LONG ISLAND FOSSIL PEAKER REPLACEMENT STUDY

STRATEGEN

PREPARED FOR NY-BEST
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YOUR PARTNER IN THE ENERGY TRANSITION

Long Island Fossil Peaker Replacement Study

Prepared for:

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Executive Summary

Long Island, New York is an expansive, densely populated island stretching east from New York City into the Atlantic Ocean, home to nearly 3 million residents in Nassau and Suffolk County. Long Islanders are increasingly vulnerable to the effects of climate change such as recurring hurricanes and rising seas. As part of New York State's commitment to halting climate change, it has mandated a carbon-free grid by 2040. Long Island has a leadership role to play in New York's clean energy transformation. This study examines the cost-effectiveness of retiring an aging and inefficient fleet of fossil-fueled peaking power plants and replacing them with energy storage, a "low-hanging fruit" in the island's energy transition. The analysis shows that replacing the aged, polluting peaker fleet will reduce energy costs, create jobs, build a more resilient power system, reduce air pollution in Potential Environmental Justice Areas and lower greenhouse gas emissions - a "no regrets" solution for all Long Islanders.

Over the next decade, deploying energy storage to replace fossil-fueled peaker plants could save LIPA customers as much as $393 million

Long Island is host to 26 fossil-fueled power plants, composed of 74 individual generation units, that seldom operate yet impose significant costs on Long Island Power Authority (LIPA) customers. Of LIPA's portfolio of 5,667 MW of emitting generators, 4,357 MW are "peaker plants" that operate at an annual capacity of 15% or less (i.e. roughly 15% of the time or less)[1]. To maintain these peakers, LIPA customers pay an estimated $473 million annually in capacity costs, almost three times the market rate for capacity resources cleared through NYISO's competitive markets.[2]

This report presents analysis demonstrating that it is feasible and cost-effective to replace over 2,300 MW of Long Island's fossil-fueled peaker plants with energy storage over the next decade. Approximately half of these resources, 1,116 MW, could be retired and replaced with energy storage by 2023. The remaining 1,209 MW could be replaced with energy storage by 2030, using the storage to supplement the state's planned deployments of increased solar, energy efficiency, and offshore wind, which will also help enable fossil fuel retirements in Long Island's transmission constrained East End load pocket.

[1] Of the initial 4,357 MW peaker selection, 69 units with about 3,053 MW of capacity operated at 10% or less of the time while a subset of 36 units accounting for 1,249 MW ran less than 1% of the time in 2019.
[2] Based on net cost of contracted capacity (after estimated energy and AS revenues) through Power Supply Agreement between Lipa and National Grid and Strip Auction market prices in Zone K (averaged for the last 5 years). See section *1.1.1 Peaker Fleet Costs.*

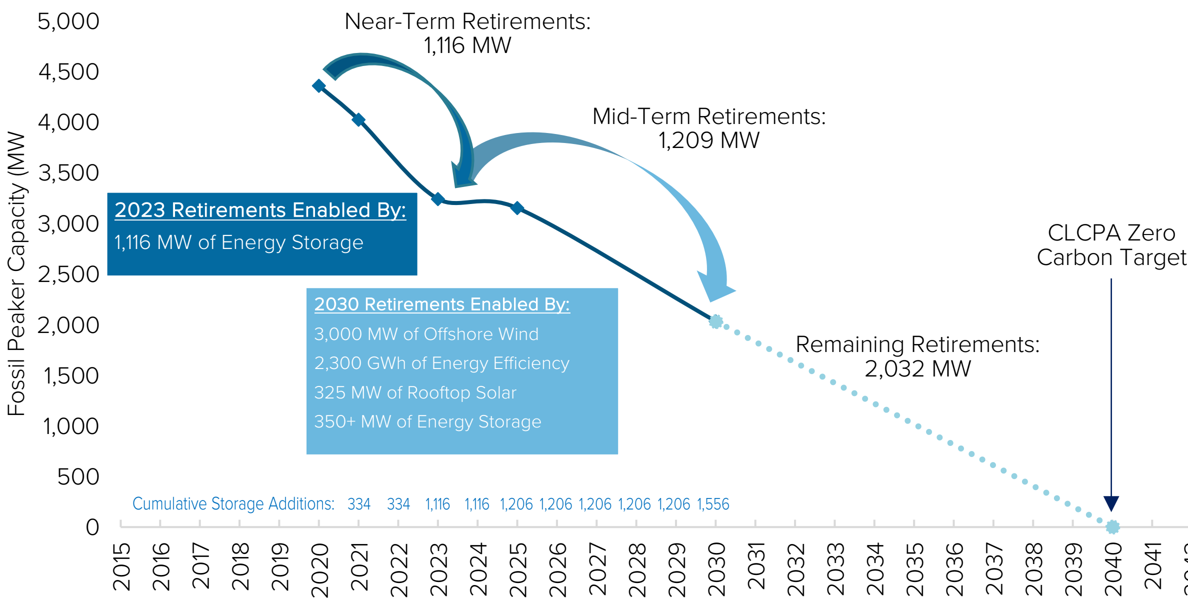

Figure 1. Phased Replacement of LIPA Peaker Capacity

This trajectory of fossil-fuel retirement and replacement with storage would put Long Island on trajectory to comply with the state's Climate Law and Community Protection Act (CLCPA), which requires a carbon-free grid by 2040. Moreover, it would provide much needed new flexible capacity into the Long Island transmission zone while preparing Long Island to integrate expected and forecast renewable capacity. NYISO reliability studies show that peaking needs could become an issue in the future if replacement generation is not added, particularly in localized areas with transmission constraints.[3] Given that New York has established emissions reduction goals limiting replacement generation to clean energy options, energy storage represents a technologically feasible, commercially available, cost-effective, policy-compliant solution to help ease out aging fossil-fueled plants.

In addition to the carbon reduction imperatives established by the CLCPA, New York City and Long Island have established rules to help encourage the retirement of many of these plants that run on fuel oil. Fuel oil is known to be one of the highest polluting fossil fuel sources.[4] As a result, although they operate infrequently, when they do operate, they are major contributors to ozone pollution and local air quality problems. However, these shorter duration operations mean that these peaking assets are excellent candidates for replacement with energy storage. In fact, 17 of LIPA's 26 plants are subject to recent rules established by the Department of Environmental Control (DEC) to reduce local NOx emissions from oil-fired power plants. Of these 17 plants, only 8 of the plants already comply with the emissions control requirements established by the DEC, while another 6 are planning to install costly emissions control mechanisms – costs paid by LIPA customers that could be avoided altogether if these plants were simply retired. The remaining 3 are planning to either retire or be kept as black start only generators.

[3] NYISO, *2019-2028 Comprehensive Reliability Plan.* https://www.nyiso.com/documents/20142/6001938/04%202019-2028%20CRP%20Report%20Draft.pdf
[4] EPA, *Emissions Factors for Greenhouse Gas Inventories.* https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

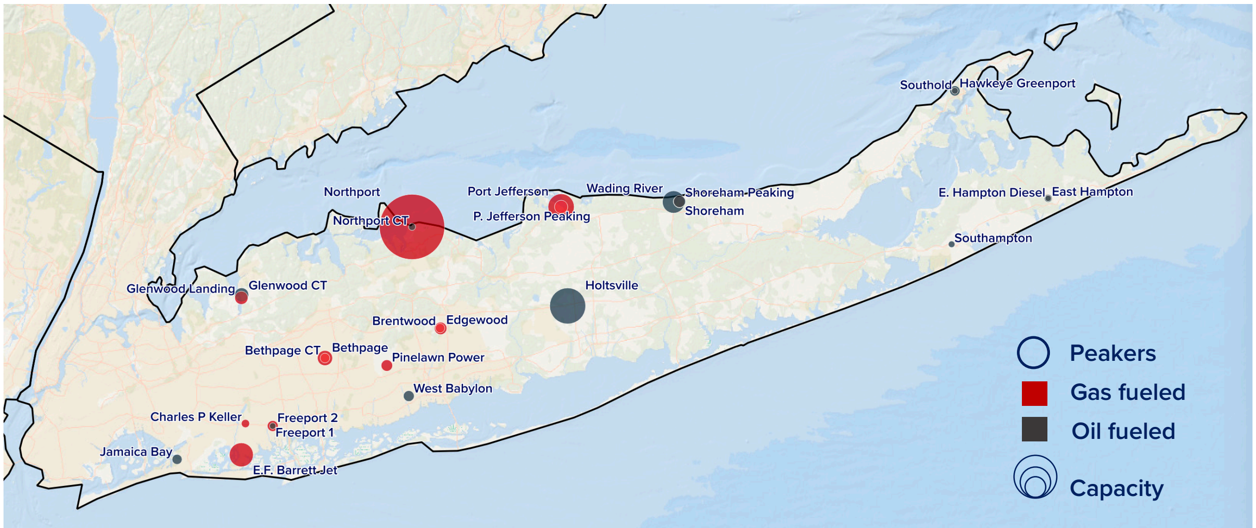

Figure 2. Peaker Plants in Long Island

Retiring and replacing these aging assets has the potential to create $10.5 million of savings per year in 2021, growing to $150 million per year in 2030. Over the next decade, fossil peaker replacements could save LIPA customers as much as $393 million, net present value[5], representing savings of around $360 per household across LIPA's 1.1 million customers.

On top of the value that these retirements and replacements could create in structured energy markets, they provide additional social and environmental benefits in the form of emissions reduction. The peaker fleet considered in this analysis annually emits 2.65 million metric tons of CO_2, 1,910 tons of NOx, and 639 tons of SO_2. The estimated societal cost of these annual emissions is over $160 million.[6] Moreover, these pollutants disproportionately impact Potential Environmental Justice Areas, many of whom are already exposed to some of the highest levels of pollution in the state. Exposure to ozone above background levels causes New Yorkers to suffer annually from about 400 premature deaths, more than 800 asthma related hospital visits, and over 4,500 asthma related emergency room visits. A reduction in ozone levels by just 10% could prevent 180 premature deaths, 180 hospital admissions and 970 emergency department visits annually.[7]

[5] Assumes a discount rate of 7% based on industry standards.
[6] Annual emission cost estimates are based on the social cost of CO_2 and the morbidity and mortality of NOx and SOx as precursors to PM 2.5.
[7] New York City Department of Health and Mental Hygiene, *Air Pollution and the Health of New Yorkers.* https://www1.nyc.gov/assets/doh/downloads/pdf/eode/eode-air-quality-impact.pdf

Key results of this Long Island Fossil Peaker Replacement Study show:

- It is feasible and cost-effective to replace 1,116 MW of Long Island's fossil-fueled peaker plants with energy storage by 2023 and over 2,300 MW by 2030.
- Potential savings of up to $393 million of savings can be achieved for LIPA customers over the next decade by retiring and replacing aging fossil assets.
- Replacing peakers with storage will eliminate 2.65 million metric tons of CO_2, 1,910 tons of NOx, and 639 tons of SO_2 of emissions annually, resulting in societal benefits of $163 million annually.
- Of the 2,300 MW of fossil peaker plant replacements, 334 MW could be retired and replaced immediately, and another 782 MW could be phased out by 2023, coinciding with the implementation of local emission control regulations and the expiration of existing LIPA long-term contracts.
- In the East End of Long Island there is a near-term opportunity for up to 90 MW of fossil peakers to be displaced with energy storage, and additional opportunities over time as local constraints are addressed.

As New York establishes its leadership position in the fight against climate change, the state will need all generation plant owners and operators to think strategically and expansively about how to transition their fleets. Replacing Long Island's oldest, least efficient, and most polluting fossil-fueled peaker plants today with lower cost, emission-free energy storage is a no-regrets solution for LIPA, its customers, the environment, and the state of New York.

1. Background

1.1 Overview of Long Island Peaker Fleet

Long Island's electricity system has a fleet of 74 peaking power generation units at 26 plant locations accounting for 4,357 MW of fossil fueled generation capacity.[8] The average age of the fleet is 43 years old, with some units running since the 1940's. All these plants operate infrequently and, when they do, many run for only a few hours every time - of the portfolio of 74 units, 26 of those units, representing 1,116 MW of capacity have typical dispatch durations of 8 hours or less.[1]

Plants listed below are identified based on their resource designation in the NYISO market, though many are in the same geographic location.

Table 1. LIPA Fleet Summary

Plant Name	Owner	Number of Units at Plant	Total Peaking Capacity (MW)
Bethpage	Calpine Corp.	1	96
Bethpage CT	Calpine Corp.	1	60
Brentwood	New York Power Authority	1	47
Charles P Keller	Village of Rockville Centre	7	31.4
Edgewood	J Power	2	100
E.F. Barrett Jet	National Grid	11	293.2
East Hampthon	National Grid	4	27.3
Freeport GS	J Power	1	60
Freeport 1 & 2	Village of Freeport	5	89.7
Glenwood CT	National Grid	3	126
Glenwood Landing	National Grid	2	106
Greenport	Village of Greenport	3	6.8
Hawkeye Energy Greenport	Hawkeye Energy Greenport	1	54
Holtsville	National Grid	10	567
Jamaica Bay	Hull Street Energy	1	60.5

[8] Peaker plants were defined in this study as all fossil fueled power plants with capacity factors equal or below 15% for single units or for full plant average, and nameplate capacity equal or greater than 10 MW (one smaller plant was included due to its operational characteristics).

Northport	National Grid	4	1,548
Northport CT	National Grid	1	16
Pinelawn Power	J Power	1	82
Port Jefferson	National Grid	2	376
Port Jefferson Peaking	National Grid	3	122
Shoreham	National Grid	2	71.5
Shoreham Peaking	J Power	2	100
Southampton	National Grid	1	11.5
Southold	National Grid	1	14
Wading River	National Grid	3	238.5
West Babylon	National Grid	1	52.4
Total			***4,356.8***

On average, the peaker fleet on Long Island is only used at 8% of its full capability. However, about a third of the units actually run less than 1% of the time. Generally, these are the least efficient plants, and burn either natural gas, light fuel oil or kerosene – some without any pollution controls -- making them some of the most polluting energy assets on the grid on a per megawatt-hour basis. For such reasons, these polluting peakers can be considered the "low-hanging fruit" and ideal candidates for near-term replacement with lower cost and cleaner technologies. Not only would replacing these resources be aligned with the State's clean energy policy goals, but such replacements would also help address local resident environmental justice concerns, and lower electricity costs.

The age of the generating units is another factor for consideration. Most of the peaker fleet capacity is more than 40 years old and almost 1,600 MW are past the normal age of retirement for their specific generation technologies[9]. By 2025, that number will go up to 2,775 MW or about 65% of the total peaker capacity in Long Island.

[9] Analysis of S&P Global Market Intelligence on annual retirements in the US at unit-level data. https://www.spglobal.com/marketintelligence/en/news-insights/trending/gfjqeFt8GTPYNK4WX57z9g2

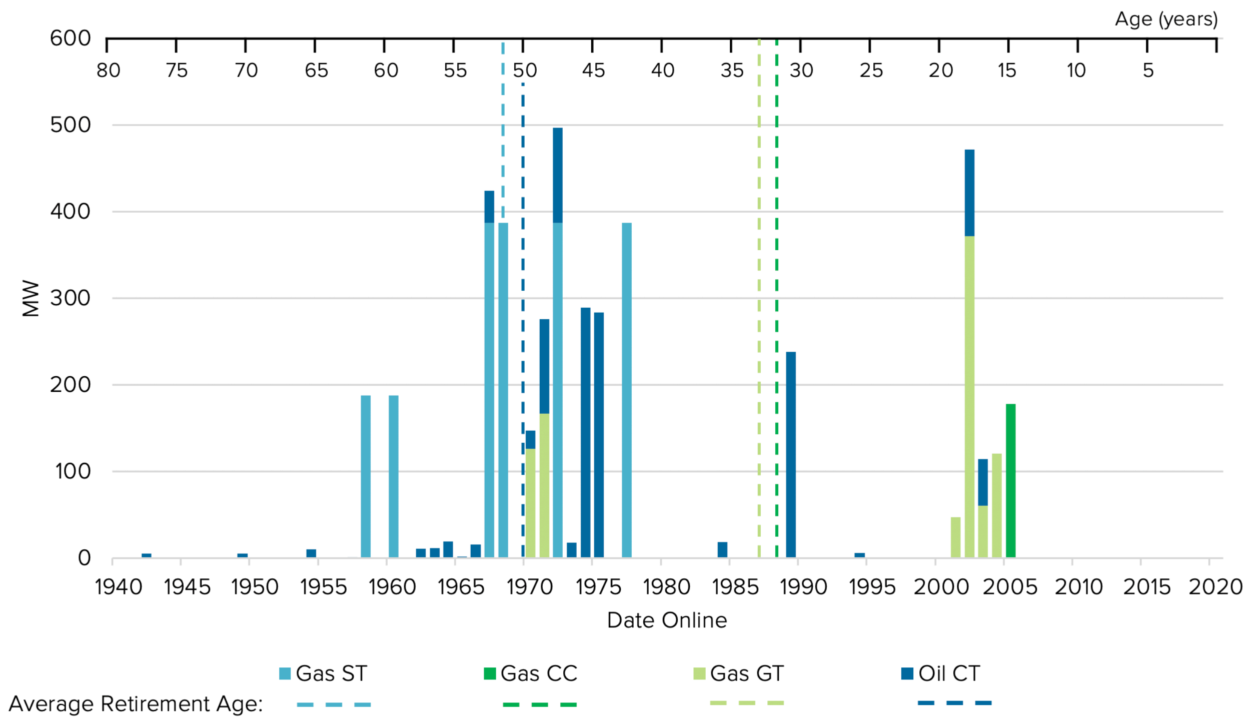

Figure 3. Age of Peaker Fleet and Typical Retirement Dates

1.1.1 Peaker Fleet Costs

The aging peaker fleet, although rarely used, leads to significant costs for by Long Islanders through their energy bills. Strategen estimates that the identified peaker fleet may be costing Long Island electricity customers approximately $473 million annually just for capacity, and that if the peaking fleet is not replaced, this cost could increase to an estimated $716 million by 2030.[10]

The bulk of these costs reflect payments for generation capacity to the plants contracted through a Power Service Agreement (PSA) between LIPA and National Grid for 3,634 megawatts (MW), of which 3,284 MW (90%) are for peaking capacity.[11] This represents a significant majority of the Long Island peaker fleet. The PSA was contracted for the period from 2013 to 2028. Although not all the plants were initially contracted to function as peaking capacity, the entry of new and more efficient generation assets into the market have resulted in older generators running much less frequently, thereby increasing the cost per unit of energy delivered for those older units. Strategen estimates that the cost for capacity of this agreement is three times higher than the relative cost of capacity on the Long Island that is cleared through NYISO's competitive capacity markets.[12]

Moreover, many of the peakers on Long Island are frequently operated uneconomically due to inefficiencies and constraints in how the system is operated, some of which could be

[10] Based on estimated 2019 capacity payments of $/kW-year (net of estimated energy & ancillary services) and an annual escalation rate of 2.5%. PSA contract cost as reported in the LIPA/NG PSA - Attachment A. The escalation rate approximates PSA annual cost increase.
[11] LIPA, *Amended and Restated Power Supply Agreement.* https://www.lipower.org/wp-content/uploads/2016/10/A-and-R-PSA-effective-28-May-13.pdf
[12] The average cost of capacity in the last 5-years for Long Island was $ 3.14/kW-month through the strip market while the net cost of capacity in the PSA was estimated to be $9.98/kW-month during 2019.

alleviated through market reforms or through deployment of modern inverter-based resources like battery storage. According to recent reports by the NYISO market monitor, over half of all gas turbine operations on Long Island appear to be uneconomic, meaning that plants are running out of merit order, unnecessarily increasing emissions and customer costs.[1] This is driven in part by out-of-market dispatch by LIPA to manage low voltage congestion and transient voltage issues, some of which arises from deficiencies in the NYISO market model and lack of real-time coordination between LIPA and the NYISO.

