New York ISO
Independent System Operator

2023-2042 System & Resource Outlook (The Outlook)

A Report from the New York Independent System Operator

DRAFT for June 27, 2024 Management Committee Meeting

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Executive Summary

New York State's power system has been continuously evolving to adapt to policy and economic drivers. In 2019, New York State's Climate Leadership and Community Protection Act (CLCPA) was signed into law, which accelerated changes in electricity generation, transmission, and demand. Along with other state economic and clean energy policies, New York's energy landscape will continue to change rapidly. The evolving system requires continuous re-examining of how to efficiently and cost-effectively balance resources and demands.

The New York Independent System Operator's (NYISO) Comprehensive System Planning Process includes forward-looking assessments, evaluations, and plans that are developed and relied upon by the NYISO to reliably serve forecasted New York demand, address transmission needs driven by public policies, and identify economic opportunities for an array of possible future system conditions. This *2023-2042 System & Resource Outlook* (the "Outlook"), conducted by the NYISO in collaboration with stakeholders and state agencies, provides a comprehensive overview of potential resource development over the next 20 years and highlights opportunities for transmission investment driven by economics and public policy in New York State. The *2023-2032 Comprehensive Reliability Plan*, which was published in November 2023, and the *2024 Reliability Needs Assessment*, which is expected to be published by the end of 2024, leverage data from the current and prior Outlook to identify generation capacity and operation trends and related bulk power system reliability impacts as the grid evolves.

The Outlook examines a wide range of potential future system conditions and compares possible pathways to an increasingly greener resource mix. By simulating several possible future system configurations and forecasting the transmission constraints for each, the NYISO:

- Postulates possible resource mixes that achieve New York's public policy mandates, while maintaining reserve margins, and capacity requirements;
- Identifies regions of New York where renewable or other resources may be unable to generate at their full capability due to transmission constraints;
- Quantifies the extent to which these transmission constraints limit delivery of renewable energy to consumers; and
- Highlights potential opportunities for transmission investment that may provide economic, policy, and/or operational benefits.

There are many potential paths and combinations of resources and transmission expansion to achieve New York's climate change policy requirements. This Outlook examines five potential futures, which expands the number of scenarios that the NYISO examined in the prior Outlook. Specifically, this Outlook first evaluates a “Base Case” as a future with little change from today. The second potential future, or the “Contract Case,” evaluates the impact of approximately 16 gigawatts (GW) of additional renewable capacity either currently or previously procured by New York State. Finally, three “Policy Case” scenarios postulate and examine three separate futures that meet New York policy mandates — a "State Scenario," “Higher Demand”, and “Lower Demand”.

The State Scenario is new to this Outlook and serves as a postulated future based on inputs specified by the New York State Department of Public Service (NYDPS), New York State Energy Research and Development Authority (NYSERDA), and Joint Utilities.[1] The intent of the State Scenario is to support the initial cycle of the Coordinated Grid Planning Process (CGPP), which the New York State Public Service Commission (NYPSC) directed, to address the Joint Utilities’ local transmission and distribution planning to achieve the mandates of the CLCPA. The assumptions in the State Scenario are closely aligned with NYSERDA’s CLCPA Integration Analysis and continue to be developed through the Coordinated Grid Planning Process. This report includes the preliminary capacity expansion results that can be used by the Joint Utilities in the CGPP for directional awareness.

By examining these potential futures in the Outlook, the NYISO staff identified key findings, which are grouped based on the main drivers of the changes to the system, as follows: demand, resources, and transmission.

Key Findings: Demand

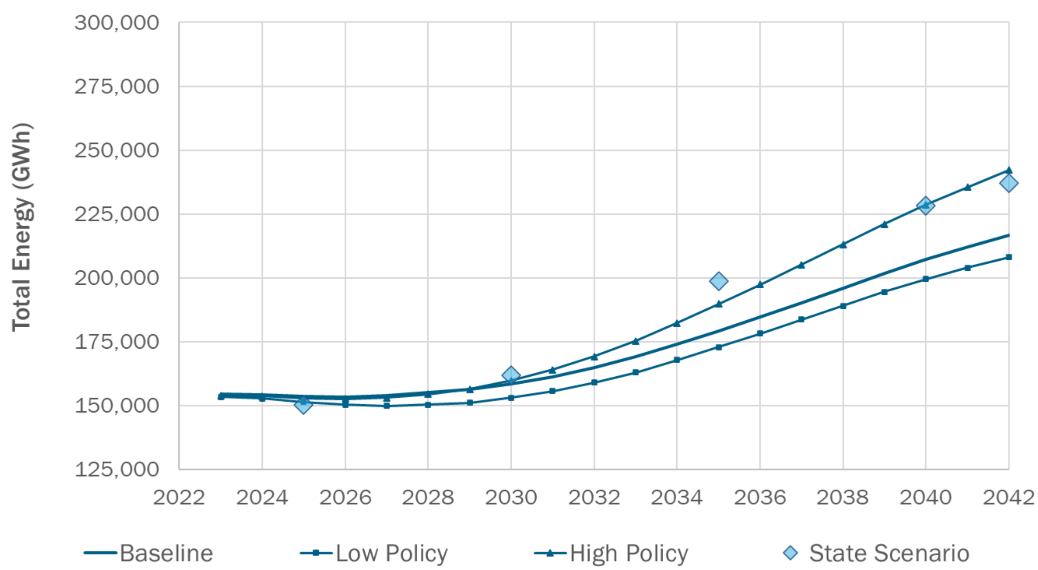
- ✓ **Electric energy consumption is projected to increase significantly in response to the economic development and decarbonization energy policies. The resources and transmission system necessary to meet the changing energy demand needs to evolve accordingly.**

New York is projected to increase electric energy consumption by roughly 50% - 90% and become a winter-peaking system over the next 20 years. This drastic change is largely driven by the electrification of essential energy-consuming systems, primarily building heating and electric vehicle charging. Influenced

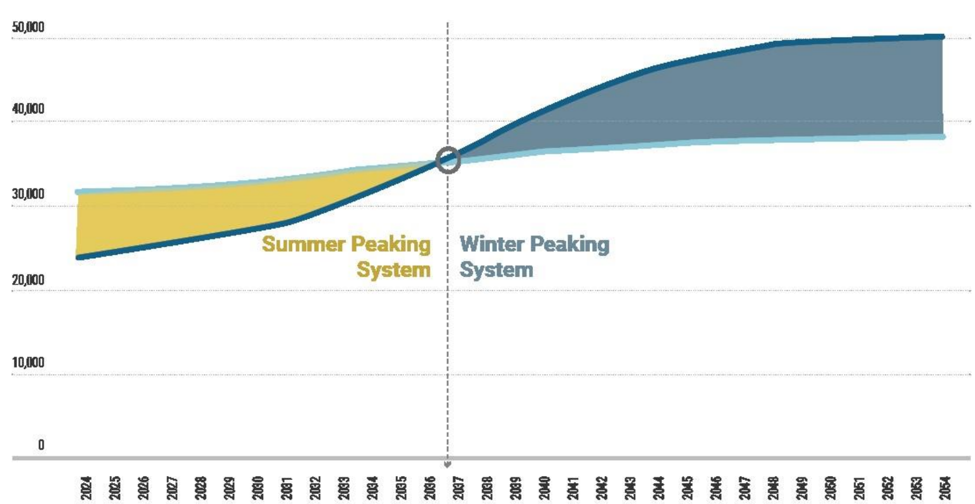
[1] The Joint Utilities are commonly referenced to include Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, Inc., Long Island Power Authority, Niagara Mohawk Power Corporation d/b/a National Grid, New York State Electric & Gas Corporation, Orange & Rockland Utilities, Inc., Rochester Gas and Electric Corporation.

by behind-the-meter resources, such as rooftop solar, the demand pattern that needs to be served via the grid by the in-front-the-meter resources is also expected to evolve accordingly.

Beyond the CLCPA's mandate for a zero-emissions grid by 2040, demand will continue to increase through 2050 as multi-sectoral electrification continues in order to meet the CLCPA's mandate to achieve 85% greenhouse gas emission reduction below 1990 levels by 2050.

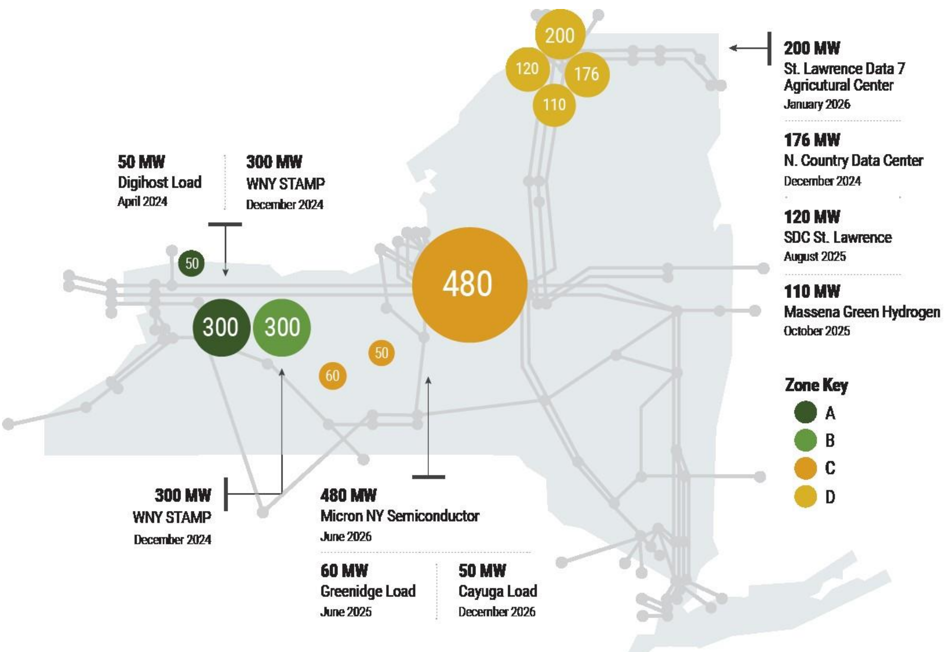


The timing of the switch to a winter-peaking system is mainly influenced by the timing and composition of heating electrification. The changing demand patterns, as well as the scale of demand increase, will impact the future generation capacity mix and resulting power flows across the system.



✓ **Siting large loads in electrical proximity to renewable resources, or siting resources near large loads, may benefit both the loads and the resources, particularly if located upstream of known constraints.**

In anticipation of the electrification efforts and economic development over the next two decades, numerous new large loads are expected to interconnect into New York, particularly in the upstate and Capital Regions. Most of these new loads consist of manufacturing facilities and data centers, as well as potential hydrogen production operations. The following diagram highlights the large loads that are assumed to be connected in the Base Case:



Interconnecting these potential economic development projects requires an extensive assessment to best leverage and develop a region's strength and reinforce its value proposition, such as accessibility to labor and land, promotion of job creation, and achievement of environmental mandates. Access to renewable resources and a robust transmission network should increasingly be an integral part of the consideration. Moreover, market forces and policy incentives should remain aligned to ensure that large load projects are located to access low-cost renewable energy while minimizing the burden on the transmission system.

When located in close proximity to renewable resources, future large loads can benefit from more direct access to renewable energy while the renewable resources themselves can benefit from higher utilization rates. Load that is located close to generation reduces the use of the transmission network whereas load located further away from generation requires the transmission network to deliver energy and is more susceptible to transmission congestion and loss costs. Furthermore, load located nearby renewable resources can more readily absorb excess energy resulting in lower curtailment levels.

For new large load projects connecting to the New York power system, the ability to move load from times of greater system demand to times with lower system demand or higher renewable energy production, or load flexibility, should be considered. Load flexibility can significantly reduce the generation capacity requirements and, in turn, potentially reduce the generation capacity buildout needed to meet policy mandates. For every one megawatt (MW) of peak load flexibility enabled, the amount of renewable capacity required is reduced by at least one MW and potentially much more.

Key Findings: Resources

Consistent with the prior Outlook, the NYISO estimates that the generation capacity required to achieve CLCPA energy mandates will be about three times the capacity of the current New York generation fleet, while the electric energy consumption is expected to increase by roughly 50% - 90%. Such new generation capacity must be obtained from a combination of renewable generation, battery storage, and other generation facilities referred to as dispatchable emission-free resources (DEFRs).

✓ **Dispatchable emission-free resources must be developed to provide the capacity, energy, and other essential grid services required to achieve the policy mandate for a zero-emissions grid by 2040.**

As the resource mix shifts from fossil generators to emission-free resources, essential grid services, such as operating reserves, ramping, regulation, voltage support, and black start, must still be available to provide New York with a reliable electric system. The intermittency of renewable resources contributes to the disproportional increase between load and generation. Today, the grid largely relies on fossil generators to provide the aforementioned reliability attributes. To achieve a zero-emissions grid, a collection of generation technologies, referred to as DEFRs, must be developed and deployed throughout the State to provide, in the aggregate, sufficient grid services to maintain reliable electric service for all New Yorkers. The importance of DEFRs continues to be a critical factor as identified in the prior Outlook.

In the Outlook, DEFRs are added to the postulated future resource mix to supply essential characteristics, such as dispatchability and flexibility capabilities to support a high renewable system. Several examples of potential DEFR technologies include long-duration batteries, small modular nuclear reactors, hydrogen-powered generators, and fuel cells. This Outlook projects that at least 20 GW of DEFR capacity would be needed by 2040 to replace the current 25.3 GW of fossil generation to support the achievement of CLCPA mandates.

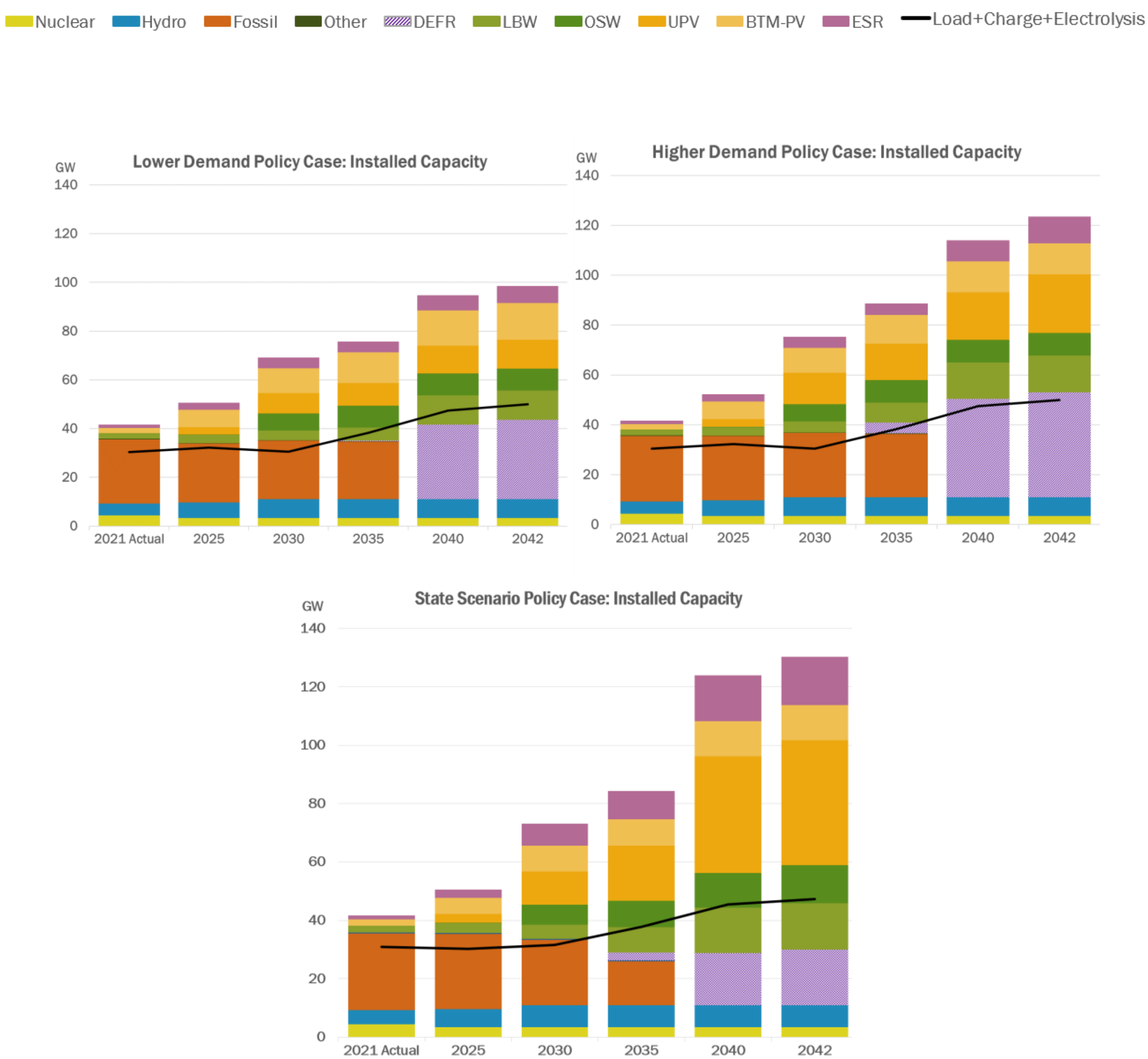
While DEFRs represent a broad range of potential options for future supply resources, two technology pathways commonly discussed as potential options for commercialization are: 1) utilization of low- or zero-carbon intensity hydrogen (typically generated by electrolysis derived from renewable generation) in new or retrofit combustion turbine or fuel cell applications, and 2) advanced small modular nuclear reactors. The DEFR assumptions in this Outlook were developed considering the cost and operating characteristics of these potential technology options. One DEFR assumption is low capital cost with high operating cost (e.g., hydrogen-fueled combustion turbine), while the second assumption is high capital cost with low operating cost (e.g., small modular nuclear reactor). In combination with other types of technologies, the aggregation of various potential options could satisfy the characteristics necessary to support the achievement of New York's energy mandates.

While essential to the grid of the future, such DEFR technologies are not commercially viable today at the necessary scale. Even assuming that they are commercially viable, there remains significant work in implementation and logistics that must be overcome to economically justify transitioning the dispatchable fleet to some combination of new technologies in the next 15 years. The research, development, and construction lead times necessary for these technologies may extend beyond the policy mandate timeline, in which case other existing generation technologies may be required to remain in operation to continue to maintain a reliable system.

The Outlook results show a greater need for grid energy to be supplied from dispatchable resources (e.g., fossil fuel or DEFR) compared to past evaluations. In the *2021-2040 System & Resource Outlook*, DEFRs were primarily included to address peak demand and, therefore, would produce energy in very few hours. The results in this Outlook, however, show an increased reliance on these resources to provide both peak capacity and hourly energy to support a highly renewable system. This increased reliance is driven by the forecasted hourly profile of demand and the limitations on the duration of energy storage resources. In this Outlook, hydrogen-powered DEFRs are generally included to provide firm peak capacity and, therefore, only produce energy for a few hours due to their high operating costs, while low operating cost DEFRs, such as small modular reactors, generally provide needed energy and other attributes throughout the year.

✓ **New York will require three times the capacity of the current New York generation fleet to meet projected future electricity demands.**

The total installed generation capacity to meet policy mandates within New York is projected to range between 100 GW and 130 GW by 2042. This conclusion is consistent with the findings from the prior Outlook. The following diagrams show the installed capacity required for each of the three Policy Case scenarios. Each color represents a different resource type as follows:



As demonstrated by the three different futures, the level of total installed capacity needed in 2040 to satisfy the state policy mandates, projected demand, and estimated capacity reserve margins is significant. Each future, however, contains differences in timing and the type of resources to meet the projected range of installed capacity. The differences among the futures are mainly due to demand growth assumptions and the type of generators that serve as resources in the future, as well as their associated costs.

In all three Policy Case scenarios, a significant amount of capacity from renewable generation and DEFRs is projected to be in service by the early 2040s, with the majority of the facilities assumed to be operational after 2035. Such capacity will be necessary to offset the fossil fuel generation retirements assumed by 2040 to comply with CLCPA mandates.

✓ **The coordination of new generator additions and existing generator retirements is essential to maintain the reliability of the New York power system while simultaneously pursuing achievement of CLCPA.**

To maintain reliability and achieve policy mandates, coordination of generator additions and retirements will be essential. For instance, coordinating the integration of renewable energy resources, the development and commercialization of DEFRs, the operation of fossil-fuel generators, and the staged deactivations of fossil fuel generators over the next 15 years will be critical to facilitate a reliable transition of the grid. The NYISO identified this concern in the prior Outlook and it remains a challenge going forward.

The NYISO's *2023 Quarter 2 Short-Term Assessment of Reliability* (STAR) highlights the importance of coordinating generator additions and existing generator retirements. The 2023 Quarter 2 STAR found a short-term reliability need beginning in summer 2025 within New York City primarily driven by a combination of forecasted increases in peak demand and the assumed unavailability of certain generators in New York City affected by the New York State Department of Environmental Conservation (DEC) "Peaker Rule."[2]

In the absence of viable and sufficient solutions, the NYISO identified dual-fuel generators on the Gowanus 2 and 3 and Narrows 1 and 2 barges as the temporary solution for this reliability need. While those generators are subject to the requirements of the Peaker Rule and originally identified to be out of service from May through September starting on May 1, 2025, the NYISO's designation of them as necessary for reliability will allow them to remain available for a period of time beyond May 1, 2025. This

[2] 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." The regulation is available here.

additional time is necessary to allow a permanent solution to be pursued and brought into service. In this case, a transmission project—Champlain Hudson Power Express (CHPE)—is expected to enter service in spring 2026, providing 1,250 MW of hydropower from Quebec to the New York City area. This project is expected to address the short-term reliability need and improve reliability margins.

The NYISO continues its ongoing efforts to evaluate and plan for the addition and deactivation of generation resources. Through the quarterly STAR studies, the NYISO continues to evaluate reliability by, among other things, assessing the continued need for the plants subject to the Peaker Rule, the progress of the new additions to the system, and other laws and regulations that affect the continued operation of resources, such as fossil-fuel generators. While the quarterly STAR studies, and other NYISO-conducted reliability studies, are well situated to evaluate and identify needs due to the addition and deactivation of resources in the 10-year planning horizon, coordination of these efforts in the longer term will be necessary.

