ENERGY STORAGE: REDUCING RELIANCE ON FOSSIL FUEL-FIRED POWER PLANTS

ABSTRACT

This study focused on opportunities to replace fossil fuel-fired power plants in NYC with battery storage. The analysis examined the impacts of New York's climate goals on its electricity mix, including the construction of new offshore wind resources and other local renewables. Accounting for the evolution of New York's electricity system between now and 2030, this research identified opportunities to fully or partially replace fossil fuel power plants with battery storage in the near-term. This included the development of a prioritization framework to identify opportunities for power plant replacement that deliver the greatest benefits to surrounding communities. The analysis also utilized spatial and physical characteristics to categorize fossil fuel power plants and included the potential of additional storage or additional local renewables.

The analysis reaffirmed that additional clean energy and transmission resources will reduce NYC's reliance on fossil fuels and replace aging power plants. City-owned unused vacant land and parking lots that could be used to deploy 400 MW of battery storage projects were identified, and sites with the potential to host around 300 MW passed an initial round of review by the relevant City agencies. While privately-owned vacant land is more abundant, these sites face greater competition for different land uses. Though repurposing power plant sites for storage would further the clean energy transition, overall site capacity would likely decrease because storage is less energy dense. The City should take steps to leverage available opportunities to site battery storage where possible.

Research Area Overview and Objective

In accordance with Local Law 99 of 2019 (LL99), this study included an assessment of the feasibility of replacing in-city gas-fired power plants with battery storage powered by renewable energy sources.[i]

This study examined the future of the electricity generation system in NYC and the opportunities to deploy battery storage. This study included the additions of new transmission (e.g., Tier 4 projects,[ii] Long Island Public Policy Transmission Need (PPTN) projects,[iii] and new offshore wind (OSW)) and how these projects will impact power plant operations in New York City, focusing on fossil fuel plant operations and opportunities for replacement with local renewables and battery storage.

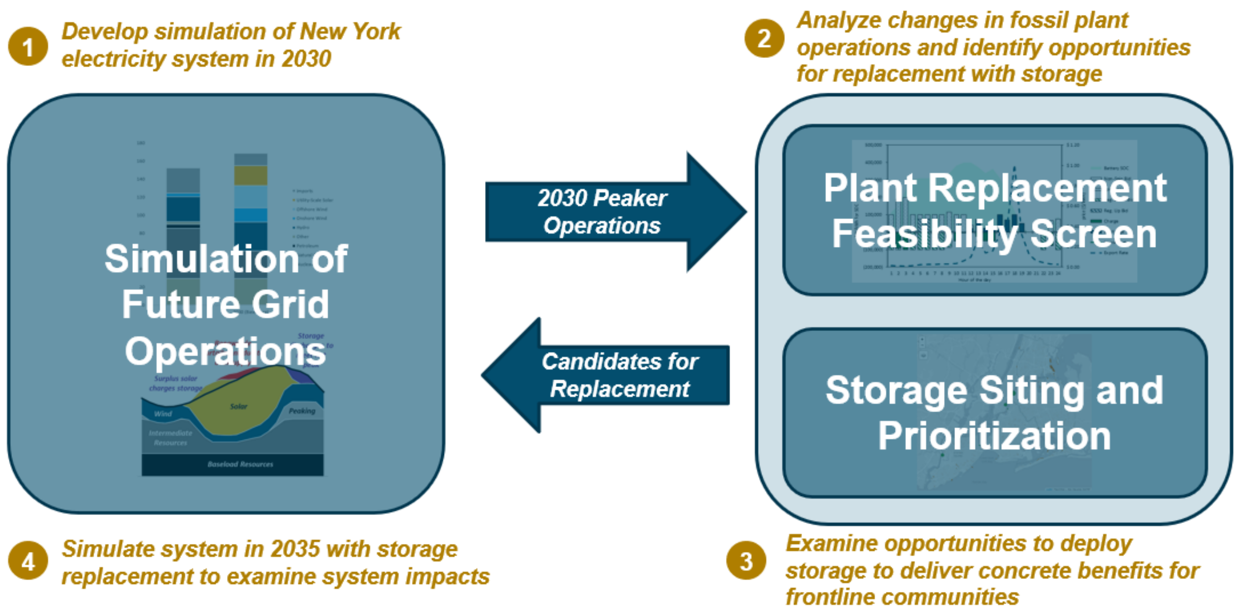
In support of Local Law 181 of 2019 (LL181), this study includes an assessment of the feasibility of installing utility-scale energy storage systems on private properties throughout the city, as defined in section 4-207.3 of the administrative code of the City of New York.[iv] The analysis also mapped opportunities for fossil fuel plant replacement and created screening criteria that could be used to identify ideal properties for local renewable and/or storage development.

Many of NYC's power plants are in environmental justice communities, where reducing the output of these units, or replacing them altogether, has been a key area of focus for many environmental justice stakeholders.[v] The recent New York State Department of Environmental Conservation (NYS DEC) peaker rule, which sets nitrogen oxides (NOx) emissions limits for peaking generation units, or "peakers", will reduce the impacts of in-city fossil fuel plants in the near term. Stakeholders have also put forward proposals for how additional fossil fuel capacity could be replaced by 2030 with local renewables and storage to benefit vulnerable communities.[vi] This research, conducted as part of PowerUp, provides a framework for how to best accelerate the development of local renewable and storage resources in a way that directly reduces reliance on NYC power plants located in environmental justice communities.

METHODOLOGY

The methodology used for this research topic consisted of two parallel workstreams: a workstream focused on modeling the bulk power system and the operations of generation facilities, and a workstream focused on identifying potential opportunities to site and build energy storage across New York City. The workstreams were designed to answer whether or not, and how, battery storage can be deployed equitably across New York City in order to reduce the city's reliance on fossil generators (shown in Figure 1 below).

