



Storage as Transmission Asset Market Study

White Paper on the Value and Opportunity for Storage as Transmission
Asset in New York

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DISCLAIMER

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Acronyms and Abbreviations

AVCE	Automatic voltage controlling equipment
BESS	Battery energy storage system
CLCPA	Climate Leadership and Community Protection Act
FERC	Federal Energy Regulatory Commission
MISO	Midcontinent Independent System Operator
MTEP	MISO Transmission Expansion Plan (regional planning process)
MW	Megawatt
MWh	Megawatt-hour
NERC	North American Electric Reliability Corporation
NPCC	Northeast Power Coordination Council
NWA	Non-wire alternative
NYCA	New York Control Area
NYSPSC	New York State Public Service Commission
NYSRC	New York State Reliability Council
NYISO	New York Independent System Operator
PAR	Phase angle regulator
PPTN	Public policy transmission need
ROW	Right-of-way
SATA	Storage as Transmission Asset
SATOA	Storage as Transmission-Only Asset
TO	Transmission owner
TSL	Transmission security limit
UPME	Unidad de Planeación Minero Energética

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Executive Summary

Energy storage projects are becoming competitive as an alternative to traditional transmission lines. Not only does an energy storage project typically have a smaller land disturbance and shorter development, permitting, and construction timelines—meaning additional savings—but energy storage can also be added incrementally to address any uncertainties in transmission needs. Beyond increasingly utilizing existing transmission networks, energy storage is suited for low or uncertain load growth scenarios and spiky peak-shaving applications to mitigate grid congestion, reduce renewable curtailment, and defer the uncertain need for new power lines.

In this study, we first discuss how grid planners and operators are currently proposing and implementing batteries as alternatives to traditional transmission. For example, Germany plans to spend €348M on its Grid Booster project. Likewise, the Midcontinent Independent System Operator’s (MISO) 2020 transmission expansion plan included its first energy storage project. MISO concluded that installing an \$8.1M, 2.5MW/50 MWh battery in the Waupaca area would be more cost-effective than rebuilding double 115 kV transmission lines for \$11.3M. In this study, we demonstrate the economic and environmental value of Storage as Transmission Asset (SATA) through a series of global use cases.

Second, we illustrate three use cases for potentially applying SATA to the currently planned New York State transmission grid to increase grid operations and utilization efficiency. The three use cases for New York support the State’s transmission upgrade pursuits by demonstrating the potential for SATA to deliver renewable energy to consumers using a cost-effective alternative to traditional transmission. SATA has the potential to reduce the grid upgrade effort, completion time, and cost, estimated to be on the order of several billion dollars in the coming decades. Finally, in addition to renewable curtailment reduction and cost savings, using SATA will greatly reduce land disturbance and thus minimize impacts on land resources and the environment.

Ultimately, the three SATA use cases illustrate viable applications and offer the following benefits:

- Use Case 1 demonstrates that SATA is a viable alternative to transmission wire solutions because it reduces congestion and cost-effectively improves transfer capability.
- Use Case 2 demonstrates that SATA is beneficial because it provides the technical advantage of grid voltage support, improving transmission capability and renewable energy deliverability.
- Use Case 3 demonstrates that SATA can improve capacity deliverability and reduce local capacity requirements beyond its role as a transmission asset.

Notably, the study focuses on storage deployed to cost-effectively improve transmission system reliability and efficiency and hence is justifiable to recover the cost through regulated rate schedules in the same manner as traditional transmission. Under certain circumstances and with changes to transmission tariffs, such storage could be a bulk power resource participating in the New York Independent System Operator’s (NYISO) grid and market operations if the storage market participation does not conflict with its designed applications and services. For example, if a one-hour duration asset sufficiently supports reliable operation of the grid, a longer-duration asset could provide other grid services, including energy adequacy to improve system resilience during high demand times, synthetic inertia, frequency regulation, voltage support, and more.

The following table summarizes the cost savings of the three use cases compared to traditional transmission solution costs.

Use Case	Battery Size	Estimated SATA Capital Cost (\$M)	Estimated Wire Solution Capital Cost (\$M)	Local Area Annual Cost Saving (\$M)	NYCA-Wide Congestion Annual Cost Saving (\$M)
#1	200 MW/200 MWh	120	700	9.9*	13.1
#2	50 MW/50 MWh + 1,500 MVAR Reactive Power Capacity	250	615	51**	55
#3	200 MW/200 MWh	120	533	30.4***	17.8

* Congestion cost saving for Zone K

** Congestion cost saving for the Central East interface

*** Zone J LCR saving and congestion cost saving

The use cases in this study show that SATA projects can provide significant cost savings compared to traditional transmission solutions. New York State is transforming its electric system into one that is cleaner and more resilient under the direction of the Climate Leadership and Community Protection Act (CLCPA) with projected multi-billion dollar spending on transmission expansion; however, present transmission planning rules and tariffs do not allow the use of SATA to optimize these investments. Done properly and permissibly, SATA could greatly reduce the impact on New York ratepayers by avoiding overbuilding wire-only solutions.

