Public Service Commission

Three Empire State Plaza, Albany, NY 12223-1350
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December 28, 2022

Via Electronic Mail

Hon. Michelle L. Phillips
Secretary to the Commission
New York State Public Service Commission
Agency Building 3
Albany, NY 12223-1350

Re: Case 18-E-0130 – In the Matter of Energy Storage Deployment Program.

Dear Secretary Phillips,

On behalf of the New York State Department of Public Service and the New York State Energy Research and Development Authority (NYSERDA), please find the attached "New York's 6 GW Energy Storage Roadmap: Policy Options for Continued Growth in Energy Storage," for filing in Case 18-E-0130. Please feel free to contact me should you have any questions.

Sincerely,

/s/ Stephanie S. McDermott

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Attachments

New York's 6 GW Energy Storage Roadmap:

Policy Options for Continued Growth in Energy Storage

CASE 18-E-0130

In the Matter of Energy Storage Deployment Program

December 28, 2022

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Executive Summary

Energy storage will play a critical role in supporting New York's decarbonized electric grid by integrating large quantities of variable renewable energy, reducing curtailment, and storing renewable generation for the times it is needed most. On January 5, 2022, New York Governor Kathy Hochul announced in her *State of the State* address an intention to double the state's 2030 energy storage deployment target, from the currently legislated 3 gigawatts (GW) of storage to 6 GW of storage by 2030. This nation-leading storage target, in addition to an interim goal of 1.5 GW by 2025 established through the 2018 Storage Roadmap process, is motivated by the rapid growth in renewable energy expected over the next decade and the role that electrification of transportation and buildings is expected to play in achieving New York State's future carbon neutral economy. These directives are outlined in New York's *Climate Leadership and Community Protection Act* (Climate Act), which calls for New York to achieve 70% renewable electricity by 2030 and 100% zero-emissions electricity by 2040. To accelerate the deployment of storage and support the transition to a clean electric grid, Governor Hochul directed the Department of Public Service (DPS) and the New York State Energy Research and Development Authority (NYSERDA) to update New York State's Energy Roadmap to double deployment, achieving at least 6 GW of energy storage deployments by 2030.

This document represents an updated Storage Roadmap, augmenting the 2018 Storage Roadmap, developed by NYSERDA and DPS Staff to meet the directive laid out by Governor Hochul. Specifically, this Roadmap assesses needed market reforms and cost-effective procurement mechanisms to achieve the increased storage target, identifies research and development needs to accelerate technology innovation, particularly for long-duration energy storage, and recommends approaches to storage deployments in a manner that furthers the state's efforts in replacing New York's most polluting fossil fuel facilities.

This updated 2022 Roadmap also analyzes the current market for energy storage in New York State, including the progress to date toward achieving the existing 3 GW target. It also serves as the Triennial Review of storage markets, policies and programs as required under the Public Service Commission's (Commission) 2018 Energy Storage Order.[1]

To serve the needs of a carbon neutral economy, analysis developed to support this Roadmap indicates that about 12 GW of energy storage by 2040 and 17+ GW by 2050 would be part of a cost-effective decarbonized electric grid, offering critical benefits in terms of grid reliability and integration of renewable generation. A new 2030 target of 6 GW will play a critical role in achieving the order-of-magnitude growth increases needed to put New York on a path towards these longer-term storage levels. A target of 6 GW of storage by 2030 is projected to reduce the projected future electric system costs by approximately $2 billion, in addition to public health benefits resulting from reduced exposure to harmful pollutants from fossil fuel resources that would otherwise operate during peak demand periods. NYSERDA and DPS Staff therefore recommend adopting an increased deployment target of 6 GW of energy storage by 2030.

A total of 1,301 megawatts (MW) of storage, representing about 87% of the 2025 target, has been awarded or contracted as of October 2022, with over 130 MW installed. Approximately 12,000 MW of proposed energy storage projects are presently in either distribution-level or wholesale-level

[1] Case 18-E-0130, In the Matter of Energy Storage Deployment Program, Order Establishing Energy Storage Goal and Deployment Policy (Energy Storage Order), issued December 13, 2018.

interconnection queues in New York. These metrics convey the rapid growth of the storage industry's interest in the state since the 2018 Roadmap. However, notable barriers to deployment persist and, to some extent, have even increased recently.

Over the past year, supply chain constraints, material price increases, and increased competition for battery cells have driven up the cost of energy storage technologies, particularly lithium-ion batteries. Many of the drivers of cost increases are expected to persist until at least 2025. These cost increases may impact the cost of any new programs designed to procure storage to be installed by 2030. In addition to cost increases, difficulties in the timely completion of interconnection processes, high interconnection costs, and downward pressure on capacity revenue create a challenging environment through the development and operational lifecycle of a storage project. Financial support will therefore be crucial for the state to achieve the 3 GW and 6 GW deployment goals.

To reach the proposed 6 GW deployment goal by 2030, roughly 4,700 MW of new projects will need to be procured and deployed in the coming years. To maximize the feasibility of these procurements, diversify technology options, and take advantage of the unique benefits provided by different market segments, NYSERDA and DPS Staff recommend new programs be developed for bulk, retail, and residential storage projects across the state.

Based on a review of procurement options, market conditions, and past programs for bulk storage resources, NYSERDA and DPS Staff recommend a two-pronged approach to bulk storage deployment. First, 3,000 MW of bulk storage projects should be procured through a new Index Storage Credit mechanism, which is anticipated to provide long-term certainty to projects while maximizing value to ratepayers. Second, NYSERDA and DPS Staff recommend that the Joint Utilities of New York (JU) be directed to study the potential of energy storage to provide non-market transmission and distribution services and identify projects that provide cost-effective services when compared to traditional alternatives, and that any storage projects developed as a result should count toward the 6 GW target.

The existing retail and residential storage programs have proven successful, and NYSERDA and DPS Staff propose to extend their funding following a design of region-specific blocks of funding similar to that used to date. New programs should include 1,500 MW of program blocks for retail projects and 200 MW for residential storage programs.

The total cost of these proposed procurement programs is estimated at between $1.0 billion and $1.7 billion. This equates to an estimated increase in customer electric bills of 0.32% – 0.54% (or $0.34 – $0.58 per month for the average residential customer) on average across New York for the 22-year period during which these programs would make payments to awarded projects. The range of these projections reflects future uncertainties, most notably those associated with energy and capacity prices.

While most of the storage projects procured through 2030 are expected to provide 4- to 8-hours of duration, long-duration storage (capable of 10+ hours of duration) is expected to become an important component of the long-term energy system. It is therefore recommended that NYSERDA programs focus on supporting research, development, and demonstration of technologies that can provide reliable, zero-carbon supply and reach commercialization in the first half of the 2030s.

This combination of storage programs provides a feasible and cost-effective pathway to achieving the goal of deploying 6 GW of storage by 2030 on a trajectory that will support full decarbonization of the electricity system by 2040.

1 Introduction

1.1 Purpose

On January 5, 2022, New York Governor Kathy Hochul announced as part of her *State of the State* address an intention to double the state's energy storage target, from the currently legislated 3 GW of storage to 6 GW of storage by 2030. This nation-leading storage target is motivated by the rapid growth in renewable energy expected over the next decade, and the role that electrification of transportation and buildings is expected to play in achieving New York State's future carbon neutral economy. These directives are outlined in New York's *Climate Leadership and Community Protection Act* (Climate Act), which calls for the state to achieve 70% renewable electricity by 2030 and 100% zero-emissions electricity by 2040. To accelerate the deployment of storage and support the transition to a clean electric grid, Governor Hochul directed the Department of Public Service (DPS) and the New York State Energy Research and Development Authority (NYSERDA) to update New York State's Energy Roadmap to double deployment, achieving at least 6 GW of energy storage deployments by 2030.

NYSERDA and DPS Staff submit this 2022 Storage Roadmap to the Public Service Commission (Commission) to update and augment the 2018 Storage Roadmap and to meet the directive laid out by Governor Hochul. This document analyzes the need for an increased 6 GW target and the barriers to storage deployment today. It provides policy recommendations to help the state achieve 6 GW of energy storage deployment by 2030.

This 2022 Storage Roadmap also serves as the Triennial Review Report, as required by the 2018 Energy Storage Order.[2]

1.2 New York's 2018 Energy Storage Roadmap Findings

The 2018 Energy Storage Roadmap initiated a process of developing policies, market mechanisms, and funding programs to support energy storage projects in New York State. Specifically, the 2018 Roadmap consisted of a statewide study to identify optimal storage buildouts under various scenarios, looking out to 2030 and incorporating the programs and policies in place at the time. The study found a heavy preference for storage deployment in downstate New York, along with synergies with deployment of solar power.[3] The study also quantified the benefits provided by storage under multiple use cases, from behind-the-meter to front-of-the-meter distribution-connected projects, and bulk storage resources.

The results of the 2018 Roadmap led to the creation of the 1.5 GW by 2025 target, as well as the goal of 3 GW by 2030, which were supported by a set of Market Acceleration Bridge Incentive programs administered by NYSERDA. Since the publication of the 2018 Roadmap, a number of changes have taken place. Firstly, and most importantly, the Climate Act was passed in 2019, codifying the 3 GW storage target and directing full decarbonization of the electricity sector, including a focus on utilizing storage for the

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[2] Regarding this review, the Energy Storage Order states, "...the Commission will conduct a review of the progress towards achieving the energy storage deployment goals and the effectiveness of the energy storage deployment policies and actions in meeting those goals." Case 18-E-0130, supra, Energy Storage Order, p. 113.

[3] Downstate New York is defined as Zones G-K in the New York Control Area, including the lower Hudson Valley, New York City, and Long Island.

integration of renewables and offsetting highly polluting peaking facilities. Furthermore, other resource-specific targets have impacted the value and need for storage resources, including the 9 GW offshore wind target, the 70% by 2030 renewable energy target, and the expansion of the NY-Sun program to 10 GW. Finally, the recent passage of the Inflation Reduction Act has created a new support mechanism for standalone energy storage projects in the form of an Investment Tax Credit. The recommendations put forth in this Roadmap consider the impact of these changes on the goal of achieving at least 6 GW of energy storage by 2030.

1.3 Organization of this Document

The 2022 Energy Storage Roadmap is organized as follows:

- Section 2 presents an overview of the current market and progress toward New York's previous storage goals. This section includes a status update on New York's bulk and retail energy storage programs and serves as the Triennial Review required by the 2018 Storage Order.
- Section 3 provides an overview and analysis of the role of New York's energy storage targets in creating a zero-emissions electricity system by 2040. It also provides recommendations on allocation of procurement efforts between the retail, residential and bulk storage market segments and the trajectory towards achieving the target.
- Section 4 details market barriers currently impacting energy storage and examines the market rules that apply to energy storage.
- Sections 5 and 6 assess options available for procurement of energy storage in the bulk and retail/residential market segments respectively, and offer recommendations.
- Section 7 considers procurement program design issues applicable across the range of storage procurement programs.
- Section 8 provides projections of the program and administrative costs associated with the proposed target and procurement amounts, together with recommendations for the mechanisms to be used to fund these programs.
- Section 9 discusses storage innovation and the role of long-duration storage.

2 Current Progress toward New York's Storage Goals and Market Overview

2.1 Progress in Energy Storage Deployments

The portfolio of programs and actions approved by the Commission in the 2018 Energy Storage Order began nurturing and expanding New York's then-nascent energy storage market. To date, 1,301 MW of energy storage projects have been awarded/contracted as of October 1, 2022. This represents 87% of the 2025 target of 1,500 MW. There are currently over 130 MW of storage projects installed across the state. The breakdown of these figures is described in Table 1.

Table 1. Total Energy Storage in New York

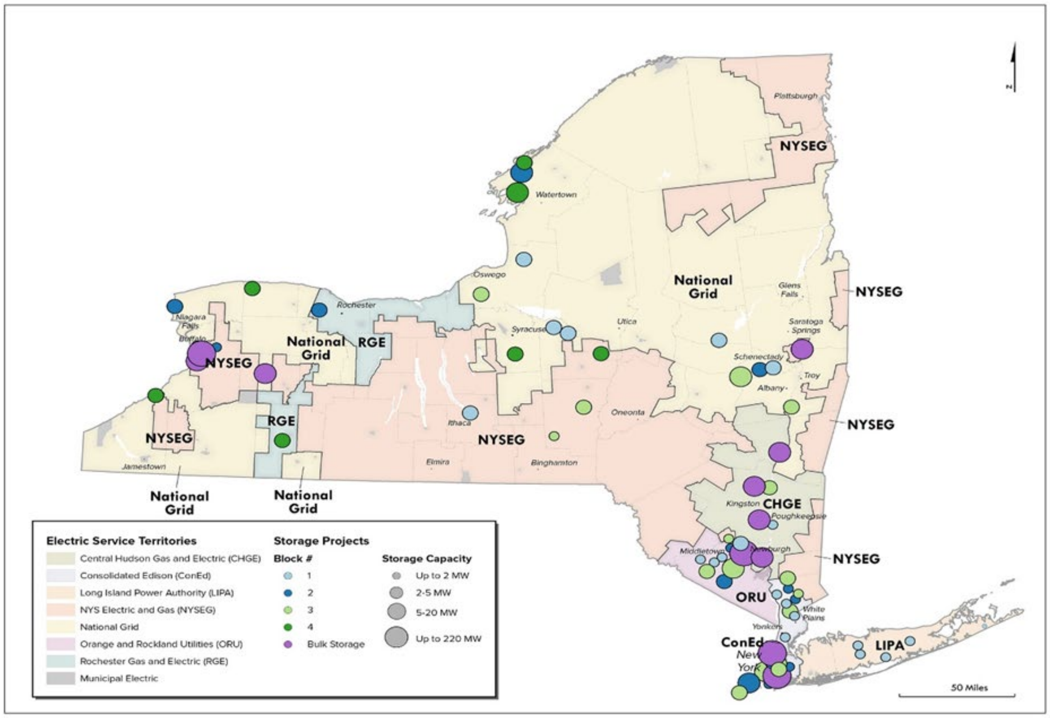
Energy Storage Deployed, Contracted and Awarded (MW)		
NYSERDA Bridge Incentive Program		811
Of which: Bulk	480	
Commercial Retail	320	
Long Island Residential	11	
Utility Bulk Storage Dispatch Rights Procurement		120
Renewable Energy Standard		240
NYPA North Country Project		20
Utility Demonstration and NWA Projects		56
Other Projects		54
TOTAL		**1,301**
% of 2025 Goal		**87%**
% of 2030 Goal		**43%**

Source: NYSERDA and DPS Staff

Approximately 811 MW have been approved for funding under NYSERDA's Market Acceleration Bridge Incentive (Bridge Incentive) program, as authorized in the Energy Storage Order.[4] The Bridge Incentive offers financial incentives to install energy storage systems for three categories of projects: (1) bulk energy storage projects larger than 5 MW providing wholesale services, listed as "Bulk" in Table 1; (2) commercial retail energy storage systems up to 5 MW, listed as "Commercial Retail" in Table 1; and (3) single-family residential energy storage systems installed with solar PV on Long Island, listed as "Long Island" in Table 1. The locations of both Bulk and Commercial Retail projects awarded NYSERDA incentives under its Bridge Incentive program are illustrated in Figure 1 below.

[4] Case 18-E-0130, supra, Energy Storage Order p. 66.

Figure 1. Energy Storage Projects Receiving Bridge Incentives



Source: NYSERDA

Of the 811 MW of projects receiving awards under the NYSERDA program, approximately 480 MW is interconnected on the bulk power system and operating within the wholesale energy markets, 11 MW is located on Long Island within the LIPA service territory, and the rest is dispersed throughout investor-owned utility (IOU) service territories within the state. The remainder of the approximately 1.3 GW of projects include: 120 MW procured under utility bulk dispatch rights request for proposals (RFP); 260 MW procured by NYSERDA under the Renewable Energy Standard (RES); 20 MW from NYPA's North Country Energy Storage project; 56 MW through utility demonstration projects and "Non-Wires Alternatives" (NWAs), as directed by the Commission under the Reforming the Energy Vision (REV) initiative; and 54 MW of other energy storage projects.

Approximately 12.3 GW of proposed energy storage projects are presently in either distribution-level or wholesale-level interconnection queues in New York. Con Edison has 676 MW of energy storage projects in its interconnection queue, LIPA has 222 MW of projects in its interconnection queue, and an additional 691 MW are in interconnection queues administered by the other IOUs throughout the State. Over 11GW of projects are presently in the NYISO queue. These interconnection queues reflect projects in the pipeline that are being considered but have not yet been built, and the vast majority are not expected to proceed to completion without further economic support.

2.2 Storage Program Outcomes

2.2.1 Market Acceleration Bridge Incentive

As described above, NYSERDA's Market Acceleration Bridge Incentive program has enabled the procurement of 811 MW of energy storage capacity across New York in the form of bulk, commercial retail, and residential storage projects. Although initial procured capacity reached even higher levels, difficulties arising from COVID-19 pandemic delays, interconnection issues, increased material costs and supply chain constraints have led to the cancellation of over 120 MW of projects.

Bulk Storage Incentive Program

NYSERDA's Bulk Storage Incentive Program was designed to procure projects over 5 MW in size that would provide wholesale services to the NYISO-managed energy markets. The program provided a fixed, up-front incentive rate in dollars per kilowatt-hour (kWh) of energy capacity, which declined over time. Projects meeting eligibility requirements could apply for funding and received a contract from NYSERDA for a fixed amount to be paid out in four equal payments, including one at project completion and three at the first three anniversaries of project completion. While the program initially procured 580 MW and 1,654 MWh of energy storage, cancellations have brought these numbers down to 480 MW and 1,314 MWh. Overall, the Bulk program has awarded $113 million in Market Acceleration funding to 12 projects. The contracted projects are expected to be completed before the end of 2025. These projects are listed below in Table 2.

Table 2. Bulk Storage Incentive Program Awarded Projects

Project	MW	MWH	Town	County	Utility	Zone
Levy Grid	152.5	300	West Seneca	Erie	National Grid	A
KCE NY 2	150	300	Montgomery	Orange	Central Hudson	G
North Catskill DG	20	120	Catskill	Greene	Central Hudson	G
Union Avenue DG	20	120	New Windsor	Orange	Central Hudson	G
Highland DG	20	120	Lloyd	Ulster	Central Hudson	G
Lincoln Park DG	20	80	Ulster	Ulster	Central Hudson	G
KCE NY 6	20	80	Blasdell	Erie	National Grid	A
Orangeville Storage	20	28	Orangeville	Wyoming	NYSEG	A
KCE NY1	20	16.5	Stillwater	Saratoga	NYSEG	F
Cleancar Energy Storage	15	60	Brooklyn	Kings	Con Edison	J
Groundvault Storage	12.5	50	Brooklyn	Kings	Con Edison	J
Stillwell Energy Storage	10	40	Brooklyn	Kings	Con Edison	J
Total	480	1,315				

While the Bulk Program was successful, project attrition has highlighted that this type of fixed, up-front contracting mechanism is limited in its ability to respond to dynamic market and supply chain issues, resulting in project attrition through cancellations. Section 5 in this 2022 Roadmap has identified other contracting mechanisms that DPS Staff and NYSERDA believe are better able to manage such challenges for bulk storage projects by providing long-term revenue certainty.

Retail Storage Incentive Program

The Retail Storage Incentive Program was administered by NYSERDA to procure distribution-connected projects up to 5 MW in capacity. The program was designed as a declining incentive block structure, similar to the NY-Sun program, with separate blocks for unique regions in New York, including blocks for New York City, Westchester, Long Island, and Rest-of-State. Overall, the program deployed $193 million and procured 320 MW and 1,070 MWh of storage across New York, with a regional breakdown as follows:

- New York City: 112.2 MW/410 MWh;
- Westchester: 23.5 MW/86 MWh;
- Long Island: 9.1 MW/47 MWh;

- Rest-of-State: 175 MW/527 MWh.

This program resulted in significant growth in distribution-connected project proposals in all utility territories. Increased development has led to increased competition, industry improvements through learning by doing, and increases in total contracted MWs. However, in some instances, particularly at the launch of new funding blocks, backlogs in project demand can lead to “boom-bust” cycles of funding and development. Future programs should consider ways to provide longer-term certainty in funding allotments and block incentive levels. Recommendations for addressing these issues in future programs can be found in the Retail Program Recommendations in Section 6.

Long Island Single-Family Residential Storage Incentive

The Long Island Residential Incentive is noteworthy as NYSERDA’s first-ever residential energy storage incentive program. NYSERDA decided to pilot a residential incentive program in Long Island to drive the adoption of residential storage paired with solar PV as a means to provide clean resiliency benefits for Long Island residents and to leverage PSEG-Long Island’s Dynamic Load Management (DLM) program, which provides a financial incentive to residential storage projects that discharge during utility-defined peaking events.[5] While the NYSERDA incentive reduces the up-front cost of a homeowner purchasing an energy storage system, the DLM tariff provides an ongoing revenue stream if the system is operated in a grid-beneficial manner.

The Long Island Residential Incentive was released in July 2019, sized for 10 MWh with an incentive rate of $250/kWh. A second block of 12 MWh was released in September 2021, with the same incentive rate. To date, the two residential blocks have supported 1,125 installations totaling 25.3 MWh with $5.6 million in awards. As of this report, $1.1 million remains in the block design, sufficient to fund an additional 4.4 MWh of projects.

2.2.2 Renewable Energy Standard

As part of NYSERDA’s annual solicitations under the Renewable Energy Standard (RES), energy storage projects may be paired with large-scale renewable generators to increase their operational flexibility and potentially increase the competitiveness of the project in the proposal evaluation process. Through the first five solicitations, the program awarded 240 MW of energy storage. Over 90% of the awarded projects pair storage with solar facilities, either at the same point of interconnection or at a different site under common control, and projects can provide facilities with several benefits, including curtailment reduction, ability to access otherwise clipped DC solar energy, and energy shifting, among others.

As a result of the Power Grid Study, the Commission authorized NYSERDA to allow future offshore wind proposals submitted to NYSERDA solicitations to be paired with energy storage projects.[6] This option was integrated into the 2022 NYSERDA offshore wind solicitation via an approach consistent with RES Tier 1 procurements, whereby proposals submitted with energy storage facilities located in NYISO Zones J and K (New York City and Long Island) are afforded scoring credit during bid evaluation.

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[5] LIPA’s Dynamic Load Management tariff: https://www.psegliny.com/businessandcontractorservices/businessandcommercialsavings/-/media/F9B52424E0FF48FBBD8AC4E336EDBE24.ashx. This program allows storage resources to receive revenue by participating in load reduction events.

[6] Case 18-E-0071, Order on Power Grid Study Recommendations (issued January 20, 2022), p. 27.

While the Tier 1 program has been successful, and the potential integration of energy storage projects into offshore wind proposals will be assessed following the results of the 2022 NYSERDA offshore wind solicitation, industry stakeholders have raised concerns that REC contracts are not binding with regard to storage project construction; specifically, that the renewable generation project can choose to cancel its storage component after being awarded a REC contract, at which point its REC compensation level would be reduced to the non-storage bid variant from the project's original proposal. This leaves storage project developers in a tenuous position when partnering with renewable projects and could lead to high levels of storage attrition in this program. It is too early to conclude whether these concerns will materialize to a significant extent. DPS Staff and NYSERDA will continue to monitor these dynamics and consider changes to future RES solicitations as appropriate.

2.2.3 Utility Bulk Storage Dispatch Rights RFP

The 2018 Energy Storage Order directed New York's electric investor-owned utilities to conduct procurements to obtain the dispatch rights for energy storage resources. The contracted resources would then provide both distribution system and/or bulk system services while providing the NYISO and the utilities with valuable experience in their operation and expected performance. Each utility was required to procure a minimum of 10 MW of energy storage resources, except for Con Edison, which was required to procure a minimum of 300 MW, provided that the cost of the contracted megawatts was less than the utility-specific bid ceiling. The utility-specific bid ceiling was calculated by each utility as the benefits assumed for each project. These benefits included projected wholesale market revenues for the resource and distribution system benefits over the life of the seven-year contract. The procurements were held in 2019 with the requirement that the resources be operational by December 31, 2022. NYSERDA's Bridge Incentive could provide partial funding at or below the then-applicable incentive rate for bulk-level projects if necessary. In response to a petition by the Joint Utilities, the Commission extended the required in-service dates for projects from December 31, 2022, to December 31, 2025.[7] The Commission also approved a 10-year contract duration to enable longer revenue certainty for prospective projects while decreasing annual costs for New York consumers.[8] LIPA also issued a bulk energy storage solicitation in 2021 for 175 MW.

The utility procurements that were held in 2019 were finalized with the winning projects' selection and contracting in 2020. National Grid selected a 20 MW/40 MWh project to assist with reliability in the northern section of their service territory. The largest winning project was a 100 MW/400 MWh battery storage project developed by 174 Power Global to be located on the land of the former Poletti Power Plant in Con Edison's service territory. This project would primarily be utilized to provide wholesale market services including energy, capacity, and ancillary services. The project received approval from the Commission in July 2021. A second utility procurement was held at the beginning of 2022. The results of this second utility procurement are still pending. Con Edison recently announced it would be conducting a third distribution-connected bulk storage procurement.[9] Con Edison plans to release this RFP in Q4 2022. Consideration of future opportunities for Bulk Dispatch Rights contracts are discussed in Section 5 and are a focus of one of the open questions in Section 5.6.

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[7] Case 18-E-0130, supra, Order Directing Modifications to Energy Storage Solicitations (issued April 16, 2021), p. 8.
[8] Case 18-E-0130, supra, Order Directing Modifications to Energy Storage Solicitations (issued April 16, 2021), p. 9.
[9] See, Con Edison's Bulk Energy Storage Request for Proposals, https://www.coned.com/en/business-partners/business-opportunities/bulk-energy-storage-request-for-proposals

2.2.4 Other Storage Deployments

In addition to the storage projects described above, several other storage projects have been developed across the state and are listed below.

- NYPA's 20 MW North Country Energy Storage Project;
- 56 MW of IOU energy storage demonstration and NWA projects, as directed by the REV initiative;
- 56 MW of projects deployed without state funding.

2.2.5 New York Green Bank

In his 2018 State of the State address, Governor Andrew Cuomo directed NY Green Bank (NYGB) to invest at least $200 million in energy storage financing to support the state's energy storage deployment targets. As of October 2022, NYGB had committed $48 million to support energy storage projects throughout the state.[10] With a robust pipeline of standalone and paired energy storage projects, between bulk and retail projects, NYGB continues to diligently evaluate new investment opportunities. With this investment of time and resources, NYGB seeks to accelerate the deployment of energy storage projects and provide a financing framework that may be utilized by private sector investors and lenders.

To date, most energy storage portfolios are financed through project finance loans. Project finance refers to the method of funding in which the lender looks primarily to the revenues generated by a single project, both as the source of repayment and as security for the loan. NYGB has developed a range of credit products to support borrowers looking for financing across various stages of project development and operations. NYGB uses its products to fill gaps between funding sources so that well-designed projects are developed and investors, both equity and debt, can earn reasonable risk-adjusted returns. Figure 2 outlines an indicative set of products which NYGB has used for energy storage projects.

Since the financing needs of borrowers are closely tied to the development status of projects, NYGB segments its energy storage products by phase: development, construction and operations. Each phase presents unique risks and levels of certainty with respect to project value, which impacts the commercial terms offered by NYGB. An operating project selling its services to a creditworthy buyer on a fully contracted basis under a defined tariff will be more easily valued than a development phase project that is planning to sell its services on a merchant basis in an ever-evolving regulatory paradigm.

In its investments, NYGB can be the direct lender in a bilateral loan to a borrower or it can participate alongside one or multiple private lenders within syndicated loans. In either case, NYGB's challenge, consistent with its mission, is to address financing gaps and offer loans that support the optimal capital structure for a borrower. Some of the key commercial terms negotiated during the underwriting process included in either bilateral or syndicated loans are listed below:

a. Use of proceeds
b. Security and guarantees
c. Loan amount /advance rate
d. Debt-to-equity ratio requirements
e. Reserves, including but not limited to: Debt service, O&M, and major equipment replacement
f. Tenor

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[10] New York Green Bank Metrics, Reporting and Evaluation Quarterly Report No. 32. https://greenbank.ny.gov/-/media/Project/Greenbank/Files/NYGB_Quarterly_Report_PSC_Jun_2022_220831.pdf

g. Amortization schedule
h. Interest Rate
i. Minimum and average debt service coverage ratio requirements

Figure 3 outlines indicative guidance that potential borrowers can use to estimate the amount of debt that could be raised against their projects. To date, these products have been successfully deployed to support combined retail solar and energy storage projects providing services through VDER or under utility procurement contracts.

Figure 2. Indicative Products by Project Development Phase

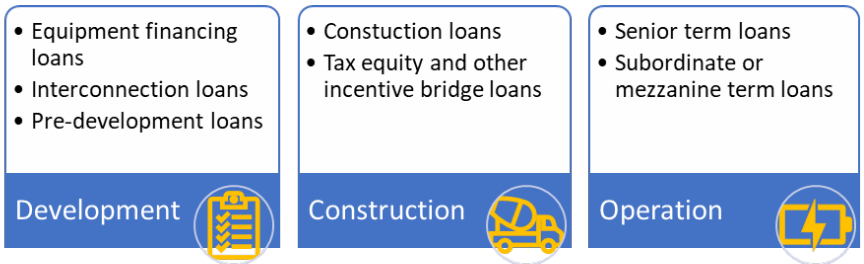
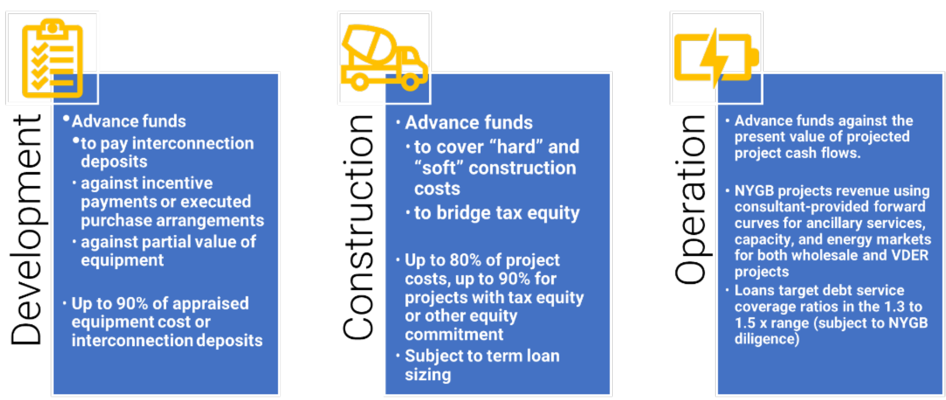


Figure 3. Loan Amount Sizing Considerations



2.3 Storage Use Cases & State of the Market

2.3.1 Wholesale Market Participation

In February 2018, the Federal Energy Regulatory Commission (FERC) released Order 841, which required Independent System Operators (ISOs) and Regional Transmission Owners (RTOs) to file tariff revisions enabling market participation for Energy Storage Resources (ESRs).[11] The NYISO filed updated tariff documents with FERC that enabled ESRs to be dispatched into the energy, capacity, and ancillary services

[11] Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, Order No. 841, 162 FERC ¶ 61,127 (2018)

markets.[12] The NYISO filed further revisions to capacity market accreditation, setting the capacity value for ESRs at 90% for a 4-hour duration resource, dropping to 75% when 1 GW of resources with a duration limitation are operational in the capacity market.[13] These values were planned to be updated as part of a quadrennial examination process, which coincides with the timeline for the NYISO Demand Curve process. However, a new annual process for setting capacity value for ESRs has been initiated through the NYISO's Capacity Accreditation process.

Compensation is ultimately determined based on the combination of the resource's Duration Adjustment Factor (DAF) and its availability during a peak load window, which is meant to represent the hours where there is the greatest reliability need. These peak load windows change from summer to winter to account for the different system conditions and needs throughout the year. For 2022, the six-hour summer peak load window runs from hour beginning 13 (HB13) to HB18, and the winter peak load window runs from HB16 to HB21. The eight-hour summer peak load window runs from HB12 to HB19, and the winter peak load window runs from HB14 to HB21. The NYISO conducts an annual review to determine if these hours are still the most representative of when reliability is most needed. These capacity rules became effective in March 2021 and are scheduled to sunset in 2024 when the new marginal capacity accreditation approach becomes effective.[14]

In 2021, the NYISO filed its co-located storage (CSR) model with FERC.[15] This participation model allows an energy storage resource to pair with an intermittent solar PV or wind resource behind a single point of injection. Each resource will still bid and operate independently under their respective participation models (i.e., the ESR will use the ESR participation model described above). However, the co-located resources can share a single interconnection request. The NYISO concluded in its market design process that co-locating an ESR with a renewable resource would improve the performance and flexibility of those renewable resources, reduce development costs by sharing interconnection facilities, and provide better access to financial incentives. Overall, this participation model helps reduce many barriers to entry for CSRs while also taking advantage of their ability to support renewable generation. The CSR model became effective in December 2021.