1.1.2 Peaker Fleet Environmental Impacts

The forecasted cost noted above also considers the addition of new NOx emissions control equipment for a portion of the peaking assets. Many of the Long Island peakers will need to be retrofitted with new NOx controls in the coming years to comply with environmental regulations[13] recently promulgated by the New York Department of Environmental Conservation. The cost of these retrofits will ultimately be passed on to Long Island electricity customers. These retrofit costs will also be exacerbated by the fact that the state's Climate Leadership and Community Protection Act (CLCPA) phases out all fossil generation by 2040, thus shortening the financial life of the peaker plant assets and any associated pollution control investments.

Retirement of peaker plants is a clear way to address harmful pollution issues in New York and yield a significant improvement to public health as peakers contribute as much as 94% percent of the State's NOx emissions on high ozone days despite providing as little as 36% of the gross load.[14] Peakers produce a disproportionate amount of emissions, and in part, this is because many of the older peaker plants do not have any form of NOx controls. The emissions of peakers have an adverse impact on New York's air quality and make it near impossible for the State to achieve attainment with NAAQS targets.

As displayed in the table below, the LIPA peaker fleet contributes significantly to local CO_2, NOx, and SO_2 emissions. Based on historic emissions and generation data from 2016-2018[15] the Long Island peaker fleet produces 2.65 MT of CO_2, 1,910 tons of NOx, and 639 tons of SO_2 annually.[16]

Table 2. Annual CO_2, NOx, SO_2 Emissions by LIPA Peaker Plant

Plant Name	NOx Controls?	CO_2 Emissions (tons)	NOx Emissions (tons)	SO_2 Emissions (tons)
Bethpage	Yes	245,849	183	1.01
Bethpage CT	No	89,934	5.2	0.42
Brentwood	Yes	32,138	2.5	0.14
Charles P Keller	No	1,469	2.8	0.1
Edgewood	Yes	64,846	125	4.6

[13] See section 1.2.2 for more information on New York NOx regulations.
[14] New York State Department of Environmental Conservation, *Adopted Subpart 227-3 Revised Regulatory Impact Statement.* https://www.dec.ny.gov/regulations/116175.html
[15] S&P Global Market Intelligence, *Annual Unit Emissions.* https://platform.mi.spglobal.com/web/client?auth=inherit&overridecdc=1&#powerplant/PowerPlantEmissionsByproduct?ID=7502
[16] For 19 peakers emissions data was directly available from S&P Global Market Intelligence. The emissions of the other 7 peakers (Charles P Keller, Edgewood, Freeport GS, Freeport 1 &2, Greenport, Southampton, Southold) were calculated from the available peakers' CO_2, NOx, and SO_2 average emissions rates (lb/MMBtu).

E.F. Barrett Jet	No	111,631	365	3.8
East Hampthon	No	11,106	32..4	0.67
Freeport GS	Yes	53,996	101	3.7
Freeport 1 & 2	No	29,399	56.5	2.0
Glenwood CT	No	3,631	10.7	3.5
Glenwood Landing	Yes	79,809	8.7	0.3
Greenport	No	21	0.04	0.007
Hawkeye Energy Greenport	Yes	13,446	2.0	0.08
Holtsville	Yes	38,561	143	41.2
Jamaica Bay	Yes	7,533	1.2	0.05
Northport	Yes	1,500,648	689	409
Northport CT	No	327	2.2	0.02
Pinelawn Power	Yes	76,641	4.6	0.55
Port Jefferson	Yes	219,980	119	160
Port Jefferson Peaking	No	37,906	5.7	0.15
Shoreham	No	3,560	12.0	4.2
Shoreham Peaking	Yes	5,260	1.4	0.04
Southampton	No	2,377	4.5	0.17
Southold	No	1,883	3.7	0.13
Wading River	Yes	16,179	19.6	0.08
West Babylon	No	2,949	9.4	2.61
Total		***2,651,077***	***1,911***	***639***

Further, many of these plants are located in some of the communities that already bear the greatest pollution burdens in New York State, and which have been designated by the State as Potential Environmental Justice Areas.[17] Bases on data from the US Census and EPA, we estimate that about 890,000 people live within a 3-mile radius of a peaker plant, and 32% of them live in Potential Environmental Justice Areas.

[17]New York State Department of Environmental Conservation, Maps & Geospatial Information System (GIS) Tools for Environmental Justice. https://www.dec.ny.gov/public/911.html

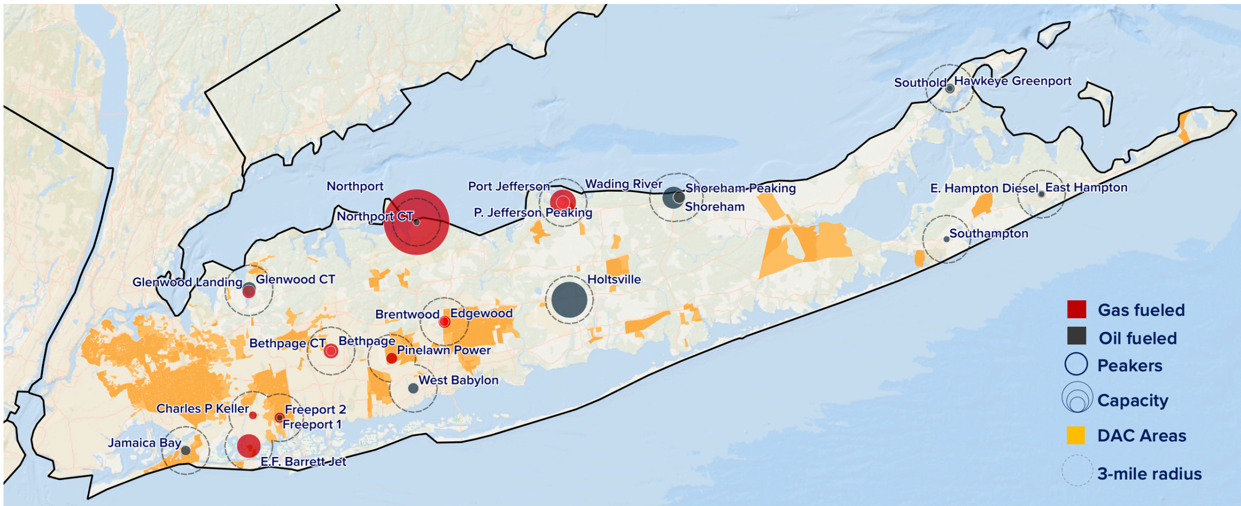

Figure 4. Peaker Proximity to Potential Environmental Justice Areas

1.1.3 Peaker Fleet Location & Local Reliability

For the peaking assets examined in this study, location is a major consideration affecting replacement feasibility. Some of these peaker plants are located in transmission constrained areas, also known as load pockets, that raise reliability concerns under the current state of the system. These concerns are addressed in this study with a special focus on the island's East End, which is one of the most location-constrained areas on Long Island according to NYISO's Comprehensive Reliability Plan 2019-2028.

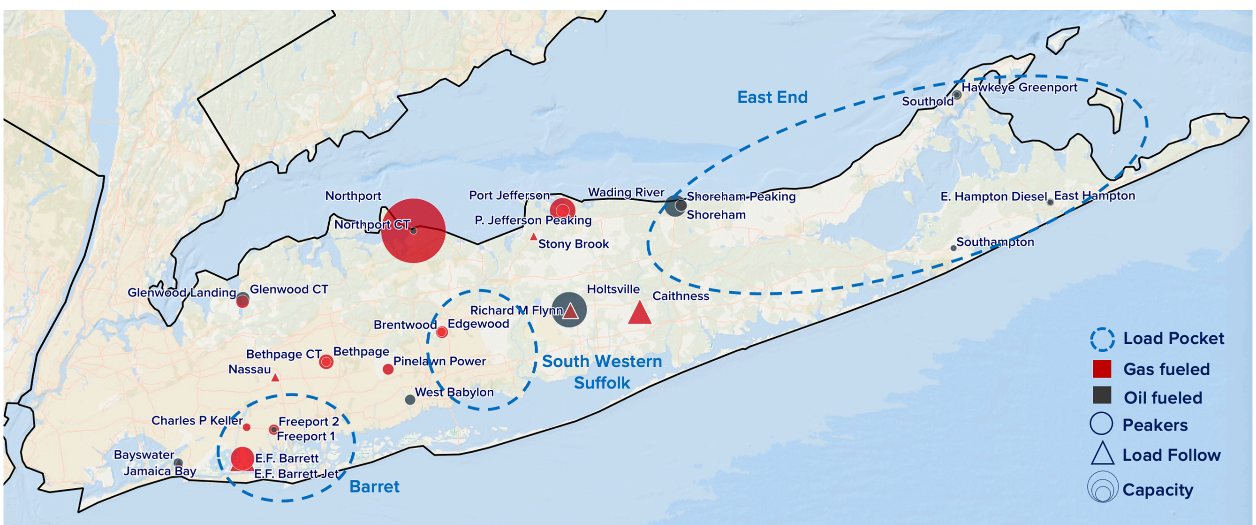

Figure 5. Peaker Power Plants and Load Pockets in Long Island

Some of the oldest and least utilized assets are smaller generators, accounting for 67.4 MW from 11 units. These units are presumed to be used as back-up generators by local municipalities and are thus excluded from consideration in this analysis. Although these were excluded from the analysis conducted in this study, such units may still be attractive candidates for replacement in the near future.

1.2 Relevant Policies and Long-Term Planning Issues

New York has already established policies to phase out polluting, fossil fuel assets (including peaker plants), and accelerate deployment of clean energy technologies like battery storage, wind and solar. The section below outlines some of the key policies and long-term planning consideration that continue to motivate resource procurements and retirements.

2020

- **Indian Point** – Deactivate units 2 & 3 by 2020 and 2021 (2.3 GW)
- **NYC Residual Oil Elimination** – Eliminate Fuel Oil #6
- **Performance Standards** – Maximum power plant emissions of 180 lbs CO_2 per MMBTU
- **NY Accelerated RE & Community Benefit Act** – Helps accelerated siting of eligible renewable projects

2025

- **CLCPA** – 6 GW of distributed solar; Reduce consumption by 185 Trillion BTU with energy efficiency
- **Goal Announced by Cuomo** – 1,500 MW of storage
- **NYC Residual Oil Elimination** – Eliminate Fuel Oil #4 (2.95 GW affected)
- **Peaker Rule** – NOx reduction compliance period (3.3 GW impacted)
- **LIPA and National Grid PSA** – Contract can be terminated early with 2 years' notice

2030

- **CLCPA** – 3 GW storage; 70% load from renewables
- **PSC Order** – 3,000 MW of storage
- **RGGI** – Reduce CO_2 emissions cap by 30% from 2020 & include peakers
- **LIPA and National Grid PSA** – Contract expires in 2028 with options to ramp down sooner

2035

- **CLCPA** – 9 GW offshore wind

2040

- **CLCPA** – 100% carbon free electricity

Figure 6. Policy and Planning Outlook Through 2040

1.2.1 Climate Leadership and Community Protection Act

On July 18, 2019, New York Governor Andrew M. Cuomo signed into law the Climate Leadership and Community Protection Act (CLCPA). New York State's CLCPA is among the most ambitious climate laws in the world and requires New York to reduce economy-wide greenhouse gas emissions 40 percent by 2030 and no less than 85 percent by 2050 from 1990 levels. The CLCPA puts New York State on the path towards net zero greenhouse gas (GHG) emissions.[18] The CLCPA consists of the most stringent economy-wide carbon target in the US. By 2050, the CLCPA mandates an 85% reduction in GHGs from 1990 levels. Emissions beyond 85% can either be directly reduced or offset through projects that remove GHGs from the atmosphere. Additionally, the CLCPA codifies a number of ambitious electric sector targets, including 100% carbon-free electricity by 2040.

To support and enable these broader decarbonization targets, the CLCPA has set resource procurement targets leading up to these decade milestones. The targets include 6 GW of rooftop solar by 2025, 3 GW of energy storage by 2030, and 9 GW of offshore wind by 2035. With clear targets for renewable energy, energy efficiency, and energy storage

[18] New York State, *Climate Act.* https://climate.ny.gov

coupled with a concrete timeline, the act seeks to drive renewable energy procurement and facilitate the rapid growth of a clean energy economy in New York.

CLCPA mandates effectively eliminate the use of all fossil energy resources by 2040, necessitating the retirement of New York's fossil fuel plants in the next 20 years and thus investments in a carbon-free replacement resources will need to occur in parallel.

1.2.2 Air Quality and NOx Regulation

In response to New York's nonattainment for the 2008 and 2015 ozone National Ambient Air Quality Standards (NAAQS), the New York Department of Environmental Conservation (DEC) implemented New York Codes, Rules, and Regulations (NYCRR) Subpart 227-3.[19] The primary goal of this regulation is to lower allowable NOx emissions during ozone season. The regulation applies to all simple cycle and regenerative combustion turbines (SCCTs) larger than 15 MW and will affect approximately 3,400 MW of SCCT capacity in New York City and Long Island that are older, pre-1986 units.

The DEC expects that most impacted facilities will opt to replace or shut down non-compliant SCCTs because those installed prior to 1986 are typically not conducive to the addition of retrofit pollution control technology and will face high installation costs for any emissions control solutions. SCCTs built before 1986 contribute up to 94% of NOx emissions on high ozone days while providing only 36% of the gross load, so retirement of these generation resources will address NAAQS nonattainment.[20] Based on estimates by DEC, replacing and retiring these older fossil units built prior to 1986 could reduce 1,849 tons of NOx emissions on some of the highest ozone days of the year, and will have the biggest impact on nearby communities, many of which are Potential Environmental Justice Areas.

New York DEC has established a phased approach, with a NOx emission limit of 100 parts per million (ppm) going into effect on May 1, 2023. Two years later, the limit will drop to 25 ppm for units using gaseous fuels and 42 ppm for units burning liquid fuels.

Further, the new emission rules stipulate that in 2023 peaking units will only be able to average emissions with similar units at the facility or with approved energy storage and renewable energy resources during the ozone season. This is contrast to current regulation, 6 NYCRR Part 227-2, which allows plant owners to average emission rates from across all facilities, including turbines and boilers.[21]

This means that under the current rules a facility can average its lower emitting, well controlled sources with higher emitting sources and calculate an average value for NOx compliance purposes. Under the new rules, this practice will no longer be allowable in 2023. Compliance options for SCCTs that exceed NOx limits consist of (a) retrofitting, shutting down, or replacing units, (b) ceasing operations during ozone season, or (c) pairing units with energy storage or renewable energy resources. As a part of this process, NYISO is planning to review any planned unit shutdown to ensure grid reliability.[22] For example, the

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[19] New York State Department of Environmental Conservation, *Adopted Subpart 227-3 Revised Regulatory Impact Statement.* https://www.dec.ny.gov/regulations/116175.html
[20] *Ibid.*
[21] New York State Department of Environmental Conservation, *Adopted Subpart 227-2 Reasonably Available Control Technology (RACT) for Major Facilities of Oxides of Nitrogen (NOx) Revised Express Terms.* https://www.dec.ny.gov/regulations/117482.html
[22] New York State Department of Environmental Conservation, *Adopted Subpart 227-3 Revised Regulatory Impact Statement, op. cit.*

NYISO 2020 RNA included a review for 3 units (Glenwood GT 1, Northport GT, and Port Jefferson GT 01) in preparation for deactivation in compliance with the peaker rule.