Figure 1: Overview of Analytical Framework



Electricity System Modeling

The electricity system modeling consisted of nodal production cost modeling performed in collaboration with PowerGem, which used its PROBE electricity market simulation software.[vii] The PROBE model was used to conduct a detailed examination of the New York electricity system in 2030 and 2035.

The study made the following assumptions about changes to the New York electricity system between now and 2030/2035:

- Electricity demand: The study used load projections from the 2021 Integration Analysis performed for the Climate Action Council's Draft Scoping Plan, relying on the projections from Scenario 2 (Strategic Use of Low Carbon Fuels).
- Existing generator capacity and transmission topology: The representation of individual generator characteristics and transmission line ratings was developed based on the NYISO Gold Book, the NYISO Reliability Needs Assessment, and the Con Edison Long-term Transmission Plan.
- Contracted projects: The modeling assumed the timely completion of all contracted Clean Energy Standard (CES) resources, including land-based wind, solar, offshore wind, and Tier 4 transmission projects.
- Policy targets: In addition to contracted resources, the modeling assumed that new resources are developed to achieve the 70% renewable target by 2030 set forth in the New York Climate Act, as well as other recently announced policies such as the 10 GW behind-the-meter solar target.
    - The additional resources needed to meet the 70x30 goals were distributed assuming an equal percentage of wind and solar and allocated to NYISO zones based on the proportion of existing and contracted resources.
    - The build-out of the 10 GW behind-the-meter solar capacity was based on the NYISO 2022 Gold Book.
    - The modeling assumed that the 9 GW Offshore Wind target by 2035 would be achieved, and that 6 GW of OSW would be developed by 2030 on the path to achieving the 2035 target.
    - To support the policy target of reaching 9 GW of Offshore Wind by 2035, the NYISO has solicited project proposals via the Public Policy Transmission Need (PPTN) process to expand the export capability of Long Island power to the rest of the New York electric system. A proxy for the LI PPTN project was included in the modeling to represent the increase in transfer capacity once a project is awarded and developed, which is expected to occur by 2030.
    - Relying on the assumptions and sources detailed above, the PROBE model was then used to simulate the hourly operations of the New York electricity system in 2030 in order to assess the impacts of the significant changes expected to occur between now and 2030.

Storage Siting Analysis

To complement the generation replaceability analysis, the research developed and applied a framework to evaluate opportunities to site battery storage in New York City. This effort was not only intended to identify storage potential for fossil fuel replacement, but also to explore storage opportunities more generally throughout the City and inform storage goals for the City. The framework consisted of three steps: (1) define storage market classifications; (2) identify siting opportunities through a geospatial screening analysis; and (3) develop prioritization metrics for the identified siting opportunities. As a result of this analysis, a dataset of screened tax lots that could be suitable for storage siting was developed, along with a list of relevant lot characteristics that can inform siting prioritization and the NYC storage market.

In step (1), battery storage types were categorized by size and use case into three market classifications: Utility Scale (over 5MW); Large, Value of Distributed Energy Resources (VDER) Eligible (1-5MW); and Residential 1-2 Family Homes located in zoning district R3 (<5kW). As detailed in Table 1, each classification differed by several key characteristics including typical capacity, the purpose and value of the resource, the typical land used for siting, the land footprint, and NYC zoning regulations. These market categories were intended to reflect general market classifications for the purpose of this analysis.

For utility-scale and large-VDER eligible projects developed on outdoor land, land area was estimated assuming a 30 MW per acre footprint; however, projects in commercial zones must be capped at 10,000 ft2 per current zoning regulations[viii]. For residential 1-2 family homes, the storage capacity was limited to 10 hours times the peak energy consumption of the home. Applying a household peak consumption of 2 kW and a 4-hour duration battery, it was assumed that the storage unit cannot exceed 20 kWh or 5 kW.

Table 1. Storage Market Classifications Analyzed

Storage Market Classifications Analyzed			
Characteristic	Utility-Scale	Large, VDER-Eligible	Residential – 1 & 2 Family Homes
Storage Capacity	5+ MW	1-5 MW	< 5 kW
Purpose/Value	Front-of-the-meter bulk operation	Front-of-the-meter bulk operation based on value stack	Behind-the-meter building peak demand reduction
Land Type for Siting	Vacant land, parking lots, repurposed power plant sites		Integrated in home/building
Land Area Footprint (Using 30 MW/acre conversion)	7,260+ ft2	1,452 - 7,260 ft2	NA
Zoning Restrictions	Manufacturing Zones (M1-3) Commercial Zones (C1-C2, C4-C6, C8)		Residential Zone R3
Methodology for Analysis	Geospatial Screening and Prioritization Analysis		Assumes all properties adopt maximum storage capacity

* Note that Utility-Scale and Large, VDER-Eligible projects developed in Commercial Districts are capped at 10,000 ft2 or 6.9 MW (assuming 30 MW per acre) in accordance with NYC zoning regulations.

In step (2), for each storage market classification, storage siting opportunities were identified by performing a geospatial screening analysis. Storage potential for the City was estimated by identifying specific land that could be suitable for storage development. Publicly available datasets were used, and are presented in Table 2. The NYC Tax Lot database (MapPLUTO), which consists of over 850,000 parcels of tax lots across NYC, was the foundation of the land data and storage potential estimates.

