted in a very small transmission security margin in New York City in 2030 before thermal overloads occur.[10] **Due to the narrow margin, it is plausible for changes in assumed conditions to occur and "tip" the system into a violation of transmission security design criteria.** Under current applicable reliability rules and procedures, a violation would be identified when the transmission security margin is negative for the base case assumptions (e.g., baseline normal weather load forecast and no pre-contingency unscheduled forced outages).

Within the Con Edison service territory, the 345 kV transmission system along with specific portions of the 138 kV transmission system are designed for the occurrence of two non-simultaneous outages and a return to normal ratings (N-1-1-0).[11] Figure 4 provides a summary of the New York City (Zone J) transmission security margin (line-item M), considering the most limiting outage combination of the Ravenswood 3 generator followed by the outage of the Mott Haven — Rainey 345 kV (Q12) cable. The transmission security margin under baseline load conditions with this contingency combination ranges from 1,714 MW in 2022 to 42 MW in 2031. Details of the tipping point evaluations are provided in Appendix D.

Other contingency combinations result in different power flows into Zone J. For example, in considering the possible combinations of N-1-1-0 events, these can include a mix of generation and transmission, two transmission events, or two generation events. Figure 3 shows the transmission security margin for the outage combinations of: Ravenswood 3 and Mott Haven — Rainey 345 kV (Q12) 345 kV, Ravenswood 3 and Bayonne Energy Center, and Sprain Brook-W. 49th St. 345 kV (M51 and M52). For outages of Ravenswood 3 and Bayonne Energy Center, the power flowing into Zone J from other New York

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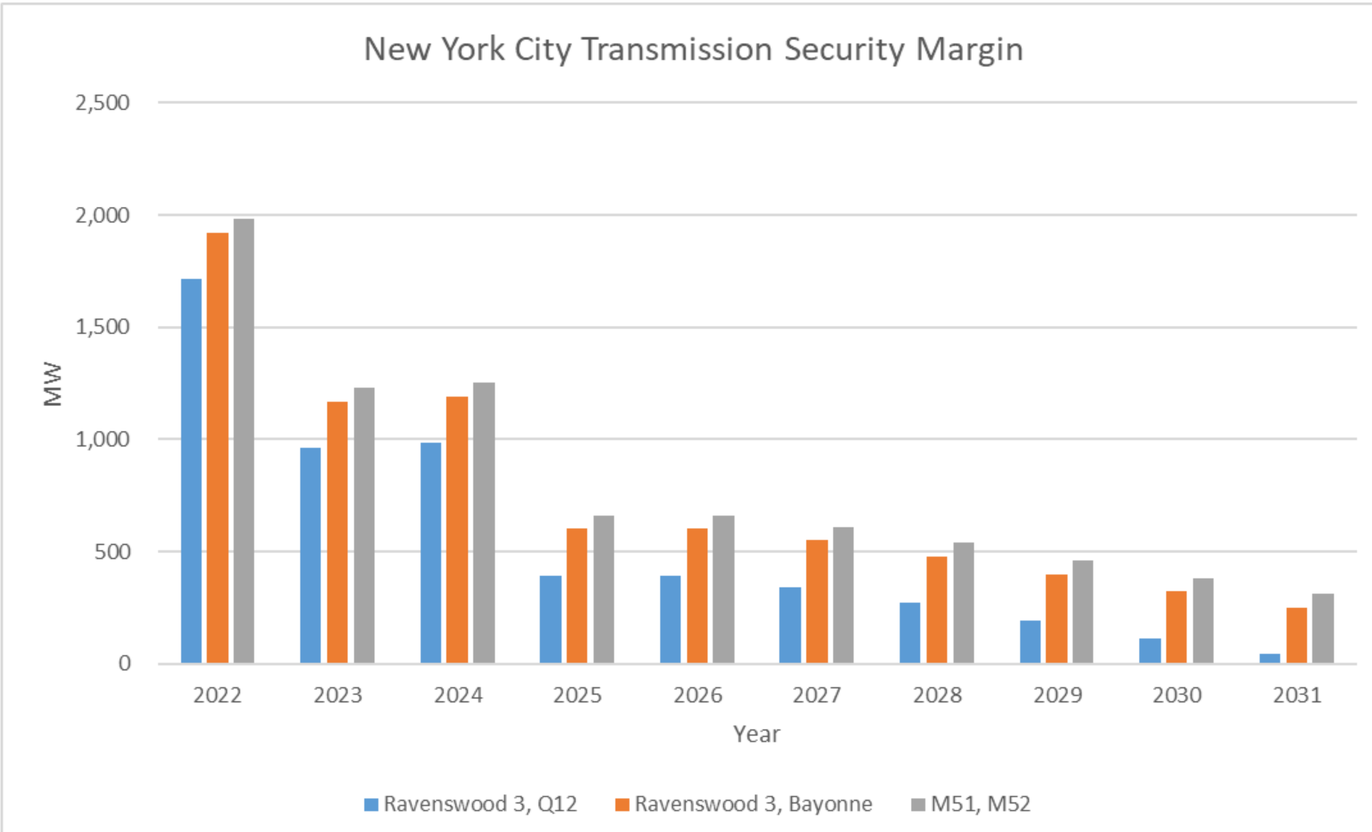
[10] https://www.nyiso.com/documents/20142/19415353/07 2020-2021RPP_PostRNABaseCaseUpdates.pdf/

[11] Con Edison, TP-7100-18 Transmission Planning Criteria, dated August 2019

zones is 4,717 MW. For Sprain Brook-W. 49th St. 345 kV (M51 and M52) the power flowing into Zone J from other New York zones is 3,191 MW. The outage combination that results in the lowest interface flow (loss of M51/M52) does not necessarily result in the worst design criteria transmission security margin.

Figure 3: New York City Transmission Security Margins for Key Contingency Events



Considering the baseline peak load transmission security margin, many different combinations of generation outages or load increases beyond the current forecast would result in a deficiency within New York City. For example, any additional load increase, generator outage, or combination more than 394 MW will tip New York City beyond its margin by 2025. The fluctuations in transmission security margin from year-to-year result from the combined impact of the Peaker Rule and load forecast.

As shown in Figure 5 under baseline load conditions, the statewide system margin (line item H) ranges between 2,303 MW in 2022 to 1,318 MW in 2031. The annual fluctuations are driven by the changes in generation and the load forecast. It is possible for other combinations of events to tip the system beyond its margin, such as increased load or a combination of reductions in total resources and load, as discussed further in the Risk Factors section of this report.

Figure 4: New York City Transmission Security Margin (Summer Baseline Peak Forecast – Normal Operations)

		Peak Load Forecast									
Line	**Item**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
A	**Zone J Load Forecast**	(11,116)	(11,075)	(11,052)	(11,029)	(11,031)	(11,082)	(11,151)	(11,232)	(11,308)	(11,381)
B	I+K to J (3)	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
C	ABC PARs to J	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)	(11)
D	**Total J AC Import (B+C)**	3,893	3,893	3,893	3,893	3,893	3,893	3,893	3,893	3,893	3,893
E	Loss of Source Contingency	(980)	(980)	(980)	(980)	(980)	(980)	(980)	(980)	(980)	(980)
F	**Resource Need (A+D+E)**	(8,203)	(8,162)	(8,139)	(8,116)	(8,118)	(8,169)	(8,238)	(8,319)	(8,395)	(8,468)
G	*Resources needed after N-1-1 (A+D)*	(7,223)	(7,182)	(7,159)	(7,136)	(7,138)	(7,189)	(7,258)	(7,339)	(7,415)	(7,488)
H	J Generation (1)	9,602	8,809	8,809	8,195	8,195	8,195	8,195	8,195	8,195	8,195
I	Temperature Based Generation Derates (2)	0	0	0	0	0	0	0	0	0	0
J	Net ICAP External Imports	315	315	315	315	315	315	315	315	315	315
K	**Total Resources Available (H+I+J)**	9,917	9,124	9,124	8,510	8,510	8,510	8,510	8,510	8,510	8,510
L	*Resources available after N-1-1 (E+K)*	8,937	8,144	8,144	7,530	7,530	7,530	7,530	7,530	7,530	7,530
M	**Transmission Security Margin (F+K)**	1,714	962	985	394	392	341	272	191	115	42

Notes:

1. Reflects the 2021 Gold Book existing summer capacity plus projected additions, deactivations, and de-rates. For this evaluation wind generation is assumed to have 0 MW output, solar generation is based on the ratio of solar PV nameplate capacity (2021 Gold Book Table I-9a) and solar PV peak reductions (2021 Gold Book Table 1-9c). De-rates for run-of-river hydro are included as well as the Oswego Export limit of for all lines in-service.
2. Includes de-rates for thermal resources.
3. The I+K to J flows are based on N-1-1-0 analysis in the post-RNA updates utilizing the models representing summer peak 2030.

Figure 5: Statewide System Margin (Summer Baseline Peak Forecast – Normal Operations)

Line	Item	Peak Load Forecast									
		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
A	NYCA Generation (1)	35,257	34,307	34,297	33,684	33,679	33,679	33,674	33,669	33,664	33,659
B	External Area Interchanges (2)	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844	1,844
C	Temperature Based Generation Derates	0	0	0	0	0	0	0	0	0	0
D	**Total Resources (A+B+C) (3)**	37,101	36,151	36,141	35,528	35,523	35,523	35,518	35,513	35,508	35,503
E	Load Forecast	(32,178)	(31,910)	(31,641)	(31,470)	(31,326)	(31,278)	(31,284)	(31,348)	(31,453)	(31,565)
F	Operating Reserve Requirement	(2,620)	(2,620)	(2,620)	(2,620)	(2,620)	(2,620)	(2,620)	(2,620)	(2,620)	(2,620)
G	**Total Capability Requirement (E+F)**	(34,798)	(34,530)	(34,261)	(34,090)	(33,946)	(33,898)	(33,904)	(33,968)	(34,073)	(34,185)
H	**Statewide System Margin (D+G)**	2,303	1,621	1,880	1,438	1,577	1,625	1,614	1,545	1,435	1,318

Notes:

1. Reflects the 2021 Gold Book existing summer capacity plus projected additions, deactivations, and de-rates. For this evaluation wind generation is assumed to have 0 MW output, solar generation is based on the ratio of solar PV nameplate capacity (2021 Gold Book Table I-9a) and solar PV peak reductions (2021 Gold Book Table 1-9c). De-rates for run-of-river hydro are included as well as the Oswego Export limit of for all lines in-service.
2. Interchanges are based on ERAG MMWG values.
3. Special Case Resources (SCRs) are assumed to be zero under normal operations.

Loss of Load Expectation

The New York Control Area (NYCA) loss of load expectation (LOLE in days/year) through the ten-year planning horizon is within reliability criteria, as shown in Figure 6. For reference, the previous results from the 2020 RNA are provided along with the current results for this 2021-2030 CRP. LOLE accounts for events but does not account for the magnitude (MW) or duration (hours) of the deficit. Therefore, two additional reliability indices are added for information purposes: loss of load hours (LOLH in hours/year) and expected unserved energy (EUE in MWh/year). [12]

LOLE is generally defined as the expected (weighted average) number of days in a given period (*e.g.*, one study year) when for at least one hour from that day the hourly demand is projected to exceed the zonal resources (event day). Within a day, if the zonal demand exceeds the resources in at least one hour of that day, this will be counted as one event day. The criterion is that the LOLE not exceed one day in 10 years, or LOLE < 0.1 days/year.

LOLH is generally defined as the expected number of hours per period (*e.g.,* one study year) when a system's hourly demand is projected to exceed the zonal resources (event hour). Within an hour, if the zonal demand exceeds the resources, this will be counted as one event hour.

EUE, also referred to as loss of energy expectation (LOEE), is generally defined as the expected energy (MWh) per period (*e.g.,* one study year) when the summation of the system's hourly demand is projected to exceed the zonal resources. Within an hour, if the zonal demand exceeds the resources, this deficit will be counted toward the system's EUE.

While the resource adequacy reliability criterion of 0.1 days/year established by the NYSRC and the NPCC is compared with the loss of load expectation (LOLE in days/year) calculation, currently there is no criterion for determining a reliable system based on the LOLH and EUE reliability indices.

[12] NYSRC's "Resource Adequacy Metrics and their Application": https://www.nysrc.org/PDF/Reports/Resource%20Adequacy%20Metric%20Report%20Final%204-20-2020[6431].pdf

Figure 6: Loss of Load Expectation Metrics

2020 RNA Base Case				2021-2030 CRP Base Case			
Study Year	LOLE (dy/yr)	LOLH (hr/yr)	EUE (MWh/yr)	Study Year	LOLE (dy/yr)	LOLH (hr/yr)	EUE (MWh/yr)
2021	0.017	0.063	34.0	2021	0.017	0.064	35.3
2022	0.019	0.061	28.7	2022	0.017	0.055	26.6
2023	0.041	0.125	61.6	2023	0.034	0.106	50.8
2024	0.038	0.125	69.3	2024	0.024	0.083	47.2
2025	0.085	0.265	138.3	2025	0.036	0.118	69.3
2026	0.097	0.315	178.3	2026	0.038	0.131	83.7
2027	0.118	0.379	208.6	2027	0.040	0.139	93.2
2028	0.135	0.421	215.4	2028	0.047	0.146	83.4
2029	0.170	0.548	308.2	2029	0.060	0.199	137.2
2030	0.187	0.609	354.1	2030	0.064	0.212	156.2

Notes:

• LOLE: Loss of load expectation (days per year). The criterion is that the LOLE not exceed one day in 10 years, or LOLE < 0.1 days/year.