These NOx compliance rules are expected to impact 3.4 GW of the fossil fueled power plants operating in Long Island, either through shutdown, reduced operation, or retrofits. These impacts are considered and explored later in this report by examining the explicit retirement of plants and as well as considering the cost effectiveness of continued investment in fossil assets as compared to the cost of transitioning to cleaner resources such as energy storage.

1.2.3 Energy Storage Roadmap and Deployment Plans

At the end of 2018, the New York Public Service Commission (PSC) issued an energy storage order establishing a goal of 3 GW by 2030.[23] It is important to note the goal of 3 GW was established by the PSC as a "no regrets" minimum threshold amount of storage and is not necessary the optimal amount of storage for the state, nor is it indicative of the level of storage deployment needed to achieve the state's goal of carbon-free electricity by 2040.

This order built upon Governor Cuomo's nation-leading goal for the State of 1.5 GW of energy storage by 2025. The PSC order was based upon the recommendations of the New York Energy Storage Roadmap, developed by NYSERDA and the New York State Department of Public Service (DPS).[24] The roadmap identified deployment opportunities and use cases for energy storage and provided recommendations of policies, regulations, and initiatives that the State could undertake to meet energy storage targets. To accelerate deployment of the mandated 3 GW of energy storage, the PSC order included incentive funds totaling $400 million available through 2025 and a directive to the state's six investor-owned utilities to hold competitive procurements for at least 350 MW of bulk-sited energy storage.

1.2.4 LIPA Contracts and Procurement

A significant part of Long Island's peaker fleet is contracted through a PSA between LIPA and National Grid. The contract started in 2013, providing LIPA with 3,634 MW of dispatchable capacity.[25] Of this capacity, 2,200 MW comes from eight steam units located at three sites: Northport, Port Jefferson and E.F. Barret. The remainder of the PSA capacity comes from 11 internal combustion power plants that provide additional peaking capacity. In recent years, the entry of new and more efficient assets on the Long Island system have led to substantially diminished output at Northport and Port Jefferson such that they now meet this study's criteria for a peaking facility (i.e. capacity factor less than 15%).

The PSA with National Grid provides LIPA with all the capacity provided by the plants, as well as limited energy and ancillary services.[26] All additional energy, ancillary services, and expenses are adjusted through monthly variable charges. These additional expenses may

[23] New York Public Service Commission, *Case 18-E-0130*.
http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bFDE2C318-277F-4701-B7D6-C70FCE0C6266%7d
[24]New York Public Service Commission, *New York State Energy Storage Roadmap and Department of Public Service/New York State Energy Research and Development Authority Staff Recommendations.*
http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b2A1BFBC9-85B4-4DAE-BCAE-164B21B0DC3D%7d
[25] LIPA, *Amended and Restated Power Supply Agreement, op. cit., p. C-1.*
[26] The National Grid PSA allows for offtake of a set amount of energy and ancillary services based on plant operational and performance characteristics. Additional energy and ancillary services are available on a cost to serve basis.

include, for example, those from environmental compliance such as NOx regulation, legal proceedings, Regional Greenhouse Gas Initiative (RGGI) allowances, and additional startups. Other costs included in the agreement are the cost of capital, property taxes, operation and maintenance costs, turbine upgrades, and new emission controls. Since its inception in 2013, the overall cost of the PSA, including the factors listed above, has increased over time with an annual average year-over-year increase of 2.5%.

1.2.5 LIPA PSA Early Termination Options

Although the term of LIPA's PSA with National Grid extends through 2028, it does include contractual options to reduce contracted capacity before the end of the PSA term – referred to as a "ramp-down". For steam units, it allows LIPA to reduce contracted capacity of up to one of the steam unit blocks (out of six total across the three steam plants) before the end of the contract, assuming a 2-year advance notice from LIPA. For internal combustion units, the PSA allows for the ramp-down of any or all of the units with a 1-year notice. In the case of a ramp-down, LIPA is required to provide National Grid with a ramp-down payment that is linked to the Net Book Value of the specific asset being ramped down. This ramp-down payment is adjusted using a 37.5% discount factor for a ramp-down occurring after 2020 and 62.5% discount factor for a ramp-down occurring after 2023.

Given this discount factor, and the fact that most of the units under the PSA are over 40 years old and thus have significant accumulated depreciation, it is reasonable to expect these ramp-down payments to be minimal in most cases (with the possible exception of newer units constructed in the 2000s). No additional discount factor is provided after 2023, meaning that there would be no potential additional savings for LIPA customers to delay retirements from 2024 to 2028. Furthermore, the entire PSA contract can also be terminated by LIPA as soon as May 2025, with a prior 2-year notice.

1.3 Clean Energy Replacement Options

1.3.1 Energy Storage

The diverse asset class known as "energy storage" technologies are a critical enabler for integrating large quantities of renewable energy into power systems. Energy storage facilitates the acceleration of the energy transition because it may be deployed rapidly, scaled easily, located virtually anywhere on the electric grid, and efficiently provide necessary grid reliability services. The energy storage industry is well developed in the United States and energy storage systems are actively supporting grids and replacing fossil fueled peaking capacity in Hawaii, California, Massachusetts, New York, and many other locations.

Indeed, New York has several examples of large-scale energy storage systems being developed, from which LIPA can learn and repeat. For example, NYSERDA signed a contract in 2019 with Lincoln Park DG to build a 20 MW storage project located at the Lincoln Park Grid Support Center. The original proposed project at the site included a natural gas-powered peaking plant, but concerns raised by the community lead to the newly approved plans to install a battery at the site.[27] Another approved New York project is at the Ravenswood site in Queens which once contained 16 peakers, of which only two remain in

[27] Power Engineering, 2019, *NYSERDA to Replace Fossil Fuels with 20MW Energy Storage System.* https://www.power-eng.com/2019/12/13/nyserda-to-replace-fossil-fuels-with-20-mw-energy-storage-system/#gref

operation today. The plant's owner has announced plans for the remaining peakers to be removed and replaced with a 318 MW battery.[28]

As New York's grid becomes increasingly decarbonized and decentralized, the operational flexibility provided by energy storage is especially important to balance supply and demand. In addition to grid flexibility, energy storage offers stacked benefits which include ancillary services, resource adequacy, deferral of transmission and distribution upgrades, increased renewable energy utilization and reduction of curtailment, GHG reductions, and portfolio diversity. Today's energy storage technology can allow the State to meet peak power needs without reliance on older, heavily polluting peakers. As of 2018, in the United States alone over 1,400 MWh of grid-connected battery storage had already been procured and installed.[29] By 2030, the energy storage industry has been projected to provide benefits to the State totaling $3 billion, create approximately 30,000 jobs, and avoid over two million metric tons of CO2 emissions.[30]

1.3.2 Role of Solar and Off-Shore Wind

New York's Climate Law mandates deployment of 6 GW of rooftop solar by 2025, 9 GW of offshore wind deployment by 2035, and 70% of electricity from renewable sources by 2030.[31] As the state's portfolio of intermittent renewable power grows to provide a more significant portion of New York's net electricity demand, new challenges are created. The addition of new renewable resources, many of which are expected to be sited and interconnected near constrained load pockets with high energy demand, will shift overall energy flow on the grid. This may help to alleviate local reliability constraints but will create additional need for resources that can balance the intermittent generation of renewable resources. With these changes, energy storage will be increasingly necessary to smooth and time-shift renewable generation and minimize curtailment to ensure grid reliability.

More specifically, it is anticipated that a large share of New York's ambitious off-shore wind portfolio will interconnect to the NYISO grid through Long Island. This will provide a significant amount of new generation to Zone K, which is location constrained. However, it will also mean there is a greater need for storage on Long Island to help overcome periods of low wind, as well as balance daily fluctuations in output.

2. Peaker Replacement Feasibility Analysis

Energy storage is positioned to become one of the primary reliability and flexibility resources for New York State's clean electric grid. Given the combined need to meet both local reliability constraints (e.g. in New York City and Long Island) and New York's commitment to achieve zero emissions by 2040, energy storage will undoubtedly play an increasingly important role in meeting the reliability needs previously supplied by fossil fueled assets. This section explores the ways that fossil fuel peakers have historically operated on Long Island as a means to understand the ways storage may need to perform

[28] CleanTechnica, 2019, *World's Largest Storage Battery- 2.5 GWh- to Replace Gas Peaker Plants in Queens. https*://cleantechnica.com/2019/10/28/worlds-largest-storage-battery-2-5-gwh-to-replace-gas-peaker-plants-in-queens/
[29] US Energy Information Administration, 2020, *Battery Storage in the United States: An Update on Market Trends.* https://www.eia.gov/analysis/studies/electricity/batterystorage/
[30] NYSERDA, *Energy Storage.* https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Storage#:~:text=Energy%20Storage%20in%20New%20York&text=A%20proposed%20target%20of%20100,by%202030%20through%20greater%20efficiency
[31] NYSERDA, *Climate Act. op. cit.*

in order to replace these assets while providing comparable reliability services in support of Long Island's clean energy transition.

A portion of this discussion focuses on understanding and accurately estimating actual reliability needs on Long Island. Long Island's peaker fleet has historically operated inefficiently and uneconomically, such that direct peaker dispatch is a useful proxy, but not a strict mandate to evaluate reliability needs. This section discusses both the use and limitations of historical peaker dispatch data to understand peaker replacement feasibility and lays out a conservative but informed approach to estimating grid needs.

2.1 Methodology for Identifying Replacement Candidates

To assess the opportunity to retire and replace existing peaking assets, peakers were first categorized by their location. The peakers in the East End load pocket are considered in a separate analysis focused on reliability in constrained local areas, and identifying how this area could be transitioned while respecting the reliability concerns identified by NYISO and LIPA in the 2019-2028 Comprehensive Reliability Plan.

After excluding the units in the East End load pocket, the remaining fossil fueled peaking fleet (which constitutes the bulk of the Long Island peaker fleet) were then further evaluated based on their historical operations and regulatory and contractual obligations on a unit by unit basis, as described below.

2.1.1 Operating Profiles

The Long Island peaker fleet was analyzed on an hourly basis using historic generation profiles as reported to the EPA.[32] The hourly profiles of individual units were analyzed for the years 2017, 2018 and 2019. Each unit was then categorized by its dispatch duration to understand the duration of storage that may be needed to replace the energy provided by peakers. Peakers with shorter duration dispatches were considered to be more cost-effective to replace as compared to peakers with longer-duration dispatches, regardless of their overall power capacity. This is due to the fact that the duration of a battery storage resources, as represented by MWh of battery capacity, is the largest driver of battery storage resources costs. Additional details of the peaker dispatch duration analysis and methodology is discussed in greater detail in the subsequent sections.

2.1.2 Peaker Groupings by Contract Expiration and NOx Compliance Dates

In addition to historical peaker operations, there are other potential considerations for identifying peaker replacement candidates. Two important factors in this regard are 1) the expiration of existing contracts with off-takers (e.g. LIPA) and 2) compliance with NOx emission standards discussed in the previous section. In the case of contract expiration, many plants have recently expired contracts. Although the PSA block will not expire until 2028, there are key milestones for possible early ramp-down or termination of the contract in the 2025 timeframe.

Of LIPA's 26 peaker plants, 17 are subject to recent rules established by the Department of Environmental Control (DEC) to reduce local NOx emissions from simple cycle combustion turbines. Of these 17 plants, only 8 of the plants already comply with the emissions control

[32] Through its Continuous Emissions Monitoring System, the EPA collects data on hourly dispatch for all power plant units over 10 MW.

requirements established by the DEC. Another 6 units, representing 1,324 MW are planning to install costly emissions control mechanisms by 2023 or 2025. Notably, these are costs paid by LIPA customers that could be avoided altogether if these plants were simply retired. The remaining 3 are planning to either retire or be kept for black start only generators, representing 16 MW retiring and 32 MW being kept for black start services.

Table 3 below shows the NOx regulation compliance status and contract expiration year for all the plants considered in this analysis. It should be noted that the plants with contract expiration dates in 2028 are all part of the National Grid-LIPA PSA, and are subject to the early termination options discussed in the previous section.

Table 3. LIPA Peaker Fleet Contract Expiration Date and NOx Compliance

Plant Name	Subject to DEC NOx Rules	Compliance Plan	Contract Expiration Year
Bethpage	No	N/A	2025
Bethpage CT	No	N/A	N/A
Brentwood	Yes	Selective Catalytic Reduction control (SCR) in place. Comply with rule	N/A
Charles P Keller	No	N/A	N/A
Edgewood	Yes	SCR & Water Injection (WI) controls in place. Comply with rule	2023
E.F. Barrett Jet	Yes	Plan to install WI	2028
East Hampthon	Yes	Plan to install WI	2028
Freeport GS	Yes	SCR & WI controls in place. Comply with rule	2016
Freeport 1 & 2	Yes	Freeport 2 has SCR & WI. Comply with rule	N/A
Glenwood CT	Yes	Plan to install WI	2028
Glenwood Landing	Yes	SCR in units 4&5. Plan to retire unit 1 by 2021 (16MW)	2028
Greenport	No	N/A	N/A
Hawkeye Energy Greenport	Yes	SCR & WI controls in place. Comply with rule	2018
Holtsville	Yes	Needs to "tune WI systems" to meet rule	2028
Jamaica Bay	Yes	SCR in place. Comply with rule	2020
Northport	No (Steam)	N/A	2028
Northport CT	Yes	Plans to go black start only by 2023	2013
Pinelawn Power	No	N/A	2025
Port Jefferson	No (Steam)	N/A	2028
Port Jefferson Peaking	Yes	Units 2&3 have SCR & WI. Unit 1 going black start only (16 MW)	2028
Shoreham	Yes	Plan to install WI	2028
Shoreham Peaking	Yes	SCR & WI, comply with rule	2017
Southampton	No	N/A	2028
Southold	No	N/A	2028
Wading River	Yes	Needs to "tune WI systems" to meet rule	2028
West Babylon	Yes	To retire December 2020	2028

2.2 Use of 90th Percentile Criterion

To date, much of the analysis in New York conducted on the use of storage to replace fossil peaker units has focused on the single longest duration runtime of a peaker unit over a set time period. For example, a 2019 study evaluating the potential to replace peakers with energy storage relied heavily on evaluating the “longest start” of each individual peaker unit and was constrained by the hourly peaker unit dispatch.[33]

Under this approach, in order for an energy storage system to be sufficient to replace a fossil peaker unit it must be capable of running at least as long as longest start of the peaker unit. This approach has several shortcomings that may unintentionally bias replacement options towards longer duration storage systems for reasons that are not reflective of true system reliability needs.

As such, this study’s analysis took a closer examination of the “longest start” approach and developed alternative criteria for determining replacement storage duration needs. We believe these criteria are still relatively conservative, but do not needlessly limit storage replacement options to arbitrarily long durations.

In re-evaluating the “longest peaker runtime” approach, there are five key factors to consider, which are discussed in greater depth through the remained of this section:

1. Peaker unit dispatch versus available zone level capacity,
2. Peaker unit dispatch versus plant level capacity,
3. Peaker unit dispatch for localized, non-peaking needs,
4. Inconsistent levels of output during longer run-times, and
5. Unit operational constraints.

2.2.1 Peaker Unit Dispatch versus Available Zone Level Capacity

In recent years, the full capacity of the fleet of peakers on Long Island has not been required to meet peaking needs in Zone K. This is clearly illustrated in the chart below, which demonstrates that in 2018, only about 2,800 MW out of 4,350 MW (or about 64%) of total peaking capacity was ever used simultaneously. In 2017 and 2016, maximum fleet usage topped out at 67% and 71% respectively.

[33] New York Public Service Commission, *The Potential for Energy Storage to Repower or Replace Peaking Units in New York State.* http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B2F0A202D-CAB9-4961-96F3-56AEA67C6052%7D

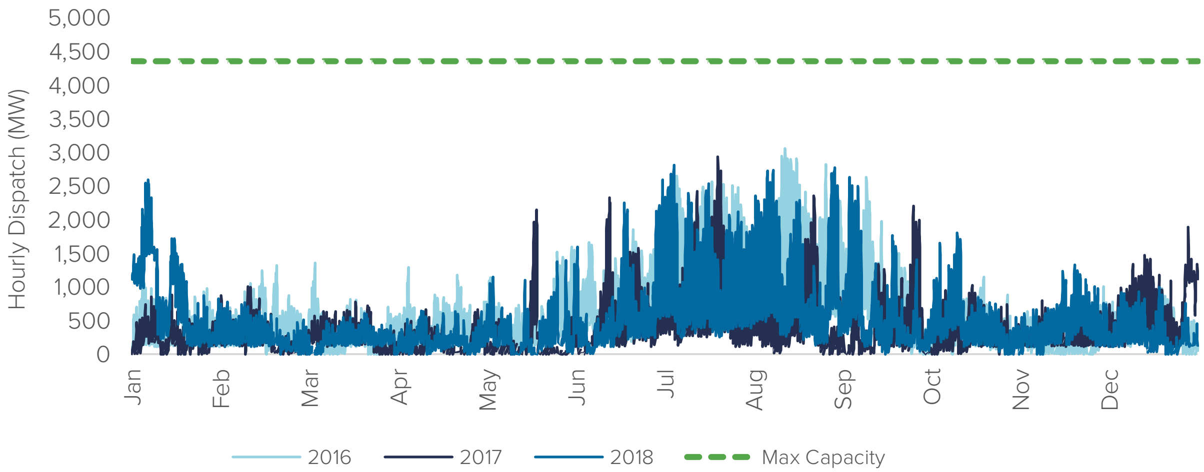


Figure 7. Peaker Hourly Dispatch in Long Island Zone K, 2016-2018

There are several implications from this. First, it indicates that there is substantially more generation on the Long Island system than is typically needed to meet peak load. This conclusion is supported by NYISO's recent analysis as part of the 2019-2028 Comprehensive Reliability Plan, which included a Resource Adequacy study of the Peaker Rule Scenario.[34] More specifically, the study demonstrated that the removal of about 1,440 MW of peaker capacity from Long Island would require only 350-500 MW in compensatory replacement generation on Long Island to maintain resource adequacy (i.e. to meet peak load) at the NYCA LOLE reliability criterion of 0.1 days/year. This means that ~1,000 MW of generation can likely be removed from Long Island with minimal impact on reliability (from a peaking capacity standpoint), even if no new generation is added.