Introduction

As the New York State Public Service Commission (NYPSC) and other key policymakers have reiterated, achieving the State’s clean energy transition goals will require diversified, innovative technologies that enable clean energy resources to benefit customers. But current transmission planning processes do not consider how SATA, as opposed to traditional transmission, can offer reliability, economics, and environmental benefits for customers. Specifically, SATA deployment allows a more cost-effective use of the existing transmission system and land conservation; hence, it is likely to receive more stakeholder support than traditional wire buildout. This study examines SATA use cases from other territories and details the analysis and results for three proposed SATA use cases in New York State. These use cases show where and how SATA can facilitate achieving policy goals, reduce renewable curtailment, and decrease energy and investment costs.

In Part 1, we evaluate SATA’s potential through a series of use cases from other jurisdictions where battery storage has been deployed as a substitute for traditional transmission. We also explain how SATA has reliably met climate policy objectives.

In Part 2, we examine three potential use cases on New York transmission systems to illustrate the scale of the opportunity and benefits of SATA in unlocking clean, cost-effective generation. These use cases evaluate techno-economic feasibility, capital requirements, and permitting and compliance advantages of realizing greater system transfer capability through the SATA applications.

1. Part 1 – Value of SATA and Use Cases

Energy storage systems can decrease the cost of achieving climate targets and should be integral to the transmission planning process. One challenge is deciding the appropriate tariff structure and the affected ratepayer group(s). Part 1 focuses on potential SATA use cases, SATA facilities currently planned or operated, their respective operating schemes, and how they satisfy reliability needs and climate policy objectives.

As the demand for transmission systems to achieve climate, environmental, curtailment, and economic policy objectives grows, shifting market conditions are eroding traditional wire transmission solutions' value relative to more flexible alternatives, especially with more elastic demand due to demand-side activities, such as distributed energy resources. One flexible alternative is SATA, a storage-based application that can be repurposed and reused for different functions. Furthermore, SATA can be used at different locations as a transmission upgrade deferral asset, wherein the project price is assessed against the transmission upgrade's avoided capital cost. Thus, potential use cases for SATA providing value to the transmission grid include the following:

1. **To increase transmission transfer capability** over major bulk transmission interfaces¹ – SATA can balance individual transmission interface line loadings and mitigate system voltage or stability issues under normal or contingency conditions. Such capabilities enable the grid to carry higher power flows over the transmission interface.
2. **To provide stability services** – SATA can provide voltage control and inertia, critical attributes for the grid to maintain constant frequency and voltage. While many synchronous generators are retiring due to today's environmental constraints and climate targets, this situation allows SATA to become a viable option to avoid otherwise-necessary costly transmission upgrades.
3. **To meet grid operation flexibility needs** with existing transmission infrastructure – As fossil peaking generators are retiring, the power grid is losing operating flexibility in affected areas. As such, expanding localities' remote access to flexible system transmission resources becomes necessary. Siting SATA in the affected areas avoids building expansive transmission lines and makes the intermittent locational resources capable of responding to grid dispatch needs. In this case, SATA would primarily control power flows to achieve better balances among transmission facility loadings, enabling more efficient use of existing transmission facilities.
4. **To address lumpiness and provide grid-forming support** beyond that of a traditional transmission project – Traditional transmission projects are lumpy² and uneconomic or inflexible to address small, incremental grid needs and thus fail in project justification at the planning stage or results and require a lengthy permitting process. By contrast, storage can be planned flexibly and built incrementally with less environmental disturbance and shorter permitting time, reducing the cost of foreclosing the option of congestion mitigation. Faster project development enables shorter time periods than the cost recovery period required for a traditional transmission project, minimizing the risk of stranded assets and preventing overbuilding transmission infrastructure. Additionally, energy storage's grid-forming technologies can provide voltage and frequency regulation capabilities for grid stability.

¹ A transmission interface consists of a set of parallel transmission facilities that separate two parts of transmission networks within a transmission system. The transfer capability for the transmission system is a measure of the ability of the bulk power, typically a high-voltage transmission system, to move electric power from one part to the other over the defined set of facilities for overall system resource adequacy requirements.

² Due to the nature of a transmission line project that can only be built in certain sizes, the investment often is lumpy. The cost is fixed over a sizable range. Within the range in capacity, there are no returns to scale.

5. **To reduce renewable curtailment** by managing congestion on non-bulk transmission networks – This potential use case is similar to 1) above but focuses on a non-bulk, lower voltage transmission system where renewable output is limited by the thermal ratings of a single transmission facility. Using SATA can help the transmission facility avoid thermal rating exceedance under normal and contingency conditions.
6. **To allow optionality in transmission planning** – Energy storage projects can be deployed in a piecemeal fashion, allowing the project to be augmented over time as needs develop and providing valuable planning and cost optionality to transmission operators.

The following sections introduce examples of energy storage being implemented in the U.S. and globally. Among the examples, the storage-based solution is consistently more cost-effective or preferred alternative to traditional transmission because of physical or societal constraints.

