Energy Storage System Performance Impact Evaluation

Executive Summary

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Executive summary

This report presents the impact evaluation of system performance of battery energy storage systems (BESS) incentivized by NYSERDA, including projects completed from 2016 through 2022. In its recent Energy Storage Roadmap,[1] NYSERDA put forth an ambitious goal to achieve 6 GW of energy storage installed or in the pipeline by 2030. With 200 storage projects currently in the New York Independent System Operator (NYISO) interconnection queue[2] and policy pressure to increase this number and bring projects through the procurement, contracting, and construction process faster, it is evident both project developers and policymakers are working to make that goal a reality. However, it is important that all stakeholders have insight into how the storage systems currently in operation are contributing to the energy transition. Initial findings suggest roundtrip efficiency, a key indicator of battery performance, is about 80% on average across sites, which is in line with industry standards and program expectations. In addition to quantitative performance metrics, this report offers recommendations of how the program can build on early success and address challenges[3].

Approach

This report presents findings from an overview of the energy storage sector, a survey of system installers, battery degradation modeling, site-level performance and operational strategy insights, and Value of Distributed Energy Resources (VDER) vs. non-VDER site benefits. Overall, the goal is to provide insight into how storage systems are currently contributing to the New York grid.

Error! Reference source not found. summarizes the objectives of this study, and the data sources used to meet those objectives.

[1] New York Department of Public Service & NYSERDA, New York's 6 GW Energy Storage Roadmap, 2022: https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/Energy-Storage/ny-6-gw-energy-storage-roadmap.pdf

[2] NYISO Interconnection Queue, October 13th, 2023: https://www.nyiso.com/documents/20142/1407078/NYISO-Interconnection-Queue.xlsx/f615d83e-eea6-ccf6-ec07-b4ecbe78d8ef

[3] It is important to note that this report focuses on early program participants. The composition of participants in NYSERDA's BESS program offerings are likely to change over time as the program and marketplace matures.

Table ES-1. Study objectives, research questions, and methods

Objective	Purpose	Method
Identify main drivers and obstacles to market adoption of energy storage systems	To understand barriers for market adoption, state of technology within the industry so as to benchmark for comparing systems in study	Market research & web surveys
Model battery degradation and expected lifespan of BESS systems	To understand how design factors like battery technology and performance characteristics like round-trip efficiency affect the longevity of the battery	Battery AI model
Investigate technical operational performance	To understand how site characteristics like primary use case, system size, and meter position relate to performance and operational strategies of systems	Review of AMI interval data, largely from 2020 through 2022, for 42 NYSERDA incentivized sites + contextual program tracking data
Investigate benefits for BESS and hybrid DERs	To understand the system and site benefits provided by BESS and co-located solar PV + BESS systems—to both system owners and the grid—across different revenue streams	Review of AMI interval data, largely from 2020 through 2022, for 42 NYSERDA incentivized sites + contextual program tracking data + utility electric rates and other market information

Table ES-2 provides the main results from each component of the study. More detailed findings are reviewed in Section **Error! Reference source not found.**, but these findings, coupled with the conclusions and recommendations, provide the key takeaways for the NYSERDA team.

Summary of results

Table ES-2. Results by section of the study

Topic	Main Takeaways
Installer Surveys	- Respondents indicated a wide range of components that can contribute to unexpected or premature degradation/underperformance of storage systems. - There are a variety of mechanisms which may provide value to projects, and respondents were aware of and utilize many. - Respondents self-reported that issues with systems are, on average, able to be addressed quickly, and few projects file warranty claims.
Battery Degradation	- Per this study's modeling of battery degradation related to operational and time-based characteristics, none of the 40 [4] BESS projects evaluated for battery

4 Two of the 42 project sites (5 and 91) were excluded as their designed P-rates of 0.71 and 1.2, which were above the rates of what Battery AI could model.

Topic	Main Takeaways
	degradation are expected to reach end of life by year 20, where end of life is defined as when the BESS has 60% or less of capacity retention remaining. - An increase in battery cycling (e.g., operational characteristics) has a greater impact on battery degradation than designed P-rates (e.g., Inverter kW / Battery kWh ratio). An increase from 0.25 cycles per day to 0.5 cycles per day saw 8 to 9% more degradation over the course of 20 years, whereas an increase in P-rate from 0.25 to 0.5 saw 1% more degradation over the course of 20 years. Note that environmental factors were not explicitly considered in degradation models.
Site-level System Performance	- VDER systems cycle 50 times a year on average, far less than the 700+ and 100+ cycles averaged by the two Ancillary Services sites and four Demand Reduction sites, respectively. This may be in part due to VDER site operators dispatching power only when the financial incentive is strongest. - Average round-trip efficiency across the 37 batteries with valid estimates was 79%, which is lower than the expected range of 3 of 4 cited in Table 1-2. However, 20 of the 37 had RTE values above 85%, and it is possible data quality issues suppressed the RTE estimate for some sites.
VDER Benefits	- Total compensation increased significantly from 2020 to 2022, going from $60,000 to $10 million. In 2022, the average VDER compensation per site was $345,000. - Increasing from 5% in 2020 to 33% in 2022, energy value has displaced demand reduction value as the largest revenue stream for VDER sites' storage exports. This mirrors the trend on the solar export, side.
Other Site Benefits	- Site benefits from cumulative energy savings and demand reduction were calculated for the five sites for which we had rate information. These benefits were modest when compared to VDER compensation. For example, $21,000 was the largest annual sum of site benefits, accrued at site 14 in 2022. Other sites were in the <$5,000 range.

