2021 Master Plan

Reliability and Markets for the Grid of the Future

A Report by the
New York Independent System Operator

Initial Draft - June 2021

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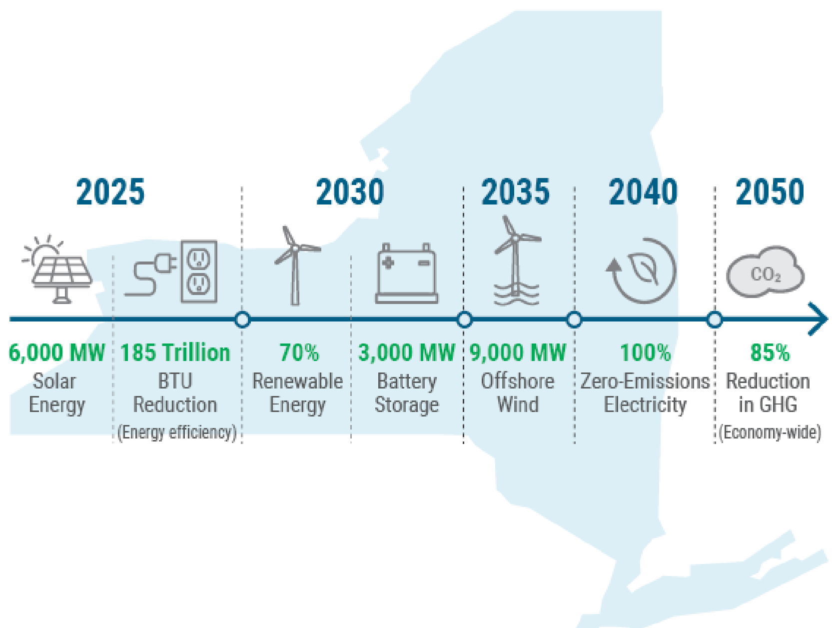
Introduction

The NYISO serves the public interest and provides benefit to consumers by fulfilling an array of essential responsibilities, which include reliable operation of New York's bulk power system, fair and open administration of competitive wholesale electricity markets, planning for the future of New York's power system, and advancing the technological infrastructure of the electric system serving New York.

Wholesale energy markets have successfully facilitated efficiency gains on the grid and cleaner energy production in the state since their inception. Over time, those gains and improvements have worked to influence more efficient (and often cleaner) generation, and investments in the grid that have further enabled energy production from cleaner resources. The NYISO wholesale markets are an effective platform for reflecting public policy and technological influences in an economically efficient manner to reliably meet consumers' energy needs.

The Master Plan for the NYISO wholesale markets examines the market structures, rules and processes, and enhancements over the next five years that will help maintain the reliability and economic efficiency of the grid, while supporting the public policies of the state of New York as outlined in the Climate Leadership and Community Protection Act (CLCPA).

In New York State, a rapid transition is underway from a power grid where energy is largely produced by central-station fossil fuel generation towards a grid with a substantial increase in renewable, intermittent resources and distributed generation.

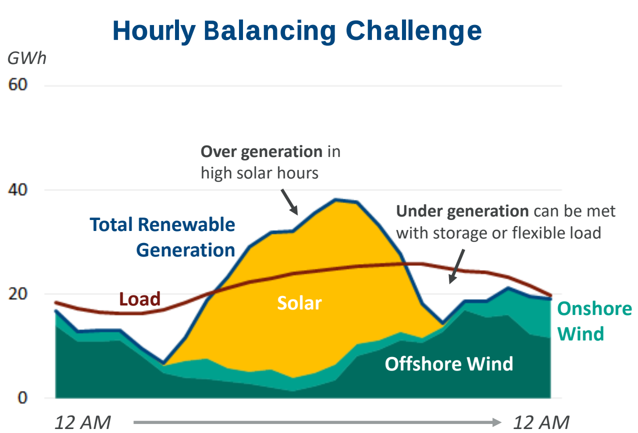


A Grid in Transition

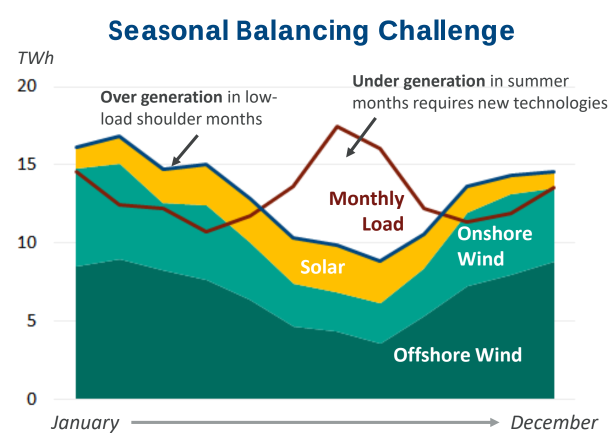
As the portion of electricity produced from intermittent renewable sources grows, maintaining grid balance will become increasingly more difficult. Periods of over-generation will increase renewable curtailment, while periods of low renewable generation will require large amounts of flexible, dispatchable generation (*e.g.*, fossil fuel power plants which run at low capacity factors but provide system balancing services) together with an increasing component of energy storage devices.

The figure below shows typical load profiles with typical generation profiles for wind and solar resources. The hourly balancing challenge appears when load exceeds generation in the morning and evening hours when the sun is not shining and when there is excess solar production in the afternoon hours. So while there may be enough energy overall to meet demand, it will be necessary to shift the generation from the afternoon to the morning and evening hours.