- ✓ **Uncertainty in siting new renewable generation could lead to delays in or inefficient expansion of the transmission and distribution systems.**

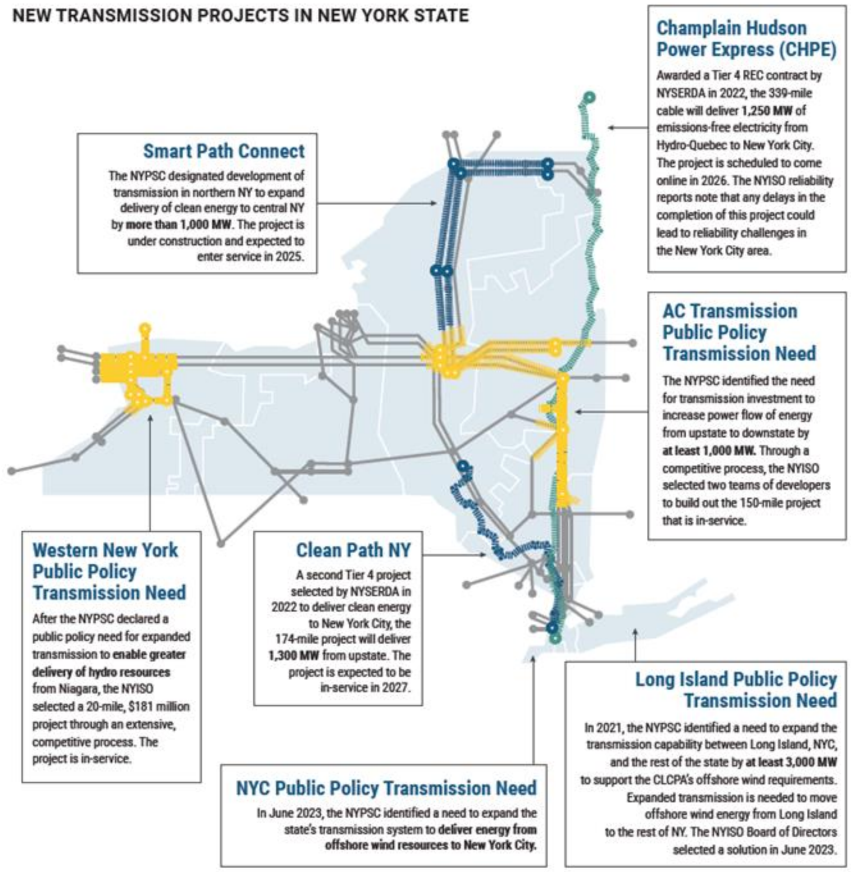
The footprint of renewable generation resources can be much more substantial than fossil fuel generators. Combined with the large amount of total power that must be derived from new renewable generation under CLCPA mandates, the potential acreage required to install these resources will be significant and likely will result in siting uncertainty. For example, a utility-scale solar plant typically needs approximately between 3 to 5 acres of land per MW of generating capacity and land-based wind typically needs approximately 15 acres per MW, while 25 acres of land could accommodate a 1,000 MW (1 GW) combined cycle power plant. Siting of renewable generation, therefore, requires not only a location with an abundance of the natural resources to serve as fuel (i.e., solar or wind) but also sufficient access to land to accommodate the footprint of the facility. Such uncertainty in locating real property and siting new renewable resources could be significant and affect the ability of developers to secure specific connection points of new renewable generation and DEFR projects, especially in the longer term (i.e., 2035 and beyond) as New York approaches its zero-emissions grid mandate.

Transmission development goes hand-in-hand with the placement of generation on the system. Optimal placement of generation or storage resources can help with balancing the need for new transmission expansion that is required to integrate renewable resources. However, where transmission expansion is required, uncertainty associated with siting of those resources may impact the efficient and timely build out of the transmission and distribution systems.

Key Findings: Transmission

✓ **Historic levels of investment in the transmission system are happening but more will be needed.**

The Outlook shows that the recently completed transmission projects that the NYISO Board of Directors selected through the Public Policy Transmission Planning Process have significant benefits to the system and toward the achievement of New York policies. The two transmission projects selected to address the AC Transmission Public Policy Transmission Needs (i.e., Segment A and Segment B) have significantly increased the ability of the New York grid to deliver power across the state and provide ratepayers with efficient access to resources. In June 2023, the NYISO Board of Directors selected another transmission project for purposes of addressing the Long Island Offshore Wind Export Public Policy Transmission Need identified by the NYPSC. The selected transmission project will provide transmission capability to deliver at least 3,000 MW from offshore wind projects—advancing the state closer to its mandate of 9,000 MW of offshore wind energy by 2035. The Outlook shows that this transmission project also efficiently relieves renewable pocket congestion previously identified in prior NYISO analysis.



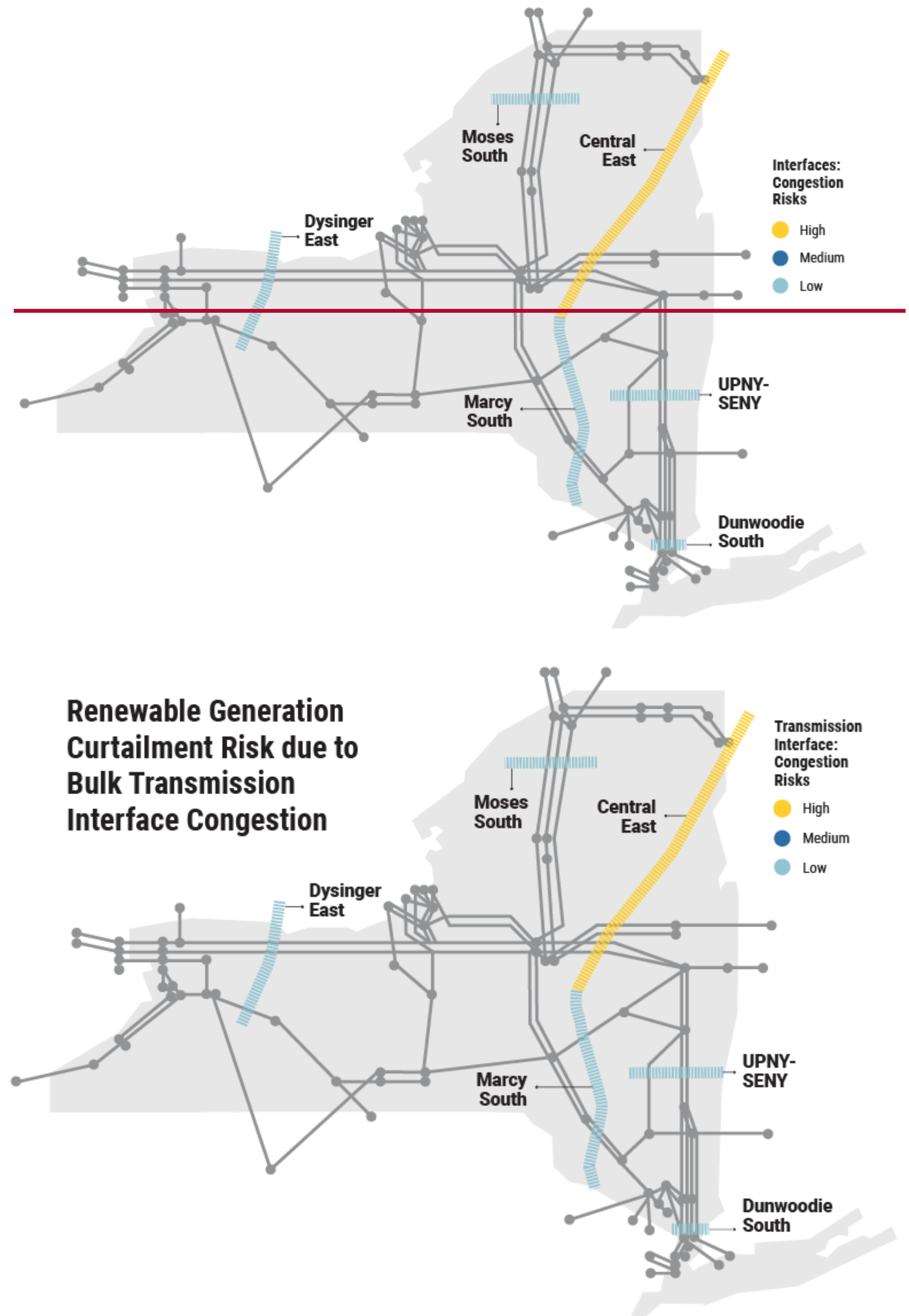
Other transmission and distribution expansions either identified by the local utilities or approved by the NYPSC for development also demonstrate significant benefits. For instance, the NYPSC approved New York utilities' Phase 1 and 2 local transmission upgrades. The Outlook results find these upgrades to be highly effective in increasing energy deliverability of resources and decreasing congestion on the lower voltage system. Renewable generation pockets that the *2021-2040 System & Resource Outlook* identified as high-risk are now shown to be at a reduced risk of renewable curtailment with these projects in the near term.

Even with this level of bulk and local transmission expansion investment, which is the most substantial build out of the transmission system in the last 40 years, the Outlook identifies opportunities to expand the transmission system efficiently and cost-effectively to, among other things, achieve CLCPA mandates.

✓ **Actionable expansion opportunities: Additional dynamic reactive power support must be added to the grid in upstate New York to alleviate congestion and fully utilize the transmission capability of the Central East interface.**

Local transmission projects are effective in solving congestion and curtailment of renewables on a localized basis in the near term. As local constraints are alleviated by local transmission and distribution upgrades, more renewable generation is delivered onto the bulk transmission system and, therefore, able to be transmitted across the state. However, bulk transmission constraints may then become the limitation for efficient delivery of renewable energy across the state in the long term (i.e., beyond 2030).

Continued investment in the bulk electric grid will be required to accommodate the 100-130 GW of emission-free generation resources needed to accomplish New York policy mandates. To achieve policy mandates by 2040, a minimum of 15 GW of new renewable generation is expected to be sited in Western, Central, and Northern New York, which is upstream of the Central East transmission interface. This will lead to continually increasing flows over the Central East interface towards southeast New York as upstate renewable project development progresses. Eventually, the flows would lead to significant curtailment of upstate renewables if the voltage performance of the system is not addressed. The following diagram illustrates the Central East transmission interface.



To fully utilize the transmission facilities already in place, additional dynamic reactive power support must be added to the grid in upstate New York to alleviate congestion caused by the Central East interface

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voltage performance. Reactive power supports the overall voltage performance of the grid and may be provided by generators, dedicated fast responding dynamic reactive power devices, such as synchronous condensers or other power electronics (e.g., STATCOMs), or potentially other specialized Grid-Enhancing Technologies (GETs). This kind of specialized technology can improve the delivery of electricity via existing transmission lines. As the fossil fuel generators tied to the Central East voltage collapse limit are deactivated by 2040 to comply with the CLCPA mandate, the full benefits of the Segment A transmission project will be diminished leading to transmission congestion and renewable curtailment if left unaddressed.

The Outlook finds that by replacing the dynamic support services from these fossil fuel generators to support the Central East interface voltage performance, the future potential congestion across Central East could be largely eliminated and curtailment of renewable energy reduced by approximately 40~~130~~-220 GWh in 2035.

- ✓ **Opportunities for further transmission investment in Western and Northern New York should be monitored as resources are developed in those regions.**

As renewable generation buildout continues in Western New York, the transmission corridors that carry significant power from the Niagara and Buffalo areas may experience congestion in the future due to constraints on the 230 kV transmission network associated with the Dysinger East transmission interface. Bulk transmission upgrades on these 230 kV paths, combined with the planned local transmission upgrades, could remove transmission barriers for new renewable resources and DEFRs that are required to meet policy mandates.

Northern New York is experiencing significant growth in both renewable generation projects and transmission expansion. This Outlook finds that most local transmission constraints in the associated renewable generation pockets that were identified in the prior Outlook have been resolved, primarily due to the Smath Path project and planned Phase 1 and Phase 2 local transmission upgrades. This Outlook, however, finds that several 115 kV and 230 kV transmission paths may become limiting as more renewable projects are added. Development of local and bulk transmission projects to address these limitations on the 115 kV and 230 kV transmission paths would ensure the energy deliverability of renewable generation resources, including existing hydro generation and imports, in Northern New York.

Western and Northern New York are two renewable resource regions with significant opportunities for additional renewable generation development. Should a shift or increase in new generation siting occur in Western and Northern New York, the need for transmission could be accelerated.

- ✓ **Planning energy exchange with neighboring systems is becoming more complex and will be increasingly so in the future as each system transitions to more decarbonized systems.**

New York has strong interregional transmission connections to ISO New England, PJM Interconnection, L.L.C., Ontario's Independent Electricity System Operator, and Hydro-Québec. The neighboring systems' independent pursuits of their respective climate policies will fundamentally change the availability of energy for interregional exchange. As these nearby systems approach achievement of the various carbon-free mandates, which is estimated to be generally around 2050, the availability of excess generation for exchange will be highly dependent upon the generation types adopted. Solar, land-based wind, and offshore wind production is relatively coincident across the NYISO and its neighboring systems. This, however, may limit the ability of neighboring systems to absorb excess energy from New York or vice-versa as each region seeks pathways towards a more decarbonized grid. Alternatively, when weather-driven renewable resource production is low in one system it is probable that renewable production will also be relatively low in surrounding locations. In this situation, each system would need to depend on internal DEFRs or external resources (but only if available) to meet its demand.

At the time of publishing this report, there are several notable efforts evaluating the expansion of interregional transfer capability. For example, North American Electric Reliability Corporation (NERC) is conducting an Interregional Transfer Capability Study that will analyze the amount of power that can be moved or transferred reliably from one area to another area of the interconnected transmission systems. The Department of Energy is also conducting its process to designate geographic areas as National Interest Electric Transmission Corridors where the development of new transmission would advance national interests, such as reliability and reduce consumer costs. The NYISO will continue to monitor these and other efforts, and if appropriate, incorporate the analysis in future studies.

Next Steps

The Outlook has built upon the data, modeling, and studies developed within the NYISO's Comprehensive System Planning Process and serves as another building block for continued analyses and study work both within and outside of the NYISO. The data and findings provided by the Outlook are designed and intended to be used by policymakers, investors, and other NYISO stakeholders to identify the challenges and opportunities associated with achieving state policies in an economic and efficient manner.

The *2024 Reliability Needs Assessment*, which is expected to be published by the end of 2024, will leverage data from the Outlook to identify generation capacity and operation trends and related bulk power system reliability impacts as policy mandates are approached.

The 2024-2025 cycle of the Public Policy Transmission Planning kicks off in August 2024, at which time the NYISO will provide an opportunity for any stakeholders or interested parties to submit comments regarding proposed transmission needs that may be driven by public policy requirements. The findings from this Outlook present an opportunity for interested parties to consider and formulate transmission needs based on the transmission opportunities identified in this report and the underlying analysis.

Recommendations and Observations

The important findings identified in the 2023-2042 System & Resource Outlook are the basis for several recommendations to address the challenges revealed by the study:

1. Thanks to recent transmission and distribution expansion projects, transmission constraints are no longer a major impediment to achievement of the 70% renewable energy by 2030 (70x30) policy mandate as projects facilitate high energy deliverability of renewables. The timely construction of the identified transmission projects to enable the integration of renewable energy resources by 2030 is vital to the policy's achievement.
2. Every incremental advancement towards policy achievement matters on the path to a greener and reliable grid in the future; not just at the critical milestone years, such as 2030 and 2040. Beyond the zero-emissions grid mandate by 2040, demand will continue to increase as multi-sectoral electrification continues to meet the CLCPA energy mandates to achieve 85% greenhouse gas emission reduction below 1990 levels by 2050. The need for new generation resources will continue well beyond 2040, while the new solar and wind resources will become less effective at meeting peak load after a significant amount of capacity is built.
3. This Outlook identifies the following notable transmission expansion opportunities:
    - **Central East Interface** – act on installing dynamic reactive power support;
    - **Western New York/Southern Tier** – monitor bulk transmission expansion to accommodate future renewable generation and/or dispatchable emission-free resource development; and
    - **Northern New York** – monitor bulk transmission expansion to accommodate future renewable generation and/or dispatchable emission-free resource development.

System & Resource Outlook Overview

This second biennial System & Resource Outlook (the "Outlook") evaluates the performance of and identifies potential challenges presented to the New York power system under multiple future scenarios over 20-years from 2023 through 2042. Each scenario projects a different possible future system with primary adjustments in energy demand profiles, generation capacity mixes, and approved proposed transmission and distribution projects. Each scenario is independently evaluated to inform on various potential future system outcomes. This Outlook primarily focuses on select years 2025, 2030, 2035, 2040, and 2042 to highlight how the system is evolving through time to accommodate the anticipated energy transition over the next two decades.

This 2023-2042 Outlook updates and builds upon the findings from the prior *2021-2040 System & Resource Outlook* (hereinafter, the "prior Outlook") published in September 2022. Like the prior Outlook, this report identifies challenges and opportunities for the New York power system as it continues a path towards decarbonization and achievement of policy mandates. In addition, this Outlook evaluates the grid with an increased number of proposed generation and transmission projects in the near term to recognize energy certificate awards to renewable energy resources[3] and approval of transmission and distribution upgrades. The scope of this Outlook was expanded to evaluate five scenarios (as compared to four in the prior Outlook) to accommodate an additional set of modeling assumptions from state entities for further use in the Coordinated Grid Planning Process (CGPP).[4]

This Outlook evaluates various generation capacity mixes over the next 20 years, quantifies projected congestion on the transmission system, identifies transmission investment opportunities on the New York grid, and highlights challenges associated with full achievement of New York's Climate Leadership and Community Protection Act (CLCPA) mandates and other applicable policy objectives. Given the NYISO's role to provide authoritative, fact-based information on the planning of the New York electric power system, the results and findings from the Outlook are intended to assist policymakers, investors, and other NYISO stakeholders in planning for a cleaner grid. While analyses from this Outlook informs other studies, such as the *2024 Reliability Needs Assessment* (RNA) and aspects of the NYISO's evaluation of proposed solutions in the New York City Offshore Wind Public Policy Transmission Planning Process, the Outlook is not a reliability study and should not be presumed that the scenarios evaluated adhere to all current or future reliability criteria. Additional assessments of reliability will need to be performed by the NYISO and to evolve as the grid transitions to meet policy mandates and goals.

3 Lockdown date for the assumptions for the Contract Case was October 30, 2023 and, therefore, such assumptions include the status of renewable energy certificate awards to generators as of that date.
4 While the NYISO developed four of the scenarios in consultation with Market Participants and other interested parties, the set of modeling assumptions that are intended to inform the CGPP (commonly referred to as the "State Scenario") were implemented "as is" based on the direction of the applicable State entities.

The scenarios representing the various futures evaluated in this Outlook are as follows:

- **Base Case** – The base case is a "business-as-usual" future that aligns with the Reliability Planning Process to define the load, generation, and transmission assumptions (including, among others, the selected Propel NY T051 project to address the Long Island Offshore Wind Export Public Policy Transmission Need and the NYPA Smart Path projects). Strict inclusion rules limit the amount of new generation projects that is assumed in this case, including generic future generation to meet reliability, if needed. The base case uses the base demand and energy forecasts from the NYISO's *Load & Capacity Data Report* (Gold Book). This case is not intended to and does not meet policy mandates.
- **Contract Case** – This case builds on the Base Case by adding 16 GW of high probability generation and several transmission projects that have been either currently or previously awarded financial commitments (e.g., NYSERDA Renewable Energy Certificate (REC) contracts and Offshore Wind Renewable Energy Certificate (OREC) contracts), including the approximately 7.5 GW contracts canceled in 2024. Nearly 17 times as much renewable generation capacity is included in this case above and beyond the new generation projects assumed in the Base Case. Additional transmission upgrades included are Clean Path New York, Brooklyn Clean Energy Hub, and other local transmission and distribution projects recently approved by the New York State Public Service Commission (PSC).
- **Policy Case** – Building upon the known contracted resources, the NYISO developed policy case scenarios to examine different pathways for full achievement of the CLCPA mandates. Examples of policies modeled include the 70% renewable energy by 2030 and the zero-emissions grid by 2040 mandates. The policy case scenarios for the 2023-2042 Outlook will evaluate three scenarios to represent various potential future system conditions: higher demand, lower demand, and a state-driven policy case (hereinafter, "State Scenario").

To create each case, a set of model input assumptions are adjusted to best reflect the future that is being projected. The table below highlights some of the major assumptions that the NYISO used to create each case.

Figure 1: 2023-2042 System & Resource Outlook Scenario Assumptions

Assumptions	Base Case	Contract Case	Policy Case
Energy Demand	2023 Gold Book Baseline Forecast	2023 Gold Book Baseline Forecast	2023 Gold Book Policy Forecasts, Climate Action Council Integration Analysis
Firm Generation	2023 Gold Book List of Generators	Consistent with Base Case	Consistent with Contract Case (including new generation)
New Generation	As per the inclusion rules in the 2022 RNA/2023 Q3 STAR	2022 NYSERDA RFP additions	Determined by policies and economics via model to optimize generator additions/retirements
Generation Retirements	2022 RNA/2023 Q3 STAR	Age and contract based	Determined by policies and economics via model to optimize generator additions/retirements
Transmission Topology	2022 RNA	2022 RNA	2022 RNA
New Transmission Projects	Propel NY (LIPPTN), Champlain Hudson Power Express, Northern NY Priority Transmission	Propel NY (LIPPTN), Champlain Hudson Power Express, Northern NY Priority Transmission, Joint Utilities Phase 1 and Phase 2 upgrades, Brooklyn Clean Energy Hub, Clean Path NY	Propel NY (LIPPTN), Champlain Hudson Power Express, Northern NY Priority Transmission, Joint Utilities Phase 1 and Phase 2 upgrades, Brooklyn Clean Energy Hub, Clean Path NY

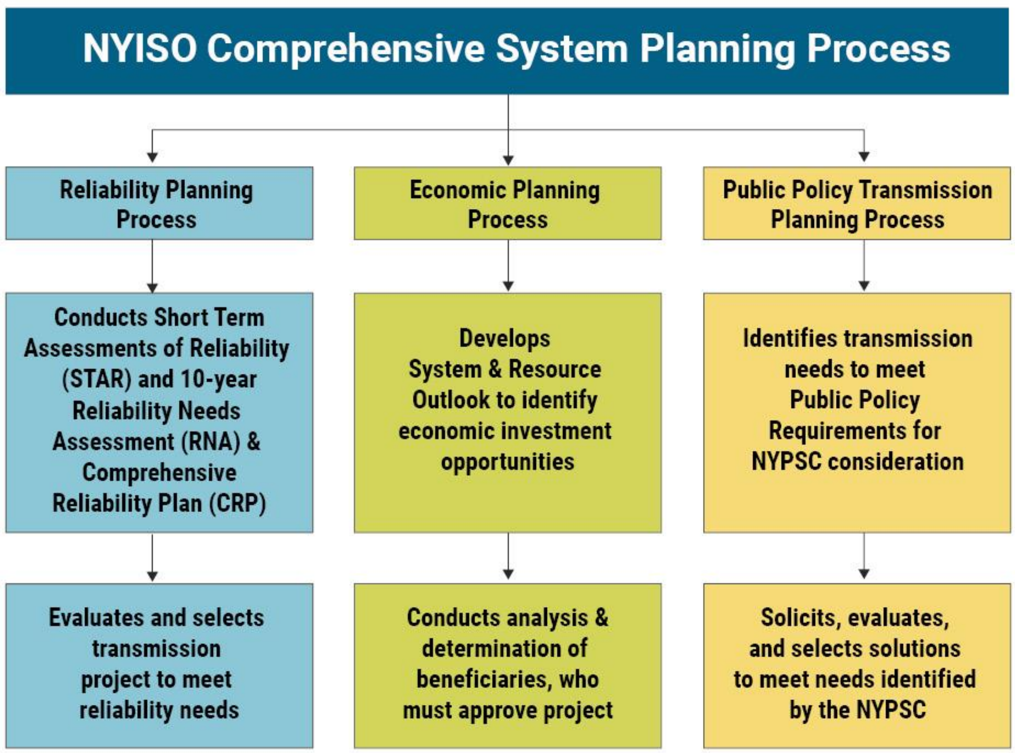
State of System & Resource Planning

The Outlook is developed by the NYISO System & Resource Planning department through the Economic Planning Process, which is a component of the NYISO's Comprehensive System Planning Process (CSPP). The Outlook provides a comprehensive overview of the potential system resource development and transmission constraints throughout New York, and highlights opportunities for transmission investment driven by economics and public policy. While this report is produced through the assessments performed under the Economic Planning Process, the CSPP contains numerous assessments, evaluations, and plans that are developed and relied upon by the NYISO to conduct system planning, including demand forecasting and analysis, reliability planning, public policy planning, interregional planning, and interconnection studies. The CSPP has been evolving to match the pace of change on the grid while continuing to find needs and opportunities for investment to promote reliable and efficient operation of the New York system. The use and reliance of the various data, modeling, studies, and plans from each component has facilitated its evolution. In addition, the State Scenario from this Outlook is used by New York utilities and state agencies in New York State's Coordinated Grid Planning Process.