For Utility-Scale and Large, VDER-Eligible scale projects, several types of land were identified and distinguished: (1) vacant land that is City-Owned or Leased Properties (COLP) and deemed to have no use (as specified by the COLP database); (2) vacant land that is privately owned; (3) municipal outdoor parking lots; and (4) existing fossil fuel power plant sites. Coordination with the Department of City Services (DCAS) helped distinguish between properties managed by DCAS and other agencies. For parking lots, it was assumed that 15% of the lot would be available for a storage project.

For Utility-Scale and Large, VDER-eligible storage development, several screening layers were applied. The first layer applied included zoning and land area restrictions, as defined in Table 1, to ensure lot eligibility for storage development and sufficient space to accommodate projects. Next, sites with wetland features as specified in the National Wetlands Inventory, such as marine wetland and deep water, lakes, freshwater ponds, freshwater forested/shrub wetland, were removed. Sites with flood risk, including lots with a 2015 FEMA Preliminary Flood Insurance flag in MapPLUTO (reflecting overlap with a 1% annual chance floodplain) and flood zones based on the NYC Stormwater Flood Map were also filtered out. The remaining sites were identified as opportunities worth pursuing for siting Utility-Scale and VDER-eligible projects in NYC.

For existing power plant sites, it was assumed that the entire power plant would be decommissioned, and the land would be repurposed for storage. Estimated storage potential at the 14 power plants was modeled in PowerGEM. Because power plant sites often occupy either a fraction of a tax lot or multiple tax lots, a more precise (albeit approximate) area was estimated by visually mapping the footprint with an online tool[ix] that provides the total acreage. While the storage potential is estimated for each of the plants, not all the plants are likely to be candidates for replacement with battery storage due to operation patterns.

For Residential 1-2 Family Homes, the MapPLUTO database was filtered to include lots located in the R3 zoning district with a Land Use category pertaining to "One & Two Family Buildings." This screen was intended to capture a very approximate upper bound estimate of scale. A more detailed assessment would be needed to consider the actual home peak electricity demand, storage duration, and other building factors that would impact the ability to adopt storage.

Table 2. Assumptions for Geospatial Analysis of Storage Siting Opportunities and Potential

Storage Siting Analysis Inputs		
Siting Framework Component	Dataset	Description
Tax Lot Datasets & Screening Layers	NYC Tax Lot Database (MapPLUTO)[x]	NYC tax lots, containing > 850,000 parcels, including land use type, owner type, zoning districts, land area, etc.
	City Owned and Leased Properties[xi]	Tax lot database for properties that are City-owned or leased by the City to other entities.
	National Wetlands Inventory[xii]	Geospatial inventory of wetland features (e.g., marine wetland and deep water, lakes, freshwater ponds, freshwater forested/shrub wetland, rivers, etc.)
	NYC Stormwater Flood Mapxiii	Geospatial layer of current stormwater flooding
Prioritization Layers	Existing fossil generators[xiv]	NYISO Gold Book and EIA 860: Capacity, technology type, coordinates, online year, etc.
	Substations[xv]	Public database of electric substations from the Infrastructure Foundation Level Database (HIFLD)
	NYC Environmental Justice Area Census Tract Designation[xvi]	NYC EJ areas defined by Local Law 64 (2017)
	Con Edison Network Outages	Historical network level outage data on Con Edison's distribution network

In step (3), metrics and characteristics were determined to facilitate the prioritization of the identified siting opportunities based on economic, social, and environmental factors. These include distance of lots to existing substations and existing fossil fuel generators, lots that include NYC Environmental Justice Areas, and lots that include Con Edison Network areas with recent history of outages. For example, utilizing available capacity within existing electrical infrastructure could help defer new investments that otherwise may be necessary to accommodate energy storage. Furthermore, replacing power plants in EJ areas could bring important air quality benefits to surrounding communities. These metrics and characteristics are provided in the storage siting opportunity dataset that resulted from this analysis.

