2021-2040 System & Resource Outlook (the Outlook)

A Report from the New York Independent System Operator

Table of Contents

Executive Summary

Driven by the state's Climate Leadership and Community Protection Act ("CLCPA") and other state clean energy policies, New York's electricity generation and demand landscape is rapidly changing. This shift leads to re-thinking how and where electric supply and storage resources evolve, and how to efficiently enable their adoption to achieve energy policy targets.

This System & Resource Outlook ("the Outlook"), conducted by the New York Independent System Operator ("NYISO") in collaboration with stakeholders and state agencies, provides a comprehensive overview of potential resource development over the next 20 years in New York and the constraints revealed throughout the New York transmission system. A key purpose of this marquee planning report is to highlight opportunities for transmission investment driven by economics and public policy in New York State. Together with the NYISO's publication of the 2021-2030 Comprehensive Reliability Plan, this 2021-2040 System & Resource Outlook provides a full power system outlook to stakeholders, developers, and policymakers.

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

- projected possible resource mixes that achieve New York's public policy goals while maintaining grid reliability;
- identified regions of New York where renewable resources may be unable to generate at their full capability due to transmission constraints;
- quantified the extent to which these transmission constraints limit delivery of renewable energy to consumers, and;
- identified potential opportunities for transmission investment that may provide economic, policy, and/or operational benefits.

Key Takeaways

There are many potential paths and combinations of resource and transmission builds to achieving New York's climate change requirements. As the current power system continues to evolve, evaluating a multitude of expansion scenarios will facilitate identification of common and unique challenges to achieving the electric system milestones New York State has set for 2030 and

2040. A thorough understanding of these challenges will help build a path for investors and policymakers to achieve a greener and reliable future grid. This Outlook evaluates four possible scenarios to better understand the challenges ahead and provides the following key findings:

- Significant new resource development will be required to achieve CLCPA energy targets. The total installed generation capacity to meet policy objectives within New York is projected to range from 111 GW and 124 GW by 2040. At least 95 to 110 GW of this capacity will consist of new generation projects and/or modifications to existing plants[1] and still may not be sufficient to fully meet CLCPA compliance criteria[2] and maintain the reliable electricity supply that New York consumers have come to rely on. The sheer scale of resources needed to satisfy system reliability and policy requirements within the next 20 years is remarkable.

- 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. In general, resource and transmission expansion take many years from development to deployment. By year 2030, roughly seven years from the publication of this report, an estimated 20 GW of additional renewable generation needs to be in-service to support the energy policy target of 100% zero-emission generation by 2040. For reference, 12.9 GW of new generation has been developed since wholesale electricity markets began more than 20 years ago in 1999. Over the past five years, 2.6 GW of renewable and fossil-fueled generators came on-line while 4.8 GW of generation deactivated. This Outlook demonstrates the need for an unprecedented pace of project deployment that will require significant labor and materials available for New York over a long period of time.

- Transmission expansion is critical to facilitating efficient CLCPA energy target achievement. The current New York transmission system, at both local and bulk levels, is inadequate to achieve currently required policy objectives. Renewable generation pockets throughout the State become more constrained as an increasing number of intermittent generation resources connect, necessitating transmission upgrades to make the renewable energy deliverable. Bulk and local transmission constraints on today's grid will limit the effective delivery of renewable energy to consumers throughout the State. A significant portion of

[1] As compared to the 2021 baseline, including the in-front-of the meter and behind-the-meter renewable generation addition by 2040, assuming deactivation of the existing fossil-fire generation

[2] This report does not attempt to identify the resources needed to achieve full policy attainment.

projected renewable generation will be built in upstate New York areas, which are geographically and electrically distant from the major consumer hubs in downstate New York, while downstate fossil generation is being retired. Without significant timely transmission expansion to provide access to renewable energy resource rich areas, the renewable energy cannot efficiently traverse New York State and be delivered to consumers.

- To achieve an emission-free grid, dispatchable emission-free resources (DEFRs) must be developed and deployed throughout New York to replace the various electrical attributes that are provided today by fossil generation. DEFRs that provide sustained on-demand power and system stability will be essential to meeting policy objectives while maintaining a reliable electric grid. While essential to the grid of the future, such DEFR technologies are not commercially viable today and will require committed public and private investment in research and development efforts to identify the most efficient and cost-effective technologies with a view towards the development and eventual adoption of commercially-viable resources.
- The capacity contribution of intermittent renewable resources declines as more are added to the system. The limited contribution of incremental resources to system reliability inhibits the ability of the power system to effectively meet mandatory resource requirements and to serve load in hours in which renewable generation is limited or unavailable. The scale and technology of DEFRs necessary to meet state energy needs will also depend upon the buildout of the transmission and distribution grids.
- Essential grid services will remain critical to provide New Yorkers with reliable and predictable electric system that consumers require. This means that new resources will need to provide these services prior to the exit of existing resources.
- Resource buildout to meet minimum capacity requirements is not sufficient to efficiently achieve the state's climate change policy requirements. This study shows that if new resources are not built in excess of reserve requirements to serve loads reliably, New York will likely rely on importing a significant amount of external energy that may or may not be renewable. New York is fortunate to have strong interconnections with neighboring areas and has enjoyed reliability and economic benefits from such connections. As the energy policies in the neighboring areas evolve independently, the amount of import and export could vary significantly due to the resulting resource and load shifts in the neighboring

areas. Balancing the need to serve loads reliability while achieving New York's emission-free target will require continuous monitoring and collaboration with our neighboring states.

- When dispatched effectively, energy storage would help to increase the utilization of the renewable generation, but energy storage alone cannot completely resolve the transmission limitations in the pockets analyzed.
- Peak load management should be further integrated as a measure to facilitate CLCPA energy target achievement. Thanks to the peak load management measures already announced and implemented, New York is expected to see peak load forecast gradually decrease over the next few years. However, in the long term, the demand is likely to increase beyond historical levels due to electrifying buildings and transportation. By lowering the peak load and avoiding system buildout to serve the highest demand hour, less DEFR buildout would be needed, and during the transition fossil fueled plants could be utilized less to meet lower peaks.
- Electrification from other sectors, such as building and transportation, into the power sector should be monitored and managed closely. Electrification is one of the largest factors driving peak and annual energy demand. Electrification must be in lock step with new resource additions and resource retirements. While other sectors, such as transportation, currently account for a larger share of greenhouse gas emissions, unmanaged electrification of the electricity sector could lead to higher costs and reduced reliability.
- Coordination of renewable energy additions, commercialization and development of DEFRs, and fossil fuel plant operation over the next 18 years will be essential to facilitate an orderly transition of the grid. The large amount of renewable energy additions required to achieve the CLCPA mandates will impact the operations of the existing fossil fuel fleet in the remaining 18-year transition to an emission-free grid. There will be a greater need for resources that can operate more flexibly to meet the increased variability associated with wind and solar generation. This Outlook demonstrates that the flexible units will be dispatched more frequently as the transition unfolds.

Grid in Transition: Implementation of Contracted Renewables

Through an annual request for proposals, NYSERDA solicits bids from eligible new large-scale renewable resources and procures Renewable Energy Certificates ("RECs") from these facilities.

The "Contract Case" evaluated in this Outlook adds approximately 9,500 MW of new contracted renewable resources, including 4,262 MW of solar, 899 MW of land-based wind, and 4,316 MW of offshore wind. The addition of these resources to the Baseline Case system representation provides insights regarding their impact on system performance in the future.

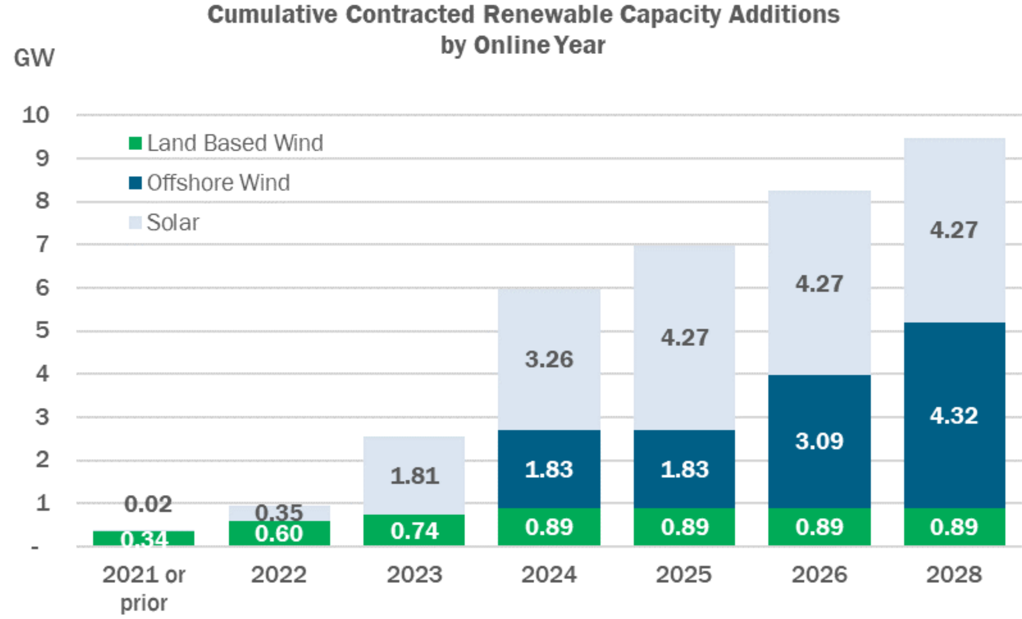
The analysis performed focuses on transmission congestion and how patterns change through time and as New York State contracted renewable projects are added to the system. It is important to note that neither case models generation additions or retirements beyond what was included in the 2021-2030 Comprehensive Reliability Plan or what has been contracted by the State.

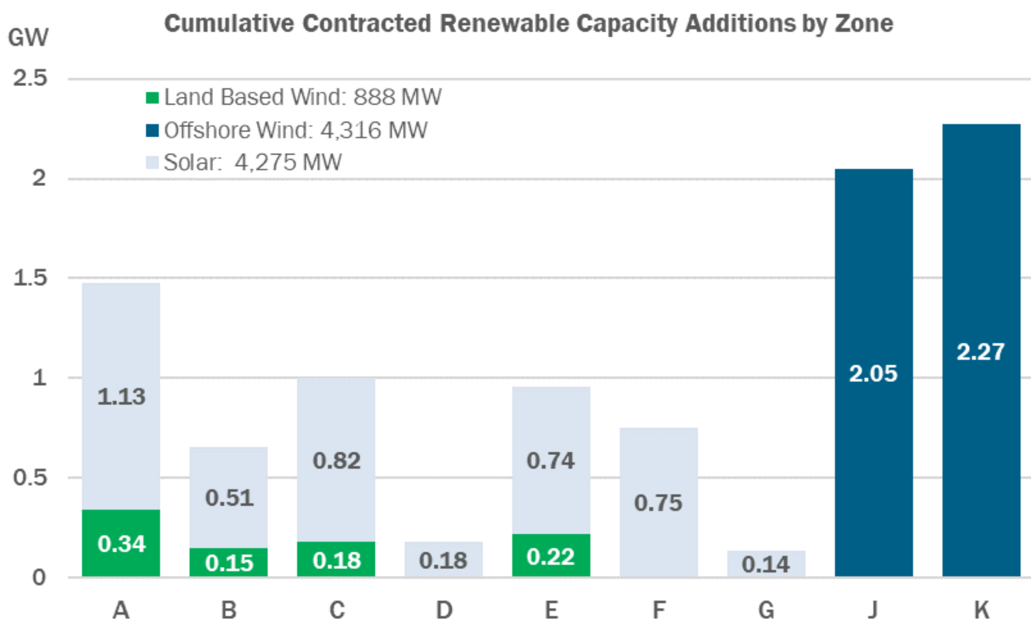
The contracted renewable project portfolio will exacerbate existing transmission congestion and will encounter new local transmission constraints throughout New York State. Working from the Baseline Case, the Contract Case was formulated by adding approximately 9,500 MW (9.5 GW) of future renewable generation projects, including land-based wind, solar, and offshore wind generation. The charts below show the geographic dispersion of renewable project procurements through time added in the Contract Case. Most of the renewable projects are upstate solar or downstate offshore wind projects scheduled for installation prior to 2026.

The additional contracted projects represent a nearly five-fold increase in utility scale renewables compared to what exists on the system today. Without any major transmission upgrades planned to specifically address this large influx of contracted renewables, transmission congestion increases. When the contracted renewable projects are added, several additional constraints appear, causing a 23% increase in congestion statewide by 2030.

A major impact of the transmission constraints is that larger amounts of renewable generation experience curtailment. Renewable generators average approximately 5 GWh of annual curtailment in the Baseline Case, whereas curtailments increase to an annual average of 163 GWh in the Contract Case. Most of the curtailments are experienced by offshore wind projects connected to Long Island due to inadequate transmission capacity.

Contracted Renewable Capacity

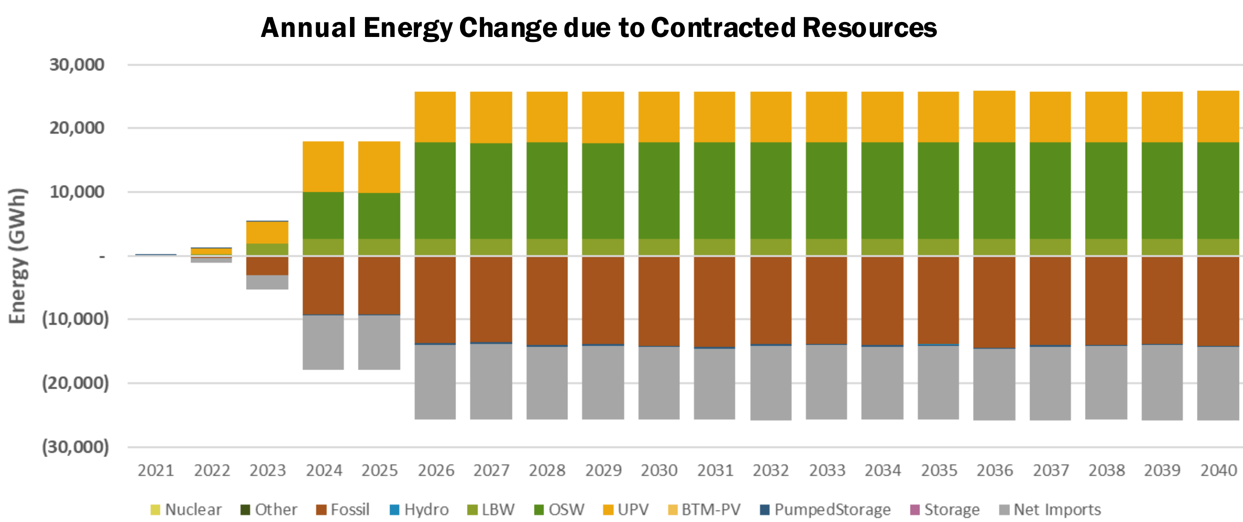




AC Transmission Public Policy projects and Ontario nuclear retirements greatly reduce current Central East interface congestion. With the planned completion of the NYISO AC Transmission Public Policy Projects in 2024, which represent substantial upgrades to the electric grid in the Mohawk and Hudson Valleys, transmission congestion on the Central East/Total East interface is nearly eliminated in the Baseline Case. However, the potential addition of more renewable generation upstream of the Central East interface may results in greater future congestion, as demonstrated in the Policy Case.

A secondary contributing factor to reducing Central East congestion is the nuclear retirements and refurbishments planned by the Ontario Independent Electric System Operator ("IESO"). Between 2021 and 2025 over 10,000 MW of nuclear plant capacity is planned for either retirement or long-term refurbishment. This represents over 25% of the generation capacity in Ontario, which typically enables economic energy exports to the NYISO, nearly all of which traverses the Central East interface. Without inexpensive excess capacity in Ontario for export, the NYISO experiences reductions in Ontario imports and a decrease in congestion on the Central East interface.

Energy production from contracted renewable projects is projected to displace some of the New York fossil generation and energy imports from external systems. The energy produced by the 9,500 MW of additional renewable generation projects tends to displace equivalent amounts of in-state fossil generation as well imported generation from neighboring systems. The chart below shows the increase (positive values) in renewable energy as well as the decrease (negative values) in fossil and imported energy in the Contract Case relative to the Baseline Case. The displacement from renewable energy would be even greater if curtailments are eliminated through transmission investment.



The displacement of in-state fossil generation is focused in the Capital and New York City zones while the reduction in imported energy is primarily observed from PJM with a similar reduction in New York exports to ISO-NE.

Road to 2040: Resources to Achieve Policy Targets

Building upon the known contracted resources, the NYISO developed postulated scenarios that reflect full achievement of the CLCPA targets. The scenarios are collectively referred to as the "Policy Case." Examples of policies modeled in this case include the 70% renewable energy by 2030 ("70 x 30") renewable mandate and the 100% carbon-free by 2040 directive ("100 x 40"). These system representations involve many assumptions and unknowns but provide an informed view of the future to enable sound decision-making by policymakers and stakeholders[3]. The Policy Case will also be utilized as part of the Public Policy Process, including evaluation of the Long Island Offshore Wind Export Public Policy Transmission Need.

Dozens of preliminary scenarios were evaluated. Key factors such as capital cost and demand forecast were adjusted to investigate the key drivers for resource addition and possible pathways to policy achievement. Among all factors tested, the demand forecast demonstrated the largest impact on the resulting capacity expansion.

After discussions with stakeholders, including state agencies (NYSDPS and NYSERDA), two distinct scenarios were selected for evaluation as Policy Cases:

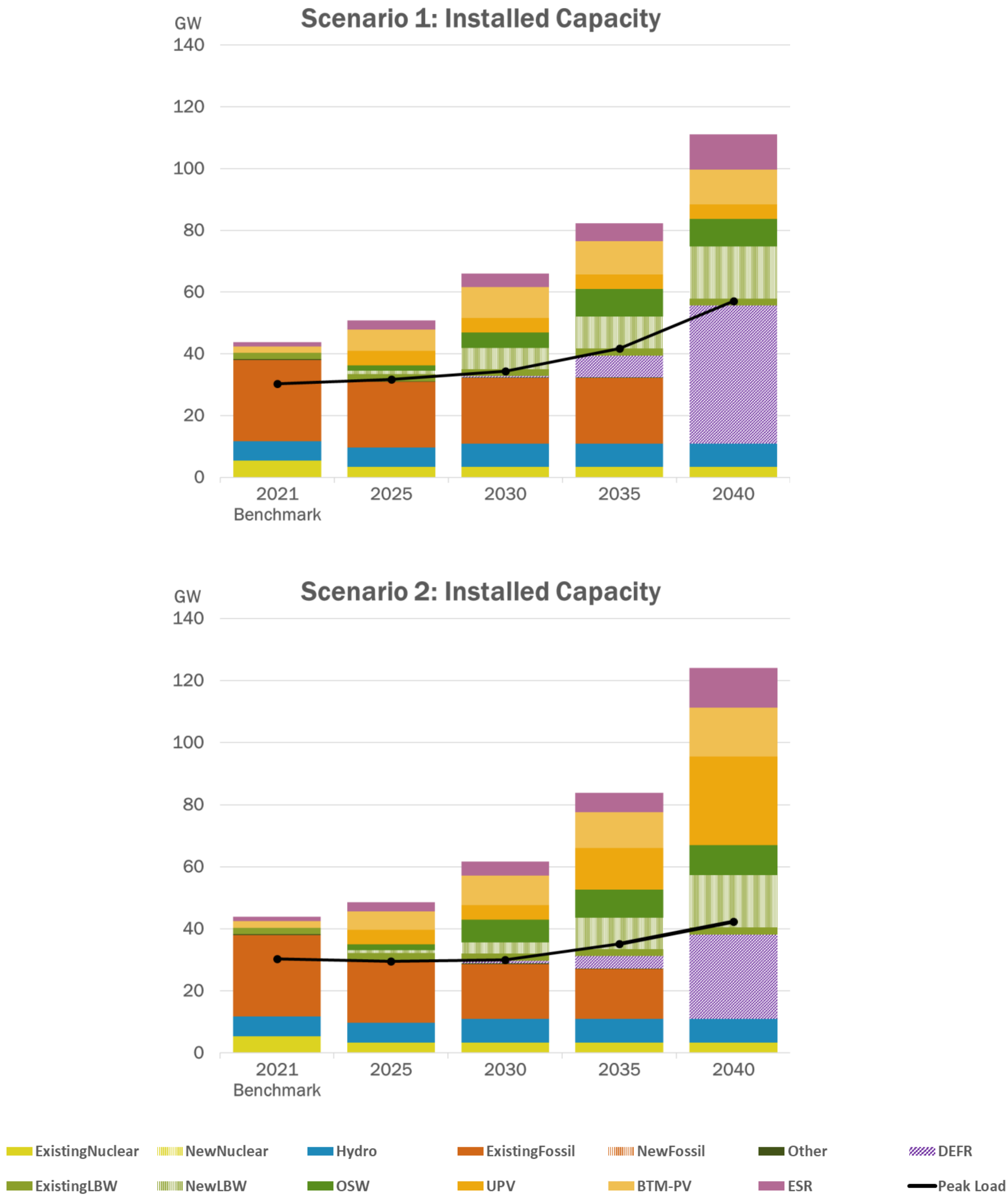
- Scenario 1 ("S1") utilizes industry data and NYISO load forecasts, representing a future with high demand (57,144 MW winter peak and 208,679 GWh energy demand in 2040) and assumes less restrictions in renewable generation buildout options.
- Scenario 2 ("S2") utilizes various assumptions consistent with the Climate Action Council Integration Analysis and represents a future with a moderate peak but a higher overall energy demand (42,301 MW winter peak and 235,731 GWh energy demand in 2040).

The load and capacity forecast for the two scenarios are shown in the following charts. Both scenarios produce a blend of land-based wind ("LBW"), offshore wind ("OSW"), utility-scale solar ("UPV"), behind-the-meter solar ("BTM-PV") and energy storage ("ESR") to meet the CLCPA policy

[3] The complexity of detailed numerical assessment specific for year 2040 is beyond the limitation of the commercial software utilized in this study. Certain details, such as local constraints, were removed from the model.

targets through 2035. By 2040, all existing fossil generators are forced to retire to achieve the CLCPA target for a zero-emission grid, and the model selects DEFRs as a replacement technology.

New York Generation Resource Mix Scenarios



Scenario 1 favors land-based wind technologies to meet emission-free targets while Scenario 2 favors a blend of land-based wind and solar. By 2040, Scenario 1 builds approximately 45 GW of DEFR generation capacity while Scenario 2 builds 27 GW. For reference, today's New York fossil fleet totals approximately 26 GW.

The large amount of DEFR capacity in Scenario 1 results from a 35% higher peak load forecast than Scenario 2 despite having a 13% lower annual energy demand in 2040. The operational needs of dispatchable generation on the system will become more demanding as the State progresses towards policy goals. The number of dispatchable generator starts/stops, daily ramping, operational range, and other flexibility attributes will increase to meet a more dynamic net-load.

Related to demand forecasts, a secondary but significant driver to both the quantity and type of generation selected by the capacity expansion model are capacity reserve margins. Wind, solar, and energy storage capacity are modeled using declining capacity value curves related to the amount of each technology added to the system. These declining capacity values reflect the limited effectiveness of wind, solar, and storage to meeting the estimated future reserve margin requirements as more of each resource type is added. The reduced values necessitate the addition of DEFR technologies to meet these minimum statewide and locational resource requirements because of their relatively high capacity valuation assumed.