Comprehensive System Planning Process

Under the CSPP, the NYISO is responsible for planning for the bulk transmission system through its Short-Term Reliability Process, Reliability Planning Process, Economic Planning Process, Public Policy Transmission Planning Process, and Interregional Planning Protocol. These processes identify needs that must be addressed and/or opportunities for transmission development. The Transmission Owners (TOs) in New York State are responsible under the Local Transmission Planning Process to plan for their respective Transmission Districts or facilities. In doing so, the TOs are responsible for identifying and addressing local needs through the development of a Local Transmission Owner Plan (LTP). The LTPs serve as inputs into the NYISO's planning studies.

Figure 2: NYISO's Comprehensive System Planning Process



Reliability Planning Process and Short-Term Reliability Process

In addition to its Economic Planning Process and the Public Policy Transmission Planning Process, the NYISO plans for the reliability of the system through several processes:

1. Each transmission owner, under the Local Transmission Planning Process, conducts a public process that plans for its transmission district and that serves as an input into the statewide planning;

2. The quarterly Short-Term Assessments of Reliability (STAR), under the Short-Term Reliability Process, address reliability needs that may arise within five years. This process assesses the potential for reliability needs arising from proposed generator deactivations, as well as other changes, such as revised transmission plans and updated demand forecasts;
3. The Reliability Needs Assessment (RNA), which is a part of the Reliability Planning Process, focuses on longer-term reliability needs for years four through ten of a ten-year, forward looking study period; and
4. The Comprehensive Reliability Plan (CRP)—also a part of the Reliability Planning Process—integrates all of the reliability planning studies into a ten-year reliability plan for New York.

Together, these processes enable the NYISO to identify reliability needs through a continuous study process ranging from localized needs to broader statewide needs arising over a ten-year horizon.

Through these reliability process, the NYISO has been providing information on the reliability margins and potential risk factors for the evolving grid over a 10-year planning horizon. In 2023, using its Short-Term Reliability Planning Process, the NYISO identified a short-term reliability need in its 2023 Quarter 2 STAR beginning in summer 2025 within New York City primarily driven by a combination of forecasted increases in peak demand and the assumed unavailability of certain generators in New York City affected by the New York State Department of Environmental Conservation (DEC) "Peaker Rule."[5] In the absence of viable and sufficient solutions, the NYISO identified dual-fuel generators on the Gowanus 2 and 3 and Narrows 1 and 2 barges as the temporary solution for this reliability need. While those generators are subject to the requirements of the Peaker Rule and originally identified to be out of service from May through September starting on May 1, 2025, the NYISO's designation of them as necessary for reliability will allow them to remain available for a period of time beyond May 1, 2025. This additional time is necessary to allow a permanent solution to be pursued and brought into service.

The NYISO also completed another major reliability report at the end of 2023. The 2023-2032 CRP[6] provided information on reliability margins and potential risk factors for the evolving grid over the next 10 years. The 2023-2032 CRP leveraged data from the current and prior Outlook to identify generation capacity and operation trends. While the NYISO did not identify any actionable reliability needs in that

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[5] 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." The regulation is available here.
[6] https://www.nyiso.com/documents/20142/2248481/2023-2032-Comprehensive-Reliability-Plan.pdf/

assessment, several risk factors to the reliability of the grid focused on the pace of generation retirements exceeding the pace of resource additions; the upward trend in peak demand coupled with electrification of essential energy-consuming and large loads; and the impact of increasing winter peak loads and consideration of non-firm gas unavailability.

The NYISO is currently performing the 2024 RNA and may leverage data from this Outlook to identify commitment and dispatch trends and related bulk power system reliability impacts that may be due to efforts to achieve New York State's policy mandates.

Public Policy Transmission Planning Process

The Public Policy Transmission Planning Process serves as the mechanism by which the NYISO considers transmission needs driven by public policy requirements. At its core, this process provides for the NYISO's evaluation and selection of transmission solutions to satisfy a Public Policy Transmission Need. The Public Policy Transmission Planning Process has seen success through the NYISO Board of Directors having selected four transmission projects to address the following Public Policy Transmission Needs: Western New York (Empire State Line), AC Transmission Segment A (Central East Energy Connect), AC Transmission Segment B (Segment B Knickerbocker-PV), and Long Island Offshore Wind Export (Propel Alternate Solution 5). The major components of the transmission projects selected to address the Western New York, AC Transmission Segment A and AC Transmission Segment B needs are currently in service, while the Propel Alternate Solution 5 project is in the early stage of development with an identified in-service date of May 2030 to the meet the need.

In June 2023, the NYPSC issued an order identifying the New York City Offshore Wind Public Policy Transmission Need and directed the NYISO to solicit proposed solutions to integrate at least 4,770 MW of offshore wind generation into New York City by January 1, 2033. The NYISO is currently administering its Public Policy Transmission Planning Process to address this New York City Offshore Wind Public Policy Transmission Need.

The 2024-2025 cycle of the Public Policy Transmission Planning Process will commence in August 2024 with a request to interested parties for proposed transmission needs being driven by Public Policy Requirements. Following the 60-day request window, the NYISO will file the submitted proposed transmission needs with the NYPSC for its consideration to identify Public Policy Transmission Needs, as well as concurrently sending proposed transmission needs to the Long Island Power Authority that would require a physical modification to transmission facilities in the Long Island Transmission District.

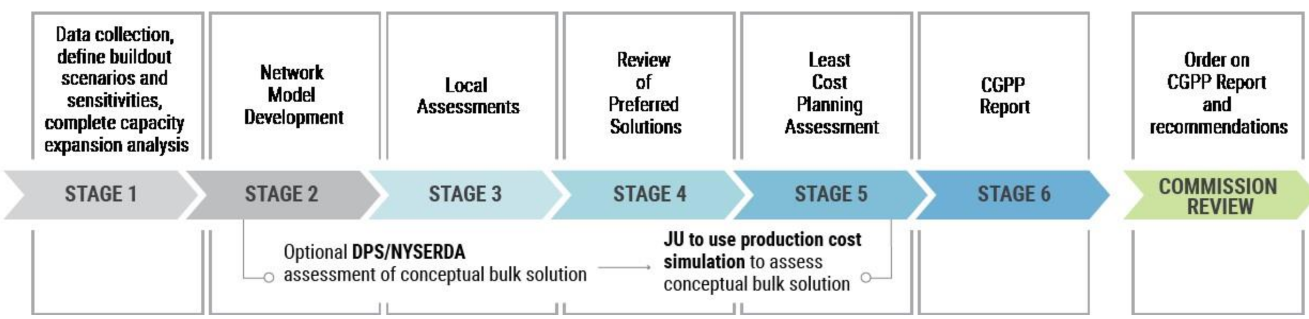
New York State's Coordinated Grid Planning Process (CGPP)

In addition to the complement of planning processes under the CSPP, New York State's Accelerated Renewable Energy Growth and Community Benefit Act created the State Power Grid Study and Investment Program to identify investments in distribution, local, and bulk transmission necessary to meet the State's requirements under the Climate Leadership and Community Protection Act. The NYPSC issued a series of implementing orders, which included, among other things, Joint Utilities to establish a Coordinated Grid Planning Process (CGPP) aimed at:

1. Improving planning processes to better coordinate the studies performed by the Joint Utilities with the NYISO's bulk power system planning and generation interconnection processes;
2. Improving the integration of local transmission and distribution (LT&D) and bulk system studies with NYSERDA's renewable generation and storage procurements; and
3. Improving forecasting of renewable generation development for specific locations on the LT&D and bulk transmission grid.

Each cycle of the CGPP includes six stages and is expected to take two to three years to complete a full cycle.

Figure 3: Coordinated Grid Planning Process (CGPP) Process Diagram



In addition to staff from New York Department of Public Service (NYDPS), NYSERDA, NYISO, and Joint Utilities, the Energy Policy Planning Advisory Council (EPPAC) was established to represent stakeholder interests and provide input and feedback on assumptions and technical approach used in the CGPP.

To support the initial cycle of the CGPP and to facilitate transparency and consistency between NYISO's planning processes and the CGPP, a "State Scenario" was established in the 2023-2042 System & Resource Outlook. The State Scenario leverages the NYISO's unique modeling and technical expertise but uses the assumptions directed by the Joint Utilities, NYDPS, and NYSERDA with the EPPAC serving in an advisory capacity. The State Scenario provides information and serves as a starting point for subsequent analyses in the six stages of the CGPP.

Generator Interconnection

While outside of the CSPP, the NYISO's transmission expansion and interconnection processes are crucial to facilitating the development and interconnection of proposed generation, transmission, and load facilities to the New York Control Area (NYCA). The transmission expansion and interconnection processes support grid reliability by requiring coordination among the NYISO, customers/developers, and associated Transmission Owners, as well as affected external systems, to identify and address potential violations of the applicable reliability criteria due to the proposed interconnection of projects. These processes are necessary to accommodate the significant portfolio of new projects, notably renewable energy, and energy storage resources, that Interconnection Customers are proposing to interconnect to the grid in response to state policies.

Beginning in 2023, the Federal Energy Regulatory Commission (FERC) issued Order No. 2023 and subsequently Order No. 2023-A that required transmission providers to amend their interconnection procedures to, among other things, address interconnection queue backlogs, improve certainty, and prevent discrimination of new technologies seeking to interconnection to transmissions systems. In response, the NYISO engaged in a significant effort to reform its interconnection procedures to comply with FERC's orders. The NYISO filed new Standard Interconnection Procedures that began on May 2, 2024[7] and will impact future proposed interconnections to the NYCA. Due to the timing of this Outlook and the implementation of the new Standard Interconnection Procedures, any references to the NYISO's interconnection queue in this evaluation are based on, among other things, the historic queue (*i.e.*, interconnection requests and applications submitted prior to start of the proposed Standard Interconnection Procedures to comply with Order Nos. 2023 and 2023-A).

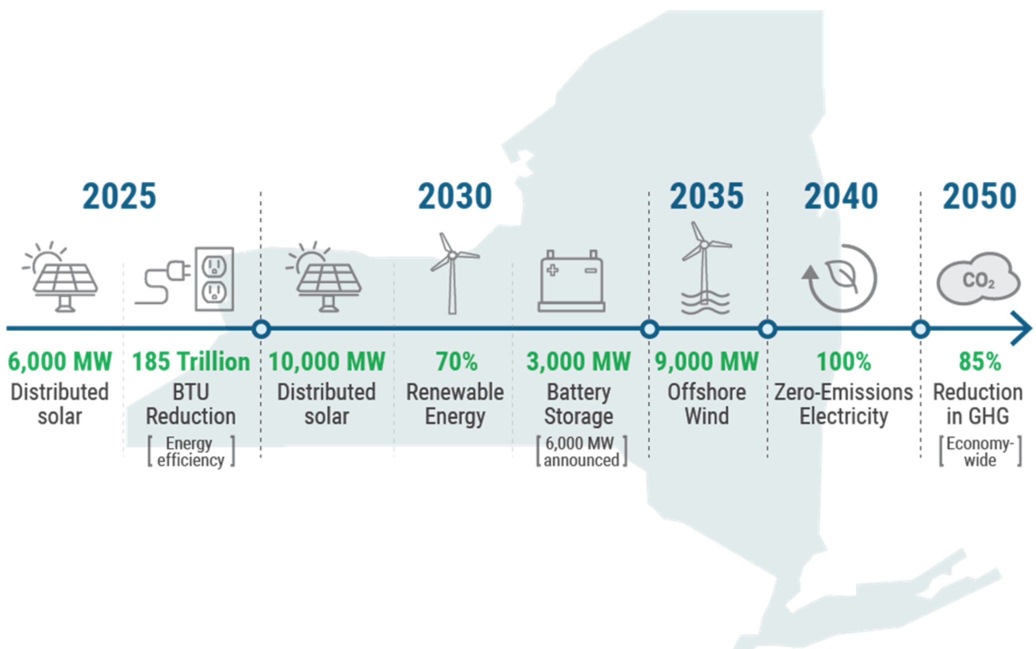
[7] See *New York Indep. Sys. Operator, Inc.*, Compliance Filing for Order No. 2023 and Order No. 2023-A; Conditional Request for Prospective Waivers, Docket No. ER24-1915-000 (May 1, 2024).

State of the New York Grid

The bulk power system in New York is continuously evolving to adapt to policy and economic drivers. In addition to longer term assessments focused on evaluating the integration of new generation, load, and/or transmission projects on the system, the NYISO produces annual publications, such as the Gold Book and *Power Trends*,[8] to provide independent sources of information and analysis on New York's electric system.

In 2019, New York State's Climate Leadership and Community Protection Act was signed into law, which accelerated changes in electricity generation, transmission, and demand. The CLCPA sets forth several clean energy mandates that impact this Outlook, such as, among others, 70% renewable energy by 2030 and a zero-emissions grid by 2040. Along with other state economic and clean energy policies, New York's energy landscape will continue to change rapidly.

Figure 4: New York State Energy Policy Mandates



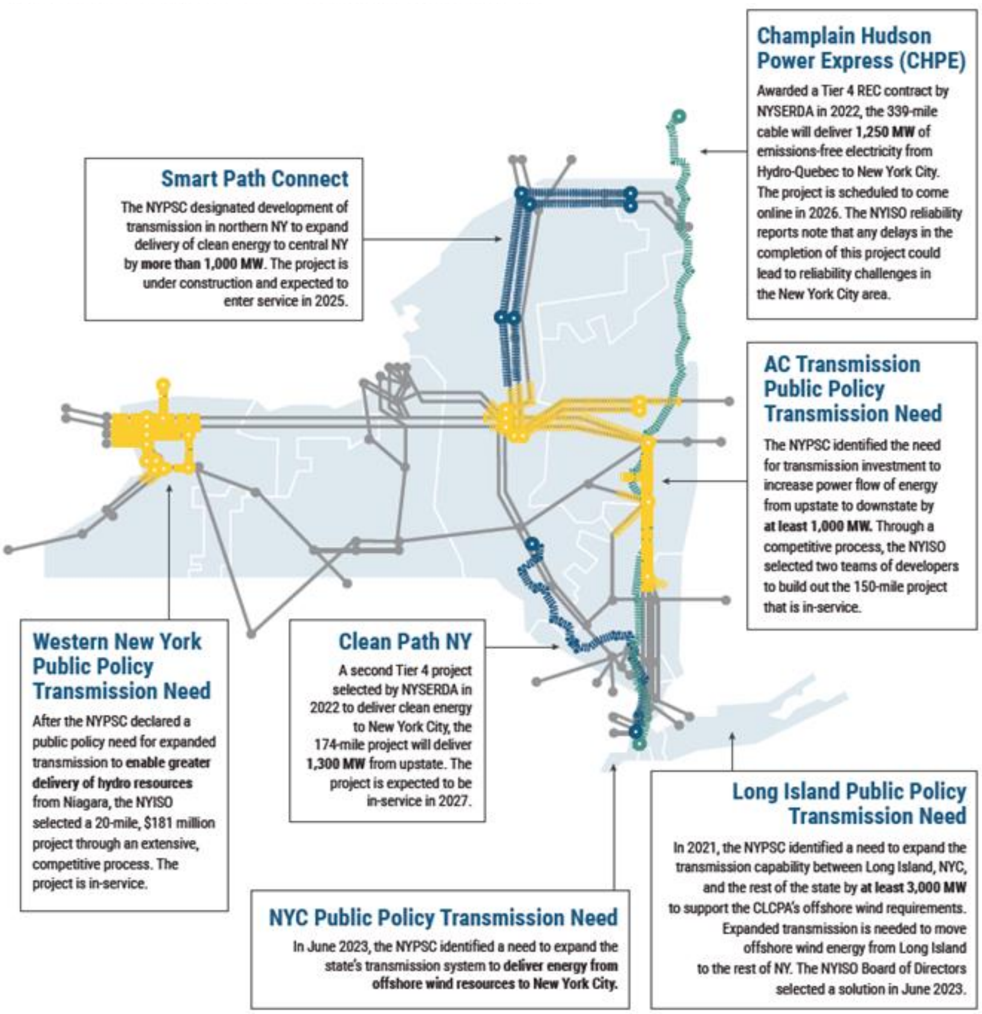
The magnitude of the resources required to achieve CLCPA necessitates significant expansion of New York's transmission system. The NYISO Board of Directors has selected several transmission projects through the Public Policy Transmission Planning Process that efficiently and cost-effectively address transmission needs driven by public policies, such as the CLCPA. The projects selected to address the

[8] Power Trends Reports, https://www.nyiso.com/power-trends

Western New York Public Policy Transmission Need and AC Transmission Public Policy Transmission Need have all completed construction and have significantly increased the ability of the New York grid to deliver power across the state and provide ratepayers with efficient access to resources. In June 2023, the NYISO Board of Directors selected another transmission project for purposes of addressing the Long Island Offshore Wind Export Public Policy Transmission Need identified by the NYPSC and is expected to deliver at least 3,000 MW from offshore wind projects by 2030. As of the publication of this report, the NYISO is in the process of receiving proposed solutions to the New York City Public Policy Transmission Need and, therefore, does not consider potential solutions as a part of this Outlook.

Outside of NYISO processes, several other significant transmission projects have been approved or developed to further the achievement of CLCPA.

Figure 5: New Transmission Projects in New York State



Planned Generation

The Outlook uses the NYISO's Reliability Planning Process inclusion rules to determine generator additions and retirements included as a starting point for the Outlook's Base Case development.[9] The amount of new generation projects that are assumed as firm new builds will be limited to those that meet the inclusion rules. Generic generating capacity is added to the model if a reliability need is identified in the latest reliability study (RNA or CRP).

Additional generation capacity beyond what meets the Reliability Planning Process inclusion rules is assumed in the Contract Case and Policy Case to account for resources that have been awarded contracts with NYSERDA.[10] These generation projects amount to approximately 16 GW of new renewable and energy storage resources that are assumed to be in service by 2030 to support the achievement of the 70% renewable resources by 2030 (70x30) mandate in the CLCPA.

Demand: Evolving Load and System Trends

The NYCA is comprised of 11 geographical zones from western New York (Zone A) through Long Island (Zone K). These zones are referred to throughout this report to provide locational details regarding system demand, projected resource mixes, and anticipated transmission constraints. A map of the NYISO load zones is shown below for reference.

Figure 6: NYISO Load Zone Map

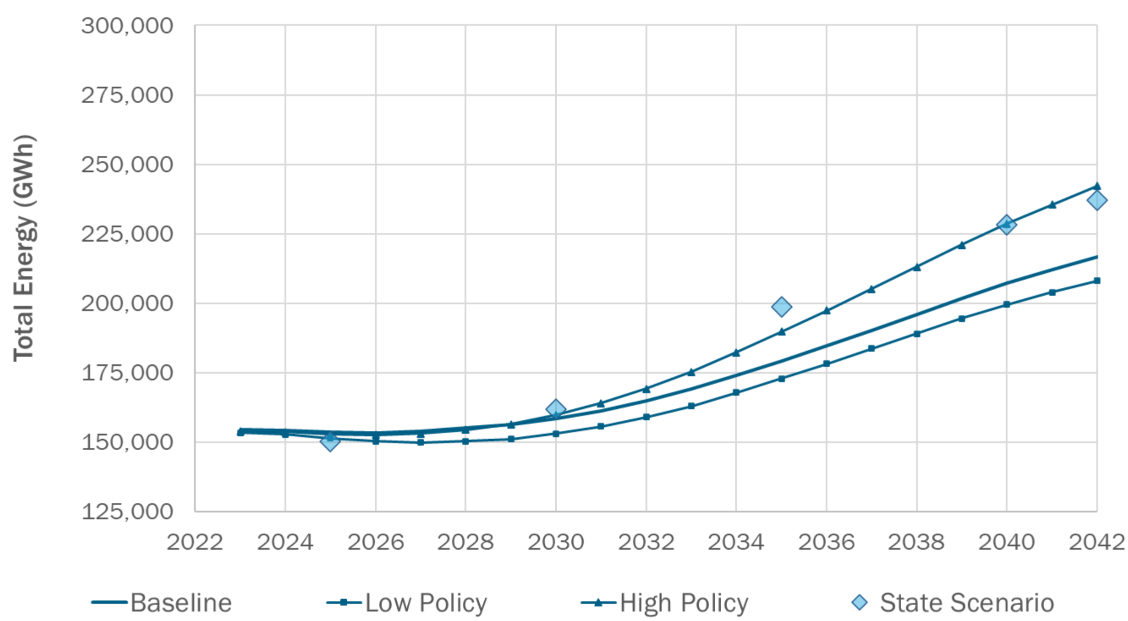
[9] See Reliability Planning Process Manual, Manual No. 36, § 3.2.
[10] Lock down date for these resource's inclusion was October 30, 2023.

Historically, electric demand has been concentrated "downstate" in New York City (Zone J) and Long Island (Zone K). Demand in "upstate" regions (generally Zone A through Zone F) is more widespread. Assumptions pertaining to the demand are captured through the use of forecasts, which serve as a principal driver of simulation results in electricity system planning models.