Second, it also means that there is a significant amount of idle capacity, or headroom among the existing fleet of peakers that could be available for redispatch during peak load hours. For example, if a single 100 MW peaker unit ("Unit A") had operated for 12 hours during a peak load day in July, the same need could have been met by operating Unit A for only 6 hours, and then re-dispatching to another 100 MW peaker unit ("Unit B"), which had previously been idle, for the remaining 6 hours. Similarly, the peaking need could be met with a 6-hour duration battery storage system replacing Unit A, plus an additional six hours of output from Unit B. In this case, the 12-hour peaker run time is not indicative of the duration of storage needed to replace Unit A since there is additional headroom on the system from undispatched units that can also contribute to peaking needs.

The above chart shows around 1,260 MW of headroom between total installed capacity and actual demand. This means that the maximum runtimes for about 1,260 MW of peakers on Long Island could be met by re-dispatching across other peaking units, thus reducing the equivalent duration requirements of replacement options for these peakers by about 50% during peak load hours.

2.2.2 Peaker Unit Dispatch versus Plant Level Capacity

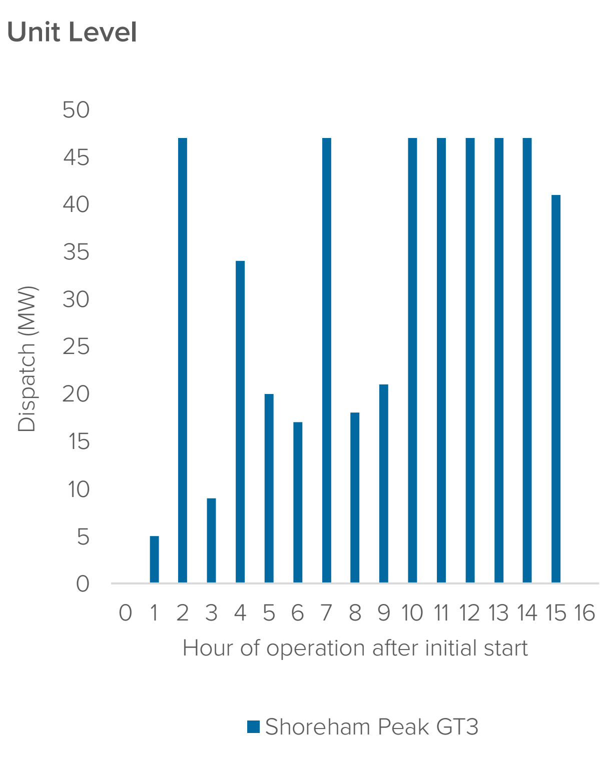
Not only is there additional headroom at the Zone K level, but there is often additional headroom among units at a single plant location. The charts below illustrate this point for Shoreham in Long Island, the site hosts two power plants: Shoreham and Shoreham

[34] NYISO, *2019-2028 Comprehensive Reliability Plan.* https://www.nyiso.com/documents/20142/6001938/04%202019-2028%20CRP%20Report%20Draft.pdf

Peaking. Shoreham Peaking is a 100 MW plant with two units of 50 MW each, while Shoreham has two units of 53 MW and 18.6 MW. In 2019, all units in the site dispatched less than 1% of their capacity.

In 2018, one specific unit in the Shoreham plant, Shoreham GT3, dispatched for up to 15 hours, its longest dispatch of the year. However, this does not necessarily mean that a 15-hr duration storage asset is needed to replace Shoreham GT3. As an initial matter it is worth noting that while the run-time in this instance is 15 hours, the actual energy needs over this time period correspond to an 11-hour storage system. This is due to the fact that the output of the unit varies considerably across those 15 hours, meaning that the battery capacity in MWh would need to be sized for less than the full output of the plant over 15 hours.

Furthermore, an examination of dispatch at the plant level including all four units, reveals that the duration needs are even less than 11-hours. In fact, a 7-hour duration storage system would suffice as a replacement for the plant's energy needs. This is because of the fact that while the peak output of the plant is about 170 MW, it is not 170 MW for the full 15 hours, or about 2,550 MWh. Instead, the output varies across those 15 hours, it only equals 1,190 MWh, or about 7-hours of duration at 170 MW.



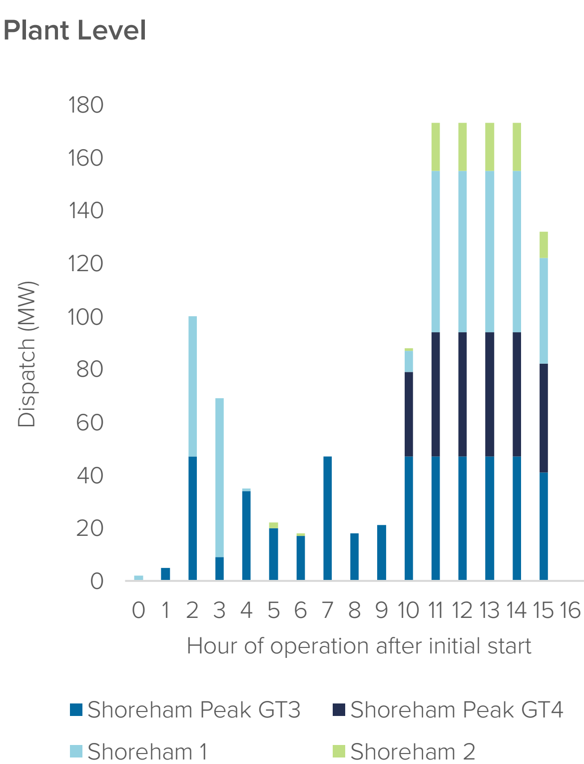


Figure 8. Comparison of Unit Level and Plant Level Run-Time for Shoreham Peaking

The reduction from a 15 to a 7 hour start duration requirement corresponds to over a 50% reduction in storage needs versus the unit level maximum start duration approach. When considering the annual dispatch distribution for Shoreham GT3, shown in the below chart, a 7-hour start duration corresponds to the 88th percentile of unit start-times for Shoreham GT3.

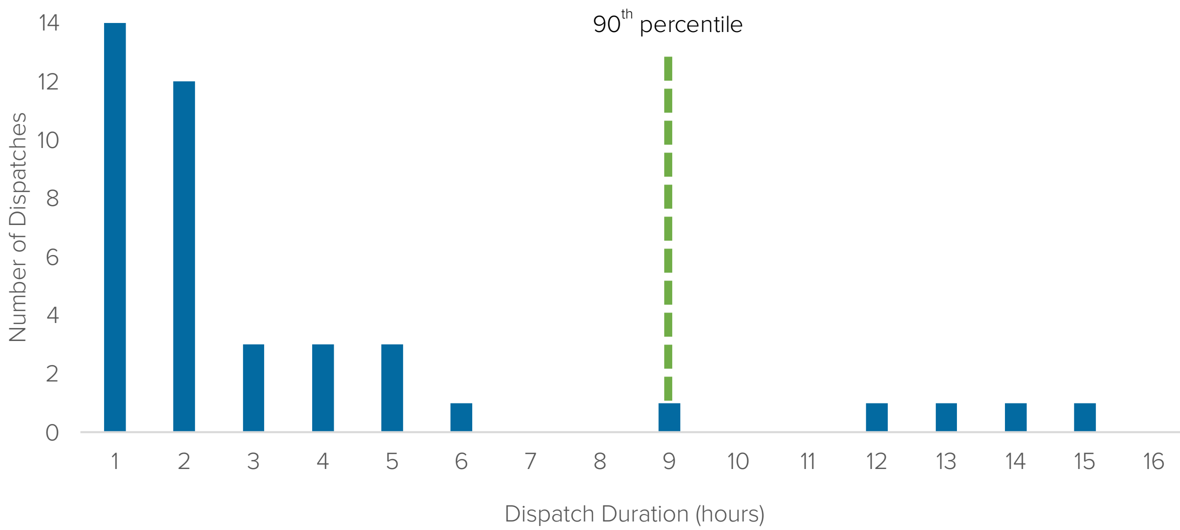


Figure 9. Shoreham Peaking GT3 Dispatch Duration, 2018

Another example of the ability to re-dispatch across the units within an individual plant can be seen in the case of the Northport Power Station. Earlier this year, LIPA analysis of retirement and repowering options for the Northport Power Station found no compelling reason to repower the Northport to maintain its existing capacity, and concluded that retiring, not replacing, one of the four units at the plant in 2022 would be the best option. Retirement of one of the Northport units would reduce customer costs by $300 million without harming system reliability. LIPA's decision to retire the Northport unit without the identifying a need for replacement indicates that there is more flexibility to remove individual peakers units from a plant than would be suggested by only looking at a more limited view of operating profiles.[35]

2.2.3 Peaker Unit Dispatch for Localized, Non-Peaking Needs

There are a variety of reasons that peakers may be operated on Long Island that are unrelated to resource adequacy (i.e. peaking needs). This is illustrated by the large amount of peaker capacity headroom during peak load hours as described above. If peaker runtimes were primarily driven by a significant peaking need, review of peaker dispatch would show a significant number of longer peaker run times that coincided across the peaking fleet and with and with highest demand hours.

However, this dispatch phenomenon is not readily apparent from historic operations, which suggests that several other drivers are likely responsible for some of the longer runtimes observed at many peaking units in Zone K. For example, as further described in section 2.2.4 below, many peaker units are operated to provide local congestion relief on the low-voltage 69 kV system, or to address transient voltage issues. In Long Island's East End load pocket, out-of-merit dispatch (i.e. uneconomic peaker starts) was used to manage transient voltage for 813 hours and 61 days of 2019. Similarly, in the East of Northport load pocket, out-of-merit actions were used to manage constraints on the low voltage (69 kV) system for 754 hours and 48 days of 2019. Assuming that these 754 to 813 hours are allocated similarly across the 48 to 61 days with voltage constraints, this suggests that these out-of-merit

[35] LIPA, *Repowering Feasibility Study Northport Power Station*. https://www.lipower.org/wp-content/uploads/2020/05/Northport-Repowering-Study_2020.05.20-Secured.pdf

actions would correspond to peaker starts of 13-16 hours on average, which could be significantly higher than the start duration needs for meeting peak load.

Moreover, as further explained below, these local voltage related needs could feasibly be addressed through alternative means that do not require sustained energy output associated with long-duration peaker starts. For example, reactive power can be supplied by inverter-based resources even when there is little to no energy output. This would obviate the need to provide a direct one-for-one replacement of peaker energy, and allow for replacement of peaker units with storage significantly shorter duration than the peaker's run time.

Furthermore, the NYISO Market Monitor (Potomac Economics), has recommended certain market reforms that could help alleviate the need to manage these issues through out-of-merit actions.[36] This could improve the efficiency of peaker dispatch, and perhaps reduce the run times of high heat rate peaker units. Thus, while it is difficult to quantify the impact on peaker run times these market reforms would have, it is reasonable to assume they could meaningfully reduce the duration need of any replacement resources.

2.2.4 Inconsistent Levels of Output During Longer Run-Times

A close examination of peaker unit operations on Long Island reveals that the energy duration equivalent of the peaker output is significantly less than the peaker run time in hours. This is caused by inconsistent peaker output throughout each start.

This could arise for a variety of reasons, but the most likely explanation is that each peaker run is not started or ended on the exact minute that the hourly interval begins or ends. As such, any start duration that is computed from historical hourly datasets will be systemically and systematically biased towards longer recorded dispatch times periods than actual historical dispatch. For example, when examining hourly generation data, a peaker unit may appear to start at hour beginning 600 at 10% of its maximum output, and then increasing to 100% in hour beginning 700. This could mean that the peaker unit started exactly at 6:00 but only at 10% of its capability. However, it more likely means the peaker unit started at 6:54. Thus when computing the run time, it will appear to be 1 to 2 hours longer than what actually occurred, depending on the timing of the start and the shut-off. This trend is visible at both the beginning and end of many peaker run times in the NYISO hourly generation data. The relevance of this phenomenon is most pronounced for peaking units that are recorded operating below their minimum operating capacity, as shown below.

For example, the below chart shows the hourly output from the unit E.F. Barrett Jet 09 over a 32-hour period. During this time, the unit is recorded dispatching for durations of up to 4 hours. However, actual output is well below 25% of max capacity for all of these dispatches, and in some cases is barely 1 MW.

[36] Potomac Economics, *2019 State of the Market Report for the New York Independent System Operator.* https://www.potomaceconomics.com/wp-content/uploads/2020/05/NYISO-2019-SOM-Report__Full-Report_5-19-2020-final.pdf

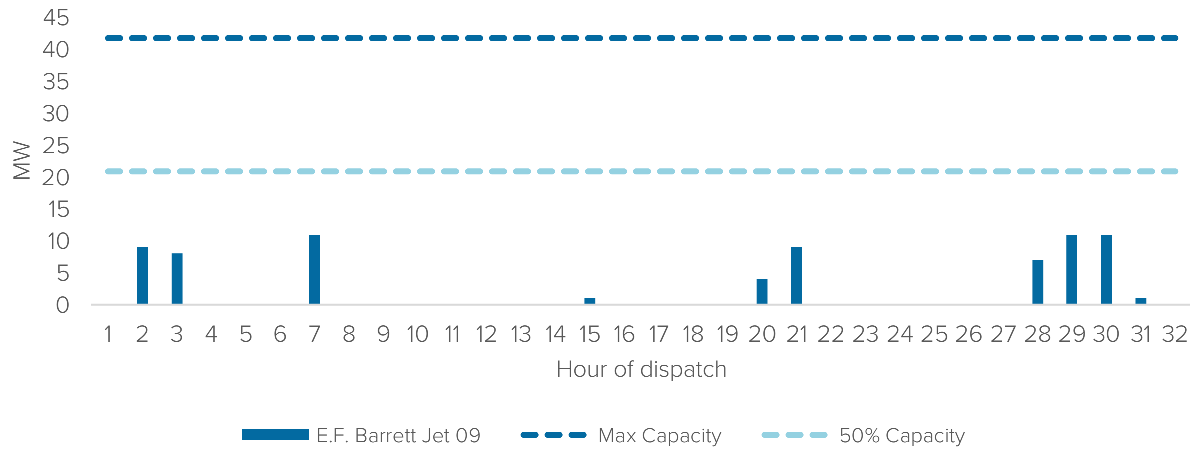


Figure 10. Illustration of E.F. Barrett Jet 09 hourly output

2.2.5 Unit Operational Constraints

Finally, there are inherent technical limitations in thermal power plant dispatch and operations that may lead plants to run longer than what would otherwise be necessary or efficient for the system if those limitations did not exist. These limitations include minimum run times, minimum down time, minimum operating capacity, and cycling costs.

While many of the peaker units analyzed in this study are gas turbines with quick start capabilities and relatively short minimum run times, the peaker portfolio contemplated for this report also includes several older steam units that run at relatively low capacity factors. These steam units typically have longer minimum run times. For example, the Northport, Port Jefferson and E.F. Barrett units all have cold start-up times exceeding 24 hours, and even when still hot, will take 8 hours to start up.[37] These constraints mean that it is often preferably to leave units running, even when not strictly needed or when not economic, to avoid the forced downtime that results from slow unit start-up times.

Additionally, steam units tend to have significant cycling costs.[38] This means that a unit that is already online will tend to stay online even if it is uneconomic to operate over the course of several hours. This is because it may be advantageous to temporarily incur losses from uneconomic generation in order to avoid cycling costs. For both of these reasons, when steam units are started, they tend to operate for longer periods of time, even if a truly optimal solution would be for them to run for fewer hours. Moreover, these limitations are not reflective of system reliability needs, but are simply reflective of the characteristics of steam generation and should not be interpreted as a requirement for the duration of a storage alternative.

The below chart shows historical operation of the Northport plant where 3 peaking units were ramped down, but not turned off, despite low demand. Notably, the overall energy from these 3 units is less than the max capacity from a single unit.