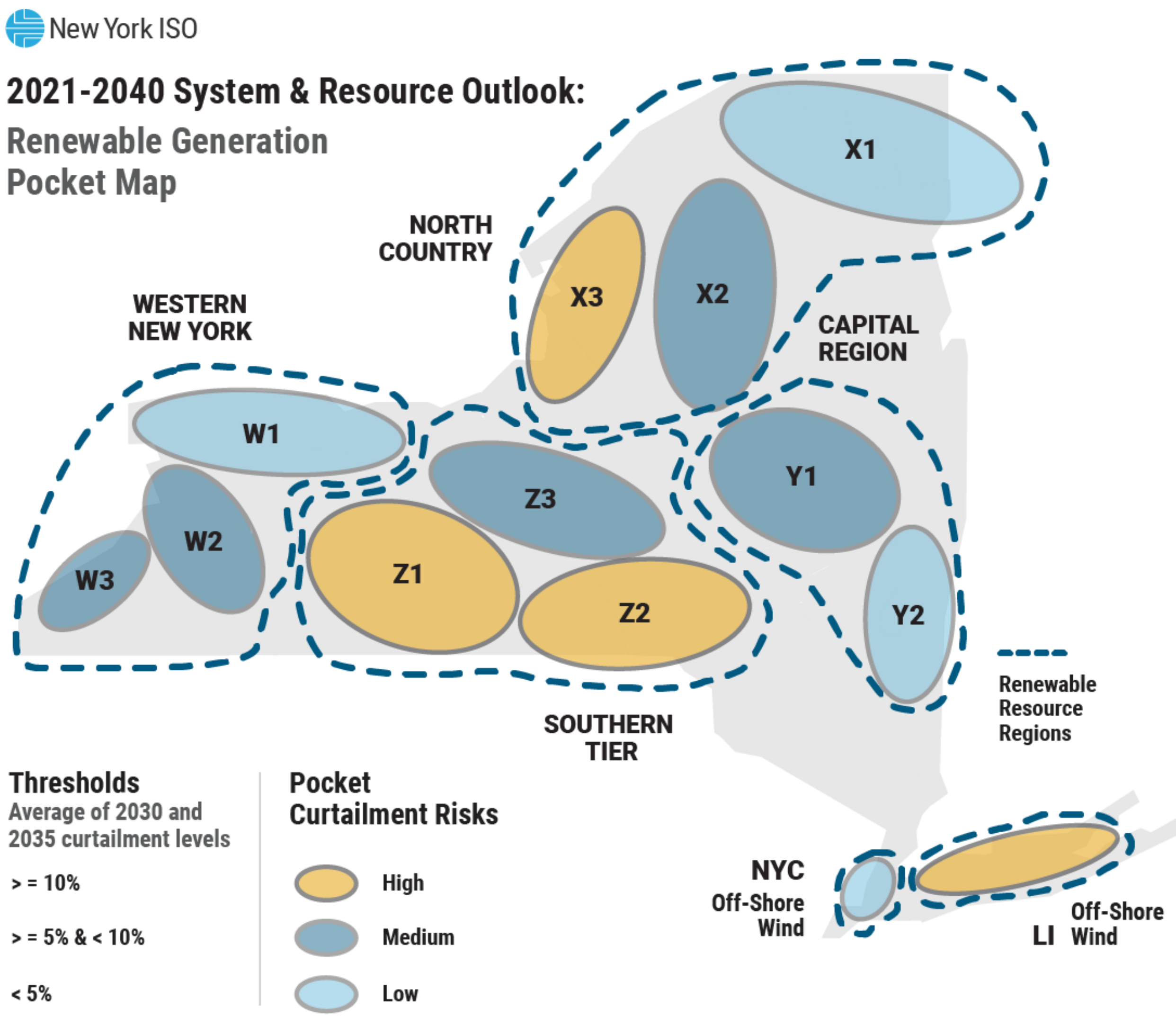
In another scenario, the NYISO analyzed the impact to the resource mix if investments are not made in research, development, and commercialization of dispatchable emission-free resources (DEFRs, such as hydrogen, renewable natural gas, nuclear, etc.). The exclusion of DEFRs as a new technology option, while enforcing the retirement of fossil generators via the zero-emission by 2040 policy, exhausts the amount of land-based wind built and results in the replacement of 45 GW of DEFR capacity in Scenario 1 with 30 GW of offshore wind and 40 GW of energy storage. Note that this capacity replacement estimate is not realistic and should only be considered as a directional proxy, which is not a substitute for the attributes provided by either today's fossil fueled fleet or by future DEFRs. Further reliability concerns, such as voltage support and dynamic stability, may require other transmission system reinforcements to maintain reliability in the future grid.

Renewable Generation Pockets: Transmission Challenges and Opportunities

Due to the significant resource additions, new transmission constraints appear across the system as CLCPA achievement approaches in 2040. To better understand the impacts from these new constraints, generation pockets are identified based on their geographical locations. Each pocket depicts a geographic grouping of renewable generators, and transmission constraints in a local area and that are further highlighted in sub-pockets. The renewable generation pocket concept originated with the "70 x 30" scenario in the 2019 economic planning study, and a similar framework was used for this Outlook with the addition of the new energy deliverability metric.

Energy deliverability represents the ability of renewable generation (wind, solar, and hydro) to inject energy into the grid to serve end use consumers without curtailment. The following charts highlight the energy deliverability findings in 2030 and 2035. Generally, energy deliverability is reduced as more renewable capacity is added to the system, driven by transmission constraints across the system. The greater the renewable generation curtailment in a given pocket, the greater the opportunity for transmission investment. High curtailment pockets represent transmission needs that must be addressed in order to achieve the public policy targets of the CLCPA.

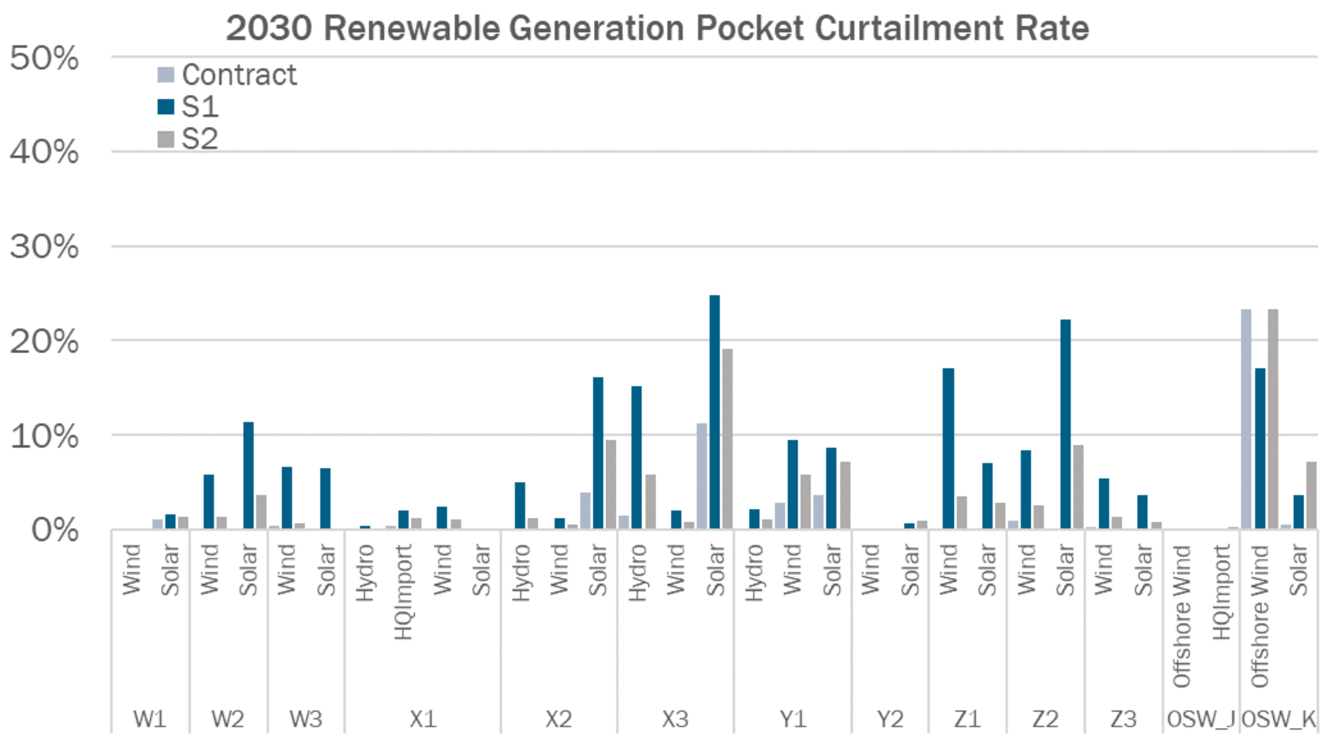
The renewable generation pocket map below was created using renewable energy deliverability results and transmission congestion results from the Contract and Policy cases. The naming conventions and geographic areas for the renewable generation pockets are consistent with those originally identified in 2019, but the transmission constraints and new generation differ.

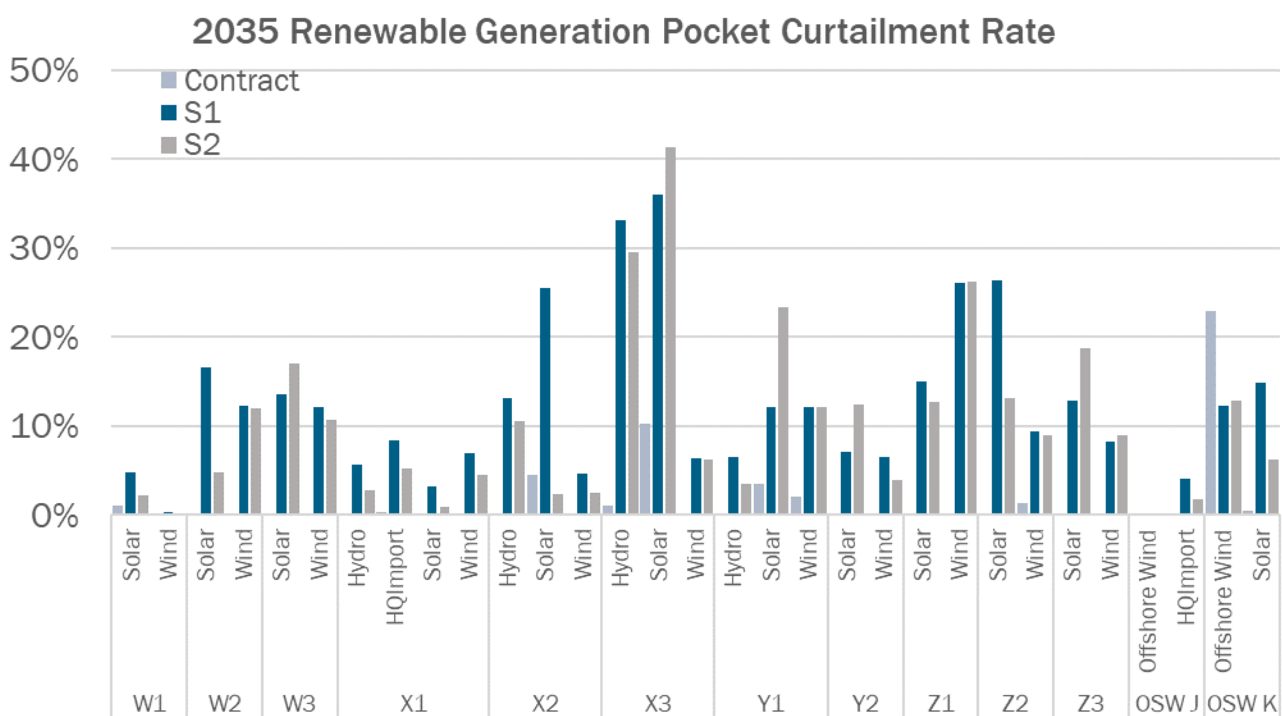


Four pockets will particularly benefit from transmission expansion: Finger Lakes (Z1), Southern Tier (Z2), Watertown (X3), and Long Island. Without investment in transmission, these areas of the New York grid will experience persistent and significant limitations to deliver the renewable power from these pockets to consumers in the upcoming years.

Curtailment of renewable generation occurs when a transmission line would become overloaded if renewable generation were not dispatched to a lower output level. The decision to curtail a specific renewable generator is dependent upon both electrical location and energy market bids. A second form of renewable generation re-dispatch, termed "spillage," can also occur. Spillage of renewable energy can occur when all relevant dispatchable resources have been set to minimum levels and energy export limits have been reached, which would necessitate a reduction in renewable generation output to balance the system. Spillage conditions are projected to occur as early as 2030 and would be most prevalent during the spring season when electricity demand is low and renewable generator production is high.

Renewable Generation Pocket Curtailment Rates by Generation Type in 2030 and 2035





New York is strongly interconnected to neighboring regions through the high-voltage transmission network. Energy is transmitted in interstate commerce along the interstate grid based on bids and offers across regional lines as provided by federal market rules approved by the Federal Energy Regulatory Commission under the Federal Power Act. The economic and operational impact from neighboring electric systems will continue to evolve as the neighboring states also strive to achieve their respective energy policy targets. While the strong interconnection provides many economic and reliability benefits, it also makes the New York grid susceptible to changes outside of the region, such as nuclear refurbishment/retirement in Ontario leading to reduced congestion on the Central East interface, and potential imports from external CO_2-producing fossil generation, which impacts the zero-emission policy attainment in 2040. The interregional impacts of state-specific polices are dynamic and the rapid changes will require continuous monitoring and assessment. The Northeastern ISO/RTO Planning Coordination Protocol provides a mechanism by which studies of these impacts can be performed. Potential interregional transmission solutions can be identified to further energy deliverability among regions. The extent to which regions outside New York adopt clean energy goals of their own will determine the mix of renewable and non-renewable resources that are available to serve New York.

Next Steps

The Outlook has, for the first time, built upon the data, modelling, and studies developed within the NYISO's System & Resource Planning Department and will serve 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 stakeholders to identify the challenges and opportunities associated with achieving state policies in an economic and reliable manner.

The 2022 Reliability Needs Assessment will leverage data from the Outlook to identify commitment and dispatch trends and related bulk power system reliability impacts as policy goals are approached. The 2022 Grid in Transition study the NYISO is also performing will leverage data from the Outlook to continue analysis surrounding potential grid needs and inform market designs for the future grid.

The 2022-2023 Public Policy Transmission Planning cycle kicks off in August, 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 and for which transmission solutions should be requested and evaluated. Interested parties should consider the key findings from the Outlook when submitting comments identifying Public Policy Transmission Needs for consideration by the New York State Public Service Commission.

Recommendations

The important findings identified in the 2021-2040 System & Resource Outlook bring forth several recommendations to address the challenges revealed by the study:

- Many transmission needs will arise over the next 20 years driven by public policy requirements, most notable the New York State climate mandates enacted in 2019 and 2020. The most notable and urgent transmission needs include:
    - Long Island offshore wind export: the NYISO is currently evaluating the viable and sufficient project proposals to the Long Island Offshore Wind Export Public Policy Transmission Need ("Long Island PPTN"), based on the Order issued by the New York State Public Service Commission on March 19, 2021. If a more efficient or cost-effective solution is selected to meet the Long Island PPTN, the congestion in Long Island is expected to be reduced significantly. However, offshore wind resource additions of up to 20 GW that are under discussion[4] may necessitate additional transmission to deliver offshore wind energy to New Yorkers.
    - The Watertown/Tug Hill Plateau renewable generation pocket (X3): the 115 kV network is expected to limit the availability of the already-contracted wind and solar generation in this area, and the limitation will become more severe when more renewable resources are interconnected. Additional transmission is necessary to provide the resources access to the bulk grid.
    - Southern Tier renewable generation pocket (Z1, Z2): the land and natural resource availability in this region (wind and solar) attract renewable generation buildout in this area. Transmission expansion from this pocket to the bulk grid would benefit New York consumers statewide.
- Future uncertainty is the only thing certain about the electric power industry. From policy advancements to new dispatchable emissions-free resource technology development, the system is set to change at a rapid pace. Situational awareness of system changes and continuous assessment are critical to ensure a reliable and lower-emissions grid for New York. The

[4] New York State Climate Action Council Draft Scoping Plan, December 30, 2021, available at, https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan.

Economic Planning databases and models will be continually updated with new information and the Outlook study will be improved and performed on a biennial basis.

- To meet the minimum capacity requirement in 2040, at least 95 to 110 GW of new emission-free resources, including approximately 9.5 GW of new contracted renewable resources, will be required to come on-line. Furthermore, to fully achieve the emission-free grid target by 2040, even more resources will likely be needed along with transmission to deliver the clean power to consumers. The scope of the additional renewable resource need is remarkable. Compared to the 2.6 GW capacity entering into service in the past five years while New York experienced a net loss of approximately 2.2 GW, the installation rate in the next 20 years must increase significantly to achieve state law climate change requirements. State agencies should consider releasing a clear procurement schedule for renewable resources to guide the long-term system planning and provide clarity to the market.

- The challenges identified in the Outlook cannot be solved by any single entity. New York's Climate Action Council has released a draft scoping plan to reduce New York State's carbon footprint across all sectors, make our communities more resilient, and adapt to a changing climate. This report further supports the mission by quantifying the evolving challenges in the electricity sector and making recommendations to address those challenges. In addition to much more renewable resources, this report identifies other key factors for success, such as significant transmission expansion, and efficient peak load management. The full set of comprehensive electric system requirements will need participation among policy makers, generator owners, transmission owners, and consumers. Communication and collaboration between stakeholders are essential to making progress towards achieving policy objectives while maintaining an efficient power market and reliable power grid.

System & Resource Outlook Overview

In 2020, the NYISO undertook a comprehensive review of its Economic Planning Process to determine how the studies, tools, and metrics in that process could be enhanced. The impetus for the review arose from the rapidly shifting resource landscape toward renewable resources driven by the CLCPA and other state clean energy policies. This changing landscape led the NYISO to engage stakeholders to examine how the NYISO's Economic Planning studies could be enhanced to identify the most economic and efficient locations for the construction of renewable resources, the transmission needed to deliver energy to consumers from onshore and offshore renewable resources, and the impact of the renewable resources on the transmission system. The enhancements developed extend the study outlook to 20 years and broaden the benefits considered in evaluating potential projects to address congestion, such as the deliverability of energy output from new renewable resources and capacity cost savings associated with transmission expansion. These enhancements were approved by stakeholders and were accepted by FERC in April 2021.

For the first time, the NYISO has compiled this 20-year System & Resource Outlook ("The Outlook"). The Outlook provides a comprehensive overview of system resources and transmission constraints throughout New York, highlighting opportunities for transmission investment driven by economics and public policy. Together, the Comprehensive Reliability Plan and the System & Resource Outlook provide a full power system outlook to stakeholders, developers, and policymakers.

The Outlook provides a wide range of potential future system conditions and enables comparisons between possible pathways to an increasingly lower emissions resource mix. By forecasting transmission congestion, the NYISO will:

- Identify regions of New York where renewable generation may be heavily curtailed due to transmission constraints;
- Quantify the extent to which these constraints limit delivery of renewable energy to consumers; and identify potential transmission opportunities that may provide economic and/or operational benefits.

The new Outlook process provides transmission developers and resources the ability to request their own studies using the NYISO tools to identify the most economic opportunities for investment. Moreover, if a developer proposes a regulated transmission project to address constraints identified in the Economic Planning Process, the NYISO will perform an evaluation of the proposed project. Load serving entities identified by the NYISO as the project beneficiaries must approve the selection of a proposed regulated transmission project by a super-majority vote. If a project is approved, it is eligible for cost allocation and recovery through the NYISO tariffs.

In the Outlook, the system is evaluated under various future system conditions and resource buildouts to provide multiple potential future outcomes for analysis. Unlike previous Economic Planning studies, which only evaluated a single base case, the Outlook evaluates three reference cases. The development of each of the reference cases leverages NYISO's expertise in power system data and modeling as well as consistent and meaningful engagement with stakeholders.

The three reference cases are:

Baseline Case - The Baseline is a "business-as-usual" type scenario that aligns with the Reliability Planning Process to define the demand, generation, and transmission assumptions. Strict inclusion rules limit the amount of new projects that are assumed to be completed in this case, and generic future generation is added to meet reliability requirements through 2030, if needed. The Baseline utilizes the demand and energy forecasts from the 2021 NYISO Load & Capacity Data Report ("Gold Book").

Contract Case - This case builds upon the Baseline Case by adding incremental renewable generation projects that have obtained financial contracts with the state (e.g., NYSERDA Renewable Energy Certificates ("REC") contracts) and thus have a higher likelihood of completion, even though they do not yet meet Baseline Case inclusion rules. Incremental projects may include both those within New York and within the neighboring regions.

Policy Case - Assumptions in the Policy Case reflect the federal, state, and local policies that impact the New York power system. Examples of policies modeled in this case include the "70 x 30" renewable mandate and the 2040 zero-emissions directive. This system representation will also be utilized as part of the Public Policy Process, including evaluation of the Long Island offshore wind export Public Policy Transmission Need.

The suite of analyses in the Outlook provides a wide range of potential future system conditions and afford the ability to compare possible pathways to the future resource mix. Through the projection of future transmission congestion utilizing complex hourly production cost simulations, the NYISO will: (1) identify regions of New York where renewable generation "pockets" are expected to form, (2) quantify the extent to which those pockets limit delivery of renewable energy to consumers, and (3) present information for stakeholders to identify potential transmission opportunities that may provide economic and operational benefits. In addition, the NYISO will utilize the simulations to investigate and assess future system performance including ramping, reserves, and cycling of conventional thermal generators. These analyses will, in turn, inform reliability studies, including the 2022 Reliability Needs Assessment.

State of System & Resource Planning

The Outlook is developed through the Economic Planning Process, which is part 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. Through the CSPP, numerous assessments, evaluations, and plans are developed and relied upon by the NYISO to conduct system planning, including demand forecast & analysis, reliability planning, economic planning, public policy planning, interregional planning, and interconnection studies.

State of the Grid

How New York's power grid serves consumers is changing dramatically, and the bulk power system is evolving to meet the state's clean energy objectives. The NYISO offers two annual publications: the Load & Capacity Data Report[5] ("Gold Book") and Power Trends[6], that provide independent sources of information and analysis on New York's complex electric system.

The New York Control Area (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 zones is shown in **Figure 1.**

Figure 1: NYISO Load Zone Map

5 2022 Load & Capacity Data Report

6 2022 Power Trends

The detailed data and analysis of the generation in New York can be found in Power Trends. A summary of the current system resources is provided below to facilitate understanding of the findings in this report. **Figure 2** depicts the projected mix of resource capacity expected to be available for the 2022 summer capability period. **Figure 3** provides the energy production by fuel sources in 2021. In 2021, zero-emission resources made up 91% of upstate production, while fossil units downstate made up 89% of the production from that region.