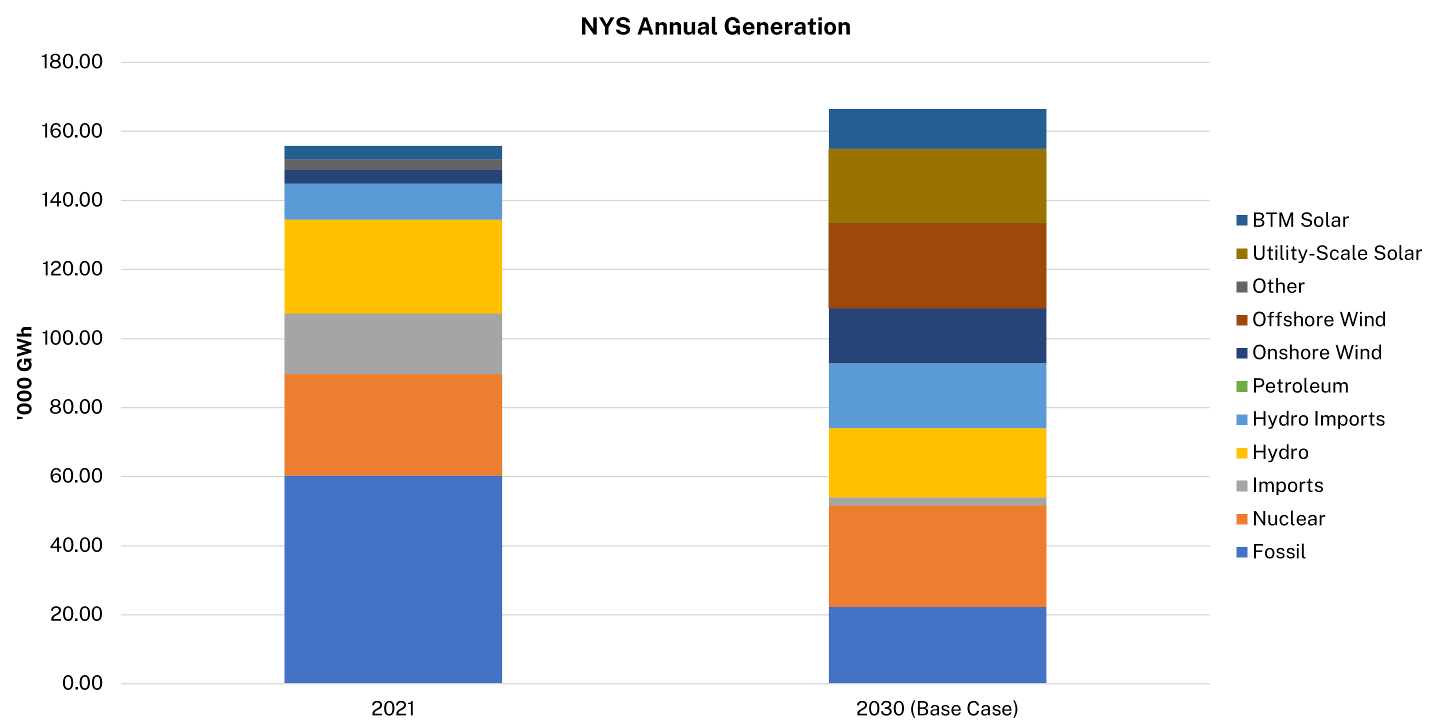
KEY FINDINGS

The key findings from this research are two-pronged. First, the analysis reaffirmed that additional clean energy and transmission resources present a significant opportunity to reduce New York City's reliance on fossil fuels, and new battery storage resources may be able to replace aging power plants. Second, when considering zoning and other land constraints, limited opportunities exist to deploy battery storage on City-owned unused land and parking lots, and while privately-owned land presents substantially greater potential, these lots face greater competition among different land uses. Therefore, the City should take steps to leverage available opportunities where possible.

Electricity System Modeling

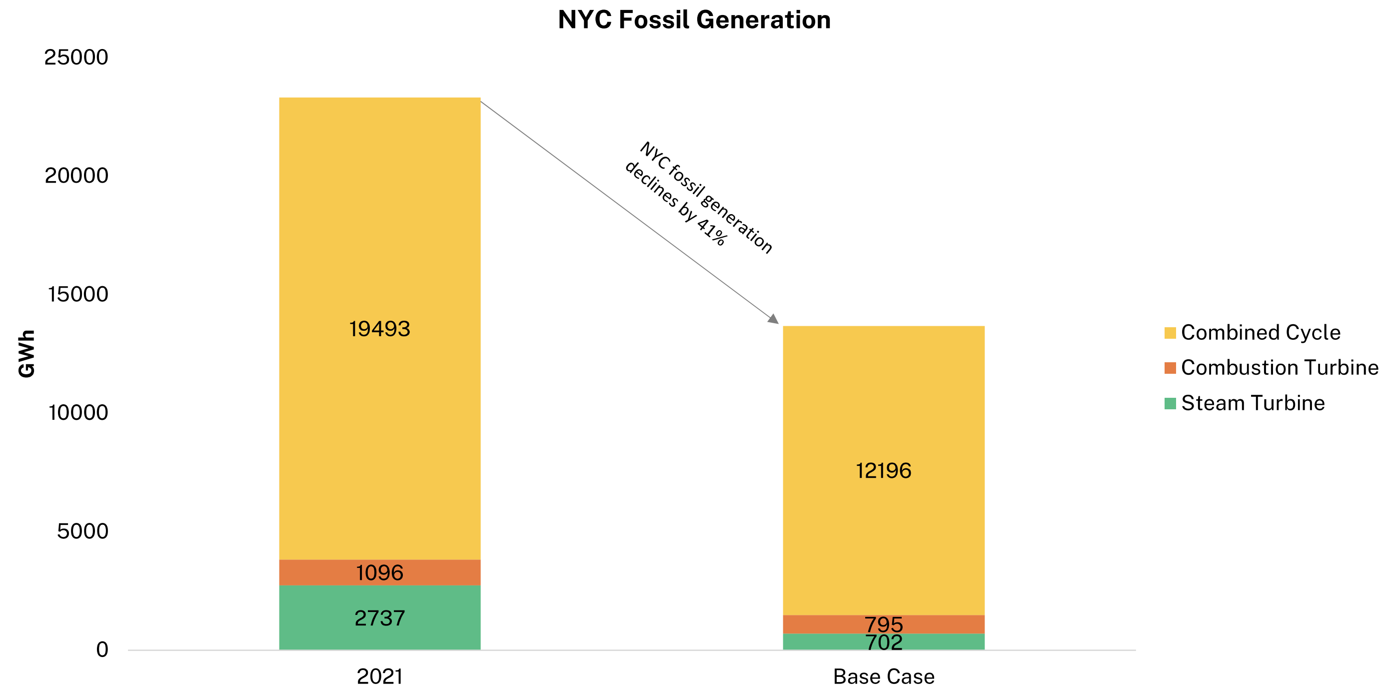
The analysis demonstrated that the operations of fossil power plants across New York State are expected to decline significantly between 2021 and 2030 as a result of projected clean energy and transmission additions. At the statewide level, fossil fuel-based generation is projected to decline by over 60 percent between now and 2030. The projected evolution of the generation mix between 2021 and the 2030 Base Case is illustrated in Figure 2 below.