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[37] LIPA, *Amended and Restated Power Supply Agreement, op. cit., p. E-1.*
[38] NREL, 2012, *Power Plant Cycling Costs*. https://www.nrel.gov/docs/fy12osti/55433.pdf

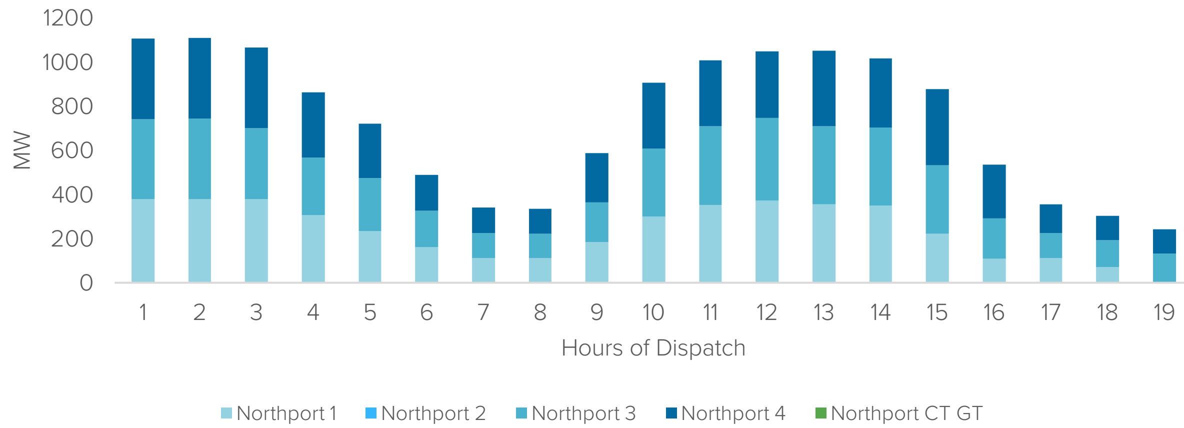

Figure 11.Illustration of typical dispatch at Northport steam and gas turbine units

2.2.6 Conclusions on Use of 90th Percentile for Evaluating Peaker Start Duration

Given the cumulative impact of the five factors described above, use of maximum start duration is an inappropriate and unnecessarily conservative approach to evaluate the feasibility of replacing fossil peaker units with storage. For example, as shown in the figure below, many peaker units operate for very short durations even during the critical summer peak load hours, and some units do not even run at all during those times. However, some consideration must be given to the fact that peak load in Zone K must be met even under high load conditions and that some peaker starts can be a result of the need to meet these high load conditions. As such, this analysis adopts a compromise approach of determining storage duration needs based on the 90th percentile of peaker run times at each unit.

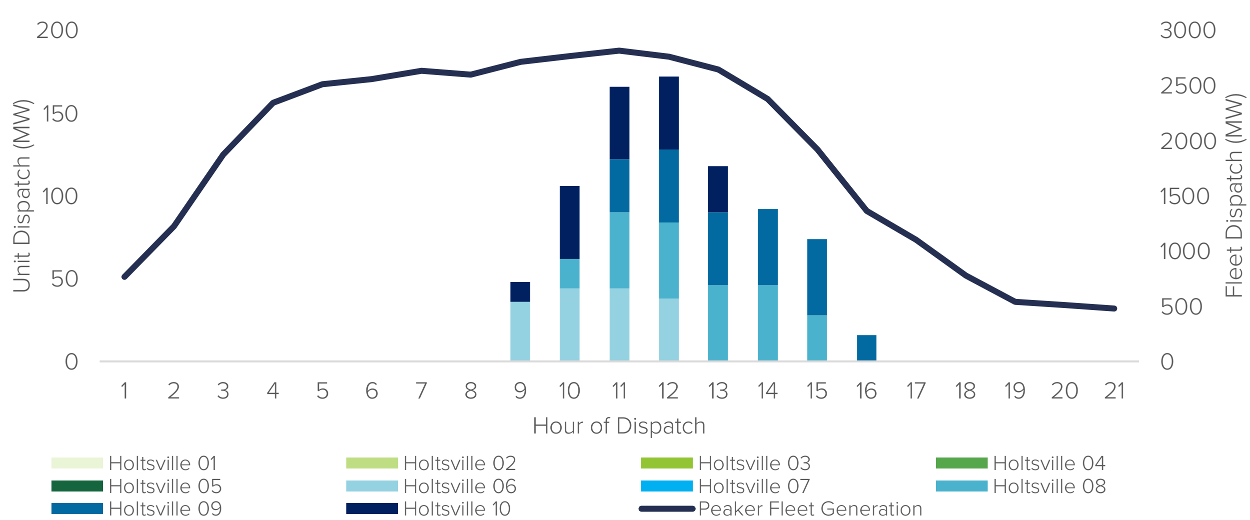

Figure 12.Illustration of dispatch duration at each of 10 units at the Holtsville plant during peak summer load hours in 2018

This approach strikes an appropriate balance of ensuring that duration needs are not inappropriately biased towards longer start times while still maintaining a very conservative approach to system reliability. Moreover, given the headroom in terms of overall capacity in Zone K, and the results of the 2019-2028 Comprehensive Reliability Plan analysis on the

Peaker Rule Scenario, there is strong indication that there is little risk involved (from a resource adequacy standpoint) in replacing the first 1000 MW (or more) of peaker units with energy storage as a form of compensatory generation.

2.3 Start Duration Analysis

Further reinforcing the analysis in the previous section, assessment of hourly dispatch of the units considered for this study shows that the majority of unit starts are for relatively short durations. In fact, Long Island peaking units were most frequently dispatched for 2 hours or less as illustrated in Figure 8 below. Of all unit starts, over half were recorded to last for 4 hours or less. Over 90% of all recorded unit dispatches were for 13 hours or less.

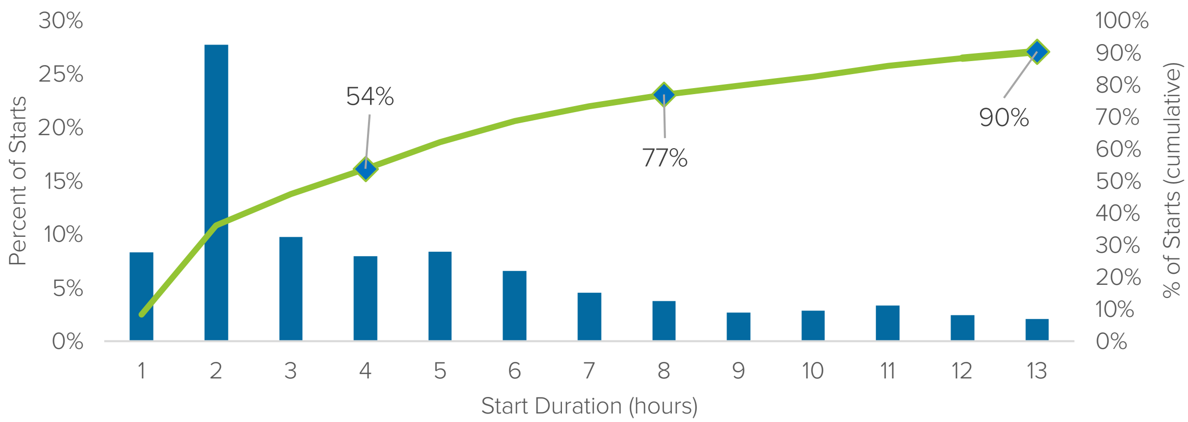

Figure 13. Peaker Start Duration Analysis

This portfolio-wide dispatch pattern was also demonstrated in individual peaking units. For example, E.F. Barrett Jet 04 was called on in 2018 to run for as long as 49 hours, but most frequently it ran for 2 hours or less, and over 90% of its dispatches were for 12 hours or less.

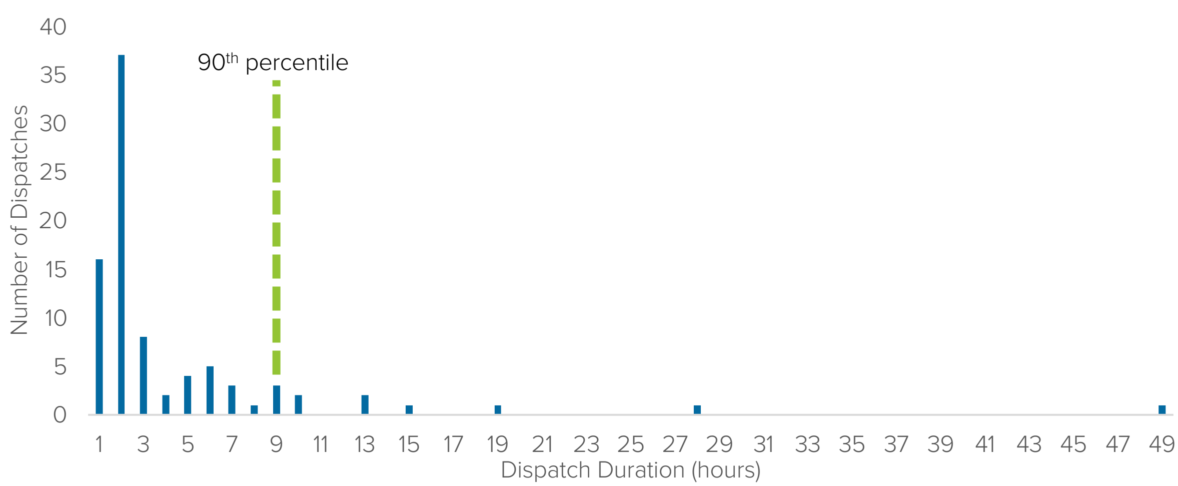

Figure 14. E.F. Barrett Jet 04 Dispatch Duration Frequency, 2018

Analysis further demonstrated that these dispatch patterns remain relatively consistent across multiple historical years. Nearly 2,000 MW of fossil fueled capacity on Long Island typically ran for around 12 hours or less over the last 3 years.

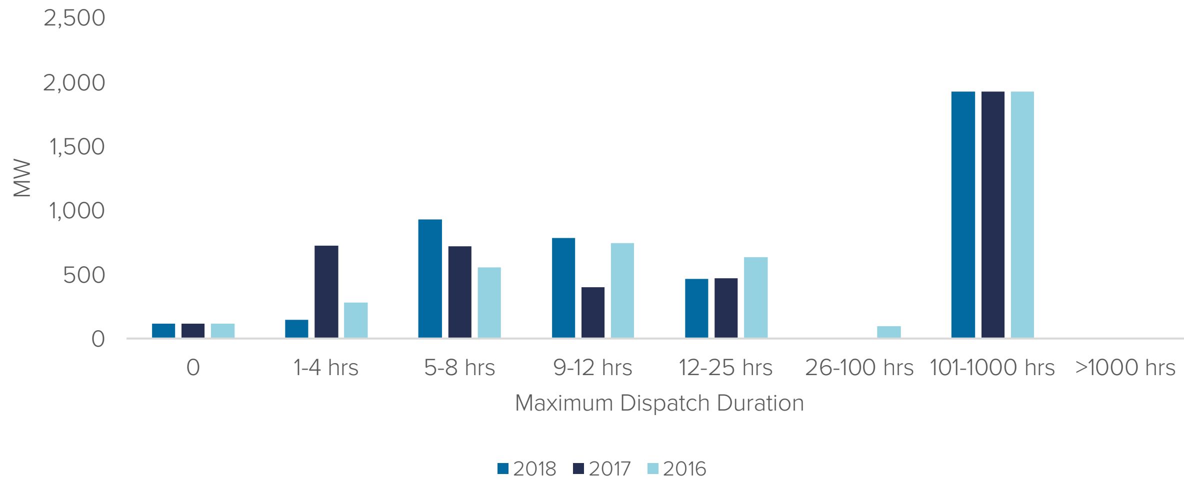

Figure 15. Consistency of 90th Percentile Peaker Dispatch Duration, 2016-2018

2.3.1 Candidate Portfolio Based on Start Durations

To identify feasible replacement candidates, peaker units were categorized into three groups for potential retirement based on their 90th percentile dispatch duration. A fourth group was also included to identify peakers that would be difficult to retire based solely on extensive dispatch duration. The first group included all peakers that were typically dispatching for 4 hours or less during the year. This group included the below 193 MW of installed peaking capacity.

Table 4. Peaker Group 1

Unit Name	Plant	Installed Capacity (MW)
E.F. Barrett Jet GT01	E.F. Barrett Jet	18
East Hampthon 2	East Hampthon	2
East Hampthon 3	East Hampthon	2
East Hampthon 4	East Hampthon	2
Glenwood GT02	Glenwood CT	55
Holtsville 03	Holtsville	56.7
Northport CT GT	Northport CT	16
Port Jefferson Peaking GT1	Port Jefferson Peaking	16
Southampthon 1	Southampton	11.5
Southold 1	Southold	14
Total		***193***

The second group included all peakers that were typically dispatching for 8 hours or less across the year and was comprised of the below 927 MW of peaking capacity.

Table 5. Peaker Group 2

Unit Name	Plant	Installed Capacity (MW)
E.F. Barrett Jet 03	E.F. Barrett Jet	18
E.F. Barrett Jet 05	E.F. Barrett Jet	18
E.F. Barrett Jet 06	E.F. Barrett Jet	18
E.F. Barrett Jet 09	E.F. Barrett Jet	41.8
E.F. Barrett Jet 10	E.F. Barrett Jet	41.8
E.F. Barrett Jet GT02	E.F. Barrett Jet	18
Freeport GS CT1	Freeport GS (Equus)	60
Holtsville 01	Holtsville	56.7
Holtsville 02	Holtsville	56.7
Holtsville 04	Holtsville	56.7
Holtsville 05	Holtsville	56.7
Holtsville 06	Holtsville	56.7
Holtsville 07	Holtsville	56.7
Holtsville 08	Holtsville	56.7
Holtsville 09	Holtsville	56.7
Holtsville 10	Holtsville	56.7
Shoreham 1	Shoreham	52.9
Shoreham 2	Shoreham	18.6
Shoreham Peaking GT4	Shoreham Peaking	50
Wading River 2	Wading River	79.5
Total		***927***

The third group consisted of all peaking units with typical dispatch duration of 12 hours or less, representing 782 MW of installed capacity.

Table 6. Peaker Group 3

Unit Name	Plant	Installed Capacity (MW)
E.F. Barrett Jet 04	E.F. Barrett Jet	18
E.F. Barrett Jet 08	E.F. Barrett Jet	18
E.F. Barrett Jet 11	E.F. Barrett Jet	41.8
E.F. Barrett Jet 12	E.F. Barrett Jet	41.8
Edgewood GT2	Edgewood	50
Freeport CT2	Freeport 1 & 2	60.5
Glenwood GT01	Glenwood Landing	16
Glenwood GT03	Glenwood CT	55
Glenwood GT05	Glenwood Landing	53
Jamaica Bay GT2	Jamaica Bay	60.5
Port Jefferson Peaking GT2	Port Jefferson Peaking	53
Port Jefferson Peaking GT3	Port Jefferson Peaking	53
Shoreham Peaking GT3	Shoreham Peaking	50
Wading River 1	Wading River	79.5
Wading River 3	Wading River	79.5
West Babylon 4	West Babylon	52.4
Total		*782*

Finally, the last group included all peakers with typical dispatch greater than 12 hours. Though all of these units operate at less than 10% capacity factor, dispatch durations across this group varied significantly. Some, such as Glenwood Landing and Edgewood, generally dispatched for no more than 13-14 hours. Others, such as the Northport plants, often dispatched for as much as 400 or more hours. This is in part due to the operational constraints of steam units discussed earlier and requires a different analytical approach to retirement and replacement decisions. This final portion of the portfolio represents the largest share of installed capacity, at more than 2,300 MW total.

Table 7. Peaker Group 4

Unit Name	Plant	Installed Capacity (MW)
Bethpage 3	Bethpage	96
Bethpage CT GT4	Bethpage CT	60
Brentwood	Brentwood	47
East Hampthon GT1	East Hampthon	21.3
Edgewood GT1	Edgewood	50
Glenwood GT04	Glenwood Landing	53
Greenport Hawkeye GT1	Greenport Hawkeye	54
Pinelawn Power 1	Pinelawn Power	82
Northport 1	Northport	387
Northport 2	Northport	387
Northport 3	Northport	387
Northport 4	Northport	387
Port Jefferson 3	Port Jefferson	188
Port Jefferson 4	Port Jefferson	188
Total		*2,387*

2.3 Load Pocket Analysis and Local Reliability Issues

Local reliability constraints may also limit replacement options in certain limited areas of Long Island such as the East End, Barrett, and East of Holbrook locations. However, some amount of replacement is still feasible in near term. According to its Comprehensive Reliability Plan, NYISO and LIPA estimated that there is sufficient headroom for storage to replace peaker capacity in the Barrett and East of Holbrook locations. Meanwhile, about 250 MW of local peaker plant capacity in the East End that cannot be easily replaced by storage due to charging limitations. However, Strategen estimates that at least 90 MW of the 250 MW deficiency could be replaced with storage of 8 hours or less. Additionally, expected deployments of solar, off-shore wind, and energy efficiency could mitigate the remaining need for compensatory generation in the East End load pocket. This section discusses replacement and retirement options in these transmission constrained areas.

2.3.1 Review of NYISO Reliability Studies

In 2019, the NYISO completed its 2019-2028 Comprehensive Reliability Plan. The Plan included analysis of a "Peaker Rule Scenario" which the ISO studied (in coordination with LIPA and ConEd) to understand the potential reliability impacts and any necessary mitigation measures from implementing the DEC's "Peaker Rule."[39] This rule will apply new limits to NOx emissions from peaking generation units, most of which are located in New York City and Long Island. In the Scenario studied, the ISO assumed that by 2025 about 1,445 MW (name plate) of peaking capacity would be removed from Long Island (Zone K) and 1,758 MW would be removed from New York City (Zone J).