Figure 2: Summer Installed Capacity (MW) by Fuel Source – Statewide, Upstate, & Downstate New York: 2022

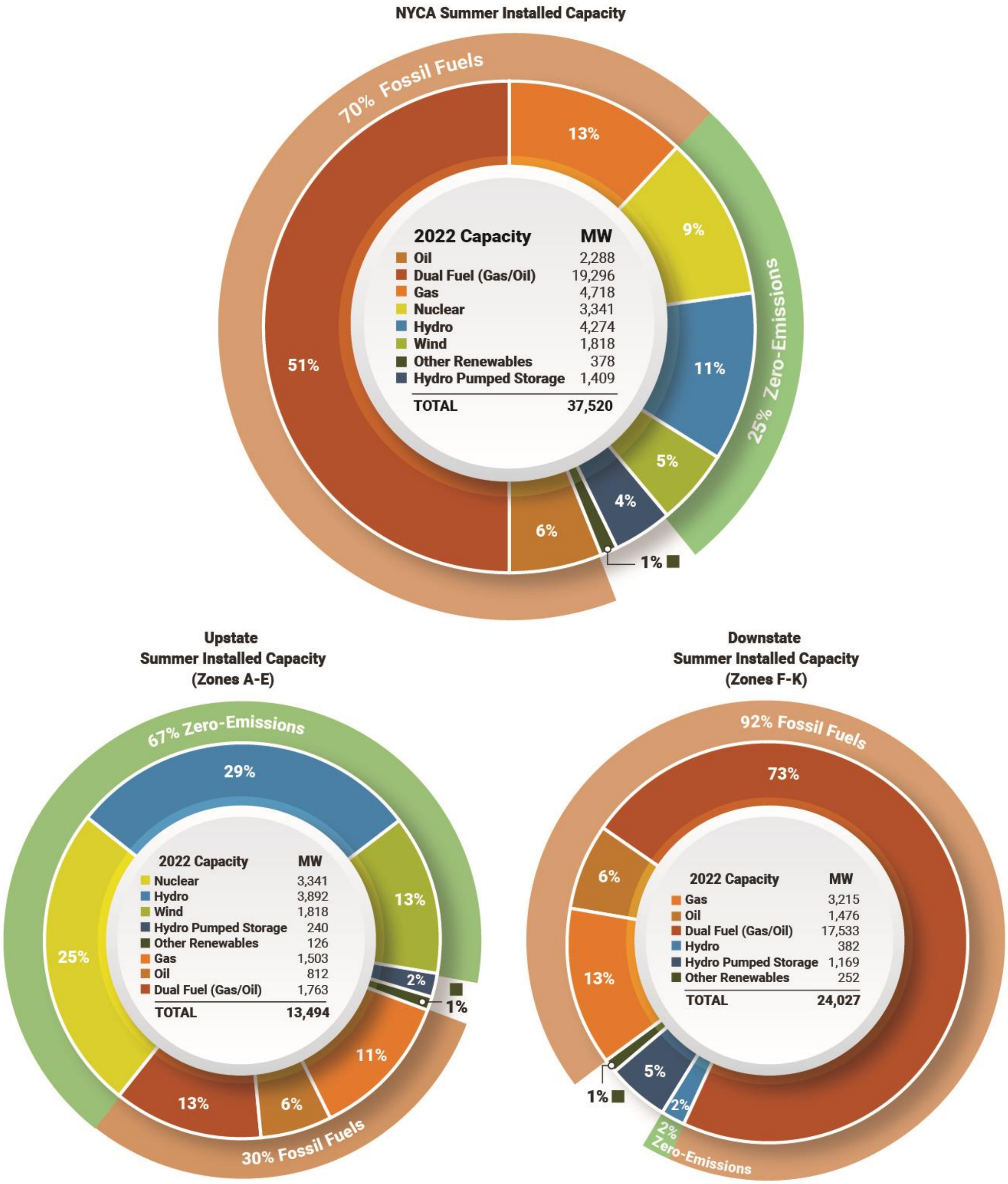
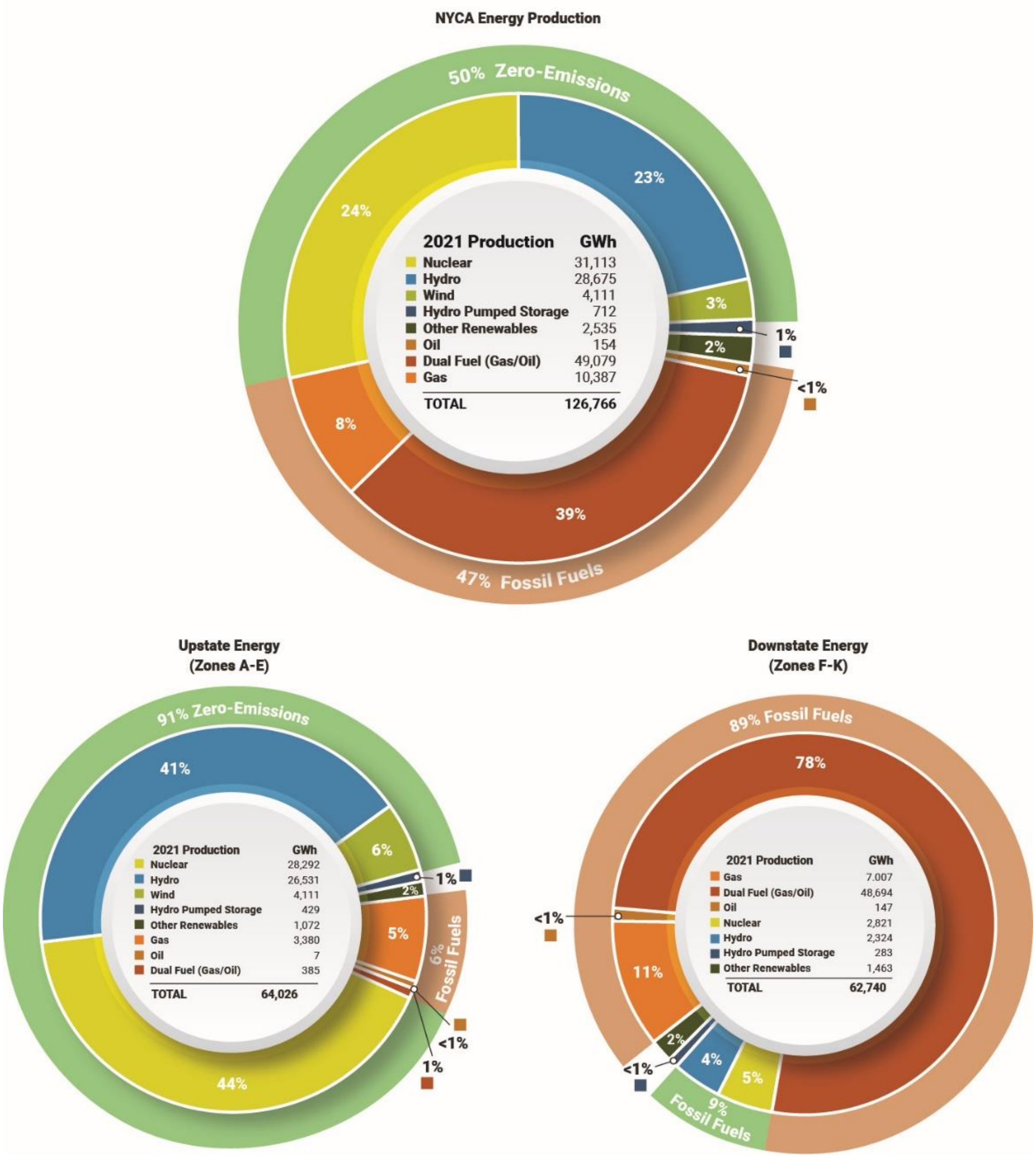


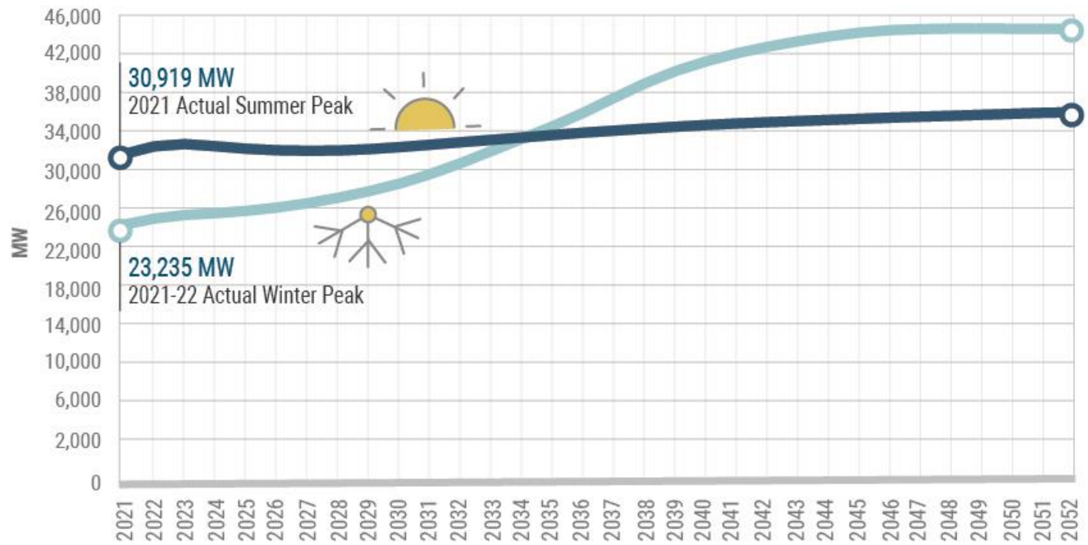
Figure 3: Energy Production by Fuel Source (GWh) – Statewide, Upstate, & Downstate New York: 2021



Demand Forecasting & Analysis

The 2022 Gold Book presents the NYISO load and capacity data for 2022 and future years, including historic and future energy and peak forecasts through 2052, existing and proposed generating capacity projected through 2032, and existing and proposed transmission facilities.

Figure 4: Electric Summer and Winter Peak Demand – Actual & Forecast: 2021-2052



Over a 30-year horizon, the New York Control Area (NYCA) baseline energy and summer peak demand forecast growth rates both increased compared to 2021, as shown in the following table:

Figure 5: Gold Book Average Annual NYCA Baseline Energy and Summer Peak Demand Growth Rates

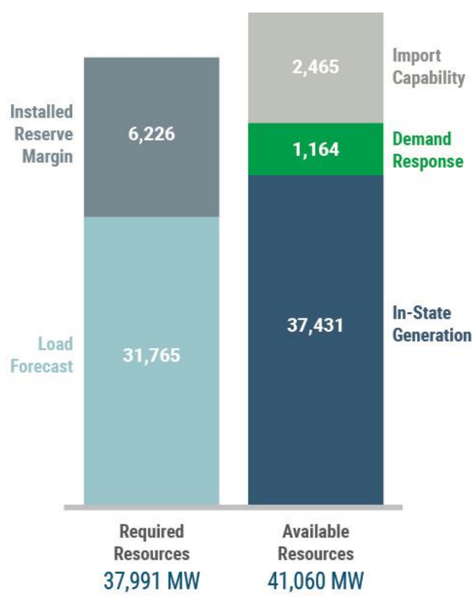
Publication	Average Annual Growth Rates							
	Baseline Energy Usage				Baseline Summer Peak Demand			
	Years 1-30	Years 1-10	Years 11-20	Years 21-30	Years 1-30	Years 1-10	Years 11-20	Years 21-30
2021 Gold Book (2021-2051)	0.96%	-0.28%	1.15%	1.88%	0.20%	-0.24%	0.44%	0.39%
2022 Gold Book (2022-2052)	1.04%	0.22%	2.25%	0.49%	0.39%	0.14%	0.68%	0.32%

Peak load and energy demand remains stable over the first decade of the forecast, as energy efficiency and BTM-PV installations offset expected econometric load growth. Demand increases in the latter decades as increased adoption of electrification end uses in the building and transportation sector more than offset continued load reductions from energy efficiency and BTM-PV. Due to these forecasted changes, the NYCA system is expected to transition from a summer to a winter peaking system, driven principally by electrification of space heating, in the mid-2030s. The actual loads experienced by the electric system will depend on assumptions related to load flexibility and adoption rates of electrification across scenarios.

Total generation resource capability in New York for the summer of 2022 is projected to be 41,060 MW, which includes 37,431 MW of generating capability, 1,164 MW of Special Case Resources ("SCR"), and 2,465 MW of net long-term purchases and sales with neighboring control areas. The generation capacity projection beyond 2022 is discussed further in this report.

For the 2022-23 capability year beginning May 1, 2022, the approved Installed Reserve Margin ("IRM") is 19.6%. Based on a projected summer 2022 peak demand of 31,765 MW, the total installed capacity requirement for the upcoming summer capability period is 37,991 MW.

Figure 6: Statewide Resource Availability: Summer 2022



Transmission Additions

Three public policy transmission projects have been included in all of the analyses, as selected by the NYISO Board of Directors: Western New York (Empire State Line by NextEra Energy Transmission New York, Inc.), AC Transmission Segment A (Segment A Double Circuit by LS Power Grid New York, LLC and NYPA), and AC Transmission Segment B (Segment B Knickerbocker-PV by National Grid and New York Transco). The Empire State Line is now in-service while Segment A and Segment B are under construction.

Additionally, three proposed transmission additions beyond the baseline are included in the Road to 2040 Policy Case analysis: the Smart Path Connect Project and two "Tier 4" projects. Even though these projects are not under construction yet, they have certain approvals by the New York

Public Service Commission ("NYPSC") to meet CLCPA targets.

New York Power Authority's Smart Path Connect Project[7] is a "priority transmission project" upgrading the existing 230 kV lines in Northern New York to 345 kV, along with substation construction and upgrades. Two other projects received Tier 4 renewable energy credit (REC) awards to establish transmission corridors to bring renewable energy to New York City:

- Champlain Hudson Power Express project[8] (CHPE), jointly developed by Transmission Developers, Inc. and Hydro-Québec, is a 1,250 MW, 375-mile submarine and underground HVDC transmission project delivering power from Québec, Canada to New York City.
- Clean Path New York project[9] (CPNY), jointly developed by Forward Power (a joint venture of Invenergy and EnergyRe) and the New York Power Authority, is a 1,300 MW, 174 mile underground and submarine HVDC transmission line from Fraser substation in upstate New York to New York City.

Comprehensive System Planning Process

Understanding the impacts to the generation, transmission, and load components of the bulk electric system is critical to understanding the challenges to reliable electric service in the coming years. The NYISO is evolving its CSPP to match the pace of change on the grid while continuing to find needs and opportunities for investment to promote reliable and efficient operations.

The CSPP establishes the rules by which the NYISO solicits, evaluates, and selects the more efficient or cost-effective solutions to address reliability, economic, and public policy-driven transmission needs in New York. The NYISO's CSPP has four components—the Local Transmission Planning Process, the Reliability Planning Process/Short-Term Reliability Process, the Economic Planning Process, and the Public Policy Transmission Planning Process. In concert with these four components, interregional planning is conducted with the NYISO's neighboring control areas in the United States and Canada under the Northeastern ISO/RTO Planning Coordination Protocol.

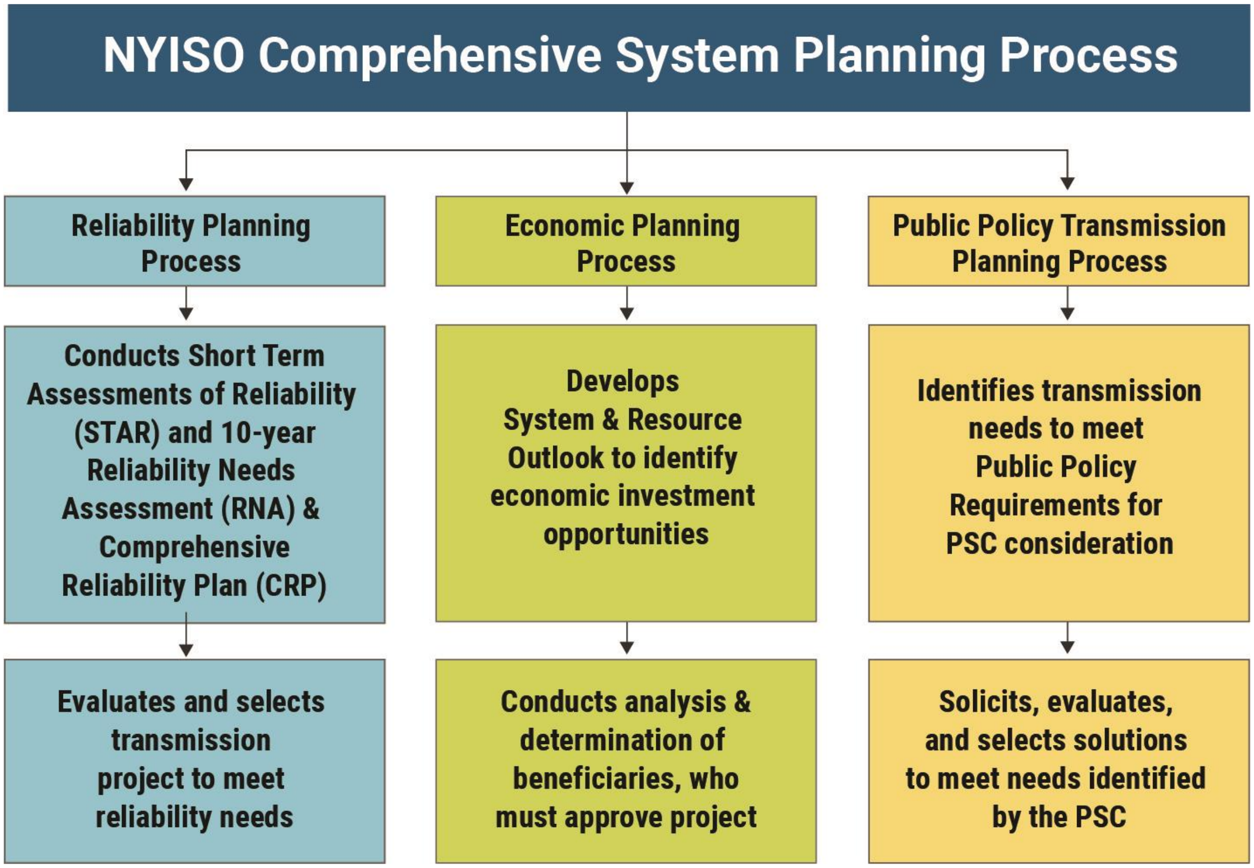
---

[7] Smart Path Connect (nypa.gov), approved in October 2020 by NYSPSC under New York's Accelerated Renewable Energy Growth and Community Benefit Act

[8] https://chpexpress.com/

[9] https://www.cleanpathny.com/

Figure 7: NYISO Comprehensive System Planning Process



Reliability Planning Process

The Reliability Planning Process is composed of four components:

1. Each transmission owner conducts a public Local Transmission Planning Process for its transmission district that feeds into statewide planning;
2. The quarterly Short-Term Assessments of Reliability (STARs) address near-term needs, with a focus on needs arising in the next three years. The Short-Term Reliability Process includes assessing the potential for reliability needs arising from proposed generator deactivations;
3. The Reliability Needs Assessment (RNA) 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) integrates all of the planning studies into a ten-year reliability 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 the next decade.

The 2021-2030 Comprehensive Reliability Plan (CRP)[10] completed the NYISO's 2020-2021 cycle of the Reliability Planning Process. The 2020 Reliability Needs Assessment (RNA)[11], approved by the NYISO Board of Directors in November 2020, was the first step of that process. The CRP followed the 2020 RNA and post-RNA updates and incorporated findings and solutions from the quarterly Short-Term Reliability Process. The CRP concluded that the New York State Bulk Power Transmission Facilities as planned will meet all currently applicable reliability criteria from 2021 through 2030 for forecasted system demand in normal weather. Some risk factors to system reliability are noted, namely tightening reserve margins due to additional loss of generation, any delays in planned transmission projects, and extreme weather events such as heatwaves or storms.

The CRP also notes that the mandates in New York's Climate Leadership and Community Protection Act ("CLCPA") of 70% of electricity from renewable resources by 2030 and zero-emissions electricity by 2040 marks significant changes to the electric system, and that understanding the impacts of these mandates is critical to understanding the challenges of maintaining system reliability. Transmission will play a key role in moving energy from the renewable resources to the load centers. Several transmission projects have been approved across upstate to accommodate delivery of renewable energy from northern New York. The NYISO is currently evaluating transmission solutions to address the NYSPSC-identified need for facilities to deliver power from offshore wind. Even with the potential benefits provided by these bulk system projects, several renewable generation pockets across the state are projected to persist, which could constrain output from renewable resources, including production from offshore wind. As the level of renewable resource generation increases, the grid will need sufficient flexible and dispatchable resources to balance variations in wind and solar output.

The integration of batteries will help store energy for later use on the grid, which will aid with the short duration and daily cycles of reducing renewable resource output. The scope of planned battery storage alone, however, will not meet system needs to balance intermittent resources when renewable resources are unavailable.

Looking ahead to 2040, the policy for a zero-emissions electric system will also require the

[10] https://www.nyiso.com/documents/20142/2248481/2021-2030-Comprehensive-Reliability-Plan.pdf/

[11] https://www.nyiso.com/documents/20142/2248793/2020-RNAReport-Nov2020.pdf

development of new technologies to maintain the supply demand balance. Substantial dispatchable emission-free resources (DEFR) will be required to fully replace fossil fueled generation, which currently serves as the primary balancing resource. Long-duration, dispatchable, and emission-free resources will be necessary to maintain reliability and meet the objectives of the CLCPA. Resources with this combination of attributes are not commercially available at this time but will be critical to future grid reliability.

Public Policy Transmission Planning Process

The Public Policy Transmission Planning Process (PPTPP) is conducted in parallel with the RNA and the CRP. It occurs in two phases: Phase I, Identify Needs and Assess Solutions; and Phase II, Transmission Evaluation and Selection. In Phase I, the NYISO solicits stakeholder input regarding transmission needs driven by Public Policy Requirements, and the NYSPSC identifies transmission needs and defines additional evaluation criteria. The NYISO holds a technical conference and then solicits solutions to address the identified needs. After receiving the submissions, the NYISO determines which ones are viable and sufficient to meet the public policy need. In Phase II, the NYISO evaluates the viable and sufficient transmission solutions that decide to proceed and recommends the more efficient or cost-effective solution. Thereafter, the NYISO Board may select a transmission solution for purposes of cost allocation and recovery under the NYISO Tariff.

In August 2020, the NYISO solicited stakeholder input and received 15 proposals for transmission needs driven by Public Policy Requirements, including the CLCPA and the Accelerated Renewable Growth and Community Benefit Act, and submitted those proposals to the NYSPSC. Eleven of those proposals, associated with the development of transmission in support of offshore wind generation, were also submitted to the Long Island Power Authority for consideration. In its comments to the NYSPSC, the NYISO expressed its support for declaration of Public Policy Transmission Needs to deliver renewable energy to consumers from upstate generation pockets, offshore wind facilities connected to Long Island, and offshore wind facilities connected to New York City.

The Long Island Power Authority Board of Trustees identified a transmission need for offshore wind onto and exported from Long Island to the rest of New York State to meet state climate change law requirements. Based on this referral and input from the NYISO and other interested parties, the NYSPSC issued an order declaring that offshore wind goals are driving the need for additional transmission facilities to add at least one transmission cable to deliver at least 3,000 MW of offshore wind output from Long Island to the rest of New York State, along with local transmission system upgrades on Long Island itself. The NYSPSC referred the identified need to the NYISO to solicit potential solutions. Nineteen projects were proposed by four developers, sixteen of which were found to be viable and sufficient. The NYISO is evaluating those projects to recommend to the Board of Directors the more efficient or cost-effective project to meet the need, with results expected in 2023.

The 2022-2023 cycle of the Public Policy Transmission Planning Process will commence in August 2022 with a request for proposed transmission needs being driven by Public Policy Requirements. Following the 60-day request window, the NYISO will file the proposals with the PSC for their consideration to identify Public Policy Transmission Needs.

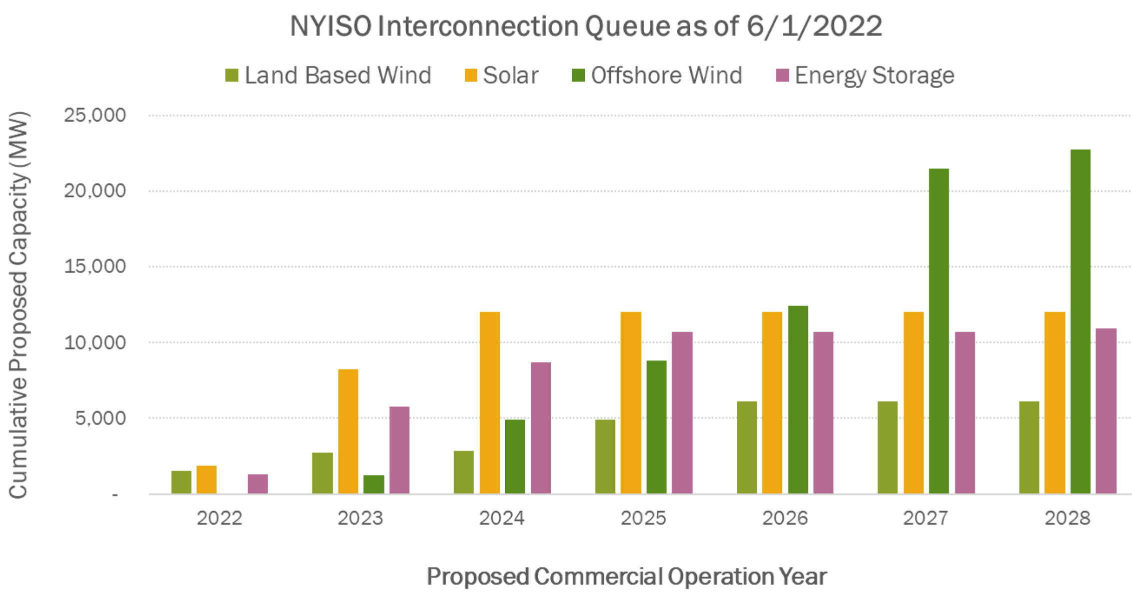
Interconnection Studies

The NYISO's interconnection processes[12] are crucial to facilitating the development and interconnection of proposed generation, transmission, and load facilities to the NYCA system. The interconnection process supports grid reliability by identifying potential adverse impacts due to proposed projects, and requires coordination between the NYISO, developers, and associated transmission owners throughout the process. These ongoing processes are necessary to accommodate the significant portfolio of new projects that developers are proposing to interconnect to the grid in response to state policies. Of note, a significant portion of the new projects are renewable energy and energy storage resources, as shown below in

[12] https://www.nyiso.com/interconnections

Figure 8 to help address these policies.

Figure 8: Proposed Renewable Energy Capacity in the NYISO Interconnection Queue



Similar to other NYISO planning studies, the NYISO's interconnection process is key to the generation and load assumptions in the 2021-2040 System & Resource Outlook study. As it pertains to the Outlook study, the NYISO's Interconnection Queue was used as a reference in each of the three cases (Baseline, Contract, and Policy Cases), for purposes of generation placement within New York. The Baseline and Contract Cases include proposed generation and load projects based on the NYISO's Interconnection Queue, as determined using inclusion rules for each case. Specific to the Policy Case, the Interconnection Queue was one of many sources of information in guiding the process of translating the generation expansion results from the capacity expansion model at a zonal level into discrete generators at the nodal level in system modeling. Additional information on the generator placement process for the Policy Case is provided in [section placeholder].