1.1 Energy Storage Application in Germany

In Germany, “more and more electricity from renewable energy needs to be transported from the windy northern part of the country to the [load] centers of demand in the south and west.”³ Thus, the German power grid is reaching its limits. To address this, “a 1,300 MW portfolio of energy storage known as GridBooster was proposed in 2019 to ensure grid stability and lower network (i.e., redispatch) costs. As a first phase, three projects totaling 450 MW have been approved for procurement by TransnetBW and TenneT to provide backup transmission capacity, as opposed to the grid operators maintaining an entire additional transmission line on standby to provide N-1 contingency relief.”⁴

In addition to building new transmission lines, full use of the existing transmission lines enabled by using new technologies triggered the German Federal Network Agency (BNetzA) to approve two innovative pilot facilities for grid boosters in the Network Development Plan in December 2019. The project,⁵ known as Grid Booster (in German, Netzbooster), is to be completed in 2025 and has the following features:

- At 250 MW/250 MWh, the planned battery storage unit in Kupferzell, a major German transmission grid hub, helps better use existing powerlines in normal operations without having to secure potential contingency conditions. During normal system operation, the storage will be charged and remain so. During contingency situations or grid failure, the storage will intervene within seconds to inject or absorb power into the line to which it is connected and will mimic power flow on transmission lines, enabling time for grid operators to redispatch generation.
- The project’s cost is part of the €348M budgeted for the Grid Booster initiative. While grid boosters cannot replace the grid expansion needed after 2030, they can defer and delay the costly immediate transmission upgrades, providing optionality to the system. Further, “if the pilot facilities work well, other technical solutions will also be feasible rather than large-scale centralized storage units. For example, there could be lots of distributed storage units, or ‘flexible loads,’”⁶ according to Germany’s Federal Ministry for Economic Affairs and Climate Action.

³ Federal Ministry for Economic Affairs and Climate Action, “What Is a Grid Booster,” February 26, 2020, <https://www.bmwi-energiewende.de/EWD/Redaktion/EN/Newsletter/2020/02/Meldung/direkt-account.html>.

⁴ Kiran Kumaraswamy, Achal Sondhi, Pablo Barrague, and Holger Wolfschmidt, “Building Virtual Transmission: Critical Elements of Energy Storage for Network Services,” Fluence white paper, <https://info.fluenceenergy.com/hubfs/Building%20Virtual%20Transmission.pdf>.

⁵ <https://www.transnetbw.de/de/netzentwicklung/projekte/netzbooster-kupferzell/mediathek>.

⁶ Federal Ministry for Economic Affairs and Climate Action, “What Is a Grid Booster.”

- “To support the transmission network, the [Grid Booster] will deliver a suite of complex grid services, including synthetic inertia, dynamic voltage control, contingency support, and congestion management among others.”⁷
- In operation, “the project-operating company gets production losses for which the grid operator is obliged to pay compensation in accordance with §13 and §15 of the Act for the Development of Renewable Energies (Erneuerbare-Energien-Gesetz – EEG).”⁸

1.2 Energy Storage Application in Colombia

The Caribbean region of Colombia is experiencing high rates of load growth exceeding 5.5% annually, thus stressing the transmission infrastructure and leading to severe congestion and unreliable operating regimes. Unlike the rest of the system, the Caribbean region is powered by 90% thermal resources and is interconnected to the Central system using three 500 kV lines with an operational transfer limit of 1,500 MW. The installed generation capacity is 3,000 MW, serving a peak demand of 2,000 MW.

Transmission congestion is frequently encountered during contingencies, such as the loss of a transformer or a line, in what is labeled as N-1 congestion. However, congestion can also occur in normal system conditions if the daily load peaks cause a line to overload, in what is labeled as an N-0 congestion. In the Barranquilla region, Colombia’s Mining and Energy Planning Unit (UPME) identified grid violations due to transmission congestion. In the absence of grid expansion solutions, the grid operator must operate two power plants all the time (Tebesa and Flores) to mitigate grid violations, even though one plant would have sufficed had the grid constraints been resolved. Redispatching generation away from the least-cost dispatch to avoid grid constraints is an industry-standard operational practice that is effective but costly.

UPME’s integrated resource plan identified several urban sites with congestion on the transmission network that was extremely challenging to resolve with traditional wire solutions with the right-of-ways (ROW) along the river that were subject to environmental or societal oppositions. UPME further examined the efficacy of using energy storage to resolve the grid constraints to reduce land use and impact and of using storage to shave local peak load. The system benefits were the reduced number of grid violations, lower generation cost under both N-0 and N-1 operating conditions, and less cost compared to traditional solutions.

In January 2021, UPME launched an RFP for a minimum of 45 MW/45 MWh BESS. In July 2021, the RFP was awarded to Canadian Solar at \$19M. Compared to the traditional wire solution, which was determined to be cost-prohibitive, the storage solution is effectively the only viable alternative to improve reliability and reduce consumer costs.

1.3 Energy Storage Application by MISO

MISO proposed incorporating storage devices owned by transmission owners as Storage as Transmission-Only Assets (SATOAs). The MISO proposal was to make energy storage projects eligible, under certain circumstances, for selection in the MISO transmission expansion plan (MTEP) and to provide cost-based recovery for such projects on the same basis as other MTEP projects. The SATOA

⁷ Yusuf Latief, “Grid Booser: World’s Largest Storage-as-Transmission Project Gets Green Light,” *Smart-Energy*, October 9, 2022, <https://www.smart-energy.com/storage/grid-booster-worlds-largest-storage-as-transmission-project-gets-green-light/>.