The seasonal balancing challenge is the need to balance extended periods of load generation mismatch. The mismatch between generation and load appears over the summer months when the demand is the highest but wind production generally dips, or during extended winter cold weather events. This calls for shifting large quantities of energy from the periods of energy surplus, such as the spring season, to the summer months.



Batteries and load flexibility can provide short-term balancing.



Seasonal balancing is the more difficult challenge, requiring new technologies such as seasonal storage or zero-emission dispatchable generation.

Source: The Brattle Group, New York's Evolution to a Zero Emission Power System, prepared for NYISO, June 22, 2020.

This Master Plan will focus on the key challenges for a grid transitioning to predominantly weather-dependent intermittent resources and discuss the various NYISO efforts that will better position the wholesale markets and grid operations to address these challenges. The projects included within this Master Plan are described in more detail in the project candidate descriptions that are posted as part of the annual project prioritization process.[1]

In this year's Master Plan, the NYISO describes initiatives that require prompt attention and are recommended for action over the next five years. Many of these options were identified in the *Reliability and Market Considerations for a Grid in Transition* paper and will require continued stakeholder collaboration. As with each Master Plan, projects that the NYISO and its stakeholders believe will bring considerable value to the wholesale markets are planned for continuation into future years, whereas other efforts may no longer have as high a priority due to changes in priorities throughout New York and the broader energy industry.

The Master Plan ties these initiatives into a cohesive five-year plan for our wholesale market platform. With the help and input of our stakeholders, this document discusses the NYISO's recommendations for evolving the wholesale markets and planning processes that the NYISO administers. Projects discussed in this Master Plan include those developed or suggested in one or more of the following publications or projects:

- Power Trends 2021 (NYISO, May 2021)
- Preparing the Capacity Market for the Grid in Transition (NYISO, April 2021)
- Climate Change Impact Phase II (Analysis Group, September 2020)
- New York's Evolution to a Zero Emission Power System (The Brattle Group, June 2020)
- Reliability and Market Considerations for a Grid in Transition (NYISO, December 2019)
- Carbon Pricing Proposal, (NYISO, December 2018)

The NYISO released the *Reliability and Market Considerations for a Grid in Transition* report (Grid in Transition report) at the end of 2019. The Grid in Transition report includes suggestions for operating and market design changes that will better prepare the NYISO to maintain and enhance grid reliability and resilience while continuing to enable New York State's energy and environmental policies. The set of projects featured in this 2021 Master Plan is largely informed by the findings from the Grid in Transition report and discussions to date with our stakeholder community on their priorities.

The NYISO continues to believe that its *Carbon Pricing* proposal, or another economy-wide carbon pricing mechanism, has the potential to provide significant value as a means to integrate public policy into the

[1] 2021 Approved Market Projects https://www.nyiso.com/documents/20142/18488223/03%202021%20BPWG%20Approved%202021%20Market%20Project%20Descriptions.pdf

NYISO markets. The NYISO's *Carbon Pricing* proposal seeks to harmonize New York State (NYS) public policy and the NYISO's wholesale markets by incorporating the social cost of carbon dioxide ("carbon") emissions when scheduling resources through the energy markets and ancillary services markets. NYS public policy promotes carbon-free resources through the CLCPA[2] and CES.[3] However, the wholesale electricity markets operated by the NYISO are not designed to fully align with these policy objectives. As a result, the wholesale markets are restricted in their ability to signal cost-effective carbon abatement options and send effective price signals to retain needed units to sustain the reliable operation of the grid. Implementation of the NYISO's carbon pricing proposal would allow resources to compete on emissions costs, in addition to fuel costs. The NYISO will look to move forward with a stakeholder vote on *Carbon Pricing* only with agreement on the proposal from New York State.

The NYISO also performed the Reliability Needs Assessment ("RNA") in 2020 to assess the reliability of the New York Bulk Power Transmission Facilities ("BPTF") and will be performing the Comprehensive Reliability Plan ("CRP") in 2021. The RNA and CRP help determine whether there are emerging reliability considerations and possibly signal the need for additional market rule changes in response to any such identified reliability considerations.

The Master Plan identifies market reforms within the energy, ancillary services and capacity markets that address the challenges posed to the grid with increased intermittent resource penetration. These market design changes along with planning process improvements are intended to place the NYISO-administered wholesale electricity markets in the best position to attract and retain the necessary resources and infrastructure to reliably operate the grid.

[2] Chapter 106 of the Laws of the State of New York of 2019.

[3] New York Public Service Commission, *Order Adopting a Clean Energy Standard*, Issued and Effective August 1, 2016. Available at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B44C5D5B8-14C3-4F32-8399-F5487D6D8FE8%7D .

Energy Market

The wholesale energy markets effectuate the sale and procurement of electrical energy on a least-cost basis through a competitive bid-based process. This provides the primary incentive for units to perform in real-time and respond to rapidly changing system conditions. The ancillary services market rewards attributes that support the efficient delivery of energy to consumers. Ancillary services typically include functions that help maintain grid frequency and voltage, provide short-notice on-demand power should the sudden loss of supply or transmission occur, and allow for balancing of supply and demand.

The following sections will focus on the key challenges the energy and ancillary services markets will encounter with increased intermittent resource generation and the market design enhancements or changes that can address these specific challenges.