Currently, the NYISO and its stakeholders are developing a participation model that expands beyond the co-located storage model.[16] This hybrid storage resource (HSR) model would potentially allow a storage resource to pair with another solar PV, wind, or run-of-river hydro resource and receive a single point identifier (PTID), bid, schedule, and settlement; the paired resources may share an interconnection request as if they were a single resource. As part of this effort, the NYISO is also considering expanding the CSR model to allow pairing of an ESR with landfill gas, run-of-river hydro, and combustion turbines. The NYISO expects to develop the market design and functional requirements for this project by the end

[12] See Docket ER19-467, New York Independent System Operator, Inc.; Compliance Filing and Request for Extension of Time of Effective Date (Filed December 3, 2018).
[13] See Docket ER19-2276, filed June 27, 2019
[14] See Docket ER22-772, Order Accepting Tariff Revisions Subject to Condition, 179 FERC ¶ 61,102 (filed May 10, 2022)
[15] See Docket No.ER21-1001, New York Independent System Operator, Inc., Proposed Tariff Revisions to Implement Co-located Storage Resources (filed January 29, 2021).
[16] NYISO Hybrid Aggregated Storage (HSR) Model – Tariff Modifications, Interconnection, ERIS, CRIS. https://www.nyiso.com/documents/20142/33257202/HSR%20Tariff%20Modifications%20-%20Interconnection,%20CRIS,%20ERIS.pdf/d04f6b82-b701-0ff1-e2c5-3f4c4a6c1e2d

of 2022. If it is selected to go forward in 2023, the goal will be to develop the necessary market software for implementation.

Additionally, in January 2020, FERC accepted a proposal from the NYISO to create rules for distributed energy resources (DERs), which include ESRs, to participate in the wholesale markets as part of an aggregation. This gives more participation opportunities for ESRs and other resources that are sized between 100 kilowatt (kW) and under 20 MW. The DER model has not yet been fully implemented. The NYISO, utilities, and Staff are working together to target implementation by the first quarter of 2023. However, this is intermixed with efforts to implement the aggregation model, described below, and may be delayed pending further development of the aggregation model.

In 2020, FERC released Order 2222, requiring ISOs and RTOs to create rules that allow distributed Energy Resources (DERs) to join aggregations so they can bid into the market as if they were a single resource.[17] The NYISO filed its compliance filing in July 2021 with implementation expected in the coming year.[18] The filing was only partially accepted by FERC in June 2022, so the NYISO will have to make additional revisions before full implementation.[19] This, combined with other resource constraints, moved the expected implementation date for the Aggregation Model out to 2026. In the meantime, the NYISO is working toward developing the above DER model as a transition toward Order 2222 compliance. Longer-term NYISO market rule changes that are likely to impact bulk storage economics and deployment are discussed in Section 4.2.

2.3.2 Value of Distributed Energy Resources (VDER) Compensation

On March 9, 2017, the Commission issued the Order on Net Energy Metering Transition, Phase One of Value of Distributed Energy Resources, and Other Matters (VDER Order).[20] The VDER Order shifted New York's compensation policy for distributed energy resources (DERs) away from net metering and established a new compensation structure for DERs known as the Value of Distributed Energy Resources (VDER), or the Value Stack. The VDER Order applies to a variety of distributed (i.e., 5MW-AC or smaller) technologies, including solar photovoltaics (PV), wind, CHP, fuel cells, and energy storage (both standalone storage and storage paired with other generating technologies such as PV). Mass market energy storage systems (those installed on residential or non-demand commercial accounts) were permitted to receive net metering, but large on-site energy storage systems as well as those used for Community Distributed Generation or Remote Metering would receive Value Stack compensation.

The Value Stack provides monetary crediting, rather than volumetric crediting per Net Energy Metering, with temporal and locational price signals. Value Stack compensation includes several different elements:

A. Energy, based on the NYISO day-ahead hourly marginal price (LBMP) of the NYISO Zone in which the DER project is located.

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[17] Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators, Order No. 2222, 172 FERC ¶ 61,247 (2020)

[18] See Docket ER21-2460, New York Independent System Operator, Inc., Compliance Filing and Request for Flexible Effective Date, (Filed July 19, 2021).

[19] See Docket ER21-2460, Order on Compliance Filing, 179 FERC ¶ 61,198, (Filed July 19, 2022).

[20] Case 15-E-0751, In the Matter of the Value of Distributed Energy Resources, Order on Net Energy Metering Transition, Phase One of Value of Distributed Energy Resources, and Related Matters (VDER Order) (issued March 9, 2017).

B. Capacity (ICAP), calculated based on the NYISO monthly capacity auctions. Three different pricing structures ("Alternatives") are available to other DER technologies.
C. Demand Reduction Value (DRV), where each utility's DRV rate is based on a DER's expected contribution of value to the local distribution system, as calculated in the Marginal Cost of Service (MCOS) studies. DERs receive DRV compensation for each kilowatt-hour exported to the distribution network during a utility-defined set of peak hours.
D. Environmental Value (E Value), available to certain technologies and set as the higher of the Social Cost of Carbon as calculated by DPS Staff, or the latest NYSERDA Tier 1 REC price.
E. Locational System Relief Value (LSRV), similar to the DRV and awarded per kilowatt-hour exported to distribution network during local peaking events. LSRV zones are determined by each distribution utility company and are available for a finite MW capacity per zone.
F. Market Transition Credit (MTC) and Community Credit (CC) were awarded exclusively to CDG projects. The MTC and CC provided additional value stack revenue per each kilowatt-hour exported to the distribution network. At the time of the filing of this Roadmap, each utility has fully exhausted its MTC and CC allocations.

Standalone storage projects are eligible to receive the Energy, Capacity (Alternative 3 only), DRV, and LSRV elements of the Value Stack. Storage projects paired with and charged by an eligible renewable generation technology such as solar PV or wind are eligible for all Value Stack elements. Developers of distributed energy storage projects have typically attempted to maximize revenue from ICAP, DRV, and LSRV by shifting energy into higher-compensated peaking hours. Some projects have also attempted to maximize energy revenue by charging the storage system during low-cost hours and discharging during high-cost hours.

On September 30, 2022, the New York State utilities filed proposed tariffs as part of FERC Order 2222 implementation.[21] These filings would enable a storage resource to operate as both a wholesale market resource and a distribution resource by avoiding double counting of revenues and services between VDER and wholesale markets. The proposed tariffs enable standalone storage to select only the DRV component of the Value Stack and participate directly in the energy, capacity, and ancillary services markets at the NYISO.

2.3.3 Inflation Reduction Act Implications

On August 16, 2022, President Biden signed the Inflation Reduction Act of 2022 (IRA) into law. The IRA includes a range of incentives aimed at accelerating the deployment of emissions-free electricity including modification of a tax credit important to energy storage, as outlined below.

- The IRA modifies the long-standing investment tax credit (ITC) to include both residential and commercial standalone storage; previously, the ITC was only available to storage projects that were paired with solar. The standalone storage ITC is available for systems placed in service on or after January 1, 2023.

[21] Case 22-E-0549, In the Matter of the Federal Energy Regulatory Commission Order Nos. 2222 and 841, to Modify Rules Related to Distributed Energy Resources. [22] Projects that begin construction on or before the date that is 60 days after the Treasury Department issues guidance on these requirements are eligible for a 30% ITC without having to comply with the Prevailing Wage and Apprenticeship requirements. On November 30, 2022, Treasury issued such guidance, and accordingly the 60-day period begins January 29, 2023.

- For residential storage systems with capacity of at least 3 kWh and commercial storage systems with a capacity equal to or greater than 5 kWh and less than 1 MW-AC, the ITC is equal to 30% of the cost of installed equipment, with a higher credit amount available in certain circumstances.
- For commercial systems with capacity of 1 MW-AC and greater, the IRA provides an initial "base" ITC of 6%, with a 24% "bonus" adder, equaling a total ITC rate of 30%, if the project complies with certain Prevailing Wage and Apprenticeship requirements. NYSERDA and DPS expect most, if not all, commercial storage projects placed in service starting in 2023 to comply with these requirements in order to qualify for the higher ITC rate.[22] Like the residential storage systems or smaller commercial systems, the 30% ITC is increased in certain circumstances.
- Projects can qualify for a credit amount greater than 30% if the project: (i) meets specified domestic content requirements; (ii) is located in an "energy community" (as defined in the IRA, these include brownfield sites, communities affected by coal mine and/or coal plant closures and areas that have a minimum level of fossil fuel industry activity and an unemployment rate at or above the national average); or (iii) receives an allocation as a storage system installed in connection with small solar or wind projects sited in, or delivering benefits to, low-income communities or Indian land. Detailed guidance on how to qualify for credit amounts greater than 30% will be released by the Department of Treasury in the upcoming months.
- In addition to the cost of the storage system, the cost of interconnection upgrades can now be included to calculate the ITC, provided the project's net output is not greater than 5 MW-AC.
- The value of the ITC will begin to phase-down the second calendar year following the later of either (i) the calendar year in which greenhouse gas (GHG) emissions from US electricity production are equal to or less than 25% of the annual GHG emissions from US electricity production for calendar year 2022, or (ii) 2032.
- Beginning on January 1, 2023, certain tax-exempt entities, such as state or local governments or charities, may elect to receive direct payment from the federal government in lieu of a reduction in tax liability through the application of their ITC ("direct pay").
- Beginning on January 1, 2023, certain entities, such as for-profit businesses, may elect to sell their ITC to an unrelated taxpayer ("tax transferability").

Overall, the enactment of the IRA – specifically, its extension and modification of the ITC as it relates to standalone storage – is anticipated to have a transformative effect on the deployment of energy storage by significantly improving the economics of standalone storage projects, helping to mitigate equipment and installed cost increases witnessed in 2021 and 2022, and expanding the siting and benefits of storage to disadvantaged and low-income communities. Given additional interpretive guidance from the Treasury Department is expected, NYSERDA and DPS Staff recommend that programs proposed in this Roadmap maintain flexibility to ensure that the maximum value of the ITC can be realized.

2.3.4 Storage as Transmission/Non-Wires Alternative (NWA)

Transmission upgrades may be necessary to ensure delivery of clean energy across New York's electric grid. However, transmission development is expensive, often challenging to permit, and takes place over

[22] Projects that begin construction on or before the date that is 60 days after the Treasury Department issues guidance on these requirements are eligible for a 30% ITC without having to comply with the Prevailing Wage and Apprenticeship requirements. On November 30, 2022, Treasury issued such guidance, and accordingly the 60-day period begins January 29, 2023.

lengthy time frames. Utilizing storage as transmission provides an alternative for providing transmission services on a shorter timescale and potentially at lower cost. Alternatively, storage may be used on existing systems to improve efficiency of operations, such as by enabling increased power flows on the transmission network or reducing curtailments of renewable energy.

The unique characteristics of energy storage, when integrated in transmission development, may unlock many services to utilities and grid operators. During normal operation, storage often has positive impacts on transmission systems by relieving peak demand through injections and reducing congestion through off-peak charging to bring power where it will be needed later. In some instances, storage used exclusively as a transmission asset could provide a faster and more cost-effective option for providing the same or similar services as traditional alternatives, while providing valuable optionality to scale or augment project size or operations in the future.

Some specific examples of transmission services that storage can provide include:

a. Contingency support to increase transmission transfer capacity (both thermal and voltage);
b. Congestion management to reduce curtailment and increase deliverability; and
c. Stability services, such as inertia and blackstart, as synchronous generators retire.

These services are not currently procured in wholesale or retail markets but are provided by traditional transmission assets and recovered through electricity rates. Moving forward, there are at least two ways to incorporate storage into transmission systems.

1) Storage could be included as a transmission solution within NYISO transmission planning processes, including the Public Policy Transmission Planning Process. At present, storage projects are not allowed to proceed under the NYISO processes, although the NYISO has agreed to proceed with an Issue Discovery project for storage as transmission in 2023.
2) Storage could be integrated in utilities' local transmission planning, such as the ongoing Phase 2 transmission planning process.[23] Storage is expected to be evaluated as a potential piece of Phase 2 projects, specifically as an advanced technology for grid services, and has the potential to provide significant value to ratepayers.

Importantly, storage should be considered not only as a complement to traditional transmission solutions, but as a component of a broader solution set.

2.3.5 Potential for Storage to Replace Existing Peaker Plants

Currently, there are approximately 4,500 MW of active fossil-fired simple cycle combustion turbines (SCCTs) across New York; these SCCTs are almost entirely concentrated in New York City, Long Island, and the Lower Hudson Valley. Many of these turbines have low utilization (generating electricity less than 5-10% of the year), are approaching an average age of 50 years and are generally used for meeting periods of high electric demand or for reliability purposes, providing operating reserves. These units, referred to as "peakers", generally provide capacity to meet NYISO locational and system capacity requirements, operating reserves, and other local (i.e., utility-level) reliability services such as voltage support and system restoration. Many of these peakers are dual-fuel and may be required to burn oil or kerosene in

[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.

the winter due to reliability rules and/or fuel constraint concerns to relieve demand on the natural gas system.

Increased integration of intermittent renewable generation calls for increased levels of integration solutions such as energy storage to minimize curtailment and ensure that clean generation meets periods of peak electric demand. Energy storage will allow New York to meet its peak power needs without solely relying on the oldest and dirtiest peak-generating plants, many of which mainly lay idle and are approaching the end of their useful lives.

Furthermore, siting and operations of fossil-fueled peaking facilities present a significant burden to impacted communities, particularly local health impacts due to air pollution. To reduce local health impacts of these facilities, in 2019, DEC promulgated rules to establish allowable NO_x limits for SCCTs.[24] A significant number of the dirtiest peaking units are expected to retire due to the new constraints; however, some of these units may stay online if there is not sufficient capacity to provide necessary grid services. Additionally, over 1 GW of peaker capacity is expected to remain on the system even after the new NO_x rules become binding. To ensure this capacity is able to retire on schedule and remaining capacity can transition to clean resources, new capacity should be deployed in highly space-constrained areas in downstate New York. These constraints highlight storage as the primary option for replacing peaking facilities due to the space-efficiency of many storage technologies. With the anticipated interconnection of offshore wind (OSW) resources in the highly constrained areas, storage could also facilitate integration of OSW power into the bulk power system.

Augmenting the significant health and market value of using storage to replace peaking facilities, the Inflation Reduction Act provides an additional 10% adder to the Storage Investment Tax Credit for projects located in “energy communities,” which often are locations where fossil-fuel facilities are sited. All of these benefits make storage a high-value resource, particularly in the 2030 timeframe, in order to ensure OSW deliverability and peaker retirements without reliability concerns.

2.3.6 Land Use

Local zoning and permitting are important pieces in the development of any storage project. NYSERDA’s Clean Energy Siting Team provides resources and services to both developers and local governments to educate involved parties on a comprehensive set of topics related to storage project siting and operations.

2.3.7 Vehicle-to-Grid and Potential Future Use Cases

The transition to electrified transportation over the course of the next decade will result in a significant increase in electric demand. The anticipated magnitude of this new load makes it imperative to manage the impact to supply infrastructure, including generation, transmission and distribution systems. However, some electric vehicles and charging stations also have the capability to inject power from the vehicle battery back into the grid, potentially becoming an important supply resource during situations when the electric grid is placed under stress.

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[24] Chapter III: Air Resource, Part 227: Stationary Combustion Installations, Subpart 227-3: Ozone Season Oxides of Nitrogen (NOx) Emission Limits for Simple Cycle and Regenerative Combustion Turbines. https://govt.westlaw.com/nycrr/Browse/Home/NewYork/NewYorkCodesRulesandRegulations?guid=I9e8759705fd311eaa71dc9fbe3ec8164&originationContext=documenttoc&transitionType=Default&contextData=(sc.Default)

In simple terms, the value proposition of explicitly pursuing vehicle-to-grid (V2G) and other options for electric vehicles to inject power into the electricity system, such as into homes and businesses, is based on the sheer quantity of assets potentially available to provide services. For example, if there are two million EVs on the road in New York by 2030, at an average battery capacity of 65 kWh and charge/discharge capability of 7 kW each, the amount of electricity stored in the vehicles would be equivalent to 14 GW and 130 GWh of energy, over twice the capacity and four times the energy of all stationary storage that could be built under a 6 GW target. Even with conservative assumptions of the availability of this new potential resource, for example 1%, V2G could provide hundreds of megawatts and thousands of megawatt-hours of energy to the grid in times of need.

Capitalizing on the capacity in electric vehicles is a matter of timing and logistics optimization that will require pre-planning of electric rates, incentives, and EV and charging technology. Certain customers, such as EV fleet owners, may provide an easy target for testing EV injection capability due to the predictable driving patterns and regular charging intervals. Personal EVs may provide less predictability in their availability for injection, but due to the size of this portion of the market, it will be important to design participation models that capitalize on the benefits the resources can provide.

Since energy injections to the grid are not the primary use of the batteries within EVs, and due to the uncertain nature of participation by EV owners, the MW/MWh contained within EVs will not be automatically counted towards the 3 GW or 6 GW targets. The Clean Transportation program at NYSERDA as well as federal initiatives provide funding for EVs and EV infrastructure. Additionally, New York State has already begun studies and proceedings associated with that program to determine best paths forward for V2G.[25] This Roadmap recommends that further support, programs and rate proposals should continue to be discussed in those proceedings. There may be instances in the future of fleet charging participating in utility programs, NYISO programs, or the VDER tariff, and in those cases, DPS Staff and NYSERDA will consider counting that storage capability towards the total storage capacity in New York. Furthermore, special cases may be designed with regard to future program funding to enable the participation of storage capacity from bidirectional charging stations, such as through an altered payment structure that connects a portion of the incentive rate to performance.

Standalone storage at charging stations can also help manage grid impacts by reducing the cost of electricity used for charging and managing instantaneous impacts to the local grid. This scenario provides significant value to EV charging station owners, EV owners, and the local grid. Storage co-located at charging stations will be counted toward the storage targets and can be used as a way to manage interconnection costs for charging stations.

2.3.8 New York Power Authority

The New York Power Authority (NYPA) is the largest State-owned electric utility in the nation. NYPA is charged with generating and transmitting clean, low-cost power and energy services to commercial, industrial, municipal, and governmental customers, amongst others, across New York. It is expected that NYPA will continue to provide support to energy storage projects as part of their operations. NYPA has been a first mover on several initiatives, while running procurement, providing financing support, and developing strategic projects at NYPA and customer sites across the State. Recently, NYPA has pursued 20

[25] Case Number 18-E-0138, Proceeding on Motion of the Commission Regarding Electric Vehicle Supply Equipment and Infrastructure.

MW of energy storage to support its North Country Operations, while taking steps to address the future of its NYC peaker fleet through a partnership with a number of community and environmental justice groups and the storage industry. NYPA's role in achieving the State's goal could evolve over time, particularly as the Inflation Reduction Act opens new financial support to projects that may develop within NYPA's portfolio.

2.3.9 Long-Duration Storage

NYSERDA's Innovation program has recently supported long-duration storage (LDS) with a total of $33.6 million of funding as part of the Renewable Optimization and Energy Storage Innovation Program. The first tranche of this funding awarded $16.6 million for five projects focused on demonstrating LDS projects that target renewable integration and emissions reductions. A further tranche of $17 million was recently made available as part of a competitive solicitation to procure additional LDS projects targeting cost, performance, siting and renewable integration challenges.

3 Role of Storage Targets

Energy storage has the potential to play a critical role in supporting a deeply decarbonized New York electricity grid, through its ability to integrate large quantities of variable renewable energy and provide reliable capacity to meet growing peak demand. This section first explores these characteristics of storage and its resulting value to the grid, reflecting the latest analysis conducted for this Roadmap (see also Appendix A). This section further examines the more specific rationale for a target of 6 GW of by 2030, based both on the analysis for the Climate Action Council Draft Scoping Plan as well as complementary analysis carried out for this Roadmap.[26] The section concludes by proposing allocations of the 6 GW target across the range of storage sectors.

3.1 Services and Value Provided by Storage

Energy storage can provide significant value to the New York electricity system across multiple services and timescales.

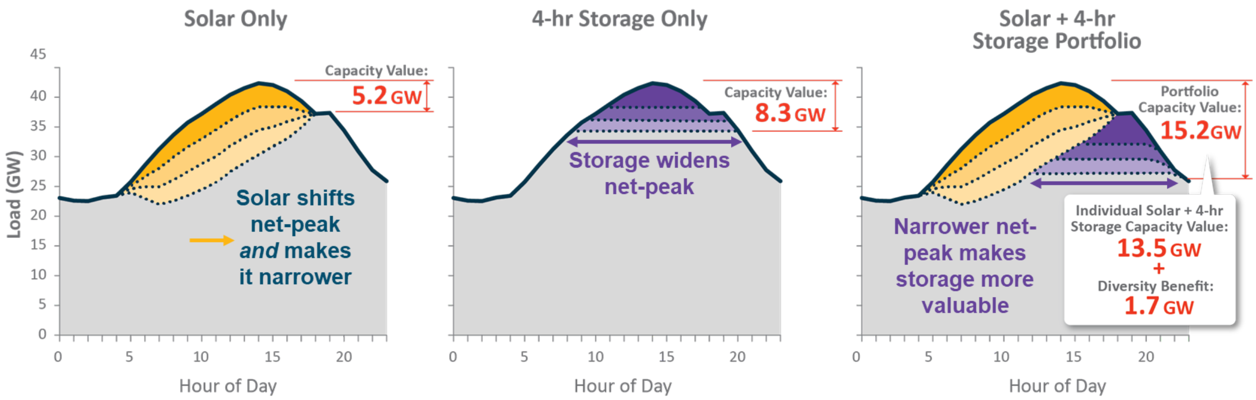
3.1.1 System and Local Reliability

Driven by the electrification of buildings, transportation, and industry, the analysis carried out in support of the Climate Action Council Draft Scoping Plan projects electricity demand to increase rapidly between 2030 and 2050, with New York transitioning to a winter-peaking system by 2035 and peak demand increasing up to approximately 50 GW by 2050. These changes in both the seasonality and magnitude of demand, coupled with the expected retirement of many of New York's aging fossil resources, will place pressure on the State's ability to add new capacity that can ensure that demand continues to be met reliably. Battery storage can provide significant reliability contributions as a standalone resource, and when coupled with renewable energy can also enhance the overall reliability of the portfolio.

Solar, for example, provides energy for charging storage. Solar also enhances the capacity value of storage by narrowing the window in each day during which capacity shortfalls may occur. This makes it easier for limited-duration resources to meet the shortfall as illustrated in Figure 4 below. In this example, solar alone achieves a capacity value of 5.2 GW, while storage alone achieves a capacity value of 8.3 GW. However, the capacity value of solar and storage together is 15.2 GW, 1.7 GW higher than the sum of the solar and storage values. This means that adding solar and storage together yields a "diversity benefit" of 1.7 GW. It will be important for resource adequacy planning to incorporate these benefits into any evaluation of the capacity value of storage resources.

[26] Climate Action Council Draft Scoping Plan, Technical Appendix. https://climate.ny.gov/-/media/Project/Climate/Files/Draft-Scoping-Plan-Appendix-G-Integration-Analysis-Technical-Supplement.pdf

Figure 4. Illustrative Diversity Benefit with Solar and Storage[27]



In the near term, energy storage can play a key role in meeting peak demand, especially in constrained local areas such as New York City and Long Island, where reliability needs are currently met by aging fossil resources. NYISO has recently identified narrowing reserve margins and determined that accelerating the build-out of battery storage could help bolster system and local reliability and reduce near-term risks.[28] In the longer term, as the pace and scale of electrification increases, storage should continue to provide valuable contributions to meeting increases in system and local peak demand. Over time, as more storage is added to the system, the marginal contributions of each MW will decline as the net peak becomes longer. As a result, the economics of new storage resources may shift towards longer-duration resources, and analysis performed for this Roadmap suggests a critical role for increased duration resources over time.

To support resource adequacy, energy storage has the potential to provide significant capacity value to the system, which will increase as system peak loads grow. As shown in Appendix A (Figure 27), analysis of the New York system indicates storage resources provide about a quarter of the grid's effective capacity need by 2040, and about 30% in 2050.

3.1.2 Renewable Integration

As more wind and solar generation is added to the New York electricity system, more sophisticated approaches will be required to smooth out volatility, address intermittency, and reduce curtailment. The integration of renewable energy into the electricity system will require balancing on three timescales: (1) sub-hourly and hourly, to manage volatility; (2) intraday, to shift renewable output to times of high demand; and (3) interday, to shift excess renewables across weeks or seasons to ensure reliability during stretches with low renewable output. Short-duration storage can play a critical role in balancing renewables, such as by providing ancillary services and energy shifting capabilities, on the first two timescales, and long-duration storage resources (discussed below) represent a potential solution to help solve interday balancing challenges.

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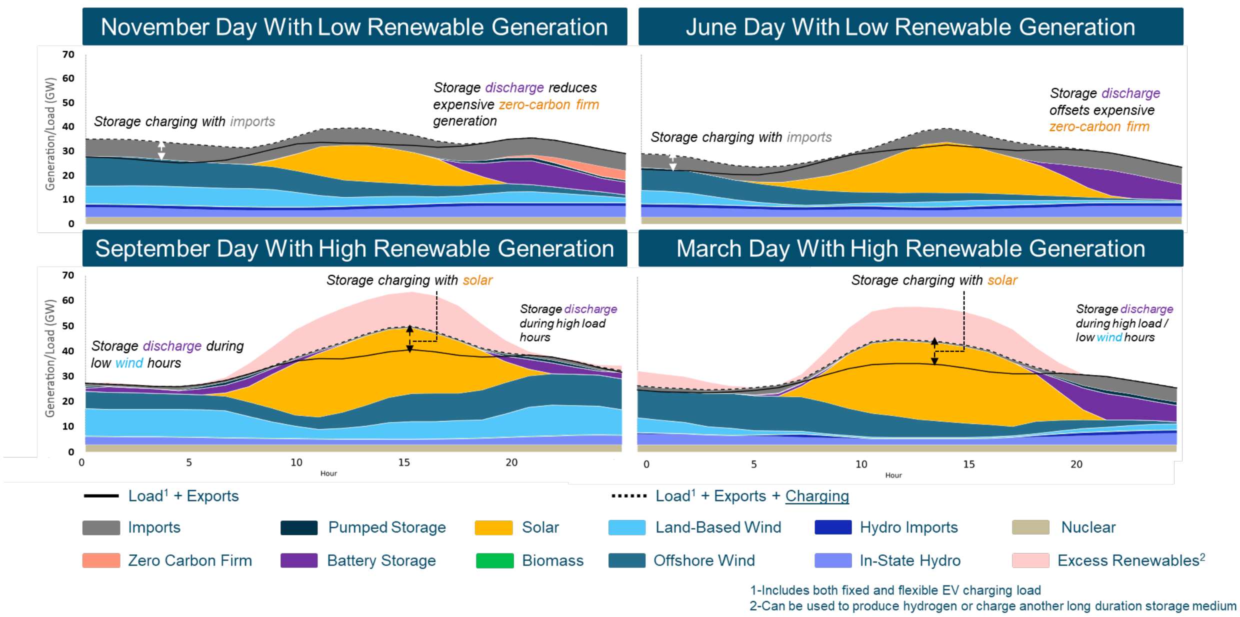
[27] E3, Capacity and Reliability Planning in the Era of Decarbonization: Practical Application of Effective Load Carrying Capability in Resource Adequacy, August 2020. https://www.ethree.com/wp-content/uploads/2020/08/E3-Practical-Application-of-ELCC.pdf

[28] NYISO, 2022 Reliability Needs Assessment, November 2022. https://www.nyiso.com/documents/20142/2248793/2022-RNA-Report.pdf/b21bcb12-d57c-be8c-0392-dd10bb7c6259

Figure 5 illustrates the role of energy storage in shifting generation to meet load, based on Roadmap analysis of the New York electricity system under portfolios consistent with the Climate Act.[29] On days with excess solar, the modeled battery storage system charges from excess solar power concentrated in the middle of the day. Battery storage then helps the system to maintain reliability in events when load is high, and overnight when wind generation is low. Alternately, on low renewable output days, storage can charge from other resources, including imports, and reduce the need for more expensive firm resources.

Figure 5. Energy Value: Storage Dispatch in Modeled Analysis of the New York Electric System in 2040



3.2 From 3 GW to 6 GW Storage Target

New York is on a trajectory to transform its energy system to rely primarily on clean energy, with a mandate to decarbonize its electric grid by 2040 codified in the State's Climate Act.[30] To enable this energy transition, which includes achieving 70% renewable electricity by 2030 and 100% zero-emissions electricity by 2040, the Climate Act provided a directive for the state to build 3 GW of energy storage by 2030. This nation-leading target put New York on a path to double its 1.5 GW by 2025 target over the five subsequent years.

To achieve the goals of the Climate Act, the New York electricity system faces a two-pronged challenge: (i) the generation and transmission system must expand significantly to meet rapidly growing electricity demand as a result of the electrification of the building, transportation, and industrial sectors; and (ii) the system must transform to become powered primarily by variable renewable energy. New wind and solar resources will be foundational to meeting the Climate Act's mandates and are projected to serve a significant share of total electricity demand. The 2021 Integration Analysis, an analysis of pathways that achieve the Climate Act GHG emission limits completed to inform the Climate Action Council's Draft

[29] See Appendix A for details on the analysis.

[30] https://www.nysenate.gov/legislation/bills/2019/S6599 New York State Public Service Law §66-p (2)(b).

Scoping Plan, projected that over 60 GW of solar capacity, between 16-19 GW of offshore wind capacity, and 16-17 GW of land-based wind capacity may be added to the New York electricity system by 2050.[31]

Energy storage can play a critical role in supporting the integration of such large quantities of variable renewable energy, as well as providing reliable capacity to meet growing peak demand. The analysis performed for this Roadmap suggests that about 12 GW of short-duration storage by 2040 and more than 17 GW by 2050 will be core elements of a cost-effective decarbonized electric grid.[32] Compared to current statewide storage deployments of around 130 MW, these projections reflect orders-of-magnitude increases. New York has recognized the need to help the industry scale to such levels, including gaining operating experience with multiple use cases, and building and interconnecting storage resources at a feasible pace. Interim targets such as New York's 2025 target of 1.5 GW and 2030 target of 3 GW play a critical role in providing the glide path towards the levels of storage needed for the longer term; however, maintaining the 3 GW target by 2030 could induce a challenging pace of storage deployments between 2030 and 2040.

Accelerating the pace of storage deployments over the next decade to achieve a 6 GW target by 2030 would place the state on a more sustainable trajectory and would ensure that the resources needed to integrate renewables are online and operational well ahead of potential challenges. The analysis performed for this Roadmap (see Section A.1 in Appendix A) estimates that deployment of 6 GW of storage by 2030 will yield an estimated $1.94 billion (net present value) in net societal benefits to New York, due to increased delivery of renewable energy and reduced reliance on other more expensive firm capacity resources. These benefits reflect the value of avoided electricity system expenditures. Further societal benefits, not quantified here, would include improved air quality in communities impacted by fossil generation.

Furthermore, the analysis highlights the opportunity to leverage federal incentives to build out most of the expected 2040 storage deployments earlier, given that these credits could phase down as early as 2032. This Roadmap analysis finds that nearly all the 12 GW of storage chosen in the modeling is deployed by 2035, to meet system needs and maximize cost-effectiveness by capturing the federal Investment Tax Credit. Figure 6 illustrates these analytical findings, indicating that the projected 2040 quantity of 12 GW could be fully deployed as early as 2035 in order to maximize this opportunity. This context underscores the importance of an increased 2030 target of 6 GW in order to position New York to pursue such an accelerated opportunity.[33]

Based on these considerations, NYSERDA and DPS Staff propose to increase New York's 2030 target for storage from 3 GW to 6 GW. Estimates of the costs associated with reaching this target are provided in Section 8.

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[31] E3 and Abt Associates, New York State Climate Action Council Draft Scoping Plan, Integration Analysis Technical Supplement, December 2021, https://climate.ny.gov/-/media/Project/Climate/Files/Draft-Scoping-Plan-Appendix-G-Integration-Analysis-Technical-Supplement.pdf.
[32] See Appendix A for details.
[33] See Appendix A for further details on the analysis underpinning these findings.

Figure 6. Statewide Battery Storage Capacity Targets and Storage Deployment to Meet System Needs

3.3 Locations and Durations of Expected Storage Value

Storage is expected to provide value to the New York electric grid in each region of the state. The ability of downstate storage to integrate offshore wind, and to help meet local capacity requirements, makes downstate storage builds attractive. In the long run, the larger potential for cheaper land-based wind and solar development upstate and the lower cost of storage construction upstate are expected to drive storage builds in zones A through F. Specifically, analysis conducted for this Roadmap found that approximately 2 GW of the 6 GW of modeled storage buildout by 2030 and 9.6 GW of the buildout of 17.2 GW by 2050 is cost-effectively deployed in zones A-F, reflecting about 55% of total storage being sited upstate by 2050 (see Appendix A for further details on this analysis).