Contracted Renewable Resources

The policies and laws mandated by the CLCPA are driving an unprecedented change in New York's power sector as it transitions to an emissions-free electric system. While the transition is being implemented by many different entities, NYSERDA plays a key role. Through an annual request for proposals, NYSERDA solicits bids from eligible new large-scale renewable resources and procures Renewable Energy Certificates ("RECs") from these facilities. These credits enable an entity to sell the renewable attribute of their electrical output and thereby procure financing for their projects. The "Contract Case" evaluated in this Outlook adds approximately 9,500 MW of new contracted renewable resources, including 4,262 MW of solar, 899 MW of land-based wind, and 4,316 MW of offshore wind. The addition of these resources to the Baseline system representation provides insights regarding their impact on system performance in the future.

The analysis performed focuses on transmission congestion and how patterns change through time as New York State contracted renewable projects are added to the system. This section begins with the Baseline to establish a reference point then advances to the Contract Case to calculate the impact of contracted resources. It is important to note that neither the Baseline nor the Contract Case models generation additions or retirements beyond what was included in the 2021-2030 Comprehensive Reliability Plan or what has been contracted by the State.

Baseline Assessment

The Outlook Baseline Case can be viewed as a "Business as Usual" case starting with the most recent Reliability Planning Process Base Case and incorporating incremental resource changes based on the NYISO's Reliability Planning Process study inclusion rules.[13] The strict inclusion rules limit the amount of new projects that are assumed to be completed in this case, and generic future generation is added to meet reliability requirements through 2030, if needed. The Baseline utilizes the demand and energy forecasts from the 2021 NYISO Load & Capacity Data Report ("Gold Book").

Key Assumptions

The 2021-2040 Outlook study period aligns with the ten-year planning horizon for the 2021-2030 Comprehensive Reliability Plan plus an additional ten years to extend to 2040. Study assumptions are based on any conditions that met the NYISO's inclusion rules as of the lock-down date for data inputs into the Outlook. The NYISO chose August 1, 2021 as the Baseline Case lock-down date as it aligns with the most recent reliability case lockdown date for the 2021-2030

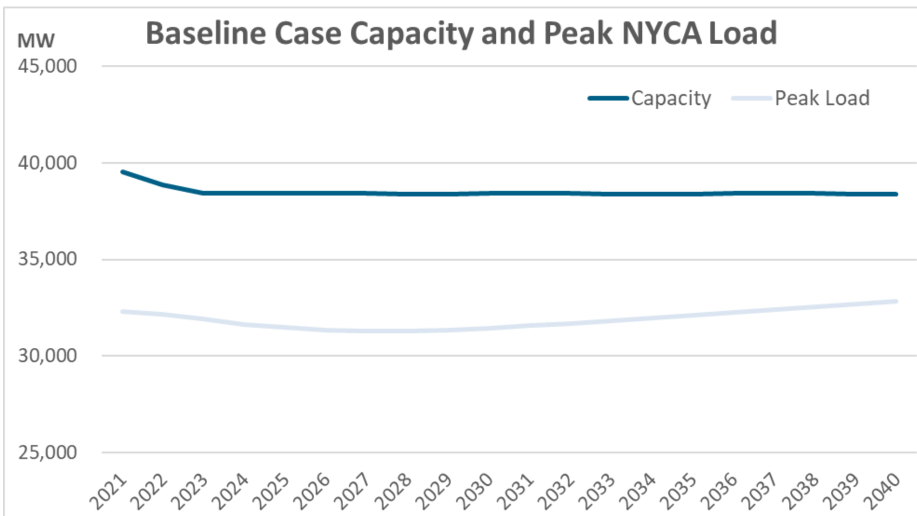
[13] See Reliability Planning Process Manual, Manual No. 36, § 3.2.

Comprehensive Reliability Plan. The proposed generator status changes related to the DEC Peaker Rule are included according to each unit's compliance plan[14].

Appendix placeholder includes a detailed description of the assumptions utilized in the Outlook analysis. Some key assumptions for the Baseline Case are:

- The load and capacity forecasts are updated using the 2021 Load and Capacity Data Report ("Gold Book") Baseline forecast for energy and peak demand by zone for the 20-year study period. New resources and changes in resource capacity ratings were incorporated based on the Reliability Needs Assessment inclusion rules.

Figure 9: Baseline Case NYCA Capacity and Peak Loads



- The network configuration aligns with the 2021 Reliability Planning Process as the starting point and is updated with the latest information from the 2021 Gold Book.
- The transmission and constraint model utilizes a bulk power system representation for most of the Eastern Interconnection. The model uses transfer limits and actual operating limits from the 2021 Reliability Planning Process case.
- Production cost curves, unit heat rates, fuel forecasts, and emission allowance price forecasts were developed by the NYISO from multiple data sets, including public domain information, proprietary forecasts, and confidential market information. The model includes scheduled generation maintenance periods based on a combination of each unit's planned and forced outage rates.

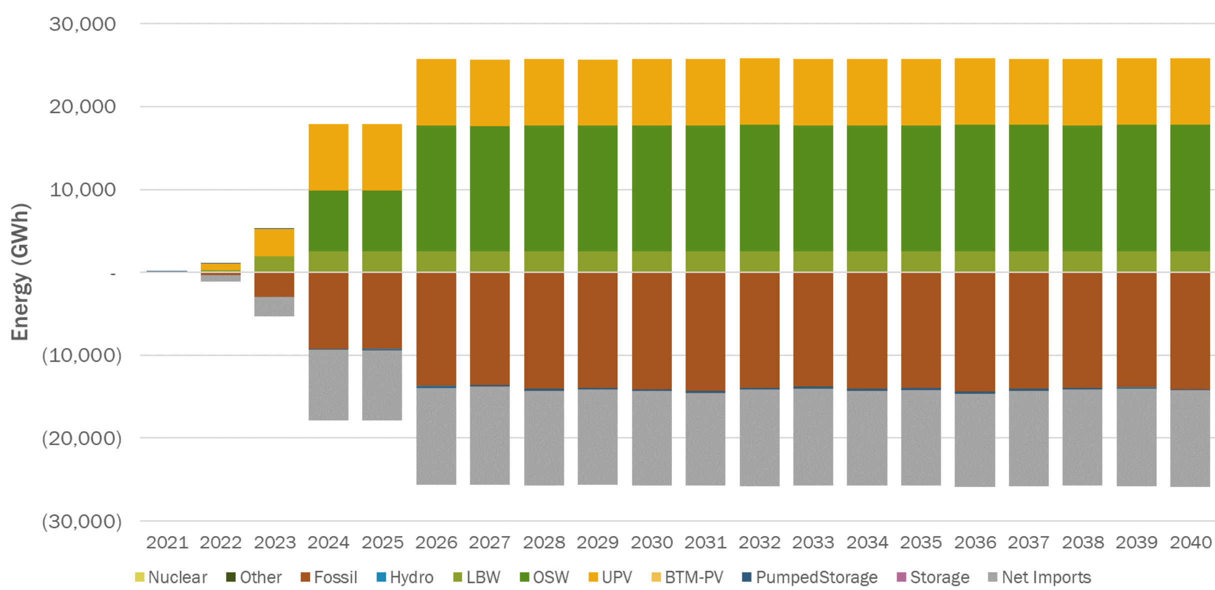
[14] Table VI-6, Proposed Generator Status Changes to Comply with DEC Peaker Rule, 2022 Gold Book

Supply and Demand Analysis

A production cost simulation is performed to provide a projection of the types of generation to meet energy demand through time on an hourly basis, like today's day-ahead energy market.

Figure 10 shows the annual projection of generation by unit type, along with the forecast of net imports and load.

Figure 10: Baseline Case NYCA Generation and Net Imports (GWh)



Under Baseline conditions, demand is projected to continue to be served primarily by fossil generation. Only a small percentage of generation is sourced from solar and wind generation. The increase in demand through the study period is met by incremental fossil generation and imports.

Transmission Congestion Assessment

The Outlook includes the development of a twenty-year projection of future costs of transmission congestion (demand$ congestion). This projection is combined with the past five years of historic congestion to identify significant and recurring congestion on the New York transmission system. A detailed assessment of historic and projected congestion is located in Appendix placeholder.

The identified congested elements from the twenty-year projection are appended to the past five years of identified historic congested elements to develop twenty-five years of demand congestion statistics for each initially identified top constraint. The twenty-five years of statistics are analyzed to identify recurring congestion. Ranking the identified constraints is initially based on the highest present value of congestion over the twenty-five year period.

The demand congestion is projected to reduce significantly in the Baseline Case. The key drivers include: the addition of the Western New York and AC Transmission Public Policy Transmission Projects, and the retirement and refurbishment of nuclear generators in Ontario as well as an increase in forecasted energy demand in that region. As a result, the 20-year total projected total demand congestion on Central East interface is a fraction of the 5-year historical total. Figure 11 lists the ranked elements based on the highest present value of congestion over the twenty-five years of the study, including both positive and negative congestion.

Figure 11: Ranked Elements Based on the Highest Present Value (2021 $M) of Demand$ Congestion over the 25-Year Aggregate (Baseline Case)

Congested Transmission	Historic Total (5 Years)	Projected Total (20 Years)	Historic + Projected Total (25 Years)
Central East Interface	3,487	1,061	4,548
Dunwoodie - Long Island (Y49 & Y50)	733	467	1,200
Edic - Marcy 345 kV	359	0	359
Leeds - Pleasant Valley 345 kV	266	5	271
North Waverly - East Sayre 115 kV	0	251	251
Greenwood Load Pocket	203	22	225
Dunwoodie - Motthaven 345 kV	164	35	199
Packard - Huntley 230 kV	184	0	184
Elwood - Pulaski 69 kV	0	161	161
Chester - Shoemaker 138 kV	34	101	135
Volney - Scriba 345 kV	7	107	114
New Scotland - Knickerbocker 345 kV	0	73	73
UPNY - ConEd Interface	10	58	67
Sugarloaf - Ramapo 138 kV	0	59	59
Northport - Pilgrim 69 kV	0	55	55
Greenbush - Stephentown 115 kV	0	49	49

The historic and future congestion analysis shows that several of the most severe bulk-level transmission constraints, such as Central East, will decline compared to historic levels. Three of the top four congested elements will decline directly due to the AC transmission projects.

Contracted Renewable Generation Assessment

Through an annual request for proposals, NYSERDA solicits bids from eligible new large-scale renewable resources and procures Renewable Energy Certificates ("RECs") from these facilities.[15]

[15] https://data.ny.gov/Energy-Environment/Large-scale-Renewable-Projects-Reported-by-NYSERDA/dprp-55ye

The Contract Case builds off the Baseline Case and additionally models the awarded generation units through NYSERDA's 2020 Solicitation that have not yet met the inclusion rules of the Outlook Baseline Case. Approximately 9,500 MW of new renewable units are added in this case, including 4,262 MW of solar, 899 MW of land-based wind, and 4,316 MW of offshore wind. The zonal breakdown of these additions is shown below.[16] On June 2, 2022 NYSERDA released the results of the 2021 REC Solicitation, announcing contracting with 22 new solar projects totaling 2,408 MW, which were not included in this assessment at they were announced after the analysis was complete.[17]

Figure 12: Zonal Renewable Generation Additions in the Contract Case (MW)

Zone		Resource Addition (MW)				LBMP Impact ($/MWh)	
		Solar	Land Based Wind	Offshore Wind	Total	2030 LBMPs	Reduction from Baseline Case
A	West	290	339		629	$ 38.32	$ 5.86
B	Genesee	1,330	200		1,530	$ 37.90	$ 6.02
C	Central	852	147		999	$ 39.51	$ 6.25
D	North	180			180	$ 36.13	$ 4.78
E	Mohawk Valley	739	213		952	$ 36.71	$ 6.72
F	Capital	730			730	$ 40.34	$ 3.69
G	Hudson Valley	140			140	$ 40.76	$ 3.82
J	New York City			2,046	2,046	$ 41.85	$ 3.55
K	Long Island			2,270	2,270	$ 40.81	$ 6.97
Total		4,262	899	4,316	9,476	$ 39.61	$ 4.96

Supply and Demand Analysis

Similar to the Baseline, a production cost simulation is performed to provide a projection of the types of generation utilized to meet energy demand through time on and hourly basis, like today's day-ahead energy market. The figure below shows the annual energy generation by each resource type in the Contract Case.

[16] A more detailed list of units added to the Contract Case can be found at https://www.nyiso.com/documents/20142/26278859/System_Resource_Outlook-Contract_Case_Renewables.xlsx/

[17] https://www.nyserda.ny.gov/All-Programs/Clean-Energy-Standard/Renewable-Generators-and-Developers/RES-Tier-One-Eligibility/Solicitations-for-Long-term-Contracts/2021-Solicitation-Resources

Figure 13: Projected NYCA Energy Generated by Fuel Type, Contract Case

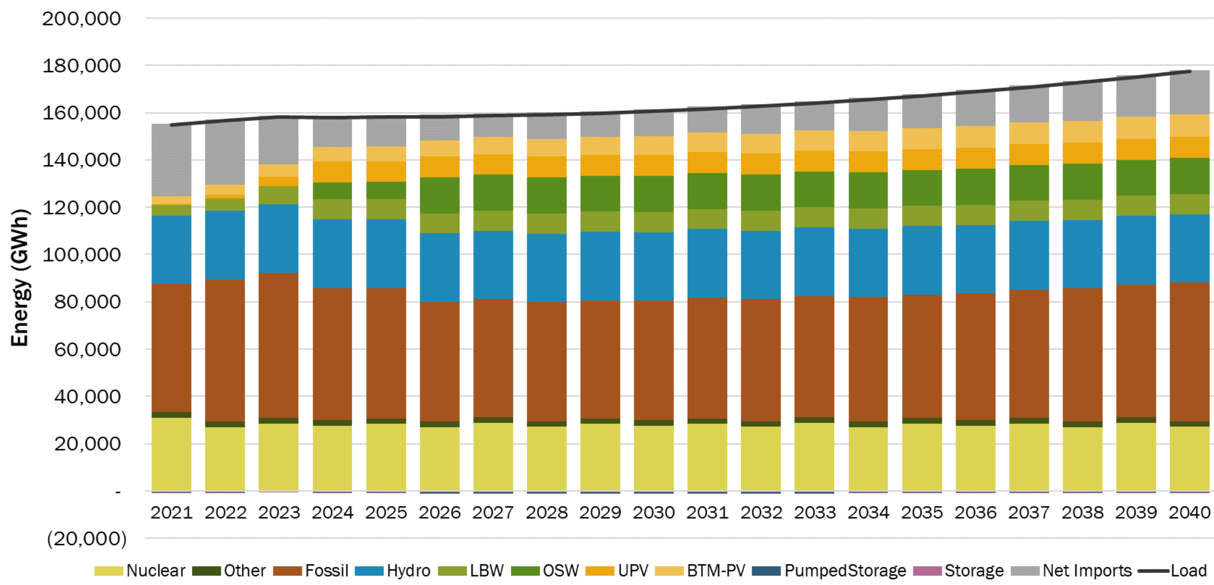
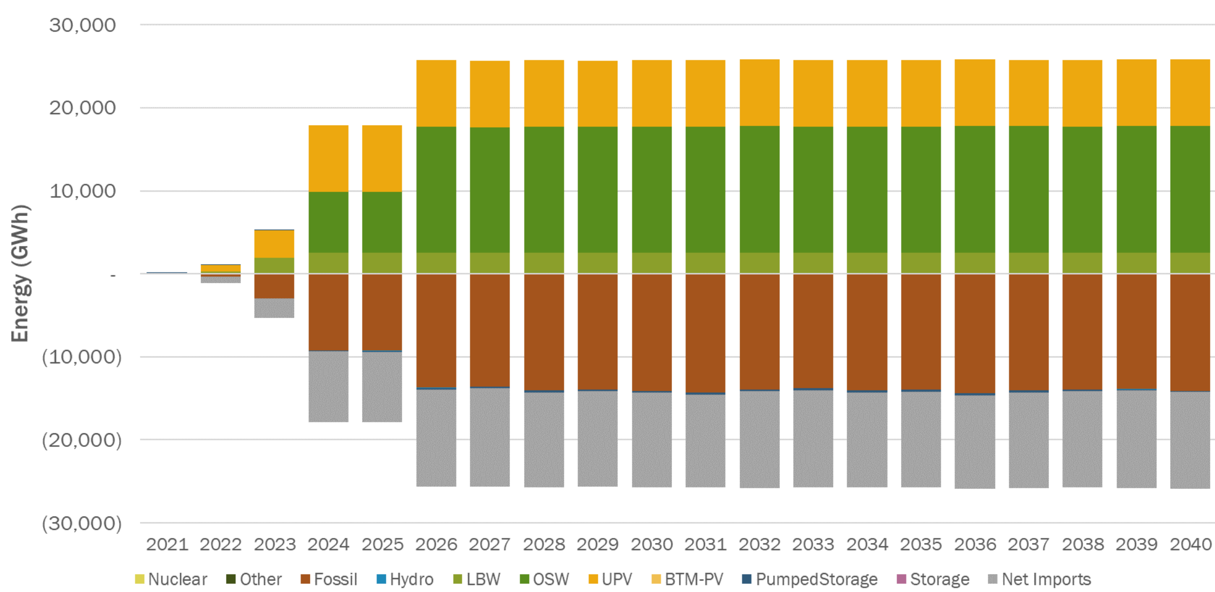


Figure 14 shows the changes in projected NYCA generation from the Baseline Case to the Contract Case, by fuel type. As renewable energy from wind and solar increases, it displaces in-state fossil-fueled generation and net imports from neighboring regions. The addition of over 9 GW of renewable capacity produces over 20 GWh of energy annually.

Figure 14: Projected Change in NYCA Energy Generated by Fuel Type, Contract Case



Transmission Congestion Assessment

Bulk level constraints that are historically binding remain among the most congested elements. Some constraints could become more congested and new constraints might appear due to resource shifts in the system. Generation from fossil fueled plants in the model is replaced with output from land-based wind and solar renewable energy resources additions located upstate and away from load centers in Southeast New York.

The NYISO observes the most significant increase in congestion in in Southeast New York due to the addition of offshore wind resources. The constraints with the most prominent increases in congestion are Sugarloaf to Ramapo, New Scotland to Knickerbocker, Central East Interface, and Dunwoodie to Long Island (Y49 & Y50 lines).

Figure 15: Number of Congested Hours by Constraint, Baseline and Contract Cases

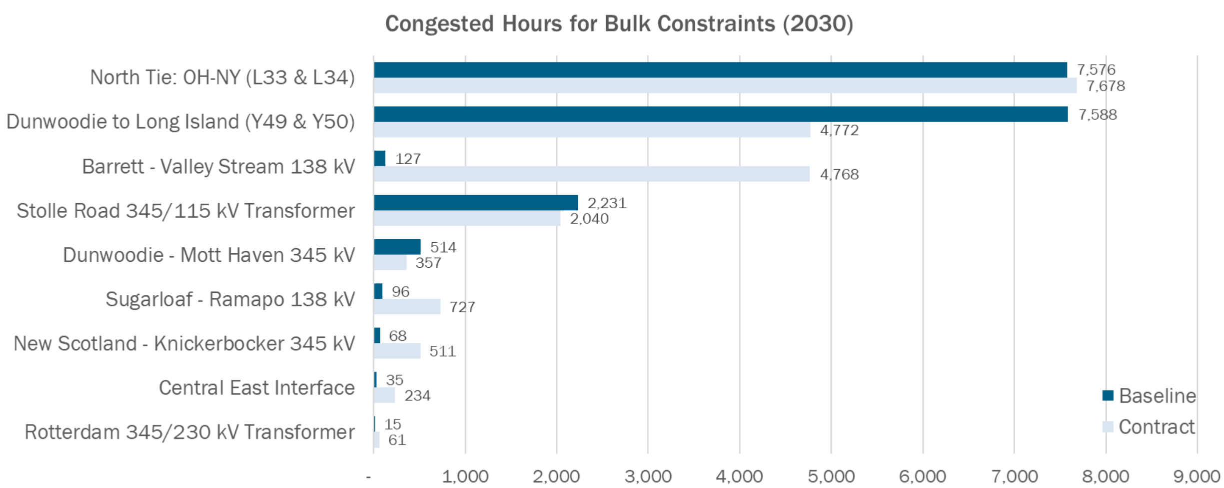


Figure 15 shows the number of hours that bulk level constraints are congested in the year 2030. Since most of the contracted resources are scheduled to be in-service by this time, using 2030 as the reference year for comparison between the Baseline and Contract cases is particularly meaningful. The number of congested hours is the primary metric used to identify congested elements in the pocket analysis for the contract and policy cases. It indicates the amount of time the flow on a particular element is at its limit or exceeds its limit in a specific year.

Historically congested paths such as the *Central East Interface* show very low numbers of congested hours in the Baseline Case as well as the Contract Case. This can be attributed to the following major factors: (1) the completion of AC Transmission Public Policy Projects scheduled for December 2023, (2) lower imports from Ontario due to nuclear refurbishments and retirements there, and (3) higher loads overall in upstate New York compared to prior study cycles due to new proposed large load projects. The *Dunwoodie to Long Island* interface (Y49 & Y50 lines), which is highly congested in the Baseline Case, is congested for fewer hours in the Contract Case as a result of offshore wind resources injecting into Long Island and counteracting some of the flow coming into the island through the Y49 and Y50 lines. The *North Tie: Ontario-NY interface,* which is comprised of the St. Lawrence L33 and L34 PARs on the New York to Ontario border, remains highly congested in both cases.

The two parallel 138 kV lines from Barrett to Valley Stream on Long Island are some of the most congested elements in the system in the Contract Case. Congestion on these lines results from the injection of offshore wind energy interconnected to the Barrett substation. This study does not model the proposed Long Island Offshore Wind Export Public Policy Transmission, nor does it include system interconnection upgrades that are yet to be determined for contracted resources in the NYISO Interconnection Process.

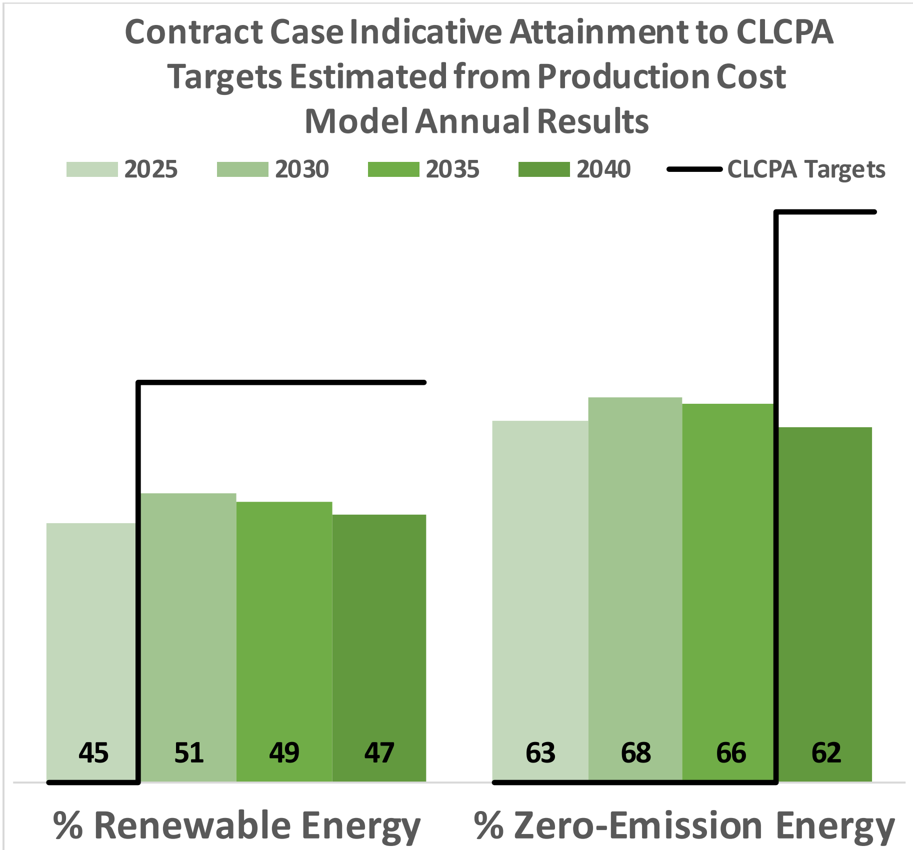
The NYISO is currently evaluating the viable and sufficient project proposals to the Long Island Offshore Wind Export Public Policy Transmission Need ("Long Island PPTN"), based on the Order issued by the NYPSC on March 19, 2021. If a more efficient or cost-effective solution is selected to meet the Long Island PPTN, the congestion is expected to be reduced significantly.