To meet overall system resource adequacy needs (i.e. peaking needs), about 1,000 MW of "compensatory generation" would need to be added, equally split between Zones J and K, by the year 2028. This need decreases to 700 MW total if expected AC Transmission Projects are completed on time.[40]

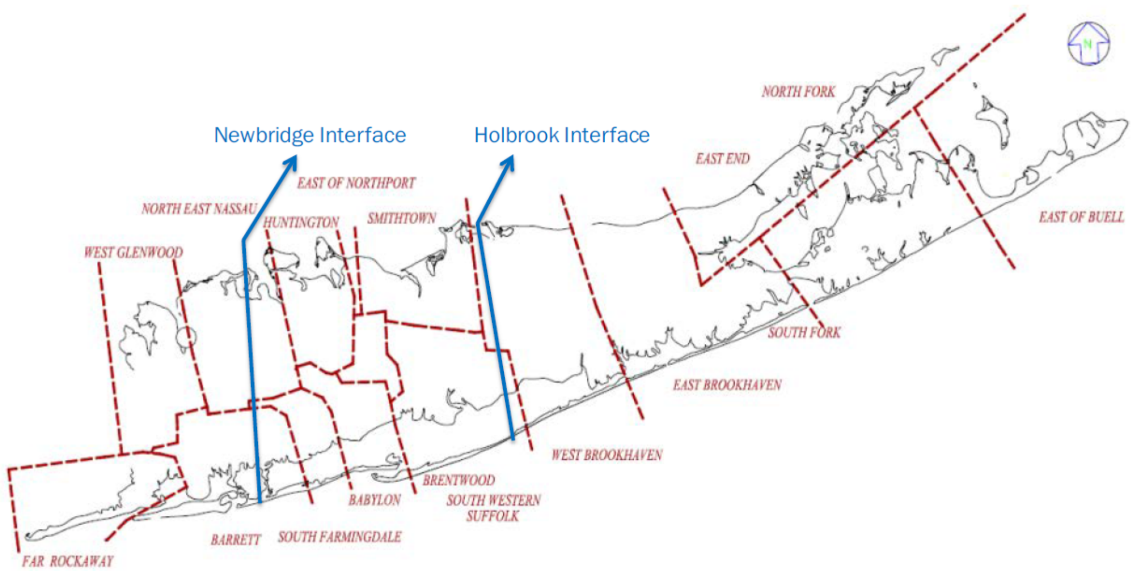

Figure 16. Long Island Load Pockets and Interfaces[41]

In addition to NYISO's overall resource adequacy needs, LIPA conducted its own analysis of local transmission security issues under the Peaker Scenario in the 2028 timeframe.[42] The results of this analysis showed that thermal overloads on the Long Island transmission system were possible during peak conditions unless 620 MW of local compensatory generation were added. This 620 MW deficiency arises from the combined needs of three critical load pockets -- East End, East of Holbrook and Barrett – each of which has its own unique limitations.

Despite the local transmission constraints identified for Holbrook and Barret, these load pockets remain prime candidates for storage. As shown in the two charts below, the overall load profile in these regions provides sufficient headroom for storage charging, with the MWh total of headroom during off-peak hours exceeding the deficiency during the on-peak hours.

[39] NYISO, *2019-2028 Comprehensive Reliability Plan. Op. cit.,*, p. 28.
[40] AC Transmission projects T027 + T019 in service by January 2024.
[41] NYISO, *2019-2028 Comprehensive Reliability Plan. op. cit.,* p. 19.
[42] PSEG Long Island, *CRP: Peaker Scenario.* https://www.nyiso.com/documents/20142/5552484/LIPA-Simple%20Cycle%20Retirement%20Assessment%203-03-2019.pdf/31d43e9f-d9f7-476f-605f-df31ef7d7674

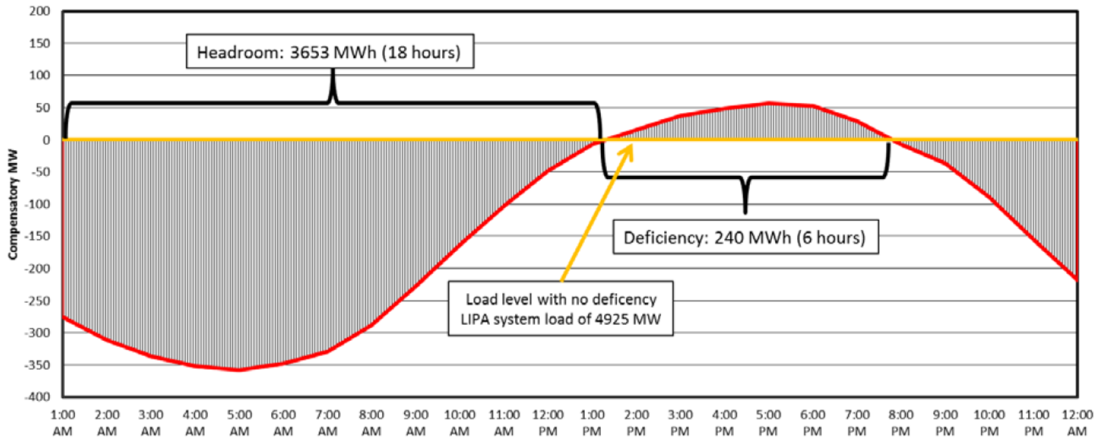

Figure 17. Barrett Load Pocket Duration Curve[43]

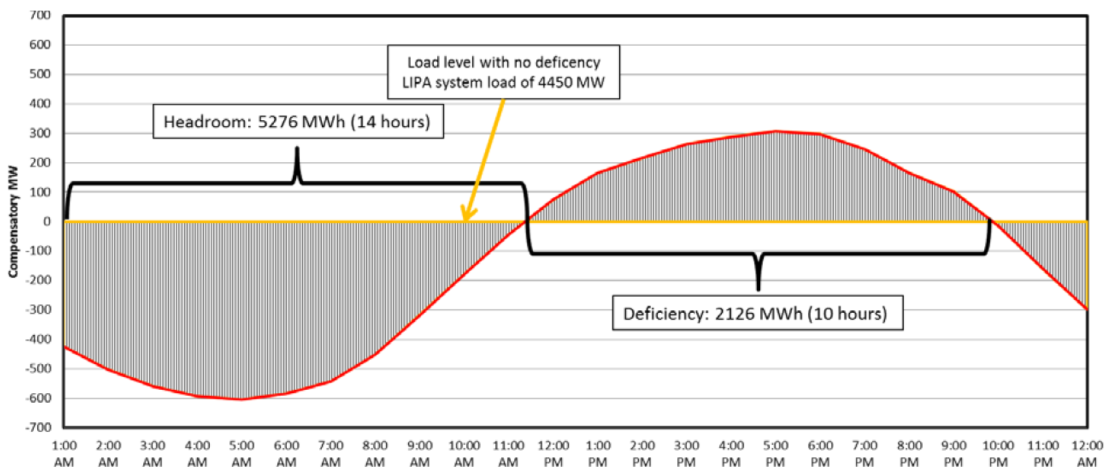

Figure 18. South Western Suffolk Load Duration Curve[44]

Of these three, East End presents the largest challenge for ensuring reliability can be maintained if the compensatory generation comes in the form of energy storage. This is due to the long duration of the deficiency identified and the limited headroom available during off-peak hours for charging energy. In fact, as illustrated in the chart below, the energy required during the deficiency is greater than the charging energy available under the present transmission constraints of the East End load pocket.

[43] *Ibid.,* p.22.
[44] *Ibid.,* p.21.

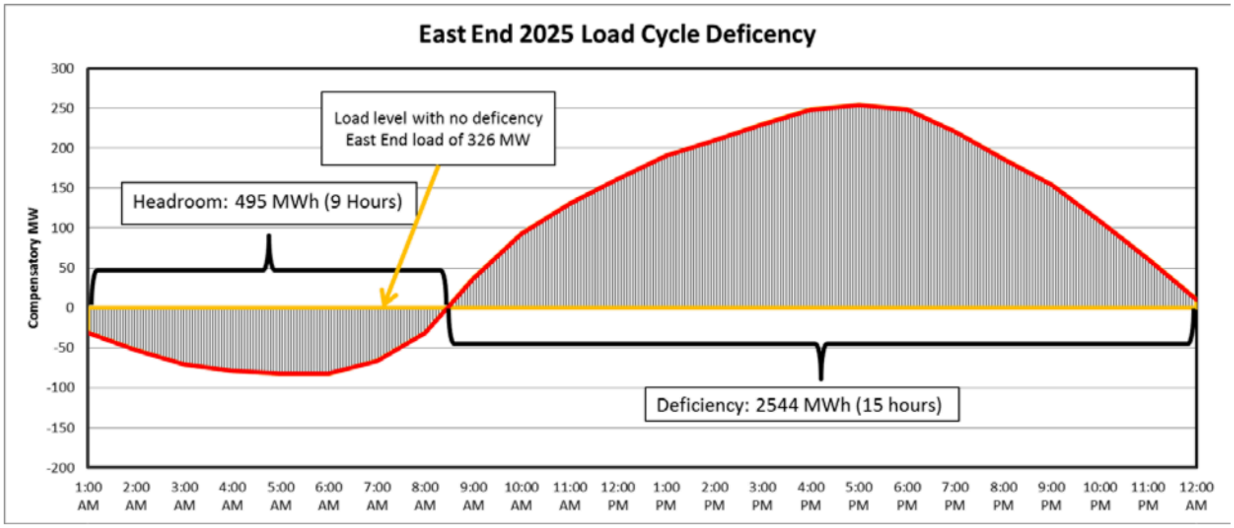

Figure 19. East End Load Cycle Deficiency, 2028[45]

Due to these challenges, we initially excluded the following peaker plants located in the East End area from the portfolio assessment of potential replacement candidates:

Table 8. Groups 1 & 2 Excluded Peaker Plants in East End

Unit Name	Plant	Ultimate Parent
East Hampthon 2	East Hampthon	National Grid
East Hampthon 3	East Hampthon	National Grid
East Hampthon 4	East Hampthon	National Grid
Southampthon 1	Southampton	National Grid
Southold 1	Southold	National Grid
Shoreham Peaking GT4	Shoreham Peaking	Manulife Financial & Electric Power Dev.
Shoreham Peaking GT3	Shoreham Peaking	Manulife Financial & Electric Power Dev.
Shoreham 1	Shoreham	National Grid
Shoreham 2	Shoreham	National Grid
Wading River 2	Wading River	National Grid

However, while a full replacement of these units with storage may not be both feasible and cost-effective in the near term, it is worth noting that 1) a partial replacement may still be feasible and cost-effective, and 2) a full replacement may become feasible and cost-effective in the longer term. Factors that could enable a full replacement include: a) battery costs declines sufficient to allow longer duration storage to become cost effective, b) changes to net load patterns change in the East End load pocket shift due to off-shore wind,

[45] *Ibid.*, p.21.

solar PV, and energy efficiency measures that reduce and narrow the peak, and c) additional buildout of transmission facilities that alleviate load pocket constraints.

Regarding the partial replacement option described above, the chart below illustrates how at least 90 MW of peaker capacity in the East End could be feasibly replaced with a combination of 3-hour, 6-hour, and 8-hour duration storage, rather than the 15 hour duration requirements suggested by the Comprehensive Reliability Plan.[46]

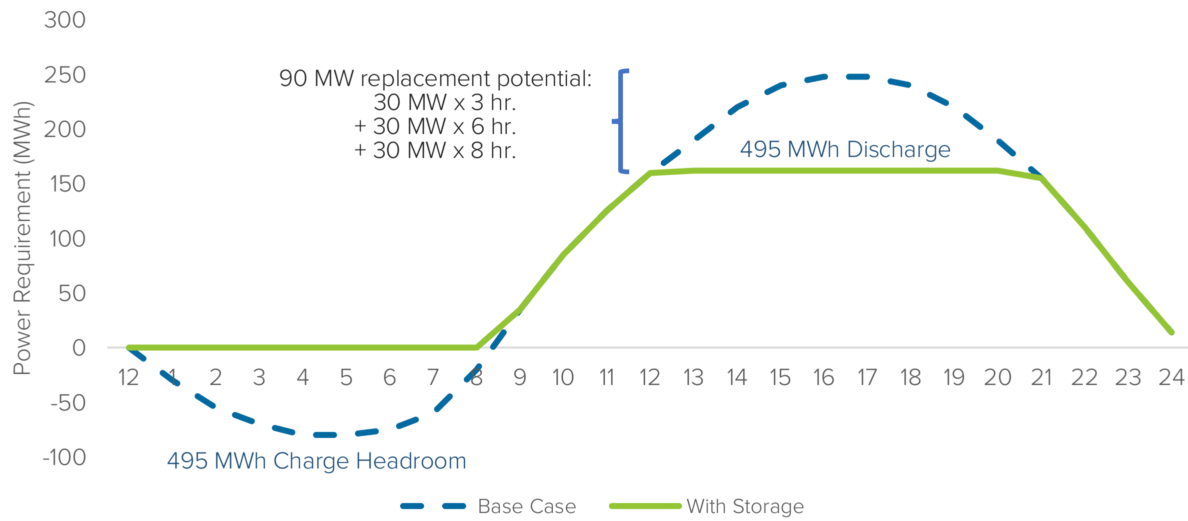

Figure 20. Partial Replacement of East End Load with Storage, 2025

2.3.4 Uneconomic Peaker Operation for Local Reliability

One of the most important characteristics about the operation of existing peaker units on Long Island is that they are frequently dispatched uneconomically, or "out of merit" and for reasons other than meeting peak load needs. In fact, according to the 2019 NYISO State of the Market:

> *"[Out of Merit] dispatch was frequently used to manage 69 kV constraints and voltage constraints (i.e., TVR requirement on the East End of Long Island)."*[47]

In other words, Long Island peakers are frequently used to resolve two local reliability issues:

1. Resolve congestion on the low voltage (69 kV) system and,
2. Manage Transient Voltage Recovery (TVR) in the East End.

In both cases, the local Transmission Owner (i.e. LIPA) takes actions to manually resolve these issues through uneconomic dispatch of peakers, which ultimately lead to sub-optimal results. These actions are generally not coordinated with NYISO and are not optimized through NYISO's day-ahead and real-time market software. As a result, units are often operated unnecessarily and inefficiently, while also leading to depressed LBMPs that send

[46] *Ibid.,* p. 21.
[47] Potomac Economics, *op. cit.,* p. 40.

inaccurate price signals to potential future investment, and requiring millions of dollars in uplift charges.[48] Regarding the 69 kV congestion, NYISO SOM states the following:

> *[W]hen a 69 kV facility is constrained flowing into a load pocket, the local [Transmission Owner] often provides relief by starting a peaking unit in the pocket. However, when this is done on short notice and there is no least-cost economic evaluation of offers, the local TO often runs oil-fired generation with a relatively high heat rate when much lower-cost resources could have been scheduled to relieve the constraint."*[49]

The proportion of hours where out-of-merit actions were taken to resolve congestion issues (versus times when the market was used to resolve these) were quite significant throughout Long Island and are more pronounced in certain locations. For example, in the Brentwood area, 99% of congested hours in 2019 were managed through out-of-merit actions rather than through the DA and RT markets.

Additionally, the NYISO has identified the fact that issues frequently arise due to lack of coordination between the local TO and NYISO regarding the scheduling of Phase Angle Regulators ("PARs") to manage congestion:

> *"If the local TO frequently adjusts a PAR to relieve 69 kV congestion, the NYISO will have difficulty predicting the PAR schedule since it does not model the constraint that the PAR is adjusted to relieve. Consequently, errors in forecasting the schedules of the Pilgrim PAR on Long Island in the day-ahead market and in the RTC model has been a significant contributor to unnecessary operation of oil-fired generation, balancing market congestion residuals, and inefficient scheduling by RTC."*[50]

Additional analysis performed by the NYISO market monitor suggests that the majority of gas turbine (i.e. peaker) unit commitments being made in real time were not clearly economic, including for units on Long Island. This is clearly illustrated in the figure below, where the green bars indicate economic unit commitment and the other colored bars represent operation that is inefficient, and units are being started despite the fact that their offer prices (which reflect their operating costs) exceed the prevailing market price, by over 50% in many instances.

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[48] For example, according to the 2019 NYISO State of the Market Report, the net revenues for a new generator on Long Island could increase by $27/kW-yr if these inefficient practices were addressed (see p A-78).

[49] Potomac Economics, *op. cit.,* p. 41.

[50] *Ibid.,* p.41.

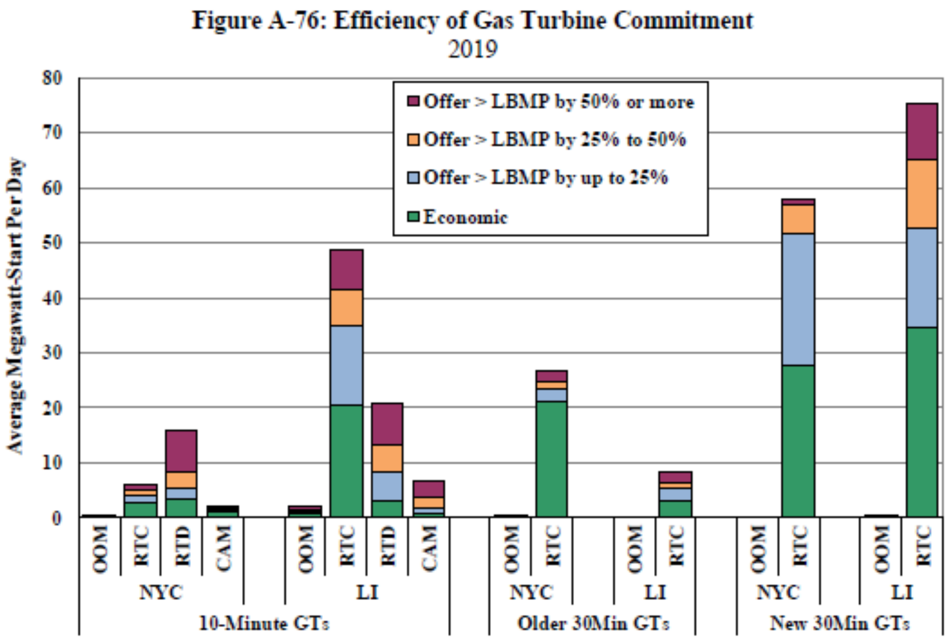

Figure 21. Uneconomic Peaker Unit Commitments, 2019[51]

Taking together the information in these SOM reports, it is apparent that the peakers on Long Island are frequently operating inefficiently and uneconomically and appear to be doing so to meet local voltage and congestion issues that could potentially be alleviated through modest NYISO market reforms and/or better coordination between NYISO and LIPA. If these steps were taken, we believe that long-duration peaker would become much less prevalent. This provides further proof that examining the maximum duration of peaker starts in recent years is not a sound approach for determining the feasibility of replacement via energy storage. For example, many of these longer starts may have been simply have been due to local voltage issues that could have just as been easily resolved through a replacement resource regardless of its duration.