As more short-duration storage is added to New York's power grid, longer durations of storage will be required to discharge across all peak hours, as illustrated by Figure 4 above. In other words, to sustain a high capacity value, storage with progressively increasing duration is needed. The analysis estimates that by 2035, over 4 GW of 8-hour storage will be deployed as part of a cost-effective scenario that optimizes ITC use before expiration. Over 70% of the statewide 8-hour storage will be placed in Zones J and K in the 2030s as fossil-based generators retire. By 2050, the New York electric grid would rely on 6.8 GW of 8-hour storage. Based on these results, a substantial portion of New York State's energy storage resources by mid-century may be longer duration (i.e., more than 4-hour).

3.4 6 GW Target Allocation Across New and Expanded Programs

New York's energy storage procurement will need to bridge the gap between today's commitments of approximately 1.3 GW and the 6 GW by 2030 target. Therefore, at least 4.7 GW of new projects are required to be procured in time for deployment by 2030.

The different market segments that are able to support achievement of the 6 GW target have different interconnection and installation requirements and vary dramatically in terms of time from origination to commissioning. Residential projects can often be constructed within months of initial customer contact, while retail projects often require multiple years to complete interconnection studies, construction and commissioning. Bulk projects often take more time than retail projects, from interconnection request to commissioning, due to the extended interconnection process required of transmission-level resources. These timelines must be considered when designing programs to meet a target for project deployments by 2030.

- For residential programs, the short timelines of project development allow the program to allocate funding across the time horizon to 2030, spreading project deployment across several years.
- Retail projects average over three years from interconnection request to commissioning, which means future retail blocks must be designed to allow awarded storage projects enough time before the end of 2030. This likely means retail projects must be procured before the end of 2027, with procurement spread between program launch and the end of 2027 relatively evenly, or even weighted toward earlier years, to optimize the state's ability to meet its targets.
- Bulk projects require four to six years to proceed through the interconnection process, which significantly compresses the timeline available for future bulk procurements. This timeline requires that bulk projects be procured starting as soon as possible and only as late as the end of 2026. On this timeframe, NYSERDA and DPS Staff expect bulk projects will reach commissioning between 2028 and 2030 under any future program.

As noted, residential storage projects benefit from shorter deployment timelines than bulk storage, sometimes significantly so, which increases the likelihood of reaching the State's near-term deployment goals. Incorporating energy storage into residences can help manage high energy costs, integrate on-site renewable energy, and provide much-needed resilience to consumers. Furthermore, residential systems have the ability to provide additional services to the grid during times of peak demand through tariffs or demand response programs. There is significant demand for residential storage in New York State, with over a thousand installations on Long Island alone. The residential segment can play an important part in providing value to adopters while providing a unique asset to grid operators. However, given the size of the installations – less than 10 kW per project on average – and the installation rates observed in previous programs, the total contribution that residential storage could make to the state's overall 2030 needs is expected to be limited to 200 MW, which would represent at least 20,000 installations over the next seven years.

The retail segment – projects under 5 MW primarily operating under the VDER tariff – has grown significantly throughout the duration of previous funding programs. More than 300 MW of projects have been contracted under NYSERDA's Market Acceleration Bridge Incentive Program, and over 1 GW now exists in the pipeline of the utility interconnection queues. As is the case with residential projects, retail storage development timelines are shorter than those of bulk storage projects. However, even with a likely expansion of interest that may occur with the potential creation of new funding programs, the size of these projects and the overall pipeline opportunity limits the total contribution retail storage can make to the 2030 goals. Given expected rates of deployment and observed growth of the project pipeline, NYSERDA and Staff propose that this segment provide 1.5 GW of new projects by 2030.

The bulk storage segment is expected to deliver the most significant increase in deployment compared to the efforts to date. The bulk segment currently has over 10 GW of energy storage in the pipeline, with additional projects at earlier stages of development. NYSERDA and DPS Staff therefore propose relying on bulk storage for a significant proportion of new projects, with at least 3 GW of bulk storage procured and installed by 2030.

For bulk storage, annual procurements should be undertaken to give certainty in the availability of program support. Given the current timeline, the first projects are unlikely to be contracted before 2024 and will need to be procured by the end of 2026. NYSERDA and DPS Staff therefore recommend that NYSERDA be authorized to procure a total of 3 GW of bulk storage projects over three annual procurements starting in 2024. An average annual procurement volume of 1 GW over this period would strike a balance between "frontloading" procurements to ensure that the 6 GW deployment target is achieved by 2030, versus "backloading" procurements towards leveraging the benefits of battery and equipment price reductions, expected to manifest in the second half of this decade, to minimize program costs and ratepayer burden.

NYSERDA should retain flexibility as to the procurement amount each year to procure the most cost-effective storage projects, as in the Large-Scale Renewables Program, while taking into account uptake levels in other segments, in particular retail and residential.

For retail and residential programs, deployment amounts depend on market demand over time. Table 3 below illustrates the annual procurement amounts consistent with the total target allocation of 3 GW of bulk, 1.5 GW of retail and 200 MW of residential storage. These trajectories for retail and residential storage are representative and may vary depending on the timing of new programs and specific project commissioning dates. Target allocations can be adjusted over time according to deployments in other programs as necessary.

Storage projects awarded and deployed through the Large-Scale Renewable REC Solicitations, Offshore Wind Solicitations, and potentially storage projects procured through other initiatives, such as utility T&D ownership (see Section 2.3.4) or storage procured through the NYISO transmission planning process, could reduce the procurement amounts needed through the bulk, retail, and residential procurement programs in order to reach the 6 GW target. On the other hand, if any procured projects fail to reach deployment ("attrition"), these procurement amounts might be insufficient. Experience has shown that in the retail and residential sectors, attrition is low, and where projects do fail to materialize at expected levels, funds that would have been committed towards such projects may be recycled to procure alternative projects in a timely manner. NYSERDA and DPS Staff recommend that funding from retail and residential cancellations be rolled over to become available to new projects. However, given the long development timelines of bulk projects, the same approach might not lead to replacement projects being realized in time to contribute to the 2030 target. In addition, there is insufficient data available on such dynamics at this stage to allow an appropriate amount of "over-procurement" to account for expected attrition to be determined. Accordingly, NYSERDA and DPS Staff recommend that NYSERDA assess the combined procurement trajectory from the above sectors – including bulk, retail and residential, and other potential initiatives including storage procured through the utilities or the NYISO – after concluding the three bulk procurement solicitations referenced above; if NYSERDA concludes that additional procurement beyond the amounts indicated above is needed in order to reach the target, NYSERDA should then be able to conduct one or more further solicitations accordingly. NYSERDA and DPS Staff recommend that to the extent it is infeasible at that point to deploy the additional procurements in time by 2030, projects with a commercial operation date (COD) after 2030 should be eligible to enable the goal to be reached as soon as possible after 2030.

Studies undertaken through the Comprehensive Grid Planning Process (CGPP), which is currently under development, may help inform the trajectory of storage as transmission, as well as the locations, durations, and technology types sought under the programs recommended above. NYSERDA and DPS Staff recommend that the storage programs stay aligned with the CGPP and maintain flexibility to incorporate the best available information into program requirements.

Table 3. New Program Procurement Schedule

New Program Procurements	2023	2024	2025	2026	2027	2028	2029	2030
Bulk (3,000 MW)	0	1,000	1,000	1,000	0	0	0	0
Retail (1,500 MW)	0	375	375	375	375	0	0	0
Residential (200 MW)	13	27	27	27	27	27	27	27
Annual Total	13	1,402	1,402	1,402	402	27	27	27
Cumulative Total	13	1,415	2,817	4,218	4,620	4,647	4,673	4,700

4 Storage Deployment Barriers

4.1 Supply Chain and Material Costs

The rapid growth of the energy storage and EV industries has been fueled by the technological improvements and price reductions in lithium-ion batteries. Lithium-ion batteries represent an overwhelming majority of all stationary and mobile storage deployments, resulting in both competition between automotive and grid-connected segments and sensitivities across segments to supply chain issues and material price increases.

Since July 2021, prices for lithium carbonate, a key ingredient of lithium-ion batteries, have increased 500%.[34] Among projects awarded NYSERDA incentives, average total installed costs for non-residential, retail projects averaged $567/kWh for installations occurring in 2022 and 2023, up from $464/kWh for installations in 2020 and 2021, an over 20% increase in total costs.[35] This is consistent with recent industry reports that indicate near-term increases in storage costs.[36] Also in 2021, the electric vehicle market more than doubled while global energy storage deployments tripled.[37] Manufacturing and distribution of battery components and battery packs have struggled to keep up with the pace of demand growth. This has led to delays in deliveries, higher costs for storage assets, and in some cases, unmet demand. These factors are likely to impact the ability of storage to be deployed by the market until supplies increase.[38] Furthermore, this combination of factors has kept energy storage from being able to be deployed in the absence of market support mechanisms.

Efforts by the Federal Government, as well as the European Union, seek to expand and diversify supply in the coming decade to address overall supply, supply chain, and material cost issues.[39] However, the impacts of these interventions will take time to manifest and are unlikely to begin easing the cost issues until 2024-2025 at the earliest, with major improvements only expected by the end of the decade and into the 2030s. Given the time required to plan, study, construct, and commission energy storage projects, simply waiting for cost reductions, driven by factors outside New York's control, before beginning new deployments is not an option as the state pursues its decarbonization and renewable integration goals. For example, large-scale bulk storage projects often require five years or more between interconnection request and commissioning. Waiting to procure these resources until price reductions have been achieved near the end of the decade will result in projects coming online in the mid-2030s, beyond the timeline

[34] McKinsey & Company: Lithium mining: How new production technologies could fuel the global EV revolution. https://www.mckinsey.com/industries/metals-and-mining/our-insights/lithium-mining-how-new-production-technologies-could-fuel-the-global-ev-revolution

[35] Case 18-E-0130, supra, Department of Public Service Third Annual State of Storage Report (issued April 1, 2022), p. 8 H

[36] E&E News: Climatewire. Calif. Sprints to install batteries but can't find parts. https://www.eenews.net/articles/calif-sprints-to-install-batteries-but-cant-find-parts/

[37] Wood Mackenzie: Global lithium-ion battery supply and demand update: H1 2022. https://www.woodmac.com/reports/power-markets-global-lithium-ion-battery-supply-and-demand-update-h1-2022-150048235/

[38] Wood Mackenzie: Global energy storage: staggering growth continues – despite bumps in the road. https://www.woodmac.com/news/opinion/global-energy-storage-staggering-growth-continues--despite-bumps-in-the-road/

[39] Energy Storage News: Overcoming the great disconnect in the battery storage supply chain. https://www.energy-storage.news/overcoming-the-great-disconnect-in-the-battery-storage-supply-chain/

required to enable fossil fuel retirements, offshore wind and large-scale renewable integration, and transmission relief.

4.2 Market Rule Changes

The 2018 Roadmap identified cost as a significant barrier to storage deployment. Since then, the cost challenge has been exacerbated by supply chain and materials costs. While the ITC now available under the IRA provides significant support to storage projects, it is insufficient on its own to overcome the remaining cost gap. Furthermore, current wholesale market revenue is insufficient to support energy storage deployment. Ultimately, the gap is expected to be addressed by higher market revenues for storage in a future zero-carbon grid; in the meantime, however, alternate sources of financial support are required to incentivize deployment of energy storage. Current wholesale market revenue inadequacy is a combination of opportunities and markets not yet developed, market pricing not fully representative of system needs, and the fact that market prices are based on current system conditions. Much of the value energy storage will provide will be in high-renewable and tighter supply-demand conditions expected in the future.

Storage As Transmission

While it is challenging to predict what wholesale market products will be needed in the future to maintain reliability and increase system efficiency, current developments and analysis have provided insight into future needs. One area where energy storage is beginning to play a larger role is storage as a transmission only asset (SATOA). Integrating storage into the transmission system can provide many of the benefits that traditional transmission upgrades provide including increasing the amount of power transmitted. Energy storage can inject or absorb power on existing lines to increase the line utilization and efficiency; this can serve as an alternative to upgrades of the existing transmission system, especially in constrained load pockets. Energy storage can also inject and absorb power quickly to help stabilize power flows, rather than forcing the system operator to make other, more costly adjustments to the system. Energy storage as transmission could also be incorporated explicitly into system planning. In the most recent Public Policy solicitation, a proposal that included energy storage was removed from consideration because the NYISO tariff does not include provisions for evaluating or considering storage as transmission.[40] Simply including energy storage as another option for potential system planning solutions can serve to increase efficiency and help minimize costs. The NYISO is currently considering exploring storage as transmission after being broadly supported by market participants, and NYSERDA and DPS Staff recommend that storage deployed as a transmission asset under the NYISO transmission planning processes count toward the 6 GW target.

Energy Markets

While it is unlikely there will be extensive energy market changes in the near future, energy market revenues for energy storage may increase over time. Starting in 2023, and again in 2025, there is likely to be a wave of fossil fuel generator retirements from the implementation of the DEC Peaker Rule. These retirements will make the system supply increasingly tighter and will likely lead to more periods of supply scarcity. This may increase opportunities for energy revenues from available resources. Additional

[40] NYISO: Long Island Offshore Wind Export Public Policy Transmission Need Viability & Sufficiency Assessment. https://www.nyiso.com/documents/20142/22968753/LI-OSW-Export-PPTN-Viability-Sufficiency-Assessment_Report.pdf. This document indicates that the proposed energy storage solution was sufficient to address the transmission need.

retirements of fossil resources are expected as the State progresses towards its 100x40 clean energy mandate. It is also expected that as more renewable resources enter the market, periods of low and/or negative pricing will increase. These pricing occurrences will increase the opportunities for energy storage to charge at negative and/or low prices and inject at higher-priced periods. Other changes recommended to ancillary services markets will manifest in energy pricing as well due to market co-optimization and opportunity costs.

Capacity Markets

Recent and historical capacity market changes have resulted in unpredictable and volatile expected capacity revenues. Recent changes to eliminate buyer-side mitigation for energy storage resources provide certainty that storage resources will be receiving capacity revenues. However, the development of capacity accreditation rules and values continues to be uncertain. As described in Section 3.1, the analysis conducted for this Roadmap suggests that long-duration storage (eight hours or more) continues to maintain a high marginal value over time as penetration increases, while shorter-duration storage values decline more rapidly. However, as more renewable resources enter the market, intermittent resources will likely have a positive impact on the capacity value that energy storage resources provide. In the future, as more intermittent resources enter the system, it will be important to reflect the availability of resources to meet capacity needs in real-time. This value may be reflected in ancillary services such as Operating Reserves, as well as in a resource's capacity value, if properly accounted for in capacity accreditation.

As capacity values are more closely aligned with the Installed Reserve Margin (IRM) process and assumptions, the New York State Reliability Council may need to consider additional changes. For example, there has been recent analysis on the process by which previous load shapes and load forecast uncertainty are scaled to produce load shapes.[41] Scaling both previous load shapes and load forecast uncertainty across all hours equally may lead to unreasonably high and long peak forecasts, which can undervalue limited-duration resources like energy storage. Therefore, corresponding improvements could be made in the IRM process to better reflect expected system conditions and the resulting anticipated resource performance from energy storage.

Ancillary Services

Energy storage resources are well positioned to benefit from new ancillary service products or improvements to ancillary market pricing due to their ability to respond rapidly and their availability on short notice. Potomac Economics, the NYISO Market monitor, has made several recommendations to these markets that likely benefit energy storage resources. Improving both the locational price signals and the pricing associated with Shortage Pricing are imperative. The NYISO has already implemented Operating Reserve requirements for New York City and is currently working on a market design to require Operating Reserves in different load pockets throughout the state. This more geographically granular pricing approach will encourage the development of energy storage in locations that are most valuable.

[41] Astrape Consulting: Valuing Capacity for Resources with Energy Limitations – Independent Assessment. https://www.nyiso.com/documents/20142/5020603/Astrape%20presentation%20021519.pdf

New Market Products

It is also important for the NYISO to continue to work on improved pricing for times when the system needs resources the most. While the capacity market can provide resources with an incentive to be available or else suffer a derate, increasing payments for resources that are available when needed in the energy and ancillary markets is a more desirable approach. This approach will ensure that the resources that provide the highest-value energy to the system receive the highest compensation for doing so. It is also likely that new products will be needed as the grid transforms from baseload, fossil generation to intermittent, renewable generation. For example, the need for a fast-ramping product may increase as the penetration of solar and wind resources increase and the corresponding intermittency increases. A project likely to be prioritized by the NYISO for 2023 aims to examine this issue. The project termed "Balancing Intermittency" states, "[t]he NYISO is actively working on market enhancements to meet these future challenges. A grid characterized by high levels of intermittent renewable resources, Energy Storage Resources (ESR), and Distributed Energy Resources (DER) will require new thinking to adequately balance intermittency on the system and the associated system ramps. The NYISO approaches this work with two guiding principles: (1) all aspects of grid reliability must be maintained; and (2) competitive markets should continue to maximize economic efficiency and minimize the cost of maintaining reliability while supporting the achievement of New York's climate policy codified in the CLCPA."[42] Other potential future market products could include a ramping product, reactive power, synthetic inertia and more granular energy or reserve products.

Altogether, these current or future proposed market projects could play critical roles in providing energy storage resources with the incentives and revenues they need to help New York meet the Climate Act mandates and goals, help maintain grid reliability, and provide symbiotic effects when paired with intermittent renewable resources. NYSERDA and DPS Staff will continue to engage with energy storage stakeholders to identify opportunities for important market rule changes through the NYISO Stakeholder process.

4.3 Financing Barriers to Energy Storage in New York State

As highlighted in other sections of this Roadmap, one of the most critical barriers to energy storage projects relates to the uncertain and insufficient nature of the revenue available through existing markets and tariffs, particularly capacity revenue. Retail or distribution-level projects, participating in certain regions through VDER, provide investors with a more certain revenue stream; however, these projects are still difficult to underwrite given the variable nature of both capacity and energy prices. Further, capacity prices in New York have materially declined in recent years, supporting the narrative that capacity market revenue available to storage projects is not predictable. Incentives are critical to project developers working to deliver standalone VDER storage projects because the market revenue available to be earned is not enough to attract investors, particularly lenders. When new incentives are announced or planned, developers will continue to approach New York as prospectors, locking in land lease options, incentives, and interconnection queue positions, but absent market changes or new funding programs, few projects may move toward construction and operation.

[42] NYISO: 2023 Market Project Candidates. https://www.nyiso.com/documents/20142/31033357/02%20Market%20Project%20Descriptions%20Clean.pdf/a94602d1-84a4-8cdc-e8e7-c9a68c6ad48c

5 Bulk Storage Program Design

This section assesses the range of program options for achieving the target allocation of 3 GW of bulk storage as described in Section 3. While experience with standard offer upfront rebates has been positive for retail and residential programs, this has not proven to be the optimal approach for large-scale project procurement. Significant upheaval in the supply chain and markets for bulk storage has created new pressures on projects given the fixed nature of the initial funding support in previous programs. With a view to action on a wider scale than previous programs to achieve New York's storage targets going forward, it is appropriate at this point to review available procurement options for bulk resources in more detail.

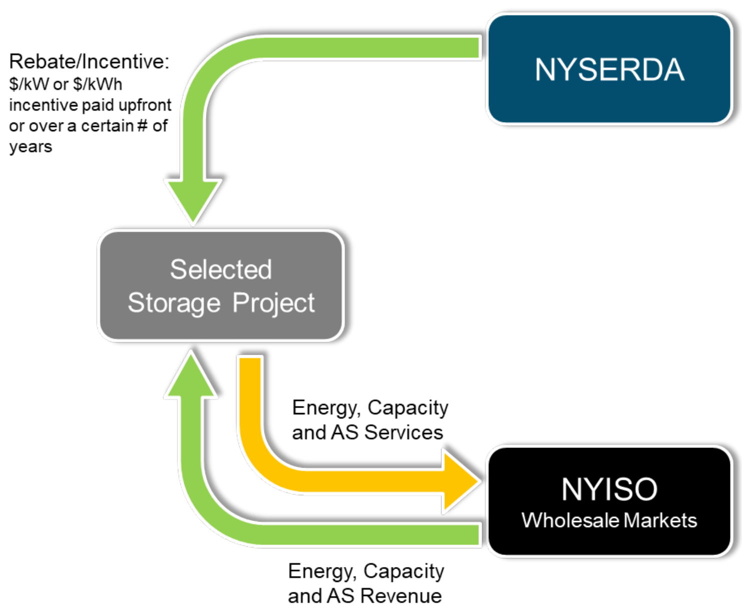
Based on the analysis of the options under consideration, and a review of energy storage procurement mechanisms in other jurisdictions, this section presents recommended procurement strategies for bulk storage, as well as recommendations on a number of design features for the proposed new bulk procurement mechanism.

5.1 Bulk Storage Procurement Structure Options and Assessments

This Roadmap considers the following six options for bulk storage procurement going forward.

1) **Upfront Rebate/Standard Offer Incentive**: Under this approach, support payments are provided in the form of a preset incentive, such as per kW or kWh of installed capacity, for which projects may apply once they have reached acceptable levels of project maturity, among other requirements. Projects meeting funding criteria receive a contract for a fixed dollar amount that is paid out upfront or over a certain number of years. This option would be similar to the approach utilized to date.

Figure 7. Procurement Option 1: Upfront Rebate/Standard Offer Incentive



2) **Index Storage Credit**: This option would be analogous to the "Index REC" approach adopted by the Commission and currently applied in NYSERDA's offshore wind and onshore large-scale renewables procurements, with the goal of unlocking similar benefits that the Index REC provides in those programs. Under this approach, storage project developers would bid a "Strike Price" into a competitive solicitation, which would be evaluated and awarded as discussed further below. Payments to the awarded projects would be made over time, likely linked to the expected operational lifetime of projects and/or the contract tenor bid to NYSERDA. Payments made at predetermined intervals would be determined by comparing the Strike Price to a "Reference Price". The Reference Price would be derived from one or more price indices that represent an approximation of available market commodity revenue that projects could reasonably expect to earn. Projects would not be required to participate in any particular market – the calculation of the Reference Price would be based on indices and would be independent of the project's actual market activity. To the extent the Strike Price exceeds the Reference Price – indicating a shortfall in the amount of available commodity revenue based on market conditions at that time – the difference would constitute the net support payment from NYSERDA to the subject project. Conversely, if at certain times the Reference Price were to exceed the Strike Price, the difference would be paid by the project to NYSERDA or netted from future payments from NYSERDA to the project. These two scenarios are illustrated in Figure 10.

   Similar to the approach taken with regard to large-scale renewable procurements, NYSERDA would select and contract with the storage projects based on pre-determined evaluation criteria including price and non-price factors. The price evaluation would be based on reasonable projections of the expected amounts to be paid to each project, based on subtracting projected Reference Prices from each project's as-bid Strike Price. The non-price factors would likely include project viability and economic and societal benefits to New York.

   Funding for the payments to be made by NYSERDA would likely be provided through bill collections from New York's Load-Serving Entities (LSEs), as is the case with NYSERDA's large-scale renewables and offshore wind Index (O)REC programs (See also Section 8.4 below).

   Market revenue to be captured through the Reference Price could include the range of available storage revenue opportunities, including an energy arbitrage revenue component and a capacity market revenue component. Since the Reference Price would be determined to reflect one or more market revenue indices, as is the case in the offshore wind and large-scale renewables Index (O)REC structures, projects would continue to be at liberty to pursue actual revenues above, or different than, those indicated by the index or indices, maintaining market signals and dynamics that encourage maximization of revenue and system value.

Figure 8. Procurement Option 2: Index Storage Credit

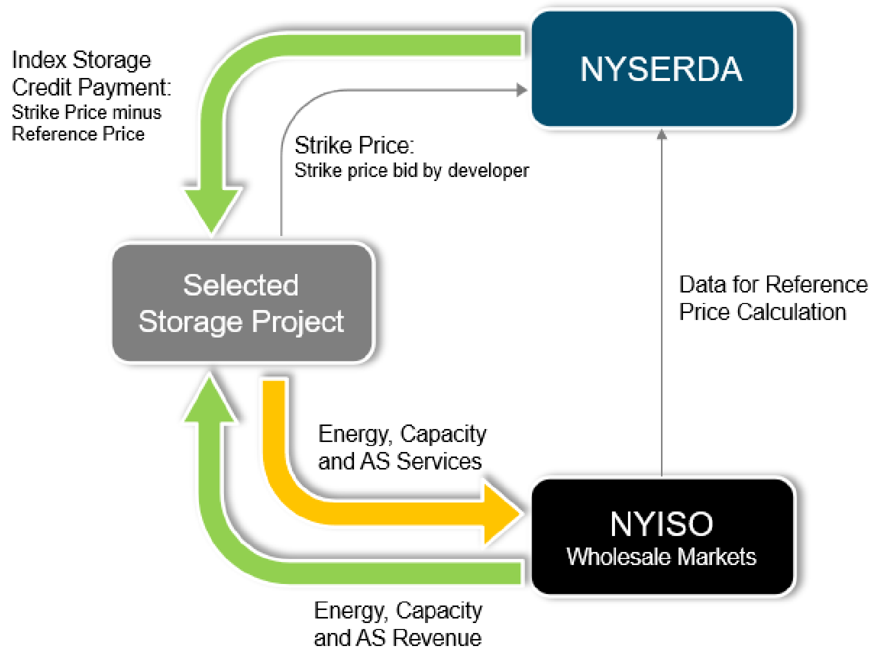
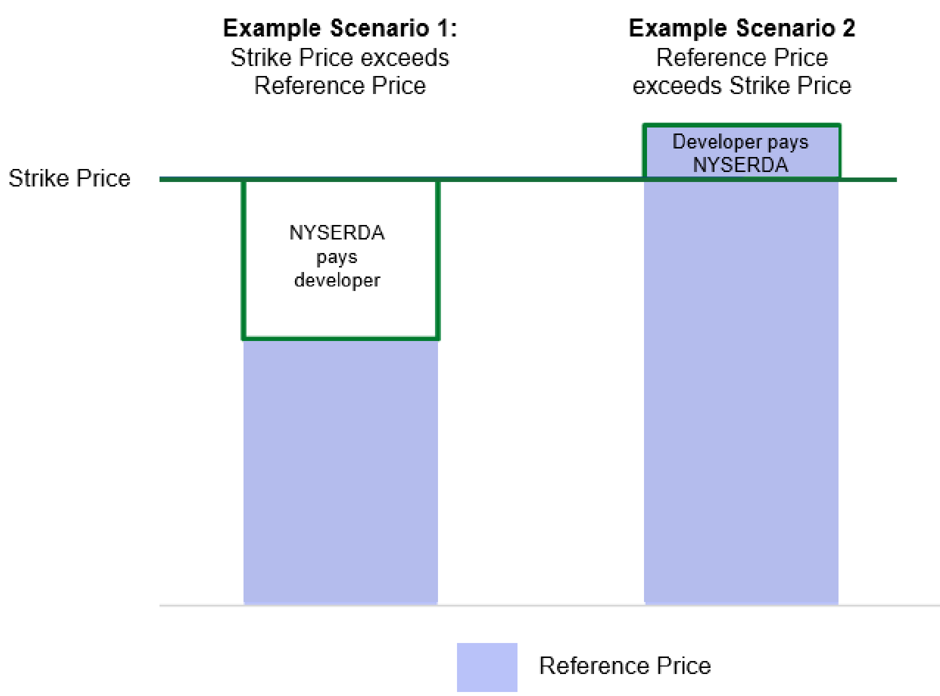
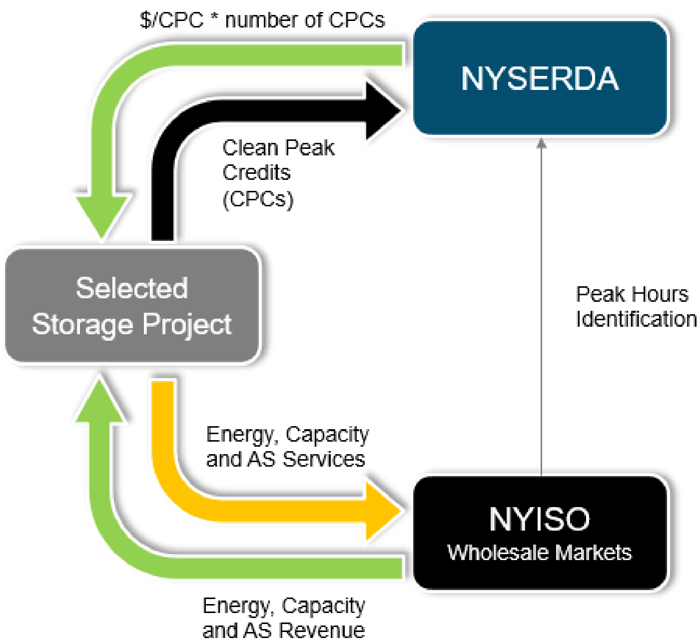


Figure 9. Illustration of ISC Operation



3) **Preset Hourly Revenue Support/ "Clean Peak Credit"**: Under this option, storage projects could receive additional compensation for discharging at certain pre-determined "peak hours". This approach would be similar to the Massachusetts Clean Peak Program, which requires LSEs to serve an increasing proportion of load in such peak hours through zero carbon resources. In order to comply with this obligation, Massachusetts LSEs offer additional compensation to zero carbon resources. [43] As a variation, a fixed level of compensation for eligible resources that meet load during pre-set "peak hours" could be determined within the program design itself.

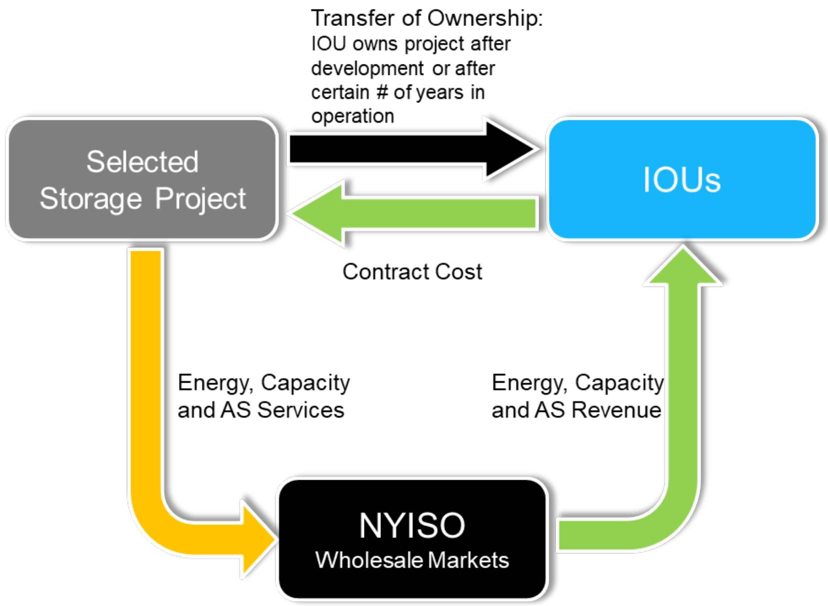
Figure 10. Procurement Option 3: Preset Hourly Revenue Support/"Clean Peak Credit"



4) **Utility Ownership with Traditional Market Participation**: In this option, utilities would seek contracts for market-based projects by means of "Build-Transfer" or "Build-Operate-Transfer" contract options, or full ownership throughout development. The utilities would solicit developers to develop and build storage projects to utility specifications before either transferring the project to the utility to own or operate, or operating the project for a certain number of years before transferring the project to the utility.