Energy and Peak Demand Forecasts

For this Outlook, the NYISO assessed four unique demand forecasts in the five scenarios to evaluate a range of projected annual energy and peak demand forecasts. Three of the demand forecasts evaluated in this Outlook were produced in the *2023 Gold Book*,[11] while the fourth forecast, which was used in the "State Scenario" Policy Case, was developed as part of the Climate Action Council's Integration Analysis[12] to support New York's Final Scoping Plan.[13]

Figure 7: NYCA Demand Forecasts Annual Energy Demand



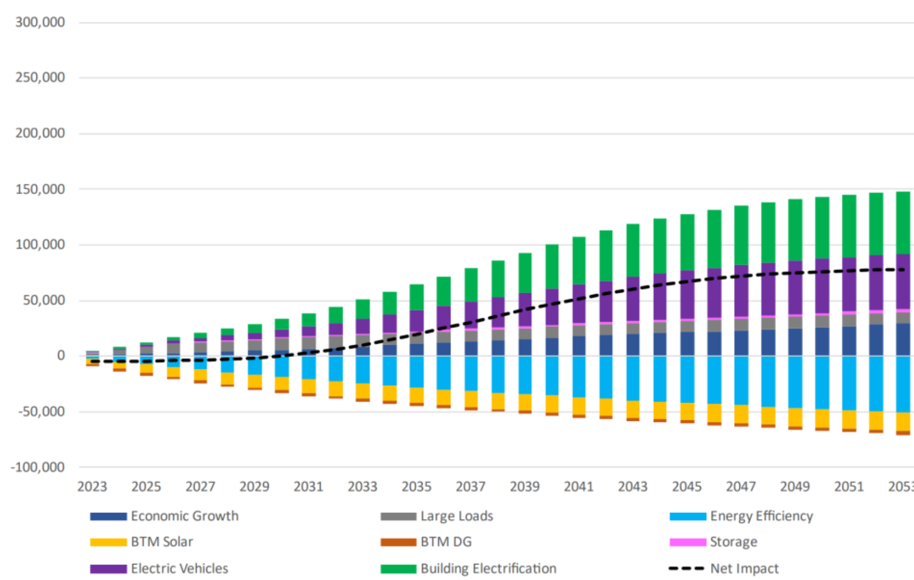
Critical components of the demand forecasts include, but are not limited to:

[11] The three load forecasts from the 2023 Gold Book include: (1) the Baseline Forecast, (2) the Lower Demand Policy Scenario, and (3) the Higher Demand Policy Scenario. *See* Section I of the 2023 Load and Capacity Report.
[12] https://climate.ny.gov/resources/scoping-plan/
[13] https://climate.ny.gov/-/media/Project/Climate/Files/NYS-Climate-Action-Council-Final-Scoping-Plan-2022.pdf

Major Factors Impacting Demand Forecast	
Increasing	**Decreasing**
Building electrification	Behind-the-meter solar generation
Electric vehicles	Energy efficiency
Large load projects	

The figures below separate out each component of the projected load forecasts and quantify them either as an increase or decrease in projected energy demand. For example, behind-the-meter (BTM) solar resources (yellow) can be seen as a decrease in net demand energy, while electric vehicles (purple) increase net demand energy. All of the energy forecasts used in this Outlook project increased net demand energy through time. Notably, electrification and large loads have a significant impact on the projected increase; however, the extent to which these projections increase due to the applicable component vary by forecast.[14]

Figure 8: Base & Contract Case: Demand Energy Impact by Type (GWh)



[14] Additional electrification beyond what is included in these forecasts would increase demand even further. For example, electrification of the Con Edison steam system to comply with policy would lead to a further increase in projected demand. *See generally*, [The Evolution and Future of the Con Edison Steam System]().

Figure 9: Policy Case - Lower Demand Scenario: Energy Impact by Type (GWh)

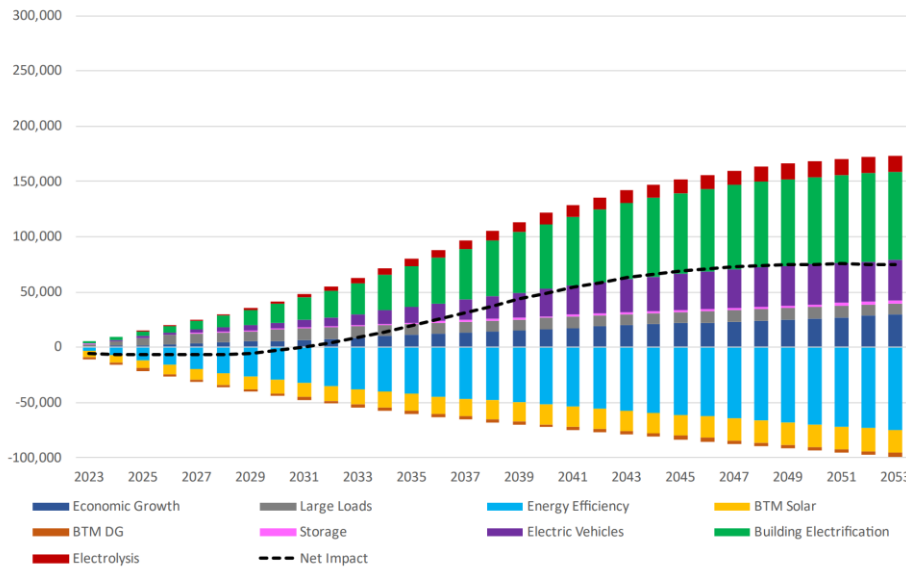
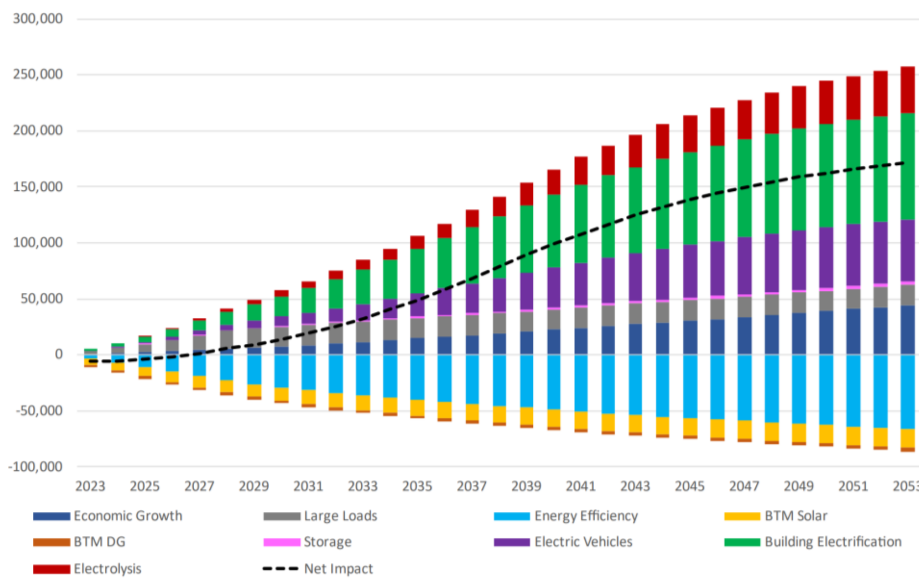
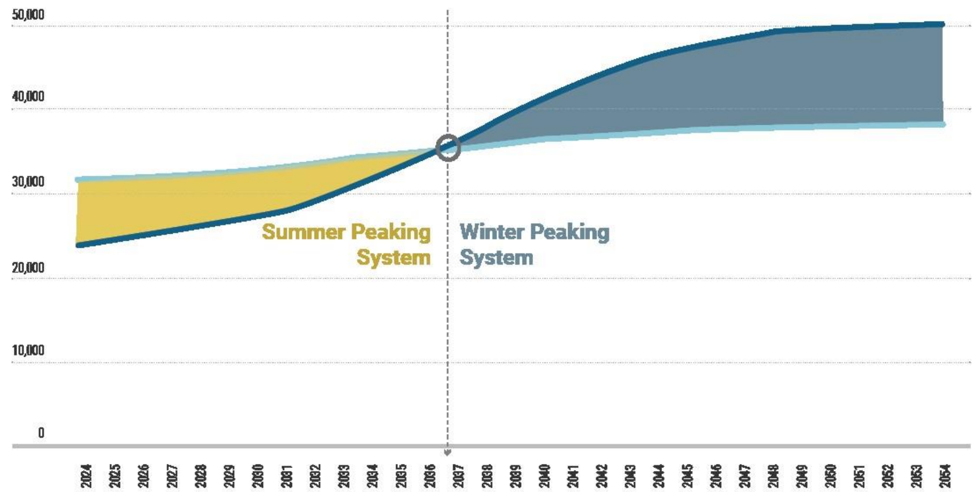


Figure 10: Policy Case - Higher Demand Scenario: Energy Impact by Type (GWh)



New York is currently a summer-peaking system but is projected to transition to a winter-peaking system as CLCPA mandates are pursued and achieved. The timing of the switch is uncertain and will be mainly influenced by the adoption rate and composition of heating electrification. Current projections show the switch to be in the mid to late 2030s. The changing demand pattern, as well as the scale of the increase in demand, will impact the future generation capacity mix and resulting power flows across the system.

Figure 11: Peak Load Forecast for Summer & Winter (MW)



Large Loads

In anticipation of the electrification efforts and economic development in the next two decades, numerous new large loads are expected to interconnect to the New York system, particularly in the upstate and Capital regions. Most of these new loads consist of manufacturing facilities and data centers, as well as hydrogen production operations.

Since 2005, only three large load projects with a total capacity of 310 MW have been connected to the New York system through the NYISO's load interconnection procedures.[15] The number of new load interconnection requests in New York has grown dramatically over the past several years with 15 projects requesting to interconnect a combined total of 3,000 MW of load between 2025 and 2030.[16] It is projected that over the next decade numerous additional manufacturing and data center projects will enter commercial operation and begin consuming relatively large amounts of electricity. The following figure highlights the large loads assumed to be connected in the Base Case.

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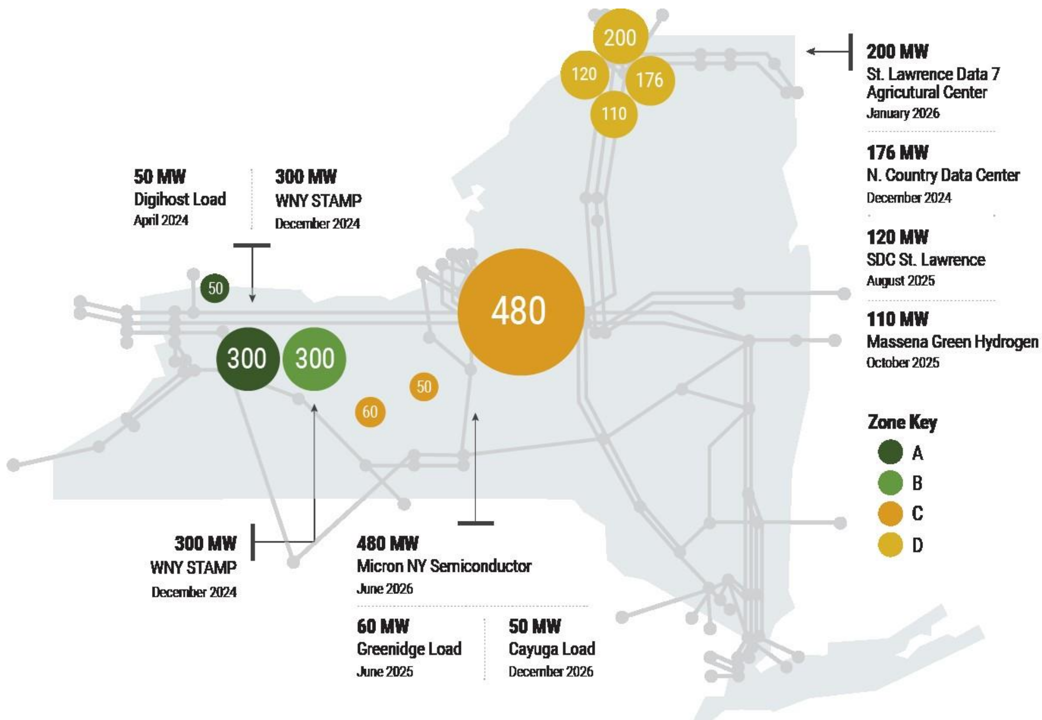
[15] Load interconnections that are subject to the NYISO's procedures include requests that are either (a) greater than 10 MW connecting a voltage level of 115 kV or above or (b) 80 MW or more connecting at a voltage level below 115 kV. Loads that do not meet one of the aforementioned criteria are handled through the Transmission Owner's procedures.

[16] NYISO Interconnection Queue, accessed 5/22/2024, Interconnection Queue Spreadsheet

Figure 12: New York Large Load Projection



All of the cases in this Outlook assume the interconnection of future large loads. The Baseline forecast from the *2023 Gold Book*[17] is assumed in the Base, Contract, and Lower Demand Policy Case scenarios. The Baseline forecast includes the expected load growth from large load projects in the NYISO Interconnection Queue, along with impacts from other significant projects. The Higher Demand Policy Case scenario leverages the Higher Demand forecast from the *2023 Gold Book* to assess higher energy impacts from large loads. The annual energy contributions from these two forecasts are included below.

[17] *2023 Gold Book*.

Figure 13: Large Load Forecasted Energy Contributions in the Outlook[18]

Large Load Energy Forecasts (GWh)		
Year	Baseline	Higher Demand
2025	6,180	7,190
2030	10,030	17,680
2035	10,030	18,100
2040	10,030	18,100
2042	10,030	18,100

While the Outlook includes these large loads in the case assumptions, there could be further economic development projects in New York coming to light in the next decades. Interconnecting these potential economic development projects requires an extensive assessment that best leverages and develops a region's strength and reinforce its value proposition, such as accessibility to labor and land, promotion of job creation, and achievement of environmental mandates. Access to renewable generation resources and a robust transmission network should increasingly be an integral part of the consideration of where to locate large load projects. Moreover, market forces and policy incentives should remain aligned to ensure that large load projects are sited to access low-cost renewable energy while minimizing the burden on the transmission system.

When located appropriately in close proximity to renewable resources, future large loads can benefit from more direct access to renewable energy while the renewable resources themselves can benefit from higher utilization rates. Load that is located close to generation reduces the use of the transmission network whereas load located further away from generation requires the transmission network to deliver energy and is more susceptible to transmission congestion and loss costs. Furthermore, load located nearby renewable resources can more readily absorb excess energy resulting in lower curtailment levels. For instance, there are currently a number of large loads requesting to interconnect in upstate New York. As more fully described in the "Renewable Generation Pockets" section, the large loads in these zones help to decrease local transmission congestion and curtailment in renewable generation pockets, as well as help to reduce bulk transmission congestion on the Dysinger East and Central East interfaces. Absent sufficient renewable generation, the impact of large loads is found to increase CO_2 emissions from existing fossil-fuel generators to meet system demand.

In addition to the location of large loads, the ability for large loads to be flexible in usage is extremely important. This is particularly true during times of peak system demand. Generation capacity in New York

[18] The State Scenario Policy Case leverages the Baseline forecast, with adjustments per DPS and NYSERDA directive.

is secured to ensure that demand can be met at all times, including for new large loads added to the system. The NYISO requires generation capacity above and beyond the maximum load to ensure reliability and resource availability. This means that new large load interconnections will increase the requirement for generation capacity to a value greater than the load. This will have a large impact on the need for new renewable generation and dispatchable emission-free resource capacity.

Enabling load flexibility, or the ability to move load from times of greater system demand to times with lower demand or higher renewable energy production, for new large loads added to the system can significantly reduce the generation capacity buildout required. For every one MW of peak load flexibility enabled, the amount of renewable capacity required is reduced by at least one MW and potentially much more.

Large load projects can also be added to the system at a much faster pace than the new generation projects required to serve them. In the short term, this i) increases the pace required for constructing new renewable generation projects and ii) increases the reliance on existing fossil-fuel generators, which thereby increases CO_2 emissions. The coordination of new large load additions with new generation capacity is very important to policy achievement.

Key Takeaways

- ✓ **Electric energy consumption is projected to increase significantly in response to the economic development and decarbonization energy policies. The resources and transmission system necessary to meet the changing energy demand needs to evolve accordingly.**
- ✓ **Siting large loads in electrical proximity to renewable resources, or siting resources near large loads, may benefit both the loads and the resources, particularly if located upstream of known constraints.**

Resources: Pathways to Policy Achievement

Supply and Demand Analysis

There are many potential paths and combinations of resource, demand, and transmission expansion scenarios to achieve New York's decarbonization and clean energy policy mandates. This Outlook examines five potential futures, which expands the number of scenarios that the NYISO examined in the prior Outlook, to recognize the increased uncertainty from a number of variables. The scenarios enable a holistic evaluation of many potential futures and help stakeholders and policymakers examine various pathways to policy achievement.

Figure 14: Outlook Scenario Diagram

Scenario Capacity & Demand

Assumptions for each future scenario were developed in collaboration with NYISO staff and stakeholders and are intended to provide a wide range of potential outcomes.[19] A summary of many of the key system parameters evaluated, such as energy demand, peak demand, and generation capacity, for each of the Outlook scenarios is detailed below. Resource additions in the Policy Case scenarios represent optimized resource expansions based on the result of the capacity expansion modeling, which is further described in the "System Resources in the Scenarios" section below.

[19] "State Scenario" is based on inputs specified by the New York State Department of Public Service, New York State Energy Research and Development Authority, and Joint Utilities

Figure 15: Outlook Scenarios - 2030 Generation Capacity, Energy, & Peak Load[20]

Capacity and Peak Load 2030 (MW)					
Generator Type	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario	Policy Cases: State Scenario
Nuclear	3,342	3,342	3,342	3,342	3,342
Fossil	25,911	25,911	25,911	25,911	22,424
DEFR	-	-	-	-	-
Hydro	4,868	4,868	4,868	4,868	4,868
LBW	2,951	3,881	3,881	4,403	4,815
OSW	130	6,990	6,990	6,990	6,990
UPV	1,428	8,422	8,422	8,619	11,265
BTM-PV	10,032	10,032	10,153	10,032	8,972
Pumped-Storage	1,405	1,405	1,405	1,405	1,405
Battery Storage	50	290	3,000	3,001	6,000
Total Capacity	50,440	64,196	69,468	70,163	73,080
Summer Peak Load	33,290	33,290	30,490	33,495	29,861
Winter Peak Load	27,816	27,816	29,624	31,467	26,999

Capacity and Peak Load 2030 (MW)					
Generator Type	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario	Policy Cases: State Scenario
Nuclear	3,342	3,342	3,342	3,342	3,342
Fossil	25,911	25,911	25,911	25,911	22,424
DEFR	-	-	-	-	-
Hydro	4,868	4,868	4,868	4,868	4,868
LBW	2,951	3,881	3,881	4,403	4,815
OSW	130	6,990	6,990	6,990	6,990
UPV	1,428	8,422	8,422	12,465	11,265
BTM-PV	10,032	10,032	10,153	10,032	8,972
Pumped-Storage	1,405	1,405	1,405	1,405	1,405
Battery Storage	50	290	3,000	3,001	6,000
Total Capacity	50,440	64,196	69,468	70,163	73,080
Summer Peak Load	33,290	33,290	30,490	33,495	29,861
Winter Peak Load	27,816	27,816	29,624	31,467	26,999

[20] Community Wind is assumed in service starting December 2030 and would be considered incremental to the capacity reported in this figure.

Generation and Energy Demand 2030 (GWh)				
	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario
Nuclear	27,430	27,225	27,279	27,370
Fossil	69,205	40,840	37,975	45,573
DEFR	-	-	-	-
Hydro	27,528	27,189	27,292	27,449
LBW	7,696	10,370	10,440	12,075
OSW	403	29,573	29,557	29,544
UPV	2,672	15,315	15,500	16,188
BTM-PV	11,887	7,494	12,032	11,887
Pumped-Storage	(684)	(1,033)	(1,018)	(1,050)
Battery Storage	(10)	(58)	(148)	(177)
Annual Energy Demand	158,567	158,567	153,043	159,820
HQ Net Imports	21,194	20,856	15,997	16,056
Net Imports	10,146	(4,000)	(6,431)	(8,547)
Curtailment	19	1,670	1,112	501

Generation and Energy Demand 2030 (GWh)				
ıerator Type	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario
Nuclear	27,430	27,225	27,279	27,283
Fossil	69,205	40,840	37,975	42,438
DEFR	-	-	-	-
Hydro	27,528	27,189	27,292	27,080
LBW	7,696	10,370	10,440	11,931
OSW	403	29,573	29,557	29,532
UPV	2,672	15,315	15,500	21,994
BTM-PV	11,887	7,494	12,032	11,887
Pumped-Storage	(684)	(1,033)	(1,018)	(1,103)
Battery Storage	(10)	(58)	(148)	(195)
Annual Energy Demand	158,567	158,567	153,043	159,820
HQ Net Imports	21,194	20,856	15,997	15,882
Net Imports	10,146	(4,000)	(6,431)	(4,766)
Curtailment	19	1,670	1,112	2,791

Figure 16: Outlook Scenarios - 2035 Generation Capacity, Energy, and Peak Load

Capacity and Peak Load 2035 (MW)					
Generator Type	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario	Policy Cases: State Scenario
Nuclear	3,342	3,342	3,342	3,342	3,342
Fossil	25,911	25,911	25,455	25,455	15,022
DEFR	-	-	235	4,332	2,676
Hydro	4,800	4,800	4,800	4,800	4,800
LBW	2,951	3,881	5,325	8,025	8,658
OSW	130	8,260	9,000	9,000	9,000
UPV	1,428	8,422	9,204	9,298	18,963
BTM-PV	11,420	11,420	12,644	11,420	8,973
Pumped-Storage	1,405	1,405	1,405	1,405	1,405
Battery Storage	50	290	3,000	3,228	8,273
Total Capacity	51,761	68,055	71,556	77,904	84,299
Summer Peak Load	35,546	35,546	31,557	36,589	34,033
Winter Peak Load	34,956	34,956	38,297	43,338	37,047

Capacity and Peak Load 2035 (MW)					
enerator Type	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario	Policy Cases: State Scenario
Nuclear	3,342	3,342	3,342	3,342	3,342
Fossil	25,911	25,911	25,455	25,455	15,022
DEFR	-	-	235	4,332	2,676
Hydro	4,800	4,800	4,800	4,800	4,800
LBW	2,951	3,881	5,325	8,025	8,658
OSW	130	8,260	9,000	9,000	9,000
UPV	1,428	8,422	9,204	14,692	18,963
BTM-PV	11,420	11,420	12,644	11,420	8,973
Pumped-Storage	1,405	1,405	1,405	1,405	1,405
Battery Storage	50	290	3,000	3,228	8,273
Total Capacity	51,761	68,055	71,556	77,904	84,299
Summer Peak Load	35,546	35,546	31,557	36,589	34,033
Winter Peak Load	34,956	34,956	38,297	43,338	37,047

Generation and Energy Demand 2035 (GWh)				
	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario
Nuclear	28,324	28,147	28,097	28,204
Fossil	79,333	48,944	38,835	48,908
DEFR	-	-	-	-
Hydro	27,521	27,249	26,955	27,287
LBW	7,696	10,390	14,275	21,360
OSW	404	34,532	35,683	35,681
UPV	2,673	15,428	16,624	17,293
BTM-PV	13,797	13,797	9,609	8,690
Pumped-Storage	(604)	(1,071)	(1,056)	(1,061)
Battery Storage	(10)	(58)	(179)	(212)
Annual Energy Demand	179,261	179,261	172,946	189,794
HQ Net Imports	21,124	20,795	15,785	15,945
Net Imports	18,585	1,304	(345)	58
Curtailment	29	1,478	2,372	1,906

Generation and Energy Demand 2035 (GWh)				
ıerator Type	Base Case	Contract Case	Policy Case: Lower Demand Scenario	Policy Case: Higher Demand Scenario
Nuclear	28,324	28,147	28,097	28,116
Fossil	79,333	48,944	38,835	45,893
DEFR	-	-	-	-
Hydro	27,521	27,249	26,955	26,759
LBW	7,696	10,390	14,275	21,126
OSW	404	34,532	35,683	35,679
UPV	2,673	15,428	16,624	24,312
BTM-PV	13,797	13,797	9,609	13,797
Pumped-Storage	(604)	(1,071)	(1,056)	(1,139)
Battery Storage	(10)	(58)	(179)	(228)
Annual Energy Demand	179,261	179,261	172,946	189,794
HQ Net Imports	21,124	20,795	15,785	15,688
Net Imports	18,585	1,304	(345)	2,727
Curtailment	29	1,478	2,372	6,280

The Generation and Annual Energy Demand figures above portray the amount of generation for each resource type included in the Outlook scenarios. Values reported for pumped and battery storage are the negative net contributions to account for the round-trip efficiency losses of these resources over the course of a year. Additionally, net imports from Hydro-Québec (HQ) are assumed to be renewable hydro power for the purposes of modeling policy mandates. The net imports reported are incremental to the HQ net imports and represent the remaining transfers with the other neighboring systems.