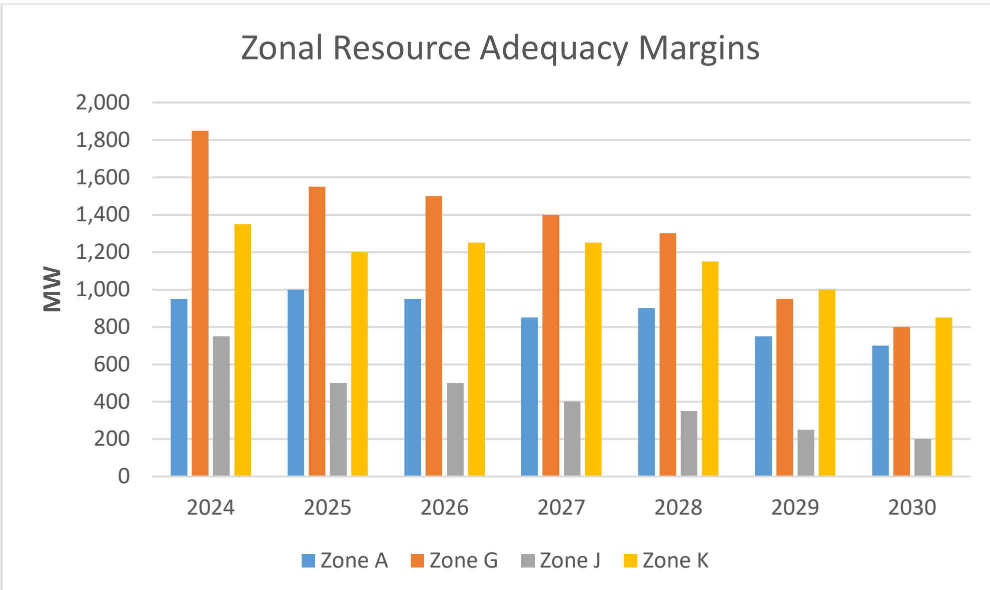
• LOLH: Loss of load hours (hours per year).

• EUE: Expected unserved energy (megawatt-hours per year).

Zonal Resource Adequacy Margins

Resource adequacy simulations were performed on the CRP base cases[13] to determine the amount of "perfect" capacity" in each zone that could be removed before the NYCA LOLE reaches 0.1 days/year (one-event-day-in-ten-years), and to offer another relative measure of how close the system is from not having adequate resources to reliably serve load. As shown in Figure 7, **this analysis found tightening margins across the New York grid through time, with a margin of only 200 MW in New York City (Zone J) and only 700 MW in western New York (Zone A) by 2030.**

Figure 7: Summary of Key Zonal Resource Adequacy Margins



Resource capacity is reduced one zone at a time to determine when violations occur, in the same manner as the compensatory "perfect" MW are added to mitigate resource adequacy violations, but with the opposite impact. "Perfect capacity" is capacity that is not derated (*e.g.,* due to ambient temperature or unit unavailability), not subject to energy durations limitations (*i.e.*, available at maximum capacity every hour of the study year), and not tested for transmission security or interface impacts. A map of NYISO zones is shown in Figure 8, and the zonal resource margin analysis (ZRAM) is summarized in Figure 9**.**

[13] The CRP base cases already reflect the DEC Peaker Rule compliance plans submitted by the affected generation owners to DEC; summarized in the assumption's tables from Appendix B of this report.

Figure 8: NYISO Load Zone Map

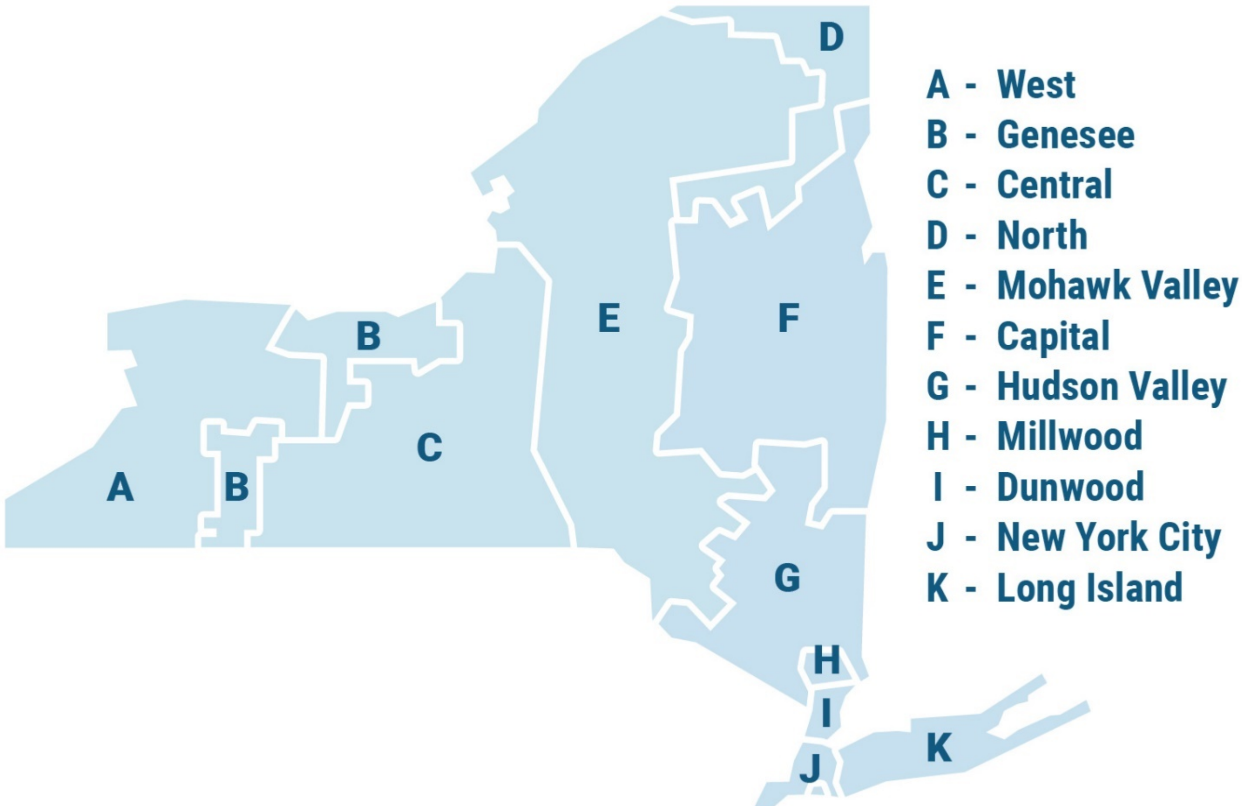


Figure 9: Zonal Resource Adequacy Margins (MW)

Study Year	LOLE	Zone A	Zone B	Zone C	Zone D	Zone E	Zone F	Zone G	Zone H	Zone I	Zone J	Zone K
2024	0.02	-950	EZR	-1850	-1800	EZR	-1850	-1850	EZR	EZR	-750	-1350
2025	0.04	-1000	EZR	-1550	-1550	EZR	-1550	-1550	EZR	EZR	-500	-1200
2026	0.04	-950	EZR	-1500	-1500	EZR	-1450	-1500	EZR	EZR	-500	-1250
2027	0.04	-850	EZR	-1400	-1400	EZR	-1400	-1400	EZR	EZR	-400	-1250
2028	0.05	-900	EZR	-1300	-1250	EZR	-1300	-1300	EZR	EZR	-350	-1150
2029	0.06	-750	-750	-950	-950	-950	-950	-950	EZR	EZR	-250	-1000
2030	0.06	-700	-700	-800	-800	-800	-800	-800	EZR	EZR	-200	-850

Notes:

- Negative numbers indicate the amount of "perfect MW" that can be removed from a zone without causing a violation.
- EZR - Exceeds Zonal Resources (all generation can be removed without causing a violation).
- The generation pockets in Zone J and Zone K are not modeled in detail for this analysis and the margins identified here may be smaller as a result.

The ZRAM assessment identifies a maximum level of "perfect capacity" that can be removed from each zone without causing NYCA LOLE criterion violations. However, the impacts of removing capacity on the reliability of the transmission system and on transfer capability are highly location dependent. Thus, lower amounts of capacity removal are likely to result in reliability issues at specific transmission locations. With these simulations, the NYISO did not attempt to assess a comprehensive set of potential scenarios that might arise from specific unit retirements. Therefore, actual proposed capacity removal from any of these zones would need to be further studied in light of the specific capacity locations in the transmission network to determine whether any additional violations of reliability criteria would result. Additional transmission security analysis, such as N-1-1 steady-state analysis, transient stability, and short circuit, would be necessary under the applicable process for any contemplated plant retirement in any zone.

Binding Interfaces

To determine whether a specific transmission interface impacts system resource adequacy, 'free-flow' simulations were performed for targeted interfaces. This analysis removes the limit on various transmission interfaces in resource adequacy models, either one at the time, or in various combinations (*i.e.,* "free flow"). A decrease in the NYCA LOLE resulting from removal of an interface limit is an indication that the flow of power across the interface is "binding" due to transmission constraints.
The results of these simulations shown in Figure 10.

Figure 10: Binding Interface Analysis

	2021-2030 CRP Base Case NYCA LOLE (days/year)				
Study Year	**Base Case**	**Unlimited I-to-J** (Dunwoodie South)	**Unlimited G-to-H** (UPNY-ConEd)	**Unlimited G-to-H and I-to-J**	**Unlimited NYCA 'Free Flow'**
2024	**0.024**	0.021	0.024	0.021	0.019
2025	**0.036**	0.027	0.035	0.025	0.022
2026	**0.038**	0.029	0.038	0.028	0.023
2027	**0.040**	0.028	0.039	0.026	0.021
2028	**0.047**	0.034	0.046	0.030	0.025
2029	**0.060**	0.043	0.059	0.037	0.029
2030	**0.064**	0.045	0.063	0.035	0.028

The results show that:

- The system resource adequacy improves when the Dunwoodie South interface constraints (Zone I to Zone J) are alleviated, which is an indication that the transmission interface is "binding." In other words, if the Dunwoodie South interface limits increase due to a system change such as a transmission upgrade, grid resource adequacy would improve. The extent of improvement to resource adequacy would depend on the nature of the system change.

- The grid resource adequacy is not materially impacted by the UPNY-ConEd constraints (Zone G to Zone H), due to the fact that most of the loss-of-load events are in Zone J, and the Dunwoodie South interface 'binds' first. Therefore, an upgrade to only UPNY-ConEd and not Dunwoodie South would not provide a material resource adequacy benefit.
- When both the Dunwoodie South and UPNY-ConEd interface constraints are alleviated together, grid resource adequacy is improved more so than if Dunwoodie South alone is upgraded.
- The difference in LOLE between the "NYCA free flow" case and the case when Dunwoodie South and UPNY-ConEd are unlimited is only approximately 0.005, which indicates that there is almost no further resource adequacy improvement that would be achieved from increasing additional interface limits for the planned base case conditions.

Risk Factors to the Comprehensive Reliability Plan

The Reliability Planning Process findings reflect the base case assumptions, which were set in accordance with applicable reliability rules and procedures. There are, however, numerous risk factors that could adversely affect the implementation of the plan and hence system reliability over the planning horizon. These risk factors may arise for several reasons including climate, economic, regulatory, and policy drivers. If any of these factors materialize, the NYISO will assess the potential impacts and, if necessary, perform an evaluation to determine whether the NYISO should solicit solutions under the Generation Deactivation Process or Gap Solution Process, as required.

Changes to Availability and Performance of System Resources

Substantial uncertainties exist in the next ten years that will impact the system resources. These uncertainties include, but are not limited to:

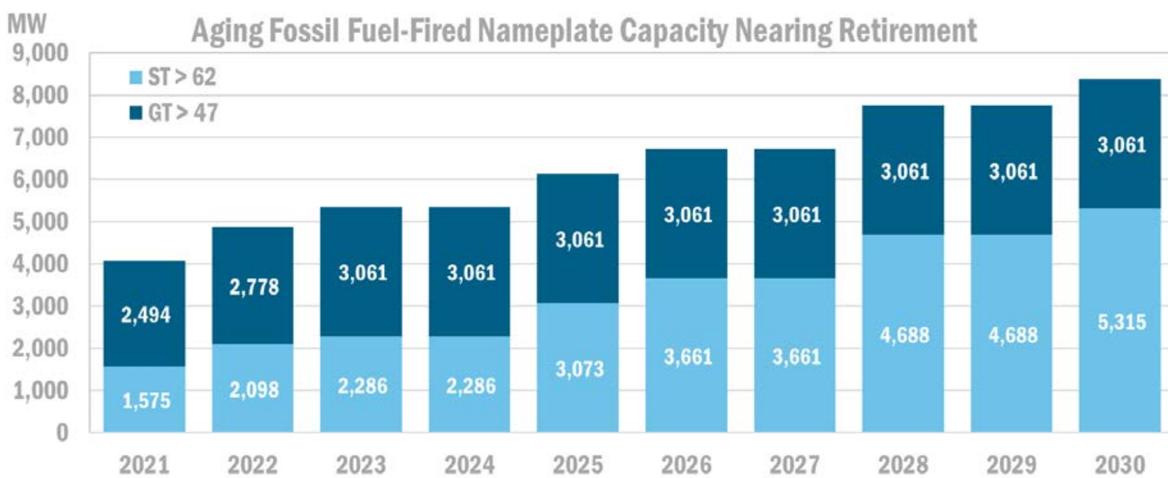
a) If expected generation projects are not built, a system deficiency may occur. The base cases include approximately 670 MW of assumed generation additions in various planning stages. The 2020 RNA also included a "status-quo" scenario. This scenario evaluated the reliability of the system under the assumption that no major transmission or generation projects come to fruition within the study period. This included the removal of all proposed transmission and generation projects that had met the inclusion rules and removal of generators that require modifications to comply with the DEC's Peaker Rule. From a resource adequacy perspective, this scenario indicates that if expected generation and transmission projects are not built, the LOLE criterion violation advances to earlier years within the study period. From a transmission security perspective, N-1-1 steady state issues in addition to those observed in the RNA baseline results may also occur.

b) If additional generating units become unavailable or deactivate beyond those units already planned for, New York reliability could be adversely affected. The base cases include approximately 5,150 MW of assumed generation deactivations or unavailability during the summer peak (*see* Appendix B for details). There are numerous risk factors related to the continued viability, compliance with emissions requirements, and operation of aging generating units. Depending on the units affected, the NYISO may need to take actions through its Short-Term Reliability Process to maintain reliability. The scenarios performed as part of the RNA indicated that the deactivation of additional generators could lead to reliability needs, in the absence of any other changes to transmission and/or generation.

c) Capacity resources could decide to offer into markets in other regions and, therefore, some of the capability of those resources may not be available to the NYCA. Accordingly, the NYISO will continue to monitor imports, exports, generation, and other infrastructure.