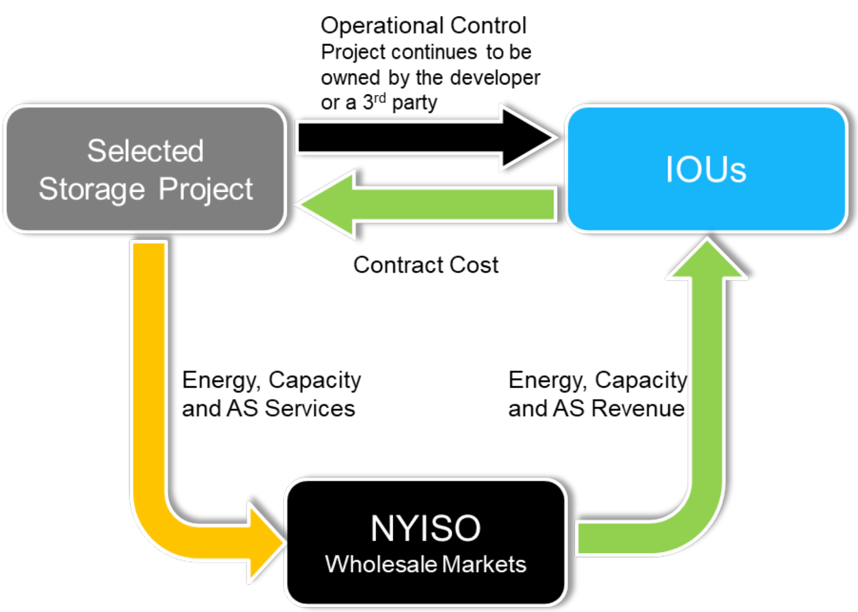
[43] Mass.gov: Clean Peak Energy Standard.
https://www.mass.gov/clean-peak-energy-standard

Figure 11. Procurement Option 4: Utility Ownership with Traditional Market Participation



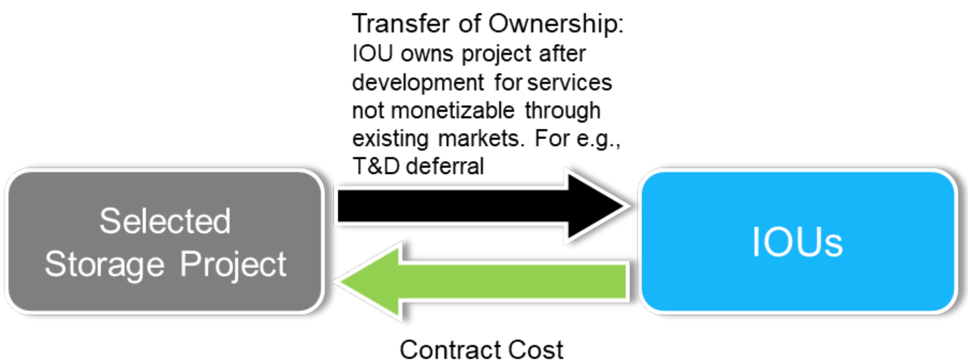
5) **Utility Dispatch Rights Contracts**: This option would continue the existing framework of utilities seeking contracts for operational control, for a certain period of time, of projects that are developed and owned by third parties.

Figure 12. Procurement Option 5: Utility Dispatch Rights Contracts



6) **Utility Ownership for Transmission & Distribution (T&D) Services**: Some use cases and revenue streams are not currently available to energy storage resources through any market, including T&D services (e.g., congestion reduction, deferral, inertia, transmission security support, curtailment reductions, frequency response). Currently the only way for energy storage to provide these services would be through utility operations, enacted through utility ownership or some form of contracted arrangement. This option would enable utilities to study their T&D systems to determine at which locations and for which services storage may represent a more beneficial and/or cost-effective option compared to alternatives. It is worth noting that the total volume of storage that may be deployed through this option is dependent on system needs and may not fully account for the Climate Act goals related to increasing onshore and offshore large-scale renewables integration, and therefore may result in significantly less than 6 GW of deployed energy storage. While this option could be implemented in parallel with other procurement mechanisms, it may be infeasible to rely on this option alone when planning a trajectory to 6 GW of deployment.

Figure 13. Procurement Option 6: Utility Ownership for T&D Services



Consistent with the findings in the offshore wind and large-scale renewable Index (O)REC assessments, procurement structures where support payments would be linked to actual market revenue received by projects (often referred to as “contracts for difference”) are not examined in this Roadmap. [44]

5.2 Assessment Criteria

This Roadmap presents four criteria used to evaluate the benefits and drawbacks related to the six procurement options listed above. These assessment criteria are broadly consistent with those applied in previous assessments of NYSERDA procurement options across a range of programs, including for offshore wind, onshore large-scale renewables, and distributed solar.

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[44] NYSERDA: Offshore Wind Policy Options paper.
https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/Offshore-Wind-Policy-Options-Paper.pdf;
NYSERDA: NYSERDA Comments on the AWEA/ACE-NY Petition Regarding Integration of an Index REC Procurement Structure into Tier 1 REC Procurements Under the Clean Energy Standard.
https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={071DDB6B-A3AA-404C-B931-97284FEC9B6E}

- Implementation Feasibility: The ease and risks of implementation and administration of the procurement option, and the likelihood that the option can drive accomplishment of state goals.
- Development Effectiveness: The extent to which the option meets developer needs for project development, ensures that projects complete construction (minimizing attrition), and maximize their operating lifespan.
- Efficiency: The extent to which policy options are able to drive storage deployment at lower program costs and thus ratepayer impacts than other policy options. In many cases, efficiency directly relates to the extent to which policy options are able to reduce project risks and thus the cost of financing, where lower financing cost translates to lower project bid prices and thus lower ratepayer costs.
- Compatibility and Acceptability: The compatibility of each option with wholesale market dispatch signals and reasonableness of locational signals recognizing prices and transmission constraints. It also evaluates cost uncertainty and risk to which ratepayers may be exposed.

5.3 Bulk Storage Procurement Options Assessment

1) Upfront Rebate/Standard Offer Incentive

- Implementation Feasibility: This option is relatively simple to implement and administer, though where incentive levels are set administratively, it could entail some implementation complexity.
- Development Effectiveness: The fixed price contract in this option does not meet developer needs for long-term revenue certainty, making the opportunity to develop in New York less attractive to developers and potentially increasing program costs compared to other options. Broad variance in bulk project economics means "one-size-fits-all" incentive rates may not be best suited to provide funding needs. There is a high risk of project attrition if market conditions change as contract funding stays the same, resulting in increased risk of not meeting goals.
- Efficiency: While an upfront rebate reduces the upfront cost the project faces, it provides no certainty with respect to future revenue levels. Project revenue will therefore consist exclusively of market revenue streams. This exposes projects to risks and uncertainties that translate to higher project costs, increasing the support levels and thus program cost needed compared to other procurement options considered here that do reduce such risks. As an alternative, an option that provides fixed payments over time, rather than an upfront incentive, provides a guaranteed revenue stream, but this would still leave projects exposed to uncertainty with respect to market revenues and thus could result in higher project costs and, therefore, increased costs to ratepayers than an approach that provides projects with revenue hedging benefits.
- Compatibility and Acceptability: This option is fully compatible with markets, as there are no specific dispatch requirements and would allow the projects to follow market signals and pursue desired revenue streams.

2) Index Storage Credit (ISC)

- Implementation Feasibility: This option builds on recent experience in the Clean Energy Standard (including the Tier 1, Tier 4, and offshore wind programs), though significant effort may still be required to structure solicitations and long-term contracts.

- Development Effectiveness: The long-term certainty and financeability of this option are both supportive of, and supported by developers, as indicated by the findings from NYSERDA's stakeholder survey and engagement process, discussed in Appendix C. For projects that bid responsibly, this approach is likely to ensure that projects enter construction even in the event of changing market conditions. Pursuing this option would thus increase the likelihood of meeting procurement and deployment goals.
- Efficiency: This option provides greater revenue certainty to developers through financial hedging, which lowers project risks and thus project costs. Reduced project cost translates to lower bid prices because a lower level of support payments is needed and therefore ratepayer costs are reduced. Using a competitive solicitation structure would further encourage projects to minimize strike prices and propose non-price benefits to be factored during project evaluation and selection, compared to solely project maturity.
- Compatibility and Acceptability: This option is fully compatible with markets, leaving market signals intact. However, as a corollary to reducing developer risk by providing revenue hedging, if energy/capacity prices were to drop significantly and maintain low levels persistently, the Index Storage Credit would pay higher support amounts to projects; this ratepayer risk is balanced by the fact that ratepayers would experience lower energy and/or capacity prices.[45]

3) Preset Hourly Revenue Support / "Clean Peak Credit"

- Implementation Feasibility: Setting peak hours would be a complex and dynamic process. This option may not be compatible with bulk resources that may have bidding requirements at NYISO which may not align with "Clean Peak" hours.
- Development Effectiveness: Certainty in revenue is provided to eligible resources for the duration of the contract, resulting in low attrition and simple operational signals.
- Efficiency: This option provides revenue certainty and hedging benefits for developers, but there is ratepayer risk, as the operational requirements needed to discharge during peak hours may limit alternate revenue opportunities, thereby increasing costs and uncertainty for project developers.
- Compatibility and Acceptability: This option is not compatible with markets. Market signals are replaced by pre-set constructs that may interfere and/or conflict with NYISO dispatch for bulk resources or distort bidding incentives.

4) Utility Ownership with Traditional Market Participation

- Implementation Feasibility: New York State policy limits utility ownership of these assets except under explicit use cases. If approved, implementation of this option would be relatively straightforward and could be set at the MW storage capacity needed to meet targets, or a portion thereof.
- Development Effectiveness: Low-to-no attrition is expected under this construct. Project maturity requirements and a rigorous evaluation process should be implemented to ensure high-value projects are selected.

[45] Case 15-E-0302, Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard, Order Modifying Tier 1 Renewable Procurements (issued January 16, 2020).

- Efficiency: This option could reduce ratepayer costs due to the low cost of capital for utilities, but other embedded costs and timing issues may offset savings.
- Compatibility and Acceptability: This option is compatible with market signals, but consideration must be given to the impact to merchant projects and utility participation in markets, including the benefits of leveraging the pre-development resources of numerous project developers towards achieving the 6 GW target.

5) Utility Dispatch Rights Contracts

- Implementation Feasibility: Implementation of this option in existing programs has been slow and extended timeframes are required for each new round of contracts. The bid ceiling and funding process would need to be revisited to provide certainty that this option would meet deployment targets.
- Development Effectiveness: Longer contracts are more financeable, but pre-COD risk, operational risk, and end-of-contract project value uncertainty significantly raises costs to developers, and utility needs to cover risks of third-party development and operation. Developers may be hesitant to support this structure due to the difficulties experienced in previous utility procurement rounds, including high cost to participate and extended timelines for the procurement process
- Efficiency: This option does not inherently minimize ratepayer costs as large risk premiums and performance requirements raise prices beyond what would be needed for merchant or utility-owned projects. Longer contracts and less stringent requirements could theoretically lower these costs.
- Compatibility and Acceptability: These projects are fully within the market and compatible with market signals.

6) Utility Ownership for T&D Services

- Implementation Feasibility: For the implementation of this option, time-consuming processes are required, and a review of methods and acceptable use cases is needed before each project could proceed through a cost-recovery framework. Implementation would likely occur as part of multiple T&D upgrade processes that are already underway.
- Development Effectiveness: This option has very low expected attrition. Once a project is identified and approved for T&D services, it is very likely to be built and operated.
- Efficiency: In most cases, projects offset existing higher-cost plans, and therefore provide very high value to ratepayers. This option is also efficient, since projects are being selected to meet clear, pre-defined current and future system needs, for both system reliability and planning for the increasing integration of renewable resources. Past experience has shown that avoiding utility ownership for these use cases has increased costs due to the conditions required by the utility from developers to ensure full-service provision.
- Compatibility and Acceptability: While some storage industry stakeholders are opposed to utility ownership, some of the expressed concerns are mitigated to a large extent under this option by only supporting projects that do not participate in existing markets. While this option completely avoids markets, this is not necessarily seen as a downside to this option, since energy storage is providing many essential services that are not yet recognized by NYISO, while simultaneously offsetting ratepayer costs. This option also does not obviate

implementation of other procurement options, as it can be additive and provides complementary benefits to private sector procurements.

Table 4. Summary of Bulk Storage Procurement Options Assessment

	Implementation Feasibility	Development Effectiveness	Efficiency	Compatibility & Acceptability
Upfront Incentive	++	--	--	++
	Limited implementation challenges, low admin burden	No hedging available, no long-term revenue support	Higher-cost financing/ratepayer costs than alternatives	Retains market signals
Index Storage Credit	+	++	+	+
	Some implementation challenges, but familiar concept	Significant hedging benefits attractive to developers and reduces attrition	Low financing cost due to high (but not perfect) level of hedging	Maintains local value and market signals, ratepayers exposed to upside and downside of commodity prices
Clean Peak Credits	-	++	-	--
	Complexity in setting peak hours and eligible resources	Highly certain revenue, simple operations	Inability to operate based on market signals may drive higher bid prices	Incompatible with markets, may conflict with NYISO dispatch
Utility Market-based Ownership	--	+	+	-
	Regulatory changes required, raises market concerns	Low expected risk of attrition	Low cost of financing	Reduces market participation/ opportunity for private sector
Utility Dispatch Rights	--	-	-	++
	Time-consuming processes, risks of delay and limited awards in current model	Attrition risk due to contract requirements, uncertainty in post-contract value	Contract requirements raise costs	Projects follow NYISO market signals
Utility T&D Ownership	-	++	++	+
	Time-consuming process to launch, unlikely to drive realization of 6 GW target if sole mechanism	Very low attrition risk after identification and approval	Provides grid services at least cost, often where upgrades are already needed	Non-market operations, but projects serve existing needs

Based on the above assessment of the various procurement mechanisms, NYSERDA and DPS Staff recommend a new Bulk Energy Storage Program be developed based on the Index Storage Credit mechanism described above, to pursue procurement of the recommended bulk storage target allocation of 3,000 MW as discussed in Section 3.

Energy storage can provide many essential grid services not currently compensated in any market. The Joint Utilities of New York (JU) are in a unique position to be able to analyze the benefits storage could provide as a T&D asset and to operate such assets for maximum benefits. NYSERDA and DPS Staff therefore recommend that the Joint Utilities of New York (JU) be directed to study the potential of energy storage to provide non-market transmission and distribution services and identify projects that provide cost-effective services when compared to traditional alternatives, and that any storage projects developed as a result should count toward the 6 GW target.

This pathway is closely related to the goals of the Advanced Technology Working Group operating as part of the Transmission Planning Process currently underway in New York. NYSERDA and DPS Staff recommend that this group be leveraged to move this work forward and suggest the formation of a subgroup specifically focused on the role of storage in future grid operations. It is expected that the outcomes of the study will lead to project-level analyses and possibly future projects that will utilize energy storage as a component of utility transmission and distribution plans, such as through the Phase 2B process.[46]

5.4 Index Storage Credit Program Design Considerations

This section considers a number of design choices relevant to the creation of a new bulk storage program using an Index Storage Credit mechanism and provides recommendations.

Definition of Index Storage Credits

As discussed, the proposed Index Storage Credit (ISC) mechanism is similar in many ways to the well-established Index REC structure adopted by the Commission and used across most of NYSERDA's Clean Energy Standard procurements. In those programs, a Renewable Energy Certificate (REC) representing the environmental attributes of renewable energy is created for each megawatt hour (MWh) of renewable electricity actually generated and supplied. The RECs are purchased by NYSERDA when they are created, ensuring that generators are compensated only for the renewable energy they generate and deliver to the grid. However, when considering the nature of energy storage, an analogous approach in which compensation would be made based on the amount of MWh of storage energy actually discharged would likely not lead to a desired outcome. For energy storage, it is important to incentivize discharge when it is most needed rather than to reward as much discharge as possible. On this basis, NYSERDA and DPS Staff propose that each ISC should represent one MWh of energy storage *capacity* that is operational on a given day. This means that each day a storage project is operational, it would be credited with and compensated for a number of ISCs equal to the MWh of storage discharge capacity of the unit. ISCs would be credited only for days when the project is operational and available for dispatch (e.g., not during days of outage or maintenance).

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[46] 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.

Under this approach, projects would generate ISCs on operational days regardless of whether and how much they discharge – there would be no performance, discharge, throughput, or operational requirements under the ISC contract. This should not lead to the conclusion that the performance-based element that underpins the Index REC programs for renewable electricity is lost in an ISC structure. Under the ISC structure, NYSERDA's payments for ISCs would be calculated as the Strike Price minus the Reference Price (details on the Reference Price are discussed further below). Projects therefore would remain exposed to price signals from the commodity markets – if they do not discharge when it makes sense given market prices, they will not generate market revenue. Without market revenue, the payment for ISCs by itself would not be expected to be sufficient to make projects economically viable.

Contract Term

The duration of the ISC support payments offered to storage projects will impact the overall cost of bulk storage projects and the effectiveness of the commodity revenue hedge. If the term is too short, the project will carry additional risks in the later years of the project's operational life that are not covered under the contracted revenue mechanism; conversely, terms of excessive lengths may result in uncertainty both for the project (which may discount such future support payments in the very distant future) and in bid evaluation. Previous program data shows projects are designed for a 15 to 20-year project life, meaning a 20-year requirement may force some projects beyond their optimal design. For this reason, NYSERDA and DPS Staff recommend a contract term of 15 years.

Eligible Technologies

NYSERDA and DPS Staff recommend that electric, chemical, mechanical or thermal-electric storage technologies will be eligible for the bulk storage program, consistent with the approach to date. As in the existing storage programs, further eligibility requirements should include that the project must store electrical energy for injection to the grid at a later time. Only projects that, once built, are electrically interconnected into the transmission and distribution systems (e.g., not behind-the-meter) in New York State will be eligible.

Storage Duration

NYSERDA and DPS Staff recommend that NYSERDA should have flexibility to stipulate specific durations of technologies being sought for each solicitation, for instance by carving out designated procurement amounts. While solicitations are expected to primarily focus on 4-hour and 8-hour duration technologies, analysis conducted for this Roadmap (see Appendix A) shows that there is a clear benefit to storage with an average duration of 8 hours, with significant deployment of these resources in 2030 and beyond. These resources are also expected to maintain a high reliability contribution in the long-term, without steep declines in marginal value often seen in short-duration assets. For this reason, NYSERDA solicitations may explicitly incorporate 8-hour duration assets into the procurement program, such as by allocating a given amount of the targeted procurement amount to these assets. Similar allocations or carve-outs on a geographical basis are discussed in Section 7.1.

Reference Price Components in the ISC Calculation

As discussed, the payment that storage projects would receive for ISCs under the program would be calculated as the Strike Price (per ISC) bid by the project into NYSERDA's solicitation, minus a Reference Price calculated based on an index or set of indices designed to approximate the amount of market revenue available to a typical project. The principal available revenue streams for storage assets in the current energy markets are energy arbitrage and capacity. Energy arbitrage occurs where a storage project charges from the grid and later discharges when energy prices are higher than when the storage project charged. Capacity revenue is available for storage assets in a similar way as for generation assets, where assets are able to qualify as capacity suppliers and receive capacity revenue by clearing in NYISO auctions and fulfilling daily bidding obligations. Accordingly, NYSERDA and DPS Staff recommend that the Reference Price should be calculated as the sum of the Reference Energy Arbitrage Price (REAP) and the Reference Capacity Price (RCP). Proposals for the design of the REAP and RCP are set out further below.

Storage projects can, depending on the circumstances, access some other energy market revenue opportunities, broadly referred to as Ancillary Services. These include, for instance, frequency regulation and operating reserves, but NYSERDA and DPS Staff recommend that these not be included in the ISC calculation. These revenue streams are currently highly uncertain and dependent on location, and no readily available indices exist to track them. At the same time, they are currently expected to form a relatively small part of projects' revenue streams under current NYISO market rules. Accordingly, they would be challenging to implement into the ISC structure, and their inclusion would offer only modest incremental hedging benefits to most projects.

Payment Caps

As discussed, a key feature of the ISC structure is that it would result in lower ISC payments to projects when energy market prices are high for a given contract settlement period, and vice versa. This approach provides hedging benefits to projects by ensuring a more stable long-term revenue stream than would be the case based on commodity revenue only. The resulting lower project risk profile enables projects to reduce their cost of finance, which is expected to translate to lower, while still viable, solicitation bids and therefore lower program costs and ratepayer bill impacts from the bulk storage procurement program.

As a result of this structure, if commodity prices were to rise significantly to the point where the Reference Price would exceed the Strike Price, projects would need to pay the difference to NYSERDA. Conversely, if commodity prices were to drop significantly (compared to forecasts), NYSERDA's payments and thus program costs could end up higher than initially projected. Both of these potential outcomes could be managed or avoided through the use of "caps and collars" that could stipulate minimum payment levels to projects and/or rule out negative payments (payments from the project to NYSERDA), or stipulate maximum payment levels.

These concepts have not been applied in NYSERDA's Index (O)REC programs, and NYSERDA and DPS Staff do not recommend that such caps or collars should be applied in the ISC program. A key benefit of the ISC structure (as in the Index REC structure) is that if commodity prices do rise to the point where they can sustain projects, the structure avoids making unnecessary incentive payments. If prices experience sustained high levels and ratepayers are therefore facing high energy bills, it is particularly critical to minimize program cost bill impacts, and the possibility of payments from projects to NYSERDA would help further reduce ratepayer impact. In the opposite case, where commodity prices would be low, a symmetrical approach (i.e., without maximum cap on ISC payments) allows the ISC structure to unlock the greatest benefit to ratepayers from reduced project finance costs, since this approach is what reduces projects' exposure to commodity price downside. While this approach would result in higher program costs in this situation, ratepayers would at the same time benefit from lower energy bills overall. In effect, the indexed approach helps to reduce ratepayers' exposure to both extreme high and low energy bills.

Inflation Adjustment

NYSERDA's onshore and offshore large-scale renewable energy procurement programs have adopted an optional provision that provides for the Strike Price of awarded projects to undergo a one-time adjustment to reflect changes in certain pre-determined cost indices between the time the project is bid to a NYSERDA procurement and the time at which the project proceeds to construction.[47] Such a provision reflects the risk that inflation and cost uncertainties pose to projects with long development times, and these risks also apply in the bulk storage market. On this basis, NYSERDA and DPS Staff recommend that a similar provision be included in the design of the ISC program.

Reference Energy Arbitrage Price (REAP): Market Choice

The large-scale renewables Index REC structure under the CES utilizes day-ahead NYISO energy market pricing for the energy price component of Reference Price calculations and contract settlement. Similar considerations apply to the Index Storage Credit, in that day-ahead market pricing is likely to be more stable and easier to operationally implement compared to real-time market prices, providing benefits in forecasting reference pricing and evaluating Strike Price bids. NYSERDA and DPS Staff therefore recommend aligning with other CES programs to utilize day-ahead energy market pricing for the calculation of the ISC Reference Price.

Reference Energy Arbitrage Price: Location/Geographic Precision

As in existing programs, NYSERDA and DPS Staff consider NYISO zonal LBMPs to be the optimal Reference Price forecast and settlement option. More granular pricing data reduces feasibility and increases administrative burden while mitigating incentives for projects to seek injection at higher value injection points with greater benefits afforded to grid reliability and energy deliverability. Zonal LBMPs address these issues and are a well-established measure for reference price calculations.

Reference Energy Arbitrage Price (REAP): Arbitrage Calculation

Unlike technologies compensated by the existing Index REC structure, energy storage is not purely a generation source. The requirement to withdraw energy for future injections means revenue from energy pricing captured by storage is based on arbitrage values. NYSERDA and DPS Staff seek to incorporate this fact into calculation of the Reference Energy Price for the Index Storage Credit.

Energy storage projects will seek to maximize revenue by charging in lower-price hours and discharging in higher-price hours. NYSERDA and DPS Staff therefore recommend utilizing an approach that calculates the arbitrage opportunity between the top and bottom priced hours in the day-ahead energy market. For 4-hour duration resources, NYSERDA and DPS Staff recommend using the difference between the average of the top 4 and bottom 4 hours in the day-ahead energy market to calculate the daily REAP. This approach would allow for the number of hours to be increased as needed for longer-duration assets. Based on monthly settlement, the average of this daily calculation would be applied over the course of the given

[47] 2022 NYSERDA Offshore Wind Solicitation (https://www.nyserda.ny.gov/All-Programs/Offshore-Wind/Focus-Areas/Offshore-Wind-Solicitations/2022-Solicitation); 2022 NYSERDA Tier 1 Large-Scale Renewables Solicitation (https://www.nyserda.ny.gov/ces/rfp)

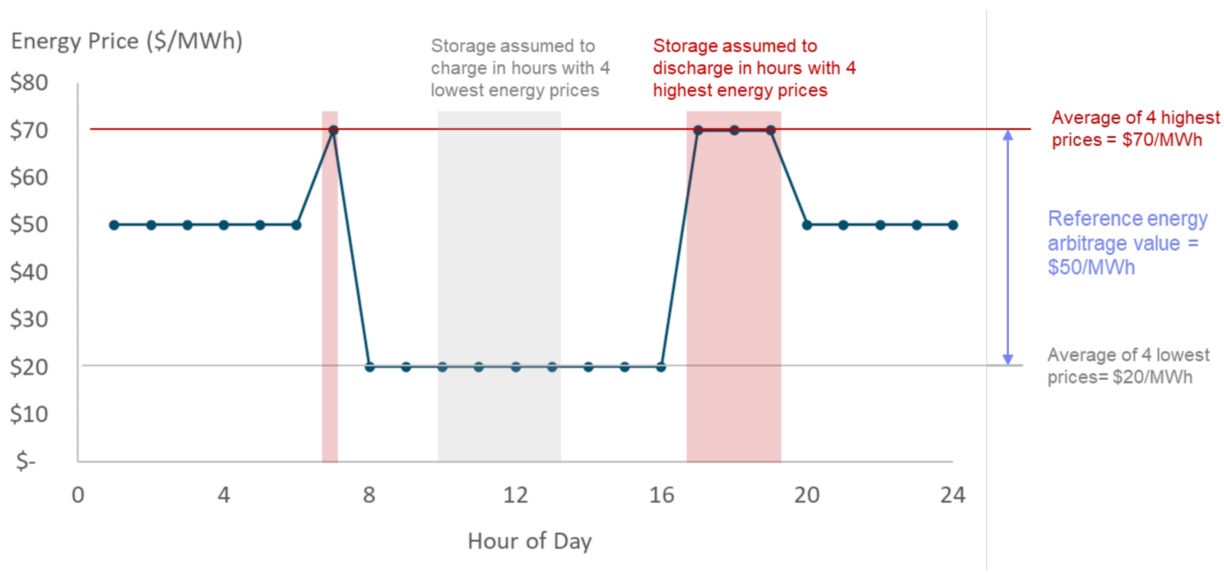
calendar month. This construct is in use as a hedging mechanism in other jurisdictions already and has proven to be a successful contracting option.[48]

Despite the round-trip efficiency losses that require assets to charge longer than this construct indicates, NYSERDA and DPS Staff recommend not incorporating these losses into the Reference Price calculation. This is due to the additional complexity of calculating round trip efficiency that may vary across project types, as well as the fact that omitting this measure maintains an incentive to utilize more efficient technologies in the program.

NYSERDA and DPS Staff acknowledge that calculating the REAP based on the daily top and bottom priced hours will result in the REAP being reflected in the ISC calculation at the maximum possible level of revenue available in the day-ahead market. Without perfect foresight of each day's hourly prices, projects may not be able to realize this level of revenue in the day-ahead market; conversely, by accessing revenue from the intraday market or ancillary services in addition to or instead of revenue from the day-ahead market, projects might be able to realize more revenue than calculated in the REAP. As discussed further above, these dynamics are intentional and ensure that projects respond to market price signals. As a result, projects would assess the extent to which they expect to generate more or less revenue than the REAP and reflect any deviation in their Strike Price bid, resulting in increased competitive pressure during the bidding process.

Calculation of REAP on a single day is illustrated in Figure 14 below.

Figure 14. Reference Energy Arbitrage Price Calculation Example for 4-hr Storage



[48] See discussion of this hedging contract structure in Orrick Energy Storage Update 2021-2022. Available at: https://media.orrick.com/Media%20Library/public/files/insights/2021/orrick-energy-storage-update-2021-2022-v5.pdf

Reference Capacity Price (RCP): Market Choice

Similar to NYSERDA's existing Index programs,[49] NYSERDA and DPS Staff recommend utilizing the NYISO Installed Capacity (ICAP) spot auctions to calculate the RCP. This is due to the administrative ease as well as the fact that the spot auction is the largest and most-utilized auction structure in the State, which optimizes the hedging structure.

Reference Capacity Price: Geographic Precision

The New York Control Area has multiple separate capacity pricing areas. The price for capacity can vary significantly between areas, and since capacity value is a primary driver of storage revenue, this difference must be incorporated into the reference capacity price. NYSERDA and DPS Staff therefore recommend utilizing locality-specific pricing to maximize the efficiency of the RCP hedge.

Reference Capacity Price: Adjustment Factors

The capacity market participation model for energy storage in the NYISO markets results in variability in a resource's capacity value year-over-year, independent of the underlying market pricing. The NYISO's Capacity Accreditation construct will calculate, on an annual basis, the capacity accreditation factor for energy storage resources which will be applied along with the resource's specific UCAP rating to determine its capacity value. To provide hedging value while maintaining projects' incentives to maximize their own capacity value, NYSERDA and DPS Staff recommend calculating the RCP in a manner that adjusts the Monthly NYISO ICAP Auction value of capacity in the locality[50] where the storage is sited according to the prevailing Capacity Accreditation Factor for each storage duration type. The RCP formula will be conceptually similar, but not necessarily identical, to the RCP formula used in CES procurements and contracts. For example, it may be preferable not to require projects to include a UCAP factor in their bids given the shifting landscape of the capacity market for energy storage described above. NYSERDA and DPS Staff propose that NYSERDA would establish the final RCP formula to be used in solicitations in accordance with the above parameters and in consultation with DPS Staff after the conclusion of NYISO's capacity accreditation stakeholder process.

Settlement Period

The nature of the Index Storage Credit allows numerous options for settlement periods. Settlement could be as granular as a single day or as infrequent as annual or longer. However, NYSERDA and DPS Staff believe monthly settlements provides an ideal balance between administrative burden and ongoing value to projects. This is consistent with the structure of previous programs and will simplify administration across efforts.

An example of calculation and settlement of the ISC based on the above recommended design features is set out in Figure 15 below.

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[49] Market choice here reflects the same proposal as adopted in the LSR programs. Case 15-E-0302, Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and Clean Energy Standard, NYSERDA Comments on the AWEA/ACE-NY Petition Regarding Integration of an Index REC Procurement Structure into Tier 1 REC Procurements Under the Clean Energy Standard (filed October 2, 2019).

[50] NYISO Installed Capacity Manual, Section 4.11.1 Permissible Aggregations. https://www.nyiso.com/installed-capacity-market

Figure 15. Index Storage Credit Calculation Example

Day	Daily Energy Arbitrage Index	Day	Daily Energy Arbitrage Index
1	$70	16	$22
2	$15	17	$21
3	$61	18	$17
4	$33	19	$24
5	$20	20	$20
6	$9	21	$22
7	$19	22	$26
8	$29	23	$19
9	$27	24	$21
10	$21	25	$22
11	$18	26	$23
12	$40	27	$32
13	$30	28	$54
14	$29	29	$64
15	$18	30	$38

Strike Price	$80
Monthly Energy Arbitrage Reference Price	$29
Capacity Reference Price	$20
Monthly Settlement	$31

High Volatility (≥ $40)	5 days
Medium Volatility ($20>X>$40)	17 days
Low Volatility (≤ $20)	8 days

Settlement Calculation Example
Assume 100 MW / 400 MWh asset

ISC = Strike – Energy Ref – Capacity Ref
ISC = 80 – 29 – 20
= **$31 per ISC**

Total ISCs = installed energy capacity x days in the month
Total ISCs = 400 MWh x 30 days
= **12,000 ISCs**

Settlement = 12,000 ISCs x $31 per ISC
= *$372,000 for the month*

Future Wholesale Market Rule Changes

As discussed in Section 2 and 4, a number of future reforms to commodity markets relevant to energy storage are either under consideration or underway. These could result in changes to the types and level of compensation storage projects receive for their services in ways that may not have been captured adequately in the ISC reference commodity price formula that will be applied to projects procured under an ISC program. As is the case in the existing CES programs, NYSERDA and DPS Staff recommend that ISC contracts be designed to enable amendments to the ISC formula if this occurs.

Bid Evaluation Criteria

In keeping with the approach in NYSERDA's other large-scale procurement programs, such as under the CES, NYSERDA and DPS Staff recommend that NYSERDA evaluate bids under the ISC bulk storage program based on price and non-price factors. Price evaluation would reflect the projected levelized net ISC cost based on zonal energy and capacity price forecasts. Non-price evaluation factors would include project viability, economic benefits, and societal benefits, such as the extent to which the proposed project would drive reductions in the use of fossil fuel peakers, as specified in the Climate Law[51] and Governor Hochul's 2022 State of the State proposal.[52] NYSERDA and DPS Staff recommend that non-price factors be considered as is the case in Tier 1 of the Clean Energy Standard, with further specifics on the evaluation factors to be developed by NYSERDA for each solicitation.

Maximum Bid Prices

Similar to the approach in NYSERDA's large-scale renewables program, NYSERDA and DPS Staff recommend that ISC procurements should apply a maximum bid price evaluation metric, applied in the form of a maximum levelized net ISC cost, to help ensure cost effectiveness from a ratepayer perspective and to simplify the evaluation of bids in the event that bids above the maximum bid price are received in

[51] PSL §66-p(7)(a).
[52] 2022 State of the State Book, p.143.

future solicitations. Implementation of this feature would follow the approach taken for current CES large-scale renewables programs.