⁸ Rotorsoft, “EisMan & Redispatch 2.0,” <https://www.rotorsoft.de/en/features/eisman-redispatch-20/>.

can “resolve a discrete, non-routine transmission need that only can be addressed by storage under MISO's functional control, and not by a resource operating in MISO's markets,”⁹ with the following tariff specifications:

- “MISO's discretion in selecting SATOAs is ‘appropriately bounded’ by [its MTEP process].”
- “Prevents SATOAs from being included in its expansion plan when they cannot be shown to solve a particular non-routine transmission need.”
- “SATOAs are most likely to qualify as baseline reliability projects or other projects for which transmission owners maintain a right of first refusal to build.”¹⁰
- SATOA is excluded from market participation. Energy transactions are settled to the extent necessary to provide transmission services. Annual net market revenues are used to offset transmission revenue requirements.

The MTEP process developed a SATOA project to improve local load serving reliability and grid voltage performance. The Waupaca area in Northern Wisconsin involves a local 69 kV system supported by a nearby multi-segment 115/138 kV transmission line. When both ends of the 115/138 kV supply line are out of service (planned or forced), the local loads cannot be sustained.

This SATOA project is a hybrid storage project with a total of 14 MVAR capacitors and a 2.5 MW/5 MWh battery to improve customer reliability. It will enhance system reliability and operating flexibility in responding to multiple contingencies and maintenance outages. The storage is largely automated and triggered as a post-contingency action based on transmission line status and other system conditions. Maintaining a proper charge state will be coordinated between the transmission operating utility and MISO.

Whereas the SATOA's capital cost is \$8.1M, a traditional solution of rebuilding a 115 kV transmission line to double circuits costs \$11.3M. Thus, the SATOA project is more cost-effective.

1.4 National Grid's Nantucket Storage Project

“The island of Nantucket in Massachusetts traditionally receives its electricity from undersea supply cables from the mainland, but . . . summer energy demand has grown dramatically in recent years” because of the island's load growth. “To ensure electric reliability for customers during peak summer months and defer the need for an additional expensive underwater supply cable to the island, National Grid installed a 6 MW/48 megawatt-hour (MWh) battery storage project.”¹¹

This storage project, “together with the 15 MW diesel generator and a power control house, . . . cost[s] \$81 million.”¹² Compared to the \$200M submarine cable alternative, New England consumers avoided a \$120M cost.

⁹ FERC Docket No. ER20-588, comments filed June 1, 2020, by MISO.

¹⁰ Zach Hale, “MISO's ‘Storage-as-Transmission’ Proposal Wins FERC Approval,” *S&P Global Market*, August 11, 2020, <https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/miso-s-storage-as-transmission-proposal-wins-ferc-approval-59872358>.

¹¹ National Grid, “Two National Grid Projects Selected as Energy Storage North America 2019 Innovation Award Winner, *National Grid US*, <https://www.nationalgridus.com/News/2019/11/Two-National-Grid-Projects-Selected-as-Energy-Storage-North-America-2019-Innovation-Award-Winner/>.

¹² Iulia Gheorghiu, “There once was a 48 MWh Tesla battery on Nantucket, which saved National Grid \$120M in its budget,” *Utility Dive*, October 10, 2019, <https://www.utilitydive.com/news/Tesla-national-grid-battery-energy-storage-8hour-long-duration-diesel-generation-system-nantucket/564428/>.

2. Part 2 – Three Use Cases

Utility and ISO planning goals are driven by conducting transmission system performance assessments to maintain acceptable system performance and demonstrate compliance with the NERC and regional planning standards (NERC, NPCC, NYSRC, and TO's local rules). As part of the planning process, projects are developed to reliably serve electric customers during normal and emergency operating conditions, and project costs are recovered from the tariffs of responsible TOs or the ISO. Part 2 describes three use cases that illustrate how the transmission planning process could include consideration of SATA with respect to the following:

- Technical grid modeling study and incorporation in grid operations
- Comparison to traditional transmission solutions
- Estimating the opportunity's scale and benefits

The study illustrates how energy storage can function as a transmission substitute to serve the electric grid's reliability needs as identified by the grid planners and operators. In particular, for bulk power transmission, we illustrate three SATA use cases as non-wire alternatives (NWAs) to transmission upgrades:

- 1) Battery storage at the Shore Rd 345 kV substation to reduce congestion between Lower Hudson Valley (Zone I) and Long Island (Zone K) by discharging the stored energy to keep the Dunwoodie – Shore Road 345 kV (Y-50) cable loading under applicable ratings in the event of a contingency, including the outage of the Spring Brook – East Garden City 345 kV (Y-49) circuit.
- 2) Battery storage at the Oswego complex or near the Edic 345 kV substation as an automatic voltage controlling equipment (AVCE) to provide voltage support to maintain a consistent Central East interface transfer capability that otherwise would reduce up to 300 MW if the voltage support from the generators in the Oswego complex were not available.
- 3) Battery storage at the Mott Haven 345 kV substation to increase transmission security limits (TSLs) into New York City (Zone J) to improve local reliability and reduce Zone J's installed capacity requirement.

The cost recovery for the SATA would be similar to traditional transmission asset cost recovery, although wholesale market participation may create additional revenue opportunities. The potential market revenue could reduce the revenue requirement for SATA-based solutions. The use case examples discuss the benefits due to congestion relief, lower installed capacity cost, and reduced renewable production curtailment.