Renewable Resource Characterization

The characterization and representation of hourly renewable energy generation production is an important feature of the models used in the Outlook. In recognition of this, the NYISO integrated significant improvements into this Outlook compared to prior studies. Over twenty years of hourly data for site-level generators in New York were aggregated by zone and technology type to create inputs to the zonal capacity expansion model as a key input to inform potential generator additions.

The tables below are intended to help summarize and visualize the extensive dataset used by the NYISO for this Outlook. The first table shows a "heatmap" for the combined land-based wind, offshore wind, and utility scale solar net capacity factor by month and hour for the Contract Case in year 2030. The second table then overlays this information with the forecasted gross load to quickly show both very low-load periods (lighter color, hours 11-12 in April) and high-load periods (darker color, hour 19 in July).

Figure 17 "12x24" Average Net Capacity Factors of Combined Wind and Solar Generation and Net Loads (GW): 2030 Contract Case

Utility-Scale Wind and Solar Resources

2000-2021	Hour Beginning																								
Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Mean
January	32%	32%	31%	30%	30%	30%	30%	30%	38%	43%	43%	43%	43%	42%	41%	40%	32%	29%	31%	32%	33%	33%	33%	33%	35%
February	31%	31%	30%	30%	29%	29%	29%	33%	44%	46%	47%	46%	46%	46%	45%	45%	38%	29%	29%	31%	32%	32%	32%	32%	36%
March	31%	31%	30%	30%	29%	29%	31%	42%	49%	50%	51%	51%	50%	50%	50%	49%	45%	34%	29%	30%	31%	31%	32%	32%	38%
April	31%	30%	30%	29%	28%	29%	39%	48%	51%	52%	53%	53%	53%	52%	51%	50%	48%	40%	29%	29%	30%	30%	31%	31%	39%
May	27%	27%	26%	26%	25%	29%	40%	45%	47%	48%	49%	49%	49%	48%	48%	47%	45%	40%	30%	25%	26%	27%	27%	27%	37%
June	25%	24%	23%	23%	22%	28%	38%	41%	44%	45%	46%	47%	48%	48%	48%	47%	45%	41%	32%	24%	25%	25%	25%	25%	35%
July	20%	19%	19%	18%	17%	22%	33%	38%	41%	42%	44%	45%	45%	45%	45%	44%	42%	38%	28%	20%	21%	21%	21%	21%	31%
August	18%	17%	17%	16%	16%	17%	27%	35%	38%	40%	42%	43%	43%	43%	42%	40%	38%	32%	20%	17%	18%	19%	19%	18%	28%
September	21%	20%	20%	20%	20%	19%	26%	38%	41%	42%	43%	43%	43%	42%	41%	40%	36%	24%	18%	19%	20%	21%	21%	21%	29%
October	27%	27%	26%	26%	25%	25%	26%	36%	41%	42%	42%	42%	42%	42%	41%	40%	31%	24%	25%	26%	27%	27%	27%	28%	32%
November	29%	29%	28%	28%	27%	27%	26%	30%	39%	40%	41%	41%	40%	40%	39%	36%	27%	26%	27%	29%	29%	30%	30%	30%	32%
December	31%	30%	30%	29%	29%	28%	28%	28%	35%	38%	39%	39%	39%	38%	38%	34%	28%	29%	30%	31%	32%	32%	32%	32%	33%
Mean	27%	26%	26%	25%	25%	26%	31%	37%	42%	44%	45%	45%	45%	45%	44%	43%	38%	32%	27%	26%	27%	27%	27%	27%	34%

Average Net Load (GW)

2000-2021	Hour Beginning																								
Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Mean
January	12.7	12.2	11.9	11.9	12.3	13.2	14.8	15.9	14.2	12.7	12.0	11.5	11.4	11.8	12.5	13.9	17.5	19.5	19.6	18.9	18.0	17.1	15.6	14.2	14.4
February	11.8	11.3	11.0	11.0	11.3	12.2	13.7	13.8	11.3	10.3	9.5	9.1	9.0	9.1	9.7	10.9	13.9	17.7	18.4	17.8	16.9	15.8	14.4	13.1	12.6
March	9.9	9.4	8.7	9.1	9.4	10.3	11.1	9.2	7.3	6.4	5.6	5.3	5.2	5.3	5.8	7.0	9.2	13.3	15.4	15.4	14.7	13.7	12.3	11.0	9.6
April	7.9	7.4	7.0	7.0	7.2	7.7	6.3	4.5	3.7	3.0	2.3	1.9	1.9	2.3	3.0	4.2	6.0	9.1	12.3	12.6	12.3	11.4	10.2	8.9	6.7
May	8.5	7.9	7.5	7.4	7.6	6.9	5.0	4.4	3.9	3.4	2.9	2.7	3.0	3.5	4.3	5.4	7.0	9.1	12.1	13.2	12.9	12.2	11.0	9.7	7.1
June	11.3	10.5	10.1	9.8	9.9	8.6	6.8	6.4	6.1	5.8	5.5	5.5	5.8	6.4	7.3	8.6	10.3	12.2	14.7	16.4	15.9	15.4	14.2	12.7	9.8
July	15.9	15.0	14.4	14.0	14.0	13.1	11.0	10.4	10.4	10.5	10.6	10.9	11.6	12.5	13.7	14.9	16.6	18.6	21.3	22.7	21.7	20.8	19.1	17.5	15.1
August	15.0	14.1	13.5	13.1	13.2	13.3	11.4	10.0	9.7	9.4	9.2	9.4	9.9	10.8	12.0	13.3	15.2	17.6	20.6	20.8	20.1	19.1	17.7	16.3	14.0
September	10.9	10.2	9.7	9.4	9.5	10.1	9.5	7.0	6.2	5.7	5.3	5.3	5.6	6.4	7.2	8.6	10.9	14.5	16.1	16.0	15.2	14.3	13.1	11.8	9.9
October	8.7	8.2	7.8	7.7	7.9	8.8	9.9	8.4	6.8	6.2	5.6	5.4	5.5	6.0	6.6	7.9	11.1	13.7	14.2	13.9	13.1	12.1	10.9	9.6	9.0
November	9.2	9.0	8.4	8.3	8.6	9.5	11.0	11.0	8.7	7.8	7.2	6.9	7.0	7.7	8.5	10.6	14.1	15.4	15.4	14.7	13.8	12.8	11.5	10.3	10.3
December	11.2	10.6	10.3	10.2	10.5	11.4	12.9	13.9	12.5	11.4	10.8	10.5	10.5	11.0	11.7	13.6	16.7	18.0	17.9	17.2	16.3	15.2	13.9	12.5	12.9
Mean	11.1	10.5	10.0	9.9	10.1	10.4	10.3	9.6	8.4	7.7	7.2	7.0	7.2	7.7	8.5	9.9	12.4	14.9	16.5	16.6	15.9	15.0	13.7	12.3	11.0

The relationship between weather dependent renewable generation and the increasingly weather dependent electric energy consumption will be an important feature of system planning and operations to consider during the transition of the grid. For instance, net loads show highest in the winter and summer after the sunset hours and lowest in the mid-day spring and fall.[21]

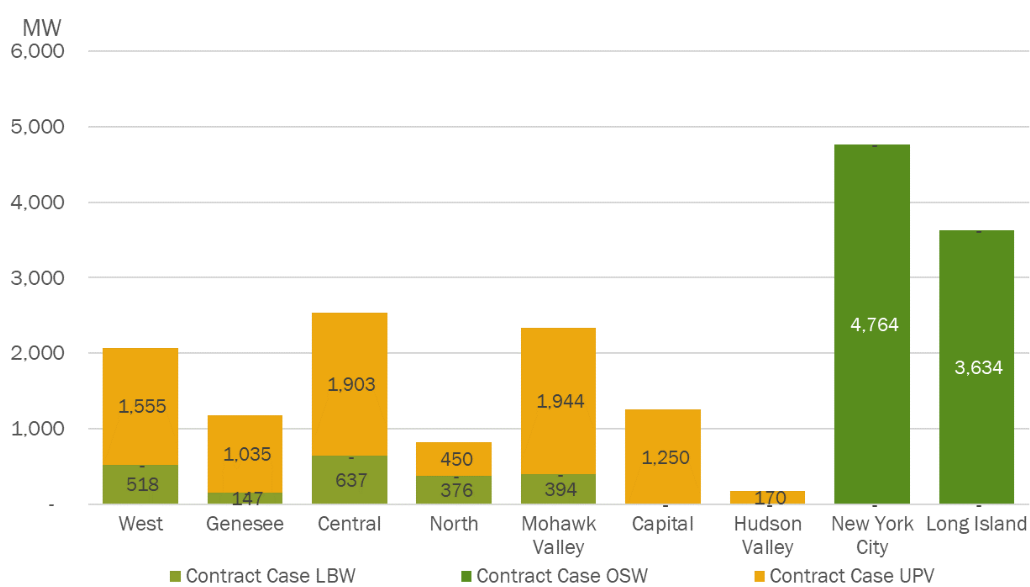
More details on the renewable profiles characterization and comparison to load shapes are discussed in the Appendix E: Renewable Profiles and Variability.

System Resources in the Scenarios

The five scenarios evaluated in this Outlook examine a range of system conditions to simulate various futures as New York State approaches its clean energy mandates prescribed in the CLCPA. As noted above, the Base and Contract Cases include limited new resources and show incremental progress in the near term towards the clean energy transition. The three scenarios evaluated in the Policy Case assess full achievement of policy objectives through various future conditions.

The Outlook assumes a set of resources as firm additions in the near term and does not contemplate attrition of these resources. These resources are informed by NYSERDA awards and represent approximately 16 GW of new renewable resources assumed as in-service by 2030 to support the achievement of the 70x30 mandate.[22] The majority of new land-based wind projects are located in the West, Central, and Mohawk Valley load zones, while utility solar is more evenly distributed among all of the upstate zones. The figure below shows the breakdown of these renewable resource additions by zone.

Figure 18: Renewable Generation Capacity Modeled as Firm Additions



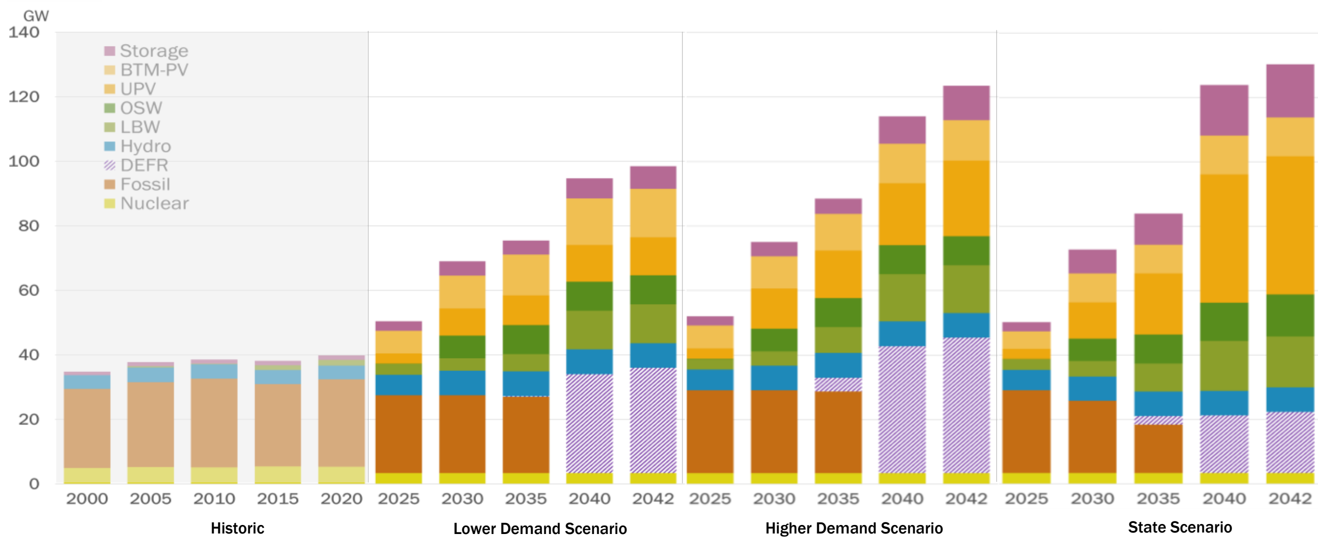
[21] Net load is calculated over a 22-year period using the same load in each year but with varying the renewable energy shapes for each of the years in the 22-year historic period.
[22] The generators assumed as firm new resources align with those deemed as "awarded" status of the lockdown date for this Outlook—October 30, 2023. A reduction in the amount of "awarded" resource additions would subsequently result in incremental new generation projected in the Policy Case scenarios to comply with policy mandates for this case.

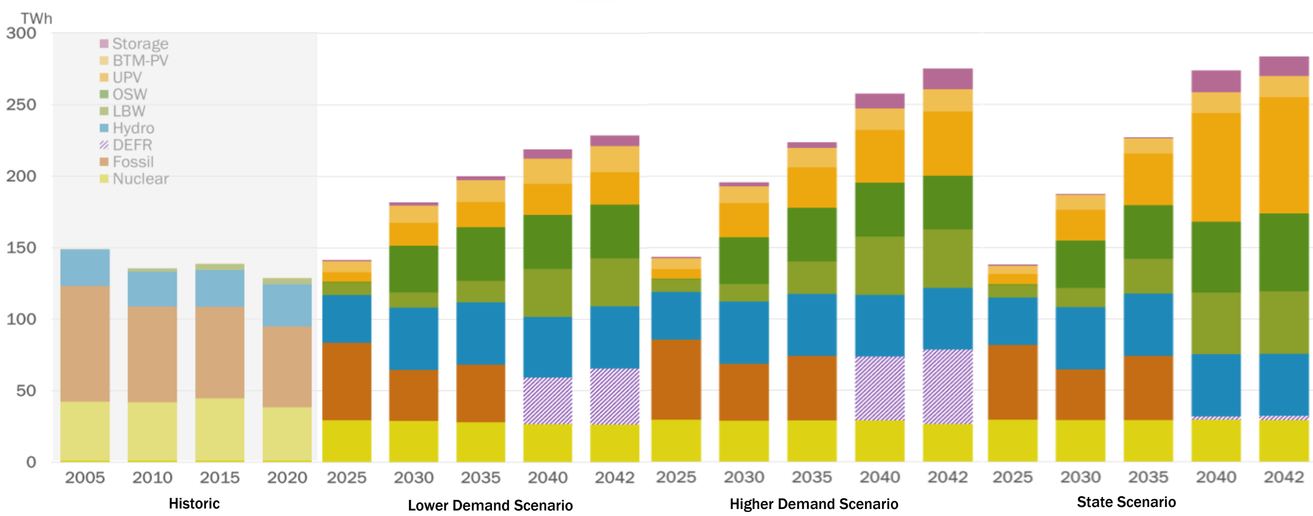
Three of the scenarios in this Outlook postulate and examine distinct futures that explicitly adhere to New York policy mandates over the next two decades. This enables the NYISO to evaluate potential resource mixes, above and beyond the resources assumed as firm additions. The NYISO has modeled all fossil-fuel units as retired by 2040 under the assumption that these generators would no longer be able to operate to comply with the zero-emissions grid mandate. Existing zero-emitting generation, such as nuclear, hydro, LBW, and UPV, is assumed to remain operational in the NYCA throughout the study horizon.

The total installed generation capacity to meet policy objectives in New York is projected to range between 100 GW and 130 GW by 2042 for the scenarios evaluated in this Outlook. The differences in timing and type of resource additions between the various futures are mainly driven by projected load growth, potential resource types for future generation, and the assumed costs of generation. For example, the State Scenario assumes that DEFRs are represented as hydrogen-powered units with corresponding electrolysis loads in upstate and, also allows the expansion of headroom to accommodate incremental generation.

The NYISO estimates that the generation capacity required to achieve CLCPA mandates will be about three times the capacity of the current New York generation fleet, while the electric energy consumption is expected to increase by roughly 50% to 90%. The scale of and pace at which new generation will be needed on the system to satisfy these policy mandates, projected demand, and estimated capacity reserve margins is unprecedented. The figures below show a comparison of the historic generation capacity and annual NYCA generation starting in 2000 and extending through year 2042.

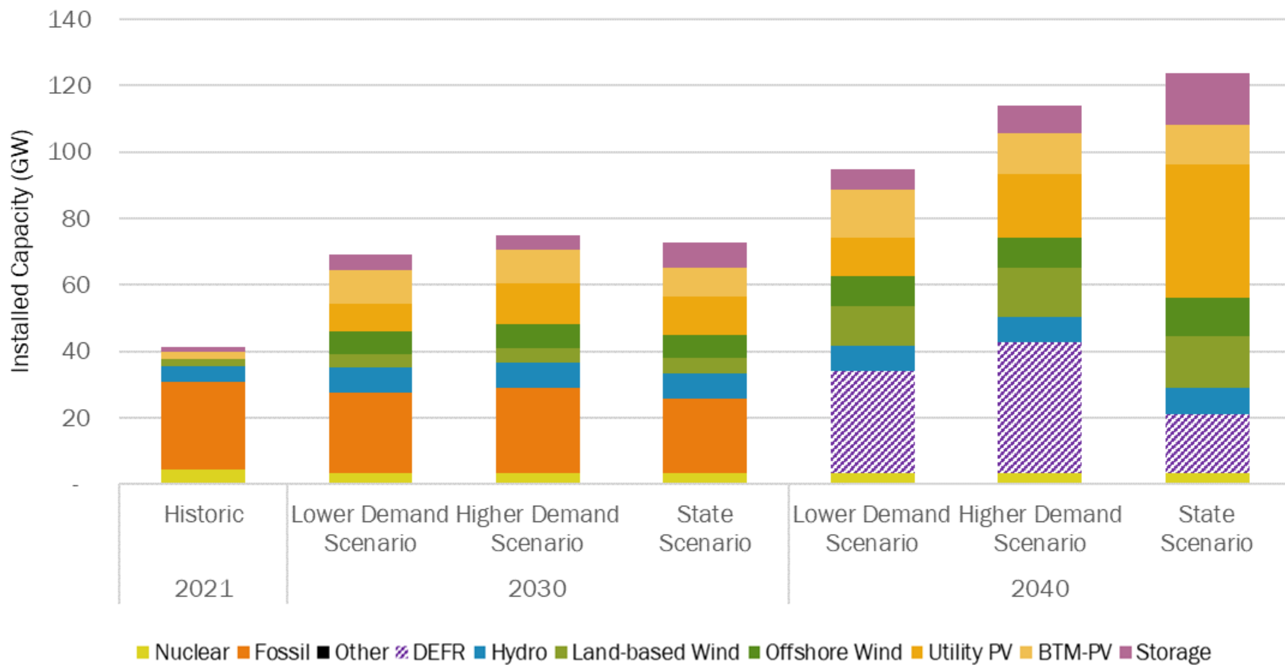
Figure 19: NYCA Installed Capacity and Annual Generation: Past and Projected for each Policy Case Scenario





All of the scenarios show that a significant amount of renewable generation capacity will be needed to achieve CLCPA mandates, such as 70x30, and that DEFRs will be required to support the system in the longer term. Key drivers of the amount and types of new generator builds are the capital costs of generators, the maximum potential of resources (e.g., geographic locations, land use, etc.) based on technology type, and resource capacity factor. Consistent with the prior Outlook, the amount of new DEFR capacity is projected to be similar in magnitude to the fossil capacity currently on the system to provide the capacity, energy, and other essential grid services to support a zero-emitting grid. Additional detail on the impact of DEFRs is included in the following sections.

Figure 20: Comparison of NYCA Installed Capacity for Policy Case Scenarios

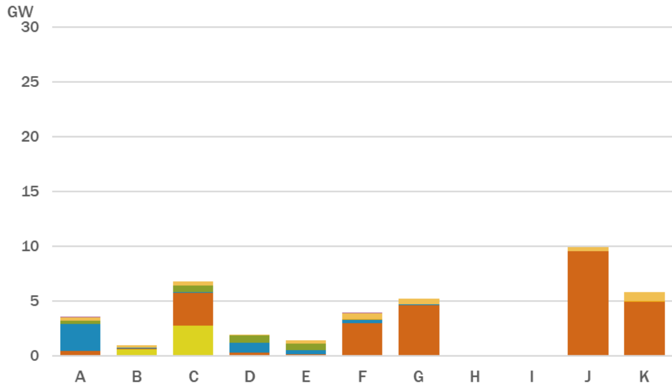


Geographic Distribution of New Resources

The amount of new resource capacity projected in this Outlook is informed by extensive modeling and analyses. One of the primary drivers in projecting new resources is the assumed capital cost investment for each resource type. The NYISO uses locational-specific costs to reflect different cost profiles of developing technologies in various areas of the state. As compared to the Lower and Higher Demand scenarios in the Policy Case, the State Scenario assumes additional cost options for renewable resources to represent more granular cost assumptions in a zonal model. This assumption will impact the zonal placement of new generators and the transmission development opportunities to support those renewable resources.