Policy Implications of Renewable Contracts

Figure 16 shows progress towards the 70% renewable energy and 100% emission-free CLCPA targets based on the Contract Case results. Given that renewable resources were added through the 2020 REC Solicitation, the policy targets are not expected to be attained with current contracts alone. As show in

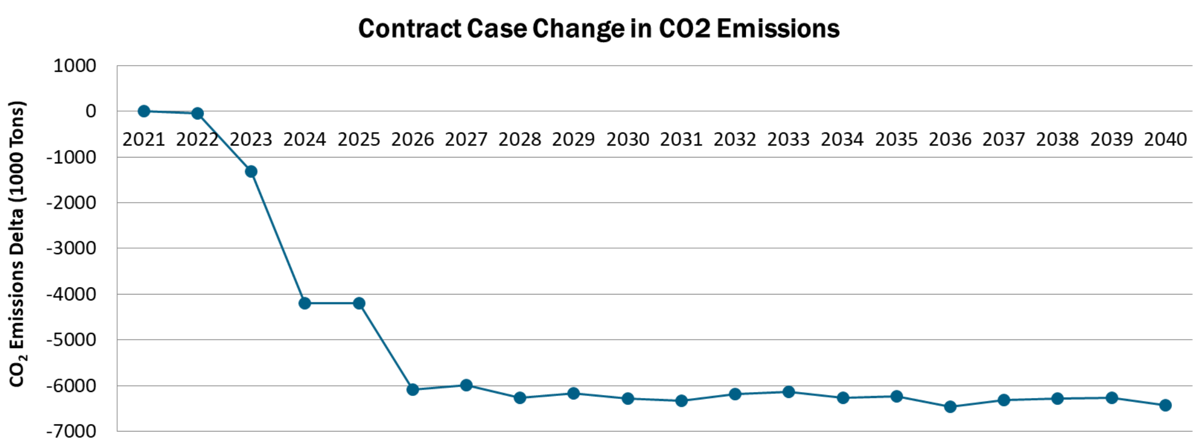
Figure 16, the renewable energy percentage range is around 50% over the course of the study period, while the zero emissions energy resides in the mid-60% range. Percentages decrease beyond 2030 because of the static generation fleet and increasing load levels assumed.

Figure 16: Contract Case Policy Progress Estimate



While policy targets are not met through the assumed amount of renewable generation in the Contract Case, CO_2 emissions decrease significantly. **Figure 17** shows the projected change in CO_2 emissions due to additional contracted renewables as represented in the Contract Case.

Figure 17: Projected Change in CO2 Emissions, Contract Case



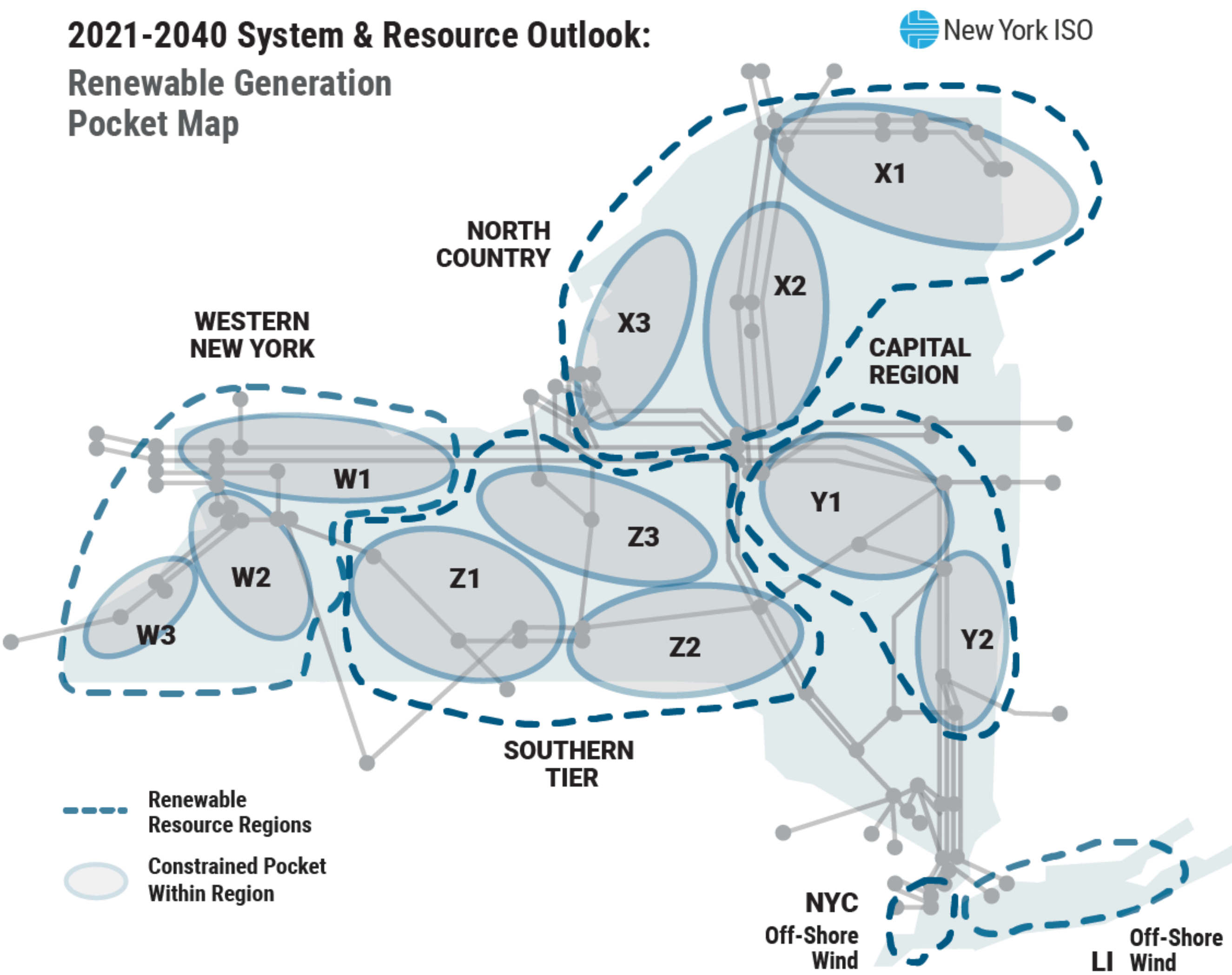
New York State sees an annual reduction of approximately 6 million tons of carbon dioxide over most of the study period.

Renewable Generation Pockets: Contract Case

Prior NYISO economic planning studies[18] examined the formation of renewable generation pockets driven by transmission congestion and constraints. These pockets illustrated transmission constraints that, if unaddressed, prevent full utilization of renewable resources within the area. A similar analysis was performed here for the Contract Case for the year 2030 and two Policy Case scenarios for years 2030 and 2035. The renewable generation pockets first identified in 2019 were utilized as the starting point to identify constraints and generators within the pockets in the Contract Case as well as the Policy cases.

[18] 2019 CARIS Phase 1 Study: https://www.nyiso.com/documents/20142/2226108/2019-CARIS-Phase1-Report-Final.pdf

Figure 18: Outlook Renewable Generation Pocket Map

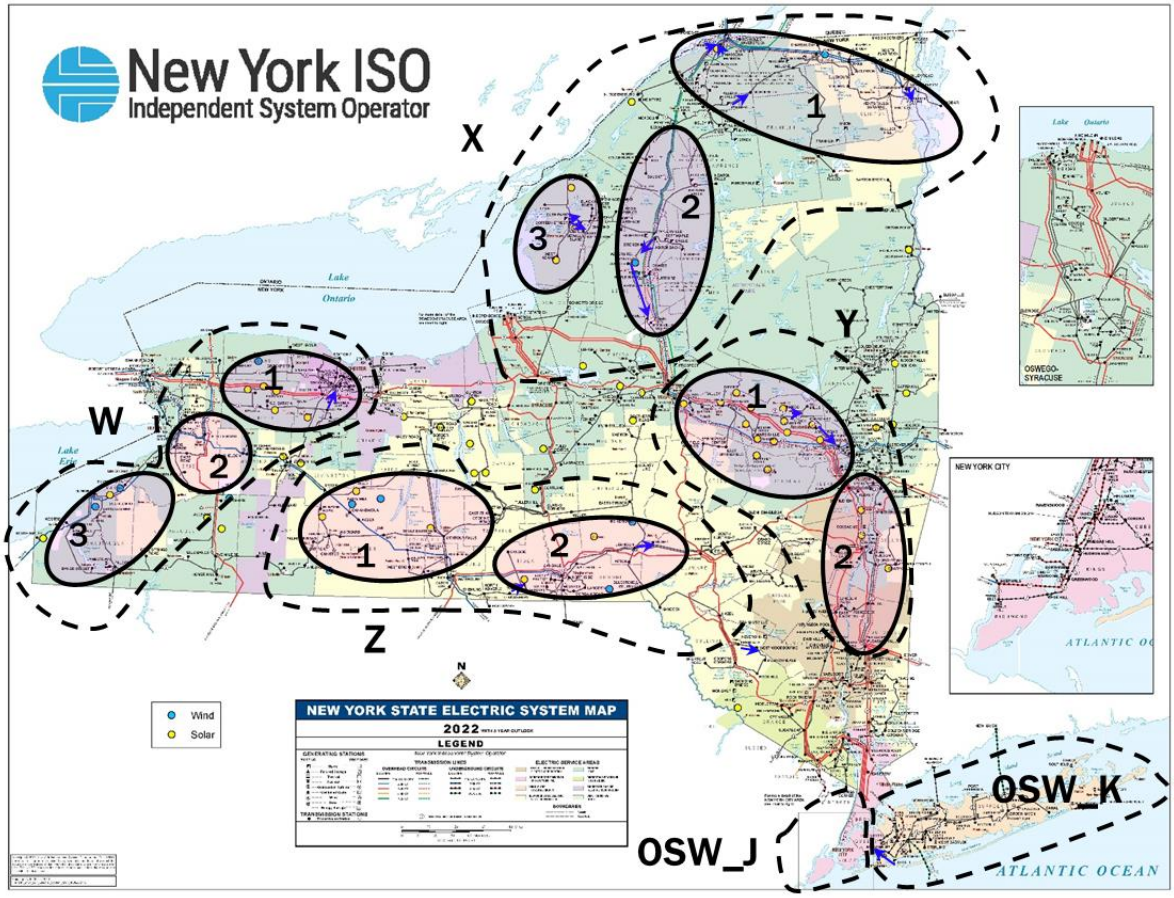


The pocket analysis indicates potential areas where transmission constraints could lead to curtailment of nearby renewable resources. The renewable curtailments identified could result from a combination of drivers, including: (i) resource siting location, (ii) size of renewable buildout, (iii) the congestion pattern of transmission constraints, (iv) existing thermal unit operations, and (v) zonal load level and shape. Renewable generation located upstream of transmission constraints is more likely to be curtailed compared with renewables located at downstream of the constraints. In general, renewable curtailments caused by transmission constraints include constraints inside generation pockets, tie line constraints, and constraints outside of generation pockets.

The generation pocket assignments are defined by two main considerations; renewable generation buildout location and the congestion results from the contract case. 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 a local area.

- **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 (115kV)
- **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 (115kV)
  3) **Z3**: Central and Mohawk Area Wind and Solar (115kV)
- **Offshore Wind:** offshore wind generation connected to New York City (Zone J) and Long Island (Zone K)

Figure 19: 2030 Contract Case Pocket Map

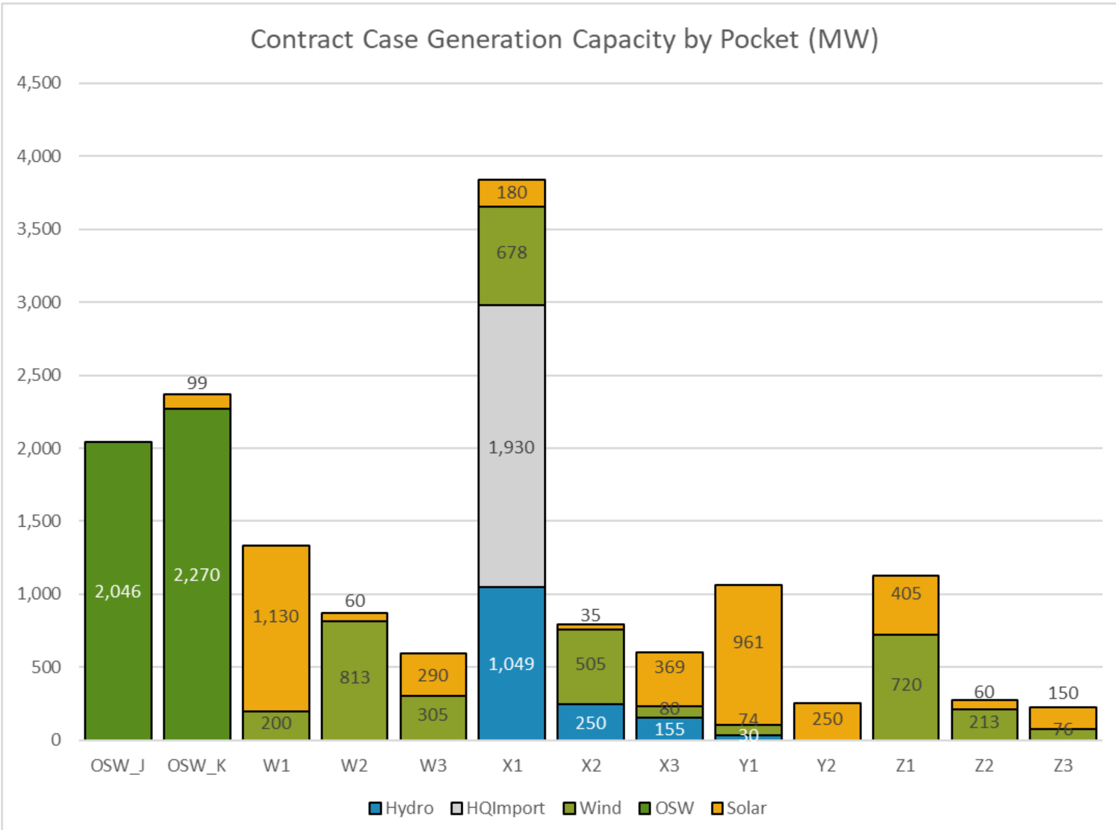


In **Figure 19**, blue and yellow colored circles show approximate locations of new contracted renewables (wind and solar generation respectively) that are not included in the Baseline Case. Blue arrows overlayed on transmission paths indicate the direction of congested elements within a pocket.

The identified congested paths are generally on the lower voltage networks and electrically close to new contracted generators added in the Contract Case. Congestion on lines around the pocket could cause curtailment of generators within the pocket. While higher voltage bulk level constraints typically limit the flow of energy across the state, lower voltage constraints tend to become congested first, limiting the amount of energy that can flow out of the generation pocket and onto the bulk system.

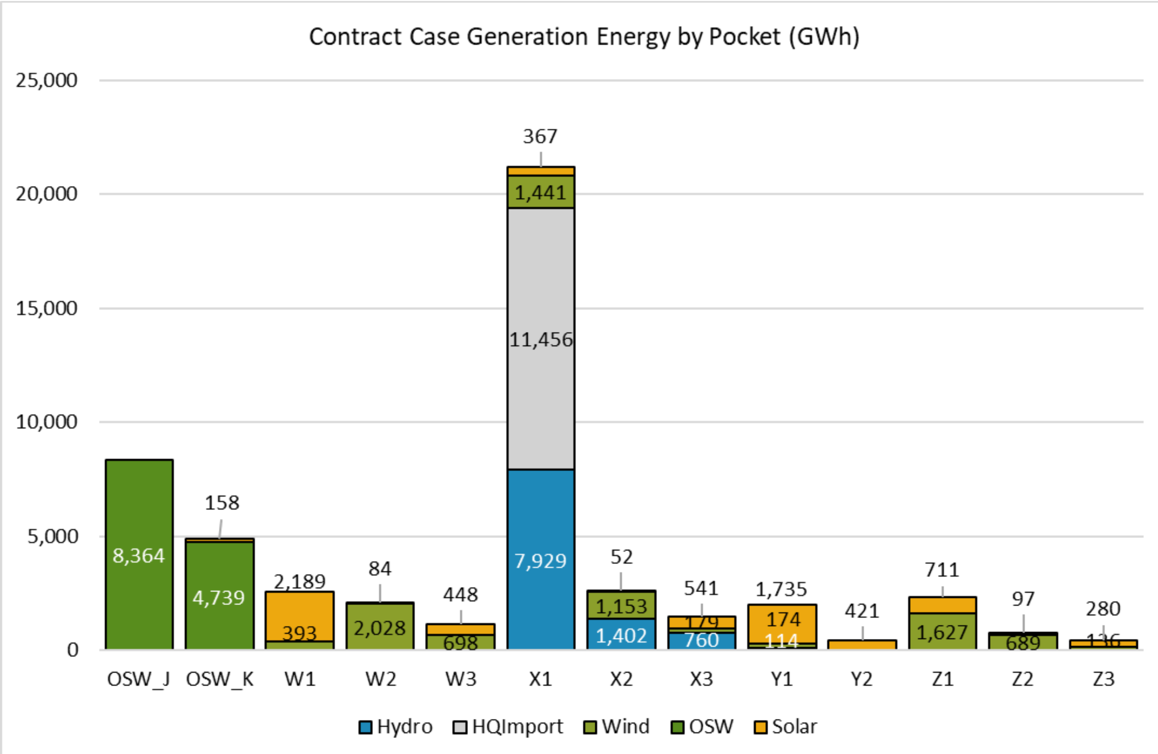
Renewable capacity by generation pockets is shown below in **Figure 20** for the Contract Case, and the energy by generation pockets after curtailment is considered is in **Figure 21**. Almost all of the renewable generation (99%) is located within a pocket. Offshore wind makes up the majority of renewable generation added in New York City and Long Island (Zones J and K). Upstate renewable generation is a mix of utility-scale solar and land-based wind resources. The existing Hydro-Québec (HQ) imports into Northern New York (Zone D) are considered qualifying renewable generation injecting into the X1 pocket.

Figure 20: Contract Case Generation Capacity by Pocket (MW)



Each renewable generator is associated with an hourly generation profile in the production cost simulation. Owing to load, renewable scheduled generation, local transmission topology, and system conditions, a portion of potential renewable generator output may be curtailed. Curtailment of scheduled generation usually results when a generator locates upstream of a transmission bottleneck or in localized pockets with limited transmission export capabilities.

Figure 21: Contract Case Generation Energy by Pocket After Curtailment in 2030 (GWh)



Energy Deliverability: Contract Case

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 table below shows the Energy Deliverability metric by pocket and resource type.

Figure 22: Contract Case Energy Deliverability for 2030 by Pocket and Resource Type

Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Dispatched Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Wind	200	393	393	0	100.0%
	Solar	1,130	2,214	2,189	25	98.9%
W2	Wind	813	2,029	2,028	2	99.9%
	Solar	60	84	84	0	100.0%
W3	Wind	305	700	698	2	99.6%
	Solar	290	448	448	0	100.0%
X1	Hydro	1,049	7,929	7,929	0	100.0%
	HQImport	1,930	11,498	11,456	41	99.6%
	Wind	678	1,441	1,441	0	100.0%
	Solar	180	367	367	0	100.0%
X2	Hydro	250	1,405	1,402	3	99.8%
	Wind	505	1,154	1,153	0	100.0%
	Solar	35	54	52	2	96.2%
X3	Hydro	155	771	760	11	98.6%
	Wind	80	179	179	0	100.0%
	Solar	369	609	541	69	89.9%
Y1	Hydro	30	114	114	0	99.8%
	Wind	74	179	174	5	97.3%
	Solar	961	1,801	1,735	66	96.5%
Y2	Wind	-	-	-	-	-
	Solar	250	421	421	0	100.0%
Z1	Wind	720	1,628	1,627	0	100.0%
	Solar	405	711	711	0	100.0%
Z2	Wind	213	696	689	7	99.0%
	Solar	60	97	97	0	100.0%
Z3	Wind	76	136	136	0	99.7%
	Solar	150	280	280	0	100.0%
OSW_J	Offshore Wind	2,046	8,366	8,364	2	100.0%
	HQImport	-	-	-	-	-
OSW_K	Offshore Wind	2,270	8,891	6,815	2,076	76.7%
	Solar	99	159	158	1	99.5%

The majority of curtailment occurs in Long Island for offshore wind. This results in a low energy deliverability percentage compared to other pockets and resource types. Constraints that lead to significant curtailment of offshore projects and any associated upgrades will be studied as part of the current NYISO Public Policy Transmission Planning Process addressing the Long Island Offshore Wind Export Public Policy Transmission Need. Some solar generation curtailment is observed in the North Country and Capital Region (pockets X2, X3, and Y1), which have increasing amounts of solar projects proposed in the Interconnection Queue. These curtailments are generally due to a lack of a strongly interconnected network to deliver power, at both bulk and local system levels.

A detailed analysis of each pocket identified in the Contract and Policy Cases is included in Appendix placeholder of this report.

Baseline System and Contracted Renewables: Key Takeaways

- In the Baseline Case (business-as-usual), demand congestion declines sharply in the first five years of the study period across the Central East interface. The key drivers include the addition of the NYISO-selected public policy transmission projects (Western New York and AC Transmission Segments A and B), retirement and refurbishment of nuclear generators in Ontario, and an increase in forecasted energy demand in Ontario that diminishes available surplus power. As a result, the projected 20-year total congestion on the Central East interface is a fraction of the five-year historical total.

- In many parts of the New York grid, transmission constraints form a perimeter around renewable resource development areas, creating renewable generation pockets. The greater the transmission constraints in the pockets, the greater the renewable generation will be curtailed (i.e., prevented from generating their full potential energy). These pockets result in an inability of renewable resources to deliver the potential energy to the grid and to consumers. More pockets may develop in the system where geographic locations might be suitable for renewable energy development but existing transmission infrastructure may not be adequate to allow all such renewable generation to operate.

- New proposed large loads, including new cryptocurrency mining facilities located in Western, Central, and Northern New York (Zones A, C, and D, respectively) are served primarily by increased output from fossil fueled generation located upstate. As a result, CO_2 emissions and zonal demand congestion increase as such large demand centers are added to the grid.

- Curtailment of resources and congestion patterns are highly dependent on the type of resources added, where the resources are located in the system, the transmission system topology, and capability of available transmission lines to deliver power to loads.

- Overall, the majority of curtailment in the Contract Case is attributable to offshore wind resources connected to Long Island. Injecting large amounts of power into a transmission system not designed to handle such levels causes curtailment.

Road to 2040

The Climate Leadership and Community Protection Act establishes several policy requirements to materially change the resource mix and system demand of the New York electric grid. Over the next twenty years, the CLCPA mandates that New York be served by 70% renewable energy by 2030 ("70 x 30"), includes specific technology-based targets for distributed solar (6 GW by 2025, additional 4 GW by 2030), storage (3 GW by 2030), and offshore wind (9 GW by 2035) and ultimately establishes that the electric sector will be carbon free by 2040. These policies will likely result in the acceleration of conventional generation retirements well in advance of the 2040 target year. As part of the Outlook, the NYISO assesses a range of future scenarios to understand the breadth of challenges and potential system risks.

The dramatic transformation of New York State's energy industry aimed at mitigating the effects of climate change is primarily driven by public policies and is being undertaken by branches of the New York State government. The climate change related policies in the electric sector are being implemented through many initiatives, including the development of renewable generation and storage, reductions in CO_2 emissions, and specific technology-based targets. Each goal or target drives project procurement decisions made by NYSERDA. The Contract Case includes projects with existing contracts implemented through the 2020 REC Solicitation. That case represents the current outlook of the system with contracts in hand at the time assumptions were locked down on December 1, 2021. Recognizing that the Contract Case does not aim to achieve the State policies, the NYISO has established a Policy Case to evaluate future scenarios that expand renewable resource capacity meet those policy objectives.

Policy Case Process Overview

The assessment of the Road to 2040 has the following major components; (1) resource assessment via capacity expansion simulation, (2) transmission congestion assessment via production cost simulation, and (3) an evaluation of policy attainment.

Given the significant uncertainty that exists surrounding the path to achieving policy objectives, the NYISO has modeled capacity expansion in the Economic Planning Process to evaluate many alternative paths to achieving the renewable resource buildout. The capacity expansion model optimizes future generation buildout to minimize capital and operating costs while also achieving each specific policy modeled (e.g., 70 x 30 and zero-emissions by 2040 targets).