2.1 N-1 Security Constraint Management

This use case evaluates energy storage projects reducing congestion, thereby improving the utilization of existing transmission assets. More concretely, using storage for congestion relief can enhance the transmission system's capacity to overcome emergency situations caused by a contingency. Such situations would otherwise require transmission expansion or less efficient generation dispatch. Therefore, SATA is an NWA solution and mitigates reliability violations from traditional pre-contingency preventive measures to post-contingency corrective actions by taking advantage of the storage technology's fast reaction.

In grid operations, N-1 contingencies must be secured when a wholesale market is cleared to comply with NERC reliability criteria. These N-1 constraints often result in more expensive, out-of-merit

generation dispatch to ensure that load is met and that line loadings and generation are within limits under the N-1 conditions. Storage can mitigate these N-1 contingency costs by immediately counterbalancing the overload upon the N-1 contingencies before any transmission facility is damaged. The above thought process is illustrated in Figure 1, where the three transmission lines are each rated at 0.5 MW:

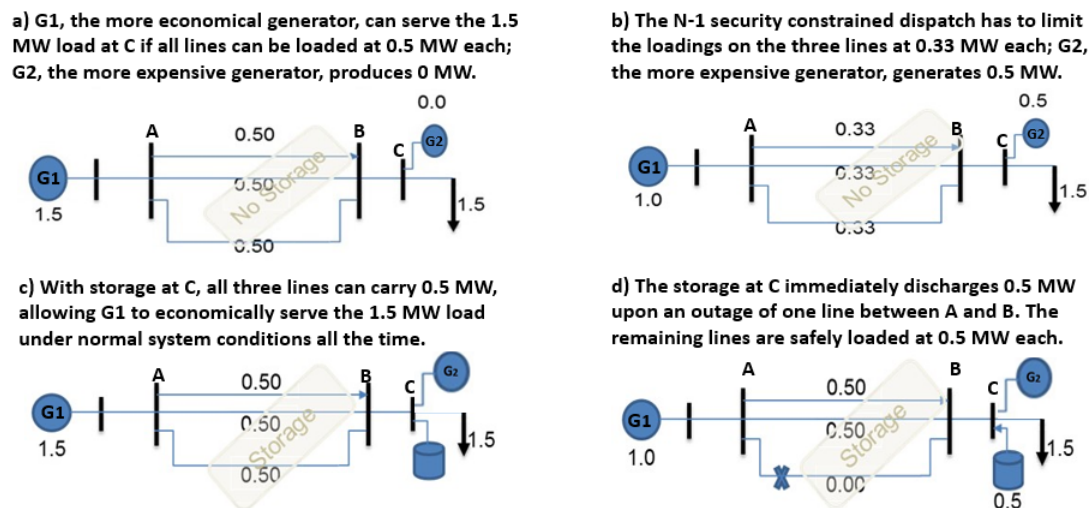


Figure 1. SATA for Transmission Congestion Relief¹³

Applying the same concept to reducing congestion between Zones I & J and Zone K, a SATA consisting of a 200 MW/200 MWh storage could be sited at the Shore Rd 345 kV bus to prevent the Dunwoodie – Shore Road 345 kV (Y-50) circuit from being overloaded under contingency conditions. Currently, transmission between Zones I & J and Zone K is constrained, particularly upon the outage of Y-50's parallel circuit, the Spring Brook – East Garden City 345 kV (Y-49) cable. Additionally, stuck breaker contingencies in Zone I and an outage of the 345/138 kV transformers at Shore Road also constrain the flow from Zones I & J to Zone K.

This SATA use case can be part of the grid operation to secure all the tie lines into Long Island. The other three tie lines (Northport – Norwalk, Jamaica – Valley Stream, and Jamaica – Lake Success) are already automatically controlled by phase angle regulators (PARs). The automatic PAR control would make each of the other three tie lines self-correcting for outages of any tie line over several minutes. With this SATA, the only free-flow tie line, Y-50, will become controllable too, and SATA would react within sub-seconds of the outage of Y-49 or any contingencies discussed above. Two power cases, representing summer peak and winter peak conditions, were created to evaluate if SATA can relieve congestion and increase transfer capability between Zones I & J and Zone K. Table 1 shows the overload on the Y-50 circuit upon the contingency of losing the Y-49 circuit. Under summer and winter peak conditions, Y-50 will be 119% and 117% overloaded, respectively.

Table 2 lists the transfer limits from Zones I & J to Zone K with and without the 200 MW/200 MWh storage at the Shore Road 345 kV substation, which shows that the SATA can increase the transfer limit by approximately 200 MW. The storage is sized to fully resolve the overload on Y-50 with respect to Y-49 related contingencies.

¹³ Without the storage at Bus C, the transmission limit between Buses A and B is 1.0 MW; with the storage at Bus C, the limit is 1.5 MW.

Table 1. Overload on Y-50 upon the Loss of Y-49

Overload (%)	Summer	Winter
Y-50 upon the loss of Y-49 (Rate B)	119%	117%
Storage required at the Shore Rd 345 kV bus (MW)	180	170

Table 2. Transfer Limit from Zones I & J to Zone K

Transfer Limit (MW)*	Summer (MW)	Winter (MW)
Zones I & J to Zone K	965.5	1,077.9
Zones I & J to Zone K with 200 MW storage at Shore Rd	1,167	1,280.1

* All transfer limit numbers are set by the most severe contingency, the Y-49 outage.