Figure 2: Statewide Generation, 2021 and 2030 (Simulated)



Historically, power flowing from upstate New York to New York City has been constrained by the Central East transmission interface. Although several major transmission projects will increase the delivery of clean energy to New York City, transmission constraints both into and within New York City persist. As a result, declines in fossil fuel generation in the city are not as large as declines statewide, but there is still a significant decline in the city's reliance on fossil fuel-based generation of over 40% between 2021 and 2030, as shown in Figure 3. When examining generation by technology type within New York City, the largest reductions occurred from steam turbine (ST) generators with declines of over 70%. Many of these steam turbine generators are some of the oldest power plants in the City and have relatively high levels of pollution per MWh of electricity generated; replacement of specific units with battery storage may provide disproportionate benefits.

Figure 3: New York City Fossil Generation by Technology Type, 2021 and 2030 (Simulated)



The power system modeling demonstrated that the additions of new clean energy resources, as well as new transmission to support the delivery of those resources, can be a critical tool in reducing New York City's reliance on fossil fuels for power generation. The operations of the entire fossil fuel generating fleet are projected to decline significantly, and many of New York's peakers, including some of its oldest, least efficient units, may operationally decline naturally to the extent that these units' output could be matched by short-duration battery storage.

In its System and Resource Outlook study, NYISO identified that 95% of steam turbine units have retired at or before they reach an age of 62 years old, assuming any units beyond that age will have retired by 2030. This study did not make any assumptions about plant retirements beyond those already planned. However, many of the units that are over the NYISO's age threshold have been identified in this analysis as good individual candidates for replacement with battery storage due to low utilization in the electricity system modeling. The table below provides the list of units across the city by technology, age, and potential for replacement with 4-hour battery storage. Importantly, the "replaceability" provides an indication of whether battery storage could operate during the same run-times as the individual fossil fuel unit; the operations of each unit are intertwined, and the results should not be interpreted as a total cumulative capacity that could be replaced with battery storage.

Table 3: Feasibility Analysis of Individual Unit Replacement with Battery Storage

Power Plant Replacement Feasibility Analysis					
Unit	**Power Capacity [MW]**	**Tech**	**Age**	**2030 4-hr Replaceability Score**	**2030 8-hr Replaceability Score**
Steam Turbine Units					
Arthur Kill Generating Station 2	358	ST	63	**High**	**High**
Arthur Kill Generating Station 3	518	ST	53	**High**	**High**
Astoria Generating Station 2	177	ST	68	**High**	**High**
Astoria Generating Station 3	370	ST	64	**High**	**High**
Astoria Generating Station ST5	376	ST	60	**High**	**High**

Power Plant Replacement Feasibility Analysis					
Unit	Power Capacity [MW]	Tech	Age	2030 4-hr Replaceability Score	2030 8-hr Replaceability Score
East River 6	147	ST	71	Low	Low
East River 7	188	ST	67	Low	Low
Ravenswood 1	365	ST	59	Low	Low
Ravenswood 2	392	ST	59	Medium	High
Ravenswood 3	987	ST	57	High	High
Combustion Turbine Units					
Bayonne Energy Center GT2	62.8	GT	10	Low	Low
Bayonne Energy Center GT9	66	GT	4	Low	Low
Bayonne Energy Center GT10	66	GT	4	Low	Low
Bayonne Energy Center GT1	66.1	GT	10	Low	Low
Bayonne Energy Center GT7	66.1	GT	10	Low	Low
Bayonne Energy Center GT8	66.1	GT	10	Low	Low
East River 2	201.4	GT	17	Low	Low
Bayonne Energy Center GT5	66.1	GT	10	Low	Low
Bayonne Energy Center GT3	66.1	GT	10	Low	Low
Bayonne Energy Center GT6	66.1	GT	10	Low	Low
Bayonne Energy Center GT4	66.1	GT	10	Low	Low
East River 1	200.3	GT	17	Low	Low
Combined Cycle Units					
JFK Airport Cogen	117	CC	27	Low	Low
Astoria Energy II	612	CC	11	Low	Low
Poletti	553	CC	45	Low	Low
Ravenswood 4	277	CC	18	Low	Low
Linden Cogen Plant 1	310	CC	31	Low	Low
Linden Cogen Plant 3	417	CC	31	Low	Low
Linden Cogen Plant 2	310	CC	31	Low	Low
Astoria Energy	644	CC	16	Low	Low
Brooklyn Navy Yard Cogeneration 1	174	CC	26	Low	Low
Brooklyn Navy Yard Cogeneration 2	174	CC	26	Low	Low

Notes:

(1) Analysis includes units located outside of New York City that are electrically interconnected into Zone J.

(2) Analysis excludes NYPA-owned units because NYPA has conducted its own study of the feasibility of replacing those units.
(3) Analysis excludes units that have submitted plans to retire, or be offline during Ozone season, in compliance with the DEC NOx Rule.

In its Reliability Needs Assessment, NYISO also conducted a resource adequacy assessment on a portfolio that achieves policy compliance and uses the same load forecast used in this study ("Scenario 2"). In its analysis, NYISO found that the portfolio remained reliable even with the retirement of the units beyond the identified age threshold. While there are some differences in the portfolio between NYISO's Scenario 2 and the assumed portfolio used in this modeling, the resource adequacy findings generally support the conclusion that many of these units can feasibly be fully or partially replaced with storage without any compromise to system reliability. Additional analyses (e.g. transmission security) by both NYISO and ConEd would be needed to assess reliability in more detail before an asset owner would be able to proceed with the retirement of any individual unit.

It is also important to note that the findings in this assessment are dependent on the successful completion of contracted projects and achievement of policy targets. If renewable projects or transmission projects are delayed beyond their expected timelines, that may delay the ability to reduce the City's reliance on fossil fuels. On the demand side, the study that was used to inform the demand forecast included the achievement of managed electrification strategies, in which the addition of heat pumps and electric vehicles are paired with investments in energy efficiency, charging infrastructure, and other investments and policies that mitigate the impacts that electrification has on peak electricity demand.