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

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

Additionally, as the variable cost of wind and solar resources are close to zero or even negative, due to renewable energy credits and tax incentives, it is possible that the wholesale market clearing prices become unsustainably low when these resources become marginal more frequently. This can lead to wholesale market signals not supporting infra-marginal revenues for the type and quantity of resources needed to maintain supply to the grid when intermittent resources are not available. Improving price formation is crucial for wholesale energy and ancillary services markets to continue to support dispatch behavior needed to maintain grid reliability, properly value locational grid needs, incent attributes valuable to the grid, and to avoid unnecessary out-of-market actions.

Balancing Intermittency

While increased intermittent resource output is necessary to address climate change and to satisfy the CLCPA, this raises hourly, multi-day and seasonal balancing challenges due to the intermittent nature of these resources.

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

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

A resource mix with an increasing amount of intermittent and energy limited resources places flexibility (fast starting, ramping, and load following capabilities) at a premium. As both the net load and forecasted supply will tend to be more volatile and uncertain, firm generation available for balancing the grid needs to be flexible and able to address the risks to reliability through time.

Currently, the NYISO procures fixed quantities of reserves in specified regions across the state. The NYCA-wide reserve requirement is based on the largest single source contingency (static value). This static modeling approach uses a pre-determined value to procure reserves, which potentially reduces the flexibility of the market model to reflect current grid conditions (*e.g.,* generation commitments and electrical flows on transmission) and to maintain system reliability with a least cost solution. Operationally, the largest contingency could change based on the current commitment of generation. Additionally, the static modeling of reserves, specifically locational requirements, does not optimally account for the real-time transmission flows and available transmission capability that could be used to deliver reserves from a more cost-effective reserve region. *Dynamic Reserves* is a novel approach that will explore more efficient scheduling of operating reserves based on system conditions and transmission system capability. This will not only allow for appropriate reserves to be procured to cover the largest source contingency that could potentially occur under the current system conditions, but will also allow for more reserves to be scheduled in cost-effective regions.

As intermittent generation grows in certain import constrained areas, the amount of reserves to be carried in such areas may need to be increased to be able to address the loss of supply. As part of the *More Granular Operating Reserves* effort, the NYISO is exploring the implementation of reserve requirements within certain constrained load pockets in New York City that would better represent the value of short-notice resources in desirable locations. The NYISO believes that an efficient and effective solution to implement load pocket reserves is dependent on *Dynamic Reserves*. This is because static requirements in these load pockets can result in situations where holding reserves on supply is infeasible since all supply is providing economic energy and the reserves, or head room, have been shifted to the importing transmission lines. A dynamic determination of these requirements that accounts for available transmission capability into the load pocket, could potentially reduce the amount of reserves scheduled in these load pockets thereby improving market efficiency.

In addition to reserves, other ancillary services such as regulation, voltage control, and frequency response are essential to maintain grid reliability and resilience. In the future, there may be additional grid needs which are essential for continued system reliability. Based on the incentives and capabilities of renewable generators, the current market design focuses on maximizing energy output from renewable generators. As the grid needs evolve, incentives change, and the renewable generation technology advances, continued review of the potential grid services that renewable generators are capable of providing to maintain grid reliability should be undertaken.

The 2021 *Grid Services for Renewables* study has examined relevant reliability rules, as well as the necessary upgrades to typical inverters and controls to allow renewable generators to provide grid services. Additionally, the study has considered potential enhancements to current market designs to allow renewable generators to provide the grid services they are capable of providing. Specifically, this study has identified the ability of renewable generators to provide regulation service in the downward direction by potentially backing down their energy output. The NYISO regulation product currently requires providers to be capable of responding to basepoints to both increase and decrease output. Thus, the current market structure would need to be revised to create separate regulation "up" and "down" products in order to enable participation from renewable generators. Bifurcating the regulation market could enable greater resource participation and competition to provide service l, which could reduce the overall costs of procuring regulation service.

Meeting the CLCPA and effectively addressing climate change will also require electrification of various sectors such as transportation and heating. Additionally, with the increase in behind-the-meter and energy storage resources, predicting the load-shape and managing multiple load peaks throughout the day will become increasingly complex.

To address this increased complexity, the *Review of Real-Time Market Structures* study will evaluate the Real-Time Market to ensure it is capable of supporting market and grid operations in a future of greater reliance on intermittent resources, higher forecast uncertainty, and increased reliance on distributed energy resources. This study would evaluate if the current structure and optimization horizons of the Real-Time Commitment (RTC) and Real-Time Dispatch (RTD) are designed to best manage the challenges of the future grid.

Along with the *Review of Real-Time Market Structures*, another concept that may help address the challenge of the future grid is having sufficient available energy or reserves to balance intermittent resource output over a longer duration of time. The NYISO's current 10 and 30 minute reserve products may not be sufficient when dealing with variations of generation on a longer timeframe. *Reserves for Energy Security* can be helpful in balancing intra-day volatility by reserving capacity on generation that is sustainable for longer duration than the current reserve products. These reserves could assist in maintaining reliability when there are extended variations in intermittent resource output or load forecast that would result in longer energy needs than those addressed by the current reserve products.

Improving Price Formation

Efficient, transparent, and reasonable pricing of all products and services in the day-ahead and real-time markets provides proper incentives for resources to offer flexibly and to be responsive to real-time system changes, particularly as conditions transition between when supply is ample and when it is scarce.