As generators age and experience more frequent and longer duration outages, the costs to maintain the assets increase. These costs may drive aging generation into retirement. A growing amount of New York's gas-turbine and fossil fuel-fired steam-turbine capacity is reaching an age at which, nationally, a vast majority of similar capacity has been deactivated. As shown in Figure 11, by 2028 more than 8,300 MW of gas-turbine and steam-turbine based capacity in New York will reach an age beyond which 95% of these types of generators have deactivated.

Figure 11: Cumulative NYCA Nameplate Capacity MW Past the Age When 95% of Similar Units Have Retired



The impact of the unavailability of system resources can readily be seen through tipping point evaluations. **While transmission security within New York City (Zone J) is maintained through the ten-year period in accordance with design criteria, the margin would be very tight starting in 2025 and would be deficient beginning in 2028 if forced outages are experienced at the historical rate**, as shown in Figure 12.[14] Transmission security within Long Island (Zone K) is also maintained through the ten-year period, with the slimmest margin in the first few years as shown in Figure 13. If forced outages are experienced at the historical rate the Long Island margin would be sufficient through the study period.

[14] Additional transmission, resources, or demand reduction within New York City may increase the margin and reduce the likelihood of future reliability needs.

Figure 12: New York City Transmission Security Margin (Summer Baseline Peak Forecast – Normal Operations)

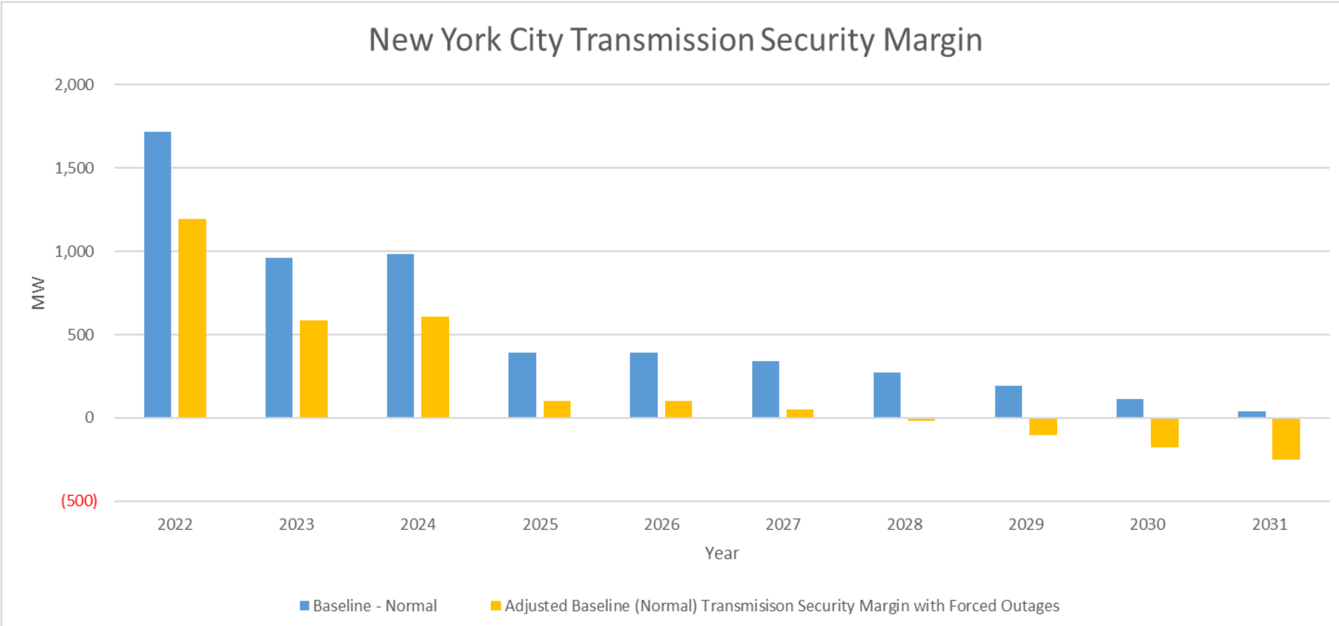
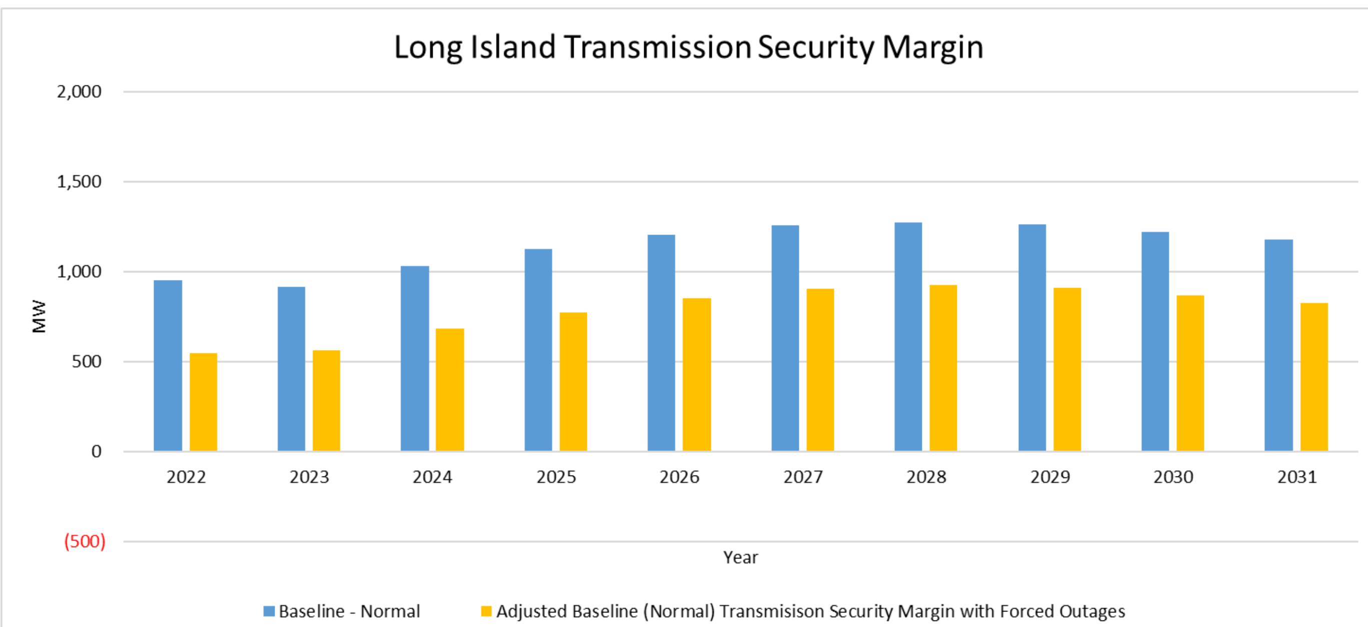


Figure 13: Long Island Transmission Security Margin (Summer Baseline Peak Forecast – Normal Operations)



Completion of Public Policy Transmission Plans

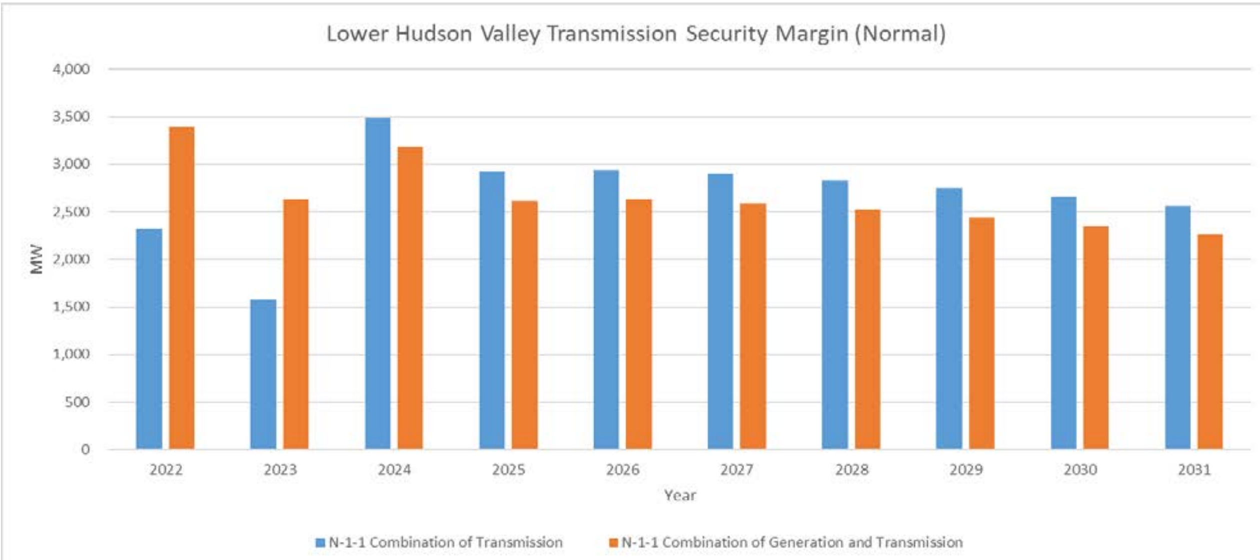
There are several public policy transmission developments in progress that will increase the system capability to transport power. As part of the NYISO's Public Policy Transmission Planning Process, the New York State Public Service Commission (PSC) has identified needs to expand the state's transmission capability to deliver additional power from generating facilities located in upstate New York, including important renewable resources, to the population centers statewide.

- The Western NY Public Policy Transmission Project (the Empire State Line Proposal 1, Q545A), developed by NextEra Energy Transmission New York, Inc., was selected by the NYISO Board in October 2017 and was included in the reliability plan starting with the 2018 RNA. This project includes a new 345 kV circuit and phase angle regulator (PAR) that will alleviate constraints in the Niagara area. The planned in-service date for this project is summer 2022.
- The solutions to the AC Transmission Public Policy Transmission Needs were reflected in the 2020 RNA base case and are now included in this reliability plan. On April 8, 2019, the NYISO Board of Directors selected the Double-Circuit project (Q556) proposed jointly by LS Power Grid New York and the New York Power Authority as the more efficient or cost-effective transmission solution to address Segment A. The Board also selected the New York Energy Solution project (Q543) proposed jointly by Niagara Mohawk Power Corporation d/b/a National Grid and the New York Transco, LLC as the more efficient or cost-effective transmission solution to address Segment B. The planned in-service date for the Segment A and Segment B projects is winter 2023.

As these transmission projects enter service, reliability of the New York grid will improve. If the projects were to be delayed for any reason, the grid's ability to reliably serve customer demand would be jeopardized.

As an example of the reliability benefits provided by the projects, the AC Segment B project has a direct impact on the Lower Hudson Valley transmission security margin. Figure 14 shows how the transmission security margin changes through time in consideration of the most limiting contingency combination for the year being evaluated. In years 2022 and 2023 (prior to the completion of the Segment B project) the most limiting contingency combination to the transmission security margin under peak load conditions is the loss of Leeds-Pleasant Valley (92) 345 kV followed by the loss of Dolson – Rock Tavern (DART44) 345 kV and Coopers Corners – Rock Tavern (CCRT34) due to common towers. For the remainder of the years the contingency combination changes to the loss of Ravenswood 3 followed by the loss of Pleasant Valley-Wood St. 345 kV (F30/F31).

Figure 14: Lower Hudson Valley Transmission Security Margin (Summer Baseline Peak Forecast – Normal Operations)



Completion of Local Transmission Owner Plans

The local transmission owner plans (LTPs) are an important part of the overall Comprehensive System Planning Process and the findings of this CRP. The 2020 RNA identified transmission security criteria violations, as well as resource adequacy violations. The process allows for subsequent updates, which included three projects in Con Edison: a new 345/138 kV PAR controlled 138 kV Rainey – Corona feeder planned to be in-service by summer 2023, a new 345/138 kV PAR controlled 138 kV Gowanus – Greenwood feeder planned to be in-service by summer 2025, and a new 345/138 kV PAR controlled 138 kV Goethals – Fox Hills feeder also planned to be in-service by summer 2025. These new transmission feeders are included in the plan. The NYISO will continue to track the timely entry into service of these and other projects that have been identified to relieve reliability violations.

Changes to System Load Level

A higher-than-planned load level could expose the system to potential reliability issues, necessitating interim operating procedures up to and including measures such as load shedding in some localized areas of the state. In conducting a resource adequacy scenario in the 2020 RNA with a high load forecast, approximately 2,400 MW higher than the 2020 Gold Book baseline forecast, the NYISO found that the LOLE would exceed criteria two years earlier. However, the NYISO is forecasting a decrease in energy usage during 2021 through 2030 period, which can be attributed in part to the increasing impact of energy efficiency initiatives and increasing amounts of behind the meter solar generation. Conversely, significant load-increasing impacts are forecasted due to electric vehicle usage and other electrification (*i.e.,* conversion of home heating, cooking, water heating and other end-uses from fossil-fuel based systems to electric systems). The relative behind-the–meter-solar impact on peak load declines over time as the New York summer peak is expected to shift further into the evening, when solar resources are unavailable. New York is projected to become a winter peaking system in future decades due to electrification, primarily via heat pumps and electric vehicles.

In the past decade, energy provided by the bulk grid has decreased, while energy production from Distributed Energy Resources (DERs), such as solar, has increased. These DERs are beginning to displace energy that was traditionally supplied by conventional generation through the regional electricity grid. The energy provided by many DERs is not continuous, but intermittent, and less visible to the NYISO markets and operations.

This Comprehensive Reliability Plan does not account for recent interconnection requests for large load installations in upstate New York, which may exacerbate zonal resource adequacy margins in Zones A, B, C, and D.[15] The NYISO will continue to report on energy usage and peak demand trends in its annual Load and Capacity Data Report (Gold Book), and assess any reliability impacts through its load interconnection process, quarterly STAR studies, and the 2022 Reliability Needs Assessment.

Extreme Weather

The dangers of severe weather impacting the grid have been exemplified around the country in the past year, with Texas experiencing a brutal polar vortex in February and California facing problems from extreme heat last summer. New York is not immune from such extreme weather, which could lead to greater electrical demand and more forced generator outages than currently accounted for in the baseline forecasts. Prior to each summer and winter, the NYISO presents a capacity assessment to gauge the margins available for the upcoming season in consideration of such plausible system conditions.[16]

In consideration of these risk factors, the New York grid may cross a "tipping point" in future years such that the transmission system could not fully serve the demand. Figure 15 shows the transmission security margin in New York City for a variety of plausible conditions. The baseline analysis of normal weather and limited generation outages shows a positive but narrowing transmission security margin across the ten-year period. The conditions evaluated in the 1-in-10-year heatwave (90/10) and 1-in-100-year extreme heatwave scenarios combined with the impact of forced generation outages result in deficiencies to serve demand in New York City in many of the years. **The chart shows that most of these**

[15] Recent large load requests include Q0580 –WNY STAMP, Q0776 – Greenidge Load, Q0849 – Somerset Load, Q0850 – Cayuga Load, and Q0979 –North Country Data Center.