Offshore Wind Sensitivities

The modeling of the 2030 power system examined the interconnection of Offshore Wind into different locations across the New York City and Long Island transmission systems. The Base Case assumed that the 6 GW target will be split roughly evenly between New York City and Long Island, though each subsequent sensitivity indicated a higher share of wind interconnected into the Zone J system, including interconnections in areas that are the subject of recent proposals (e.g. Clean Hub, Renewable Ravenswood, etc.).

The analysis found that each of the points of interconnection were well-suited for the delivery of offshore wind and did not result in excessive local congestion or curtailment, as measured by the comparable levels of reductions in fossil fuel generation across the Base Case and each of the sensitivities examined, shown in Table 4. This assessment should be considered a high-level "screening" exercise, and the differences across the sensitivities were not deemed to be significant; however, more detailed analyses including an assessment of the deliverability of the Offshore Wind resources over time may be needed as the details of new projects continue to emerge.

Table 4: Assessment of Impacts of OSW Points of Interconnection on 2030 Zone J Outputs

Summary of OSW Sensitivities				
	2030 Base Case	Sensitivity #1	Sensitivity #2	Sensitivity #3
Capacity Summary (MW)				
Statewide Offshore Wind Capacity	6,000	6,000	6,000	6,000
Zone J OSW Capacity	2,866	3,686	3,686	3,686
Zone K OSW Capacity	3,134	2,314	2,314	2,314
Interconnections in Zone J (MW)				
Gowanus (Empire 1)	816	816	816	816
Astoria (Beacon)	1,230	1,230	1,230	1,230
Fresh Kills	820			
Astoria / Mott Haven		1,640		
Farragut (Clean Hub)			1,640	
Ravenswood (Rise)				1,640
Zone J Outputs				
Thermal Generation (GWh)	13,693	13,349	13,186	13,162
% Change relative to Base		-2.5%	-3.7%	-3.9%

Storage Siting Analysis

The analysis examined siting opportunities for storage throughout NYC including Utility and VDER scale projects as well as residential 1-2 family projects. Table 4 presents the number of lots, land area, and storage potential by owner and land category that could be utilized for Utility- and VDER-Scale projects. 47 sites on City-Owned or Leased Property were identified with a potential of 412 MW. Of these sites, 15 are on municipal parking lots and the remaining are on vacant land deemed to have no use by the City. Substantially more lots – over 1,200 (totaling 7,219 MW) – were identified on vacant land under private ownership, though these may face greater uncertainty and competition for different land uses.

Table 5. Estimated NYC Storage Potential for Utility and VDER-Scale Storage by Owner-Land Category

Utility and VDER-Scale Storage Potential by Owner-Land Category			
Storage Category	# of Lots	Land Area (Acres)	Storage Potential (MW)
City-Owned and Leased Property	47	14	412
Vacant Land	32	12	367
Municipal Outdoor Parking (15% of Total Lot)	15	1	45
Private Vacant Land	1,241	241	7,219
Repurposed Power Plant Sites	7,577	102 - 104	3,120
Total	8,865	356 - 358	10,750

Table 5 shows the distribution of City-owned properties (vacant land and parking lots) by agency and review status. The sites were shared with the relevant City agencies for review beyond the screening analysis to determine if there were additional reasons for which the sites may not be suitable for storage development. Feedback was received from the Department of Citywide Administrative Services, Economic Development Corporation, Housing Preservation of Development, and Department of Small Business Services, resulting in 20 lots and 306 MW of storage potential. Additional sites – 27 lots and 106 MW of storage potential - were not able to be reviewed by the relevant City agency and therefore have greater uncertainty.

Table 6 Utility and VDER-Scale Storage Potential by City Agency and Review Status

Utility and VDER-Scale Storage Potential by City Agency			
Storage Category	# of Lots	Land Area (Acres)	Storage Potential (MW)
Properties Reviewed by City Agencies	20	10	306
Dept. of Citywide Administrative Services	12	2	50
Economic Development Corporation	2	0	8
Housing Preservation and Development	4	2	57
Dept. of Small Business Services	2	6	191
Unreviewed City-Owned and Leased Property	27	4	106
Total	47	14	412

Total storage potential was estimated at around 3,100MW for 14 existing fossil fuel fired power plants. However, as shown in Table 6, the total capacity of the power plants is around 7,500 MW, reflecting the higher energy density per acre of the power plants (average of 73 MW per acre) relative to the assumed 30 MW per acre for storage facilities. As investigated in this analysis, only a fraction of the plants may be good candidates for replacement with battery storage based on operation patterns and the lag time between plant decommissioning and storage development.

Table 7. NYC Fossil Fuel Power Plants and Estimated Storage Potential

NYC Fossil Fuel Power Plants and Estimated Storage Potential			
Power Plant Name	Plant Capacity (MW)	Approximate Site Acres	Estimated Storage Potential (MW)
Arthur Kill Generating Station	895.5	13 - 15	420
Astoria Energy & Astoria Energy II	1,245	21 - 23	660

NYC Fossil Fuel Power Plants and Estimated Storage Potential			
Astoria Generating Station	1,345	19 - 21	600
Brooklyn Navy Yard Cogeneration	322	1 - 3	60
East River	716.2	4 - 6	150
Harlem River Yard	79.9	1 - 3	60
Hell Gate	79.9	1 - 3	60
Joseph J Seymour Power Project	79.9	1 - 3	60
Kennedy International Airport Cogen	121.2	3 - 5	120
North 1st	47	0 - 2	30
Pouch	47	0 - 2	30
Ravenswood	2,461.8	25 - 27	780
Vernon Boulevard	79.9	2 - 4	90
Total	7,520	102 - 104	3,120

Notes: This table only includes units directly located within New York City (i.e. unlike Table 3, it does not include units outside the City that are electrically interconnected into Zone J).