Findings and recommendations

Finding 1: Market signals. For the majority of systems in this study, market opportunities and their economic incentives drive operational strategy. The review of the system performance data suggests two general trends: 1) site operators try to minimize the cycling of the battery to minimize degradation and preserve its lifecycle, and 2) dispatch only when there is a significant incentive to do so, which appears to be mostly in summer, particularly for VDER sites. Given sufficient market signals, many sites could be cycling their batteries more often and at a higher rate of discharge—further bolstering the case for batteries as a flexible grid resource. For example, VDER sites, which make up 29 of the 42 sites, cycled only 50 times per year on average.

Recommendation 1: As most of the battery usage is focused on the summer months, NYSERDA can evaluate opportunities for winter-targeting programs that have defined hours of needs (e.g., winter DR programs), to which the batteries can contribute.

NYSERDA response to recommendation*: Implemented. NYSERDA routinely monitors system performance and tailors the program according to situational needs.*

Finding 2: Underutilization. The analysis team finds that it is common for sites to have extended periods of no discharge activity. In some cases, this may be a metering issue, but to the extent it reflects real idle time, it signals that these grid assets are sometimes underutilized. For example, 7 of 42 sites cycled fewer than 20 times per year.

Recommendation 2: NYSERDA should continue routine engagement with site operators, with additional focus on gathering data points throughout the life of the system on how it is being used and why. NYSERDA might consider enhanced outreach to sites identified in this report as having extended period of inactivity.

NYSERDA response to recommendation: Rejected. Based on individual site economic tolerances and site desire to optimize VDER incentives as described in Finding 1.

Finding 3: VDER revenue is driving the market currently. Estimated VDER revenues are meaningfully greater than those from other revenue streams, with an average of $345k per VDER-participating site in 2022. They also represent the revenue stream that most systems are targeting. Survey responses recognized that all six components of the VDER Value Stack provide value to projects: energy value (LBMP), capacity value (ICAP, Option 1, 2, or 3), environmental value (E) – only storage with solar, demand reduction value, locational system relief value, and community credit.

Recommendation 3a: NYSERDA should consider alternative outreach methods with stakeholders (e.g., target workshops, focus groups, etc.) to drive continued adoption of these systems.

NYSERDA response to recommendation: Pending. NYSERDA will consider alternative and/or additional outreach methods as opportunities arise with key stakeholders, and with guidance by evaluators.

Recommendation 3b: If opportunities exist to refine the VDER modeling tool, one option would be to allow vendors to look at how much they earned from VDER in order to more easily calibrate projected and actual VDER performance, further bolstering their confidence in their projected earnings.

NYSERDA response to recommendation: Implemented. NYSERDA maintains a value stack calculator to help contractors better estimate compensation for projects.

Finding 4: Normal degradation. Per this study's operational and time-based modeling of battery degradation, all of the 40 BESS projects evaluated for battery degradation are expected to have remaining useful life after 20 years of operation, where end of life is defined as when the BESS has 60% or less of capacity retention remaining. However, this finding relies on modeling and lacks important inputs, like state of charge and operating temperature. State of charge information is only collected for 9 of 42 sites and operating temperature is not tracked. Both measurements are important in accurately estimating battery degradation.

Recommendation 4: In the upcoming year, the evaluation can use the state of charge data from the nine sites for which this data is available to generate battery-level model outputs if this is of interest to NYSERDA. Ideally, however, state of charge and operating temperature would be available for all sites. Since these metrics are typically collected by the system vendors as part of the routine operational data collection, NYSERDA should consider adding this as a data collection requirement for program participants.

NYSERDA response to recommendation: Pending. This will be considered as part of upcoming retail energy storage program manual updates.

Finding 5: Consistency in interval data. Electric inputs and outputs from the battery, solar system, and grid must each be captured separately and at high rigor to enable analysis and modeling of hybrid DERs. Varying levels of data feed consistency from metering and control systems introduces uncertainty into the results that the program should address moving forward. Currently, it is difficult to parse what is real activity and what is an issue with the data feed, which complicates the effort to understand how these sites are operating and how they respond to the market incentives.

Recommendation: Moving forward, the program should put into place regular validations of control system data streams (charge and discharge) against on-site revenue-grade metering (net facility load). Such validations can alert both site operators and program staff to issues in data collection. In addition to the validations, the program could consider making addressing data collection issues' a requirement for continued participation in the program.

NYSERDA response to recommendation: Implemented. A component of program participation includes a requirement to install a revenue grade meter to directly record the net energy charged *and discharged from the energy storage system. NYSERDA routinely performs validation of energy storage system performance.*

Finding 6: Program information. Contextual information collected as part of the program—specifically in utility rate classes and VDER configurations applicable for each site—is key to accurately calculating site benefits (both VDER and otherwise). When this data is unavailable, assumptions must be made that can lead to inaccurate estimates of site benefits.

Recommendation: Require the provision and consistently collect site-level characteristics, like engineering specifications, facility characteristics, and utility rates. All contextual information about the site aids in understanding system performance.

NYSERDA response to recommendation: Implemented. This is now a standard component of program participation.