[16] https://www.nyiso.com/documents/20142/20968296/2021%20Summer%20Capacity%20Assessment%20-%20Updated%20Version.pdf

beyond-design conditions, such as a heatwave or generator outages, would result in deficiencies to serve demand in New York City considering the plans included in this Comprehensive Reliability Plan. This outlook could improve as more resources and transmission are added to New York City. Similarly, these risk factors may also result in tipping points in Long Island and statewide, as shown in Figure 16 and Figure 17.

Figure 15: New York City Transmission Security Margin

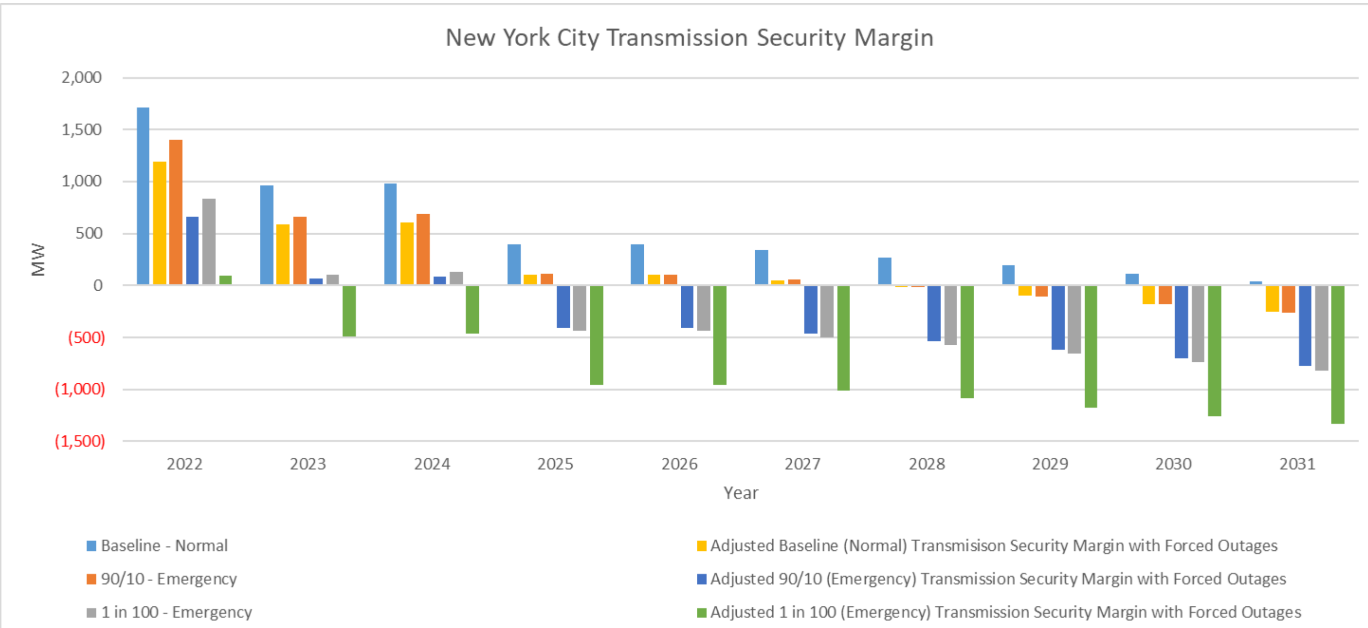


Figure 16: Long Island Transmission Security Margin

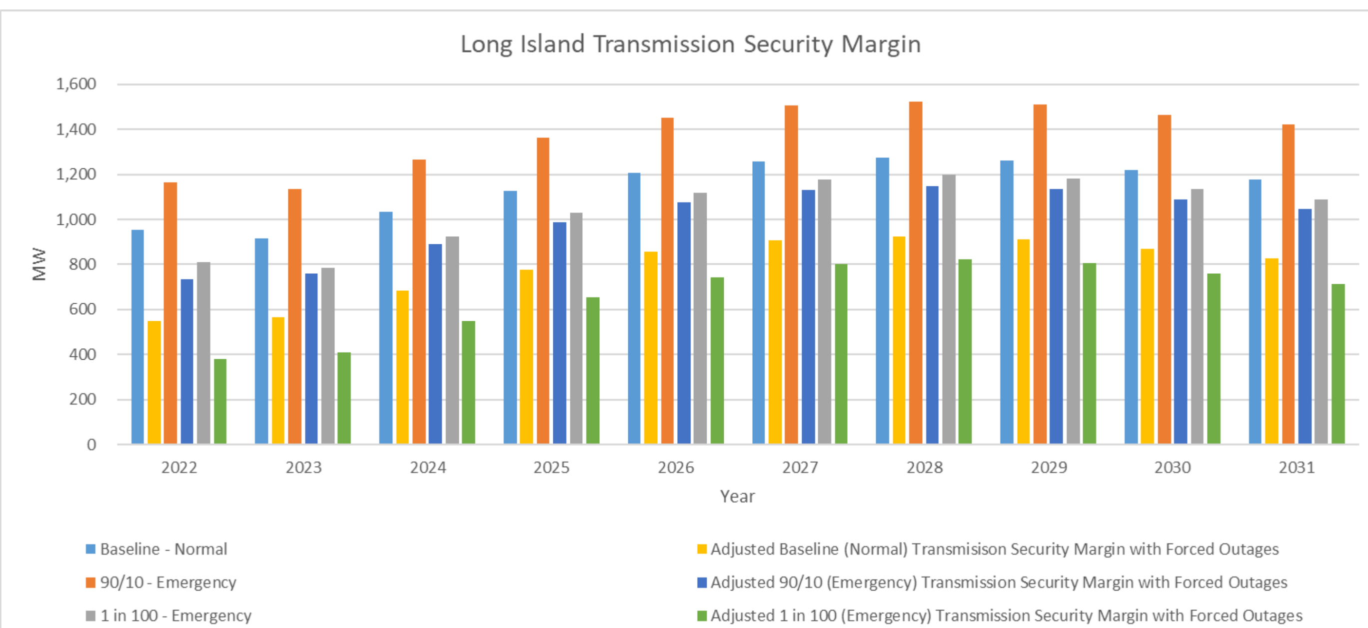
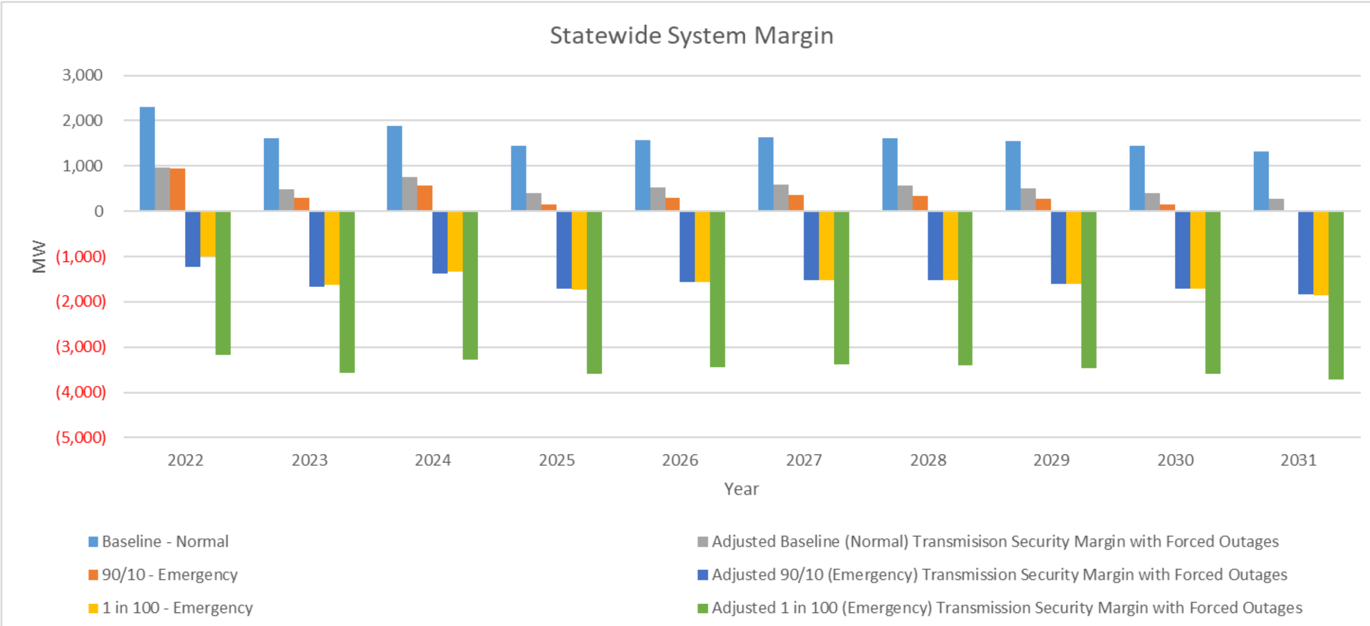


Figure 17: Statewide System Margin



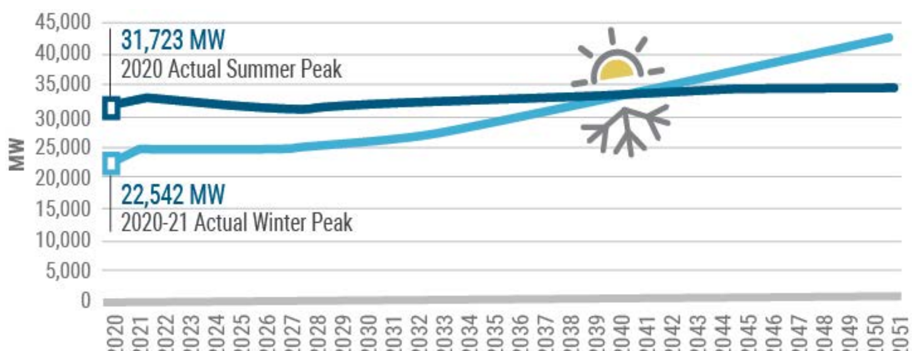
Beyond the CRP – Road to 2040

There have been several significant developments that are shaping how the New York electric grid of the future will develop. Part of the changes are climate related, which will drive temperatures higher and result in higher electricity demand. Part of the changes are due to state policies in response to climate change. The Climate Leadership and Community Protection Act (CLCPA) requires an economy-wide approach to addressing climate change and decarbonization.[17] This includes sweeping mandates that 70% of New York electricity consumed shall be produced from renewable resources by 2030 and 100% emissions-free electricity supply by 2040 while promoting electrification in other sectors of the economy. Understanding the impacts due to these two driving changes on the generation, transmission, and load components of the bulk electric system is critical to understanding the challenges in the coming year.

Load

In 2019, the NYISO commissioned the [Climate Change Study - Phase I] to examine the impacts that climate change will have on temperature and the resultant impact on load. The core finding from the study is that temperatures are rising across New York and will have a significant impact on summer peak demand. Since early 1990, temperatures across the state have been increasing from 0.06 to 0.09 degrees per year or 0.6 to 0.9 degrees per decade. On average, the statewide average temperature is increasing 0.7 degrees per decade. On an annual basis, increasing temperatures have minimal impact on system energy requirements as increasing cooling sales are largely mitigated by decreasing heating related sales. However, the system load profile will change over time with the strongest load growth in the shoulder months (April, May, September, and October). Summer and winter peak demand will also be significantly impacted by climate change. By 2050, increasing temperatures will potentially add between 1,600 MW to 3,800 MW or 10% to 23% of summer-peak cooling requirements. State policy designed to counter the impact of climate change may have an even larger impact on load than increasing temperatures. New state energy efficiency targets largely mitigate the

Figure 18: Electric Summer & Winter Peak Demand – Actual & Forecast: 2020-2051



[17] 2019 Laws of New York, ch. 106. The CLCPA requires that seventy percent of energy consumed in New York State be produced by renewable resources by 2030. By 2040 energy consumed must be completely emissions-free.

impact of increasing temperatures on summer peak demand through 2045. After that point, increasing electric vehicle demand and electrification activity eventually push loads above current trends. In the most aggressive scenario, statewide electrification programs result in the system switching from a summer peaking system to a winter peaking system; this could occur around 2035. While there is still additional analysis to be done to translate greenhouse gas targets to specific end-use impacts, the amount of electrification needed to achieve state greenhouse gas targets has significant impacts on base loads, heating loads and cooling loads. An aggressive electrification program could add more than 28,000 MW to the system summer peak by 2050, and an even larger amount to winter peaks.

In addition to higher efficiency savings, solar capacity, and electric vehicle penetration, the CLCPA adds aggressive electrification in the residential and commercial sectors. The largest targeted end-use is residential fossil fuel heating; it assumes gas, oil, and propane heating systems are replaced with cold climate heat pumps with electric resistance backup to meet heating requirements on the coldest days. Other targeted end-uses include water heating, clothes drying, and cooking. By 2040, the **summer peak could be over 47,000 MW** while the **winter peak could be over 56,000 MW**.

Load: Key Takeaways

- Climate change and electrification will result in a significant increase in summer load.
- CLCPA electrification will cause the NYCA to go from summer peaking to winter peaking.
- The winter peak load under the CLCPA will be double compared to the reference case.

Generation

In New York, the electricity originates from many different sources. In 2020, a third of New York's energy production was from dual-fuel generators that run primarily on natural gas but have the ability to use other fuels as well. Another third came from nuclear energy, and nearly a quarter came from hydropower.

For the past decade, wind and solar energy resources have played an increasingly important role in New York and their participation is expected to grow as New York approaches the CLCPA goals. The law establishes overall general targets as shown in Figure 20.