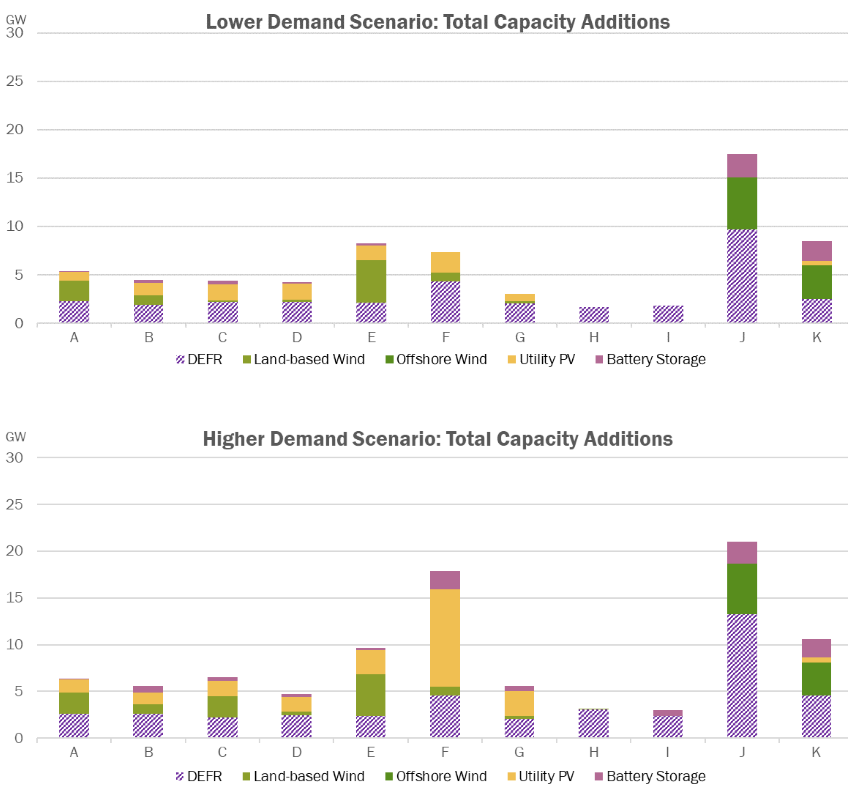
The following figures show the generation capacity on the system, as of 2022, and projected capacity additions for three of the scenarios evaluated in this Outlook. As compared to the current system, all three scenarios project a significant increase in the amount of renewable resources and DEFRs over the next twenty years as the system evolves to comply with policy mandates.

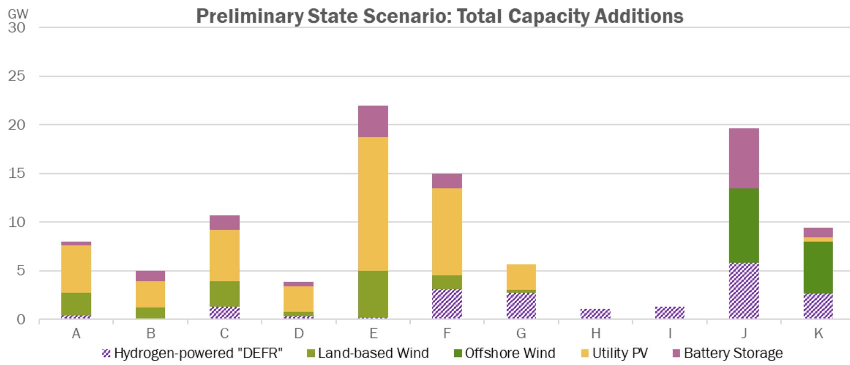
Figure 21: Existing System: 2022 Installed Capacity by Zone



Source: 2022 Gold Book

Figure 22: Policy Case Scenarios: 2042 Installed Capacity by Zone





Placement of New Resources

The footprint of renewable generation resources can be much more substantial than fossil-fuel generators. Combined with the large amount of total power that must be derived from new renewable generation to achieve the CLCPA mandates, the potential acreage required to install these resources will be significant and likely will result in uncertainty for siting. For example, a utility-scale solar plant typically needs approximately between 3 to 5 acres of land per MW of generating capacity and land-based wind typically needs approximately 15 acres per MW, while 25 acres of land could accommodate a 1,000 MW (1 GW) combined cycle power generator. Siting of a renewable generation resource, therefore, requires not only a location with an abundance of the natural resources to serve as fuel (i.e., solar or wind) but also sufficient access to land to accommodate the footprint of the facility. Considerations of the land use for each resource type is taken into account for potential new resource additions in each of the scenarios.

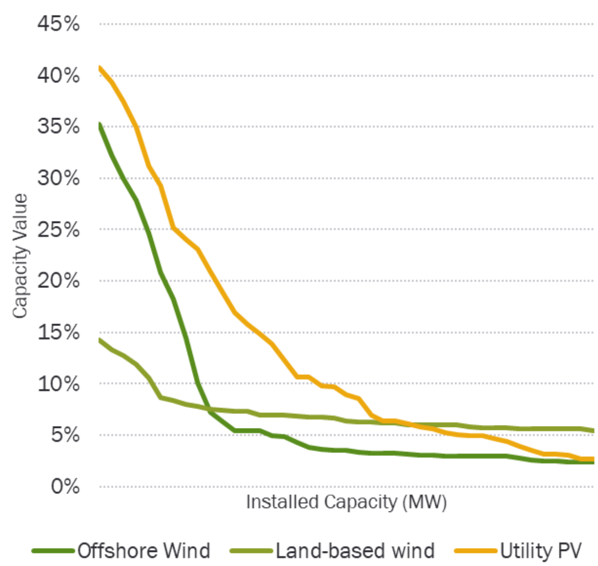
In addition to land availability, electrical connectivity is a major factor in determining where future resources will be located. In this Outlook, the NYISO leveraged information on proposed projects from the interconnection queue to inform points of interconnection for new renewable and storage resources evaluated in each scenario. DEFRs are placed on electrical locations on the bulk system (230 kV and above) in accordance with the zonal capacity additions determined through the capacity expansion model. Additional detail on the placement of new resources is included in Appendix D: Modeling & Methodologies.

Beyond 2040

While New York's electric sector mandates have a horizon year of 2040, the economy-wide decarbonization mandates in the CLCPA extend through 2050. This means that between 2040 and 2050, demand will continue to increase as electrification continues. The scenarios in this Outlook project a minimum increase of 3 GW of additional incremental generation capacity between 2040 and 2042, purely driven by load growth. The Policy Case scenario forecasts project additional demand growth between 20-60 TWh from 2040 to 2050. The need for new resources will continue well beyond 2040 to support the continually evolving grid.

One complex challenge that needs to be considered beyond 2040 is the relative ineffectiveness of new solar and wind resources to contribute during periods of reliability risk after a significant amount of capacity has been built. The NYISO included dynamic capacity value curves (ELCC curves) in its modeling to account for this phenomenon. An illustrative example of these types of declining capacity value curves is included below and show that renewable resources in New York are generally valued below 10% of their capacity rating at higher levels of adoption.

Figure 23: Renewable Resource Dynamic Capacity Value Curves: Illustrative Example[23]



Beyond 2040, this observation emphasizes the need for high-capacity value DEFR technologies to meet continued peak demand shifts and growth due to electrification as the renewable resources become increasingly ineffective to meet peak load.

Dispatchable Emission-Free Resources

Consistent with the findings in the prior Outlook, this Outlook continues to show that dispatchable emission-free resources must be developed and deployed throughout New York to support a zero-emissions grid. Specifically, there remains a need for additional supply beyond renewables and storage

[23] The Brattle Group, Presentation: *New York's Evolution to a Zero Emission Power System* (June 22, 2020), at slide 111, https://www.nyiso.com/documents/20142/13245925/Brattle%20New%20York%20Electric%20Grid%20Evolution%20Study%20-%20June%202020.pdf/

resources to be dependable during peak demand periods and when the output of renewable resources is low.

While essential to the grid of the future, such DEFR technologies do not exist as a single specific commercially viable technology option today and may be in various phases on the path from research and development to become a scalable market resource.[24] However, the needs that DEFRs will address (e.g., operating reserves, ramping, flexibility, dispatchability, etc.) can be satisfied by a combination of resources as opposed to one specific technology. In the aggregate, a collection of DEFR technologies may sufficiently provide the grid services necessary to replace the existing fossil-fuel generation fleet.

This Outlook shows that at least 20 GW, and upwards of 40 GW, of DEFRs would be required by 2040 to support the zero-emissions grid mandate. The NYISO evaluated three different scenarios to assess various resource mixes to satisfy full achievement of CLCPA policies and determined that a combination of DEFR technologies is more optimal to mitigate significant overbuild of renewable resources to support a zero-emissions grid. When limited to a single DEFR option, as in the State Scenario, there are impacts to the types and scale of other resources selected to meet energy needs. The State Scenario explicitly limits its DEFR option to be a hydrogen-powered combined cycle or combustion turbine unit, which has a comparably high operating cost and incurs additional electrolysis load on the system to generate energy. Preliminary results of the State Scenario indicate that this could be a disincentive for the hydrogen-powered DEFR to run on a regular basis to generate energy, while significantly more renewable generation capacity is needed on the system to support the peak demand and annual energy needs.

DEFRs are found to be built to support both capacity and energy needs in a system with high renewable penetration; the extent to which depends on the relative costs for each DEFR option compared to other resource types. The Outlook results show an increased reliance on these resources to also provide emission-free energy in the long term to support a high renewable system. Such increased reliance is driven by the forecasted hourly profile of demand and limitations on energy storage technology duration. In this Outlook, hydrogen-powered DEFRs operate at a much lower capacity factor due to their high operating costs and increase in demand relative to other generator options. See Appendix F: Dispatchable Emission-Free Resources and Appendix H: Capacity Expansion Scenario Results for additional information.

[24] https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=15-e-0302&CaseSearch=Search

Figure 24: Dispatchable Emission-Free Resource 2040 Capacity and Generation

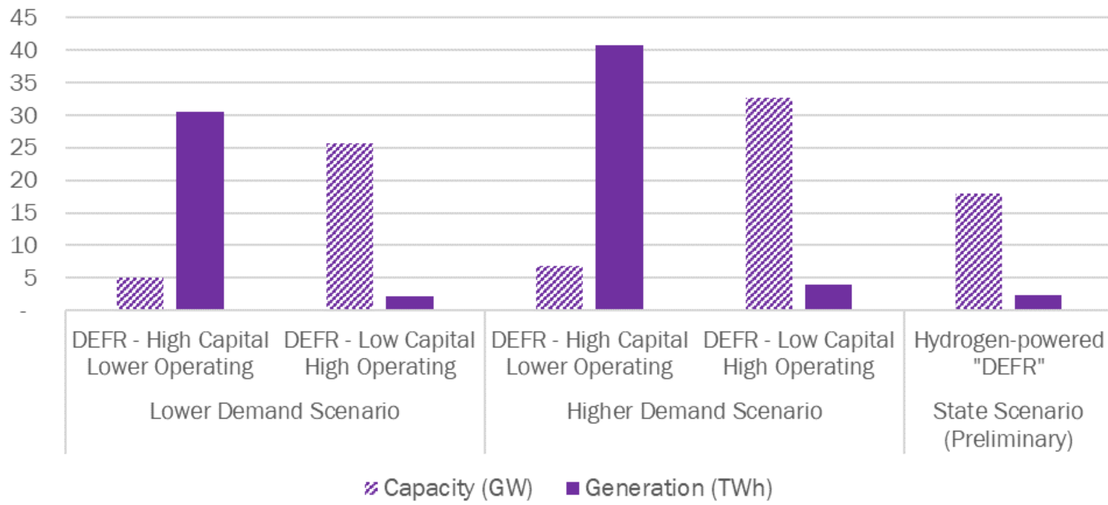
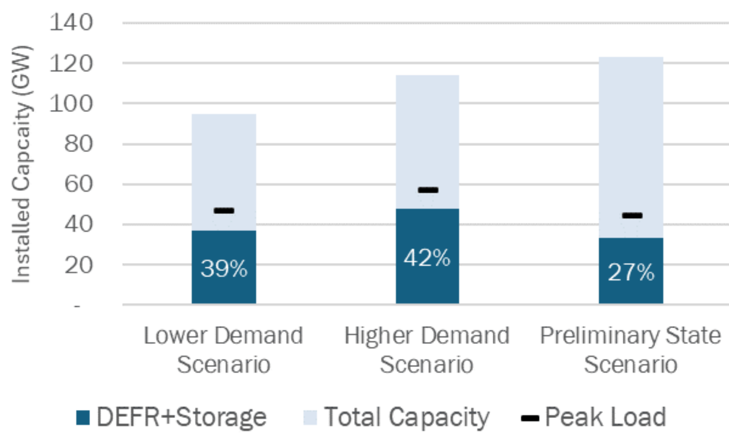


Figure 25: Dispatchable Emission-Free Resource & Storage 2040 Capacity and Percentage

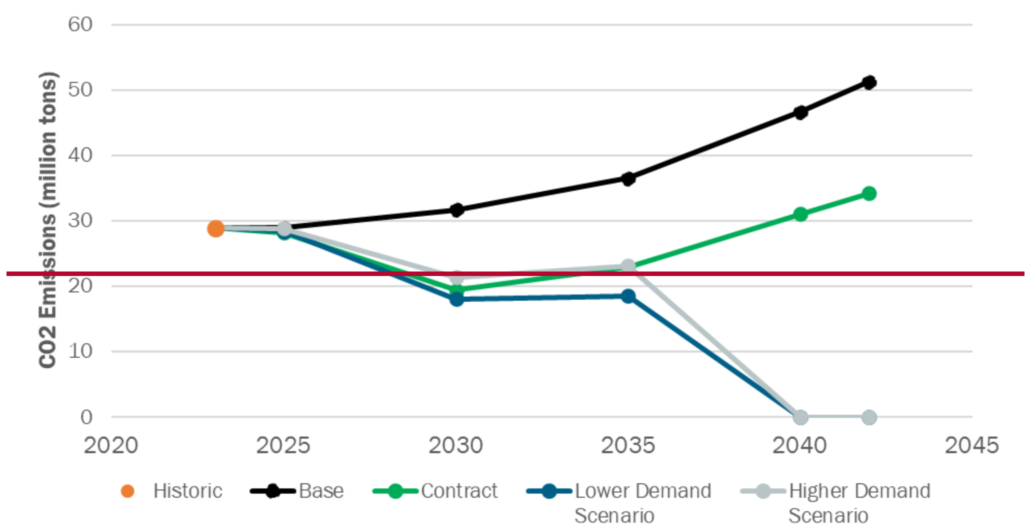


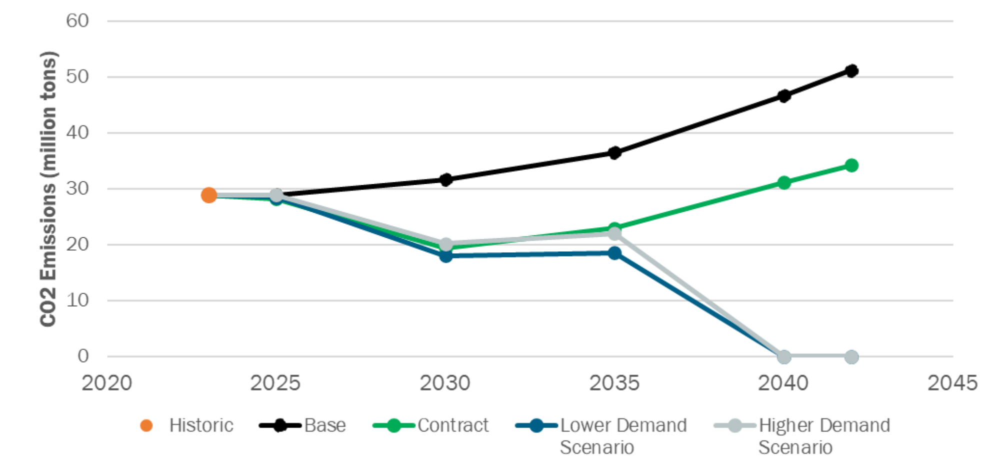
System Performance

As part of the evaluation of the potential generation capacity mixes in future years, the Outlook quantifies system performance through various metrics. Some of the key considerations include, but are not limited to: reductions in fleetwide CO_2 emissions, changes in net-load ramping requirements, and quantifying potential resource curtailment.

Absent additional clean energy resources to displace CO_2 emitting resources, emissions are projected to increase from existing units to help serve projected energy demand increases. Three of the Outlook scenarios include explicit achievement of the CLCPA mandates and optimize new generation additions to meet the policies efficiently. Analysis shows that the integration of renewable generation and DEFR technologies on the system will displace energy production from fossil-fuel generators as full policy achievement is approached.

Figure 26: Estimated Annual New York CO_2 Emissions by Scenario





New York's dispatchable generation resources are expected to encounter a drastic increase in flexibility requirements necessitated by a system driven by changes in both weather and electric demand driven by human behavior. Analysis of the net load ramp profiles inform of the hourly and seasonal trends for ramping, both up and down, that will be required of the dispatchable generation fleet. Additional detail on this analysis can be found in Appendix E - Renewable Profiles & Variability.

Not all of the renewable energy is found to be deliverable, as a result of resource curtailment driven by transmission constraints. The location of renewable resources relative to load is a key driver in its ability to deliver its capability. Additional detail on renewable energy curtailment and congestion is included in the "Renewable Generation Pockets" section below.

Key Takeaways

- ✓ **Dispatchable Emission-Free Resources must be developed to provide the capacity, energy, and other essential grid services required to achieve the policy mandate for a zero-emissions grid by 2040.**
- ✓ **New York will require three times the capacity of the current New York generation fleet to meet projected future electricity demands.**
- ✓ **The coordination of new generator additions and existing generator retirements is essential to maintain the reliability of the New York power system while simultaneously pursuing achievement of CLCPA.**
- ✓ **Uncertainty in siting new renewable generation could lead to delays in or inefficient expansion of the transmission and distribution systems.**

Transmission: Opportunities for Efficiency

Transmission expansion is critical to facilitating efficient achievement of the CLCPA. A historic level of investment in the transmission system is already happening. Transmission projects that are either planned or under construction will deliver more clean energy to consumers while enhancing grid resilience and reliability. However, as an increasing number of intermittent generation resources connect in the future, renewable generation pockets and bulk transmission interfaces throughout the state will become more constrained once again, necessitating further transmission upgrades to make renewable energy deliverable.

Renewable Generation Pockets

Renewable generation pockets have been evaluated in NYISO's Economic Planning Process since 2019. The pocket concept provides an effective mechanism to quantify and describe the electrical interaction between generation resources in a specific geographic area to the surrounding transmission network. For consistency of reporting, the NYISO names pockets based on recognizable geographic locations in New York State and has remained consistent throughout its planning cycles. Each pocket depicts a geographic grouping of renewable generators and transmission constraints in a local area that are further focused into sub-pockets. Renewable generation pockets are depicted in Figure 27 below.

In this Outlook, a renewable generation bulk transmission map is introduced to capture potential curtailment risks associated with bulk transmission congestion. Renewable generation curtailment can be caused by transmission congestion at both local and bulk levels. Generally, as local transmission projects increase the connectivity of renewable generators to the larger network, bulk transmission can become the limiting factor to transferring renewable energy and can result in curtailment. Renewable generation bulk transmission paths are depicted in Figure 28 below.

Figure 27: Renewable Generation Pocket Map

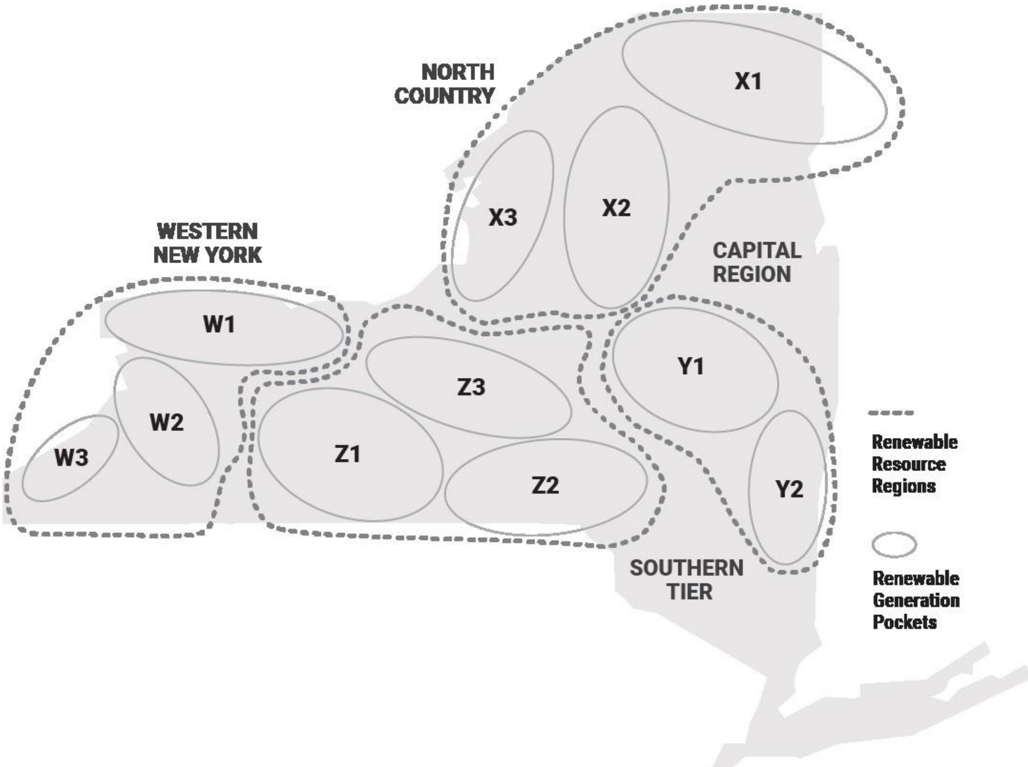
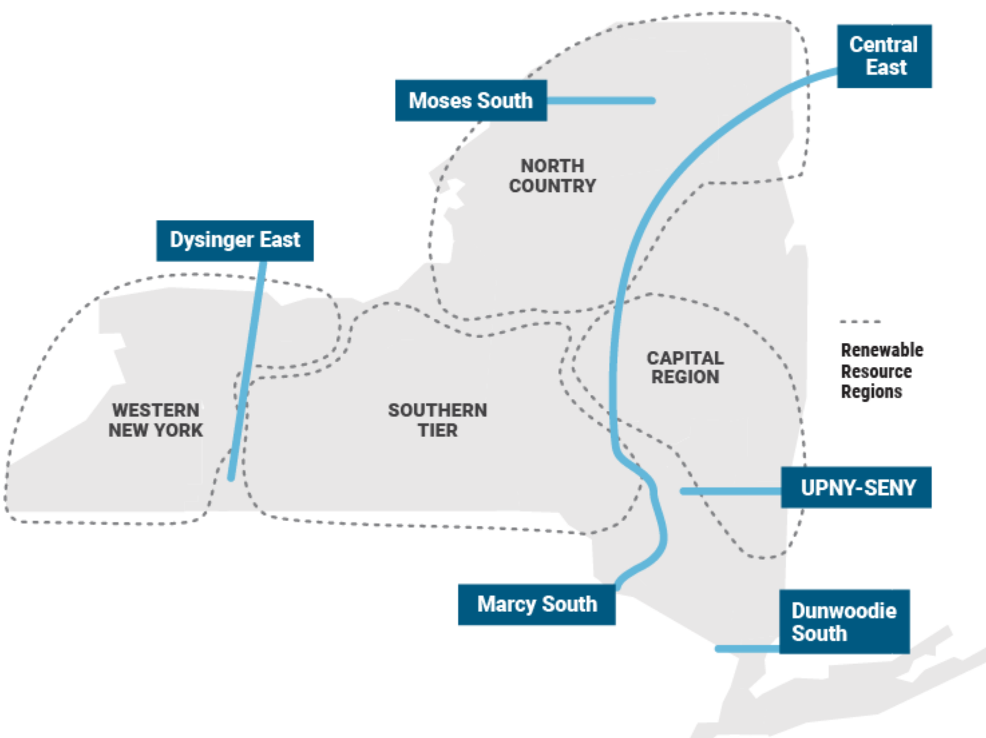


Figure 28: Renewable Generation Bulk Transmission Map



The generation pocket assignments are defined by two main considerations: renewable generation buildout location and the congestion results from the Outlook cases. Each pocket (W, X, Y, and Z), along with corresponding sub-pockets (W1, X2, Y1, etc.), depicts a geographic grouping of renewable generation and the transmission constraints in discrete local areas. The names and brief descriptions of each pocket are listed below, while detailed descriptions, including identification of the specific transmission lines and resources that make up each pocket, are included in Appendix J: Renewable Generation Pockets.