A production cost simulation evaluated the storage's benefits under 8,760 hours of operation. The SATA has increased the utilization of the interface between Zones I & J and Zone K from 9,614 GWh to 11,161 GWh, an incremental amount of 1,547 GWh. The corresponding annual congestion cost saving for Zone K is \$9.9M, and the annual congestion cost saving for the entire New York Control Area (NYCA) operated by the NYISO is \$13.1M, shown in Table 3. The saving is primarily attributable to the mitigation of the security constraints associated with Y-50 and Y-49, which have been the major limiting constraints in grid operation over the years.

The \$13.1M annual congestion saving is only one of many benefits brought about by a transmission expansion project such as the one required by a public policy transmission need (PPTN) between Zones I & J and Zone K,¹⁴ which is currently under development by the NYISO. The 1,547 GWh of incremental energy over the transmission interface between Zones I & J and Zone K demonstrates the ability of the SATA to unlock the value of the existing transmission without additional ROWs. If renewable resources used the incremental amount, an additional 1,547 GWh of renewable energy would be available from upstate New York to the load in Zone K.

Table 3. Cost Saving without/with the Storage

	Without Storage	With Storage
Zone K Total Congestion Cost (\$M)	29.02	19.14
Zone K Congestion Cost Reduction (\$M)		9.9
NYCA-Wide Congestion Cost Reduction (\$M)		13.1

The capital cost for this SATA is approximately \$120M. Compared to adding a new 345 kV tie line from Zone I or J to Zone K to mitigate the congestion between the zones, which would be approximately \$700M,¹⁵ this SATA solution could save New York consumers \$580M.

¹⁴ <http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B13FE24BB-C966-4719-8ADA-E2A85F59B7C5%7D>.

¹⁵ Substations and cable costs. Particularly, over 18 miles of underground and submarine cables will be built at the cost of approximately \$47 million and \$20.5 million per mile, respectively, according to "Petition of Consolidated Edison Company of New York, Inc. for approval to recover costs of Brooklyn Clean Energy Hub" filed by Con Edison in PSC Case No. 20-E-0197 (April 15, 2022).

2.2 Voltage Support Services Use Case

The Central East interface voltage performance depends on the generator's in-service status in Oswego and Athens. To support the voltage performance and to maintain a consistent Central East interface transfer limit, a SATA can be utilized as AVCE to control the voltage level at major transmission buses. The SATA located at one of the buses observes the bus voltages around the Central East interface and injects or absorbs reactive power into the grid to maintain the voltage within limits. Because the primary focus is to regulate the bus voltages automatically, the requirements for the real power in MW and storage durations for the battery are less important. This AVCE focus makes storage a cost-effective application when the alternative is to build another line or replace the voltage regulation function of the generators in the Oswego complex to stiffen the grid voltage response. Static VAR compensators can provide similar benefits but are relatively expensive and less flexible to meet grid operation needs.

A SATA consisting of a 50 MW/50 MWh battery with a 1,500 MVAR reactive power capability inverter can be sited in the Oswego/Edic complex to participate in grid operations, and it would maintain system voltage between 95% and 105% of the standard rating together with other switched shunt capacitors and available generators and transformer tap changers in the grid. Specifically, when the three generators in the Oswego area are not in service, the Central East interface limit is no longer reduced by approximately 300 MW. The SATA will provide the needed voltage support and control to maintain a consistent power transfer capability over the interface independent of the in-service status of some of the generators in the Oswego area.

A production cost simulation evaluated the SATA benefits under 8,760 hours of operation with the Central East interface limit at a minimal 3,250 MW when up to three generators are not available in the Oswego area. Figure 2 shows the 8,760-hour power flows over the Central East interface with and without the SATA. The SATA has increased the utilization of the Central East interface from 22,000 GWh to 23,000 GWh. Additionally, without the SATA, the Central East interface is congested for 3,037 hours, and the congestion cost is \$142M; with the SATA, the total congestion drops to 2,028 hours, and the congestion cost is \$91M. Therefore, the congestion saving over the Central East interface is \$51M, and the corresponding total NYCA congestion cost saving is \$55M.

Table 4 and Table 5 show the total renewable curtailment in upstate New York, Zones A–G, with and without the SATA. The difference shows that this SATA can reduce the renewable curtailment from 102 GWh to 67 GWh, a 35 GWh reduction.

The capital cost of the SATA is approximately \$250M, with a major cost spent on the inverter of the solution. Compared to the recently commissioned \$615M 345 kV transmission project,¹⁶ this SATA could save \$365M in capital investment for New York ratepayers if the Central East interface is further expanded.

¹⁶ The \$615M projected cost is part of 345 kV Marcy to New Scotland Transmission Upgrade Project. See LS Power, "LS Power Rate Settlement Reduces Transmission Project Cost Estimate by \$200+ Million," April 27, 2021, <https://www.lspower.com/ls-power-rate-settlement-reduces-transmission-project-cost-estimate-by-200-million/>.