Figure 19: 2020 NYCA Energy Production

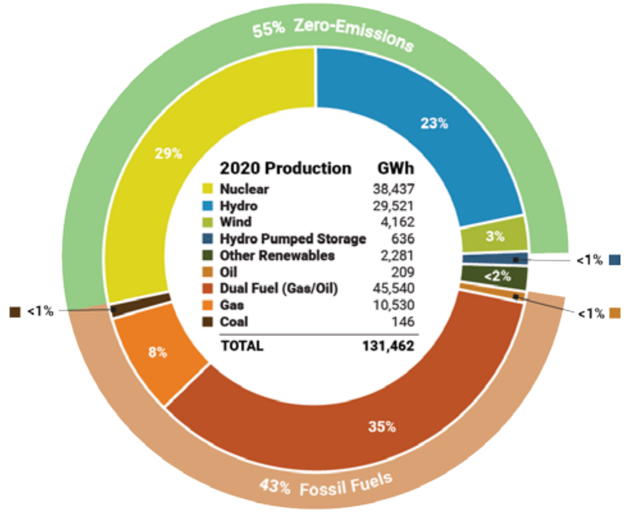
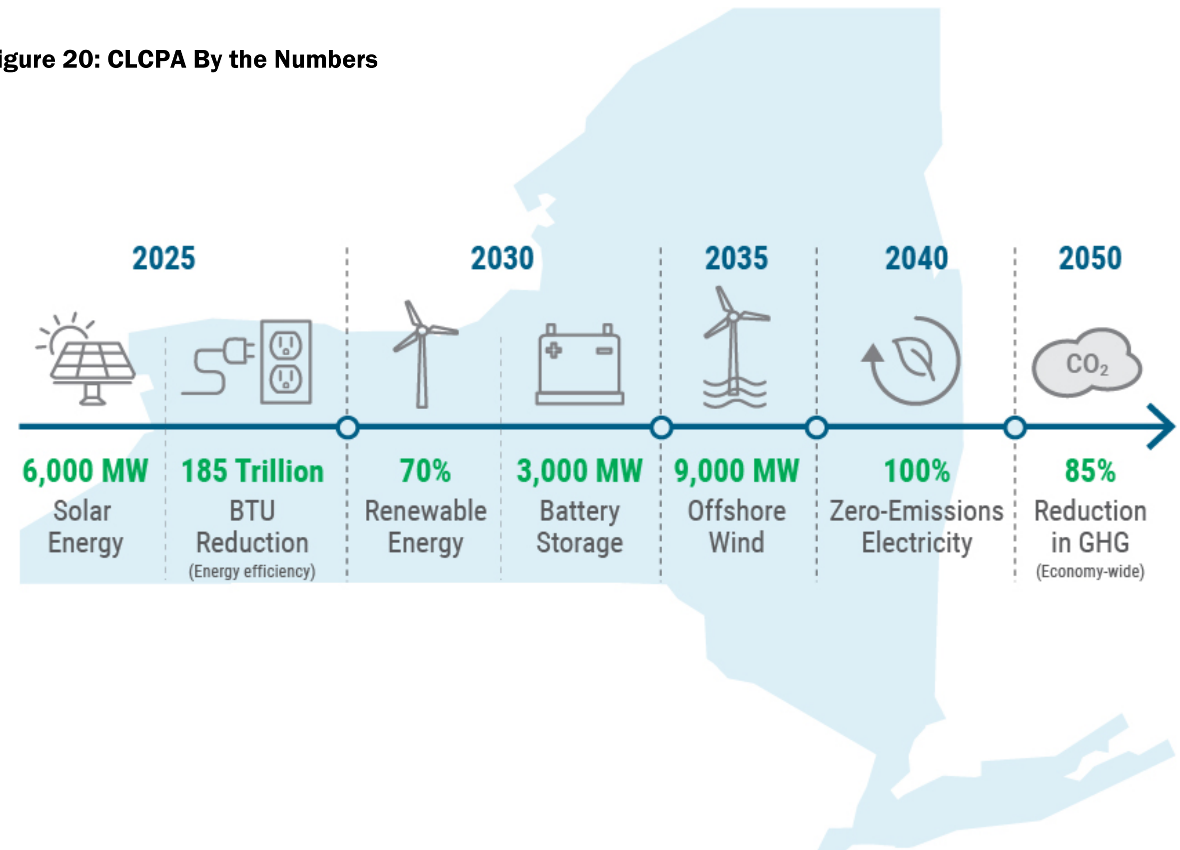


Figure 20: CLCPA By the Numbers



In addition to impacting the types of generation that can run in New York, the CLCPA will have a significant impact on the amount of electricity and from which resource type electricity can be imported into New York.

Generation resources in New York have already seen significant changes in the last two years with the retirements of 1,000 MW of coal and 2,000 MW of nuclear from 2019 to 2020. In 2020, the New York State Department of Environmental Conservation (DEC) adopted a regulation to limit nitrogen oxides (NOx) emissions from simple-cycle combustion turbines (Peaking Units) (referred to as the "Peaker Rule").[18] This rule required peakers to submit compliance plans to state how they would meet compliance with the rule, which could include retiring or not operating those generators during the summer ozone season. The compliance plans indicated that over 1,500 MW of peaker capability, mostly in New York City, will either retire or not operate during the summer ozone season by 2025, with a little over half impacted starting in 2023. All of these deactivations add up to almost 5,000 MW generation. An additional 25,000 MW of fossil fuel generation will need to deactivate over time to hit the targets in the CLCPA. These resources will need to be replaced by resources that are emission free and largely renewable. Discussed below are the attributes of these types of resources and the challenges inherent with maintaining system reliability without sufficient dispatchable resources remaining on the system.

Solar and Wind – Intermittent Resources

Solar and wind resources provide an emission-free source of electricity. As intermittent resources, solar and wind are not dispatchable (although they may be able to be dispatched down by curtailing their energy output) due to the variability of their "fuel" source. To maximize efficiencies, the location of these resources is dictated by where the wind is most constant or by where there is sufficient land for solar. This results in land-based wind locating in northern and western New York while solar resources are significantly located in these areas also. Offshore wind would connect primarily into New York City and Long Island. In 2020, the NYISO commissioned phase II of the Climate Change Study ("Climate Change Impact and Resilience Study") that examined the resources needed to meet load in a 2040 scenario. This study looked at integrating large amounts of solar and wind resources into the model and concluded that the variability of meteorological conditions that govern the output from wind and solar resources presents a fundamental challenge to relying on those resources to meet electricity demand. Solar resources will have little to no output during the evening and nighttime hours and reduced output due to cloud cover, while wind resources can experience significant and sustained wind lulls.

To continue the study efforts on this subject, the NYISO conducted additional 'wind lull' scenarios for this CRP, using the 70 x 30 models developed during the 2020 RNA. Wind lull scenarios simulated a one-week loss of either offshore wind (approximately 6,000 MW nameplate total connected to New York City

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[18] 6 NYCRR Part 227-3. See https://casetext.com/regulation/new-york-codes-rules-and-regulations/title-6-department-of-environmental-conservation/chapter-iii-air-resources/subchapter-a-prevention-and-control-of-air-contamination-and-air-pollution/part-227-stationary-combustion-installations/subpart-227-3-ozone-season-oxides-of-nitrogen-nox-emission-limits-for-simple-cycle-and-regenerative-combustion-turbines

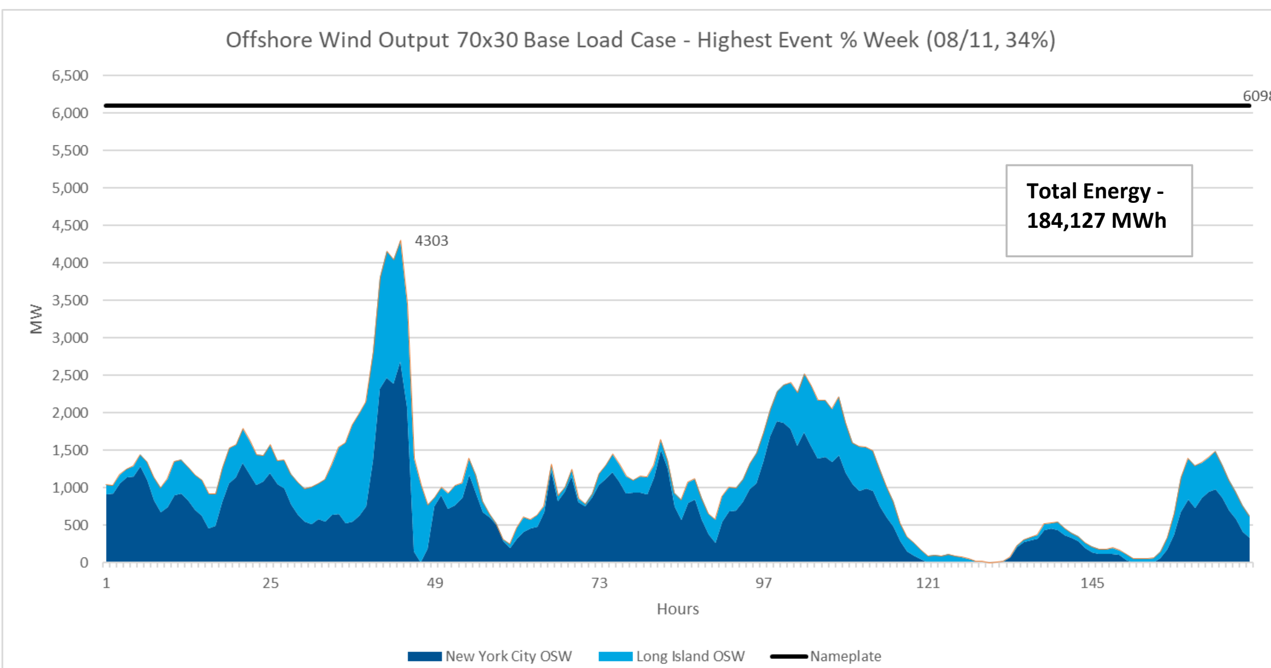
and Long Island) or land-based wind (located in Upstate New York) for various weeks. For the loss of all offshore wind, dynamic stability of the system immediately after the wind loss was also simulated.

Loss of wind energy during an entire week impacts system reliability when the wind farms are interconnected to zones that usually drive the loss of load expectation events, such as New York City (Zone J) and Long Island (Zone K). The magnitude of the impact also depends on the amount of potential energy generated during the week of the wind lull, as well as the timing of generation during each day (e.g., peak demand vs off-peak). Figure 21 provides the LOLE results for the most severe simulated offshore wind (OSW) lull weeks, showing that a one-week wind lull has the potential to significantly increase the probability of a loss of load event. The Figure 22 shows the offshore wind energy production during the simulated week. Details of these scenarios are provided in Appendix D.

Figure 21: Offshore Wind Lull for the Highest LOLE Week

Model	Event %	Initial LOLE	Wind Lull LOLE	Delta LOLE
70x30 'Base Load' at-criterion	34%	0.11	0.18	**0.07**
70x30 'Scenario Load' at-criterion	23%	0.11	0.22	**0.11**
70x30 'Scenario Load' at-low-LOLE	24%	0.03	0.06	**0.03**

Figure 22: Offshore Wind Output for the Highest LOLE Week



Additionally, a one-week outage of the largest generation source in New York City (*i.e.,* loss of Ravenswood 3 steam turbine generator) was simulated for the highest event week of the 70 x 30 "Base Load" condition. The results, shown in Figure 23, demonstrate that a one-week outage of approximately 6,100 MW of offshore wind (4,300 MW in New York City and 1,800 MW in Long Island) could have roughly the same impact to resource adequacy as the outage of a 1,000 MW conventional (*i.e.*, non-intermittent) generator.

Figure 23: Offshore Wind Lull Compared to Conventional Generator Outage

Model	Removal	Nameplate MW Removal	Initial LOLE	One-Week Outage LOLE	Delta LOLE
70x30 'Base Load' at-criterion	Offshore Wind	6098 *(4320 MW in J and 1778 MW in K)*	0.106	0.179	0.072
	Ravenswood 3	1027		0.180	0.180

With high penetration of renewable intermittent resources, the system will need dispatchable, long-duration resources to balance intermittent supply with demand especially during extended periods where the intermittent resources are not available. These types of resources will need to be significant in capacity and have attributes such as the ability to come on-line quickly, stay on-line for as long as needed, maintain the system's balance and stability, and adapt to meet rapid, steep ramping needs.

Storage Resources

Solar and wind resources are dependent on variable meteorological conditions, and thus their generating output does not always coincide with demand. Energy storage allows for time shifting of generation to meet the timing of demand. Storage resources charge during times of surplus and then discharge at other times when the power is needed.

The seasonal power capability of suppliers would typically be the main consideration when evaluating most generation resources for their ability to serve load and provide for reliability. With energy storage resources, there are two other critical aspects that need to be considered. The first is the duration needed from the storage device. Load duration curves can provide the context for how long a storage device may be needed for reliability. The duration of need can be a significant amount of time during a given day. The second critical aspect involves charging the storage device. Since the "fuel" for storage is electricity from local resources and the grid, the surplus energy in the "load pocket" where storage is located needs to be more than the energy that is needed from the storage device including losses. The NYISO Climate Change Study noted that **battery storage resources help to fill in voids created by reduced output from renewable resources, but periods of reduced renewable generation rapidly deplete battery storage resource capabilities resulting in the need for longer running dispatchable emission-free resources**. Additionally, the "Pathways to Carbon-Neutral NYC," which was commissioned by the New York City Mayor's Office of Sustainability, Con Edison, and National Grid, noted a stringent regulatory and siting regime for storage in New York City, including site-based limitations and fire codes regarding siting of battery storage.[19]

Inverter-Based Resources

With the planned increased to renewable energy resources on the system, there are several important considerations to evaluate in addition to traditional steady state and dynamics analysis. It is expected that many renewable generators will be connected to the grid asynchronously through power electronic devices (*i.e.,* inverter-based resources). The Eastern Interconnection Planning Collaborative (EIPC) recently issued the "Planning the Grid for a Renewable Future" whitepaper indicating a decline in grid performance when inverter-based resources displace conventional synchronous machines. The paper finds that degradation in performance is due to a number of factors, including the loss of, or change in, location of reactive power resources, the lack of transmission facilities to transmit the energy to load, and/or the reduction in primary frequency response due to the loss of system inertia from the retirement of legacy synchronous generation.