- **Western NY (Pocket W)**: Western NY constraints, mainly 115 kV in Buffalo and Rochester areas:
  1) **W1**: Orleans-Rochester Wind (115 kV)
  2) **W2**: Buffalo Erie region Wind & Solar (115 kV)
  3) **W3**: Chautauqua Wind & Solar (11 5kV)
- **North Country (Pocket X)**: Northern NY constraints, including the 230 kV and 115 kV facilities in the North Country:
  1) **X1**: North Area Wind (mainly 230 kV in Clinton County)
  2) **X2**: Tug Hill Plateau Wind & Solar (mainly 115 kV in Lewis County)
  3) **X3**: Watertown Wind & Solar (115 kV in Jefferson & Oswego Counties)
- **Capital Region (Pocket Y)**: Eastern NY constraints, mainly the 115 kV facilities in the Capital Region:
  1) **Y1**: Capital Region Solar Generation (115 kV in Montgomery County)
  2) **Y2**: Hudson Valley Corridor (115 kV)
- **Southern Tier (Pocket Z)**: Southern Tier constraints, mainly the 115 kV constraints in the Finger Lakes area:
  1) **Z1**: Finger Lakes Region Wind & Solar (115 kV)
  2) **Z2**: Southern Tier Transmission Corridor (115 kV)
  3) **Z3**: Central and Mohawk Area Wind and Solar (115 kV)

In addition to the assumption of new renewable generation projects, the NYISO assumed a number of transmission and distribution upgrades. Since the NYISO completed the prior Outlook, significant LT&D upgrades in New York have been approved by the NYPSC, including the Phase 1 and 2 local transmission upgrades and the Brooklyn Clean Energy Hub.[25] To account for these proposals, the NYISO included these projects as firm LT&D upgrades in many of the scenarios in this Outlook.

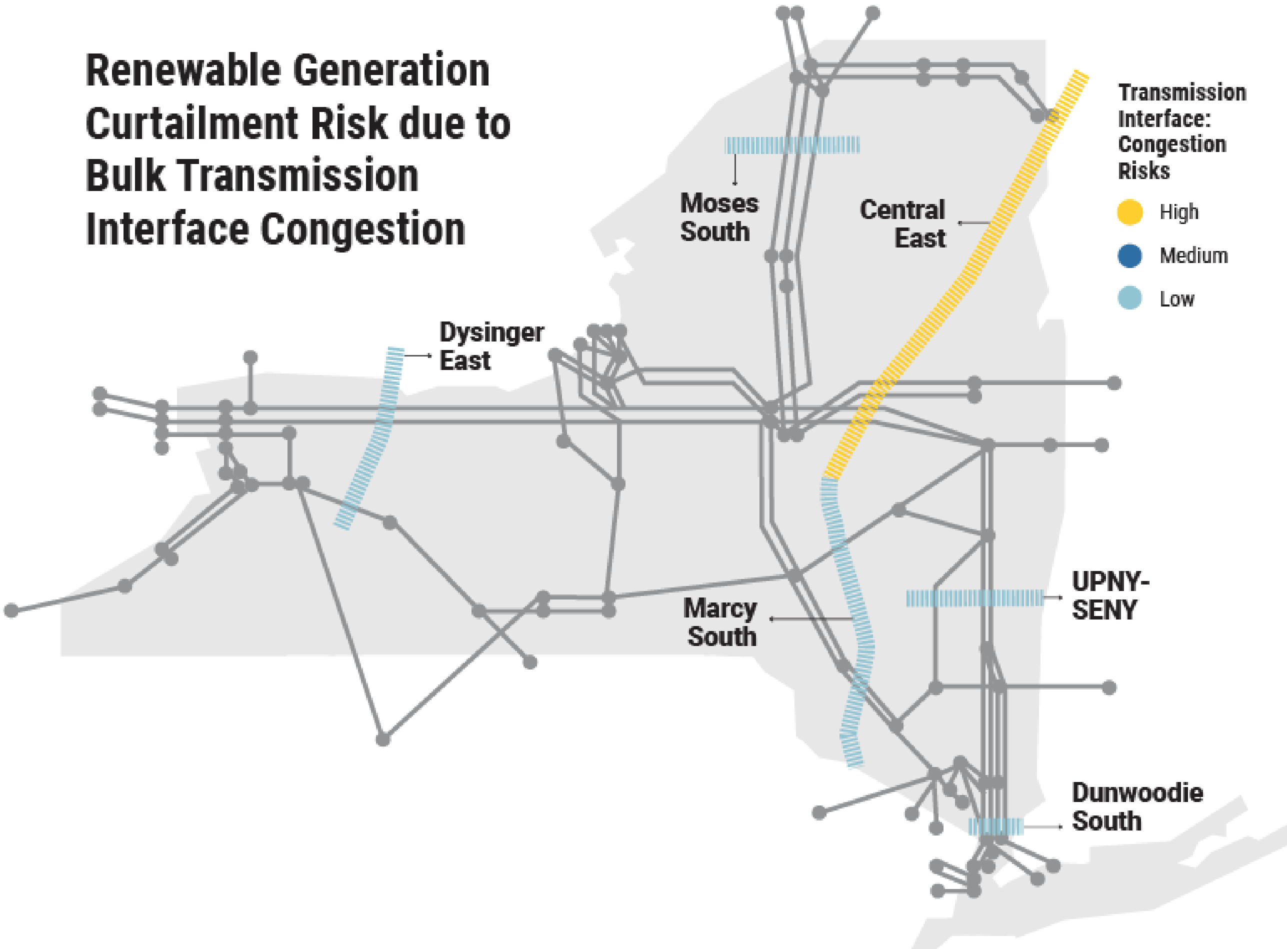
With changes to the system, such as generation mix, demand, and LT&D upgrades, the renewable generation pockets are evolving. In some instances, load growth and LT&D upgrades lead to a reduction in

[25] https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b0C1FE2AF-2922-4BF5-809C-5C93F4F73121%7d

resource curtailment within renewable generation pockets. The New York utilities' approved Phase 1 and 2 local transmission upgrades are found to be highly effective in increasing energy deliverability of resources and decreasing congestion on the lower kV system. On the other hand, increased penetration of renewable resources in the near term to achieve New York policy drives increased competition on the system and increases the risk of renewable curtailment. Through the use of renewable generation pockets, this Outlook identifies (1) transmission constraints on the system, (2) quantifies energy deliverability, and (3) identifies the relative risk of renewable curtailment for years 2030 and 2035.

As local pocket constraints are alleviated by LT&D upgrades, more renewable generation flows onto the bulk grid again and becomes constrained at historically congested bulk transmission pathways. While local transmission projects are effective in solving congestion and curtailment in the near term, bulk transmission constraints will become the limitation for efficient transmittal of renewable energy beyond 2030. The bulk transmission map below shows the major bulk transmission corridors in the NYCA and highlights the congestion risks identified in the Policy Case beyond 2030.

Figure 29



In this Outlook, the extent of LT&D upgrades included are assumed to be in service by 2030. Since the NYISO does not assume additional transmission upgrades in the later years of the study, there can be additional congestion and renewable resource curtailment in the pockets due to increased renewable generation capacity to meet policy objectives, as evaluated in the Policy Case. However, there are additional factors that impact the energy deliverability, such as the scale of load growth (including large loads), which is shown to have a correlation with higher energy deliverability in some of the Outlook scenarios.

Energy Deliverability

Energy deliverability for a generation pocket is defined as the total energy utilized to serve demand from a group of resources in that pocket. It is expressed as the ratio of energy generated to total scheduled energy for those resources. The energy deliverability metric illustrates how much of the total potential energy was delivered to the grid and how much was curtailed. The tables below show the Energy Deliverability metric by pocket and resource type for the Contract Case and Policy Case scenarios in years 2030 and 2035.

Figure 30: Renewable Generation Pocket Metrics - 2030 Contract Case

Contract Case (2030)					
Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Wind	147	392	0	100%
	Solar	2,030	4,016	181	96%
W2	Wind	813	2,271	61	97%
	Solar	60	95	1	99%
W3	Wind	305	843	1	100%
	Solar	480	799	4	100%
X1	Hydro	1,155	7,401	181	98%
	HQ Imports	1,930	10,798	340	97%
	Wind	977	2,613	186	93%
	Solar	690	1,336	145	89%
X2	Hydro	252	1,238	39	97%
	Wind	505	1,386	55	96%
	Solar	80	128	10	92%
X3	Hydro	224	658	14	98%
	Wind	80	217	4	98%
	Solar	469	879	12	99%
Y1	Hydro	32	100	5	94%
	Wind	74	182	3	99%
	Solar	1,700	3,305	189	94%
Y2	Hydro	39	101	7	94%
	Wind	-	-	-	-
	Solar	290	512	11	98%
Z1	Wind	691	1,890	4	100%
	Solar	927	1,707	15	99%
Z2	Wind	213	701	0	100%
	Solar	205	389	14	97%
Z3	Wind	76	189	2	98%
	Solar	290	539	8	99%

Figure 31: Renewable Generation Pocket Metrics - 2035 Lower Demand Policy Scenario

Lower Demand Scenario (2035)					
Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Wind	339	962	2	100%
	Solar	2,030	4,018	317	92%
W2	Wind	1,476	4,159	92	98%
	Solar	60	95	1	99%
W3	Wind	894	2,529	126	95%
	Solar	480	799	42	95%
X1	Hydro	1,149	7,397	264	96%
	HQ Imports	1,930	5,685	244	96%
	Wind	977	2,613	230	91%
	Solar	1,308	2,574	154	94%
X2	Hydro	252	1,238	135	89%
	Wind	505	1,387	68	95%
	Solar	244	454	57	87%
X3	Hydro	224	657	24	96%
	Wind	80	218	10	95%
	Solar	469	879	16	98%
Y1	Hydro	32	100	5	95%
	Wind	74	182	5	97%
	Solar	1,700	3,305	172	95%
Y2	Hydro	39	102	5	95%
	Wind	-	-	-	-
	Solar	290	512	8	98%
Z1	Wind	691	1,894	22	99%
	Solar	927	1,706	26	98%
Z2	Wind	213	702	0	100%
	Solar	205	389	15	96%
Z3	Wind	76	189	6	97%
	Solar	290	540	15	97%

Figure 32: Renewable Generation Pocket Metrics - 2035 Higher Demand Policy Scenario

Higher Demand Scenario (2035)					
Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Wind	1,001	3,049	518	83%
	Solar	2,030	4,018	149	96%
W2	Wind	1,959	5,477	239	96%
	Solar	60	95	1	99%
W3	Wind	917	2,593	142	95%
	Solar	480	799	45	94%
X1	Hydro	1,155	7,397	109	99%
	HQ Imports	1,930	5,685	20	98%
	Wind	977	2,613	115	96%
	Solar	1,396	2,752	50	98%
X2	Hydro	252	1,238	58	95%
	Wind	583	1,604	34	98%
	Solar	250	465	18	96%
X3	Hydro	224	657	10	98%
	Wind	932	2,407	4	100%
	Solar	469	879	6	99%
Y1	Hydro	32	100	2	98%
	Wind	324	889	2	100%
	Solar	1,700	3,305	89	97%
Y2	Hydro	39	102	3	97%
	Wind	151	505	0	100%
	Solar	290	512	5	99%
Z1	Wind	691	1,894	21	99%
	Solar	927	1,706	19	99%
Z2	Wind	213	702	0	100%
	Solar	205	389	6	98%
Z3	Wind	183	476	2	100%
	Solar	290	540	4	99%

Higher Demand Scenario (2035)					
Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Wind	1,001	3,049	512	83%
	Solar	2,030	4,018	230	94%
W2	Wind	1,959	5,477	254	95%
	Solar	60	95	1	99%
W3	Wind	917	2,593	144	94%
	Solar	480	799	53	93%
X1	Hydro	1,149	7,397	422	94%
	HQ Imports	1,930	5,685	334	94%
	Wind	977	2,613	249	90%
	Solar	1,396	2,752	227	92%
X2	Hydro	252	1,238	84	93%
	Wind	583	1,604	95	94%
	Solar	250	465	31	93%
X3	Hydro	150	657	24	96%
	Wind	932	2,407	10	100%
	Solar	469	879	18	98%
Y1	Hydro	32	100	15	85%
	Wind	324	889	8	99%
	Solar	4,488	8,683	1,398	84%
Y2	Hydro	25	102	6	94%
	Wind	151	504	2	100%
	Solar	856	1,579	19	99%
Z1	Wind	691	1,894	24	99%
	Solar	927	1,706	29	98%
Z2	Wind	213	702	0	100%
	Solar	205	389	15	96%
Z3	Wind	183	476	6	99%
	Solar	290	540	14	97%

The single driver for curtailment in a renewable generation pocket is transmission congestion. Most pockets include some level of curtailment that depends on the amount, type, and location of generation resources in that pocket. Pockets with generation resources that have coincident production profiles tend to have higher risks for curtailment of like resources. Patterns for renewable curtailment between the Contract Case and the Lower Demand and Higher Demand scenarios in the Policy Case all differ but exhibit some commonality on level of risk. Several metrics are useful in quantifying curtailment risk, such as: volume of resource curtailment rate (%) and GWh, persistent of risk (how many cases/how often is it a problem), and volume of resources interconnecting (and informed by interconnection queue). The figure below identifies the risks for curtailment for each scenario evaluated:

Figure 33: Renewable Generation Pocket Curtailment Risk Table

Pocket	Contract Case		Lower Demand Policy		Higher Demand Policy	
	Curtailment%	Risk	Curtailment%	Risk	Curtailment%	Risk
W1	4%	Low	6%	Med	9%	Med
W2	3%	Low	2%	Low	4%	Low
W3	0%	Low	5%	Med	6%	Med
X1	5%	Med	5%	Med	2%	Low
X2	4%	Low	8%	Med	3%	Low
X3	2%	Low	3%	Low	1%	Low
Y1	5%	Med	5%	Med	2%	Low
Y2	3%	Low	2%	Low	1%	Low
Z1	1%	Low	1%	Low	1%	Low
Z2	1%	Low	1%	Low	1%	Low
Z3	1%	Low	3%	Low	1%	Low

Average Curtailment of Pockets

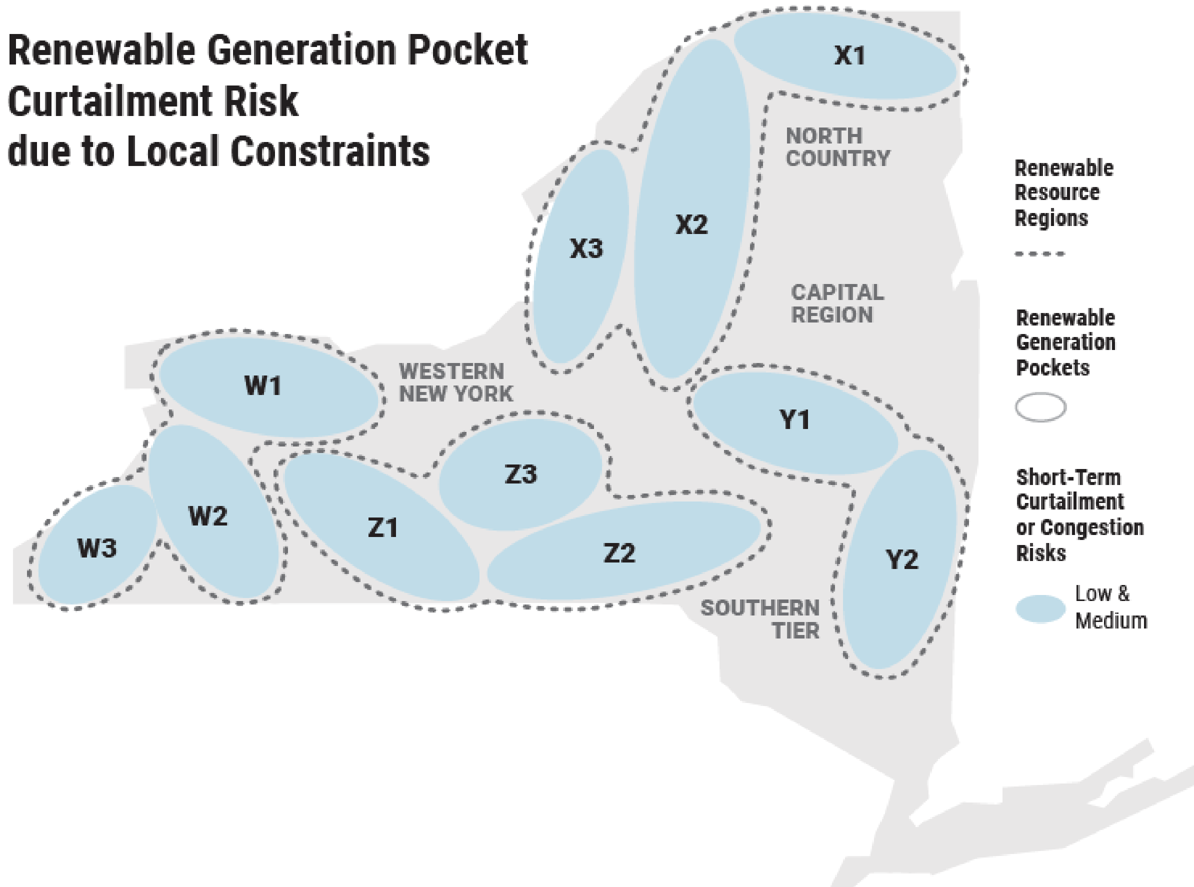
Pocket	Contract		Lower		Higher		Average of Contract, Lower & Higher	
	Curtailment %	Risk	Curtailment %	Risk	Curtailment %	Risk	Curtailment %	Risk
W1	4%	Low	6%	Med	10%	High	7%	Med
W2	3%	Low	2%	Low	5%	Low	3%	Low
W3	0%	Low	5%	Med	6%	Med	4%	Low
X1	5%	Med	5%	Med	7%	Med	6%	Med
X2	4%	Low	8%	Med	6%	Med	6%	Med
X3	2%	Low	3%	Low	1%	Low	2%	Low
Y1	5%	Med	5%	Med	15%	High	8%	Med
Y2	3%	Low	2%	Low	1%	Low	2%	Low
Z1	1%	Low	1%	Low	1%	Low	1%	Low
Z2	1%	Low	1%	Low	1%	Low	1%	Low
Z3	1%	Low	3%	Low	2%	Low	2%	Low

Average Curtailment of Sub Pockets

Consistent with the prior Outlook, the risk level is dependent on the average curtailment of resources within a pocket. It is expressed as the ratio of total curtailed energy to total scheduled energy. Resources that curtail at an average of less than 5% are categorized as Low Risk; at an average equal to 5% and less than 10% are categorized as Medium Risk; and at an average equal to or greater than 10% is High Risk. One notable difference among the scenarios is the higher risk of renewable curtailment in the Y1 pocket for the Higher Demand scenario. This higher risk is observed to be due to increased renewable capacity additions and increased congestion within this pocket primarily driven by a higher energy demand forecast.

Additionally, in the renewable generation pocket map shown below, the shaded areas summarize the findings by identifying the pockets as having a “low,” “medium,” or “high” risk for curtailment. Pockets with a “high” risk would be determined to have both persistent (occur in multiple scenarios over multiple years) and significant (% thresholds listed in key) renewable generation curtailment within the pocket. Pockets with a “low” and “medium” risk are those that would have a lower risk of renewable generation curtailment driven by local constraints through the 2030-2035 time period.

Figure 34

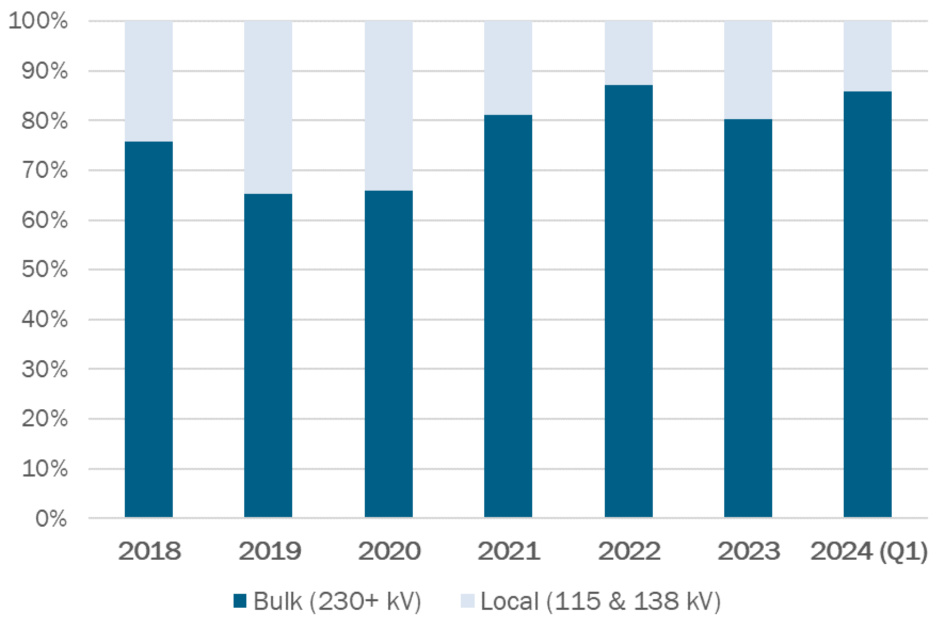


Bulk Transmission Constraints

In its role to plan the transmission system, the NYISO has communicated the challenge of bringing carbon-free electricity from upstate New York to New York City, Long Island, and the lower Hudson Valley. During periods of high demand, constraints along key transmission lines can limit the amount of energy that would otherwise be delivered from upstate to meet demand downstate. As a result, New York City and its surrounding suburbs will, at times, rely more on fossil fuels for power generation to serve customer needs. Much of this congestion is an artifact of the evolution of the bulk transmission system in New York, which was largely established prior to 1980,[26] after which electricity demand grew by 2%-5%[27] per year while the bulk transmission system remained largely unchanged.