The capacity expansion optimization was limited to the NYCA system only, and does not include imports or exports, except that the contributions from Tier 4 projects are included as soon as the projects are assumed to be in-service. Due to the CLCPA requirement of a zero emissions grid by 2040, the NYISO modeled all fossil-fueled generation as retired by that time. Existing zero-emitting generation, such as nuclear, hydro, land-based wind, and utility-scale solar generation, remains operational in the system through 2040.

The placement of future renewable generation will likely be limited by the footprint requirement of each technology. In this study, maximum allowable capacities are enforced for applicable generator types by zone based on 2040 limitations consistent with the assumptions of the Climate Action Council Draft Scoping Plan.[19]

The key input assumptions that drive the types and quantities of resource addition and replacement in the capacity expansion analysis are peak demand forecast, energy demand forecast, capital and operation and maintenance cost associated with each technology, age of the existing fossil-fueled and nuclear fleet, and energy output from existing resources. The details are included in Appendix placeholder.

The correlation between a generator's energy output and the energy demand forecast affects both the amount and the type of capacity built. For instance, the energy contribution from solar is nonexistent at night, which greatly impacts the decision as to whether it gets selected for generation expansion in the capacity optimization.

Generation expansion is enabled at the zonal level, such that one representative generator per type is allowed for each applicable NYCA zone. The generator buildouts determined by the capacity expansion optimization are then translated to discrete generators with specific substation level placements in the production cost modeling for the Policy Case to show how a selected buildout operates on an hourly basis within a networked transmission system.

The existing interconnection queue was leveraged as a starting point to identify probable points of interconnection for new resource additions in the Policy Case. The NYISO used the proposed project capacity from the interconnection queue to calculate the proportion of total zonal capacity (from capacity expansion results) to be added to the project location.

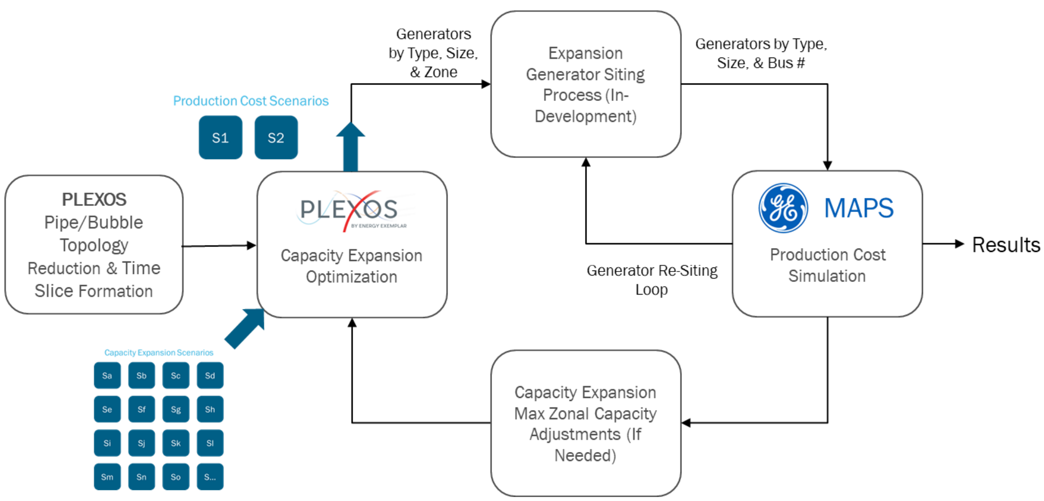
In addition to generation expansion, the capacity expansion optimization allows for generator retirements. The resulting retirement decisions from the capacity expansion scenarios are then translated to the production cost model. The higher resolution production cost models enable a

[19] Climate Action Council Draft Scoping Plan: https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan

deeper evaluation of the transmission and operational challenges related to adopting high levels of intermittent renewable generation. In addition, Scenario 2 includes an age-based retirement criteria that retires steam turbines at 62 years and gas turbines at 47 years of age, based on industry trends for the age at which 95% of the specified generation type historically retires.

The capacity estimated to achieve New York's energy policies was forecasted through capacity expansion optimization via a model that was developed, tested, and validated through the NYISO stakeholder process. The generation capacity mix determined by the capacity expansion optimization was then incorporated into production cost simulation models, and the projected transmission constraints were identified for the Policy Case. The model data-flow diagram in Figure 23 below highlights the process used in translating the capacity expansion model results to the production cost model.

Figure 23: Policy Case Modelling Process Diagram



The capacity expansion simulation adds generation capacity to meet the assumed CLCPA targets in the Policy Case. Leveraging the resulting capacity expansion build outs, the production cost simulation introduces the potential challenges associated with actual system operations.

System Resource Mix Scenarios

The NYISO utilized a capacity expansion model to estimate possible system resource mixes over the next 20 years.[20] Two specific generation buildout scenarios were selected from the multitude of

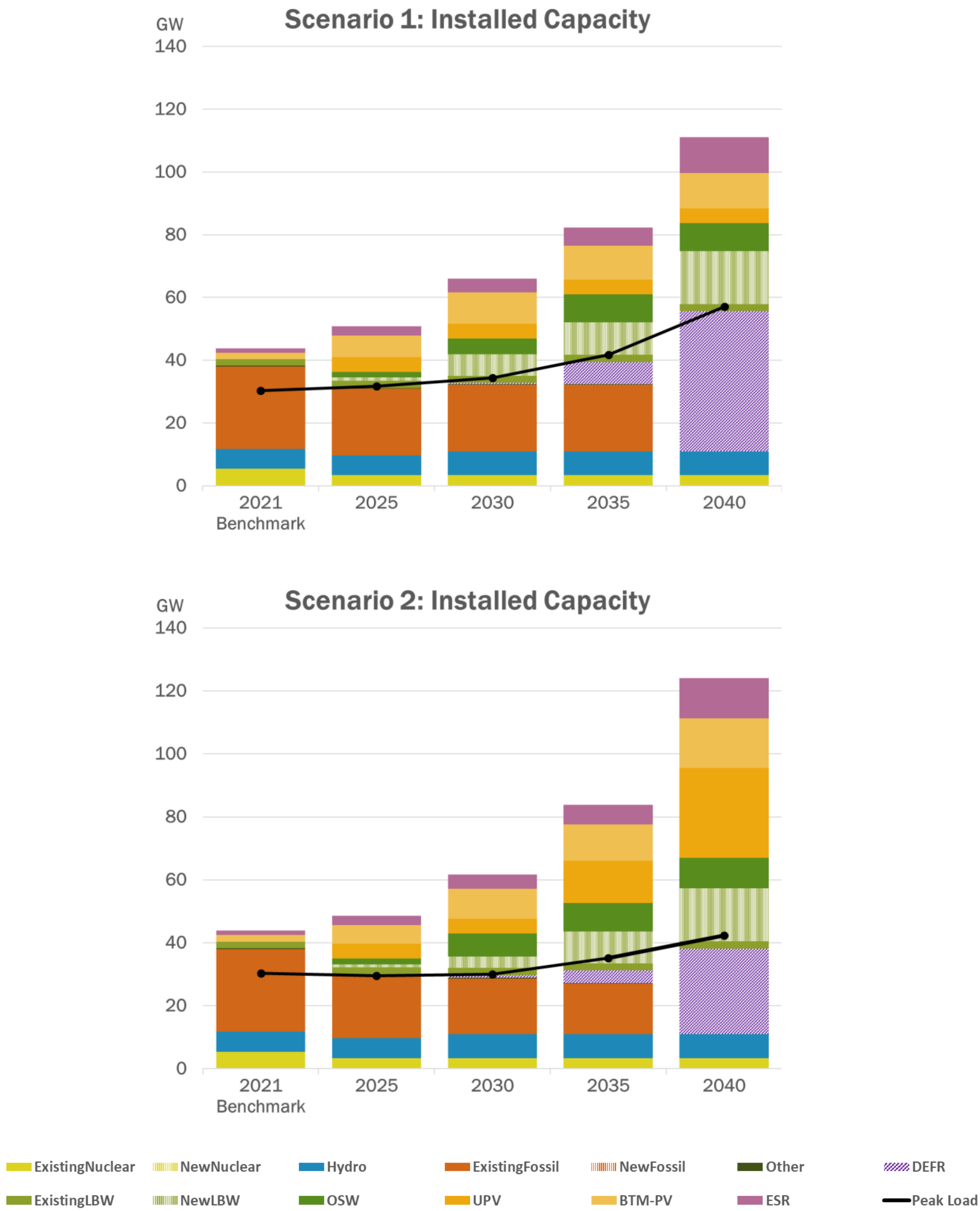
[20] The capacity expansion results in this study do not endorse outcomes under any specific set of assumptions. Instead, the results inform future transmission and generation planning.

capacity expansion simulations performed to formulate a detailed nodal production cost simulation model.

- Scenario 1 (S1) utilizes industry data and NYISO load forecasts, representing a future with high demand (57,144 MW winter peak and 208,679 GWh energy demand in 2040) and assumes less restrictions in renewable generation buildout options.
- Scenario 2 (S2) utilizes various assumptions more closely aligned with the Climate Action Council Integration Analysis and represents a future with a moderate peak but a higher overall energy demand (42,301 MW winter peak and 235,731 GWh energy demand in 2040).

Projected resource mixes for Scenario 1 and Scenario 2 are provided in **Figure 24** below.

Figure 24: Policy Case New York Capacity Expansion Results



In both Policy Case scenarios, a significant amount of land-based wind capacity was built by 2040. The model preferred land-based wind due to its assumed capital cost, energy output, and capacity ratings. In both scenarios, land-based wind capacity builds to the assumed capacity build limits imposed (~16 GW).

In both scenarios, a significant amount of capacity from renewable generation and DEFRs is projected by 2040, with the most installation forecasted in the last five years, to help offset the projected fossil-fueled generation retirements. As noted above, all existing fossil-fueled generation (~26 GW) was modeled as retired by 2040 due to the CLCPA requirement of a zero emissions grid by 2040. In addition, in Scenario 2 the age-based retirement assumption captured the retirement of 12 GW, nearly half the fossil fleet. The models expanded to approximately 111 GW of total capacity for Scenario 1 and 124 GW of total capacity for Scenario 2, inclusive of NYCA generators, BTM-PV, and qualifying imports from Hydro Québec. This level of total installed capacity would be needed in 2040 to satisfy the state policy, energy, and resource adequacy constraints for Scenario 1 and Scenario 2, respectively. Of this total, approximately 85 GW to 100 GW represent generation expansion for Scenario 1 and Scenario 2, respectively, beyond the 9.5 GW planned through state contracts.[21] For comparison, the Contract Case has approximately 51 GW of total installed capacity by 2040.

In general, resources take years from development to deployment. By year 2030, roughly seven years from the publication of this report, an estimated 20 GW of additional renewable generation needs to be in-service to support the energy policy target of 100% zero-emission generation by 2040. For reference, 12.9 GW of new generation has been developed since wholesale electricity markets began more than 20 years ago in 1999. Over the past five years, 2.6 GW of renewable and fossil-fueled generators came on-line while 4.8 GW of generation deactivated[22]. This Outlook demonstrates the need for an unprecedented pace of project deployment, which will require significant labor and materials available for New York over a long period of time.

Offshore wind capacity buildout remains near the 9 GW policy objective through 2040 for both scenarios. This outcome results primarily from the assumed high capital cost of offshore wind technology in the model, which was the highest cost renewable technology available. Additionally, considering the declining capacity value curves assumed, offshore wind is an inefficient resource to

[21] 2040 BTM-PV installed capacity in Scenario 1 was 11 GW and nearly 16 GW in Scenario 2

[22] The Path to a Reliable Greener Grid for New York, NYISO, June 2022

meet peak capacity needs and Locational Capacity Requirements.

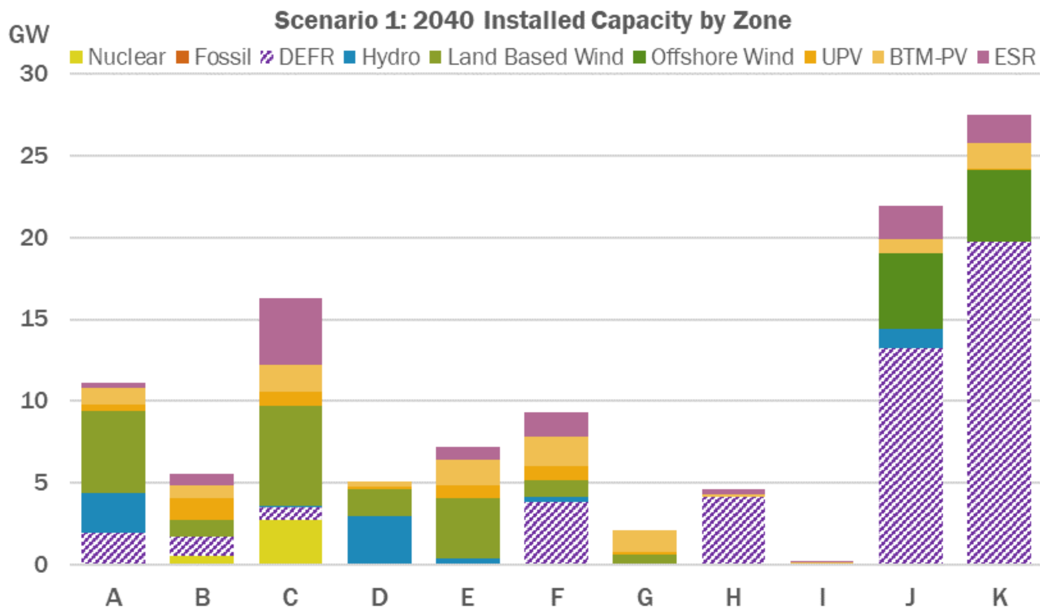
Overall, results for Scenario 2 showed a higher level of renewable buildout than Scenario 1, most notably in utility-scale solar capacity, and had a different projection of the capacity expansion throughout the study period as compared to Scenario 1 for all generator types. The main factors for these differences are the assumptions for load forecasts and differences in generator types eligible for capacity expansion as well as the maximum allowable capacity builds by technology type modeled between the two scenarios. One major difference in Scenario 2 is that a reduced land-based wind capacity limit was used, which changed the projection of capacity builds for all types. Notably, the projections for offshore wind were higher earlier in the model horizon (e.g., 2030) in Scenario 2 as compared to Scenario 1 to help achieve the 70x30 target.

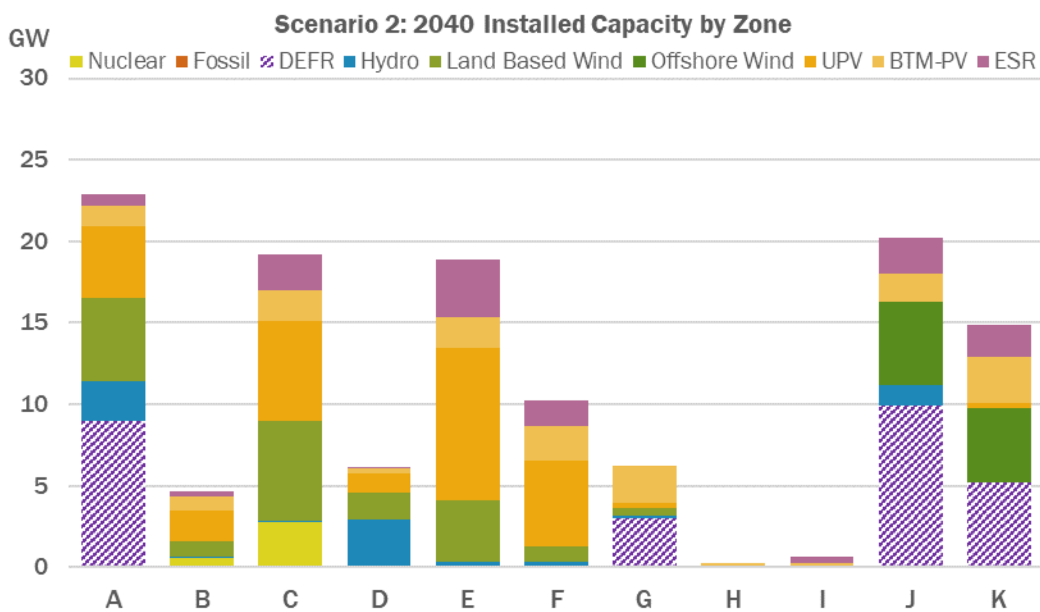
Two primary drivers are attributable to increased renewable resources in capacity expansion: (1) high operating cost of dispatchable generators, and (2) low capital costs for renewable generators. High fuel (e.g., natural gas prices, clean DEFR fuel prices) and/or high CO_2 emissions prices result in significant decrease in fossil generation and subsequent increase in renewable generation earlier than otherwise projected. Low capital costs for renewable generators result in capacity builds much earlier than otherwise projected, and often an increase in the total amount of capacity built.

In terms of the zonal location for capacity buildouts determined by the capacity expansion model, limitations were imposed on the zonal level as to which generator type(s) could build in each zone. For instance, land-based wind was eligible for expansion in upstate regions (Zones A-G), utility-scale solar was eligible for expansion in upstate regions and Long Island (Zones A-G and Zone K), and offshore wind was eligible for expansion in New York City and Long Island (Zones J and K). Dispatchable emission free resource (DEFR) technologies and battery storage were included as generation resource options in all NYCA zones.

Results for zonal capacity buildouts from simulations for Scenario 1 and Scenario 2 are provided below.

Figure 25: Policy Case 2040 Installed Capacity by Zone





Capacity reserve margins significantly contribute to the types and quantities of generation selected by the capacity expansion model. For example, the majority of DEFR buildouts occur in New York City and Long Island between year 2035 and 2040, which have an explicit locational capacity requirement. Because DEFRs have a near 100% capacity contribution, they are effective in meeting capacity requirements despite having a higher cost than other renewable generation types and storage. Furthermore, many of the DEFRs in these zones operate at a very low annual capacity factor in the model, indicating that they were selected to meet capacity needs rather than energy needs.

Given the reliance on DEFR technologies in the model, these technologies must be developed and deployed to meet policy objectives, reliability margins, and local capacity requirements. Without substantial amount of dispatchable resources to provide reliability benefits, a significant amount of excess renewable resources and/or battery storage would be required to meet capacity requirements. There are multiple potential paths to achieving policy targets. As the current system continues to evolve, the NYISO's modeling capabilities can evaluate a multitude of expansion scenarios to help in identifying paths to a greener and reliable future grid.

Renewable Generation Pockets: Policy Case

The Policy Case pocket analysis, like the Contract Case, is based on the grouping of congested lines and generators which are likely to be curtailed within a localized area. The pocket definitions and locations are the same as in the Contract Case. With the addition of new Policy Case resources resulting from capacity expansion simulations for scenarios Scenario 1 and Scenario 2, significantly more renewable energy resources are added to the system compared to the Baseline and Contract Cases.

The analysis of the Policy Case for 2030 and 2035 was conducted with a detailed transmission representation to capture the constraints at various voltage levels, consistent with the Contract Case analysis. In the transition to an emission-free grid, the Policy Case analysis for 2040 assumes sufficient transmission expansion occurs between 2035 and 2040 to relieve transmission constraints at lower voltage levels, recognizing that the transmission owners are actively developing local transmission & distribution expansion plans to meet CLCPA[23]. By doing so, the full impact to the bulk constraints due to new resources becomes more pronounced and highlights the bulk transmission expansions that will still be necessary to efficiently deliver energy to consumers.

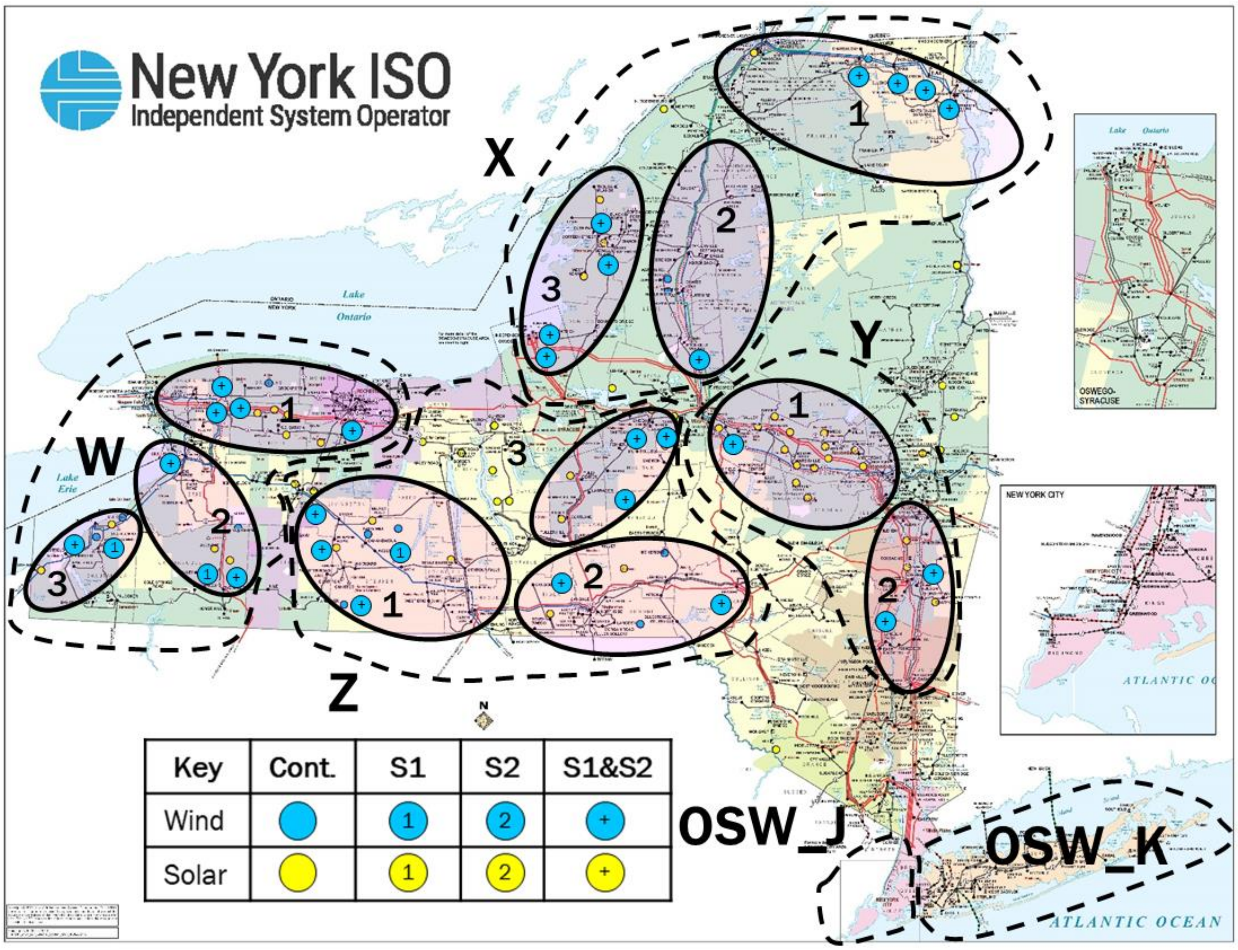
The new resource additions from the capacity expansion simulations were placed at available buses identified in the NYISO Interconnection Queue for new wind and solar facilities. These locations represent the probable sites for new resource additions and provide likely interconnection points on the existing system. Most of the additional resources are located inside the general pocket locations identified in the Contract Case. A study of local congestion within these

[23] Case 20-E-0197, Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act

pockets illustrates expected obstacles in the transmission system to transmit power out of the pockets to serve loads elsewhere. A detailed look at each individual pocket and associated metrics is provided in Appendix placeholder of this report.