The ability of inverter-based resources to function properly often depends on the strength of the grid at or near the interconnection of the resources. Grid strength is a commonly used term to describe how the system responds to system changes (*e.g.,* changes in load, and equipment switching). In a "strong" system, the voltage and frequency are relatively insensitive to changes in current injection from the inverter-based resource. Inverter-based resources connecting to a portion of the system rich in synchronous generation that is electrically close or relatively large is likely connecting to a strong part of the system. Inverter-based resources connected to a "weak" portion of the grid may be subject to instability, adverse control interactions, and other issues.[20]

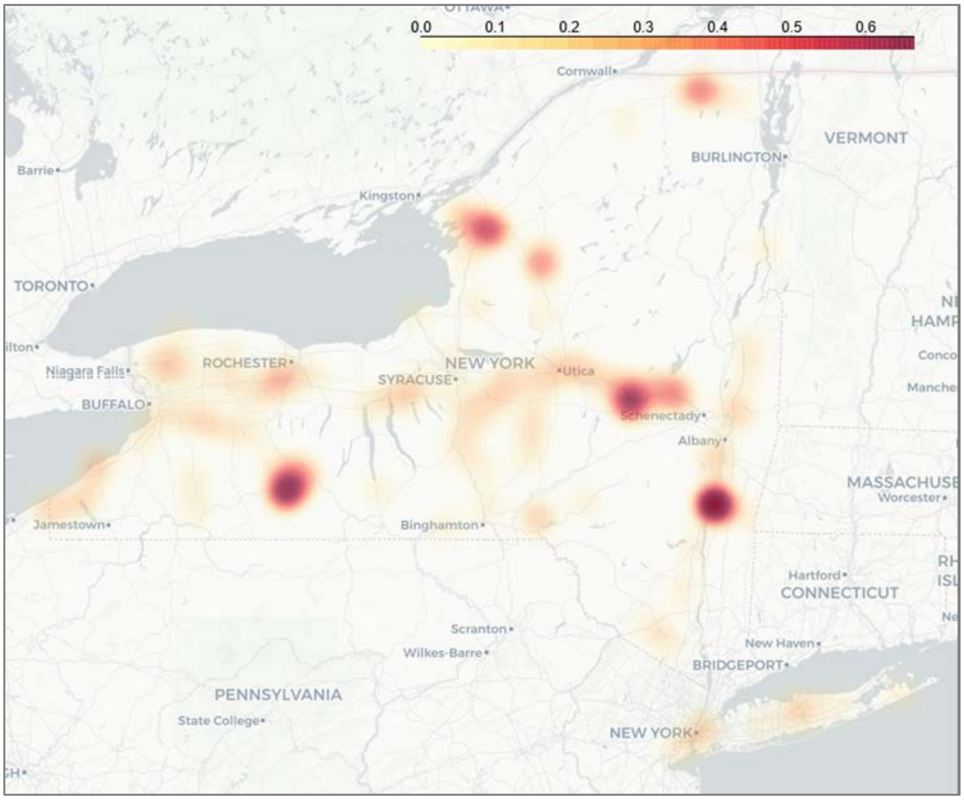
The prevailing measure of system strength is the short-circuit ratio calculation. Short-circuit ratio is defined as the ratio of short-circuit apparent power (SCMVA) at the point of interconnection (POI) from a three-phase fault at the POI to the power rating of the resource. A typical threshold for identifying weak

[19] https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/Carbon-Neutral-NYC.pdf

[20] North American Electric Reliability Corporation, Integrating Inverter-Based Resources into Low Short Circuit Strength Systems Reliability Guideline, dated December 2017.

system strength is a short-circuit ratio of 3.0.[21] Figure 24 highlights potential weak areas of the system (buses 115 kV and greater) under peak load conditions. Mitigation measures would involve the implementation and proper tuning of control systems and grid-forming inverters. Additional details are provided in Appendix F.

Figure 24: 70 x 30 Short-Circuit Ratio (Peak Load)[22]



Another measure of system strength is voltage flicker caused by the connection of large reactive devices (such as a shunt reactive device or a large motor). Flicker not only affects lighting but has the potential to disrupt industrial processes and consumer electronics. Some New York Transmission Owners have flicker (or Delta-V) criteria. For example, Avangrid criteria for voltage flicker is a change of 3% in bus voltage.[23] Figure 25 shows the areas of the NYCA (buses 115 kV and greater) that are more susceptible to voltage flicker. Mitigation measures typically involve a well-planned implementation of power electronics and synchronous compensators such as STATCOMs or synchronous condensers. Additional details are

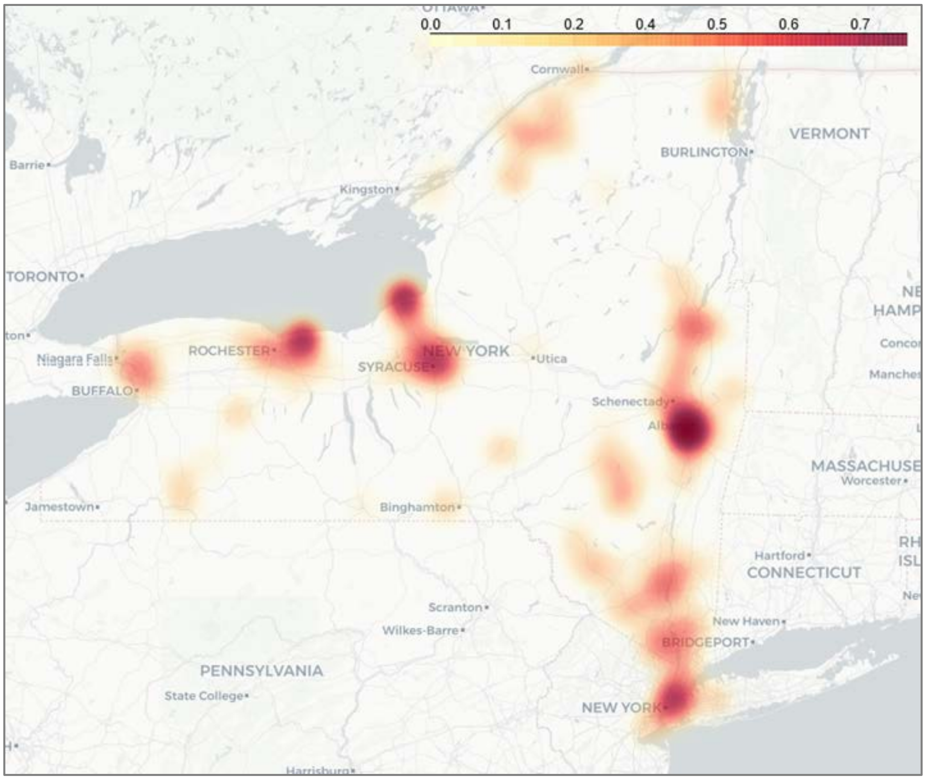
[21] North American Electric Reliability Corporation, Short-Circuit Modeling and System Strength, dated February 2018.

[22] The plot scale is the inverse of the short-circuit ratio to highlight the areas of lowest short-circuit strength

[23] Avangrid Electric Transmission Planning Manual, Technical Manual TM 1.2.00, dated June 29, 2019.

provided in Appendix F.

Figure 25: 70 x 30 Peak Load Voltage Flicker[24]



Dispatchable Resources

Given the move to a more intermittent renewable resource-based system, the NYISO has performed several studies that have shown the need for significant amounts of dispatchable resources.

The 70 x 30 scenario performed in the 2020 RNA modeled a possible renewable resource mix to meet the 70 x 30 target. The RNA scenario then determined how much fossil resources would need to be retained in order to meet reliability criteria. The analysis showed that over 6,000 MW of conventional generation in New York City out of the existing fleet of approximately 9,600 MW would need to be retained in order to maintain reliability within applicable criteria. Also, the analysis showed over 24,000 MW of conventional generation would be needed statewide. No dynamic stability issues were observed when considering the retention of conventional generation; Appendix F of this report provides details of a 70 x 30 dynamic stability analysis.

Moving to 2040, the CLCPA requires generation to be emission-free. The Climate Change Study looked at 100 x 40 (emission-free electric grid by 2040). It noted the significant amount of dispatchable resources

[24] In the plot scale, a 0 represents no change in per-unit voltage and a 1 represents a 0.03 per-unit voltage decline.

that would be needed to meet that goal but did not describe the technology that would be able to provide a dispatchable resource, instead choosing to refer to generic dispatchable, emission-free resources. Not surprisingly, the Climate Change report found that a similar amount of dispatchable resources as the RNA case would be needed to maintain reliability under baseline assumptions. **However, under CLCPA assumptions, the amount of dispatchable emission-free resources needed increases to over 32,000 MW in 2040, approximately 6,000 MW more than the total fossil-fueled generation fleet on the grid in 2021**. The Climate Change Study noted that the current system is heavily dependent on existing fossil-fueled resources to maintain reliability and eliminating these resources from the mix "will require an *unprecedented level of investment in new* and replacement infrastructure, and/or the emergence of a zero-carbon fuel source for thermal generating resources" (emphasis added)[25]. The Climate Change Study did note that while the amount of installed capacity (MW) of dispatchable resources is significant, the amount of energy generated (MWh) required from such resources would likely not be significant, with the percent of total energy being in the range of 10% — 20% range depending on the penetration level of intermittent resources.

The report *"Pathways to Carbon-Neutral NYC,"* issued April 2021[26]" stated "Both low carbon gas and battery storage can supply dispatchable electricity to the grid. However, both technologies are untested at the scale required to deeply decarbonize the city. Batteries are limited by the amount of energy that they can store and how fast that energy can be discharged. Batteries also require capital to build and space to occupy. At the same time, low carbon gas availability is uncertain, and there is no policy framework to develop these resources at scale. While maintaining gas-fired electricity generation assets can avoid new capital expenditures, sources of renewable natural gas (RNG) would need to be connected to the existing pipeline gas transmission and distribution system, requiring investments. Additionally, RNG combustion still generates air pollutant emissions, which must be considered (emphasis added)."

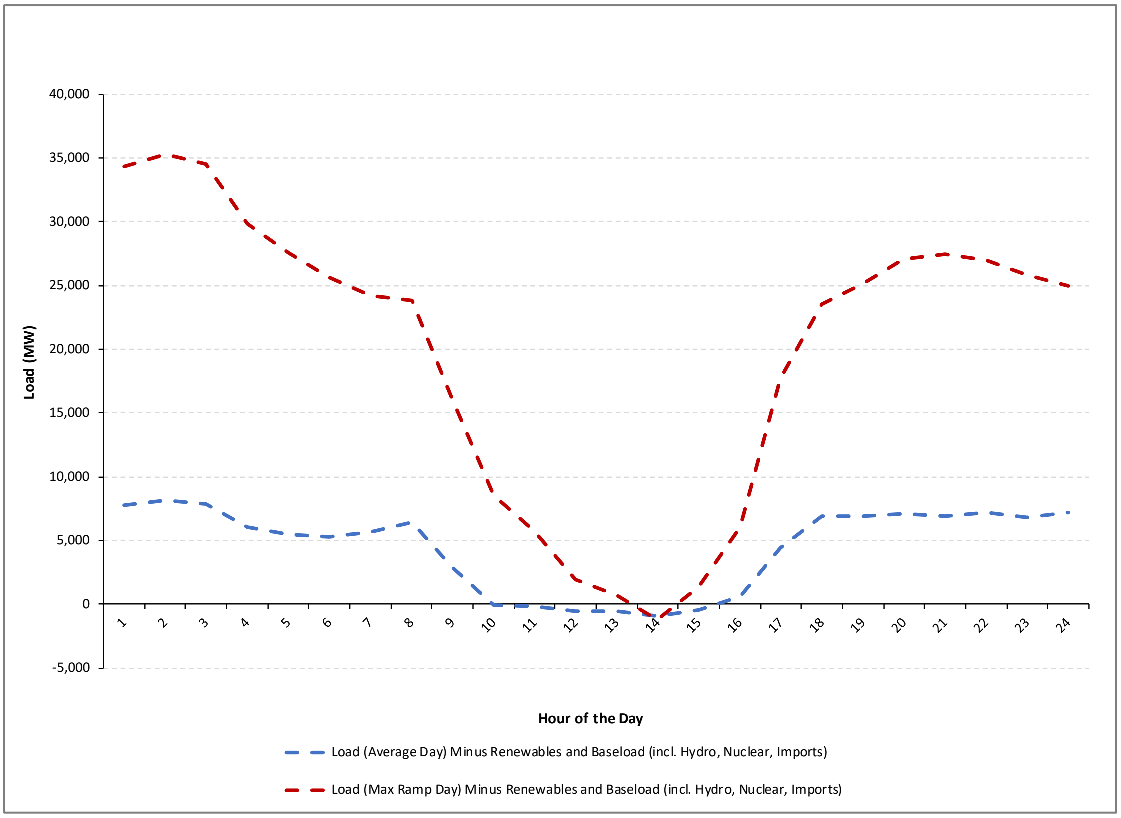
The NYISO Grid in Transition study noted that it is generally recognized today that meeting New York load with high levels of intermittent renewable resource output, particularly solar and wind generation, will require the NYISO to have sufficient flexible, dispatchable and potentially fast ramping supply to balance variations in intermittent resource output. These variations will include not only short-term variations in output during the operating day as a result of changes in wind speed and cloud cover but also a sustained ramp up of solar output at the beginning of the day as the sun rises and a sustained ramp down of solar output at the end of the day as the sun sets. The Climate Change Study noted in the winter under

[25] Page 13 of the *Climate Change Impact and Resilience Study – Phase II* https://www.nyiso.com/documents/20142/10773574/NYISO-Climate-Impact-Study-Phase-2-Report.pdf

[26] Commissioned by the NYC Mayor's Office of Sustainability (MOS), Con Edison, and National Grid: [link]

the CLCPA scenario that the one-hour ramp requirements could be over 10,000 MW and a six-hour ramp of over 25,000 MW, as noted in Figure 26.

Figure 26: Maximum Hourly Ramping Requirement - Winter CLCPA Load Scenario, Baseline Case



One last point bears noting: **While there are hundreds of projects in the NYISO interconnection queue, there are none that would be capable of providing dispatchable emission-free resources that could perform on a multi-day period to maintain bulk power system reliability. Such resources are not yet widely commercially available.**

Generation: Key Takeaways

- A system with significant amounts of intermittent resources will need significant amounts of dispatchable resources that can run for multiple day periods.
- Due to the characteristics of sun and wind resources, there will be high ramping requirements needed from the dispatchable resources.
- A 100 x 40 power system will require those dispatchable resources to be emissions-free.
- Dispatchable resources that are emissions-free, and on the scale needed, are not yet commercially available or currently in the NYISO interconnection queue.