Renewable resources also have zero or very low variable costs, which reduces energy prices when these resources are marginal. With an increase in penetration of renewable resources, energy prices will be lower on average and a greater percentage of the time. This reduction in energy market revenue due to lower energy prices places a greater emphasis on price formation to maintain efficient marginal incentives and to avoid reliance on out-of-market actions and uplift payments.

Robust energy and ancillary services price formation will provide incentives for resources to respond to real-time needs and to signal investment in resources with the necessary capabilities to support grid reliability. It will also encourage the entry of flexible resources that will be needed to balance intermittency of the future grid.

Under the current market rules, there is a potential for extreme negative prices in real-time due to offers and bids having a floor of -$1,000/MWh. Extreme negative pricing outcomes could adversely impact the participation of flexible resources in the real-time markets. The *Adjustment of Energy Offer/Bid Floor* project will investigate the impacts of increasing the offer floor for resources and the capping logic required to implement this change. This project has the potential to reduce uplift by reducing the level of extremely low pricing that is not reflective of associated costs.

Currently, reserve providers in the Long Island (LI) reserve region are paid based on the clearing prices for the larger Southern New York (SENY) reserve region due to market power concerns and operating constraints in Long Island. To meet NYS's renewable energy targets, large developments of off-shore wind projects are being anticipated in the LI zone. It will be essential to have enough reserves within LI along with sufficient import capability to recover from the loss of intermittent output on LI. To accomplish this, the wholesale markets will need to establish reserve prices for LI that properly reflect the value and associated cost of the reserves being procured within the LI zone. Therefore, the *Long Island Reserve Constraint Pricing* project will evaluate whether revisions to current compensation rules are warranted to provide additional availability incentives for Long Island suppliers. This modeling enhancement is intended to better reflect the value of reserve capability on LI.

Efficient scheduling and pricing of operating reserves becomes increasingly important to reliably operate the system when intermittent resource output is unavailable. Currently when scheduling reserves, the market software co-optimizes energy and ancillary services by seeking to minimize the total as-bid production cost to meet the energy, reserves, and regulation requirements. With respect to reserves, the markets do not expressly account for the potential cost of converting the reserves on a unit when determining dispatch schedules. The *Enhance Operating Reserve Scheduling and Pricing* project will explore an approach that would schedule reserve providers not only based on the cost to provide the reserves, but would also account for the cost associated with potential need for converting those reserves to energy. This approach could result in reserves being held on the most efficient energy suppliers that are not already providing energy to the grid and, therefore, establish reserve schedules on the set of resources most likely to be dispatched when additional energy is needed.

In addition to enhancing scheduling and pricing of operating reserve products, effective pricing and modeling of transmission constraints is necessary for improved price formation. While sufficient generation capability and operating reserves may be available to the system, without the required transmission capability or efficient modeling of transmission constraints, serving load effectively is a challenge. Currently, the NYISO's software accounts for the energy that can flow from one location to the next on the bulk electric system by accounting for transmission facility and line limits. The current transmission pricing logic relaxes certain transmission constraints assigned a zero value constraint reliability margin (CRM) without using a graduated pricing mechanism to resolve it. A 2018 study concluded that enhancements to the current transmission constraint pricing logic would be beneficial. *Constraint Specific Transmission Shortage Pricing* aims to develop a new pricing construct, under which transmission demand curve prices will increase with the severity of transmission overloads including extension of a graduated pricing mechanism to internal facilities that are currently assigned a zero value CRM. This would result in fewer occurrences of constraint relaxation and increased use of a graduated transmission demand curve mechanism to establish pricing values for shortages that exceed applicable CRM values. This project seeks to ensure that the cost of meeting transmission constraints is better reflected in locational prices. Improved pricing outcomes can assist to incentivize investment in resources and transmission in locations which would benefit the system.

To effectuate accurate pricing of transmission constraints, the pricing outcomes should be consistent with the modeling of these constraints. Currently, there is a discrepancy when physical resources are used to provide relief to a transmission facility versus when a graduated transmission demand curve mechanism is applied to provide relief. When physical resources are available to provide relief, the market software accounts for the relief from the re-dispatch on all impacted facilities. In contrast, when graduated transmission demand cure mechanism is used, any relief provided by the demand curve currently only applies to that particular constrained facility. This is of particular importance when in-series line segments are simultaneously constrained. The relief provided by a physical resource would apply to all in-series segments, while relief from a transmission demand curve would only be applied to one segment. *Line in Series Constraint Pricing* will explore a more dynamic solution for addressing the application of a graduated transmission demand curve to in-series line segments. Enhancements will seek to harmonize the results in instances when physical resources or transmission demand curves are used to provide relief. Additionally, improvements in the applicable of relief from a graduated transmission demand curve to in-series line segment could potentially reduce overall system costs and result in more efficient pricing outcomes.

Under current market rules, offline 10-minute gas turbines (GTs) are able to be used as physical resources by the dispatch software on a 5-minute basis, even though the resources may not be able to respond within the 5-minute timeframe. This causes a divergence between market schedules and market flows with the actual outputs and actual flows. Therefore, prices may not adequately reflect real-time system conditions and result in intervals of under generation. Additionally, since these offline resources are able to be used to resolve transmission constraints, locational prices may not properly reflect actual flows that are occurring on the system. The *Eliminate Offline GT Pricing* initiative will look to address this market construct and seek to develop market rules that better reflect system conditions and incentivize investment in more flexible, dispatchable resources.