Table 5 below summarizes the recommended design choices discussed above.

Table 5. Design Considerations for an Index Storage Credit Program for Bulk Energy Storage

Design Choice	Index Storage Credit Design Recommendation
Definition of ISC	1 ISC equates to 1 daily MWh of storage on operational days
Contract Duration	15 years
Eligible Technologies	See above
Reference Price Components	Reference Energy Arbitrage Price and Reference Capacity Price
Payment Caps	No payment cap or collar; allow negative payments
Inflation Adjustment	Yes
Settlement Period	Monthly Settlements
Future Market Rule Changes	Contractual amendment of ISC formula
Bid Evaluation Criteria	Price, viability, economic and societal benefits
Maximum Bid Price	Apply maximum levelized net ISC cost
Reference Energy Arbitrage Price	
Market Choice	Hourly day-ahead Zonal LBMP
Location/ Geographic Precision	Zonal LBMP
Arbitrage Value Calculation	Top X minus bottom X hours (not necessarily consecutive)
Reference Capacity Price	
Market Choice	NYISO ICAP Spot Market Auction, single locality
Geographic Precision	NYISO locality
Adjustment Factors	Utilize NYISO’s resource-specific Capacity Accreditation Factor adjustment

5.5 Storage in Tier 1 and OSW Programs

While the Inflation Reduction Act creates an ITC for standalone storage, there is value in allowing paired projects in the Tier 1 LSR and OSW RFPs now and in the future due to the remaining incremental benefits of pairing that do not exist for standalone storage projects.

When paired together, projects are able to share study and engineering costs, interconnection upgrades, permitting, and land costs (storage often does not require additional land), and allows generation resources to reduce their own potential curtailment while at the same time provide storage projects more certainty in charging their storage asset. Co-located and separately located/standalone energy storage projects that bid into the Tier 1 and OSW solicitations are still eligible to take advantage of the expanded ITC afforded by the IRA. Pairing of resources under a Tier 1 or OSW contract may also be a preferred method for development for project sponsors who may find the ability to have both resources under one contract and on one development timeline to be easier to manage than having each resource compete for funding in two separate programs, which may be on different timelines and come with different requirements for project COD and lifetime/contract tenor.

Solar projects paired with energy storage also benefit from the ability to capture otherwise unusable DC energy, known as "clipped energy", that occurs in the middle of the day due to oversized DC-AC ratios, essentially creating a new, incremental source of clean energy delivered to the grid. In the case of lower-voltage interconnections, pairing also allows storage to avoid demand charges and thereby improves the storage system's economic viability.

Barring bids paired with storage projects in the Tier 1 and OSW solicitations may not be permissible under the existing Commission orders and could pose a challenge to dedicated energy storage developers that currently participate in one or both programs. Also, due to the contract tenor typically bid into NYSERDA's Tier 1 (20 years) and OSW (25 years) solicitations, projects paired with energy storage will provide New York State ratepayers with future benefits to a rapidly changing grid which will have the majority of its generation provided by intermittent resources.

For these reasons, NYSERDA intends to maintain the eligibility of co-located and separately located energy storage projects in bids submitted to Tier 1 and OSW solicitations in current and future solicitations. However, energy storage projects would not be permitted to be compensated both through Tier 1 and/or OSW solicitations and ISC bulk storage procurements. Accordingly, an energy storage project awarded through a Tier 1 or OSW solicitation would need to be removed from the Tier 1 or OSW contract to be eligible to receive compensation under an ISC bulk storage award.

5.6 Questions for Stakeholder Comment

1. Should action be taken on the remaining JU Bulk Storage Dispatch Rights procurement requirement? Numerous utilities have yet to fulfill their requirement from the 2018 Storage Order and NYSERDA and DPS Staff are currently assessing the ramifications of future programs on these procurements.
2. What methods should be used in each program to attract storage projects in preferred locations and durations? For example, should procurements seeking 8-hour duration assets utilize a TB8 mechanism, or should all resources compete with the same reference prices in the same solicitations? What impacts do duration or location carve-outs have on competitive procurements?

6 Retail and Residential Storage Program Design

As discussed in Section 3, NYSERDA and DPS Staff propose that NYSERDA conduct further storage procurements in the retail and residential sectors by continuing and expanding existing programs.

6.1 Retail Storage

Under the first Storage Roadmap, NYSERDA's Market Acceleration Bridge Incentive Program implemented region-specific, declining block incentives for energy storage systems up to 5 MW. The program was successful in procuring over 300 MW of projects and resulted in a significant increase in the size of the project pipeline (which is now over 1 GW). While fixed-rate incentives are less robust to changes in markets and costs than other procurement options, the certainty of funding availability and amounts has proven to be valuable to developers in this market segment. Additionally, since the initial programs launched, the Allocated Cost of Service proceeding has enabled a reduction in demand charge costs to distribution-sited storage projects, and the Federal Government has instituted an Investment Tax Credit for standalone energy storage (see Section 2). These improvements help provide longer-term certainty to developers as well as lower cost and allow New York to maintain the existing declining-block funding mechanisms, which have proved efficient in administration.

As discussed in Section 3.4, NYSERDA and DPS Staff recommend continuing Retail Storage Incentive funding to procure a further 1,500 MW of retail storage by 2030, with the related recommendation that the program continue to operate on the basis of declining blocks designed to provide multiple years of project development certainty to the market and avoid boom-bust cycles within the program. Funding needs are expected to be at similar rates as the latest iterations of past programs; quantification of the requested program funding is provided below in Section 8.1.

Retail Storage Program Design Considerations

Due to the unique development pathways in various regions of the State, NYSERDA and DPS Staff recommend continuing to utilize a regional block structure as previously implemented for the retail segment. Project maturity requirements should be maintained at high levels to reduce project attrition and time between contracting and commissioning. Program implementation should evaluate funding requirements and system benefits of projects in the different regions and size funding rates and block sizes accordingly. NYSERDA and DPS Staff believe it is important to ensure that the sizing of the first block, or series of blocks, reflects the backlog of highly mature projects that has developed since program funding was exhausted in previous years. This will help avoid boom-bust cycles and reduce attrition from early projects, which is an important consideration, given early projects may reserve funding for a long period of time. If early projects fail to reach operation, the short timeline to reach the 2030 targets may not allow for replacement projects to be procured in time.

Retail storage projects have the ability to provide meaningful reliability contributions and peak energy within distribution networks. Through their operation, retail projects offset the need for other resources, often at the wholesale level, to provide peak power needs. Power generation during peak times, particularly downstate, is often far more polluting than typical operation, and results in significant impacts on cost and health outcomes for nearby residents. Energy storage's unique capability to provide dispatchable and zero-emission power in constrained areas makes it a powerful option for delivering benefits to disadvantaged communities. NYSERDA and DPS Staff therefore recommend that future regional allocations in the block structure of the program be sized in a way to maximize benefits to constrained areas and disadvantaged communities.

An important factor in the success of declining-block style incentive programs is setting the incentive rate in each block accurately and effectively communicating funding rate changes to project stakeholders. This Roadmap provides three additional recommendations related to incentive rates. First, as program administrator, NYSERDA should provide a detailed analysis of region-specific incentive rates, as well as a forecast of potential future block rates. This will provide certainty to the market regarding the methods for calculating rates and a potential trajectory for incentives. Second, NYSERDA should continue to communicate adjustments to incentive rates early in the process, so project developers are able to adjust accordingly and avoid being surprised by lower levels of funding availability. Finally, NYSERDA and DPS Staff recommend that NYSERDA build on the success of the standalone storage value stack calculator that is currently available for projects in Con Edison's service territory and develop a similar public-facing calculator for VDER storage projects statewide.[53] This effort will help educate consumers and developers on the value of retail storage in different areas of the state and provide a common resource for future discussions of funding needs in later blocks.

6.2 Residential Storage

Within the first round of energy storage incentive programs in New York, funding for residential projects has been limited to projects pairing with solar power and located on Long Island. The focus on Long Island was driven by the adoption of the DLM tariff in LIPA's service territory, enabling system services to be provided by storage located at residential homes.[54] This focus on system services has been important to this point, ensuring that ratepayers receive maximum value, even from projects located within a home. Moving forward, these requirements may be loosened due to the incremental benefits provided by storage, in terms of resilience and support of the overall transition to electrified homes and a zero-carbon energy system. Significant demand for residential energy storage exists across the State and future programs should strive to capitalize on this demand to grow a statewide residential storage market. This market can then be expected to attract and enable aggregation of residential storage resources in the state, while providing utilities with existing demand for new tariffs and participation models.

Given the small size of residential storage projects, however, the total magnitude of achievable deployment out to 2030 is expected to be only up to a few hundred MWs, spread across the state. Despite the fact that larger energy storage projects can provide larger chunks of capacity on the way to 3 GW and 6 GW, thoughtful deployment and use of residential storage can provide significant local benefits to the grid, while providing services to Disadvantaged and Environmental Justice communities that no other resource can currently provide. For this reason, NYSERDA and DPS Staff launching an extensive residential energy storage program statewide, with funding for 200 MW, available until 2030, and that emphasizes maximizing local benefits and benefits to Disadvantaged and Environmental Justice communities. This effort will likely require cooperation across programs at NYSERDA in addition to planning and design in

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[53] NYSERDA Standalone Storage Value Stack Calculator: https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Energy-Storage/standalone-storage-vder-calculator.xlsb

[54] Dynamic Load Management Tariff adopted by LIPA and available to storage projects: https://www.psegliny.com/businessandcontractorservices/businessandcommercialsavings/-/media/F9B52424E0FF48FBBD8AC4E336EDBE24.ashx

partnership with the utilities across New York. The program will be even more successful as new tariffs for residential storage participation are devised and simplified methods for aggregation are deployed.

Residential Storage Program Design Considerations

The project development process for residential storage projects is very different from that of retail and bulk storage projects. The unique interaction that exists between homeowners and installers, and the various ownership structures for the technology, raise important design considerations for residential incentives. To create a stable market for installers to educate consumers and develop projects, there must be long-term visibility regarding the availability of incentive funding. NYSERDA and DPS Staff therefore recommend designing a program with large blocks of funding at stable incentive rates, likely sized to last a year or multiple years at a time. Furthermore, for similar reasons, any future adjustments to incentive rates or program rules should be broadcast to the industry and homeowners alike with plenty of time to adjust to the new rates and rules before final implementation.

To simplify purchase decisions for energy storage projects in the program, NYSERDA and DPS Staff also recommend that the incentive be provided to the project installer upfront so as to directly drive down the cost of the project to the consumer. This avoids a situation where a homeowner must purchase and finance a project at full price before later applying for a rebate or incentive. Upfront payments to installers also limit the administrative burden of the program, as the number of different parties receiving payments will be limited to only the group of active installers, as opposed to the tens of thousands of individual homeowners.

Residential storage projects provide resilience and renewable integration to homeowners; however, based on the recommendation in this Roadmap (see Section 8.4.2) that the program be funded from statewide ratepayers, NYSERDA and DPS Staff also recommend evaluating ways in which residential storage projects can provide system-wide benefits. While current options in many utility territories are limited, there is potential to explore aggregations of residential assets for utility demand response programs. The JU could examine opportunities to maximize the value of these projects that will be developed in their territories, possibly through new tariffs, as on Long Island, or storage-specific rate structures. Opportunities may also exist in the future for aggregations into the NYISO's DER market, though implementation of that market design is not expected until at least 2024. As these opportunities develop, NYSERDA and DPS Staff recommend supporting residential storage, with a specific focus on disadvantaged community projects, without explicit requirements for operation or aggregation. Building a significant ecosystem of these flexible clean energy technologies will provide significant value in the near term and will provide a suite of new resources that can be tapped as market opportunities evolve.

6.3 Flexibility in Programs

As referenced in Section 2.3.3, detailed guidance regarding the federal ITC bonus adders made available to residential and retail storage projects through the passage of the IRA is still pending as of the date of filing this Roadmap. NYSERDA and DPS Staff therefore recommend that the residential and retail programs proposed in this Roadmap maintain flexibility in the near term, towards ensuring that the benefits of these federal incentives can be leveraged for storage projects, disadvantaged and low-income communities and ratepayers to the fullest extent possible.

7 General Storage Program Design Considerations

This Section considers a number of implementation aspects applicable across the bulk, retail and residential storage programs.

7.1 Geographic Distribution of Procurement

The topology of the electricity grid is such that resources located in different areas will have different values to the system. While the grid does not align perfectly with geographic boundaries, there are some geographic considerations that arise when discussing storage deployment. These considerations generally fall into three categories: cost (of both the electric system and the storage project itself); emissions impacts; and reliability.

Energy storage deployed in the right areas of the electric grid has the potential to reduce the cost of operating and balancing the grid while integrating renewable resources more efficiently by increasing deliverability and reducing curtailment. This Roadmap is focused on ensuring future programs consider the incremental benefit that arises from certain projects and target deployment of the highest-value projects. Relatedly, the cost to deploy energy storage is not the same across geographies; local land costs, taxes, interconnection, etc., may all cause similarly sized projects to have dramatically different costs and development timeframes. These considerations will be important to evaluate when planning storage deployments in different regions.

By charging with clean off-peak electricity and discharging at peak times, which often have the highest emission rates, energy storage can reduce emissions from the electricity grid. Furthermore, energy storage can be used in constrained areas to reduce renewable curtailments, allowing incremental clean MWh to be delivered to the grid. Importantly, energy storage also has the ability to perform dispatchable services, providing the grid with zero-emission energy in place of emitting resources for many essential grid services. Each of these values provided by energy storage is dependent on the location of the storage project and the grid topology in the area and must be evaluated in order to maximize the benefits provided by a given portfolio of storage projects.

As fossil fueled power plants, particularly in downstate New York, reach their end-of-life and move to retire, the NYISO and utilities will require dispatchable capacity to maintain reliability, both in terms of resource adequacy and transmission security. The ability of energy storage to provide these services makes this one of the highest-value deployment opportunities in New York and can help accelerate decarbonization in a reliable way. Once again, the provision of these reliability services is extremely location-dependent and will require cooperation with NYISO and the utilities to ensure projects provide maximum benefits.

Given the immense variation between values and services of different storage projects, even within a similar geographic area, this Roadmap concludes there are valuable energy storage projects across the entirety of New York State. This is particularly true when considering the long-term need to operate a zero-carbon grid statewide. The analysis carried out for this Roadmap found that two-thirds of all energy storage deployment in a least-cost scenario was developed in downstate New York, and NYSERDA and DPS Staff therefore recommend designing the program to ensure a significant proportion of energy storage is deployed downstate. Furthermore, the program should target areas where fossil fuel peaking power plants exist so that storage capacity developed in the area can provide an alternative source of clean peak energy to the state and mitigate the need for resources operating beyond their end of life. The bulk storage program should consider downstate-specific carve-outs to ensure targeted deployment, while the retail and residential programs could follow past precedent and create region-specific blocks of funding.

7.2 Disadvantaged Communities and Environmental Justice Considerations

Any program arising out of the 6 GW Energy Storage Roadmap process will be expected to comply with Disadvantaged Community (DAC) requirements, as outlined in the Climate Act.[55] Programs should also strive to maximize benefits to DACs and environmental justice communities by performing detailed evaluations of the locational benefits of projects within any future program. Energy storage has the ability to increase resiliency and improve reliability within these areas. Furthermore, energy storage has the unique capability to provide zero-carbon capacity within highly constrained areas, offsetting the need to run highly polluting fossil fuel facilities that pose a significant burden within New York.

Bulk and off-site retail storage projects deliver energy directly into the transmission and distribution system in New York, providing wide-ranging benefits across the electric system. Importantly, these benefits are tied to the electrical topology in the area where the projects are built, and not necessarily to the specific physical location of the project. In many cases, projects will be providing services on a zonal basis, often stretching into areas beyond a single county or zip code. For this reason, the benefits of bulk and off-site retail projects are considered a statewide benefit. NYSERDA and DPS Staff recommend, in order to comply with the requirements in the Climate Act, both in terms of DAC benefits and the requirement to specify a proportion of projects targeting the reduction of peaker plant emissions, that at least 35% of program funding be utilized to support projects in areas of the state with the highest benefits to DACs and peaker reductions. These areas can be found in various locations across the state, but NYSERDA and DPS Staff expect Zone J (New York City) to receive particular focus in program design.

On-site retail and residential projects provide direct local benefits to the site at which they are installed, with the value of these projects to be primarily for the benefit of the site owners. NYSERDA and DPS Staff therefore recommend that these projects be deemed local benefits for the purposes of providing DAC benefits. This means that programs should be designed so at least 35% of the funding and associated benefits of these projects are directed to projects sited in DACs.

7.3 Prevailing Wage

As discussed in Section 2.3.3, for commercial storage systems with a capacity of 1 MW-AC and greater, the Inflation Reduction Act provides an initial “base” ITC rate of 6% with a 24% “bonus” adder if the project complies with federal prevailing wage and apprenticeship requirements (detailed guidance on was released by the Department of Treasury on November 30, 2022; see 87 Fed. Reg. 73580). This provision provides a significant incentive for commercial-scale energy storage projects to utilize prevailing wage, and NYSERDA and DPS expect most, if not all, commercial storage projects that are eligible to participate in the proposed programs to comply with these requirements in order to qualify for the higher ITC rate.

Although the Inflation Reduction Act incentivizes energy storage developers to pay federal prevailing wages, there are no applicable New York State prevailing wage requirements. To ensure that commercial

[55] New York State Environmental Conservation Law §75-0117.

storage projects procured and supported in service of the 6 GW target create well-paying jobs, NYSERDA and DPS recommend that energy storage projects with a capacity of 1 MW-AC and greater participating in any NYSERDA energy storage incentive program pay New York State Prevailing Wage as a programmatic contractual requirement. This requirement would follow NYSERDA's current practice to require payment of New York State Prevailing Wage as a matter of contract for Large-Scale Renewable REC procurements as well as for NY-Sun projects 1 MW-AC and above, and be substantiated via quarterly certifications by a New York State-licensed Certified Public Accountant during the construction period.

7.4 Accountability

NYSERDA and DPS Staff recommend continuing a process of Annual Reports and Triennial Reviews, as initiated by the 2018 Storage Order.[56] These reports have served as an important tracking mechanism for program success, while also providing interested stakeholders and the public with an update of the program and potential changes to markets and policies. The Annual and Triennial reports will be especially important as a way to coordinate efforts with the federal rules and the outcomes of the CGPP process as well as review potential program changes that may be required.

7.5 Questions for Stakeholder Comment

1. For programs supporting bulk and off-site retail projects, how should incentive programs and procurements be best designed towards ensuring that at least 35% of proposed program funding is utilized to benefit disadvantaged communities and drive peaker plant emissions reductions, beyond a program focus on Zone J as proposed in Section 7.2?
2. For programs supporting on-site retail and residential projects, how could programs be optimally designed so as to ensure that at least 35% of the funding and associated benefits of these projects are directed to projects sited in DACs?

[56] Case 18-E-0130, supra, Energy Storage Order, p.113.

8 Cost

New funding will be required to deploy the quantities of storage recommended in Section 3 to be procured from each of the residential, retail and bulk storage sectors in order to achieve the 6 GW by 2030 storage goal. This section sets out cost estimates and proposals on funding mechanisms for the costs related to the recommended 6 GW by 2030 storage target and the program proposals discussed throughout this Roadmap. It includes quantification both of program cost and administrative costs.

8.1 Program Cost Estimates

Cost estimates for the target allocation levels by sector are outlined below.

Retail and Residential Storage Program

The residential program is estimated to cost $72 million to procure 200 MW of residential energy storage across the state. The retail program is estimated to require $438 million to procure 1,500 MW of retail energy storage. Taken in combination, the retail and residential programs are estimated to cost $510 million (net present value) for incentive payments for 1,700 MW of energy storage, paid out between 2023 and 2030.

Table 6. Retail and Residential Program Costs

Program	MW	Estimated Program Cost (2022$ Net Present Value)
Retail	1,500	$438,000,000
Residential	200	$72,000,000
Total	**1,700**	**$510,000,000**

Bulk Storage Program

Bulk storage program costs are estimated to be $474 million - $1.19 billion (net present value in 2022 dollars) to procure 3,000 MW of bulk storage. The range of these projections reflects future uncertainties, most notably those associated with energy and capacity prices.

Table 7. Bulk Procurement Program Cost Estimates

Program	MW	Estimated Program Cost (2022$ Net Present Value)
Bulk – Low Estimate	3,000	$474,000,000
Bulk – High Estimate	3,000	$1,186,000,000

These estimates exclude program administration costs, discussed further below.

8.2 Administration, Implementation, Program Evaluation and New York State Cost Recovery Expense Funding

The funding requested in this section will support the procurement programs proposed in this Roadmap. The following funding categories are separate and distinct from awards made to projects as part of the proposed procurement programs:

1. **Program Administration** – includes fully loaded labor costs, overhead and technology costs necessary to design, launch, implement, and scale up Storage initiatives to successfully deliver this Roadmap. See details below.
2. **Implementation Support –** includes costs associated with technical consultant support, quality assurance, measurement and verification, and business system and data warehousing development related to the implementation of the proposed bulk, retail and residential programs.
3. **Program Evaluation** – includes costs associated with impact assessments, market characterization, and process evaluation towards assessing the effectiveness, efficiency, and impact of the proposed NYSERDA-administered programs.
4. **New York State Cost Recovery Expense** – a fee assessed to NYSERDA and other public authorities by New York State for an allocable share of state governmental costs attributable to the provision of services to public benefit corporations pursuant to Section 2975 of the Public Authorities Law.

It should be noted that the majority of overall funding budgeted for the above needs pertains to the proposed residential and retail storage programs over the course of their lifetime, with an additional allocation for startup costs associated with set-up and implementation of the proposed bulk storage program. NYSERDA and DPS Staff propose that these bulk program startup costs be funded by utilizing uncommitted and available administrative and implementation support funding from legacy storage programs authorized by the 2018 Storage Order. Additional needs related to administration and implementation of the bulk program following its origination would be requested in a subsequent petition or alternative process, if so determined by the Commission.

Program Administration

NYSERDA's project planning indicates that a total of approximately $29.0 million ($24.5 million for residential and retail programs and $4.5 million for the bulk storage program) should be budgeted for program administration, inclusive of NYSERDA employees and staff augmentation resources required for the following:

i. Set-up and origination of the proposed bulk procurement program;
ii. Application and contract management related to the proposed retail and residential incentive programs;
iii. Economic, financial and programmatic analysis and forecasting activities supporting the administration of the proposed programs;
iv. Subject matter expertise, policy engagement and tracking, and stakeholder support;
v. Data management and reporting activities associated with the proposed programs;
vi. Support services including legal counsel, contracting, marketing, communications and information technology.

Of this total, approximately $14.5 million in administrative funding associated with the previous Market Acceleration Bridge programs approved by the 2018 Energy Storage Order are anticipated to be available and requested to be utilized in this proposal, meaning that approximately $14.5 million in additional administrative funds for residential and retail programs would be required and is requested.

Implementation Support

Implementation support for the proposed programs includes a number of distinct categories associated as detailed below:

i. Technical consultant support relating to wholesale and distribution market analysis, interconnection and hosting capacity, power system modeling and economic forecasting;
ii. Quality assurance (QA) activities conducted by NYSERDA's Standards and Quality Assurance (SQA) team, which includes field and photo inspections and the resolution of any issues identified during inspections;
iii. Measurement and verification (M&V) activities, which involves NYSERDA review of the performance of the system during ongoing operations.

NYSERDA's project planning indicates that a total of approximately $15.0 million should be budgeted for implementation support. Of this total, $1.9 million can be provided by existing uncommitted funds and $13.1 million in additional funds for residential and retail programs would be required and is requested.

Program Evaluation

Evaluation funding related to the proposed residential and retail storage programs will support internal NYSERDA staffing requirements and external consultant activities pertaining to impact assessments, market characterization, and process evaluation, explained individually below. Collectively, evaluation will help position the proposed programs for maximum effectiveness, and will also inform how NYSERDA's energy storage programs are helping address the goals of the Climate Act.

i. Impact assessment is used to verify that portfolio performance is meeting expectations and makes use of system infrastructure, program data, and reporting to keep costs as low as possible. Impact assessment can also serve as a benchmark to support the ongoing performance measurement of new and emerging energy storage technologies.
ii. Market characterization studies document empirical evidence of market transformation and identify any barriers that impede market transformation from occurring as expected. This may include the analysis of installed costs and balance-of-systems costs, and longitudinal measurement of awareness and adoption of new technologies.
iii. NYSERDA will also conduct process evaluation activities as warranted to assess installer and customer engagement with the program over time, including, but not limited to understanding customer satisfaction with program processes.

NYSERDA's project planning indicates that a total of approximately $3.0 million should be budgeted for program evaluation needs relating to the residential and retail programs and is therefore requested.

New York State Cost Recovery Expense

NYSERDA will allocate a proportionate share of the annual New York State Cost Recovery Fee (CRF) to the energy storage programs proposed under this Roadmap. The CRF is a fee assessed to NYSERDA and other public authorities by New York State for an allocable share of state governmental costs attributable to the provision of services to public benefit corporations pursuant to Section 2975 of the Public Authorities Law. For the past six fiscal years, the CRF assessment has averaged approximately 1.1% of NYSERDA's annual expenses, and NYSERDA allocates CRF across its programs by the weighted average of programmatic expenditures. Based on this, at 1.1% of the additional budget requested related to the proposed residential and retail storage procurement programs, NYSERDA requests $8.9 million in new funding relating to the CRF.

Table 8 lists total additional funding requested for the costs associated with the above-discussed funding categories, amounting to $39.6 million (undiscounted), or $25.5 million on a net present value basis. This budget will allow NYSERDA to effectuate the program recommendations proposed in this Roadmap, while also providing support and leadership on various efforts related to interconnection policy, rate design, wholesale market issues, storage as transmission, and other important factors impacting energy storage deployments. The budget details in the table below are listed in undiscounted dollars; however, the costs will be spread over the duration of the Programs.

Table 8. Budget Allocations and Requested Additional Funding for Administration, Implementation, Program Evaluation and New York State Cost Recovery Expense (Undiscounted)

	Residential and Retail	Bulk Startup	Total	Legacy Funds Available	Additional Requested
Program Administration	$24,502,706	$4,537,071	$29,039,778	$14,500,000	$14,539,778
Implementation Support	$13,430,000	$1,600,000	$15,030,000	$1,882,768	$13,147,232
Program Evaluation	$3,000,000	-	$3,000,000	-	$3,000,000
NYS Cost Recovery Expense	-	-	-	-	$8,961,130
Total	**$40,932,706**	**$6,137,071**	**$47,069,778**	**$16,382,768**	**$39,648,139**

8.3 Total Cost Estimate for Programs to reach 6 GW by 2030

The total cost for the three incentive programs procuring up to 4,700 MW of energy storage, inclusive of administrative costs and provided on a net present value basis (2022$), is expected to be between $1.0 billion to $1.7 billion, paid out over 22 years. This equates to an estimated increase in customer electric bills of 0.32% – 0.54% (or $0.34 – $0.58 per month for the average residential customer) on average across New York for the 22-year period of payments under these programs. The range of these projections reflects future uncertainties, including within energy and capacity prices.

Table 9 below summarizes these projected programs costs (including requested administrative and other non-program funding) and associated bill impacts, both for the retail/ residential and bulk storage programs. To allow for comparison and combination of programs, program costs are calculated on a net present value basis. Bill impacts are shown both levelized over the program period and for the peak bill impact year.[57] Retail and residential project payments will begin soon after the start of any new programs and end in 2030, since incentive payments for these projects are paid out at commissioning. Bulk project

[57] Levelized bill impact metrics for the retail/residential and bulk storage projections do not sum to the bill impacts shown for the total program due to different program periods, with retail/residential payments occurring over a period to 2030 and bulk program payments occurring over a period to 2044.

payments are spread out over 15 years, beginning when projects are operational, which may not occur for four to five years after procurement, and ending in 2044 at the latest for projects operational in 2030.

Table 9. Program Cost Estimates

	Lifetime Program Cost, NPV (2022$ Million)	Lifetime Levelized Bill Impact (%)	Peak Year Bill Impact (%)
Bulk	$474 – $1,186	0.15% - 0.37%	0.63% - 0.91% (2030)
Retail/Residential	$535	0.17%	0.69% (2027)
Total	$1,009 - $1,721	0.32% - 0.54%	1.32% - 1.60% (2030)

8.4 Funding Mechanisms

Given the differences in program structure between the bulk program as compared to the retail and residential programs, which are driven by the procurement and pay-out mechanisms in each program, NYSERDA and DPS Staff envision different funding mechanisms for the proposed bulk program on the one hand and the residential and retail programs on the other hand.

Bulk Storage Program

NYSERDA and DPS Staff recommend a funding mechanism for the bulk storage program similar to that used by Tiers 2, 3 (Zero Emission Credit requirement), and 4 of the Clean Energy Standard and the Offshore Wind Standard; i.e., a payment obligation for jurisdictional Load-Serving Entities (LSEs) in proportion to their share of Statewide load.

NYSERDA and DPS Staff also recommend that NYPA and LIPA, as non-jurisdictional LSEs, agree to participate voluntarily and accept ISC obligations in proportion to their share of Statewide load. Consistent with the approach in the Offshore Wind Standard,[58] in the event that LIPA or NYPA directly procure or develop bulk energy storage projects outside of the NYSERDA procurement program, NYSERDA would take such independent storage procurement into account in its assessment of amounts of bulk storage needed through its solicitations, as discussed in Section 3.4. Such projects, subject to meeting the requirements of the storage program proposed in this roadmap, could be credited towards their load share compliance obligation.

Retail and Residential Storage Programs

The retail and residential programs are expected to be designed in a way that pays projects the full contract amount at, or very near, the time of commissioning. The retail and residential programs expect to utilize a fixed-rate incentive approach, allowing higher certainty in budget needs and timing. For these reasons, NYSERDA and DPS Staff recommend a CEF-style collection, with a transparent pay-as-you-go methodology utilized in other recently approved programs such as NY-Sun[59], also collected on a statewide

[58] Case 18-E-0071, Order Establishing Offshore Wind Standard and Framework for Phase 1 Procurement (effective July 12, 2018), p.33.
[59] Case 21-E-0629, In the Matter of the Advancement of Distributed Solar, Order Expanding NY-Sun Program (effective April 14, 2022), p.54.

MWh load ratio share basis. This Roadmap recommends that NYPA and LIPA participate in collections on a MWh load share basis as well, consistent with previous programs.[60]

Reflecting the cost estimates set out in Sections 8.1 and 8.2, NYSERDA and DPS Staff recommend $814.6 million of funding be approved for the procurement of 1,700 MW of retail and residential storage projects between 2023 and 2030. Of this total, $775.0 million is dedicated to incentives and $39.6 million supports administration of the retail and residential storage programs. Collections could begin immediately if ordered by the Commission, though collections and payments under the pay-as-you-go methodology are likely to be more heavily focused in the later years of this timeframe due to the delay between contracting and commissioning/incentive payment.

[60] Case 20-M-0082, Proceeding on Motion of the Commission Regarding Strategic Use of Energy Related Data, Order Implementing an Integrated Energy Data Resource (effective February 11, 2021), P.19.

9 Long-Duration Storage and Innovation

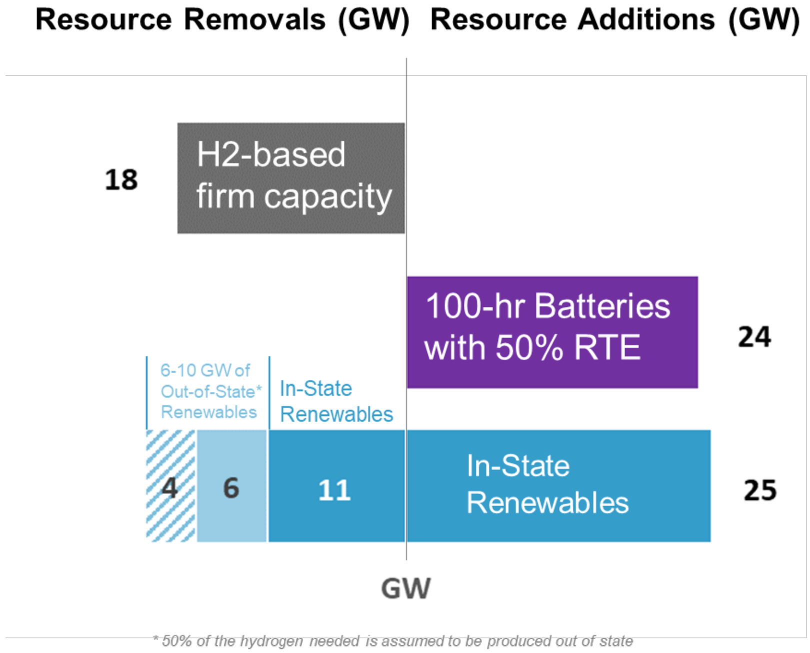
The recommended 6 GW storage target focuses on short-duration storage. Such storage, in the form of 4-hour to 8-hour storage, helps with intraday balancing, as discussed in Section 3.1. The primary role of long-duration energy storage resources in deeply decarbonized electric grids is to provide power during infrequent but critical multi-day-long periods when electric demand is high and when contributions from renewables and existing clean firm resources are not sufficient to meet demand. As a result of the electrification of building heating needs, electric demand will be higher in the winter than it is today in New York. Winter months also often coincide with extended periods of low renewables output. Such a challenging winter week is highlighted in Appendix A. Therefore, LDS resources, as well as firm zero-carbon resources, are likely to play a critical role in maintaining the reliability of electricity supply during winter in New York. Hydrogen-based firm capacity could effectively provide a form of storage to the system on the order of hundreds of hours, as large quantities of fuel can be produced during the spring and summer during times of high renewable output and relatively low electricity demand, and then utilized over the course of the winter if there is sufficient fuel storage. However, there may still be a need for other forms of long-duration energy storage in New York's electric grid, if hydrogen-based or other zero-carbon fuel-based resources were unavailable, too expensive, or infeasible to build in certain locations. From a long-term grid planning perspective, LDS resources provide an alternative to hydrogen-based or zero carbon fuel-based firm resources.