For voltage issues in particular, it is worth noting that voltage control can generally be provided by most modern inverter-based resources and that there is no fundamental need to maintain fossil peakers for this service. In fact, recent demonstrations have shown that inverter-based resources can perform just as well if not better than traditional resources for provide ancillary services.

As an example, the image below shows the real-world test results of a joint demonstration conducted by the CAISO, NREL and First Solar for a large-scale solar PV plant (which functions as an inverter-based resource similar to battery storage). The results show that the plant was capable of providing accurate voltage control (i.e. reactive power) even under conditions where it did not produce energy:

> *"One way to increase the optimal utilization of PV power plants is to use their capability to provide VAR support to the grid during times when the solar resource is not available. For this purpose, the capability of the grid-tied inverters of the 300-MW PV plant to provide reactive power support during a period of no active power generation was demonstrated. Due to the limited time window available for this testing, it was not possible to test this capability during dark hours of the day;*

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[51] *Ibid.,* p. 134.

instead, the team decided to demonstrate the VAR support capability of the plant at nearly zero active power generation. The plant's active output was curtailed to nearly zero MW on August 24, 2017. Then the command was sent to the plant controller to ramp the reactive power to produce or absorb 100 MVAR. The results of these tests along with the measured POI voltage are shown in Figure 49. The plant was fully capable of producing or absorbing the commanded MVAR levels during the whole testing time. Note that the conditions of this test are only partially realistic because special control schemes are needed for grid-tied inverters to operate as STATCOM when a PV array is fully de-energized, and a certain amount of active power needs to be drawn from the grid to compensate for inverter losses. A more realistic test for nighttime VAR mode is planned for the near future."[52]

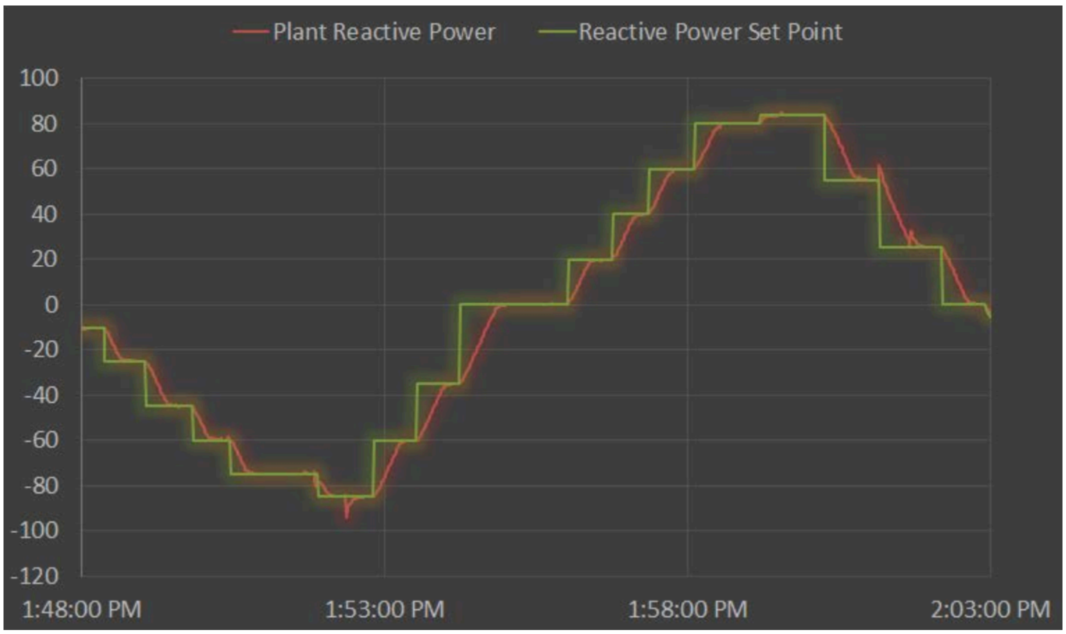

Figure 22. Demonstration of Voltage Control Provided by a Large-Scale PV Plant[53]

The same would be true of a battery storage resources, that should be capable of providing voltage control, even if the battery is not providing energy output. As such, regardless of its duration, a storage resource could serve as a viable replacement for peakers that are primarily operating to address local voltage problems, such as those occurring on the East End.

2.4 Impact of Solar, Energy Efficiency and Off-Shore Wind on Net Load Profiles

A final major contributor to Long Island local reliability will be the addition of new clean resources over the next decade. According to forecasts by NYISO, Long Island could see the addition of as much as 262 MW of new behind-the meter distributed solar by 2030, and between 2.3 to 5.2 GWh of new energy efficiency in the same period, which could provide

[52] NREL, *Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant.* https://www.nrel.gov/docs/fy17osti/67799.pdf
[53] *Ibid.*, p. 42.

as much as 580 to 1,300 MW of peak capacity.[54] The below charts shows NYISO's energy efficiency and rooftop solar forecasts for the Long Island Transmission zone. Both charts show the additional resource contributions that are expected incremental to what is already in place today. For the purposes of this analysis, the low energy efficiency forecast and high rooftop solar forecast were used to estimate net load.

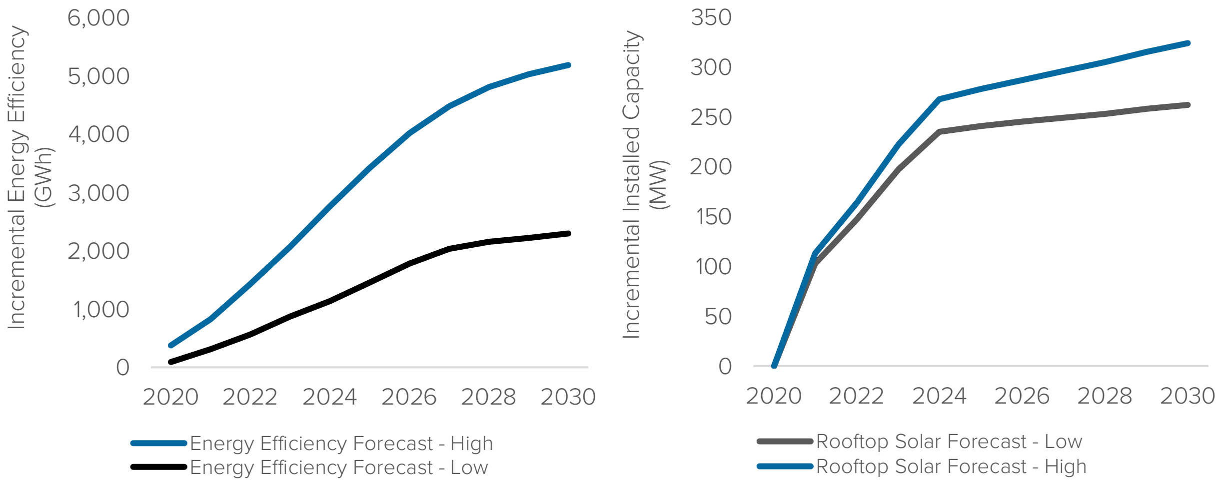

Figure 23. Long Island Cumulative Energy Efficiency Forecasts

Although New York is expecting to see the addition of incremental electrification of the building and transport sectors in pursuit of overall economy decarbonization, much of this electrification is expected to arrive between 2030 and 2040. Between 2020 and 2030, the energy efficiency shown above is expected to be greater than the incremental demand presented by electrification. In fact, as seen in the below chart, total energy demand in New York declines a small amount in the mid-2020s due to energy efficiency, and only begins to rebound in the latter half of the decade as increased demand from electrification begins to impact total statewide electric demand.

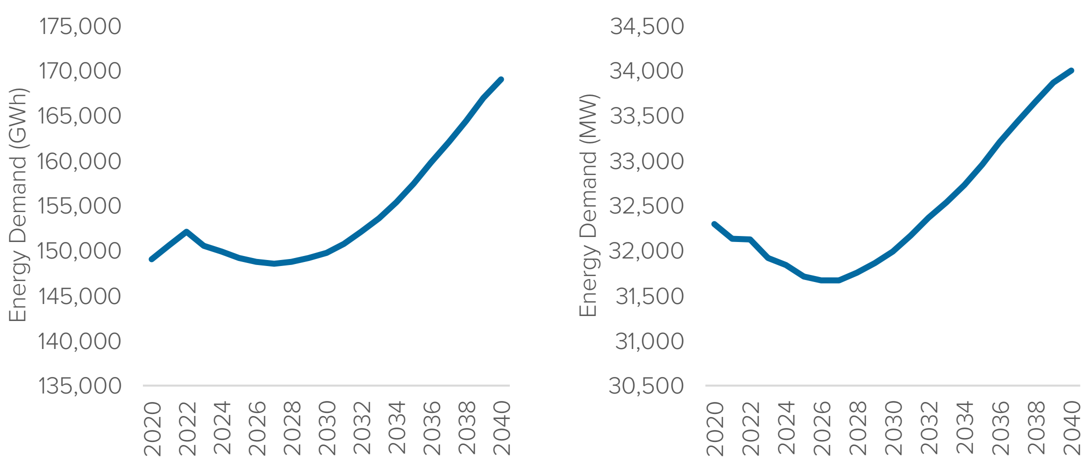

Figure 24. Baseline NYCA Energy Demand, 2020-2040

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[54] NYISO, *2020 Load and Capacity Data (Gold Book)*.
https://www.nyiso.com/documents/20142/2226333/2020-Gold-Book-Final-Public.pdf/

Meanwhile, New York is also making significant progress towards its goal of 9 GW of offshore wind by 2035. The majority of these new wind resources are anticipated to interconnect primarily into Zones J & K. Over 1,800 MW of new offshore wind has already been contract, and is expected to deliver energy into New York by 2024 or sooner. Consistent with this progress and with the 2035 goal of 9 GW of offshore wind, New York could see as much as 6 GW of offshore wind by 2030, with as much as half of that capacity interconnecting into Long Island.

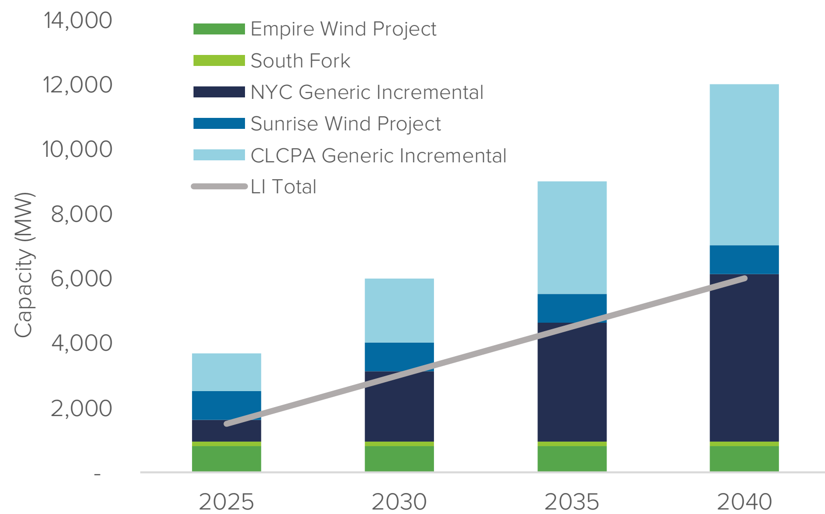

Figure 25. Planned and Forecast Offshore Wind Contracts in NY

The addition of these new resources will fundamentally change energy demands (i.e. load net of variable wind and solar) in Long Island by 2030. The below chart shows an example of how these new resources might impact net load on an average August day. August is generally the month with highest energy demand, and often sees the most significant use of peaking resources. Long Island could see a reduction in average annual net load peak by over 670 MW, which represents about 12% of current peak load.

This change in net energy demand will be even more pronounced during winter months, when offshore wind production is highest. The below charge shows an average day in January – net load has dropped by close to 2,000 MW to nearly 0 during off-peak hours. These new operating conditions will create extreme ramping and flexibility challenges for the existing fossil fleet but present an excellent opportunity for storage to help absorb excess generation and moderate overall ramping demands, helping to reduce curtailment and improve overall renewable deliverability.

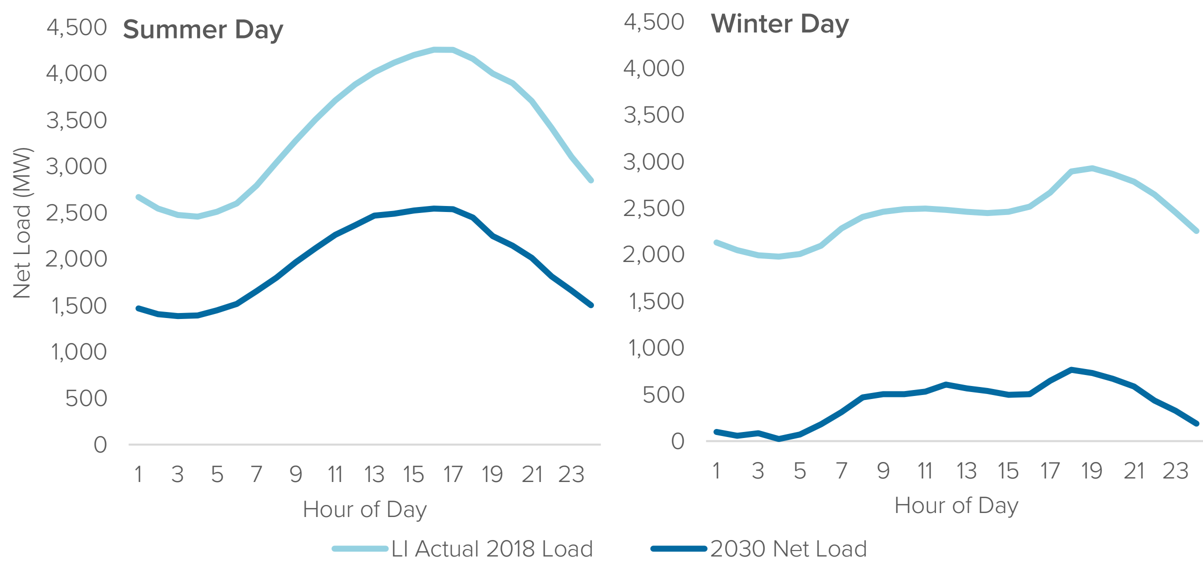

Figure 26. Forecast of 2030 Long Island Net Load: Average August and January Days

2.5 Peaker Retirement Phases

Taking into consideration all of the factors outlined in this report, a candidate set of Long Island peaker units have been identified for replacement with energy storage. In order to appropriately manage this replacement, we have further categorized these replacements into Phases reflecting their viability along a future time horizon.

Factors considered for these phases include contract expiration, NOx emission regulation, dispatch duration, load pocket location, and availability of additional clean resources discussed in the previous section, a final selection of peakers was made that represented a reasonable overall retirement and replacement portfolio.

The first phase includes 334 MW of peaking capacity that could reasonably be retired and replaced with storage today. On average, the units in this portfolio are over 40 years old. Over half of them are still reliant on fuel oil for their operation, and three plants (Northport CT, Port Jefferson Peaking, and West Babylon) are already expected to retire due to NOx regulations.

Table 9. Peaker Retirement Phase 1

Unit Name	Plant	Installed Capacity (MW)	Retirement Reason
E.F. Barrett Jet GT01	E.F. Barrett Jet	18	Dispatch Duration
Freeport GS CT1	Freeport GS (Equus)	60	Contract Expiration
Glenwood GT02	Glenwood CT	55	Dispatch Duration
Holtsville 03	Holtsville	56.7	Dispatch Duration

Jamaica Bay GT2	Jamaica Bay	60.5	Contract Expiration
Northport CT GT	Northport CT	16	Contract Expiration; NOx Regulation; Dispatch Duration
Port Jefferson Peaking GT1	Port Jefferson Peaking	16	NOx Regulation; Dispatch Duration
West Babylon 4	West Babylon	52.4	NOx Regulation
Total		*334*	

Due to the short duration dispatch cycles that these plants are to perform, the grid services provided by these peaking plants can be effectively replaced by storage resources of 4-hour duration, or by "stacked" 2-hour storage resources.[55] Stacked storage resources have the benefit of increased dispatch flexibility and can be run at reduced capacity to provide a 4-hour solution in times of greater duration of need.

The second phase includes 782 MW of peaking capacity that could be retired and replaced with storage by 2023, coinciding with the implementation of NOx regulations. These units have an average age of over 43 years, and in 2018 had an average capacity factor of less than 3%. The units that are part of the E.F Barrett Jet and Holtsville plants have both been online since the early to mid-1970s, and the Holtsville and Glenwood units continue to use fuel oil as a secondary fuel option.

Table 10. Peaker Retirement Phase 2

Unit Name	Plant	Installed Capacity (MW)	Retirement Reason
E.F. Barrett Jet 03	E.F. Barrett Jet	18	Dispatch Duration
E.F. Barrett Jet 05	E.F. Barrett Jet	18	Dispatch Duration
E.F. Barrett Jet 06	E.F. Barrett Jet	18	Dispatch Duration
E.F. Barrett Jet 09	E.F. Barrett Jet	41.8	Dispatch Duration
E.F. Barrett Jet 10	E.F. Barrett Jet	41.8	Dispatch Duration
E.F. Barrett Jet GT02	E.F. Barrett Jet	18	Dispatch Duration
Edgewood GT1	Edgewood	50	Contract Expiration
Edgewood GT2	Edgewood	50	Contract Expiration
Glenwood GT01	Glenwood Landing	16	NOx Regulations
Holtsville 01	Holtsville	56.7	Dispatch Duration

[55] "Stacked" storage resources have similar overall energy storage capabilities and similar storage battery pack sizes, but are constructed as separate, shorter duration storage resources.