Transmission

Transmission will play a key role in moving power from where the intermittent resources are located to the load centers.

The build out of transmission can be broken down into two components:

1. Inter-zonal bulk power capability
2. Intra-zonal local transmission capability

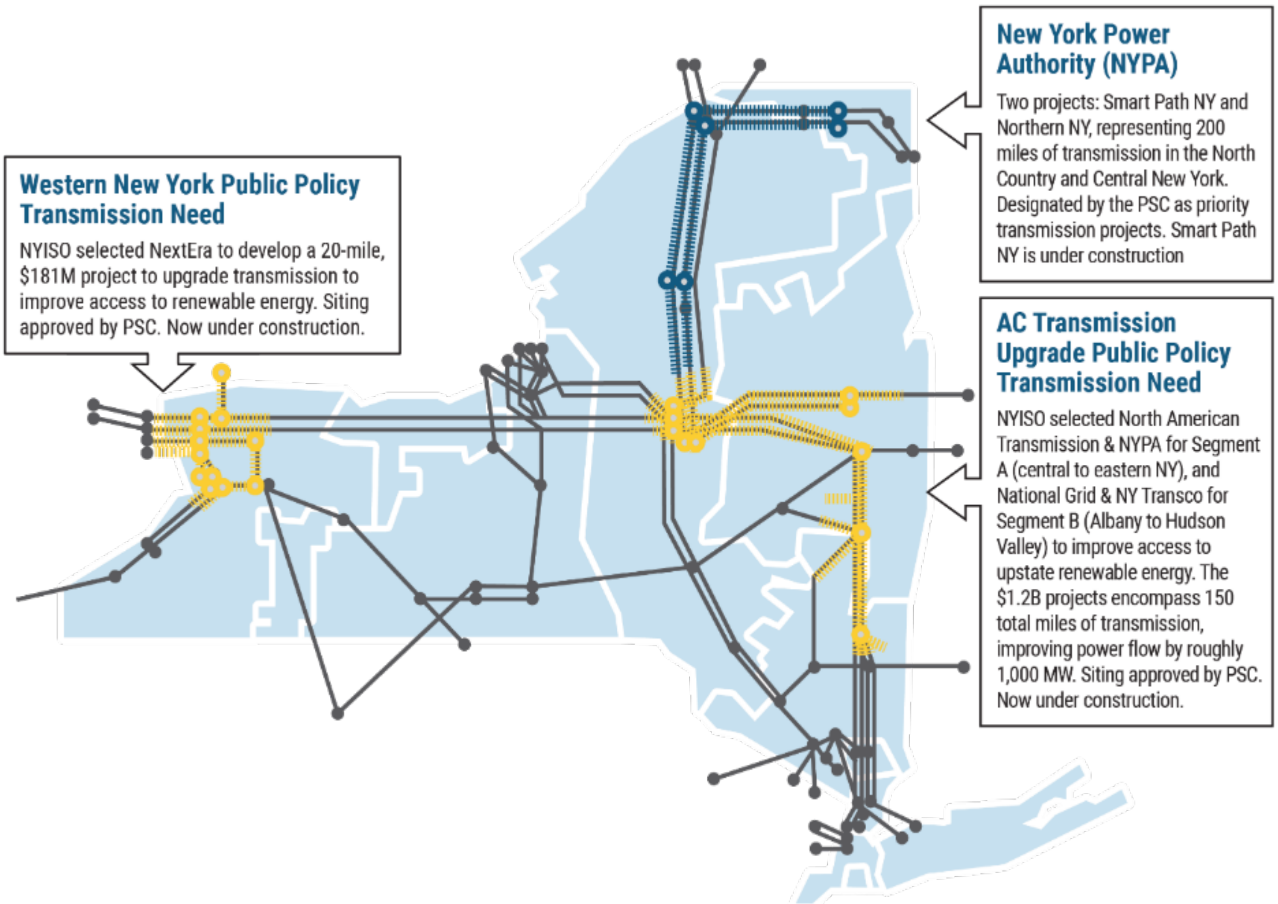
The NYISO has moved forward with three Public Policy Transmission Projects. One in the west that will provide capability to move Niagara hydro generation and Ontario renewable resource imports out of the western area of the state to serve load areas in the eastern and southern portions of New York. The other projects move power from upstate to downstate by replacing and adding transmission lines in the Mohawk River Valley and the Lower Hudson Valley.

Additionally, the 2020 New York State Accelerated Renewable Energy Growth and Community Benefit Act (AREA) seeks to accelerate siting and construction of large-scale clean energy projects.[27] The AREA authorized the New York Power Authority (NYPA) to undertake the development of transmission investments needed to achieve CLCPA targets. On October 15, 2020, the PSC adopted criteria for designating priority transmission projects. The PSC also approved NYPA's request to proceed with development of its proposed Northern New York Transmission Projects.[28] These transmission upgrades seek to increase the capacity of certain transmission lines in northern New York to accommodate incremental delivery of renewable energy. Under the new law the New York Public Service Commission authorized NYPA to pursue construction of its proposed Northern New York transmission expansion project. The project will increase the capacity of transmission lines in northern New York. These new transmission investments are depicted in Figure 27.

27 2020 Laws of N.Y. Ch. 58, Part JJJ.

28 PSC Case 20-E-0197, Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act, *Order on Priority Transmission Projects* (October 16, 2020).

Figure 27: New Transmission Projects in New York State



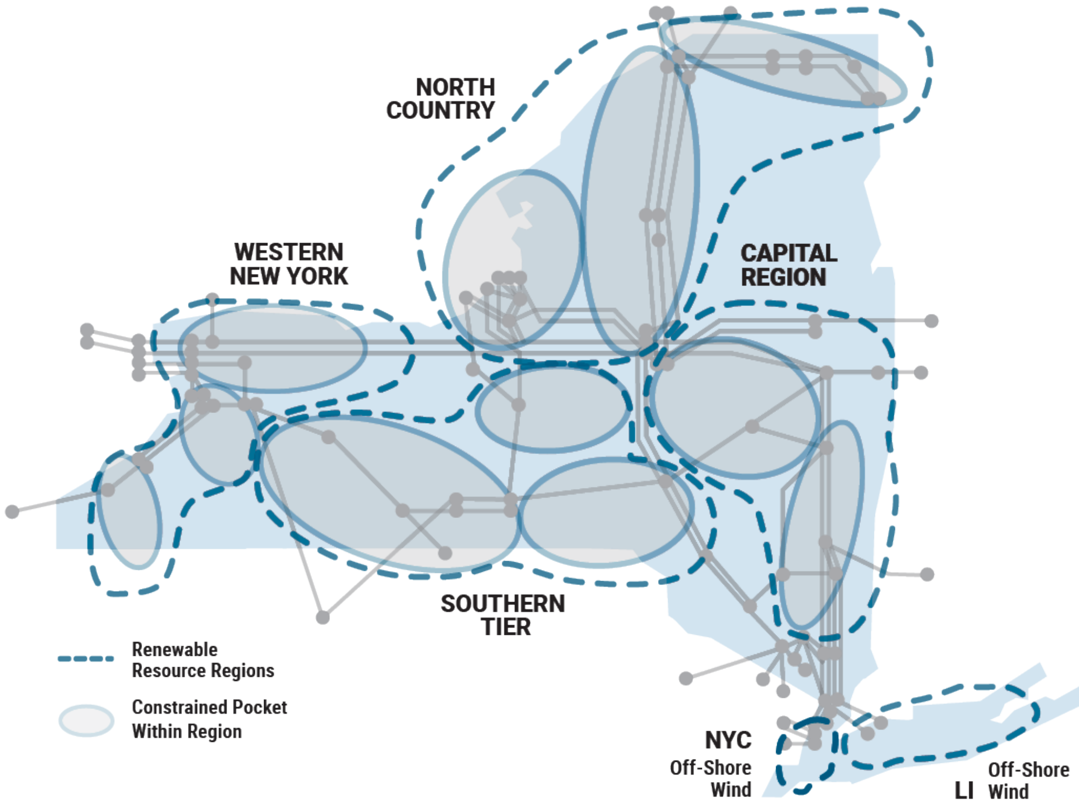
More recently, in September 2021, Governor Kathy Hochul announced two recommended contract awards for the Clean Path NY and Champlain Hudson Power Express projects to increase transmission capability to New York City. These awards are the result of New York's large-scale renewable energy solicitation for Tier 4 Renewable Energy Credits (RECs), issued by New York State Energy Research and Development Authority (NYSERDA) in January 2021. NYSERDA will submit the recommended contract awards to the PSC for review, public comment, and approval.[29]

The NYISO's Economic Planning Process has noted that **several renewable generation pockets on the 115 kV/138 kV systems across the whole state could constrain output from renewable resources such as solar and wind.[30] As shown in Figure 28, these include Western New York, the North Country, Capital Region, Southern Tier, and offshore wind near Long Island and New York City.**

[29] https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Standard/Renewable-Generators-and-Developers/Tier-Four

[30] See 2019 Congestion Assessment and Resource Integration Study (CARIS): https://www.nyiso.com/documents/20142/2226108/2019-CARIS-Phase1-Report-Final.pdf

Figure 28: Renewable Generation Pockets



DPS and NYSERDA's Initial Power Grid Study, released in January 2021, concluded that the transmission system with the inclusion of the Western New York and AC Transmission public policy transmission projects and the NYPA priority projects, along with the utilities' planned local transmission and distribution system, have positioned the state to achieve the 70 x 30 renewable energy requirements of the CLCPA without the need for further additional transmission capability. The report indicated that additional bulk transmission will be needed to achieve the CLCPA's objective of a zero-emissions electric system by 2040. The Initial Power Grid Study indicated that transmission upgrades would also be needed to deliver the 9,000 MW of offshore wind capacity called for in the CLCPA.

In its comments on the Power Grid Study, **the NYISO highlighted the need for additional transmission investment to achieve the 70 x 30 goal based on the expected location of renewable resources within the state.** The NYISO also commented on the electric utilities' November 2020 local transmission and distribution study, emphasizing the role that building out bulk and local transmission systems can play in delivering land-based and offshore wind renewable resources to consumers to meet the state's climate change policy objectives.[31] The NYISO emphasized the need for transmission to deliver renewable energy to consumers, suggesting that the PSC declare transmission needs for delivery of land-based renewable resources in upstate New York renewable generation pockets and for offshore wind resources to connect to Long Island and New York City. The NYISO noted that its streamlined competitive public policy transmission process is well positioned to fulfill those needs for the state. On September 9, 2021, the Public Service Commission an Order[32] on Local Transmission and Distribution Planning Process and Phase 2 Project Proposals.

In March 2021, the PSC issued an order declaring that offshore wind goals are driving the need for additional transmission facilities to deliver that renewable power from Long Island to the rest of New York State. The PSC referred the identified need to the NYISO to solicit potential solutions.[33] The NYISO received proposals in October 2021. The NYISO will assess the viability and sufficiency of proposed solutions and evaluate transmission solutions to determine whether to select the more cost-effective or efficient project to satisfy the PSC-identified need. As with the projects discussed above, any project selected through this process will be subject to the PSC-administered permitting process before construction is allowed to begin.

One last point bears emphasizing on the role of transmission: While increased transmission can allow more renewable resources to connect the grid, the amount of capacity (MW) of dispatchable resources needed for reliability may not reduce significantly. However, the amount of energy (MWh) from renewable resources can significantly increase with more renewable resources and transmission.

Transmission: Key Takeaways

- More transmission capacity throughout New York will be required to maintain a reliable grid with a high level of renewables penetration.
- Transmission build-out across New York would not reduce the necessary amount of installed dispatchable resource capacity within the New York Grid, but it would decrease the amount of annual energy production required from dispatchable resources.

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[31] See https://www.nyiso.com/documents/20142/18663846/20210119-NYISOCommentsCase20E0197-complete.pdf

[32] See https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=20-E-0197&CaseSearch=Search

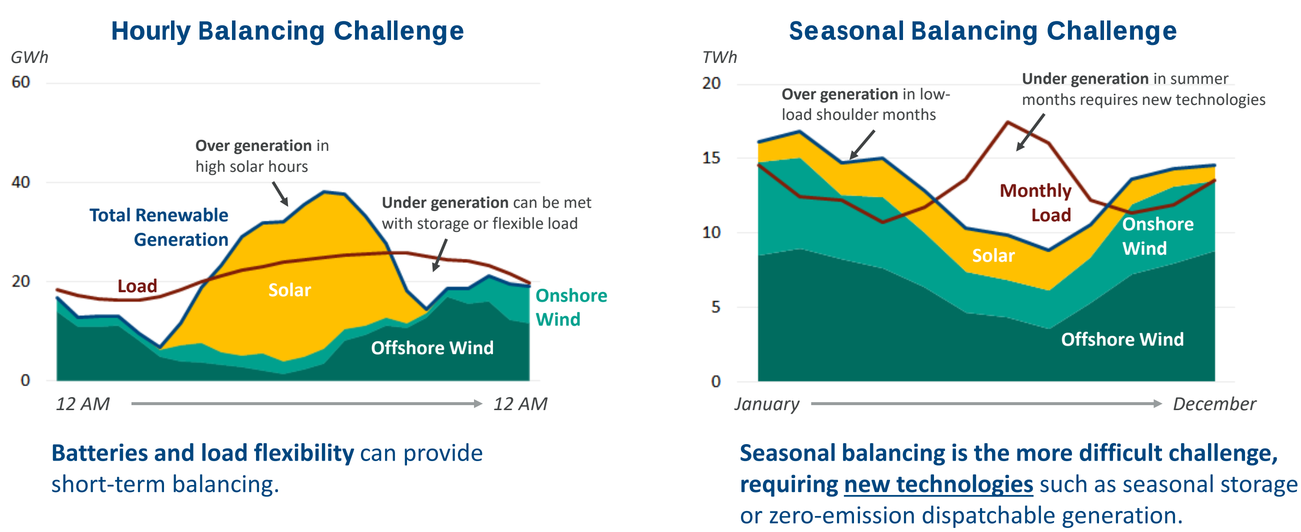
[33] Case No. 20-E-0497 and Case No. 18-E-0623, Order Addressing Public Policy Requirements for Transmission Planning Purposes (March 19, 2021).