Capacity Market

The NYISO is required to procure enough generating capacity to meet forecasted load plus a reserve margin to maintain grid reliability. The ICAP Market is designed to meet resource adequacy while also enabling generators to recover fixed costs (*i.e.*, those costs that do not vary with electricity production).

Capacity markets, in combination with robust energy and ancillary services markets, provide significantly less volatile investment price signals than an Energy and Ancillary Services (EAS)-only market.

As the resource mix transitions with increasing intermittent renewable and limited-energy resources, capacity market incentives must be sufficient to encourage resource entry when needed. Such need for market entry may be caused by factors such as the retirement of existing, higher-cost resources, reduction in resource capabilities, or expected increases in load with electrification of the transportation and heating sectors.

Comprehensive Mitigation Review

As the resource mix shifts, it is crucial to address the challenge of efficient resource entry and exit to meet policy objectives, while continuing to attract/retain resources necessary to meet established resource adequacy requirements. The NYISO is focused on a holistic review of the current mitigation framework in order to mitigate or eliminate unnecessary risk of buyer-side mitigation (BSM) for resources necessary to achieve the CLCPA's objectives and simplify an unnecessarily complex BSM process. Any process changes that are ultimately developed will need to be just and reasonable, and allow the ICAP Market to continue to attract and retain resources needed to maintain resource adequacy.

When developing changes under the *Comprehensive Mitigation Review* effort, the NYISO will look to consider rules that reduce or eliminate BSM risk to resources needed to satisfy the requirements of the CLCPA. In order to support just and reasonable ICAP Market outcomes, robust measures for capacity accreditation will also need to be considered and addressed as described below.

Capacity Accreditation Measures

It is imperative to value capacity resources accurately based on their contributions to resource adequacy. This allows market compensation for capacity suppliers to be properly aligned with individual resources' expected reliability benefit to consumers while ensuring sufficient resources are procured to meet resource adequacy requirements.

The *Improving Capacity Accreditation* project would expand on the principles established with Expanding Capacity Eligibility and Tailored Availability Metric to all resources in the ICAP Market. This effort would develop enhanced capacity ratings for all supply resources that reflect the marginal contribution to meeting resource adequacy criterion, accounting for system dynamics, resource availability and performance (including the impact of outage correlations).

The NYISO anticipates leveraging enhancements established in the *Improving Capacity Accreditation* project within the required *Capacity Value Study.* Duration limited resources have the potential to balance intermittent resource output and, as a result, contribute to reliability by aiding the NYISO in meeting its resource adequacy criteria. Recognizing both the advantages and limitations of such resources, the *Capacity Value Study* seeks to appropriately value these resources in the ICAP Market and periodically review such values.

These values will be based on the reliability benefits these resources provide to the system during the Peak Load Windows.[4] This periodic review seeks to ensure that the ICAP Market continues to efficiently support grid reliability and reflect the value that resources provide to the system, particularly during critical operating periods.

Capacity Improvements to Support Reliability

Improving the resource adequacy tools, models, and *Methods for Measuring Reliability* is critical to efficiently meeting the reliability needs of the evolving grid. Enhancements will need to account for changes in critical operating periods, changing load shapes and load variability, new technology operation such as energy storage, and consideration of regional conditions that may inhibit shared assistance. The NYISO is working with its stakeholders and the New York State Reliability Council (NYSRC) on enhancements to measuring and modeling load forecast uncertainty and improving the load shapes used in resource adequacy studies that establish New York's installed reserve margin (IRM) and Locational Minimum Installed Capacity Requirements (LCRs). The NYISO is also seeking to improve the modeling of limited duration resources within the resource adequacy tools to better align the study outcomes with operational realities of managing resources that consume electricity in order to deliver that same electricity in a future period (less conversion losses). There is also work underway to enhance the variable generation profiles for wind and solar resources used in evaluating resource adequacy. The NYISO continues to look for ways to improve and enhance its resource adequacy modeling, which helps decision makers understand the future reliability needs of New York's electric system.

The NYISO ICAP Market is intended to ensure sufficient capacity exists to satisfy resource adequacy, including requirements to maintain a minimum amount of capacity in import constrained Localities. Historically, the IRM set by the NYSRC and LCRs set by the NYISO have resulted in sufficient capacity to meet statewide resource adequacy while holding sufficient capacity within the Localities to manage transmission security requirements. This approach works well because the current resource mix includes sufficient quantities of resources capable of being deployed and dispatched in order to manage transmission system flows. However, as the resource mix transitions to one more dependent on intermittent resources and/or resources with energy duration limitations, these resources may not have sufficient electrical energy available to manage transmission security needs or electrical output that is well correlated with transmission security needs. *The Transmission Security in ICAP Market* project would evaluate a holistic way to incorporate the impact of the transitioning resource mix on transmission security, and consider ways to incorporate those impacts into

[4] The Peak Load Windows were developed through the *Expanding Capacity Eligibility* and *Tailored Availability Metric* efforts

the ICAP Market. Expanding the measures of reliability by considering resource specific contributions toward transmission security could facilitate the success of the ICAP Market in the future.

The *Demand Curve Reset (DCR)* process conducted every four years determines the parameters used in establishing the ICAP Demand Curves. The parameters are determined by a hypothetical resource's costs and estimated energy and ancillary service market revenue earnings. By periodically assessing these parameters, this process ensures that the ICAP Market continues to send transparent price signals and support resource adequacy. The NYISO and its stakeholders recently completed the DCR process for the curves in effect for May 2021 through April 2025. The next DCR process will start in 2023 to establish the ICAP Demand Curves to be used for May 2025 through April 2029.