The analysis completed for this Roadmap identifies a need for 24 GW of 100-hour battery-type storage with 50% round-trip efficiency to replace the contributions of 18 GW of a fully dispatchable hydrogen-based resource, along with 13 GW of incremental in-state renewable resources to provide additional energy to charge this storage resource. A 100-hour battery-type resource can provide firm capacity to meet system needs over several days; however, in contrast to a hydrogen-based resource with significant storage, if sufficient excess energy is not available to fully recharge the batteries following a period of utilization, their ability to meet a similar system need in subsequent weeks of the winter is diminished. As a result, a higher amount of 100-hour battery capacity is needed to meet the same level of reliability as the hydrogen-based resource modeled.[61]

Investment in innovation is critical, given the grid needs some form of clean dispatchable generation to maintain reliability, particularly in the winter during multi-day periods with high load and low solar and wind output. But large sources of uncertainty exist with both hydrogen-based and other LDS solutions. In the long-term, an optimal resource mix may include multiple types of clean firm capacity and/or LDS based on the specific needs and constraints across the State and within specific zones or regions. The amount of LDS and additional renewables required for partial replacement of hydrogen-based firm capacity are presented in Appendix A. The results of this analysis show that, depending on the duration of the LDS, LDS can serve as a one-to-one replacement for 5+ GW of other zero-carbon firm capacity. This shows that, while significant capacity and additional renewables are required to fully offset zero-carbon firm capacity in the analysis, there is likely a role for LDS to play in providing some proportion of firm energy needs competitively.

[61] See Appendix A for details on this analysis.

Figure 16. Long-Duration Storage and Renewables Additions to Replace H2-based Firm Capacity in 2040



It is expected that over the 2030 time horizon, both deployment at scale and system needs will be limited to short-duration storage. However, deployments of LDS before 2030 will be required to gain familiarity and experience with technologies that may play an important role in a fully decarbonized electric sector.

To ensure New York's long-term resource adequacy needs are met, efforts should begin now to develop, test, and demonstrate long-duration energy storage technologies that are capable of providing reliable power for ten or more hours at a time with zero emissions.

Importantly, the focus should be on resources that are scalable and able to be sited in New York State. The analysis for this Roadmap indicates that 5 GW or more of these resources could provide near-perfect capacity in a fully decarbonized energy system. Therefore, NYSERDA and DPS Staff recommend that NYSERDA's Innovation program prioritize those resources that have a high likelihood of success in supply, production, development, and operation of the technology that will allow them to provide value to the State on the GW scale before 2040. Future programs could also analyze compensation pathways for LDS, as the unique characteristics of this technology may not be appropriately compensated through existing market products.

As referenced in Section 2, NYSERDA's Innovations program is currently supporting research, development and commercialization of LDS technologies. It is recommended that the Innovations program continue to evaluate further funding needs within the existing program framework, particularly related to the ability to begin demonstrating projects at a larger scale. A large-scale demonstration, on the order of 50-100 MW, of the operation and business models of LDS will grant new insight into the value and use case considerations relevant to utilities and the NYISO that smaller pilot projects have yet to evaluate. Such a demonstration can be explored in a way that enables information sharing and learning to be disseminated widely to inform best practices in the development and operation of LDS on the transmission and distribution systems in New York.

LDS deployments are not reflected in the storage amounts to be procured through the proposed bulk, retail and residential deployment programs, and would be complementary to the strategies laid forth in this document to achieve 6 GW of storage deployment by 2030. However, any deployment occurring within the LDS segment is proposed to count toward the 6 GW target and inform the volume of storage required to be procured in other segments.

9.1 Questions for Stakeholder Comment

1. What type and size of LDS demonstration projects should be considered in future programs, and how should the program be designed to maximize value and learning?
2. What mechanisms need to be considered when evaluating options for operating and compensating LDS projects on the grid?

Appendix A. Storage Capacity Expansion Analysis

A.1. Capacity Expansion in E3's RESOLVE Model

Overview

The analysis was performed leveraging the same framework used in the Climate Action Council Integration Analysis for the Draft Scoping Plan, in line with Scenario 2: Strategic Use of Low Carbon Fuels (henceforth Scenario 2).[62] Updates to assumptions relative to the 2021 Integration Analysis are provided in more detail in the following section.

E3's capacity expansion model, RESOLVE, and loss of load probability model, RECAP, were employed, as shown in Figures 17 and 18. RESOLVE optimizes long-term generation and transmission investments subject to reliability, technical, and policy constraints. RECAP performs loss-of-load probability simulations to determine the reliability of resource portfolios and the contribution from each resource within it. These contributions are measured using the Effective Load Carrying Capability (ELCC) described below. With annual and hourly load projections corresponding to Scenario 2 and ELCCs from RECAP, RESOLVE was used to develop least-cost electricity generation portfolios that achieved New York's Climate Act goals with the new 6 GW storage by 2030 target and meet New York's long term energy needs. [63]

RESOLVE was used in this study to determine the least-cost pathway to meeting New York's electric sector targets, including the requirement under the Climate Act to generate 70% of New York's electricity from renewable resources by 2030 and eliminate greenhouse gas emissions from the state's electricity generation by 2040. Designed specifically to address electric sector capacity expansion questions for systems seeking to integrate large quantities of variable resources, RESOLVE layers capacity expansion logic on top of a production cost model to determine the least-cost approach to achieving renewable resource targets, accounting for both the upfront capital costs of new resources and infrastructure and the variable costs to operate the grid reliably over time. As the nature of electric system loads evolves over time, RESOLVE also captures key changes in demand-side behavior, such as increased flexibility in building loads and electric vehicle charging.

RESOLVE has been configured to capture the operations of the New York electricity system as well as its interactions with neighboring power systems in the United States and Canada. For this study, RESOLVE was configured with nine regions: five internal regions within New York State representing NYISO load zones A-E, zone F, zones G-I, zone J, and zone K; and four regions representing the external markets that have direct ties with New York (ISO-NE, PJM, Hydro-Quebec, and IESO). Within this configuration, RESOLVE optimizes investments only on behalf of the five New York regions while optimizing the integrated operations of the entire system. Conditions and assumptions for the future loads and resources of neighboring markets are specified as inputs. RESOLVE's optimization capabilities allow it to select from among a wide range of potential new resources.

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[62] For details on the Integration Analysis, see: https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan.
[63] For details on the RESOLVE model, see: https://climate.ny.gov/Our-Climate-Act/Draft-Scoping-Plan

Figure 17. Economy-wide Modeling Framework for the Draft Scoping Plan, Starting Point for the Storage Roadmap Modeling

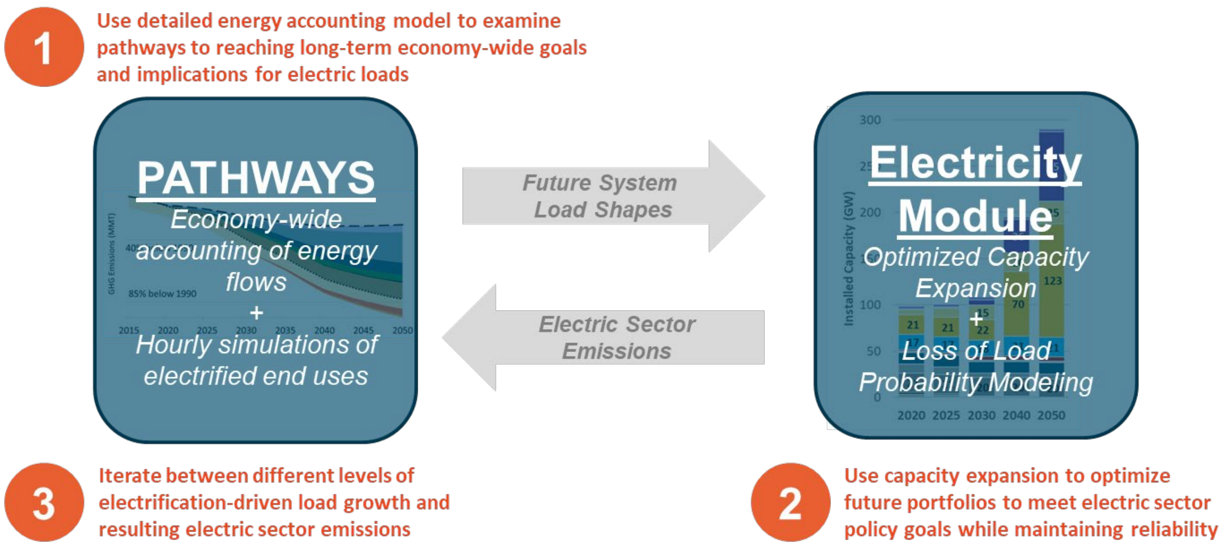
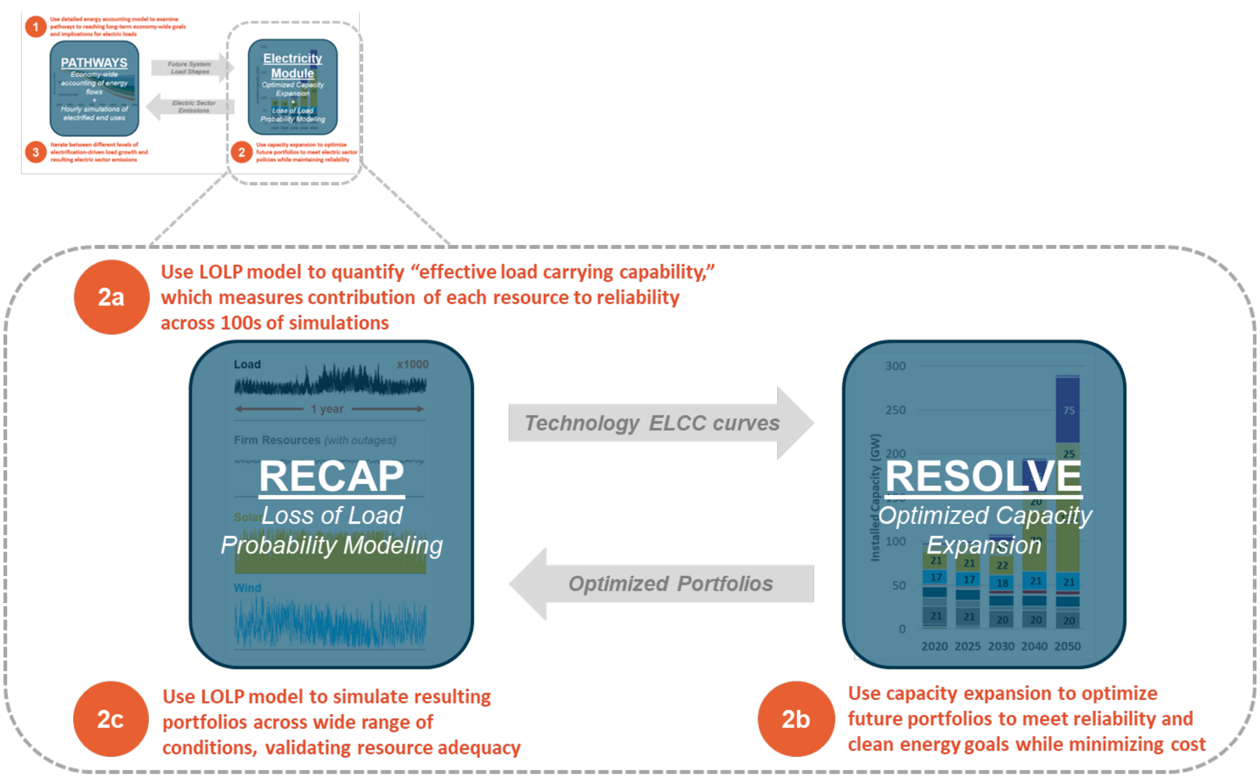


Figure 18. Electricity Sector Modeling Framework for the Draft Scoping Plan, Starting Point for the Storage Roadmap Modeling

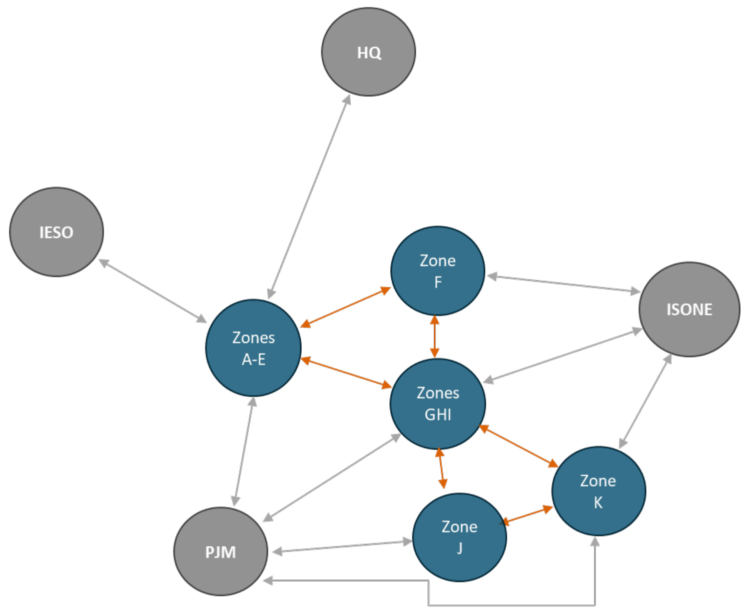


RESOLVE's optimization includes the annual cost to operate the electric system across RESOLVE's footprint; this cost is quantified using a linear production cost model embedded within the optimization.

The following are key components of the RESOLVE model and its representation of the operations of New York's electricity system:

1. **Zonal transmission topology**: RESOLVE uses a zonal transmission topology to simulate flows among New York and its neighbors as shown in . RESOLVE includes nine zones: five zones capturing the New York system and four zones representing neighboring power systems.
2. **Aggregated generation classes**: rather than analyzing each generator within the study footprint independently, generators in each region are grouped together into categories with other plants whose operational characteristics are similar (e.g., nuclear, gas CCGT, gas CT, and fuel oil CT). Grouping like plants together for the purpose of simulation reduces the computational complexity of the problem without significantly impacting the underlying economics of power system operations.
3. **Linearized unit commitment**: RESOLVE includes a linear version of a traditional production simulation model. In RESOLVE's implementation, this means that the commitment variable for each class of generators is a continuous variable rather than an integer variable, which significantly reduces the amount of time the model needs to solve. Additional constraints on each generator class (e.g., minimum, and maximum power output, ramp rate limits, minimum up and down time) are included to represent their operational characteristics and limitations.
4. **Co-optimization of energy & ancillary services**: RESOLVE includes reserve requirements in its generator dispatch, which is co-optimized to meet load while simultaneously reserving flexible capacity within NYISO to meet the contingency and flexibility reserve needs across the New York zones.
5. **Smart sampling of days**: whereas production cost models are commonly used to simulate an entire calendar year (or multiple years) of operations, RESOLVE simulates the operations of the New York system for 30 independent days. Load, wind, and solar profiles for these 30 days, sampled from the historical meteorological record of the period 2007-2012, were selected and assigned weights so that taken in aggregate, they produced a representation of complete distributions of potential conditions. Daily hydro conditions were sampled separately from the period 1970-2016 to provide a complete distribution of potential hydro conditions. This allows RESOLVE to approximate operating costs and dynamics over an entire year while simulating operations over a smaller subset of days.
6. **Reliability consideration:** RESOLVE includes a statewide planning reserve margin (PRM) constraint and local capacity requirements (LCRs) as a function of system and local peaks, consistent with current NYISO requirements. To ensure that the system remains reliable under changing load and resource conditions, the PRM and LCR constraints are applied on an unforced capacity (UCAP) basis and capture the reliability contributions of renewables and storage through ELCC curves developed in RECAP. RECAP performs loss-of-load probability modeling over hundreds of simulated operating years, using 40 years (1979-2018) of weather data to capture linkages between weather, load, and renewable generation conditions.

Figure 19. Transmission Topology in RESOLVE



Key Assumptions

The analysis performed for this Roadmap builds off the 2021 Integration Analysis to examine the potential impacts of the achievement of a 6 GW battery storage target. Detailed assumptions associated with existing and candidate resources, transmission system topology, and system needs over time including load projections for Scenario 2 can be found in the Technical Supplement (Appendix G) of the Draft Scoping Plan.[64] The remainder of this section focuses on updates to input assumptions relative to the 2021 Integration Analysis.

There were several input updates made as part of this 6 GW Storage Roadmap study to reflect the latest market and policy conditions, and to allow for a more detailed examination of the value that battery storage provides to the New York system under different targets and assumptions:

- Updates to battery storage installation cost trajectories
- Incorporation of Inflation Reduction Act tax credits
- Updates to the reliability contributions of 8-hour storage (ELCC)
- Disaggregation of peaking thermal units by technology type

This analysis incorporated updated storage cost projections, particularly in the near term, to account for the recent increase in commodity prices and higher than expected demand for finished products. Costs in 2022-2024 were benchmarked to recent project costs and reflect supply constraints and competition from EVs. Cost declines are assumed to begin in 2025 as manufacturing capacity expands, and benefits of scale and innovation are realized. Current costs are about 10% higher than those assumed in the 2018 Storage Roadmap and about 40% higher than that assumed in the 2021 Integration Analysis. The new "Base" cost forecast converges to the forecast used in the 2021 Integration Analysis by 2035. The "High" and "Low"

[64] https://climate.ny.gov/-/media/Project/Climate/Files/Draft-Scoping-Plan-Appendix-G-Integration-Analysis-Technical-Supplement.pdf

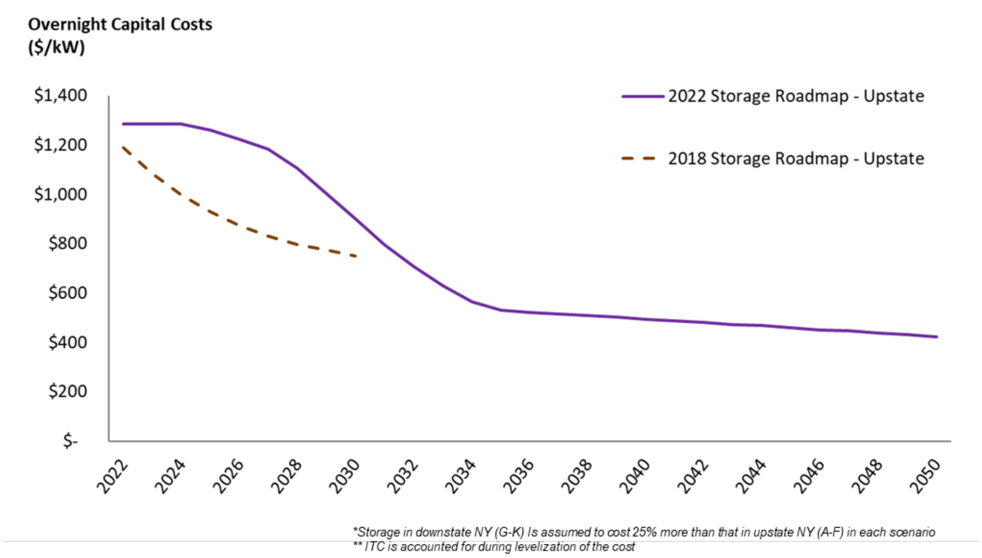
cost trajectories are 20% above and below the "Base" and help account for the significant uncertainty regarding market evolution. The cost trajectories shown in Figure 20 correspond to storage in upstate NY (A-F). Storage in downstate NY (G-K) is assumed to be 25% more expensive.

The costs of building renewable technologies and battery storage were also updated to reflect the tax credits passed in the Inflation Reduction Act in August 2022. This analysis assumes that the tax credits phase down in 2032, with a safe harbor period through 2035, giving storage projects with a COD in 2035 a 27% credit (full 30% ITC adjusted for 90% capture) assuming they begin construction before the ITC expires.

The ELCC of 8-hour storage was also updated to more accurately reflect their reliability value relative to 4-hr storage. In addition, the 2021 Integration Analysis included a single peaker resource in each zone that reflected the contributions of both combustion turbine and steam turbine resources, which was a reasonable approximation given their low utilization. In the Roadmap analysis, CT and ST resources were disaggregated by technology and by region to better account for their differences and perform a more granular examination of the economics of retirement and replacement with storage in RESOLVE.

Each of these updates to input assumptions has also been incorporated into the 2022 Integration Analysis, which will inform the Final Scoping Plan.

Figure 20. Assumed Storage Cost for 4-hr Li-Ion Battery in Upstate NY ($2020/kW)



Benefits and Limitations of Approach

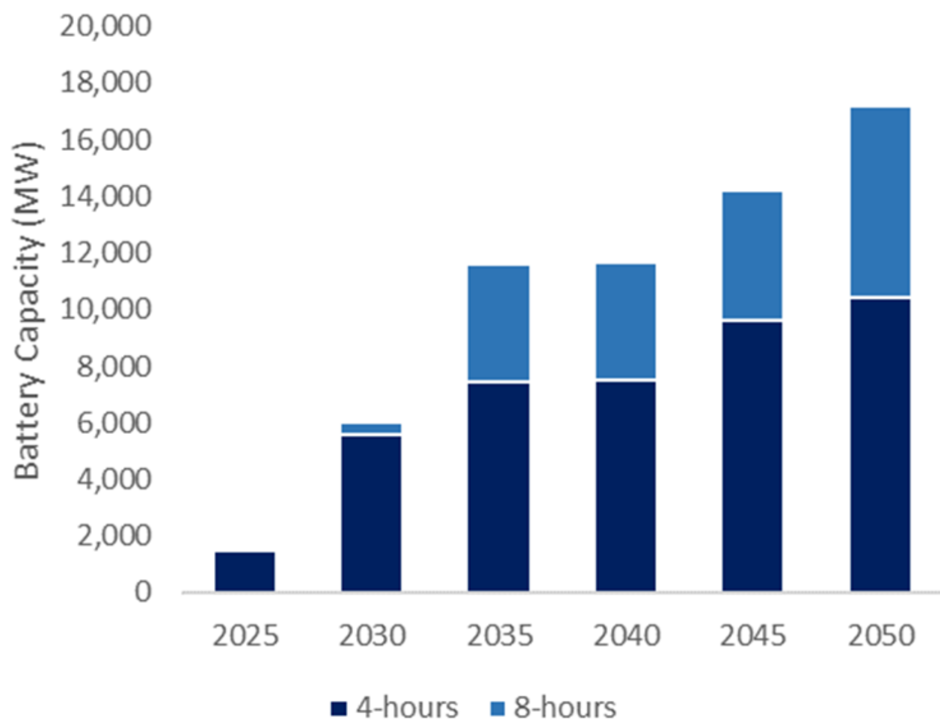
RESOLVE can help identify the optimal location and duration of storage associated with the 6 GW target. Since the modeling period extends to 2050, these decisions are made accounting for longer-term needs. Given the 5-zonal representation, RESOLVE only captures dynamics on the "bulk-system" level. It does not account for local (sub-zonal) system dynamics such as congestion and impacts on the distribution system. The optimal storage duration reported must be taken as an average for the region. Actual duration of any specific project may be less or more than the average based on local requirements.

Results

The base cost trajectory results in state-wide build shown in Figure 21 by duration. Most storage selected until 2030 carries a 4-hour duration. As the penetration of renewable and short duration storage increases on the New York system, the periods of need to get longer. A need for approximately 4 GW of 8-hour storage is identified by 2040. A glide-path is introduced as a result, to require 400 MW of the 6 GW by 2030 to carry 8 hours in duration, increasing to at least 1.6 GW of 8-hr storage by 2035. This glide-path reflects the need for near-term deployment of longer duration storage to spur innovation and learning-by doing. However, the analysis finds that all the 8-hr storage needed in 2040 is economically selected in 2035, to reap the ITC.

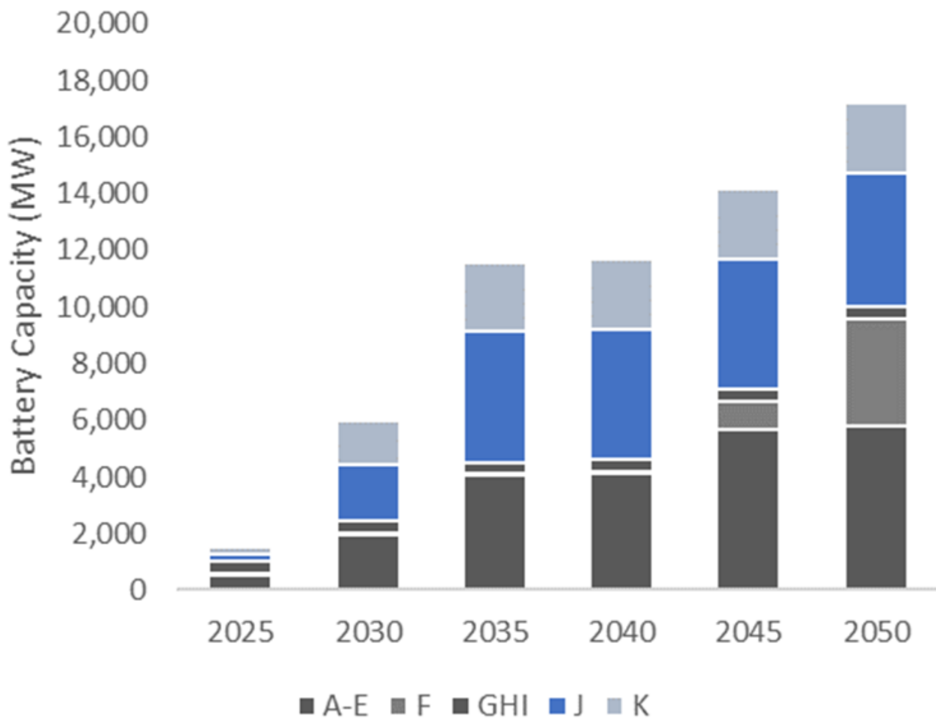
Figure 22 shows the build by location. Energy storage selected in G-K helps meet LCRs and balance offshore wind generation; 4 of the 6 GW in 2030 is placed in G-K. Over 70% of the statewide 8-hr energy storage is placed in J and K in the 2030s as fossil-based generators retire. Energy storage can help balance the abundance of land-based renewable capacity in A-F too. In addition, energy storage in A-F can also help meet the growing statewide PRM requirements more cost-effectively. Thus, more of the energy storage is selected in A-F by 2050; 9.6 of the 17.2 GW by 2050 is selected in A-F. Figure 23 shows the evolution of New York's energy storage fleet over time in terms of capacity, duration, and location.

Figure 21. Storage Build by Duration



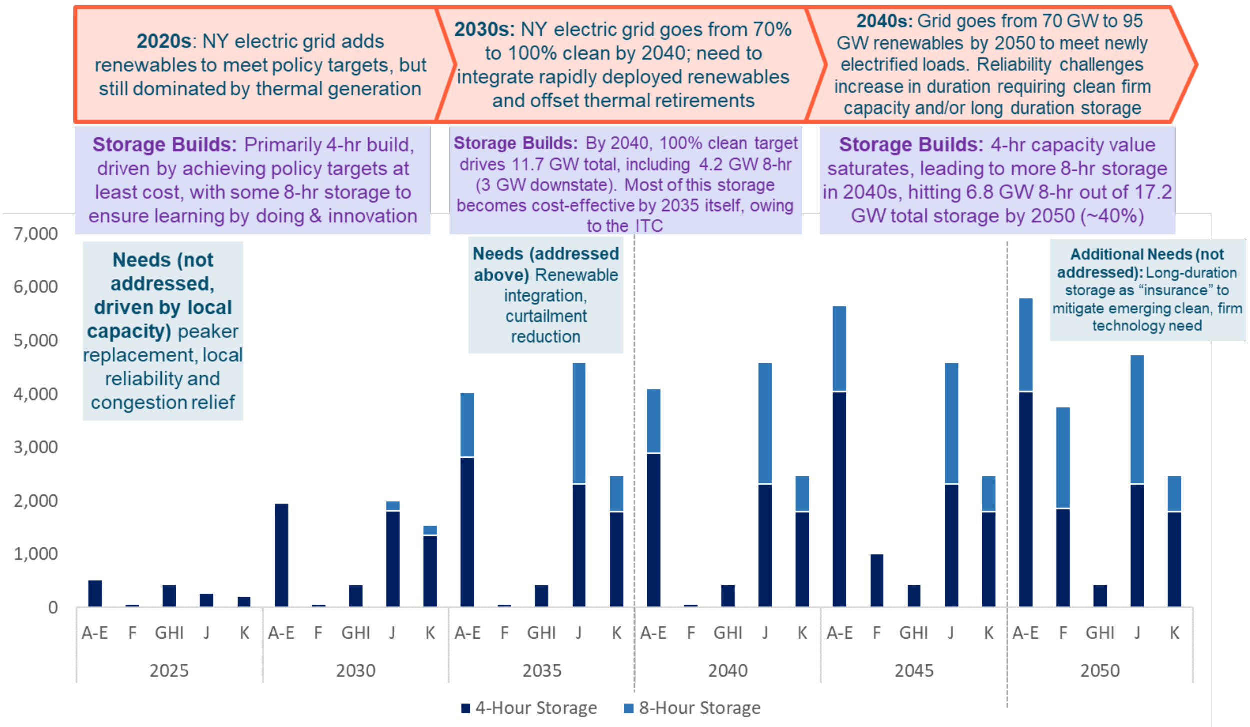
Storage Summary by Duration						
	2025	2030	2035	2040	2045	2050
4-hours	1,500	5,600	7,413	7,486	9,606	10,448
8-hours	0	400	4,179	4,179	4,575	6,761
Total (MW)	1,500	6,000	11,593	11,665	14,181	17,208

Figure 22. Storage Build by Location



Storage Summary by Zone						
	2025	2030	2035	2040	2045	2050
A-E	519	1,954	4,030	4,103	5,663	5,808
F	60	60	60	60	1,016	3,759
GHI	430	430	430	430	430	430
J	275	2,005	4,600	4,600	4,600	4,739
K	216	1,551	2,473	2,473	2,473	2,473
Total (MW)	1,500	6,000	11,593	11,665	14,181	17,208

Figure 23. Storage Build by Duration and Location



A counterfactual "No Storage" scenario retains existing pumped hydro storage facilities but does not permit selection of any battery storage. This counterfactual scenario is a modeling exercise intended to highlight the value of storage for New York.