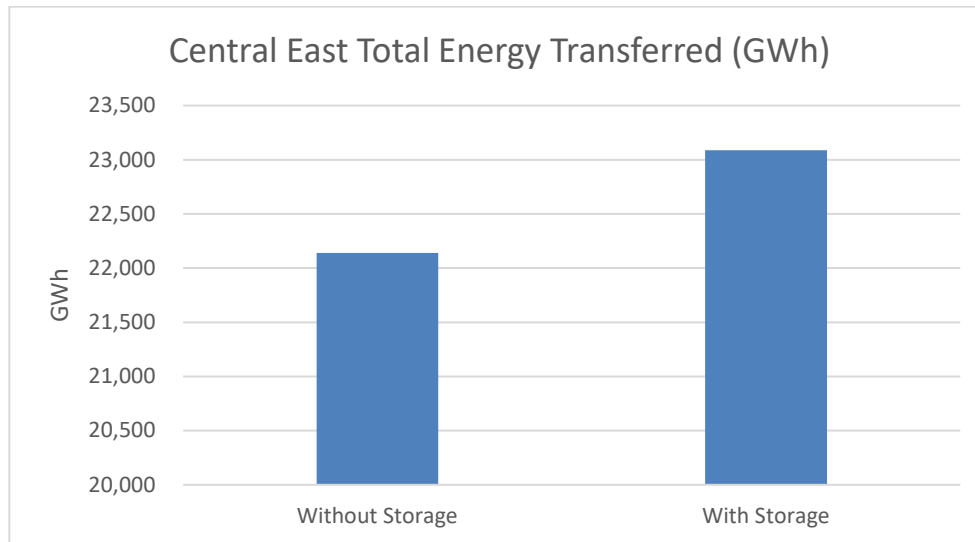


Figure 2. Central East Total Energy Transferred

Table 4. Curtailment in Zones A–G in Production Cost Simulation without SATA

Year 2030	Renewable (GWh)	Curtailment (GWh)	Curtailment %
NYZA	3,770	7	0.2%
NYZB	3,433	11	0.3%
NYZC	5,586	13	0.2%
NYZD	2,561	4	0.1%
NYZE	4,903	59	1.2%
NYZF	2,168	6	0.3%
NYZG	496	1	0.2%
Total	22,917	102	0.4%

Table 5. Curtailment in Zones A–G in Production Cost Simulation with SATA

Year 2030	Renewable (GWh)	Curtailment (GWh)	Curtailment %
NYZA	3,773	4	0.1%
NYZB	3,438	7	0.2%
NYZC	5,593	7	0.1%
NYZD	2,563	1	0.1%
NYZE	4,922	40	0.8%
NYZF	2,168	6	0.3%
NYZG	496	1	0.3%
Total	22,952	67	0.3%

2.3 Example of Reduced Local Capacity Requirement

For the Zone J Locality interface, the TSLs use New York State Reliability Council (NYSRC) Local Reliability Rule G.1-R1. The G.1-R1 rule states that “certain areas of the Con Edison system are designed and operated for the occurrence of a second contingency.” Generation and PAR schedules

under N-2 conditions are developed to maximize the TSL import capability while maintaining all bulk power system transmission element power flows are within normal ratings (i.e., N-2-0).

Modeling a 200 MW/200 MWh SATA sited at or interconnected to the Mott Haven 345 kV substation illustrates how a SATA can increase the TSLs into Zone J to improve local reliability and reduce the local capacity requirement (LCR) for Zone J.

The TSL improvement is evaluated over the Dunwoodie South interface, and the transfer limit was tested with and without the SATA. The FERC 715 2027 Summer power flow model was used for this analysis. Generation redispatch for the N-2 outage case will recognize the NYISO’s ability to redispatch generation in support of maximizing TSLs. The result is shown in Table 6, where the limiting facility is the Dunwoodie – Mott Haven Line 71 with a normal rating of 785 MVA; the limiting contingency is the double outage from Sprain Brook – W49th St 345 kV cables (M51 and M52). The improvement in the TSL is 329.5 MW.

Table 6. TSL Limits with and without the Mott Haven SATA

Dunwoodie South Transfer Results	Contingency Name	Emergency Transfer Limit without SATA (MW)	Emergency Transfer Limit with SATA (MW)	Emergency Transfer Limit Improvement (MW)
Dunwoodie South Interface Limits	M51+M52	2,644.5	2,974	329.5

With the incremental 329.5 MW in the TSL, Zone J can purchase an additional 329.5 MW capacity from upstate New York and reduce the LCR requirement by 329.5 MW. Based on the example in NYISO’s “Proposed Updates to the Transmission Security Limit Method for the 2022–2023 Capability Year LCR Determinations,” September 9, 2021, the LCR requirement for Zone J would be reduced from the current 77.6% to 74.7% $(=(11,217-2,920-329.5+407)/11,217)$, where the 11,217 MW is Zone J’s peak load, 2,920 MW is the existing TSL, and 407 MW is Zone J’s resource unavailability amount.

In sum, the 329.5 MW incremental in the TSL could reduce the LCR by 2.9%, resulting in an annual LCR cost saving of \$12.6M based on the New York Installed Capacity auction prices in 2022. In addition, the increased transmission capacity would reduce transmission congestion by \$17.8M per year for Zone J. In total, this SATA can save New York electricity ratepayers \$30.4M annually.