The ICAP Demand Curves are based on the net cost of new entry (Net CONE) of a hypothetical resource for each curve (referred to as a "peaking plant"). These Net CONE costs are estimated in ICAP-terms and then converted into Unforced Capacity (UCAP)-terms based on the regional average derating factor, which reflects the forced outage rates of the existing fleet as well as UCAP-ICAP ratios of intermittent resources. Since the peaking plant is expected to have a low forced outage rate, this method can result in monthly UCAP-based curves being set higher than if the derating factor of the peaking plant were used for each curve. This inconsistency is expected to be more pronounced as additional intermittent resources are added to the system. The *Demand Curve Translation Enhancement* will look to minimize these structural inconsistencies to improve the ICAP Market price signals for maintaining resource adequacy.

The *CRIS Expiration Evaluation* project focuses on making the rules for Capacity Resource Interconnection Service (CRIS) expiration more stringent in cases where CRIS is not fully utilized, as well as modifications to allow for increased flexibility with respect to CRIS transfers. Further enhancements to the CRIS expirations rules will more appropriately address the retention of CRIS by retired facilities and facilities no longer fully participating in the ICAP Market. These changes are intended to more accurately account for the capacity deliverability headroom of the system and potentially lower the cost of market entry to future facilities seeking to participate in the ICAP Market.

The Transmission Owners (TOs) currently assign capacity obligations to LSEs serving retail load within each TOs service territory based on the measured share of load consumed by each LSE during the NYCA peak load hour. The *Expanding Application of Peak Hour Forecasts* project will explore using multiple peak and near-peak load hours to allocate capacity obligations within a Transmission District. This may improve the capacity obligation determination process, potentially incent additional dynamic load responsiveness during critical operating periods, and better reflect cost causation.

New Resource Integration

The NYISO markets are resource agnostic. This allows for fair treatment of all resources by valuing the characteristics needed to maintain grid reliability rather than preferring a particular resource type. The operational characteristics of renewable technologies, battery technologies, demand side technologies and distributed generation technologies may not fit the existing models used to represent supply resources in the wholesale markets. Therefore, refinements to the existing models and the creation of new models are sometimes needed to properly reflect characteristics such as limited energy capabilities or lack of fuel certainty. By enhancing these models, the NYISO seeks to enable grid operators to continue meeting the rigorous electric system reliability requirements of New York State.

Enabling New Resources and Capabilities

New technologies have the potential to diversify the system resource mix, support New York's clean energy and de-carbonization objectives, and make load more dynamic and responsive, providing an opportunity to improve overall system efficiency.

The variability of meteorological conditions that govern the output from wind and solar resources presents a fundamental challenge to relying on these resources to flexibly meet electricity demand. It is imperative to consider new clean energy technologies with long duration energy output capabilities that are dispatchable.

Integration of new resources will ultimately support New York's clean energy objectives, compliance with FERC Order Nos. 719, 745, 841, and 2222 as well as other FERC efforts that explore new resources such as hybrid storage resources. While some new models may be required to fully integrate new resources, looking for opportunities to enhance existing models first will help integrate new resources while minimizing the operational matrix of market rule sets.

As new assets are developed and built, there is an accompanying desire to couple assets of different technology types to participate as a combined resource in the wholesale markets. This desire provides an opportunity to leverage the complementary characteristics of different technology types such as coupling intermittent, renewable generation with energy storage to reduce the generation volatility. Additionally, state and federal programs and procurement initiatives provide incentives for developers to couple storage and intermittent renewable assets. Recognizing these opportunities for developers and the associated benefits to the wholesale market, in 2020, the NYISO developed the *Hybrid Co-located Model* that enables grid-scale wind or solar and energy storage resources to participate as co-located resources behind a single interconnection point.

In 2021, the NYISO will build on this framework via the *Hybrid Aggregation Model,* which aims to allow energy storage resources to aggregate with generators of at least one other technology type that are all co-located behind the same point of interconnection to form a single resource. The resources in this type of aggregated will share a single point identifier (PTID).

Historically, the majority of wholesale demand has been considered inelastic or uncontrollable by system operators. However, as deployments of intermittent resource generation increase, so does the opportunity for more flexible demand. Flexible demand will play a role in both balancing intermittent supply provided by these new types of intermittent generators and in providing ancillary services to the NYISO markets. The *Engaging the Demand Side* project seeks to broaden avenues for market participation by flexible loads by informing the demand side about where and when to consume and aligning incentives to follow those instructions. This alignment may require improvements to consumer metering, communication platforms, close coordination with utilities, modifications to retail rate structures or expanded application/availability of retail rate structures reflecting real-time wholesale market prices, and wholesale market enhancements to further enable the participation of flexible load.

Effectively, *Engaging the Demand Side* could result in more robust price formation by reflecting consumers' willingness to pay in addition to suppliers' willingness to provide. Although the NYISO markets currently feature demand side participation opportunities through various wholesale demand response programs, price responsive load bids in the Day-Ahead Market, and eventually the Distributed Energy Resource (DER) participation model, the emergence of new technologies provides a strong use case for price-responsive demand in the real–time markets. The transition to the future grid requires a wholesale market structure that allows for new and existing technologies to compete on equal footing. This includes the capability for wholesale price-responsive demand to play an active role in the wholesale markets, and the integration of a wide array of emerging load-shifting and distributed-resource technologies.