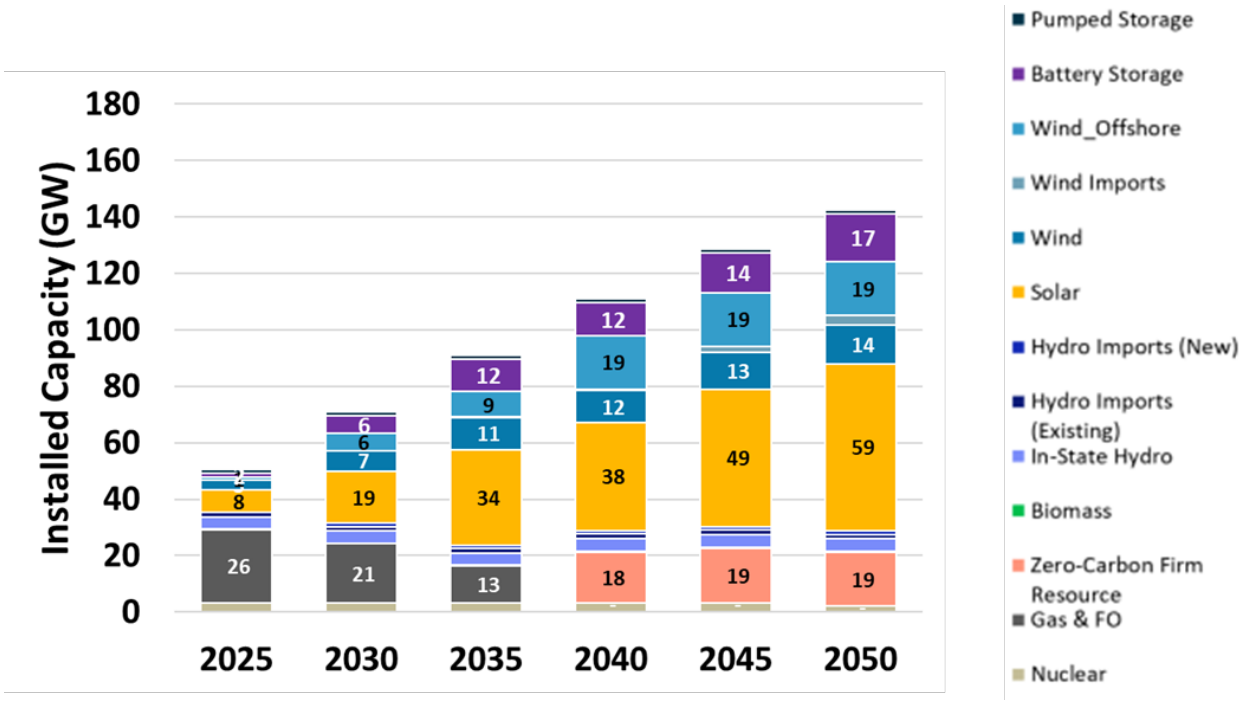
Figures 24 and 25 show the total resource portfolio with and without storage, respectively. In the absence of any battery storage throughout the study period, there is a reduction in solar capacity of 10 GW, which is partially offset by 4 GW more wind capacity. Wind output is better aligned with electrified heating loads that peak in winter mornings and evenings, and as a result is not as reliant on storage for intraday shifting. Of the renewable energy that remains, more energy is curtailed (3.8% without storage and 0.9% with storage by 2050). Note that this estimate is close to a lower bound of potential curtailment, given RESOLVE does not capture local transmission constraints and congestion.

The absence of storage as an available resource in the "no storage" scenario leads to a higher reliance on more expensive and uncertain firm zero-carbon technologies/fuels, represented by hydrogen-based resources in this analysis. In the absence of storage, there are significantly higher levels of hydrogen-based capacity added to the system, increasing from 19 GW to 35 GW by 2050. In addition to the increase in capacity build-out, there is also higher demand for hydrogen fuel, and a quadrupling of hydrogen burnt, from 27 to 107 TBtu, is also observed in 2050 in the absence of battery storage. This increase in hydrogen consumption also has implications for the amount of delivery and storage infrastructure required to support the higher reliance on hydrogen in the electric sector. Figure 26 shows curtailment and hydrogen consumption in the presence and absence of storage.

While the procurement of 6 GW to achieve the 2030 target increases costs slightly in the near term, storage provides meaningful net costs savings for the New York electricity system over the study period.

Driven by the cost-effective integration of renewables and reductions in firm zero-carbon capacity discussed above, the analysis finds that storage yields a net saving of $1.94B over the period to 2050 (2022 net present value).[65] Quantification of societal benefits in the analysis was limited to those reflecting avoided electricity system expenditures. Further important storage benefits have not been quantified, including those resulting from reductions in emissions of harmful pollutants such as SO_x, NO_x and PM 2.5. In addition, storage also provides a critical hedge against significant uncertainty surrounding both the availability and costs of firm zero-carbon technologies and fuels that are not yet commercially available at scale. While continued operational experience with Li-Ion battery storage is key, it is a commercially available technology that has the potential to act as insurance if novel technologies do not materialize as expected.

Figure 24. Total Resource Portfolio



[65] A real discount rate of 3.6% is used to calculate net present value.

Figure 25. Total Resource Portfolio: No Storage Counterfactual

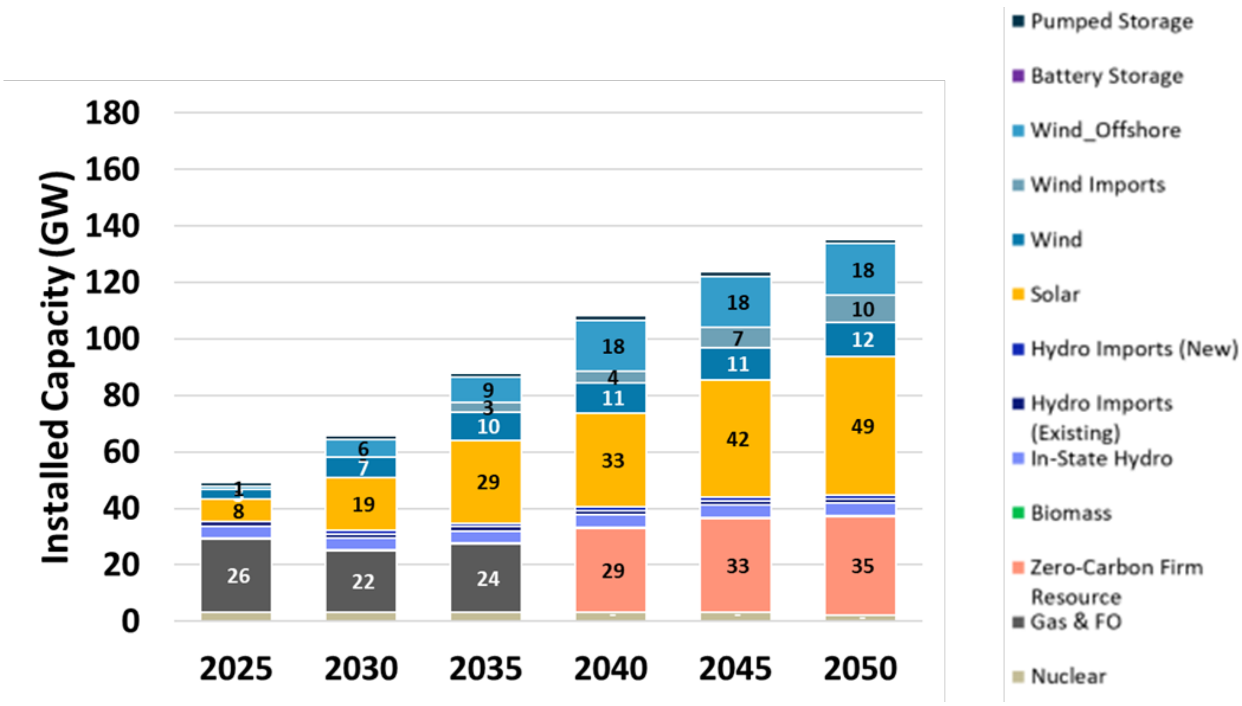
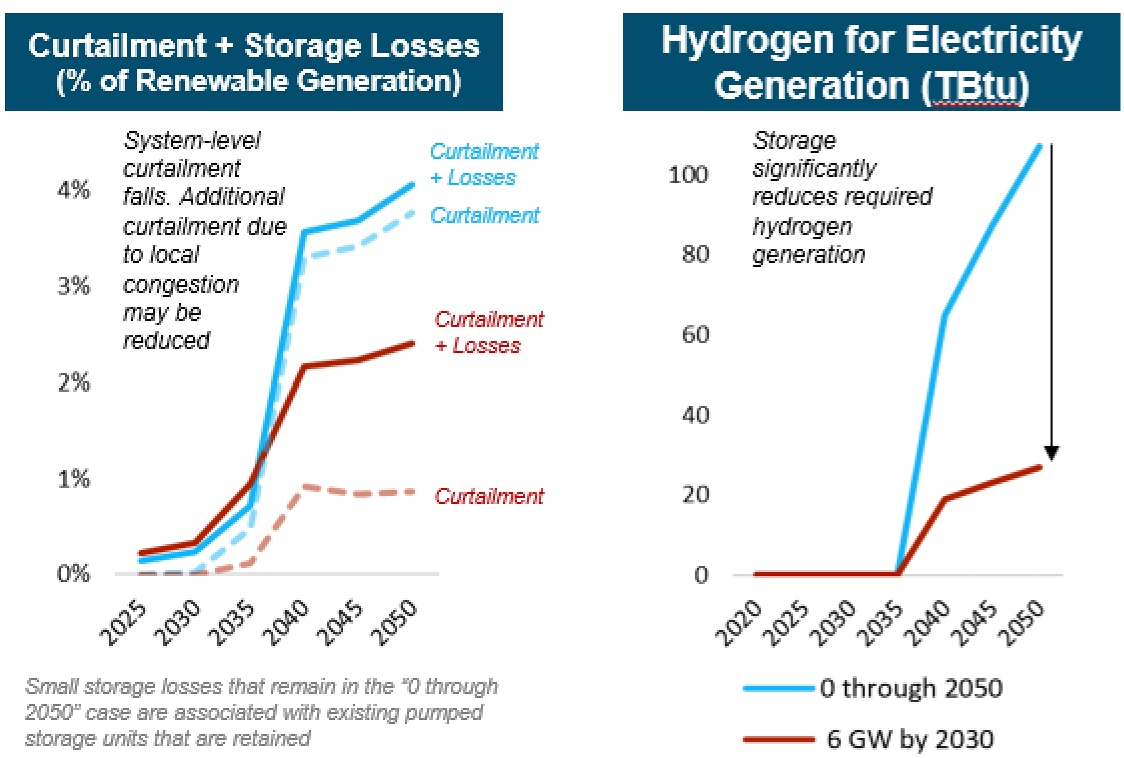


Figure 26. Impact of Storage on Curtailment and Hydrogen Consumption



In addition to enabling energy arbitrage, energy storage also provides significant capacity value to the system by discharging in challenging hours. ELCC curves calculated for 4-hr storage in 2050 using RECAP are shown in Figure 27. The incremental ELCC curve shows the ELCC that each incremental tranche of storage would get without accounting for interactive benefits with solar. For context, the average ELCC curve is also shown which is the ratio of the cumulative ELCC to the cumulative nameplate at any given point on the curve. Figure 28 shows the marginal ELCC of 4-hr storage with no solar and with 50 GW of solar on the system. The difference between the two curves is the interactive benefit associated with having both solar and storage on the system. Such curves were generated at different solar penetrations and input into RESOLVE to accurately account for the capacity value and potential diversity benefit between these resources. These curves are also scaled in RESOLVE in proportion to the peak load as it changes between now and 2050. 8-hr storage ELCC was represented as twice the 4-hr storage ELCC without solar, capped at 100%.

Figure 27. Average and Incremental ELCC for 4-hr Storage in 2050 Developed by E3 for Integration Analysis

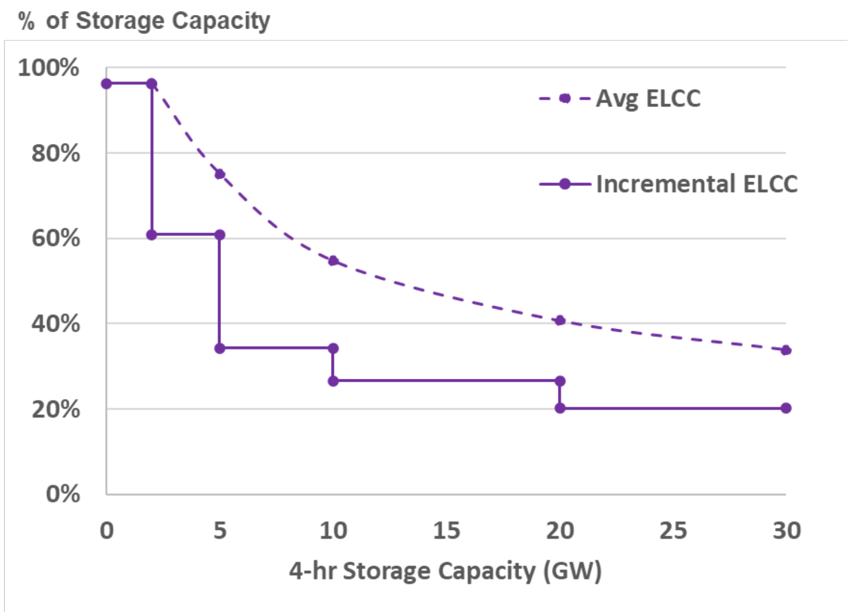
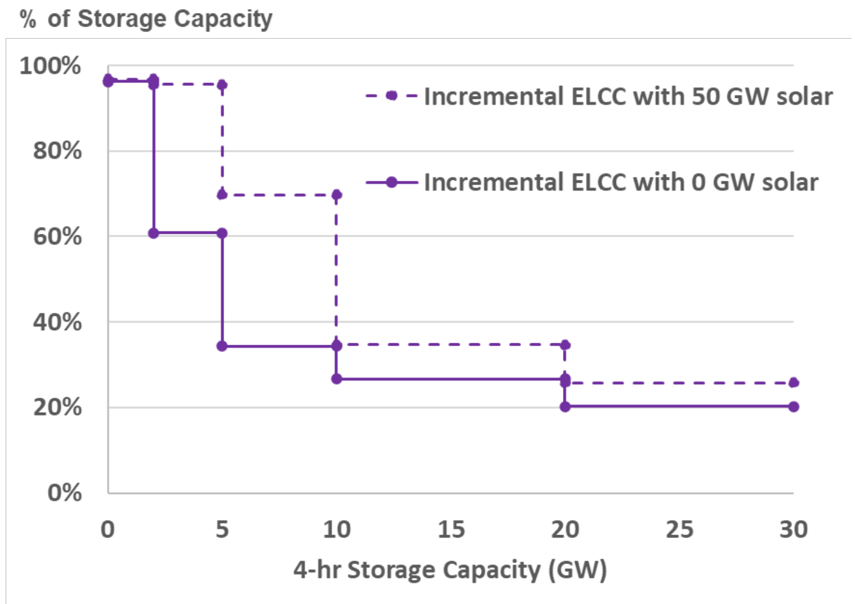


Figure 28. Incremental ELCC for 4-hr storage in 2050 with and without solar developed by E3 for Integration Analysis



As shown in Figure 29, energy storage provides 12% of the statewide PRM requirement by 2030 increasing to 30% by 2050. Figure 30 shows resource contribution towards meeting LCRs. The requirement and resource contributions in the figure are shown in effective capacity (ELCC) terms accounting for derates associated with forced outages, resource unavailability due to weather or lack of charge, etc. In the 2030 timeframe, New York is projected to be long on capacity and the primary capacity value exists in New York City and on Long Island to replace aging fossil-based steam turbine peaking units. However, recent energy storage cost increases and diminishing ELCC make economic replacement of larger portions of the thermal fleet based on capacity value alone challenging, as highlighted in Figure 31. Nevertheless, energy storage has the potential to provide significant capacity value in the long run owing to the increase in peak loads with electrification and potential age-based thermal retirements. Partially counteracting diminishing ELCC value as storage penetration increases, the economics of storage relative to thermal resources will improve over time on an installed cost basis, as energy storage costs fall and remaining thermal resources need to be retrofitted to rely on hydrogen and/or new, expensive forms of zero-carbon firm resources are needed.

Figure 29. Effective Capacity Contribution by Resource Type Towards State-wide PRM: 6 GW Storage Roadmap

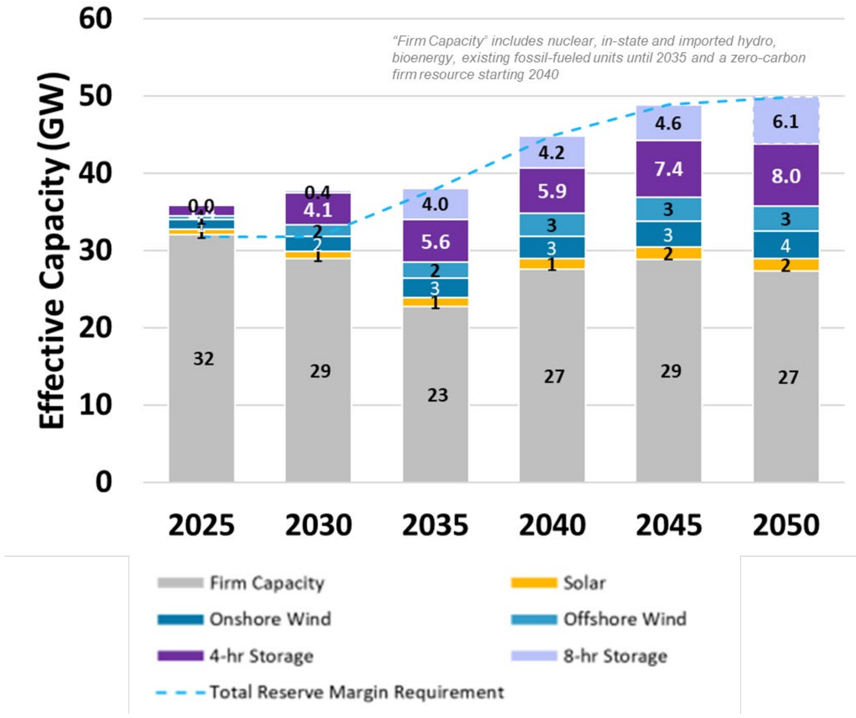


Figure 30. Effective Capacity Contribution by Resource Type towards LCRs: 6 GW Storage Roadmap

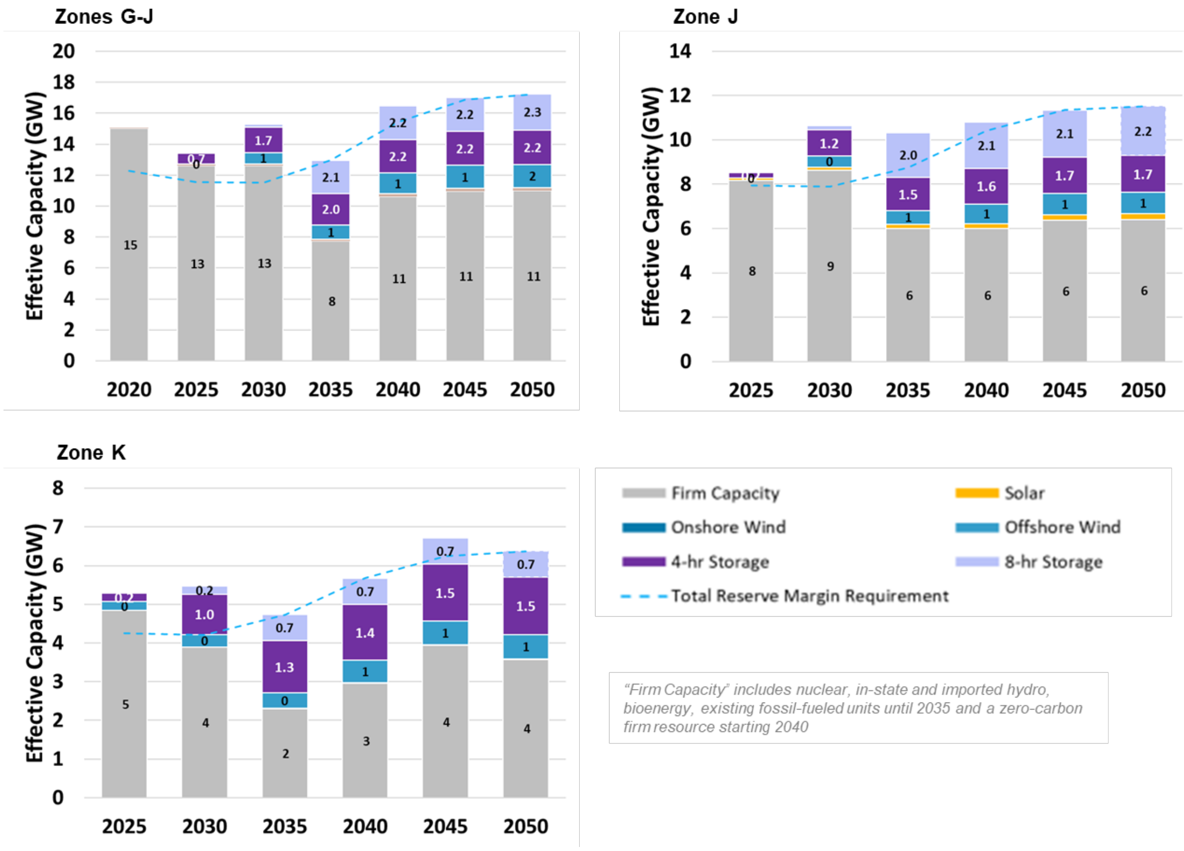
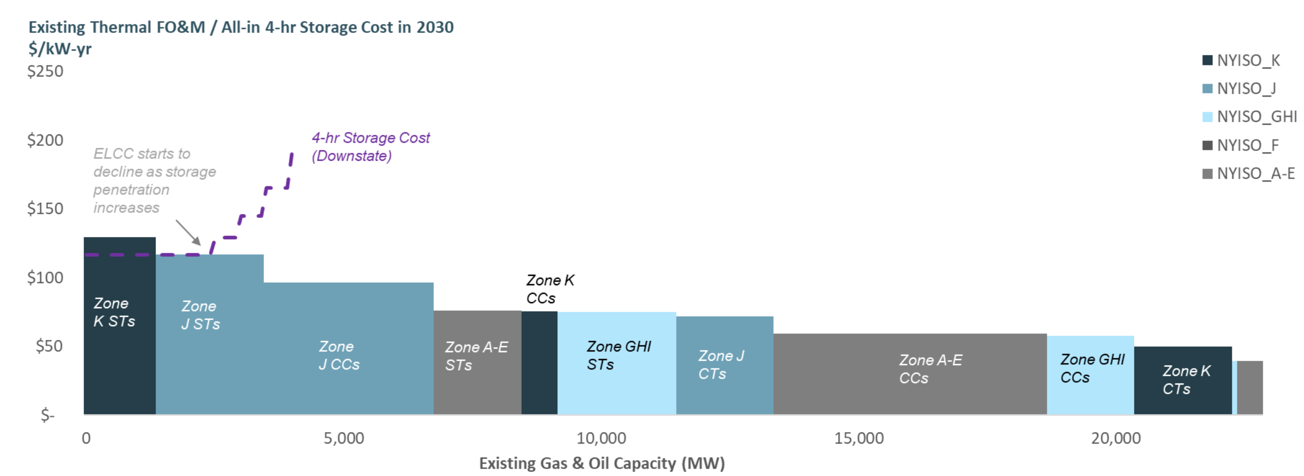


Figure 31. Cost of Effective Capacity from Existing Thermal Resources and Storage in 2030



Results: Load Flexibility Sensitivities

Customer load shifting can provide many of the same flexibility attributes as battery storage, by enabling reductions in peak demand, and shifting demand to times of high renewable output. As a result, there are direct impacts of lower or higher amounts of end use flexibility on the economics of battery storage. In the base case, 12.5% of the light duty EV charging load is assumed to be flexible by 2030, increasing to 25% by 2050. In addition, 50% of the hydrogen required economy-wide is assumed to be generated via electrolysis within New York, and this electrolysis load is assumed to be highly flexible as well to make the most of excess renewable energy when it exists. These assumptions are consistent with those made in the Mitigation cases in the 2021 Integration Analysis. In the absence of flexible EV charging and electrolysis, 2 GW more storage may be cost-effective by 2050. In the absence of storage, an equivalent amount of firm capacity would be needed. The presence of energy storage also helps more than halve the curtailment that exists when load flexibility and storage are both absent.

Figure 32. Impact of Load Flexibility on Storage Need

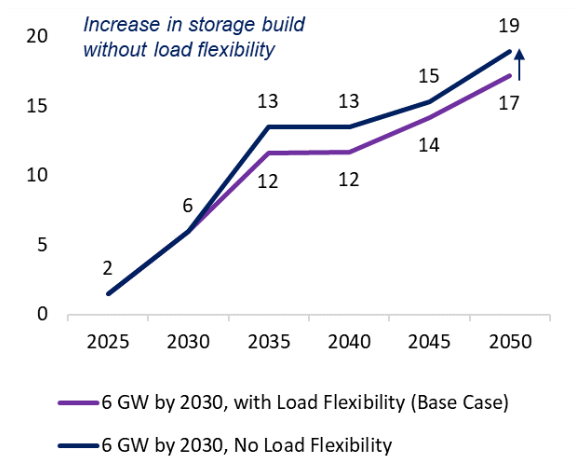


Figure 33. Impact of Storage and Load Flexibility on Curtailment

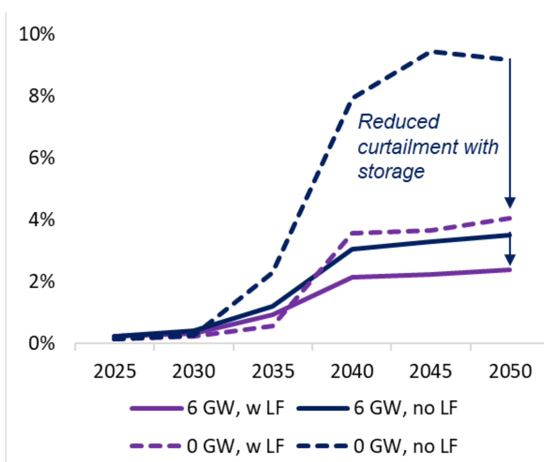
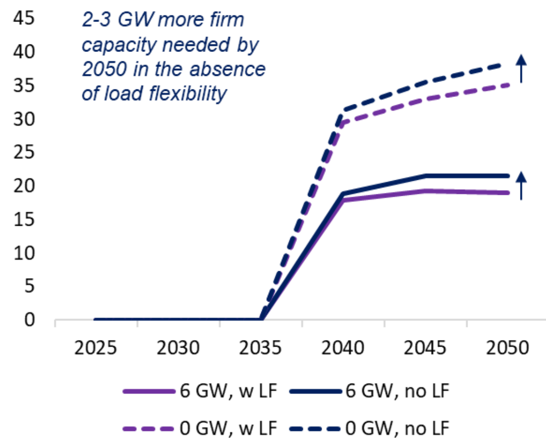


Figure 34. Impact of Storage and Load Flexibility on New Firm Capacity Need



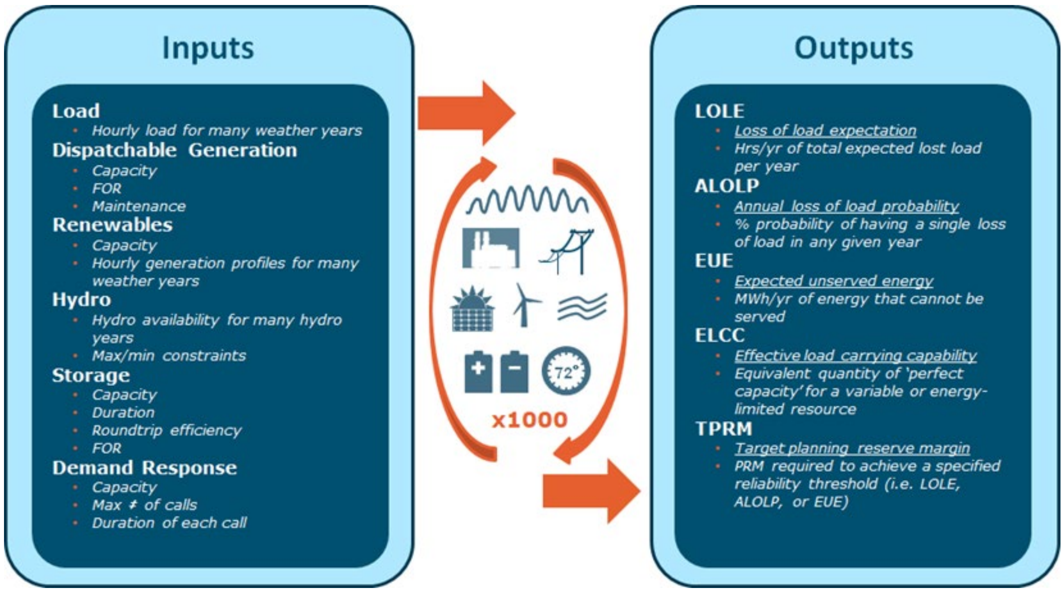
A.2. Loss-of-Load Probability Modeling in E3's RECAP

E3 relied on its Renewable Energy Capacity Planning Model (RECAP) to evaluate the potential for long-duration energy storage to replace firm capacity within the model. RECAP is a loss-of-load-probability model designed to evaluate the resource adequacy of electric power systems, including systems with high penetrations of renewable energy and other dispatch-limited resources such as hydropower, energy storage, and demand response.

RECAP evaluates resource adequacy through time-sequential simulations of hundreds of years of plausible system conditions to calculate a statistically significant measure of system reliability metrics as well as individual resource contributions to system reliability. The modeling framework is built around capturing correlations among weather, load, and renewable generation. RECAP also introduces stochastic forced outages of thermal plants and transmission assets and time-sequentially tracks hydro, demand response, and storage state of charge. This study used 40 years (1979-2018) of historical weather data in New York to inform the correlations between weather, loads, and renewable generation conditions represented in RECAP.

Figure 35 provides a high-level overview of RECAP including key inputs, Monte Carlo simulation process, and key outputs.

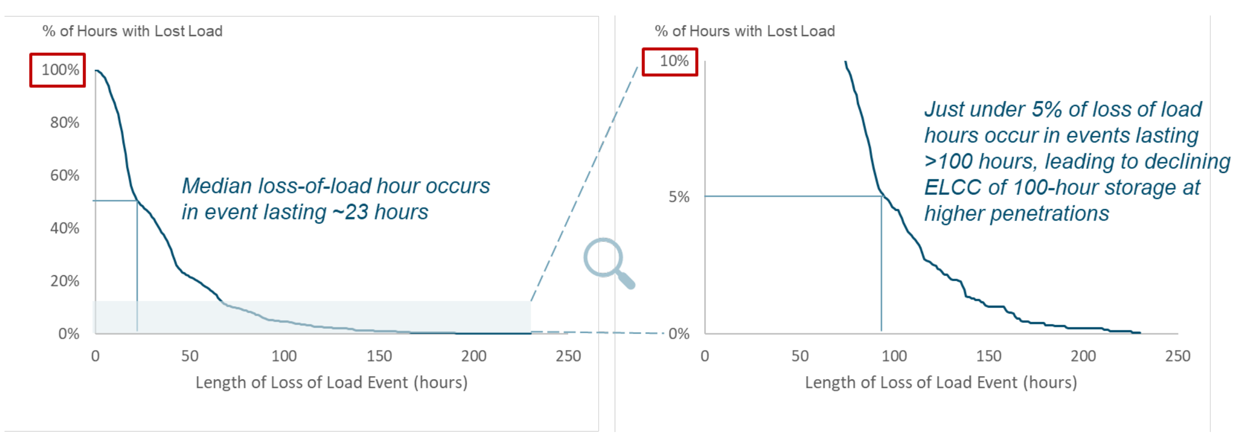
Figure 35. RECAP Model Overview



Results: Reliability Challenges and the Role of Long Duration Storage

To examine the characteristics of loss of load events, a reliability analysis was performed by first removing firm capacity from the system; in other words, an under-reliable system was modeled to examine the reliability challenges and the resources that could meet system needs. Without some form of zero-carbon firm capacity or LDS, loss of load events would grow deeper and could span over multiple days during periods of low solar and wind output. In the absence of firm capacity or LDS, and without additional renewables to generate hydrogen or charge the LDS, the median loss-of-load event would be ~23 hours and many events would last over several days. The cumulative distribution of loss of load event duration under such conditions is shown in Figure 36. This distribution curve of an under-reliable New York system (with significant capacity removed from the system for this analytical exercise) provides insight into the characteristics of resources needed to bring the system back to its reliability criteria.

Figure 36. Cumulative Distribution of Loss of Load Event Duration in the Absence of Firm Capacity and Long Duration Storage



Short to medium duration storage (4-8 hours) primarily helps with intra-day balancing, as illustrated in Figure 37. In this spring week, energy storage helps reduce curtailment by charging with excess renewable output and then discharges it in hours with low renewable output. However, during weeks with persistently high load and low renewable output, one of which is highlighted in Figure 38, 4–8-hour energy storage is insufficient. Energy storage systems will quickly be depleted and, without opportunities to recharge, will fail to maintain reliability, consistent with the length of reliability events identified in Figure 36 as well. Zero-carbon firm capacity on the order of 18-19 GW is identified to maintain reliability in such times. This firm resource is modeled as a hydrogen gas turbine in RESOLVE but could be one or a combination of several different emerging technologies.

Additional analysis was performed on one such emerging technology in RECAP, modeling a 100-hr battery with 50% RTE. The analysis finds that 24 GW of this 100-hr battery storage and 25 GW of in-state renewables (4-14 GW incremental in-state renewable capacity) can satisfy the reliability need otherwise satisfied with hydrogen-fueled resources, as shown in Figure 39.