The SATA’s capital cost is approximately \$120M. Compared to adding a new 345 kV transmission cable from Dunwoodie to Mott Haven, which would cost over \$533M,¹⁷ this SATA provides over \$400M in savings for New York electric consumers.

¹⁷ Over 11.35 miles of underground cables will be built at the cost approximately \$47 million per mile.

3. Conclusions and Discussion

The use cases in this study show that SATA projects can provide significant cost savings compared to traditional transmission solutions. Not only does a SATA project typically have a shorter development, permitting, and construction duration—meaning additional savings—but the SATA can also be added incrementally to address any uncertainties in the transmission needs. In addition to increasing transmission transfer capability by utilizing existing transmission facilities more efficiently, SATA is also well suited for low or uncertain load growth scenarios and spiky peak-shaving applications, as illustrated by the MISO and Colombia use cases, respectively.

While traditional transmission expansion projects can significantly increase the thermal transfer capability across major transmission interfaces, building a transmission line to meet a circuit peak MW loading may not be necessary if the peak’s duration is short and there is excess capacity in off-peak hours, resulting in cost savings. One metaphor for this mitigation measure is that building a large pipe trickling water 99% of the time, which is full only 1% of the time, is expensive and inefficient. Instead, running a garden hose 99% of the time but filling a reservoir 1% of the time is cheaper and more efficient. Such a scenario could be applicable in developing transmission projects in response to the PPTN project currently under development by the NYISO. Done properly and permissibly, SATA could save New York ratepayers millions of dollars by avoiding overbuilding wire-only solutions.

This study has specifically performed studies on three use cases for the New York State transmission grid in its 2026 state. The three use cases demonstrate the potential for delivering renewable energy to consumers as required by the CLCPA:

1. Use Case 1 demonstrates that SATA is a cost-effective solution to incrementally increase the transfer capability and reduce congestion between Lower Hudson zones and Long Island.
2. Use Case 2 demonstrates that SATA beneficially and dynamically regulates grid voltage to maintain constant transfer capability for the Central East interface, greatly increasing renewables' energy deliverability in upstate New York.
3. Use Case 3 demonstrates that SATA can improve the TSLs in New York City, hence reducing local capacity requirements and saving consumers' capacity payment.

The following table summarizes the cost savings of the three use cases compared to traditional transmission solution costs.

Use Case	Battery Size	Estimated SATA Capital Cost (\$M)	Estimated Wire Solution Capital Cost (\$M)	Local Area Annual Cost Saving (\$M)	NYCA-Wide Congestion Annual Cost Saving (\$M)
#1	200 MW/ 200 MWh	120	700	9.9*	13.1
#2	50 MW/50 MWh + 1,500 MVar Reactive Power Capacity	250	615	51**	55
#3	200 MW/ 200 MWh	120	533	30.4***	17.8

* Congestion cost saving for Zone K

** Congestion cost saving for the Central East interface

*** Zone J LCR saving and congestion cost saving

SATA can achieve these benefits not only by employing its charging and discharging cycles but also with reactive power injections and withdrawals through its (smart) inverter. The meshed nature of

transmission networks allows a single SATA project to ameliorate overloads on a relatively weak link under various contingency conditions. With the advance in technology, a SATA project can be flexibly utilized interactively or combined with transmission circuits and loads as dispatchable resources to address overloads and voltage violations, achieving the highest efficiency possible in timing and cost-effectiveness.

New York is transforming its electric system into one that is cleaner and more resilient under the direction of the CLCPA with projected multi-billion dollar spending in transmission expansion.¹⁸ As renewable resource integration continues, certain portions of the New York State transmission system are becoming more congested. At the same time, new flow patterns caused by the intermittent renewable resources will lead to different power flow patterns and varying utilization of the existing transmission facilities. SATA is uniquely suitable to address these kinds of varying, incremental, and sometimes uncertain transmission capacity needs.

Additionally, though not addressed explicitly in Part 1 or Part 2, SATA will reduce land disturbance and thus enable New York to meet environmental targets through land conservation. For a green field overhead transmission solution, 10 miles of transmission with a 120 ft ROW disturbs 144 acres, potentially more if the ROW is larger. By contrast, 100 MW/400 MWh of SATA doing the same function disturbs less than 10 acres (assuming about 50 MWh per acre with room for switchgear, connecting facilities, perimeter offsets, and stormwater management). Thus, SATA offers New York not only climate and cost-savings benefits but also environmental benefits.

Developing cost-effective SATA in transmission planning processes requires changes in the planning rules and tariff, together with changes in market designs. Current market rules and transmission planning tariffs have resulted in denying SATA applications as well as regulating rate recovery and often inhibiting SATA development. The current planning process should be revised to include SATA at the need and solution assessment stages and to allow SATA cost recovery under the ISO tariff.¹⁹ Additionally, as many ISOs are contemplating new market rules allowing flexible system resources to accommodate renewables and load variability, co-optimal use of SATA facilities as dispatchable resources for the grid operators can lead to a more reliable and resilient electric power grid.

¹⁸ Multiple interveners' comments on NYSPSC Case 20-E-0197.

¹⁹ Alternative regulated solutions selected by the ISO as the more efficient or cost-effective transmission solution to reliability are identified in the Reliability Planning Process, NYISO OATT, Section 31, "Attachment Y - New York ISO Comprehensive System Planning Process."