The NYISO's *DER Participation Model* is the next step toward animating load in the wholesale markets. This participation model builds upon the NYISO's experience with demand response programs, and will be key to enabling demand-side technological advancements that may be needed in the near future. By creating an opportunity for participation of distributed generation in the wholesale market, the NYISO hopes to maintain rules universally applicable to small resources desiring to participate in aggregate. This initiative directly supports compliance with FERC Order No. 2222, improving access to wholesale electricity markets for small, distribution-connected assets.

When evaluating new and enhanced market models that the NYISO should be developing to enable new technologies, it is important to consider the state initiatives that may inform future market needs. One example is the development of rules for *Internal Controllable Lines*. Currently, there are no internal controllable lines in operation within the NYCA. However, state and local initiatives such as New York City Local Law 97[5] and Tier 4 REC procurements provide incentives for developers to deliver renewable generation to constrained areas using high voltage direct current (HVDC) lines. This effort is intended to facilitate the scheduling and pricing of internal controllable lines within the Energy markets while supporting the state and local programs. Additionally, this effort would evaluate and revise, if necessary, the ICAP Market rules for Internal Unforced Capacity Deliverability Rights (UDRs).

Improving Market Models

In addition to introducing new market models for new technology types entering the markets, it is important to consider enhancements to the current market models. This could enable continued efficient scheduling of current resources and also assist in providing additional flexibility to the current market software by balancing intermittent resource output. These enhancements typically are informed by operational experience and look to improve market models to align with reliable operations.

Duration limited resources, such as energy storage resources and energy limited resources, can enable the balancing of intermittent resource generation output. However, these resources can only provide uninterrupted energy for a limited time. *Enhance Run Limited Resource Modeling* would review the operation of existing limited energy resources and look to improve the modeling of such resources in the market software, which, in turn, could improve the efficiency of market outcomes to support grid reliability and effectively using these resources when they are most needed.

Increased flexibility is essential as the penetration of intermittent renewable resources increases. Currently, the Real-Time Dispatch (RTD) schedules a significant portion of internal generation on a five-minute basis. However, interchange with external control areas is scheduled either on a 15-minute or an hourly basis by the Real-Time Commitment (RTC) software. Scheduling external transactions with our neighboring control areas on a five-minute basis would increase flexibility in the energy and ancillary services markets and improve reliable grid operations. The *5-Minute Transaction Scheduling* initiative will evaluate how best to schedule external transactions every five-minutes with neighboring areas that are able to support a reduced scheduling horizon, aligning the scheduling of external interchange with internal resources and improving the options for maintaining grid reliability. This project also has the potential to converge prices between the

[5] https://www1.nyc.gov/assets/buildings/local_laws/ll97of2019.pdf

RTC and the RTD, thus reducing the volatility of real-time prices.

Increased intermittent resource penetration leads to variability and uncertainty in scheduling such resources. Any enhancements to market models which improve or eliminate other uncertainties can help balance the system. The *Improve Duct Firing Modeling* project will evaluate market software enhancements that are required to reflect the operating characteristics of a combined cycle generator in the duct-firing range. This enhancement in intended to enable more efficient scheduling of a combined-cycle resource for both energy and operating reserves. Furthermore, this enhancement could provide additional flexibility to the RTD to make cost effective dispatch decisions by more accurately reflecting the operating characteristics of such resources.

Planning for the Future

In response to reliability needs identified by the NYISO and public policy needs identified by the New York State Public Service Commission, the NYISO has the ability to call for market-based and regulated solutions to meet these needs and, if appropriate, select the more efficient or cost effective regulated transmission solution to address such needs. These planning processes support the reliability and efficiency of the electric grid and the ability of the electric grid to support public policy goals.

Load Forecasting Enhancements

Forecasting load and operating the bulk power system becomes more complex as additional intermittent resources integrate onto the grid, customers reduce load with behind-the-meter resources, and electrification of other sectors, such as transportation and space conditioning (heating and cooling), increases in response to the CLCPA.

This complexity is due to the fact that shifting load from the bulk power system to behind-the-meter resources is not the same as eliminating load. When behind-the-meter (BTM) resources are unavailable to produce energy, the bulk power system must act as backup and provide energy to the homes and businesses with behind-the-meter resources. The NYISO must therefore consider energy provided by behind-the-meter resources when planning for the reliable operation of the bulk power system. Additionally, the NYISO must consider the impacts of electrification of various sectors as it is widely expected to cause significant changes in the seasonal peaks, as well as hourly and monthly electricity usage patterns.

With continuing growth in behind-the-meter solar resources, maintaining accurate assessments of this generation capacity is imperative to both short-term and long-term load forecasting efforts. The *BTM Solar Demand Forecasting Product Enhancements* project aims to employ a more-automated tracking process for

BTM solar capacity. This process would significantly improve the accuracy of load forecasts. Additionally, the automation would improve interactions between BTM solar forecast and DER market systems, resulting in increased efficiencies when integrated with NYISO's DER aggregation system.