Market Design for a Grid in Transition

The New York grid is facing an unprecedented transition driven by the CLCPA mandate that 70% of New York State's end-use energy be generated by renewable energy systems by 2030 ("70x30") and the target of an emission-free resource mix by 2040. A central question arising for the NYISO is how the wholesale markets in New York can continue to provide the pricing and investment signals necessary to reflect system needs and to incent resources capable of resolving those needs. The market design challenge is to anticipate the needs for existing and new grid reliability services and evolve the wholesale market design to achieve reliability. The NYISO is actively working on market enhancements to meet these future challenges with two guiding principles: 1) all aspects of grid reliability must be maintained; and 2) competitive markets should continue to maximize economic efficiency and minimize the cost of maintaining reliability while supporting the achievement of the CLCPA.

The key challenges that arise in the energy and ancillary services markets with significant penetration of weather-dependent, intermittent resources are balancing intermittency and improving price formation. As depicted in Figure 29, the grid of the future will require resources that can balance intermittence for extended periods of time, resources that can quickly turn on and are flexible in dispatch, and resources able to meet the sharp and occasionally sustained ramping needs created by the sudden disruption in solar or wind output.

Figure 29: The Balancing Challenge Across Multiple Timescales (*Grid In Transition,* June 2020)



Sources and Notes: Illustrative examples. Load data is from NYISO's 2020 "High Electrification" CLCPA Load Case forecast. Generation capacities in both examples set such that total renewable generation over the period matches load. Left: Forecast for 8/19/2020; capacity of 63 GW assumed of each renewable type. Right: Capacity of 22 GW assumed for each type.

Specifically, intermittent resource variation needs to be balanced in six timeframes.

1. The time frame of the regulation balancing instruction (6 seconds);
2. The time frame of the Real-Time Dispatch (5-minutes);
3. The time frame of the intra-day unit commitment decisions (15-minutes to a few hours);
4. The time frame of the Day-Ahead Market (24 hours);
5. The seasonal time frame (summer, spring, fall, winter); and
6. The time frame in which investments in resources able to provide balancing will be made.

As the level of intermittent resource generation increases, the grid will need sufficient flexible and dispatchable resources to balance variations in intermittent resource output for both short durations as a result of cloud cover or changes in wind speed, and prolonged periods (daily/seasonally) of renewable output lulls. Depending on the duration of need, enhancements to various market design aspects may be required including reserves, regulation, load forecasting and the potential need to develop a ramp product. To ensure continued grid reliability in all timeframes, balancing intermittency needs to be addressed through various market design improvements.

Over the next several years, market projects will continue to address the changes needed in the energy and ancillary services as well as prepare the markets for new resource classes. These efforts will focus on improving signals for the characteristics and attributes needed for continued grid reliability with increasing amounts of intermittent resource generation.

Energy and Ancillary Services Product Design: Improving the energy and ancillary service market design is crucial for proper wholesale electricity market price formation that signals the investment and dispatch behavior needed to maintain grid reliability, properly value locational grid needs, incent flexibility and other attributes valuable to the grid, and avoid unnecessary out-of-market actions. In addition to reserves, other ancillary services such as regulation, voltage control, and frequency response are essential to maintain grid reliability and resilience. In the future, there may be additional grid needs which are essential for continued system reliability. Effective pricing and modeling of transmission constraints are also necessary for improved price formation. Improved pricing outcomes can assist to incentivize investment in resources and transmission in locations which would benefit the system.

Capacity Market Design: The NYISO's energy and ancillary services markets, particularly with the enhancements described above, will differentially reward the resources that can most efficiently and effectively serve evolving operational needs — whether that means generating more during shortages or ramping more quickly during ramp-limited periods. However, the energy and ancillary services markets alone do not provide enough revenue to attract sufficient investment to meet New York's traditional "1-day-in-10-years" (1-in-10) resource adequacy standard. Thus, capacity markets will continue to be needed to provide the additional revenue stream to support adequate investment to maintain the required levels of resource adequacy. As the fleet transforms and creates new challenges, ongoing efforts will be needed to provide that capacity auction design supports adequate investment.

As the resource mix shifts, it is crucial to address the challenge of efficient resource entry and exit to meet policy objectives, while continuing to attract/retain resources necessary to meet established resource adequacy requirements. Currently, the Installed Reserve Margin (IRM) is set annually by the NYSRC as a percentage of the forecasted peak load for the year and establishes the minimum amount of Installed Capacity (ICAP) that must be on the system throughout the year. In a future with high penetrations of wind and solar, a capacity construct focused primarily on having enough MW available (plus a reserve margin[21]) may miss these increasingly diverse reliability challenges. Today's capacity products will need to improve the methods used to measure capacity for all resource types to better align reliability needs throughout the year.

A number of market design changes are underway to position the capacity markets to support the transitioning grid. The NYISO is focused on a holistic review of the buyer side mitigation framework to establish a durable going forward approach. Process changes will need to be just and reasonable and allow the ICAP Market to continue to attract and retain resources needed to maintain resource adequacy. As part of capacity accreditation, the NYISO recognizes that it is imperative to value capacity resources accurately based on their contributions to resource adequacy. This allows market compensation for capacity suppliers to be properly aligned with individual resources' expected reliability benefit to consumers while ensuring sufficient resources are procured to meet resource adequacy requirements. In addition, the NYISO is pursuing enhancements to its resource adequacy models. The NYISO is continuously evaluating the accuracy and robustness of its underlying resource adequacy models, reliability metrics, and probabilistic tools, and updating them to incorporate changing characteristics of the power system and resource fleet.

The NYISO is actively preparing for the resource changes and their operational and reliability implications and will continue to work with stakeholders on evolving the market design to provide clear signals for the attributes and services needed to support grid reliability.

Conclusions and Recommended Actions

This Comprehensive Reliability Plan (CRP) concludes that the New York State Bulk Power Transmission Facilities as planned will meet all currently applicable reliability criteria from 2021 through 2030 for forecasted system demand in normal weather. Nevertheless, the Comprehensive Reliability Plan contains the following recommendations based on risks to bulk power system reliability:

Monitor and Track Transmission Owner Plans

To provide for the long-term reliability of the system and minimize reliance on interim operating procedures, the Transmission Owners need to complete the projects identified in their Local Transmission Owner Plans (LTPs) on schedule and as planned. It is important that the local transmission projects that are identified in this CRP to maintain reliability be sited and constructed on a timely basis. The NYISO will continue to monitor the completion of the identified projects and the progress of local transmission projects as they relate to the Reliability Needs initially identified in the Reliability Needs Assessment. These include the following:

- Updated Local Transmission Owner Plans to address local reliability deficiencies as presented by Con Edison at the January 25, 2021, ESPWG/TPAS [link]:
  - A new 345/138 kV PAR controlled 138 kV Rainey — Corona feeder in 2023
  - A new 345/138 kV PAR controlled 138 kV Gowanus — Greenwood feeder in 2025
  - A new 345/138 kV PAR controlled 138 kV Goethals — Fox Hills feeder in 2025
- Short-Term Reliability Process solution for addressing the 2023 short-term need identified in the 2020 Quarter 3 STAR [link]. The solution changed the planned operating status of existing series reactors, starting summer 2023 through 2030:
  - In-service: series reactors on the following 345 kV cables: 71, 72, M51, M52
  - Bypass: series reactors on the following 345 kV cables: 41, 42, Y49
- Transient voltage response issues were observed on Con Edison's non-BPTF system from 2025 through 2030, while the BPTF violations were observed starting in 2029. Con Edison will address the non-BPTF violations with a Corrective Action Plan as required by NERC Standard TPL-001-4. When the non-BPTF violations are addressed, the BPTF violations will no longer occur. [link]

Monitor and Track Potential New Developments

The energy industry is in transition. Economic conditions, governmental programs and environmental regulations are changing quickly, resulting in financial stresses that may lead to the loss of resources or, alternatively, that could positively affect system conditions. New market-based generation and transmission projects under study in the NYISO's interconnection process could increase the reliability margin of the electric system in the long-term if such capacity comes into service during the study period. The NYISO will monitor and track these developments and consider their potential impacts on future system reliability. The NYISO will administer its Short-Term Reliability Process to address Generator Deactivation Notices and other system changes on a quarterly basis. The NYISO will continuously evaluate a forward-looking five-year period, and, if necessary, seek solutions. In addition, if a threat to reliability appears to be imminent, the NYISO may request immediate solutions outside of the normal planning cycle, in accordance with its tariffs and procedures.

Monitor Risk Factors

As discussed in this report, reliability margins will shrink in upcoming years due primarily to the planned unavailability of simple cycle combustion turbines that are impacted by the DEC's Peaker Rule. New York may experience even smaller margins if additional power plants are unavailable or if system conditions are more severe than currently designed for. The dangers of severe weather impacting the grid have been exemplified around the country in the past year, with Texas experiencing a brutal polar vortex in February and California facing problems from extreme heat last summer. New York is not immune from such extreme weather, which could lead to greater electrical demand and more forced generator outages than currently accounted for in the baseline forecasts. In consideration of these risk factors, the New York grid may cross a "tipping point" in future years such that the transmission system could not fully serve the demand. Through the quarterly Short-Term Reliability Process and biennial Reliability Planning Process, the NYISO will continue to address reliability issues identified for the ten-year planning horizon.

While the environmental rules, such as the DEC Peaker Rule, mainly target emissions from the natural gas peaker plants, New York's reliance on natural gas as the primary fuel for electric generation continues to justify vigilance regarding the status of the natural gas system. The NYISO is actively involved in natural gas/electric coordination efforts with New York State and federal regulators, pipeline owners, generator owners, local distribution companies, and neighboring ISOs and Regional Transmission Operators (RTOs). The NYISO's efforts with respect to gas supply assurance focus on: (1) improving communication and coordination between the gas and electric sectors; (2) annual, weekly and, when conditions warrant, *ad hoc* generator surveys of fuel supplies to enhance awareness in the control room and provide electric system reliability benefits; and (3) addressing the electric system reliability impact of the sudden catastrophic loss of gas.

Consider Enhancements to Rules and Procedures to Maintain Reliability and Resiliency

Reliability rules require that New York carry enough capacity to meet peak demand levels, as well as additional resources to provide a margin of reliability safety for certain conditions. Grid planners develop models that depict what would happen to the grid if we lost the use of certain energy resources due to weather, fuel constraints, transmission outages, or other system conditions. This allows us to be ready for contingencies, including the potential loss of some of our largest supply resources.

As we continue working on the grid of the future, we operate under the most stringent reliability rules in the nation. Our long-range reliability planning requires us to examine scenarios such as extreme weather events and unexpected transmission failures to maintain reliability. This Comprehensive Reliability Plan demonstrates that system margins are expected to narrow to such a level that warrants review of current reliability rules, procedures, and practices.

The NYISO's independent structure and shared governance process, in partnership with the New York State Reliability Council, gives all members of the energy sector a say in decisions affecting our markets and the reliability of our grid.

Continue Coordination with the New York State Public Service Commission

The NYISO will continue to coordinate its system planning activities with the PSC, including as part of the Public Policy Transmission Planning Process that is addressing transmission needs in Western New York, the Mohawk Valley and Hudson Valley transmission corridors, and for integration of offshore wind as part of the NYISO's overall Comprehensive System Planning Process (CSPP). If the PSC determines that there is an additional Public Policy Requirement that is driving the need for bulk transmission, the NYISO will solicit projects from developers to fulfill that need.

In addition, the State of New York is presently considering expanding and extending a variety of clean energy programs that are designed to increase deployment of energy efficiency, renewable generation and DERs. Existing energy efficiency, codes and standards, distributed generation and solar (behind-the-meter) program initiatives are reflected in the load forecast and resources modeled in this CRP. However, there are new initiatives that have not been implemented yet or recognized in this Reliability Planning Process cycle that could positively affect bulk power system reliability. The NYISO will continue to monitor and participate in other planning activities including, but not limited to, PSC proceedings considering; (1) fulfilling the requirements of the Climate Leadership and Community Protection Act (CLCPA), (2) implementation of the Accelerated Renewable Energy and Community Benefit Act (AREA), (3) Reforming the Energy Vision (REV), (4) Offshore Wind Standard and procurements, (5) Renewable Energy Credits (RECs) including Tier 4 RECs, (6) Zero-Emission Credits (ZECs), (7) Distributed Energy Resources (DERs), (8) Energy Storage Resources (ESRs), (9) energy efficiency, and (10) individual proceedings on transmission siting and generation deactivation and repowering.

Future NYISO Studies

Quarterly STAR: The NYISO will administer its quarterly STAR through the Short-Term Reliability Process to capture events such as generator deactivations and other system changes. Through the Short-Term Reliability Process, the NYISO will address every quarter Reliability Needs arising within five years, with an emphasis on needs arising in years one through three. If necessary, the NYISO will seek solutions to address any Reliability Needs identified through that process. For generators affected by the Peaker Rule, the NYISO could enter into Reliability Must Run agreements with specific generators to continue to operate for a two-year period, with a possible two-year extension, until market-based projects or permanent transmission solutions are built. Moreover, the NYISO continuously monitors all planned projects and any changes to the New York State transmission system and may request solutions outside of its normal planning cycle if there appears to be an imminent threat to the reliability of the bulk power transmission system arising from causes other than deactivating generation.

2022 RNA: The next cycle of the Reliability Planning Process will begin in 2022, for which preparations will begin later this year. The 2022 RNA will provide a new reliability assessment of the New York Bulk Power Transmission Facilities for years four through ten of the planning horizon (2026 through 2032). The 2022 RNA will be based on updated data, system models and assumptions, and will review the status of the risk factors discussed in this CRP, together with other reliability issues.

System & Resource Outlook: For the first time, the NYISO is currently undertaking a 20-year System & Resource Outlook, to be issued in 2022. The Outlook will provide a comprehensive overview of system resources and transmission constraints throughout New York, highlighting opportunities for transmission investment driven by economics and public policy.

Together, the Comprehensive Reliability Plan and the System & Resource Outlook will be the marquee NYISO planning reports that will collectively provide a comprehensive power system outlook to stakeholders, developers, and policymakers.