[26] New York STARS Phase II Report, April 2012
[27] EIA, U.S. economy and electricity demand growth are linked, but relationship is changing - U.S. Energy Information Administration (EIA)

Figure 35: Historic Annual Bulk vs Local Transmission Congestion



Thankfully, the "Tale of Two Grids" is proceeding into a new chapter. A historic level of investment in the transmission system is happening with projects under construction that will deliver more clean energy to consumers while enhancing grid resilience and reliability. The bulk transmission projects shown in Figure 5 are either completed, under development, or contracted for development in the near future.

While these projects represent a significant improvement in New York's ability to efficiently transfer larger amounts of energy across the bulk system, continued bulk transmission development will be required to meet CLCPA policy mandates through 2040 and beyond.

As described in the Renewable Generation Pockets section, this study finds that the Phase 1 and Phase 2 local transmission upgrades are effective in alleviating transmission congestion and reducing curtailment in future renewable generation pockets. These projects enable efficient energy delivery to the bulk transmission system, which can be accessed by demand statewide. However, with approximately three times the amount of today's capacity needed to meet energy policy mandates in the next twenty years, flows on the bulk transmission system, particularly on the major interfaces, are shown to be limited in the longer term.

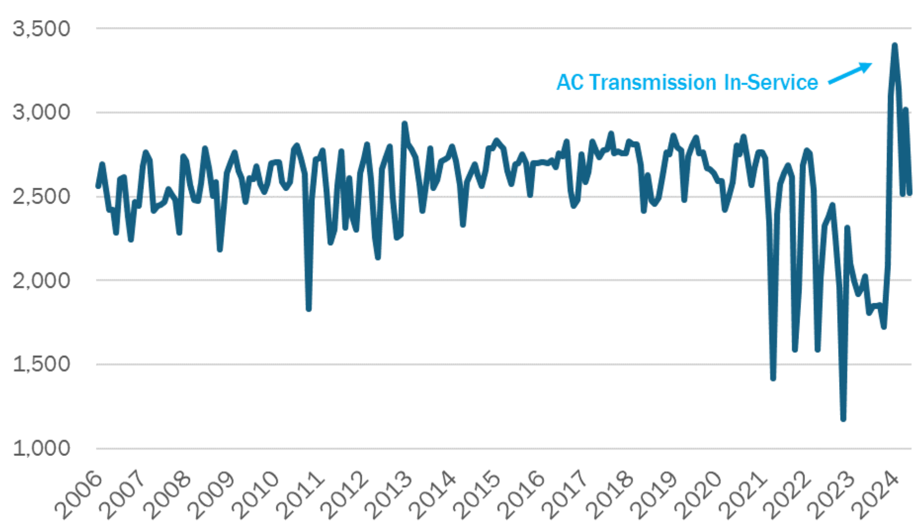
Actionable E~~e~~xpansion O~~o~~pportunities: Dynamic R~~r~~eactive P~~p~~ower S~~s~~upport for Central East

NYISO's Central East interface is historically one of the most limiting transmission paths in New York State. The path acts as a central corridor for the transfer of energy between upstate and downstate.

At the end of 2023, the Central East Energy Connect, which was developed through the NYISO's Public Policy Transmission Planning Process to address Segment A of the AC Transmission Needs, completed construction. The project has increased the transfer capability across the NYISO's Central East interface by 1,000 MW or more with significant benefits already being realized.

On December 12, 2023 at 5:30 pm, the NYISO's Central East interface flow surpassed 3,000 MW for the first time since the NYISO began publishing interface flow data in 2005 and experienced a record 3,399 MW transfer during one dispatch interval in early 2024. The increased capability on this interface is vital to enabling energy deliverability from existing and future renewable projects in upstate New York.

Figure 36: 2006-2024 Central East Maximum Month Flow (MW)



The ability to transfer power across Central East depends on the dynamic reactive support services currently provided by three nuclear and four fossil-fuel generators surrounding the transmission path.[28] If the nearby fossil-fuel synchronous generators tied to the Central East voltage collapse limit are deactivated by 2040 to comply with CLCPA mandates, the full benefits of the Central East Energy Connect will be diminished due to a lower transfer limit leading to transmission congestion and renewable curtailment.

Additionally, the energy transfer capability of the Central East interface is very sensitive to transmission equipment outages. The interface consists of four 345 kV and three 115 kV circuits and is supported by over twenty reactive power compensation devices at nearby substations. Outage (planned or unplanned) of these transmission circuits or reactive power generating devices supporting Central East

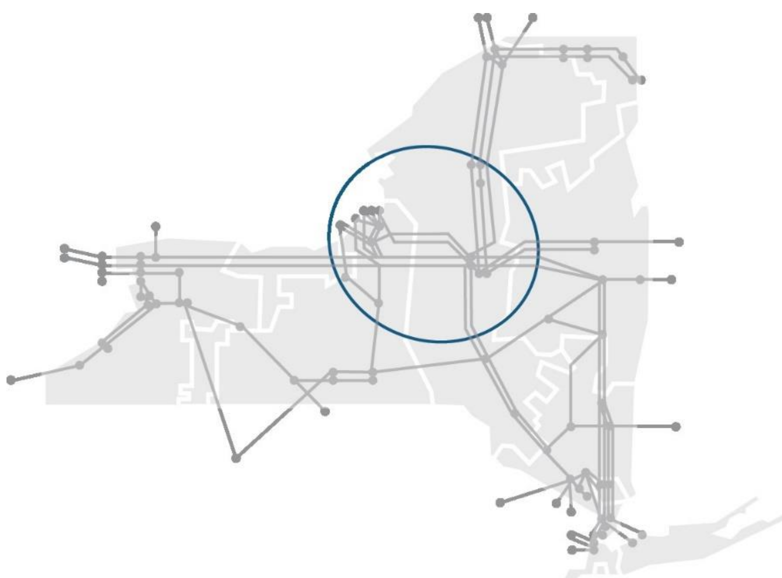
[28] https://www.nyiso.com/documents/20142/3692791/Central-East-Voltage-Limit-Study-2024-FINAL.pdf

will reduce the transfer limit.

To achieve policy mandates by 2040, a minimum of 15 GW of new renewable generation is expected to be located west and north of the Central East interface in Zones A through E. Approximately half of renewable energy produced and not consumed in these zones traverses the Central East interface. This will lead to continually increasing flows as upstate renewable project development progresses eventually leading to significant curtailment.

In the Lower and Higher Demand scenarios the NYISO found that the Central East interface was limiting between ~~26~~13% and ~~50~~33% of the total hours by~~in~~ ~~2035~~ 2042 and was the major contributing factor to renewable curtailment throughout the state. The addition of renewable resources downstream of the Central East interface in the Higher Demand scenario results in a comparative reduction in the number of limited hours for Central East.

Figure 37: Central East Bulk Transmission Renewable Regions



To fully utilize the transmission facilities already in place, additional dynamic reactive power support must be added to the grid in upstate New York in order to alleviate congestion and fully utilize the transmission capability of the Central East interface. Reactive power supports the overall voltage performance of the grid and may be provided by generators, dedicated dynamic reactive power devices such as synchronous condensers or other power electronics (e.g., STATCOMs), or potentially other specialized Grid-Enhancing Technologies (GETs). Installation of a traditional large capacitor at a fixed output, while inexpensive, would not be able to meet the variable voltage regulation needs in the future.

The Outlook finds that by replacing the dynamic support services from these fossil-fuel generators to support the Central East interface voltage performance, the future potential congestion across Central East could be largely eliminated and curtailment of renewable energy reduced by approximately ~~130~~40-220 GWh in 2035 and more in years beyond.

This NYISO recommends further investigation into the potential benefits of additional dynamic reactive support, including the possibility of GETs, in upstate New York, and will continue to monitor other opportunities to incorporate GETs beyond this region.

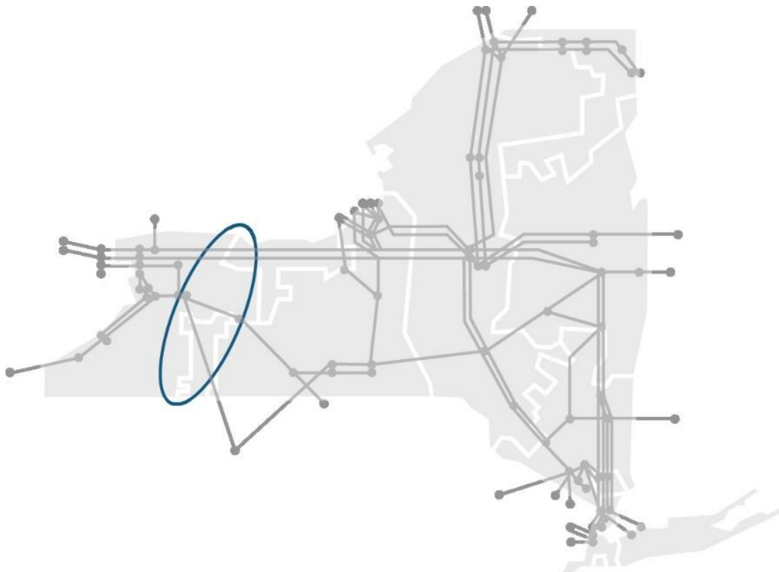
Monitor Western New York

Second to the Central East bulk transmission constraint, the constraints in the Buffalo – Erie region in Western New York were found to be limiting ~~at approximately 11% of hours~~ in 2035 for the Lower and Higher Demand scenarios and remains congested at similar levels through 2042.

The Western New York area was recently upgraded in 2022 with the Empire State Line that addressed a Public Policy Transmission Need, along with National Grid's local transmission expansion plan. The transmission system was bolstered in both the local 115 kV and bulk 345 kV system. In addition, NYSEG's Area of Concern projects in the Southern Tier will rebuild the 230 kV and 115 kV networks in this region and are expected to be in service by 2030.

The projects that are in service have already enabled increased energy deliverability from the existing Niagara hydroelectric facility, and the Outlook results shows that the planned transmission expansion effectively mitigated the congestion observed in the previous Outlook with a few remaining limitations. Looking ahead, significant renewable generation development is projected to occur in the area with nearly 3-4 GW of solar and wind projects and 2 GW of DEFRs to meet the 2040 policy mandate. The current and projected transmission paths that limit energy flows in the Western and Southern Tier areas primarily exist on the 230 kV transmission network that extends south and east of the Niagara area. Combined with the planned local transmission upgrades, bulk upgrades on the 230 kV paths could remove transmission barriers to for new renewable resources and DEFRs required to meet policy mandates.

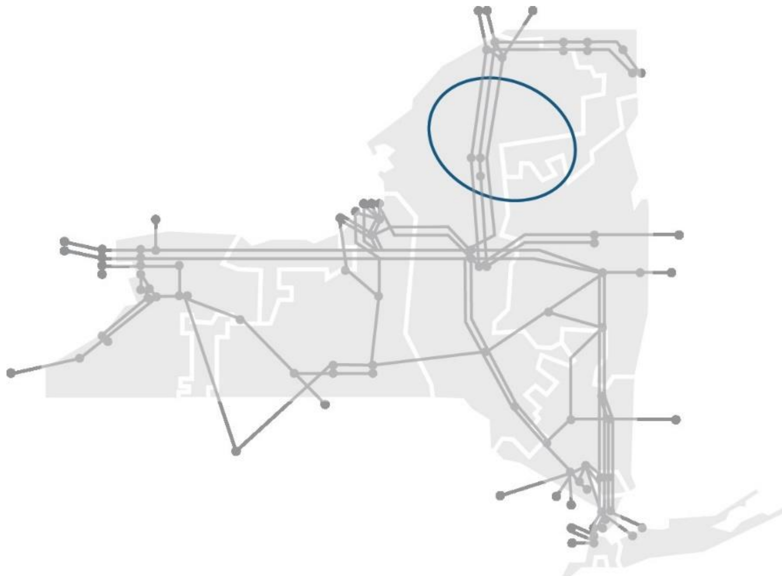
Figure 38: Southern Tier Bulk Transmission



Monitor Northern New York

The Northern New York region is north of Syracuse and Albany and encompasses Watertown, Massena, Plattsburg, and many other less densely populated towns. The Adirondack Park is situated central to this area with generation and transmission development concentrated to the North and West. With developable land available and high solar and wind resource potential, Northern New York is experiencing significant growth in both renewable generation projects and transmission expansion. Northern New York has a large portion of the land-based wind that is operational today and experiences some of the highest curtailment levels in the state. The under-construction Smart Path Connection and the planned Phase 1 and Phase 2 local transmission upgrades are projected to greatly reduce curtailment in the area.

Figure 39: Northern New York Bulk Transmission



The renewable generation pocket assessment found that most local transmission constraints identified in the prior Outlook were resolved in Northern New York. This Outlook found that several 115 kV and 230 kV transmission paths may become limiting as more renewable projects are added in Zone D and Zone E. All three of the policy scenarios evaluated estimate Zone E to have some of the largest increase of wind and solar generation capacity of all zones in the state. This is driven by a combination of lower build costs and the energy potential from resources.

To ensure that renewable generation resources, including existing hydro generation and imports, in the Northern New York area remain energy deliverable, continued development of local and bulk transmission projects is recommended.

Interregional Transmission

New York has strong interregional transmission connections to ISO-NE, PJM, IESO, and HQ that are leveraged to support the economic and reliable exchange of electric energy. New York is a historic importer of electric energy from PJM, IESO, and HQ, while it has typically exported to ISO-NE on a net-annual basis.

Figure 40: NYISO Interregional Connections

As each system independently pursues different climate policies, the availability of energy for interregional exchange will fundamentally change. In times of excess solar, wind, and/or hydro, New York has the potential to export inexpensive renewable energy to adjoining markets to meet regional demand. Because New York has enacted the most aggressive renewable policies, this scenario is most likely to occur through 2040. As neighboring systems approach full achievement of the various carbon-free mandates, which is estimated to be generally around 2050, the availability of excess generation for exchange will be highly dependent upon the generation types adopted. Solar, land-based wind, and offshore wind production is relatively coincident across the NYISO and its neighboring systems. This, however, may limit the ability of neighboring systems to absorb excess energy from New York or vice-versa as each system seeks pathways towards a more decarbonized grid. Alternatively, when weather driven renewable resource production is low in one system, it is probable that renewable production will also be relatively low in surrounding locations. In this situation, each system would need to depend on internal DEFRs or external resources (but only if available) to meet demand. In the prior Outlook, the NYISO found that external CO_2 emitting resources were leveraged to meet New York demand in 2040 when fossil-fuel resources were assumed to retire to comply with policy mandates. This finding was driven by the relative economics of different dispatchable technologies in the various systems.

To estimate the need to export excess renewable generation as the 70% renewable by 2030 mandate is achieved, the NYISO performed a "spillage" analysis using the Contract Case. The spillage analysis is a spreadsheet comparison of hourly net load to firm generation within the NYCA. The generators considered were intermittent renewables, nuclear generation, and must-run fossil-fuel units due to local reliability rules. The general trends showed that energy was "spilled" most often during the midday period when the sun is shining, thereby boosting solar generation, and during the shoulder months when load levels are lower compared to summer and winter due to milder temperatures. The annual spillage total calculated for the Contract Case was 1.7 TWh with a maximum hourly value of 8.7 GW. Further details can be found in Appendix I: Transmission Congestion Analysis.

Several key drivers are predicted to dictate how transmission flows will evolve with neighboring systems over the next two to three decades.

- Renewable Energy Production – increasing amounts of weather driven renewable energy production will impact both internal and external transmission flows. Renewable projects in close electrical proximity to external tie lines will impact flow patterns on those specific lines. When net load approaches levels near or below 0 MW, all excess supply is transacted across neighboring interties unless curtailed.
- Dispatchable Generation Cost – the relative cost of dispatchable generation resources between systems will generally determine the willingness to import and export energy. Because the adjoining power markets in the Northeast can freely exchange energy based on economics, systems with excess lower cost dispatchable energy will generally transact to higher cost systems with energy needs. The cost and availability of dispatchable generation is expected to change at a different pace state-to-state due to differing state-driven climate policies. The opportunity for policy arbitrage between states will likely increase in the future and could greatly impact how interchange transactions occur.
- Emergency Assistance – with such a high correlation in renewable energy production between Northeast states and the increased reliance on these resources, it is likely that neighboring systems will experience shortfalls simultaneously. The coordination of capacity and energy availability between systems will be a very important factor in determining transmission flows during these times. The *2024 Reliability Needs Assessment* investigates this topic in greater detail.

Multiple initiatives are currently ongoing that aim to investigate the benefits of or promoting the development of interregional transmission projects. At the time of publication this report, there are several notable efforts promoting the expansion of interregional transfer capability. For example, North

American Electric Reliability Corporation is conducting the Interregional Transfer Capability Study that will analyze the amount of power that can be moved or transferred reliably from one area to another area of the interconnected transmission systems. The Department of Energy is conducting its process to designate geographic areas as National Interest Electric Transmission Corridors where the development of new transmission would advance national interests, such as reliability and reduce consumer costs. The NYISO will continue to monitor these efforts, and if appropriate, incorporate the analysis into future studies.

Additional Bulk Transmission Benefits

The NYISO models used in the Outlook do not include real-time random events or uncertainties. The findings presented throughout this report represent a conservative estimate for transmission congestion and curtailment. When unexpected events occur in real time, oftentimes the bulk power system is relied upon to efficiently resolve the challenges encountered. Some of these may include:

- Scheduled or unscheduled transmission outages,
- Random generation outages,
- Demand variations,
- Renewable generation variations,
- Inadvertent regional interchange, and
- Extreme weather impacts.

These real-time uncertainties are part of the daily operation of the New York power system and are expected to become increasingly impactful as the system becomes more weather dependent. It is anticipated that as uncertainty in real-time conditions increases that the bulk power system will become increasingly relied upon to efficiently transfer power to areas of need.

Key Takeaways

- ✓ **Historic levels of investment in the transmission system are happening but more will be needed.**
- ✓ **Actionable expansion opportunities: Additional dynamic reactive power support must be added to the grid in upstate New York to alleviate congestion and fully utilize the transmission capability of the Central East interface.**
- ✓ **Opportunities for further transmission investment in Western and Northern New York should be monitored as resources are developed in those regions.**
- ✓ **Planning energy exchange with neighboring systems is becoming more complex and will be increasingly so in the future as each system transitions to more decarbonized systems.**

Next Steps and Recommended Actions

Key Takeaways: 2023-2042 System & Resource Outlook

Demand

Significant Demand Increase Projected

Electric energy consumption is projected to increase significantly in response to the economic development and decarbonization energy policies. Resources and the transmission system need to evolve accordingly to meet the changing energy demand.

Importance of Siting of Large Load

Siting large loads in electrical proximity to renewable resources, or siting resources near large loads, may benefit both the loads and the resources, particularly if located upstream of known constraints.

Resources

3x Generation Capacity by 2042

New York will require three times the capacity of the current New York generation fleet to meet projected future electricity demands.

Coordinate Generator Retirements & New Additions

The coordination of new generator additions and existing generator retirements is essential to maintain the reliability of the New York power system while simultaneously pursuing achievement of CLCPA.

Importance of Renewable Energy Siting

Uncertainty in siting new renewable generation could lead to delays in or inefficient expansion of the transmission and distribution systems.

New Dispatchable Emission-Free Resources Needed

Dispatchable emission-free resources must be developed to provide the capacity, energy, and other essential grid services required to achieve the policy mandate for a zero-emissions grid by 2040.

Transmission

Transmission Needed

Historic levels of investment in the transmission system are happening but more will be needed.

Central East Dynamic Reactive Power Support

To fully utilize the transmission facilities already in place, additional dynamic reactive power support must be added to the grid in upstate New York to alleviate congestion over the Central East interface.

Monitor Opportunities in Western & Northern NY

Opportunities for further transmission investment in Western and Northern New York should be monitored as resources are developed in those regions.

Continue Interregional Coordination

Planning energy exchange with neighboring regions systems is becoming more complex and will be increasingly so in the future as each region system transitions to more decarbonized systems.

Next Steps

The Outlook has built upon the data, modeling, and studies developed within the NYISO's Comprehensive System Planning Process and serves as another building block for continued analyses and study work both within and outside of the NYISO. The data and findings provided by the Outlook are designed and intended to be used by policymakers, investors, and other NYISO stakeholders to identify the challenges and opportunities associated with achieving state policies in an economic and efficient manner.

The *2024 Reliability Needs Assessment*, which is expected to be published by the end of 2024, will leverage data from the Outlook to identify generation capacity and operation trends and related bulk power system reliability impacts as policy mandates are approached.

The 2024-2025 cycle of the Public Policy Transmission Planning kicks off in August 2024, at which time the NYISO will provide an opportunity for any stakeholders or interested parties to submit comments regarding proposed transmission needs that may be driven by public policy requirements. The findings from this Outlook present an opportunity for interested parties to consider and formulate transmission needs based on the transmission opportunities identified in this report and the underlying analysis.

Recommendations and Observations

The important findings identified in the 2023-2042 System & Resource Outlook are the basis for several recommendations to address the challenges revealed by the study:

1. Thanks to recent transmission and distribution expansion projects, transmission constraints are no longer a major impediment to achievement of the 70% renewable energy by 2030 (70x30) policy mandate as projects facilitate high energy deliverability of renewables. The timely construction of the identified transmission projects to enable the integration of renewable energy resources by 2030 is vital to the policy's achievement.

2. Every incremental advancement towards policy achievement matters on the path to a greener and reliable grid in the future; not just at the critical milestone years, such as 2030 and 2040. Beyond the zero-emissions grid mandate by 2040, demand will continue to increase as multi-sectoral electrification continues to meet the CLCPA energy mandates to achieve 85% greenhouse gas emission reduction below 1990 levels by 2050. The need for new generation resources will continue well beyond 2040, while the new solar and wind resources will become less effective at meeting peak load after a significant amount of capacity has already been built at that point.

3. This Outlook identifies the following notable transmission expansion opportunities:

    - **Central East Interface** – act on installing dynamic reactive power support;
    - **Western New York/Southern Tier** – monitor bulk transmission expansion to accommodate future renewable and/or dispatchable emission-free resource development; and
    - **Northern New York** – monitor bulk transmission expansion to accommodate future renewable and/or dispatchable emission-free resource development.