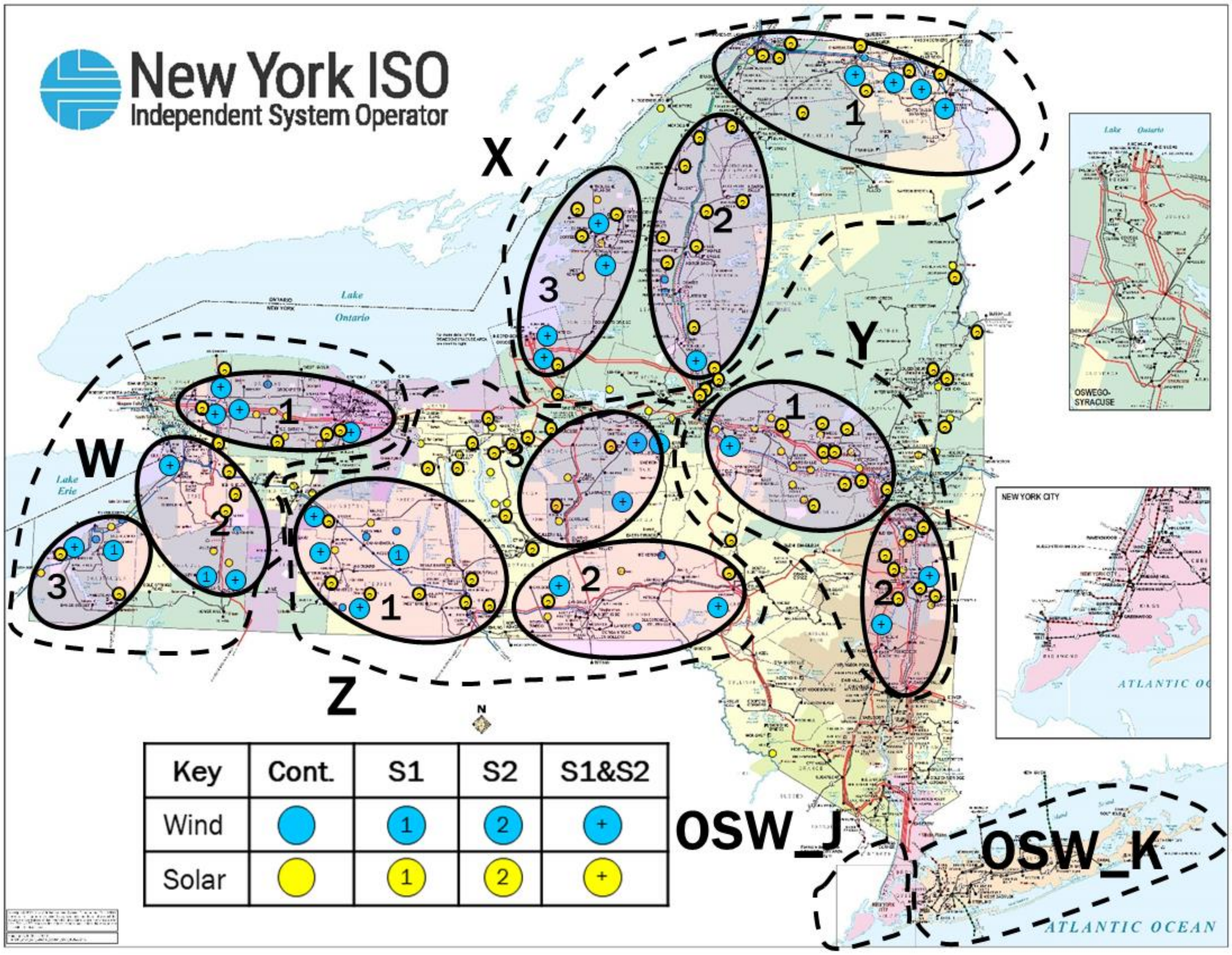
The two figures below depict the approximate locations of new resources added to the Policy Case scenarios in years 2030 and 2035, respectively. The location of renewable generation pockets in relation to the new resources is also depicted.

Figure 26: 2030 Policy Case Pocket Map



In 2030, a vast majority of new capacity in both scenarios is land-based wind. The new wind projects are above and beyond what has already been included in the Contract Case, where over four GW of solar and four GW of offshore wind is added. Projects are concentrated in the W, X, and Z pockets. Transmission constraints in the X3, Z1, Z2, and OSW_K pockets result in depressed energy deliverability values in 2030 as shown in Figure 28 and Figure 30.

Figure 27: 2035 Policy Case Pocket Map



Between 2030 and 2035, each scenario includes an increased amount of offshore wind to meet the 9 GW by 2035 policy target. Scenario 1 includes several more land-based wind projects in the X and Z pockets, which help to meet energy demand and policy objectives but increase curtailment in those areas. The incremental wind projects negatively impact energy deliverability of both wind and solar, particularly in pockets X2, X3, Z1, and Z2.

Scenario 2 builds an increased number of solar projects scattered throughout all of the upstate pockets. Solar energy deliverability is low in this scenario, especially in W3, X3, and all of the Z pocket.

Complete details on the capacity, energy, curtailment, and energy deliverability by pocket for each of the scenarios in 2035 can be found in Figure 29 and Figure 31.

Energy Deliverability: Policy Case

Energy deliverability for a pocket is defined as the total energy utilized to serve demand from a group of resources in a pocket. This calculation was performed in the same manner as the Contract Case for each of the Policy Case scenarios. The tables below quantify the curtailment energy and energy deliverability for each scenario for 2030 and 2035.

Details of the renewable project capacity and generated energy by generation pockets is shown in the tables below. Offshore wind makes up the majority of renewable generation added in New York City and Long Island (Zones J and K). Upstate renewable generation is a mix of utility-scale solar and land-based wind resources. The existing Hydro-Québec (HQ) imports into Northern New York (Zone D) are considered qualifying renewable generation injecting into the X1 pocket.

Figure 28: Policy Case Scenario 1 Energy Deliverability for 2030 by Pocket and Resource Type

Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Dispatched Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Solar	1,130	2,239	2,203	36	98%
	Wind	1,543	4,890	4,890	0	100%
W2	Solar	60	84	74	10	89%
	Wind	1,491	4,263	4,012	251	94%
W3	Solar	290	448	420	29	94%
	Wind	916	2,713	2,534	179	93%
X1	Hydro	1,049	7,929	7,894	35	100%
	HQ Import	1,930	11,498	11,264	234	98%
	Solar	180	367	367	0	100%
	Wind	876	2,062	2,013	49	98%
X2	Hydro	250	1,407	1,336	71	95%
	Solar	35	56	47	9	84%
	Wind	598	1,441	1,425	17	99%
X3	Hydro	155	782	663	119	85%
	Solar	369	678	510	168	75%
	Wind	790	2,515	2,463	52	98%
Y1	Hydro	30	114	112	2	98%
	Solar	961	1,868	1,705	163	91%
	Wind	101	273	247	26	90%
Y2	Solar	250	422	419	3	99%
	Wind	255	857	857	0	100%
Z1	Solar	405	711	661	50	93%
	Wind	1,495	4,108	3,409	699	83%
Z2	Solar	60	97	76	22	78%
	Wind	803	2,620	2,400	220	92%
Z3	Solar	150	280	269	10	96%
	Wind	265	750	709	41	95%
OSW_J	Offshore Wind	2,046	8,368	8,368	0	100%
	HQ Import	1,250	10,950	10,944	6	100%
OSW_K	Offshore Wind	2,990	11,830	9,807	2,023	83%
	Solar	99	159	154	6	96%

Figure 29: Policy Case Scenario 1 Energy Deliverability for 2035 by Pocket and Resource Type

Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Dispatched Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Solar	1,130	2,241	2,135	106	95%
	Wind	1,621	5,155	5,137	18	100%
W2	Solar	60	84	70	14	83%
	Wind	1,633	4,736	4,154	582	88%
W3	Solar	290	449	388	61	87%
	Wind	1,012	3,034	2,666	368	88%
X1	Hydro	1,068	7,929	7,485	445	94%
	HQ Import	1,930	11,517	10,553	964	92%
	Solar	180	367	356	12	97%
	Wind	1,274	3,298	3,070	228	93%
X2	Hydro	249	1,407	1,222	185	87%
	Solar	35	56	42	14	75%
	Wind	785	2,013	1,921	92	95%
X3	Hydro	156	782	523	259	67%
	Solar	369	678	434	244	64%
	Wind	1,313	4,224	3,954	270	94%
Y1	Hydro	30	114	107	7	94%
	Solar	961	1,869	1,642	227	88%
	Wind	120	337	296	41	88%
Y2	Solar	250	422	392	30	93%
	Wind	618	2,042	1,911	132	94%
Z1	Solar	405	711	605	106	85%
	Wind	2,160	6,217	4,596	1,621	74%
Z2	Solar	60	97	72	26	74%
	Wind	1,257	4,084	3,702	382	91%
Z3	Solar	150	280	244	36	87%
	Wind	413	1,224	1,123	101	92%
OSW J	Offshore Wind	4,571	17,712	17,699	13	100%
	HQ Import	1,250	10,950	10,512	438	96%
OSW K	Offshore Wind	4,430	17,652	15,490	2,162	88%
	Solar	99	160	136	24	85%

Figure 30: Policy Case Scenario 2 Energy Deliverability for 2030 by Pocket and Resource Type

Pocket	Type	Capacity (MW)	Scheduled Energy (GWh)	Dispatched Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Solar	1,130	2,239	2,207	32	99%
	Wind	735	2,180	2,180	0	100%
W2	Solar	60	84	81	3	96%
	Wind	1,074	2,891	2,852	39	99%
W3	Solar	290	448	448	1	100%
	Wind	576	1,594	1,584	10	99%
X1	Hydro	1,007	7,929	7,928	1	100%
	HQ Import	1,930	11,498	11,364	134	99%
	Solar	180	367	367	0	100%
	Wind	778	1,752	1,733	19	99%
X2	Hydro	240	1,407	1,389	18	99%
	Solar	35	56	51	5	91%
	Wind	552	1,298	1,290	8	99%
X3	Hydro	152	782	736	46	94%
	Solar	369	678	548	129	81%
	Wind	417	1,288	1,279	10	99%
Y1	Hydro	30	114	113	1	99%
	Solar	961	1,868	1,733	134	93%
	Wind	86	225	212	13	94%
Y2	Solar	250	422	418	4	99%
	Wind	123	413	413	0	100%
Z1	Solar	405	711	691	20	97%
	Wind	1,119	2,905	2,803	102	96%
Z2	Solar	60	97	88	9	91%
	Wind	512	1,673	1,629	44	97%
Z3	Solar	150	280	277	2	99%
	Wind	173	453	447	6	99%
OSW_J	Offshore Wind	5,166	19,997	19,994	3	100%
	HQ Import	1,250	10,950	10,925	25	100%
OSW_K	Offshore Wind	2,270	8,891	6,818	2,073	77%
	Solar	99	159	148	12	93%

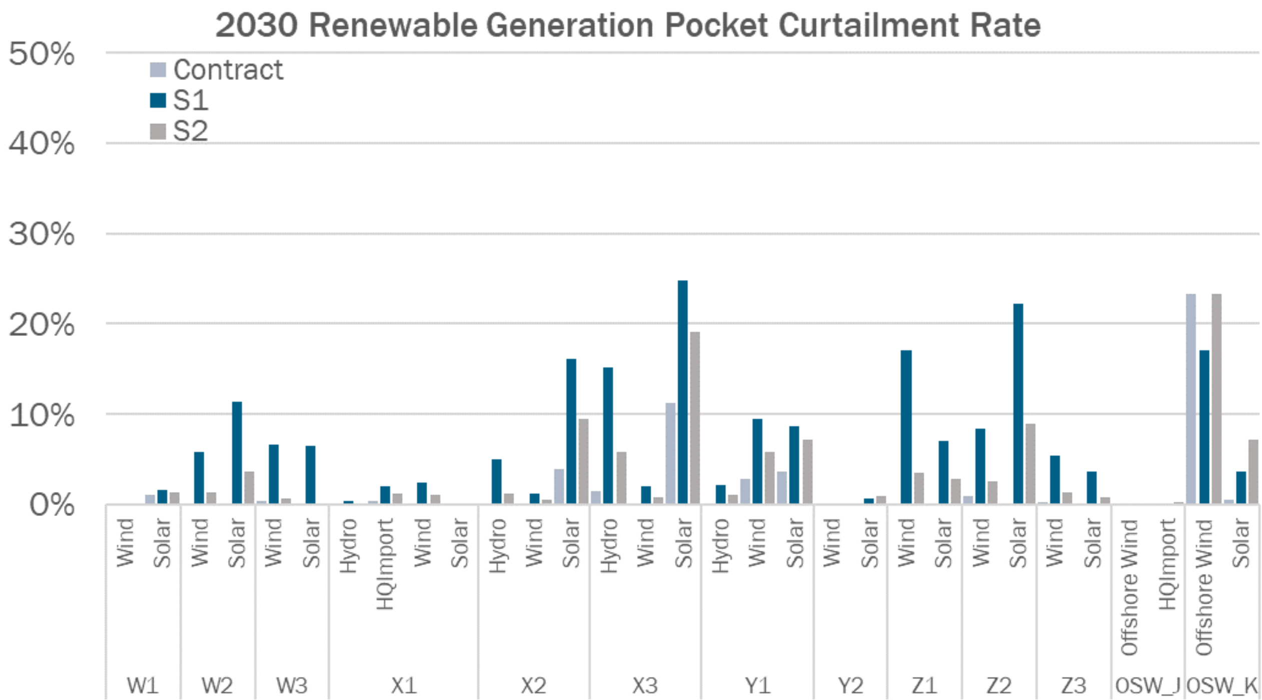
Figure 31: Policy Case Scenario 2 Energy Deliverability for 2035 by Pocket and Resource Type

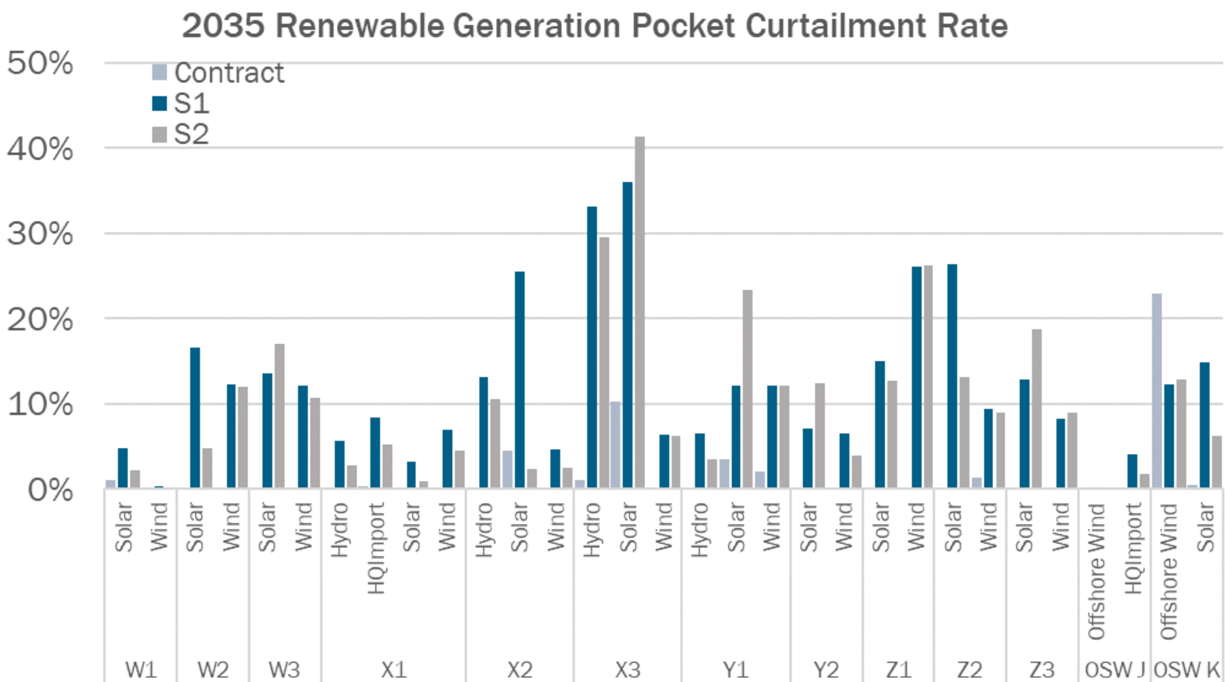
Pockets	Type	Capacity (MW)	Scheduled Energy (GWh)	Dispatched Energy (GWh)	Curtailment (GWh)	Energy Deliverability (%)
W1	Solar	2,092	3,395	3,322	72	98%
	Wind	1,375	4,318	4,315	2	100%
W2	Solar	349	451	429	22	95%
	Wind	1,633	4,736	4,168	568	88%
W3	Solar	574	790	656	134	83%
	Wind	1,012	3,034	2,711	324	89%
X1	Hydro	1,068	7,929	7,709	221	97%
	HQ Import	1,930	11,517	10,924	594	95%
	Solar	355	565	560	5	99%
	Wind	1,274	3,298	3,152	146	96%
X2	Hydro	249	1,407	1,259	148	89%
	Solar	1,043	1,188	1,161	27	98%
	Wind	785	2,013	1,964	49	98%
X3	Hydro	156	782	551	231	70%
	Solar	686	1,038	608	429	59%
	Wind	1,313	4,224	3,961	263	94%
Y1	Hydro	30	114	110	4	97%
	Solar	2,162	3,392	2,600	792	77%
	Wind	120	337	296	41	88%
Y2	Solar	626	907	795	112	88%
	Wind	618	2,042	1,962	81	96%
Z1	Solar	1,037	1,535	1,340	195	87%
	Wind	2,160	6,217	4,591	1,625	74%
Z2	Solar	443	557	484	73	87%
	Wind	1,257	4,084	3,720	364	91%
Z3	Solar	303	480	390	90	81%
	Wind	413	1,224	1,114	110	91%
OSW J	Offshore Wind	5,166	19,924	19,923	1	100%
	HQ Import	1,250	10,950	10,759	191	98%
OSW K	Offshore Wind	3,835	15,227	13,280	1,947	87%
	Solar	99	160	150	10	94%

Four pockets will particularly benefit from transmission expansion: Finger Lakes (Z1), Southern Tier (Z2), Watertown (X3), and Long Island. Without investment in transmission, these areas of the New York grid will experience persistent and significant limitations to deliver the renewable power from these pockets to consumers in the upcoming years.

Curtailment of renewable generation occurs when a transmission line would become overloaded if renewable generation were not dispatched to a lower output level. The decision to curtail a specific renewable generator is dependent upon both electrical location and energy market bids. A second form of renewable generation re-dispatch, termed "spillage," can also occur. Spillage of renewable energy can occur when all relevant dispatchable resources have been set to minimum levels and energy export limits have been reached, which would necessitate a reduction in renewable generation output to balance the system. Spillage conditions are projected to occur as early as 2030 and would be most prevalent during the spring season when electricity demand is low and renewable generator production is high.

Figure 32: Renewable Generation Pocket Curtailment Rates by Generation Type in 2030 and 2035



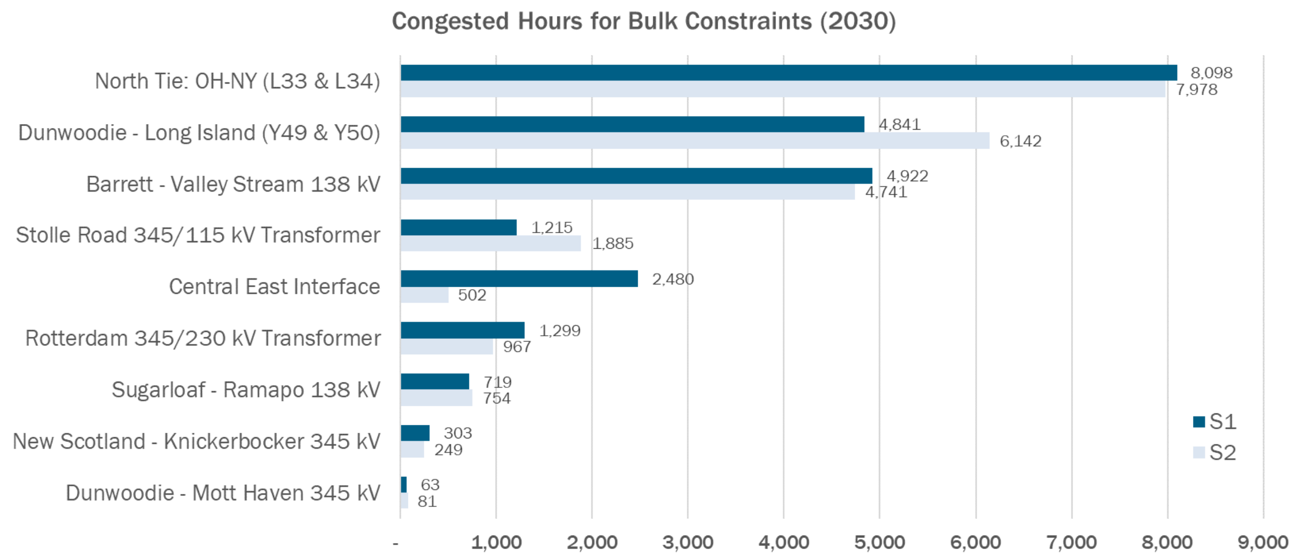


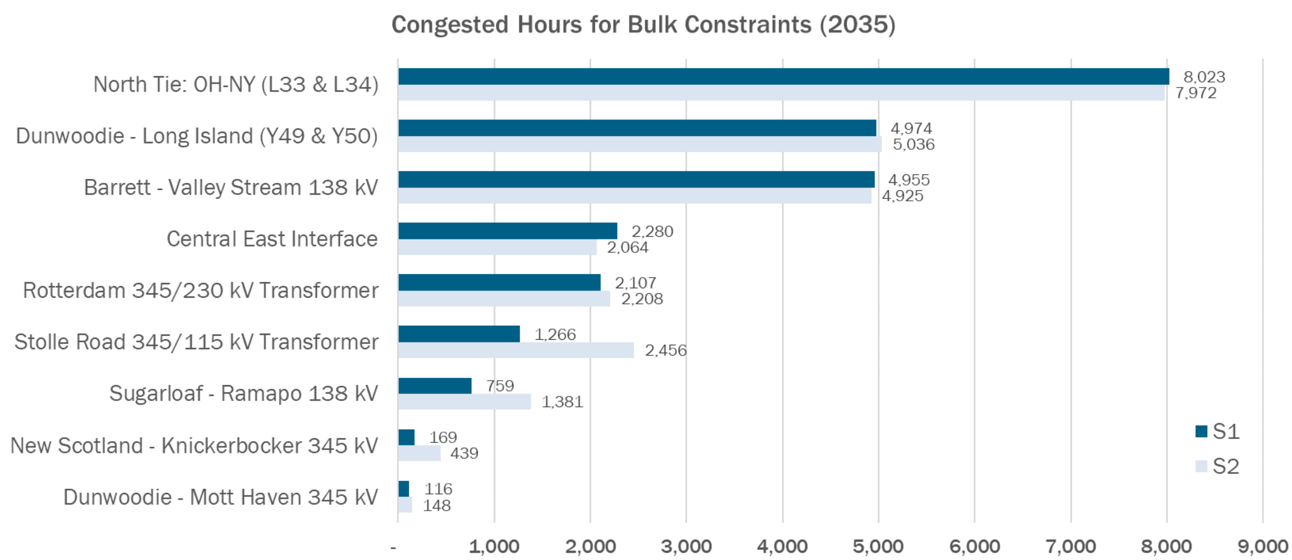
Bulk Transmission Congestion Through 2035

Bulk power transmission facilities and interfaces in the Policy Cases show the most congestion on the system, owing to their high transfer capabilities to move power from areas of high renewable resource injection to load centers. Some historically congested interfaces such as *Central East* might have different congestion patterns depending on resource buildouts and load levels on either side of the interface. Another interface that is highly dependent on resource buildout is *Dunwoodie* to *Long Island*, which usually transfers power from upstate to Long Island (Zone K). Due to high amounts of Offshore Wind resources built in the Policy Case, congestion on this interface drops as more resource capacity is added. Overall, the congestion increases on the system as more resources are added and no upgrades are made on the existing transmission system.

The chart below shows the congested hours for the same list of bulk level transmission elements as those mentioned above for 2030 and 2035. The chart below shows that the congestion on bulk system mostly increases as the model adds resources and relaxes constraints on the lower voltage system. Some interfaces also can have lower congestion due to congestion on lines further upstream at the bulk level.