The load forecast feeds into all of the planning studies that enable the NYISO to effectively plan for the future. Given the longer-term CLCPA requirements, the NYISO's load forecasting capability should expand to consider the impacts of electrifying other sectors of the economy to understand the impacts of electrification on the bulk power system. The *System Demand End-Use and Electrification Forecasting Enhancements* project aims to understand the impacts of electrification on residential and commercial end-use energy needs. This project will include developing historical data and future trends of these technologies for use in the end-use models specific to the geographic regions of New York. As a result of improvements to the end-use and hourly load modeling approach currently used, the NYISO will enhance its current forecasting capabilities leading to greater confidence in its annual, monthly, and hourly forecasts of energy demand as electrification of the grid evolves through time.

Proposed Project Timelines

	2021 Master Plan						
Energy Markets		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
	Balancing Intermittency						
1	Dynamic Reserves	SC	CP	MDC	FR	DEP	
2	More Granular Operating Reserves				MDC	FR	DEP
3	Reserves for Energy Security				SC	MDC	FR
4	Grid in Transition	ID	SC				
5	Balancing Intermittency			MDC	FR	DEP	
6	Review of Real-Time Market Structure					ID	SD
7	Grid Services for Renewables	SC	CP	MDC	FR	DEP	
	Improving Price Formation						
8	Constraint Specific Transmission Shortage Pricing	MDC		FR	DC	DEP	
9	Lines in Series Constraint Pricing		SC	MDC	FR	DEP	
10	Eliminate Offline GT Pricing					MDC	DEP
11	Long Island Reserve Pricing				MDC	FR	DEP
12	Adjustment of Energy Offer/Bid Floor			MDC	DEP		
13	Enhance Operating Reserves Scheduling and Pricing						SC
14	Carbon Pricing	SD	AWAITING NEW YORK STATE GUIDANCE				
Capacity Markets		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
	Comprehensive Mitigation Review						
15	Comprehensive Mitigation Review	MDC/DEP	DEP				
	Capacity Accreditation Measures						
16	Improving Capacity Accreditation		MDC				
17	Capacity Value Study	DEP	SD	SC		DEP	SD
	Capacity Improvements to Support Reliability						
18	Transmission Security in ICAP Market		CP	MDC	DEP		
19	Demand Curve Reset	DEP		SD	SC	DEP	
20	Demand Curve Translation Enhancement		MDC	DEP			
21	CRIS Expiration Evaluation	CP	MDC				
22	Expanding Application of Peak Hour Forecasts	CP	MDC				
New Resource Integration		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
	Enabling New Resources and Capabilities						
23	DER Participation Model	DEP	DEP				
24	Hybrid Co-Located Model	DEP					
25	Hybrid Aggregation Model	MDC	FR	DC	DEP		
26	Engaging the Demand Side	ID	SC	CP	MDC	FR	DC
27	Internal Controllable Lines		MDC	FR	DC	DEP	
	Improving Market Models						
28	Enhance Run Limited Resource Modeling					CP	MDC
29	5-minute Transaction Scheduling		CP	MDC	FR	DEP	
30	Improve Duct Firing Modeling		MDC	DEP			
Planning for the Future		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
	Load Forecasting Enhancements						
31	BTM Solar Demand Forecasting Product Enhancements		FR	DEP			
32	System Demand End-Use and Electrification Forecasting Enhancements		SC				

Key			
CD	Continued Discussions	MDC	Market Design Complete
ID	Issue Discovery	FR	Functional Requirements
SD	Study Defined	SD	Software Design Specification
SC	Study Complete	DC	Development Complete
CP	Market Design Concept Proposed	DEP	Deployment

While all of the initiatives described herein may offer value to the wholesale markets, the NYISO does not have the resources to address all of them simultaneously. Unanticipated initiatives may also result from future FERC orders, stakeholder input, and/or evolving public policies, causing the proposed timelines to require revision. In light of these and other unknowns, this plan lays out what the NYISO believes to be an efficient path toward effective wholesale market reform.

Conclusion

This Master Plan discusses various wholesale market initiatives that are important to respond to a transitioning grid while maintaining reliable electricity for all New Yorkers. While there are various challenges the future grid poses, the initiatives described in this plan will ready the NYISO's wholesale markets for the anticipated transition.

Appendix I – Project Milestone Definitions

Ongoing:

- Unique to the Master Plan, this milestone acknowledges that additional development of potential projects is required before laying out a detailed project plan.

Issue Discovery:

- NYISO has facilitated education sessions for stakeholder knowledge development of problem/issue, conducted stakeholder solicitation of potential solutions to address problem/issue, and summarized findings at a working group meeting for potential ranking and future project identification.

Study Defined:

- The scope of work for the study has been presented to stakeholders, including a discussion on the necessary input(s), assumption(s) and objective(s) of the study.

Study Complete:

- Scope of work to be performed has been completed; results and recommendations have been presented to the appropriate Business Owners and stakeholders.

Market Design Concept Proposed:

- NYISO has initiated or furthered discussions with stakeholders that explore potential concepts to address opportunities for market efficiency or administration improvements.

Market Design Complete:

- NYISO has developed with stakeholders a market design concept such that the proposal can be presented for a vote at the Business Issues Committee (BIC) and/or Management Committee (MC) to define further action on the proposal.

Functional Requirements:

- NYISO has completed documentation of the functional requirements (FRS) and the Business Owner has approved.

Software Design:

- The software design document is complete and software development is ready to begin.

Development Complete:

- Software development has been completed, packaged and approved by the Supervisor.

Deployment:

- Required software changes to support commitment have been integrated into the production environment.