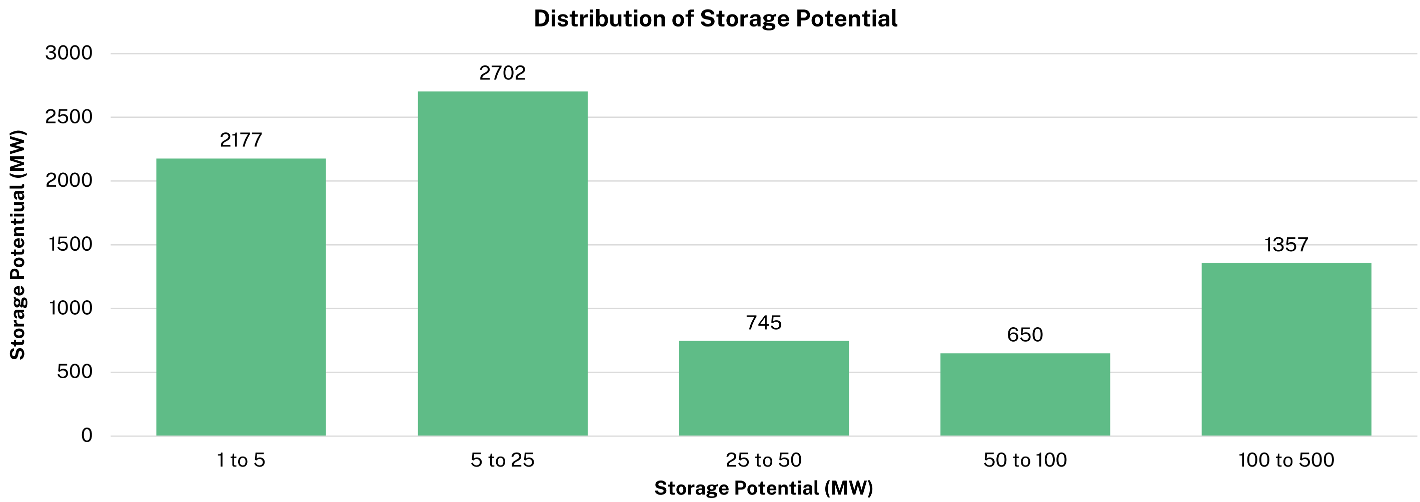
Table 7 provides additional breakdowns of identified sites, distinguished by COLP and Private, for land type, scale, borough, and zone. Of the sites analyzed, the majority occur on vacant land rather than parking lots. While there are more VDER sites identified, there is greater storage potential for Utility-Scale sites due to larger size. The majority of the private lots are in Staten Island and the majority of COLP lots are in the Bronx, while the fewest storage siting opportunities are in Manhattan. Lastly, the manufacturing districts provide the greatest opportunity for storage potential due to larger lot size and the 10,000 ft2 limit for storage projects in commercial districts.

Table 8. City and Private Lots by Land Type, Scale, Borough, and Zone (Excluding Power Plant Sites)

	COLP		Private		Total	
	# of Lots	MW	# of Lots	MW	# of Lots	MW
Land Type						
Vacant	30	359	1,241	7,219	1,273	7,586
Parking Lots	15	45	0	0	15	45
Scale						
Utility-Scale	15	331	323	5,116	339	5,453
VDER	30	72	918	2,102	949	2,177
Borough						
MN	2	9	148	481	150	490
BK	14	76	331	1,114	345	1,191
QN	12	121	259	1,230	273	1,359
BX	5	135	256	1,296	261	1,431
SI	12	62	247	3,098	259	3,159
Zone						
C1	0	0	19	51	19	51
C2	0	0	1	6	1	6
C4	16	59	170	623	186	682
C5	0	0	54	146	54	146
C6	3	12	66	218	69	230
C8	4	9	78	244	82	252
M1	19	198	710	4,632	731	4,838
M2	1	3	46	346	47	349
M3	2	122	97	953	99	1,076

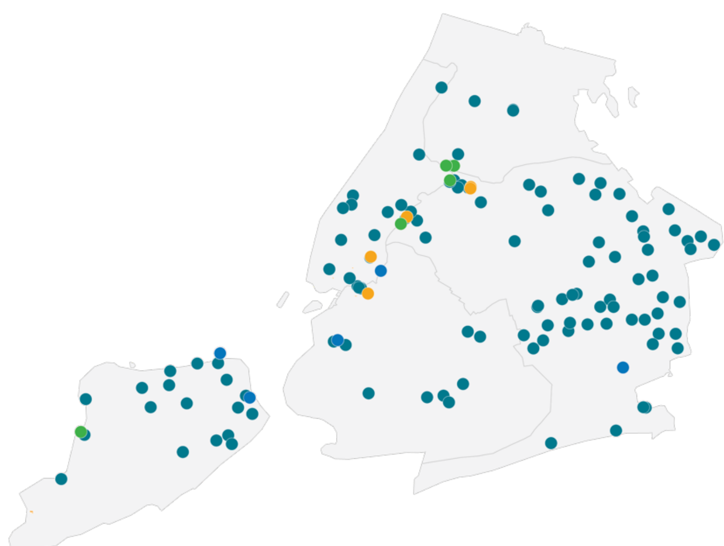
It is also important to consider the distribution of storage sizes to ensure that the results are not skewed by a few very large projects. Figure 4 presents the number of sites identified by size-range. While most sites are between 1-5 MW (VDER-eligible projects), Utility-Scale projects between 5 to 25 MW (around 2,700 total MW) provide the greatest potential. 37 sites greater than 25 MW provide an additional 2,700 MW potential, and 7 sites over 100 MW (the largest   420 MW), add another potential 1,357MW.