Figure 33: Number of Congested Hours for Bulk Constraints, Years 2030 and 2035

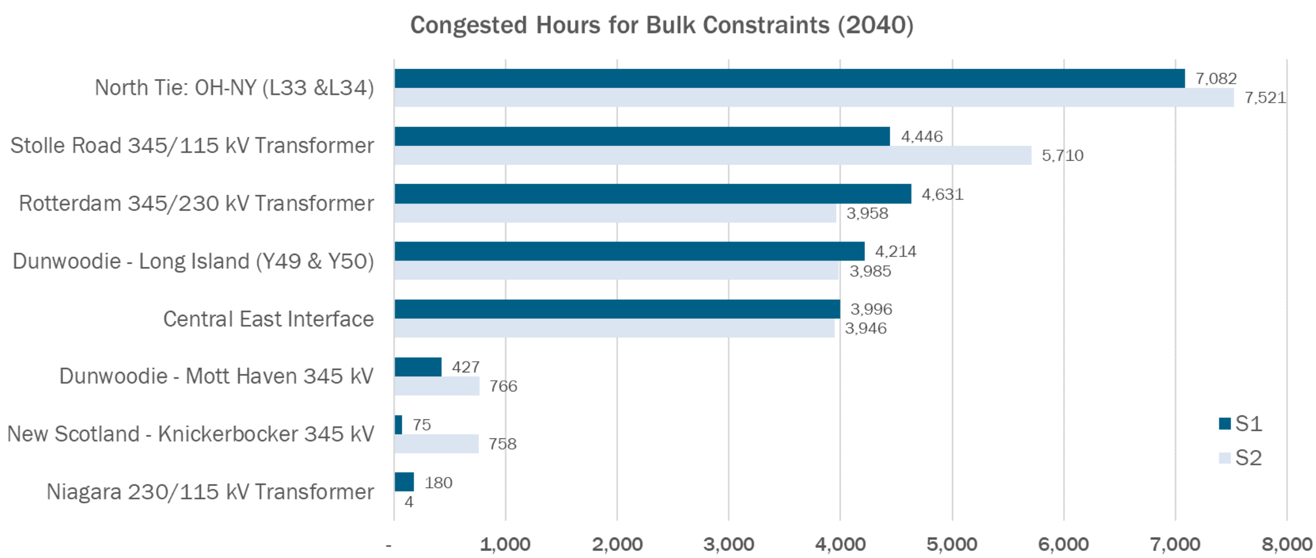




Bulk Transmission Congestion Remains After Pockets Are Resolved

As ordered by NYSPC, the New York transmission owners have proposed local transmission & distribution plan, such as Phase 1, Phase 2 and Areas of Concerns[24], Recognizing the potential system expansion, the local transmission constraints (less than 200 kV) were assumed to be relieved between 2035 and 2040. Most of the renewable resources currently propose to interconnect at this voltage level, and removing these constraints allows for additional energy to reach to the bulk level, which moves power over greater distances across the state into load centers. The remaining system constraints at the bulk level are therefore highlighted to signal the bulk transmission development needed to go hand-in-hand with the local transmission and distribution expansion.

Figure 34: Number of Congested Hours for Bulk Constraints, Year 2040



The congested hours in 2040 in upstate bulk constraints, such as Central East Interface, significantly increased. This is due to the addition of new resources upstate, and the 2040 case with lower kV lines relaxed highlights the need for additional transmission capability on the bulk system assuming all lower kV level congestion is resolved to fully utilize renewable resources.

The figures below provide a summary of energy production from various fuel sources in upstate and downstate New York. In 2021, zero-emission resources made up 93% of upstate production, while fossil units downstate made up 89% of the production from that region. In 2040,

[24] Case 20-E-0197, Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act, Order on September 21, 2021

the transition to zero-emission resources will lead to energy produced only by renewable resources, such as wind and solar, and zero-emission resources, such as nuclear and DEFR.

In upstate New York, approximately 80% of energy is produced from renewable resources and the remaining 20% comes from zero-emission resources. The system condition variations between the two scenarios, such as peak load forecast, energy consumption, and resource buildout does not have a significant impact on the resulting energy production.

In contrast, in downstate, the energy production could vary widely depending on the DEFR buildout required to maintain minimum locational capacity requirement. Up to one third of energy production could come from these resources that have yet to be developed and deployed.

Transmission expansion is critical to facilitating efficient CLCPA energy target achievement. The current New York transmission system, at both local and bulk levels, is inadequate to achieve currently required policy objectives. Renewable generation pockets throughout the State become more constrained as an increasing number of intermittent generation resources connect, necessitating transmission upgrades to make the renewable energy deliverable. Bulk and local transmission constraints on today's grid will limit the effective delivery of renewable energy to consumers throughout the State. A significant portion of projected renewable generation will be built in upstate New York areas, which are geographically and electrically distant from the major consumer hubs in downstate New York, while downstate fossil generation is being retired. Without significant timely transmission expansion to provide access to renewable energy resource rich areas, the renewable energy cannot efficiently traverse New York State and be delivered to consumers.

Figure 35: Upstate/Downstate Energy Production Comparison by Type for 2021 Actual

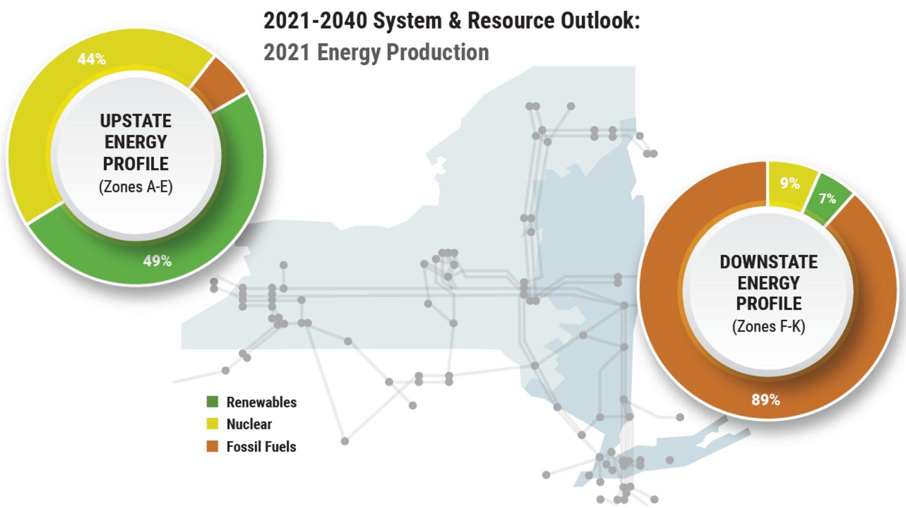


Figure 36: Upstate/Downstate Energy Production Comparison by Type for Policy Scenario 1

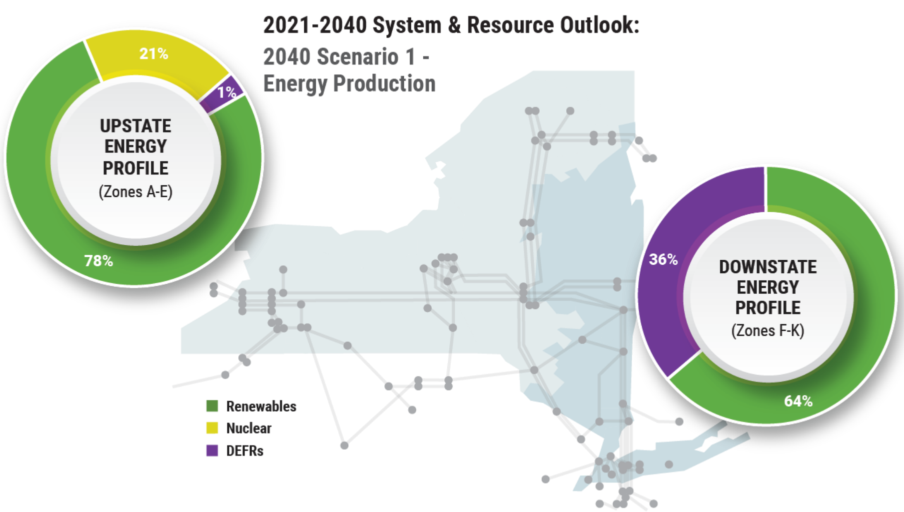
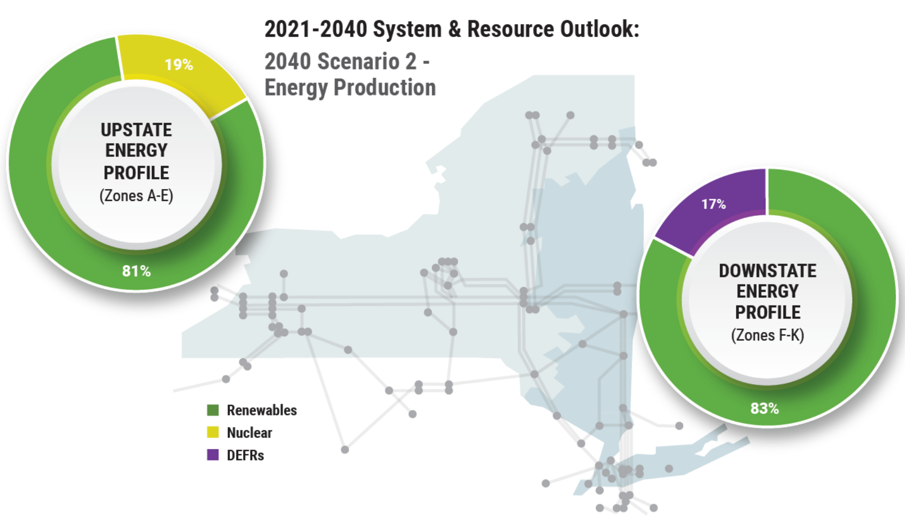


Figure 37: Upstate/Downstate Energy Production Comparison by Type for Policy Scenario 2



System Performance

System and seasonal performance will challenge achieving policy targets and are identified through operational assessment based on the results of hourly production cost simulations.[25] For example, the spring season experiences the most curtailment of wind, solar, and hydro generation. Spring in New York experiences lower energy demand, higher wind generation, moderately high solar irradiance, and high water flows due to snow melt. These weather characteristics result in significant renewable generation energy while demand is low, which ultimately leads to high levels of curtailment of resources as they are not needed. Scaling up renewable capacity to meet peak demands results in curtailments in other intervals of the year.

The existing fossil fleet currently operates to maintain the supply and demand balance in response to changes in net load, forecast uncertainty, reliability rules, and real-time events. In addition, fossil fueled generators may be called on to provide essential grid services, such as reserves, regulation, and/or other products that help maintain the reliability of the grid. Operations of the combined cycle fleet are most sensitive to increasing penetration of renewable generators.

Fossil fleet operation is at a minimum during the spring and a maximum during the summer season. The dispatchable fleet transitions from requiring maximal operation during the summer peak to during a winter peak in the mid-2030s. This transition continues into 2040 as DEFRs operate at higher levels during winter. Fossil generation online during many spring days has been committed for reliability purposes and represents the minimum potential fossil dispatch. No additional reliability constrains were imposed on DEFR units, which may impact their modeled operation, because the evolution of these requirements through 2040 is unknown.

The model observes reduced combined cycle generator output and an increase in the number of starts for these generators moving from 2025 to 2030 and 2035. Meanwhile, the simple cycle combustion turbine fleet, which typically operates less frequently, increases in both annual output and number of starts as these generators are used more often to fill in shorter intervals in the net load requirements. Although the steam turbine fleet has a more muted response to renewable additions, due to the less flexible nature of these generators, the model reveals both an increase in starts and decrease in output across the fleet.

Ramping behavior of the dispatchable fleet increases due to larger diurnal load swings driven

[25] The full set of hourly seasonal dispatch charts for both Scenario 1 and Scenario 2 details are available in Appendix placeholder, and more information on the utilization of the fossil and DEFR fleets can be found in Appendix placeholder.

by electrification and the increasing level of weather dependent intermittent renewable resources added. New resources with increased ramping capabilities will be needed to balance load with supply across the system and during different operating conditions.

The reliance on imported and exported energy to meet system demands changes by season, and the pattern of energy flow changes along the advancement of energy policy attainment. The magnitude of interchange, both imports and exports, increases through time in both scenarios as more variable renewable resources are added to the system. Historically, New York has imported energy from neighboring regions. In 2021, 37.6 TWh was imported while 10.4 TWh was exported, which resulted in a net import of 27.2 TWh. In this analysis, with the significant renewable buildout in New York to meet CLCPA[26], New York becomes an exporter up to year 2035, but then imports between 10 to 15 TWh by year 2040 when all fossil-fueled generation is assumed to deactivate.

The 2022 Grid in Transition study will leverage data from the Outlook to continue analysis surrounding potential grid needs and inform market designs for the future grid.

Tier 4 HVDC Transmission Impact Analysis

The Champlain Hudson Power Express and Clean Path New York Tier 4 HVDC transmission project were not included in the Baseline or Contract Cases, but were included in both Policy Case scenarios. Both transmission projects are assumed to contribute both in capacity and energy, and the projects were modeled as follows:

- The Champlain Hudson Power Express HVDC transmission project from Québec, Canada to New York City was modeled as importing 1,250 MW for all hours of the year from Québec to the Astoria 345kV substation in New York City. The project was assumed to provide 1,250 MW of capacity in the summer and zero in the winter toward the locational capacity requirements in the Lower Hudson Valley and New York City capacity localities. The line is assumed to be fully available and scheduled based on the economic exchange of energy.
- The Clean Path New York HVDC transmission project from Fraser 345 kV substation in Delaware County, New York to Rainey 345 kV substation in New York City was modeled as controllable transmission capable of flowing 1,300 MW from upstate to downstate. The line flows from upstate to downstate based on minimizing production cost of the system and generally transacts energy when the marginal energy price at the upstate

[26] No additional renewable buildout was included for external areas.

sending end is lower than the downstate receiving end. For the purpose of this assessment, the project is assumed to provide 650 MW of capacity toward the locational capacity requirements in the Lower Hudson Valley and New York City capacity localities.[27]

Results from the hourly production cost model show the performance of the Tier 4 transmission projects in Scenario 1 and Scenario 2. Figure **38** below shows the annual energy flows and utilization percentage for each project.

Figure 38: Tier 4 HVDC Transmission Performance

Case - Year		Champlain Hudson Energy (GWh)	Champlain Hudson Utilization (%)	Clean Path New York Energy (GWh)	Clean Path New York Utilization (%)
S1	2030	10,944	100%	3,409	30%
	2035	10,512	96%	4,031	35%
	2040*	10,458	95%	8,435	74%
S2	2030	10,925	100%	1,596	14%
	2035	10,759	98%	4,465	39%
	2040*	10,596	96%	9,439	83%

* Assumes sufficient transmission expansion occurs between 2035 and 2040 to relieve transmission constraints at lower voltage levels, resulting in greater renewable energy available for transfer across the bulk system.

For both Scenario 1 and Scenario 2, the annual energy transacted and utilized for the CHPE project decreases through time. This trend results from increased competition from offshore wind in New York City. The CPNY transmission project, which flows based on the price differential between Upstate and Downstate, increases in utilization but remains less than 40% through 2035. However, assuming transmission expansion takes place by 2040 to relieve renewable generation pocket constraints, the utilization of the Clean Path project increases significantly.

[27] The NYISO is currently developing the market participation rules for internal controllable lines. The scheduling and operation of Clean Path New York will abide by these rules. The assumptions for this study were developed to provide directional analysis.

Road to 2040: Key Takeaways

The Policy Case provides insight into the challenges that New York power system will face as the renewable resource and CO_2-emission free electric system policy objectives progress. The NYISO has identified several important insights during the analysis of Policy Case simulations and data:

- Significant new resource development will be required to achieve CLCPA energy targets. The total installed generation capacity to meet policy objectives within New York is projected to range from 111 GW and 124 GW of total generation capacity by 2040. At least 95 to 110 GW of this capacity will consist of new generation projects and/or modifications to existing plants[28], and still may not be sufficient to fully meet CLCPA requirements[29] while maintaining the reliable electricity supply that New York consumers have come to rely on. The sheer scale of resources needed to satisfy system reliability and policy requirements within the next 20 years is remarkable.
- 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. In general, resource and transmission expansion take many years from development to deployment. By year 2030, roughly seven years from the publication of this report, an estimated 20 GW of additional renewable generation needs to be in-service to support the energy policy target of 100% zero-emission generation by 2040. For reference, 12.9 GW of new generation has been developed since wholesale electricity markets began more than 20 years ago in 1999. Over the past five years, 2.6 GW of renewable and fossil-fueled generators came on-line while 4.8 GW of generation deactivated. This Outlook demonstrates the need for an unprecedented pace of project deployment, which will require significant labor and materials available for New York over a long period of time.
- Transmission expansion is critical to facilitating efficient CLCPA energy target achievement. The current New York transmission system, at both local and bulk levels, is inadequate to achieve currently required policy objectives. Renewable generation pockets throughout the State become more constrained as an increasing number of intermittent generation resources connect, necessitating transmission upgrades to make the renewable energy deliverable. Bulk

[28] Including the in-front-of the meter and behind-the-meter renewable generation addition after consideration of the deactivation of existing fossil-fire units by 2040

[29] This report does not attempt to identify the resources needed to achieve full policy attainment.

and local transmission constraints on today's grid will limit the effective delivery of renewable energy to consumers throughout the State. A significant portion of projected renewable generation will be built in upstate New York areas, which are geographically and electrically distant from the major consumer hubs in downstate New York, while downstate fossil generation is being retired. Without significant timely transmission expansion to provide access to renewable energy resource rich areas, the renewable energy cannot efficiently traverse New York State and be delivered to consumers.

- This Outlook identifies many transmission needs expected to arise over the next 20 years driven by public policy requirements, most notable the New York State climate mandates enacted in 2019 and 2020. The most notable and urgent transmission needs include:
    - Long Island offshore wind export: the NYISO is currently evaluating the viable and sufficient project proposals to the Long Island Offshore Wind Export Public Policy Transmission Need ("Long Island PPTN"), based on the Order issued by the NYSPSC on March 19, 2021. If a more efficient or cost-effective solution is selected to meet the Long Island PPTN, the congestion in Long Island is expected to be reduced significantly. However, offshore wind resource additions of up to 20 GW that are under discussion[30] may necessitate additional transmission to deliver offshore wind energy to New Yorkers.
    - The Watertown/Tug Hill Plateau renewable generation pocket (X3): the 115 kV network is expected to limit the availability of the already-contracted wind and solar generation in this area, and the limitation will become more severe when more renewable resources are interconnected. Additional transmission is necessary to provide the resources access to the bulk grid.
    - Southern Tier renewable generation pocket (Z1, Z2): the land and natural resource availability in this region (wind and solar) attract renewable generation buildout in this area. Transmission expansion from this pocket to the bulk grid would benefit New York consumers statewide.

- To achieve an emission-free grid, dispatchable emission-free resources (DEFRs) must be developed and deployed throughout New York to replace the various electrical attributes that are provided today by fossil generation. DEFRs that provide sustained on-demand power and system stability will be essential to meeting policy objectives while maintaining a reliable

[30] New York State Climate Action Council Draft Scoping Plan, December 30, 2021, available at, https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan.

electric grid. While essential to the grid of the future, such DEFR technologies are not commercially viable today and will require committed public and private investment in research and development efforts to identify the most efficient and cost-effective technologies with a view towards the development and eventual adoption of commercially viable resources.

- The capacity contribution of intermittent renewable resources declines as more are added to the system. The limited contribution of incremental resources to system reliability inhibits the ability of the power system to effectively meet mandatory resource requirements and to serve load in hours in which renewable generation is limited or unavailable. The scale and technology of DEFRs necessary to meet state energy needs will also depend upon the buildout of the transmission and distribution grids.
- Essential grid services will remain critical to provide New Yorkers with reliable and predictable electric system that consumers require. This means that new resources will need to provide these services prior to the exit of existing resources.
- Resource buildout to meet minimum capacity requirements is not sufficient to efficiently achieve the state's climate change requirements. This study shows that if new resources are not built in excess of reserve requirements to serve loads reliably, New York will likely rely on importing a significant amount of external energy that may or may not be renewable. New York is fortunate to have strong interconnections with neighboring areas and has enjoyed reliability and economic benefits from such connections. As the energy policies in the neighboring areas evolve independently, the amount of imports and exports could vary significantly due to the resulting resource and load shifts in the neighboring areas. Balancing the need to serve loads reliably while achieving New York's emission-free target will require continuous monitoring and collaboration with our neighboring states.
- When dispatched effectively, energy storage would help to increase the utilization of the renewable generation, but energy storage alone cannot completely resolve the transmission limitations in the pockets analyzed.
- Peak load management should be further integrated as a measure to facilitate CLCPA energy target achievement. Thanks to the peak load management measures already announced and implemented, New York is expected to see peak load forecast gradually decrease over the next few years. However, in the long term, the demand is likely to increase beyond the historical level due to electrifying buildings and transportation. By lowering the peak load and avoiding

system buildout to serve the highest demand hour, less DEFR buildout would be needed, and during the transition fossil fueled plants could be utilized less to meet lower peaks.

- Electrification from other sectors, such as building and transportation, into the power sector should be monitored and managed closely. Electrification is one of the largest factors driving peak and annual energy demand. Electrification must be in lock step with new resource additions and resource retirements. While other sectors, such as transportation, currently account for a larger share of greenhouse gas emissions, unmanaged electrification of the energy sector could lead to higher energy costs and reduced reliability.
- Coordination of renewable energy additions, commercialization, and development of DEFRs, and fossil fuel plant operation over the next 18 years will be essential to facilitate an orderly transition of the grid. The large amount of renewable energy additions required to achieve the CLCPA mandates will impact the operations of the existing fossil fuel fleet in the remaining 18-year transition to an emission-free grid. There will be a greater need for resources that can operate more flexibly to meet the increased variability associated with wind and solar generation. This Outlook demonstrates that the flexible units will be dispatched more frequently during the transition.

Next Steps and Recommended Actions

Next Steps

The Outlook has, for the first time, built upon the data, modelling, and studies developed within the NYISO's System & Resource Planning Department and will serve 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 stakeholders to identify the challenges and opportunities associated with achieving state policies in an economic and reliable manner.

The 2022 Reliability Needs Assessment will leverage data from the Outlook to identify commitment and dispatch trends and related bulk power system reliability impacts as policy goals are approached. The NYISO's 2022 Grid in Transition study will also leverage data from the Outlook to continue analysis surrounding potential grid needs and inform market designs for the future grid.

The 2022-2023 Public Policy Transmission Planning cycle kicks off in August, 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 and for which transmission solutions should be requested and evaluated. Interested parties should consider the key findings from the Outlook when submitting comments identifying Public Policy Transmission Needs for consideration by the NYSPSC.

Recommendations

The important findings identified in the 2021-2040 System & Resource Outlook bring forth several recommendations to address the challenges revealed by the study:

- Many transmission needs will arise over the next 20 years driven by public policy requirements, most notable the New York State climate mandates enacted in 2019 and 2020. The most notable and urgent transmission needs include:
    - Long Island offshore wind export: the NYISO is currently evaluating the viable and sufficient project proposals to the Long Island Offshore Wind Export Public Policy Transmission Need ("Long Island PPTN"), based on the Order issued by the NYSPSC on March 19, 2021. If a more efficient or cost-effective solution is selected to meet the Long Island PPTN, the congestion in Long Island is expected to be reduced significantly.

However, offshore wind resource additions of up to 20 GW that are under discussion[31] may necessitate additional transmission to deliver offshore wind energy to New Yorkers.

- The Watertown/Tug Hill Plateau renewable generation pocket (X3): the 115 kV network is expected to limit the availability of the already-contracted wind and solar generation in this area, and the limitation will become more severe when more renewable resources are interconnected. Additional transmission is necessary to provide the resources access to the bulk grid.
- Southern Tier pocket (Z1, Z2): the land and natural resource availability in this region (wind and solar) attract renewable generation buildout in this area. Transmission expansion from this pocket to the bulk grid would benefit New York consumers statewide.

- Future uncertainty is the only thing certain about the electric power industry. From policy advancements to new dispatchable emissions-free resource technology development, the system is set to change at a rapid pace. Situational awareness of system changes and continuous assessment are critical to ensure a reliable and lower-emissions grid for New York. The Economic Planning databases and models will be continually updated with new information and the Outlook study will be improved and performed on a biennial basis.
- To meet the minimum capacity requirement in 2040, at least 95 to 110 GW of new emission-free resources, including approximately 9.5 GW of new contracted renewable resources, will be required to come on-line. Furthermore, to fully achieve the emission-free grid target by 2040, even more resources will likely be needed along with transmission to deliver the clean power to consumers. The scope of the additional renewable resource need is remarkable. Compared to the 2.6 GW capacity entering into service in the past five years while New York experienced a net loss of approximately 2.2 GW, the installation rate in the next 20 years must increase significantly to achieve state law climate change requirements. State agencies should consider releasing a clear procurement schedule for renewable resources to guide the long-term system planning and provide clarity to the market.

The challenges identified in the Outlook cannot be solved by any single entity. New York's Climate Action Council has released a draft scoping plan to reduce New York State's carbon footprint across all sectors, make our communities more resilient, and adapt to a changing climate. This report further supports the mission by quantifying the evolving challenges in the electricity

[31] New York State Climate Action Council Draft Scoping Plan, December 30, 2021, available at, https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan.

sector and making recommendations to address those challenges. In addition to much more renewable resources, this report identifies other key factors for success, such as significant transmission expansion, and efficient peak load management. The full set of comprehensive electric system requirements will need participation among policy makers, generator owners, transmission owners, and consumers. Communication and collaboration between stakeholders are essential to making progress towards achieving policy objectives while maintaining an efficient power market and reliable power grid.