Figure 37. Hourly Dispatch with 4–8-hour Storage over a Typical Spring Week in 2040

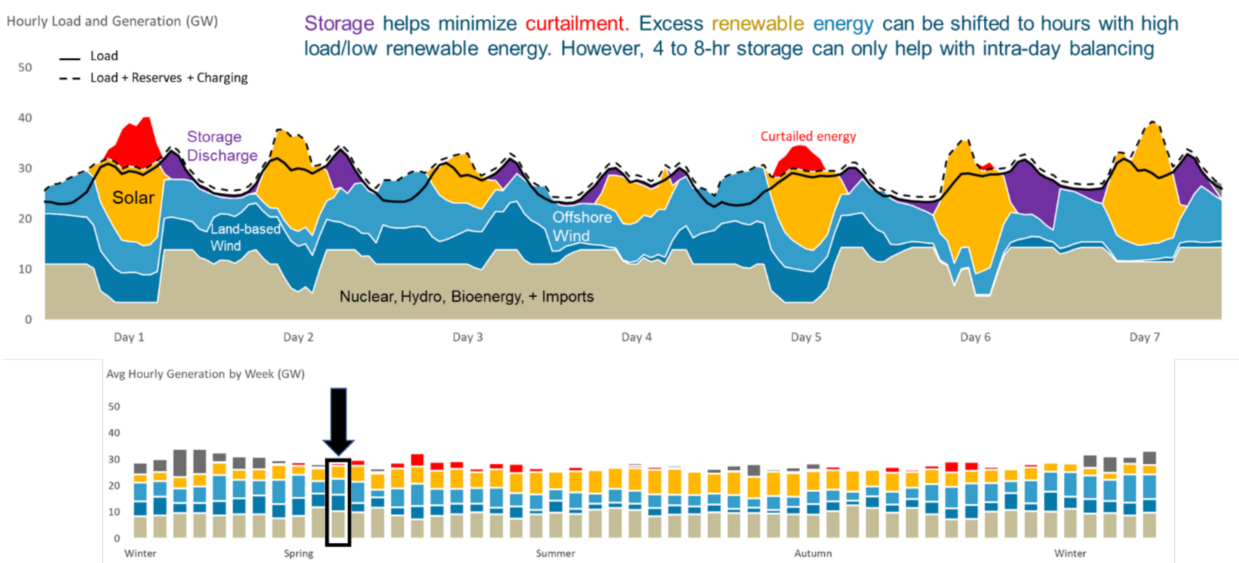


Figure 38. Zero Carbon Firm Capacity Need over a Challenging Winter Week in 2040

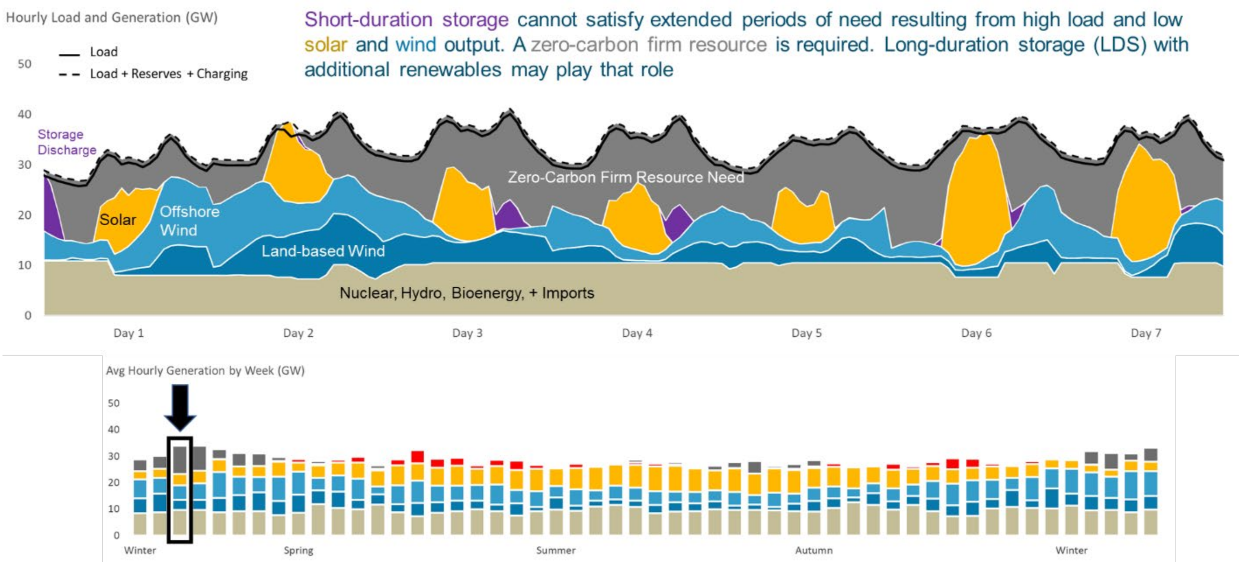
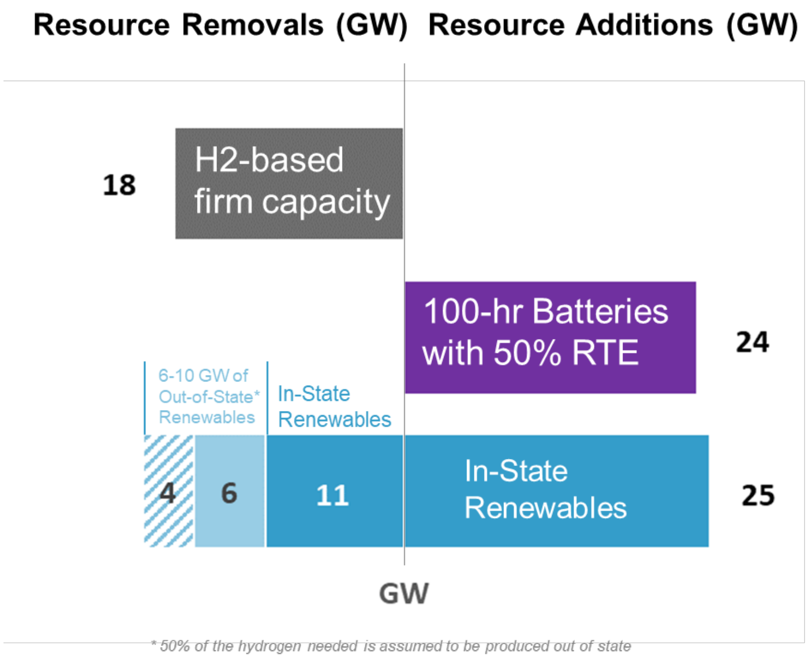


Figure 39. Long-Duration Storage and Renewables Additions to Replace H2-based Firm Capacity in 2040

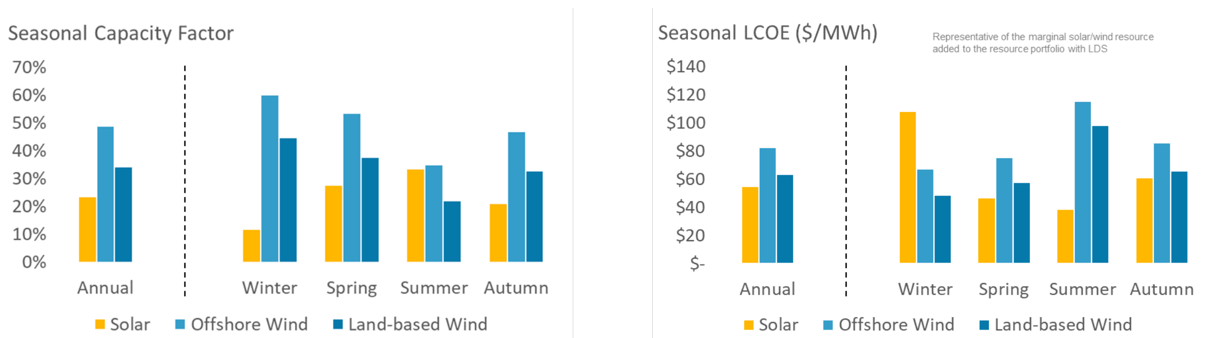


Since solar, land-based, and offshore wind output all vary over a year, the optimal mix of renewables to complement LDS depends on the timing of the system need and the duration of LDS. With seasonal storage, a renewable resource can provide charging energy at any point over the course of the year; the longer the duration of storage, the greater the system's ability to charge from the cheapest form of energy whenever it exists across the year and shift it to critical periods. With shorter duration storage resources (i.e., 100-hour), renewable resources need to provide charging energy during or in between critical periods, such as to get through multiple challenging weeks in a single winter.

Solar output is highest in the summer and lowest in the winter, and wind output is complementary to solar, as shown in Figure 40. With seasonal storage (1000+ hours), the availability of a specific resource during critical weeks – or in between multiple critical weeks in a season matters less; instead, the cheapest form of energy, such as solar in the spring and summer, can be stored and discharged over multiple winter weeks.

In the challenging weeks highlighted in Figure 41, output is lower than average while wind output is at or above average. As a result, although solar is cheaper on average over the course of the year, 100-hr storage needs to be paired with more expensive land-based or offshore wind, which can both directly meet load and be used to recharge storage between multiple critical weeks in this period. Figure 42 illustrates how the 100-hr storage with added renewables can fill the firm-resource need in the week highlighted in Figure 41.

Figure 40. Variation in Solar and Wind Generation over a Year



Notes: "Seasonal LCOE" is defined as the LCOE of the resource if its annual capacity factor was instead equal to the capacity factor in that season. For example, the Winter LCOE of solar is (Total costs) / (~10% * 8760), if the capacity factor of solar over the winter is 10%.These figures are intended to illustrate the underlying economic dynamics at a high level, but they do not capture the full complexity of loss-of-load probability analysis and portfolio optimization to ensure system reliability is maintained over many years of weather conditions.

Figure 41. Solar and Wind Generation in Challenging Winter Weeks

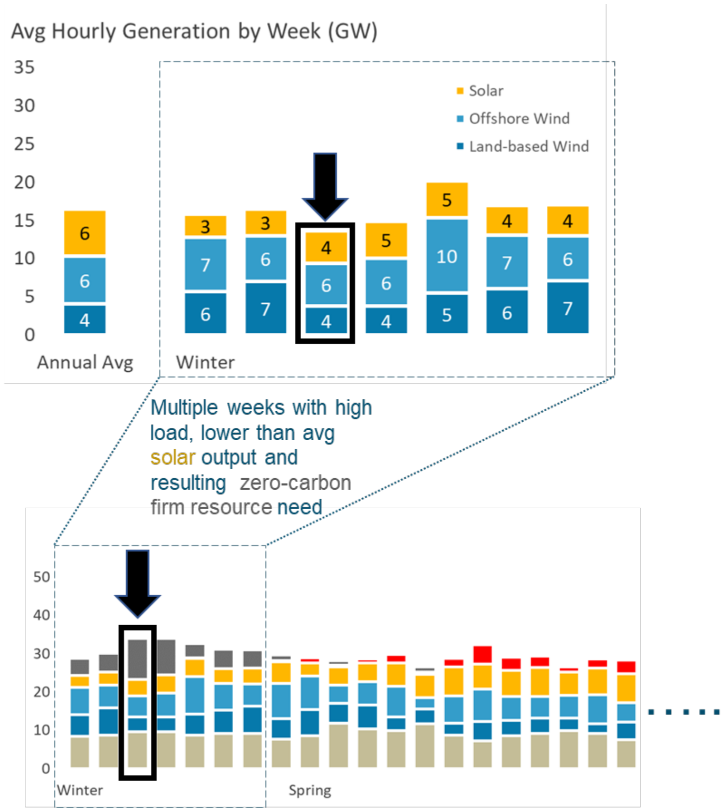
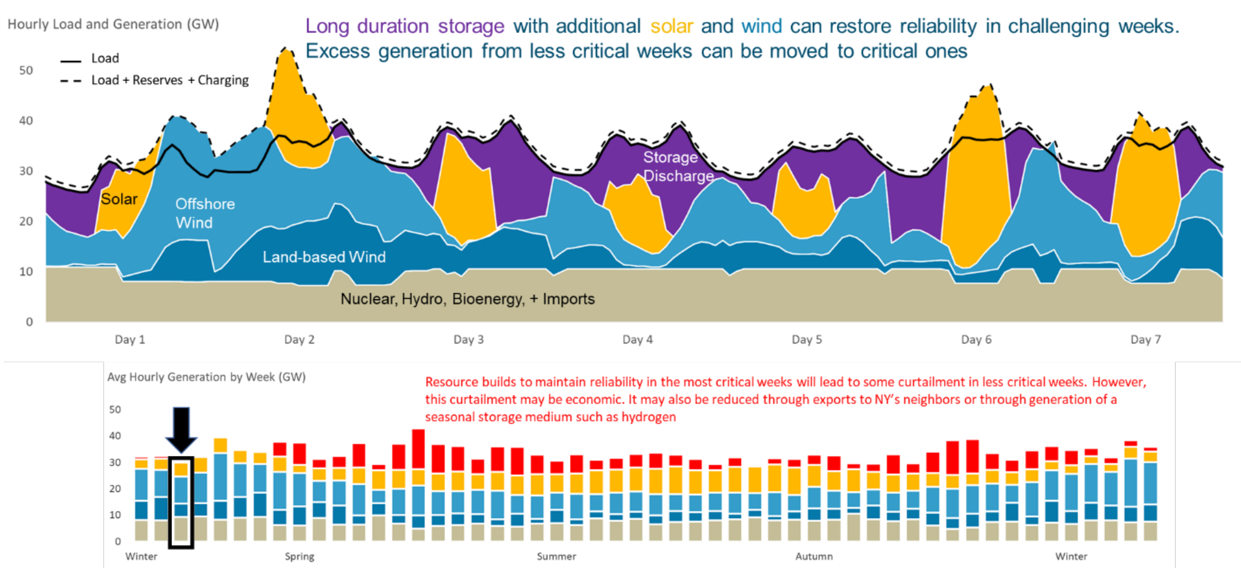


Figure 42. Utilization of Long Duration Storage and Additional Renewables to Maintain Reliability over a Challenging Winter Week in 2040

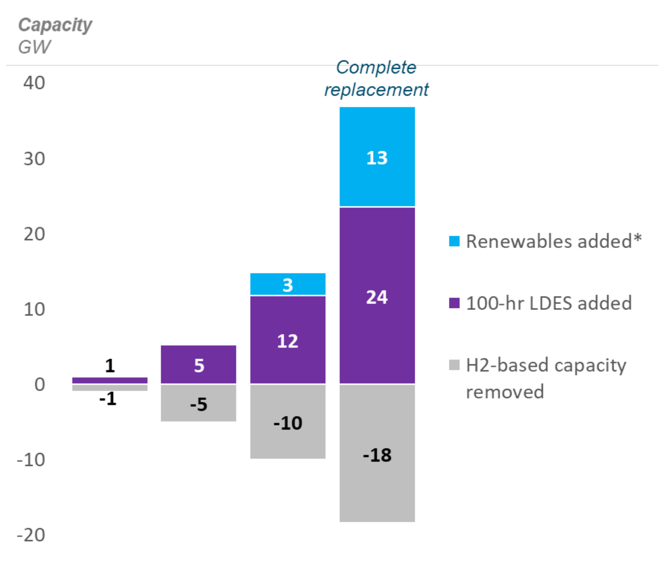


Results: Partial Replacement of Firm Capacity with Long Duration Storage

The amount of 100-hr storage with a 50% RTE and additional renewables required to completely replace the hydrogen-based firm capacity from the base case portfolio in 2040 is shown in Figure 38. Additional analysis was conducted to quantify the amount of LDS and renewables needed for partial replacement of such firm capacity. Figure 43 shows the resource additions needed for replacement with 100-hr storage. Up to 5 GW of 100-hr storage may substitute hydrogen-based firm capacity on a 1:1 basis from a reliability perspective. Sufficient renewables exist on the system to charge this storage while leading up to critical periods, requiring no further additions. When 10 GW or more of firm capacity is removed, the duration of loss of load events increases, and the excess energy leading up to and between subsequent critical periods declines too, making replacement with 100-hour storage more challenging. As a result, the reliability value of 100-hr storage with a 50% RTE thus declines and a more than 1:1 replacement with firm capacity is needed. Additional renewables are also needed that can both directly meet load, to mitigate loss of load, and be stored, when in excess, leading up to critical periods.

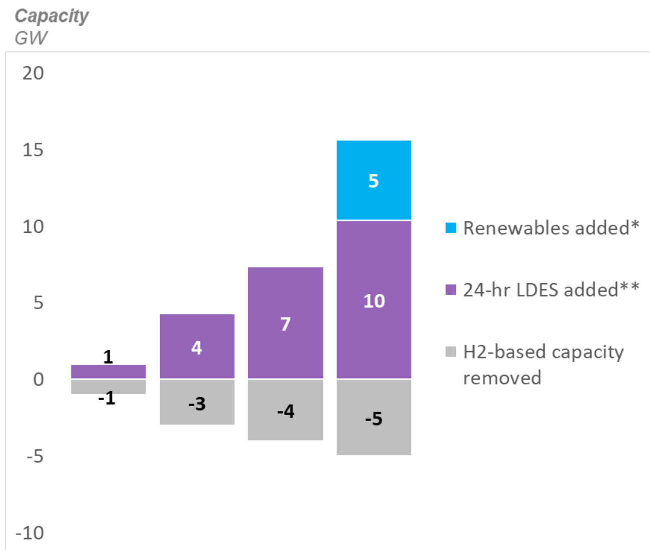
Figure 44 shows the resource additions needed for replacement with 24-hr storage with a 60% RTE, based on technologies still within research and development phases. Given the lower duration relative to the length of reliability events, smaller amounts of firm capacity can be replaced 1:1 from a reliability perspective. Replacing 5 GW or about 30% of all firm capacity in the base case would require twice the amount of 24-hr storage and 5 GW of additional renewables. Complete replacement of firm capacity with 24-hr storage would require significant overbuild.

Figure 43. Resource Additions Needed for Partial Replacement of Firm Capacity with 100-hr storage



* Represents solar and wind capacity required incremental to that for in-state hydrogen production

Figure 44. Resource Additions Needed for Partial Replacement of Firm Capacity with 24-hr Storage



* Represents solar and wind capacity required incremental to that for in-state hydrogen production
** 24-hour LDES technology is different than the 100-hour LDES technology modeled

Appendix B. Storage Program Cost Analysis

This Appendix summarizes the inputs, assumptions, and analysis methodology underpinning the estimates of incremental program costs associated with achieving the proposed 2030 target of 6 GW of short-duration storage, as presented in Section 3 of this Roadmap. Key assumptions related to each program (bulk, retail, residential) are outlined below. A discount rate of 5.98% (nominal) is applied to payments in future years, so that costs are presented as the net present value in 2022 dollars, as this is when programs are expected to launch.

B.1. Bulk Storage

For the proposed bulk storage procurement program, program costs are calculated as the incremental revenue, on top of revenue that storage assets can realize through commercial operation in the existing energy markets, that would allow such assets to reach their cost of capital. This methodology is broadly consistent with that applied to cost studies under the Clean Energy Standard.[66] Key assumptions and inputs include the costs of storage projects, the estimates of market revenue available to them, available federal incentives and the cost of capital.

Storage asset cost assumptions are discussed in Appendix A ("Key Assumptions"). Additional storage asset assumptions for the cost analysis are summarized below:

- Federal incentives are assumed at a level of a 30% Investment Tax Credit of which 90% is assumed to translate to a reduction of capex.
- The weighted average cost of capital (WACC) was assumed to be 5.77%, a 100-basis point reduction from the 6.77% WACC previously utilized in the 2021 Integration Analysis.[67] This WACC reflects a 65/35 debt/equity split in 2030, reflecting the expected evolution of capital markets for storage over time. The reduction of 100 basis points (1%) in WACC was assumed compared to storage projects that would operate based on merchant commodity revenue to reflect the reduced risk exposure of projects as a result of the hedging characteristics of the proposed Index Storage Credit structure as discussed in Section 5, broadly consistent with the findings in this respect in NYSERDA's earlier analyses relating to the Index OREC and Index REC procurement structures used for offshore wind and onshore large-scale renewables.[68]

[66] https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Clean-Energy-Standard/CES-whitepaper.pdf

[67] The 2021 Integration Analysis utilized WACC estimates based on public sources (NREL ATB 2020 and Lazard) combined with extrapolation based on expected market evolution.

[68] Offshore Wind Policy Options paper (https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Biomass-Solar-Wind/Master-Plan/Offshore-Wind-Policy-Options-Paper.pdf) and NYSERDA Comments on the AWEA/ACE NY Index REC Petition (https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={071DDB6B-A3AA-404C-B931-97284FEC9B6E}).

Revenue Assumptions

The level of commodity or market revenue available to storage assets reflects assumptions of developer participation in wholesale markets and projections of wholesale market revenue streams. The analysis projects three primary commodity revenue streams for storage assets: energy arbitrage, ancillary service and capacity revenue. Projects were modeled as participating in these markets for the duration of their project life, which is assumed to match the Index Storage Credit contract term of 15 years. Market price forecasts are taken from internal forecasts prepared by NYSERDA's Large-Scale Renewable team, based on independent third-party long-term energy price projections, consistent with the range of commodity price forecasts most recently used in NYSERDA's CES Tier 1 solicitation. Storage marginal capacity value reflects the modeling described in Appendix A and is designed to mimic NYISO's expected capacity accreditation methodology.

Energy Arbitrage Margins

A storage project receives revenue in the energy markets by charging at times of low energy prices and discharging at times of high energy prices, referred to as arbitrage. A storage project may choose to pursue energy arbitrage revenue in the day ahead market (by committing to discharge times ahead of time) or in the real-time market (responding to real-time energy prices).

To estimate energy arbitrage margins (historical day ahead, real time, and projected day ahead), it was assumed a battery could cycle up to once per day - charging at the day's lowest price hours and discharging at the highest priced hours; this is an acceptable operational assumption if all the charging hours precede the discharge hours on most days. To ensure that a battery would derive a positive margin from each price spread opportunity, round trip efficiency was factored into the volume of energy bought during the charging hours; in order to discharge 1 MWh in an hour, a battery would need to buy 1.15 MWh (1/RTE) during a charge hour. Only price spread opportunities that yielded positive margins (Discharge Price [$/MWh] * 1 [MWh] – Discharge Price [$/MWh] * 1.15MWh) were aggregated in the daily margin calculation. Lastly, augmentation of battery energy capacity was assumed to occur in the background and is accounted for in the fixed operations and maintenance cost of the battery.

For each zone within NYISO, historical day-ahead (hourly) and real-time (5 min averaged into hourly) energy prices were derived from the NYISO OASIS website.[69] From these historical prices, future prices over the lifetime of projects were escalated in line with the market price forecasts referenced above. Projected real-time (RT) energy margins were estimated based on the DA margins combined with the recent historical average premium in RT energy margins relative to day-ahead (DA) energy margins.

After aggregating the margins on an annual basis, participation factors are used to estimate what portion of the full energy arbitrage opportunity a battery realizes given participation in other services. For purposes of estimating potential developer "Strike Price", the analysis assumed that developers participate 50% time in the DA market and 50% in the real time market. The low and high bounds of the program cost estimate assume energy prices, and therefore the resulting margins, are 15% higher and 15% lower than the base estimate, respectively.

[69] NYISO: Open Access Same-Time Information System. http://mis.nyiso.com/public/

Ancillary Service Margins

Historical day-ahead (hourly) ancillary services prices were also sourced from the NYISO OASIS website for Regulation and 10-minute spinning reserves and held constant into the future. Future potential storage revenues from these services are discounted based on the assumption of 50% storage participation in this service, the percentage of the day available to participate in this service (16 hours for 4hr storage and 8 hours for an 8hr asset), and a “market clearance” rate reflecting that only a subset of batteries will clear in the ancillary market due to their relatively small size compared to the amount of installed capacity that can offer these services. The clearance rates decrease over time (especially for regulation) proportionally to ratio of ancillary product market size and assumed battery storage build. The low and high bounds of the budget estimate assume energy margins are 15% higher and 15% lower than the base estimate, respectively.

Capacity Margins

Historical capacity prices were sourced from NYISO capability period auction reports while projections were from DPS Capacity Price Forecast from October 2021. Capacity accreditation for a 4-hour asset was assumed to be 90% (NYISO ‘duration adjustment’ factor) pre-2023 after which NYISO is expected to switch to a marginal capacity accreditation framework. The projected capacity accreditation factors used represent approximate statewide marginal ELCC considering a 5% diversity benefit from solar and storage in 2040-2050 and were based on ELCC analysis developed as part of the Draft Scoping Plan (see Draft Scoping Plan, Appendix G for more information on the ELCC analysis). Lastly, capacity accreditation is assumed to scale linearly (and capped at 100%) with duration.

Deployment Trajectory Assumptions

Section 3 of this Roadmap details the proposed bulk storage procurement trajectory of 1 GW per year procured in each of the years 2024, 2025 and 2026. Underpinning this proposed trajectory, 2 GW of 4-hour durations assets are assumed to be installed evenly over the three years from 2028-2030, and 1 GW of 8-hour duration assets are assumed to be installed in 2030 due to the timing of procurements and additional timing considerations that may arise in the use of longer duration technologies. Projects are spread across the state as follows: 40% in New York City, 25% on Long Island, and 35% spread evenly between the rest of New York.

B.2. Retail Storage

The proposed retail program incentives are assumed be an average of $150 per kWh and $125 per kWh over the life of the program to provide bookends for program cost, with projects having an average duration of 3 hours. The incentive rates were chosen based on a difference between modeled revenue from the VDER calculator, as well as modeled revenue from individual project developers, and current cost projection for storage. They are set to ensure projects are able to finance their construction and operation. The analysis assumes an even distribution of projects being constructed between 2027 and 2030, with payments occurring at commissioning. Projects are spread across New York in a similar manner as the Bulk Storage assessment.

B.3. Residential Storage

Residential program projects are assumed to average 2 hours in durations and are spread evenly across the state and evenly in the years from 2024-2030. Project payments for the 200 MW of projects are set at $200/kWh or $175/kWh and are assumed to be made at commissioning.

B.4. Storage Deployment

Tables 10 and 11 summarize the planned procurement trajectory for the bulk storage program, the expected annual procurement quantities under the proposed expansion of the retail and residential programs (both as proposed in Section 2), and the resulting expected deployment trajectories. The program cost estimates provided in this Roadmap are based on these trajectories.

Table 10. New Program Procurement Schedule

New Program Procurements	2023	2024	2025	2026	2027	2028	2029	2030
Bulk (3,000 MW)	0	1,000	1,000	1,000	0	0	0	0
Retail (1,500 MW)	0	375	375	375	375	0	0	0
Residential (200 MW)	13	27	27	27	27	27	27	27
Annual Total	13	1402	1402	1402	402	27	27	27
Cumulative Total	13	1415	2817	4218	4620	4647	4673	4700

Table 11. New Program Deployment Schedule

New Program Deployments	2023	2024	2025	2026	2027	2028	2029	2030
Bulk (3,000 MW)	0	0	0	0	0	667	667	1,667
Retail (1,500 MW)	0	0	0	0	375	375	375	375
Residential (200 MW)	13	27	27	27	27	27	27	27
Annual Total	13	27	27	27	402	1068	1068	2068
Cumulative Total	13	40	67	93	495	1563	2632	4700

Appendix C. Stakeholder Survey

Over the course of April and May 2022, NYSERDA surveyed energy storage developers and installers across the three currently most active energy storage market segments (residential, retail and bulk) to gather feedback and information on a variety of topics related to the development of New York's energy storage market. The survey was conducted by means of a questionnaire sent out to NYSERDA's energy storage contractor email distribution lists and covered a range of segment-specific topics, including installed cost and equipment pricing trends, interconnection rules and policy, permitting, market rules, market support structures and procurement options. Over 50 market participants submitted responses to the questionnaire, and additional feedback was gathered through extensive one-on-one and group engagement sessions with trade associations including NY-BEST and ACE-NY. Key findings from the survey and industry engagement process are detailed by market segment below.

Bulk Storage

- **NYISO/Utility Interconnection Procedures**
  - Many respondents advocated for increases in NYISO staffing resources to improve SRIS study and Class Year timelines.
  - Several respondents indicated that tariff study timelines should be better defined and enforced, and that storage should be studied according to its proposed operations and not simply viewed as a capacity addition, especially in the case of hybrid solar-plus-storage projects.
  - Several respondents opined that NYISO's currently proposed hybrid participation model, where only hybrid systems whose energy storage capacity is less than or equal to 3% of intermittent capacity are allowed to participate under intermittent rules, needs to be reformed.
- **Wholesale Market Constructs, Products and Services**
  - Most respondents indicated that the combined price signals of energy price arbitrage, capacity prices and ancillary services do not currently result in revenue adequacy needed to support development, and that storage needs to be able to stack a range of services that best match the needs of the electric grid. Suggested future products include frequency, ramping, reactive power, short circuit level, synthetic inertia and reserve power.
  - Several respondents noted that the NYISO's proposed marginal capacity accreditation approach would translate into a material reduction in capacity market revenues for energy storage projects, and that is critical to implement marginal ELCCs consistently for thermal vs intermittent resources.
  - A number of respondents advocated for general NYISO tariff and manual changes redefining transmission to allow storage to participate as a transmission asset, and to

provide and receive rate recovery for transmission services and market services concurrently.

- **Market Support Structures, Procurement and Contracting Options**
  - Most respondents advocated for a NYSERDA-issued indexed credit mechanism, similar to the index REC concept used to support Tier 1 Large-Scale Renewables, as the most appropriate mechanism to support bulk storage projects going forward. Under this model, NYSERDA would conduct periodic competitive solicitations to procure projects under long-term contracts. Projects would bid in a strike price that would be indexed to indexed to reference capacity and energy price arbitrage revenues.
  - Most respondents indicated a preference for annual solicitations, with contracts between ten and twenty years in length to enable financing and cost-effectiveness.
- **Learnings From Other Markets**
  - Respondents pointed out that California has used its Resource Adequacy construct to support storage deployment in critical areas and specifically promotes long-duration storage.
  - With regard to storage as transmission, respondents brought up the example of MISO, which has secured FERC approval of tariff changes enabling storage as a transmission asset.
  - Respondents also mentioned that other wholesale markets (CAISO, MISO, ERCOT) have begun to introduce ramping products.
- **Additional Feedback**
  - Several respondents argued that procurement carveouts and/or separate solicitations should be considered for long-duration storage assets, and consideration of separate carveouts and/or procurements between eight-to-ten-hour storage versus multi-day/seasonal storage.
  - Many respondents advocated for the state to take on a more active role in guiding local jurisdictions' development of permitting rules.

Retail Storage

- Almost all respondents supported maintaining the structure of an upfront dollar-per-kilowatt-hour incentive block program, with regional carveouts of the previous Retail Storage program, as an appropriate mechanism to support the retail storage market going forward. Respondents were almost uniformly opposed to a competitive solicitation as a means to procure and support retail storage programs, with several arguing that solicitations should only be used for NWA procurement.
- Several respondents pointed to the need to align interconnection study timelines between hybrid and solar-only projects, and the need for CESIR studies/upgrades to be based on proposed operations versus treating storage simply as additional capacity.
- Several respondents brought up the need to address long and uncertain technology and site reviews for New York City-based projects. Multiple respondents pointed out that the cost and efficiency benefits of developing paired systems, but noted that due to land availability, development opportunities for paired systems exist primarily in Upstate New York, and that the Downstate region will continue to see primarily standalone storage deployments.

Residential Storage

- All respondents supported an upfront NY-Sun style incentive as the best mechanism to stimulate adoption of residential storage.
- With regard to tariff and/or contract mechanisms to drive system benefits, several respondents recommended supplementing the above-referenced upfront incentive with the implementation of a utility tariff or program. Options raised included an opt-out Time-of-Use rate, a monthly capacity payment program based on call events, and a utility Bring-Your-Own-Device (BYOD) program (a pay-for-performance program with the payments being either upfront with a commitment period, a seasonal performance payment, or both).
- A number of factors were raised by respondents as critical to the aggregation and operation of residential storage, including: (i) the need for a utility performance payment program, as discussed above, that issues a stable period of payments; (ii) the need for an aggregator for a demand response or similar program for non-third-party-owned systems; (iii) that a capacity limit requirement (floor) to participate in performance programs should not be too high; and (iv) that measurement of performance for BYOD programs should happen at device and not include baselining.
- All respondents identified permitting as a primary barrier to residential storage, specifically AHJ fire code issues.

Battery Pricing

Stakeholders across all segments that were surveyed or engaged with brought up increases in lithium-ion battery pricing over the course of 2021 and 2022 as a fundamental challenge to deploying storage and the development of the storage market going forward.