Figure 4. Distribution of Storage Potential (Excluding Power Plant Sites)



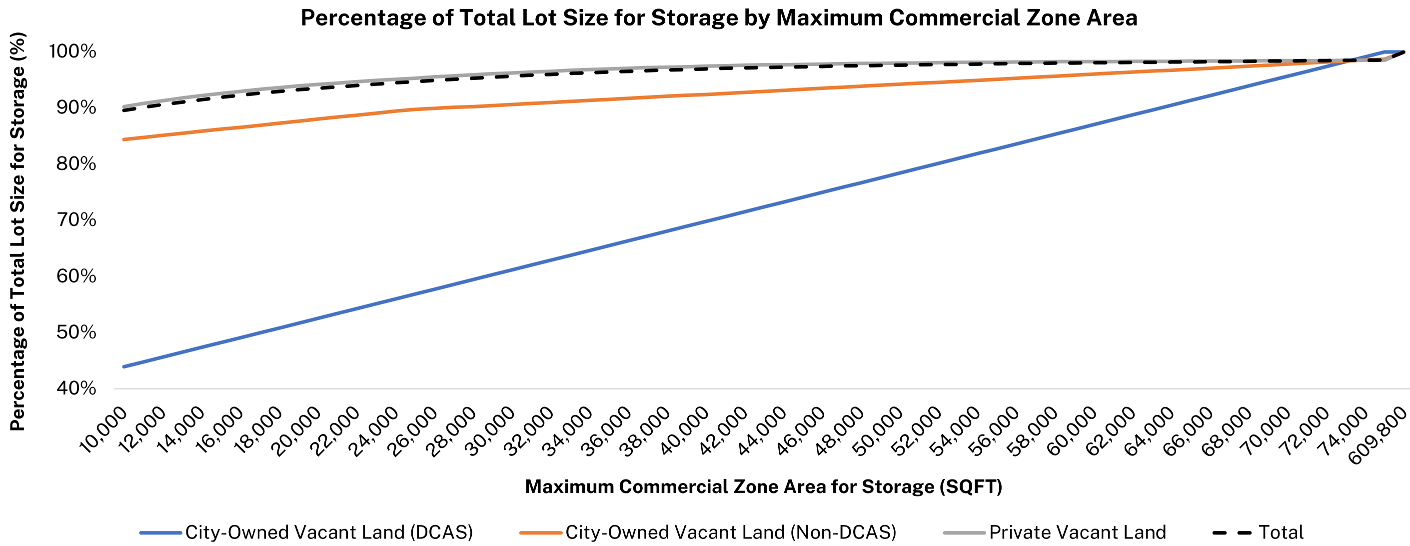
The final dataset produced by the analysis contains prioritization characteristics to help inform siting decisions. While different goals can result in different priorities, Figure 5 portrays City-owned properties and proximity to power plants (distinguished by modeled capacity factors) and substations. Some sites appear near power plants and/or substations, which could potentially help defer new infrastructure investments while other sites are more isolated and may require new infrastructure to integrate to the grid.

Figure 55. Map of Siting Opportunities and Prioritization Example



One option to increase the storage potential in NYC would be to raise or remove the current land area maximum for storage projects in commercial districts. The increase in storage potential while incrementally raising the maximum allowable land area is shown in Figure 6. It revealed that the current cap reduces total storage potential on vacant land by around 10%; that is, with the cap in place, 90% of the commercial and manufacturing land is available for storage. There was not much marginal benefit from incrementally raising the cap, reflecting the large size of the constrained lots. Instead, the cap would have to be raised substantially (or removed) to unlock most of the remaining potential.

Figure 66. Impact of Commercial Zone Maximum Storage Lot Size on Total Storage Potential



Lastly, a high-level evaluation of Residential 1-2 Family Buildings in Residential Zone R3 revealed 194,000 lots. The aggregate market potential was estimated to be approximately 970 MW if each building were to install a battery system of 5 kW. Table 5 shows this breakdown by borough, with the greatest potential in Staten Island followed by Queens.

Table 9. Storage Market Sizing for 1-2 Family Homes in R3 Zone

Storage Market Sizing for 1-2 Family Homes in R3 Zone		
Borough	# of Lots	Storage Potential (MW)
MN	0	0
BK	17,433	87
QN	78,350	392
BX	8,423	42
SI	90,043	450
Total	194,249	971

[i] Source: "Local Laws of the City of New York for the Year 2019: No. 99." City of New York
[ii] Source: New York State Energy Research and Development Authority
[iii] Source: New York Independent System Operator
[iv] Source: "Local Laws of the City of New York for the Year 2019: No. 181." City of New York

[v] Source: PEAK Coalition
[vi] Source: “The Fossil Fuel End Game: A Frontline vision to Retire New Yok City’s Peaker Plants by 2030.” PEAK Coalition
[vii] Source: PowerGEM
[viii] Source: New York City Department of Buildings
[ix] Source: Draft Logic
[x] Source: New York City Department of City Planning
[xixi] Source: New York City Department of City Planning
[xii] Source: U.S. Fish and Wildlife Service
[xiii] Source: “New York City Stormwater Flood Maps.” ArcGIS
[xiv] Source: U.S. Energy Information Administration
[xv] Source: Homeland Infrastructure Foundation-Level Data
[xvi] Source: City of New York