Holtsville 02	Holtsville	56.7	Dispatch Duration
Holtsville 04	Holtsville	56.7	Dispatch Duration
Holtsville 05	Holtsville	56.7	Dispatch Duration
Holtsville 06	Holtsville	56.7	Dispatch Duration
Holtsville 07	Holtsville	56.7	Dispatch Duration
Holtsville 08	Holtsville	56.7	Dispatch Duration
Holtsville 09	Holtsville	56.7	Dispatch Duration
Holtsville 10	Holtsville	56.7	Dispatch Duration
Total		*782*	

These grid services provided by these peaking plants can be effectively replaced by stacked storage resources of 4-hour duration. As with the stacked storage described above, stacked 4-hour storage can be dispatched on a portfolio basis to meet long-duration dispatch needs, or can be dispatched more flexibly and more economically during more typical grid conditions. Stacked 4-hour storage has been shown to be effective to meet longer dispatch needs, as seen in analysis performed by the California ISO on local capacity needs for the Moorpark Sub-Area.[56]

The third phase includes just over 1,119 MW of peaking capacity that could be brought offline by 2030 in conjunction with the rooftop solar and offshore wind targets established by New York State, and balanced by incremental storage resources. This 1,119 MW represents some of the newest and most frequently used units considered in this analysis – but these units are still, on average, over 33 years old, and used at less than 10% of their full capability. The Northport plant was built in 1967; it is now 53 years old and will be 63 by 2030. Nine of these units, representing nearly 400 MW, typically dispatch for 12 hours or less over a year, and 14 units representing nearly 750 MW typically dispatch for 20 hours or less. By 2030, all existing PSA contracts with LIPA will have expired, making all plants contractually eligible for retirement.

Table 11. Peaker Retirement Phase 3

Unit Name	Plant	Installed Capacity (MW)	Retirement Reason
Bethpage 3	Bethpage	96	Contract Expiration; Dispatch Duration
Bethpage CT GT4	Bethpage CT	60	Dispatch Duration
Brentwood	Brentwood	47	Dispatch Duration
E.F. Barrett Jet 04	E.F. Barrett Jet	18	Contract Expiration; Dispatch Duration

[56] California ISO, 2017, *Moorpark Sub-Area Local Capacity Alternative Study.* https://www.caiso.com/Documents/Aug16_2017_MoorparkSub-AreaLocalCapacityRequirementStudy-PuentePowerProject_15-AFC-01.pdf

E.F. Barrett Jet 08	E.F. Barrett Jet	18	Contract Expiration; Dispatch Duration
E.F. Barrett Jet 11	E.F. Barrett Jet	41.8	Contract Expiration; Dispatch Duration
E.F. Barrett Jet 12	E.F. Barrett Jet	41.8	Contract Expiration; Dispatch Duration
Freeport CT2	Freeport 1 & 2	60.5	Dispatch Duration
Glenwood GT03	Glenwood CT	55	Contract Expiration; Dispatch Duration
Glenwood GT04	Glenwood Landing	53	Contract Expiration; Dispatch Duration
Glenwood GT05	Glenwood Landing	53	Contract Expiration; Dispatch Duration
Northport 1	Northport	387	Contract Expiration
Pinelawn Power 1	Pinelawn Power	82	Contract Expiration; Dispatch Duration
Port Jefferson Peaking GT2	Port Jefferson Peaking	53	Contract Expiration; Dispatch Duration
Port Jefferson Peaking GT3	Port Jefferson Peaking	53	Contract Expiration; Dispatch Duration
Total		*1,119*	

Although these resources have historically dispatched at longer durations, by 2030, the addition of offshore wind, rooftop solar, and energy efficiency will displace fossil generation, reduce the overall dispatch duration needed from storage, and will increase charging opportunity for storage. For example, the below chart shows incremental resources that will be available from the addition of new energy efficiency, offshore wind, and rooftop solar on an average day in August. These resources will, on average, add as much as 1000 MW of additional capacity during evening hours of highest demand. Over the course of 2030, they will inject an expected 12,500 GWh of incremental energy availability into the system.

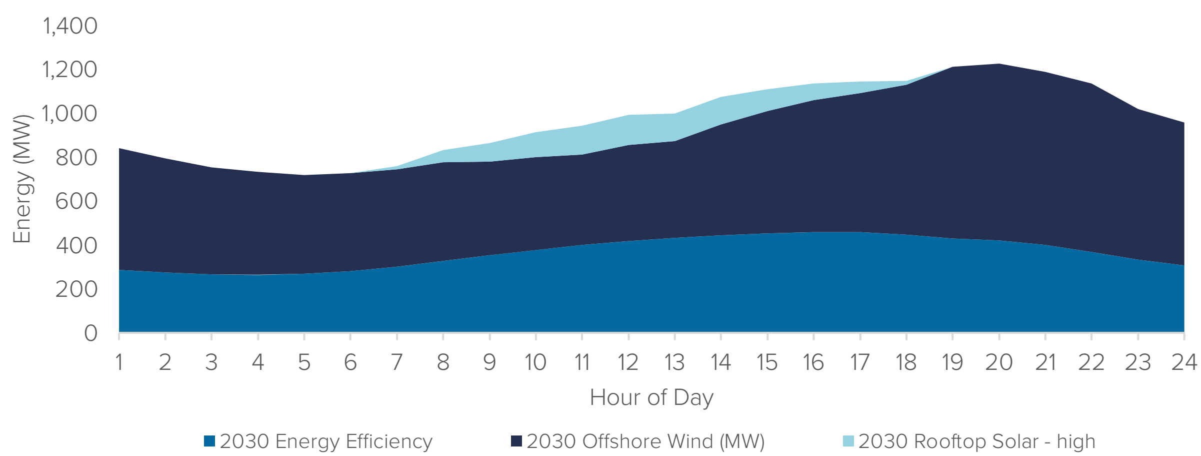

Figure 27. Average August Energy Available from Energy Efficiency, Offshore Wind & Rooftop Solar in 2030

These resources have the potential to significantly reduce the dispatch duration of any peaking or flexibility resources. In this context, the role of storage or other peaking fossil assets will be to provide integration during times of low renewable energy. For example, the below chart shows three days in August with low offshore wind production – potentially the three days of the year with highest demand for peaking energy supplied from dispatchable resources. In this instance, the role of storage or any other integrating resources would be to balance the excess generation in the early hours of the morning with peak demand later in the afternoon.

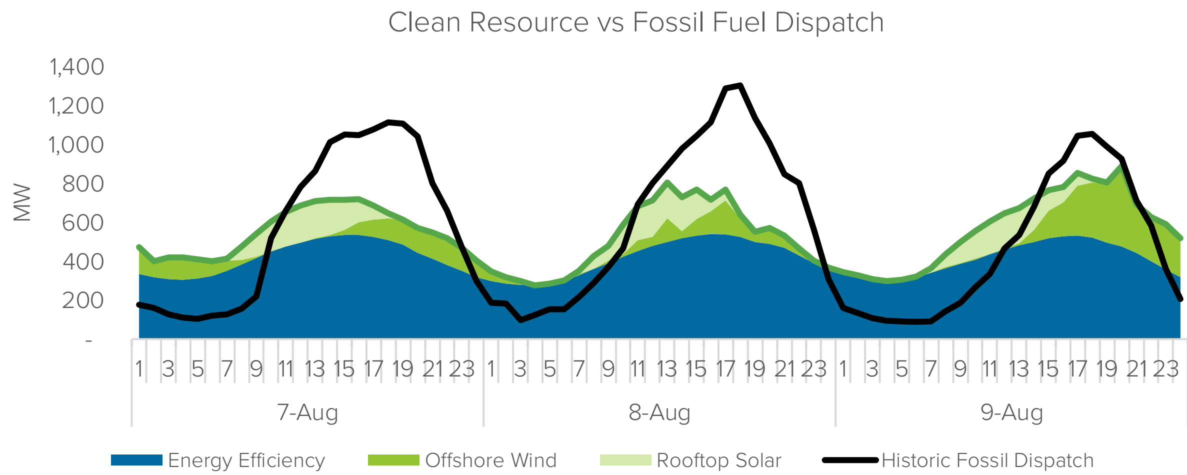

Figure 28. Energy Storage Balances Excess Generation and Peak Demand

By 2025, this analysis has proposed the addition of 1,116 MW of storage to meet the regional energy needs of Long Island. Based on analysis of the hourly net load profile for 2030, these potential resource additions could be able to meet a significant portion of the overall flexible resource needs described above. Given the addition of new customer and grid scale resources, much shorter duration storage could be used to replace the capacity of these peakers, despite their longer historic run-times. By 2030, a cumulative storage portfolio of around 350 MW could help to enable the retirement of the full 2,300 MW considered in this analysis.

Of course, the full need for grid resources such as storage in 2030 will be heavily dependent on the adoption of customer resources, such as energy efficiency and rooftop solar. Building and transport electrification, which will be cornerstones of New York's clean economy, will also drive overall grid needs.

3. Peaker Retirement & Replacement Economic Analysis

This section assesses the potential economic benefits that could accrue to LIPA customers through the retirement and replacement of fossil assets with new storage resources. Although this analysis focuses specifically on the direct economic benefits that LIPA and its customers could realize through established energy markets and value streams, the indirect benefits of storage could go far beyond this, and the final portion of this section provides some additional context on those potential benefits.

3.1 Methodology and Assumptions

At the highest level, this methodology evaluates the potential costs net of any revenue streams from NYISO markets that both fossil peaker resources and storage resources would yield for LIPA customers.

3.1.1 Net Cost Comparison

By using a net cost approach, this study evaluates the cost-effectiveness of fossil peakers against an equivalent amount of storage capacity. More specifically, the analysis compares the full resource costs and revenue streams for an equivalent NYISO capacity value for each resource.[57] Costs included, as applicable, contract costs (for existing peakers), overnight capital costs (for new storage), operations and maintenance, augmentation and warranty for storage, the costs of fuel or charging; while revenues included the market value of energy and ancillary services.

3.1.2 Peaker Costs and Benefits

For the purposes of this analysis, it was assumed that the capacity cost of the PSA between LIPA and National Grid is indicative of the bilateral contract market on Long Island. Bilateral contracts account for 87% of the cleared capacity in Long Island and the National Grid PSA accounts for 72% of those contracts, and thus comprises the bulk of Long Island's capacity resources.[58] The cost of the PSA going forward was projected based on historical increases in the cost of the contract and on NYISO's projected cost of fuel, based on the natural gas blend for Zone K and adjusted for the use of fuel oil in some plants.[59]

The revenues of the peakers are calculated through an energy and ancillary model that assumes a peaker will generally follow the day ahead market on an hourly basis. In short, it runs for all the hours that it is economic to do so based on locational based marginal prices (LBMP) and its cost to dispatch, with some exceptions described later. The revenues from the ancillary services are adjusted to reflect a limited share of the operating reserves market (primarily non-spin) that can be served by the peaker fleet.

The costs and revenues of the peaker fleet are then adjusted to reflect actual market performance as reported by the NYISO market monitor, Potomac Economics. According to the NYISO market monitor's most recent State of the Market report, over half of all gas turbine unit commitments on Long Island were not clearly economic, meaning that many peaker plants are running out of merit order, unnecessarily increasing emissions and customer cost[60]. For the purposes of this analysis, 25% of peaker plant dispatch was assumed to be uneconomic, whereby the unit's energy market revenues were less than its operating costs as determined by the plant's heat rate and cost of fuel.[61]

The NYISO 2019 market monitor report also indicates that peaker plant dispatch has historically been limited by outages, with an equivalent forced outage rate (EFORd) for older peaker units (which comprise the bulk of the Long Island fleet) of about 13%.[62] This means

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[57] Capacity value based on estimation of NYISO unforced capacity (UCAP)
[58] Estimated based on NYISO's monthly reports on Installed Capacity Market (ICAP) for Long Island. https://www.nyiso.com/installed-capacity-market
[59] NYISO, 2019. 2019 CARIS Fuel Price Forecast with Proposed Methodology Revision for Natural Gas
[60] Potomac Economics, *op. cit.,* p.103.
[61] For the old peakers in the fleet, the assumed heat rate is close to 15,000 btu/kWh, based on estimates from the market monitor in 2019. *Ibid.* p.A-206
[62] *Ibid.* p. A-188.

that on average, the unforced capacity contribution of these peakers is around 87% of installed capacity, and that a perfectly available resource will only need to replace 87% of the fleet's capacity. So, for the purposes of this analysis, fossil fuel capacity contribution was derated to capture the usable capacity of the peaker fleet more accurately when comparing it to an equivalent storage resource.

3.1.3 Energy Storage Costs and Benefits

Energy storage costs are based on projections from Lazard's 2019 Levelized Cost of Storage report,[63] are levelized for a 20-year lifetime using a 9% weighted average cost of capital (WACC) and include the cost of augmentation to maintain the storage capabilities of the batteries, as well as other O&M and warranty costs. The analysis uses lithium-ion batteries as a reference for storage costs. The analysis further assumes than LIPA would procure the most cost competitive storage solutions available, supporting the use of the lower end of Lazard's cost projections. Finally, storage capital costs projections reflect a 10% cost adder, reflecting the higher costs to develop resources in Long Island, and consistent with recommendations from NREL.[64]

The net cost of storage was calculated for several battery configurations based on their arbitrage and ancillary services potential using hourly NYISO LBMP prices from 2019. The model assumes that storage is able to complete daily cycles at its specific duration and 85% round-trip efficiency, charging during the contiguous blocks of lowest energy cost and discharging during the highest ones. The study considers the currently limited size of the ancillary services market in Zone K which will be further limited as new storage capacity begins to deliver regulation services. Conservatively, the study assumes that the market, at its present size, will be split among the current and new resources. However, it should be noted that the market for ancillary services may grow as new intermittent renewables are added to the grid in higher amounts.

Another consideration is the capacity value of storage. The study assumes a capacity value of 45% for 2-hour duration storage, 90% for 4-hour and 100% for 6-hour and larger durations, consistent with NYISO capacity market rules going into effect May 2021.[65] This means that each MW of six-hour or eight-hour duration batteries is generally able to provide capacity equivalent to each MW of unforced capacity (UCAP) from fossil peakers on a one-to-one basis. Meanwhile, each MW of peaker capacity requires about 2.2 MW of 2-hour storage or 1.1 MW of 4-hour storage for an equivalent replacement.

3.1.4 LIPA Total Annual Portfolio Savings Potential

Annual savings to LIPA customers from the proposed peaker replacement pathway was estimated by computing the difference between the levelized net cost of new storage additions and the annual net cost of the peaker capacity under the LIPA PSA. These savings were then scaled up to represent the full Long Island peaker fleet capacity, under the assumption that the PSA is generally indicative of the contracted cost of peaker capacity. These avoided costs do not reflect any "ramp-down" costs that may arise as the result of early terminations as described earlier, which were assumed to be de minimis.

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[63] Lazard, 2019. Levelized Cost of Storage V5. https://www.lazard.com/perspective/lcoe2019
[64] NREL, 2019. Cost Projections for Utility-Scale Battery Storage & 2020 Update. https://www.nrel.gov/docs/fy19osti/73222.pdf
[65] NYISO, 2019. *Expanding Capacity Eligibility,* https://www.nyiso.com/documents/20142/5375692/Expanding%20Capacity%20Eligibility%20030719.pdf/19c4ea0d-4827-2e7e-3c32-cf7e36e6e34a

3.2 Cost Effectiveness Relative to Existing Peakers

Based on the peaker groupings described above in Section 2.5, Strategen analyzed a peaker replacement pathway that would phase 1,116 MW of Long Island peakers by 2023 and another 1,206 MW (around 2,300 total) by the end of the decade. Strategen's recommended portfolio of new standalone energy storage as a replacement for this peaker capacity results in substantial potential savings to LIPA customers. We estimate total savings of $393 million (net present value) by the end of the decade, representing about $350 per household across LIPA's 1.1 million customers.

These savings are the result of avoiding the relatively high cost of contracted peaker capacity, which is expected to increase over time (based on historical trends, increasing operating costs such as fuel, and environmental retrofits for NOx emissions) relative to the ever more competitive cost of battery storage, which is only expected to decrease over time and as subsequent tranches of peaker capacity is replaced. It is also worth noting that that for the last phase of energy storage replacements, a smaller share of storage is needed relative to the amount of peaker retirements (approximately 30% of the proposed peaker retirements). This is due to the fact that significant expected additions of renewable energy and energy efficiency over the next decade will partially offset the need for peaking capacity on Long Island.

Figure 29. Annual Savings from Peaker Replacement.[66]

[66] G1, G2, and G3 refer to the different groupings of peaker units described in Section 2 (and corresponding storage replacements), while EE refers to the East End location-constrained capacity.

Retiring and replacing aging peaker units has the potential to create $10.5 million of savings per year in 2021, growing to $150 million per year in 2030. The growth in projected savings over the next decade are driven by both the growing differential in peaker and storage costs, as well as the increased scale of savings due to replacing a larger portion of the portfolio (i.e. growing from 324 MW in 2021 to 2,325 MW by 2030). The following graphics demonstrate the underlying estimates of net cost construct for contracted peaker capacity and new energy storage throughout the next decade.

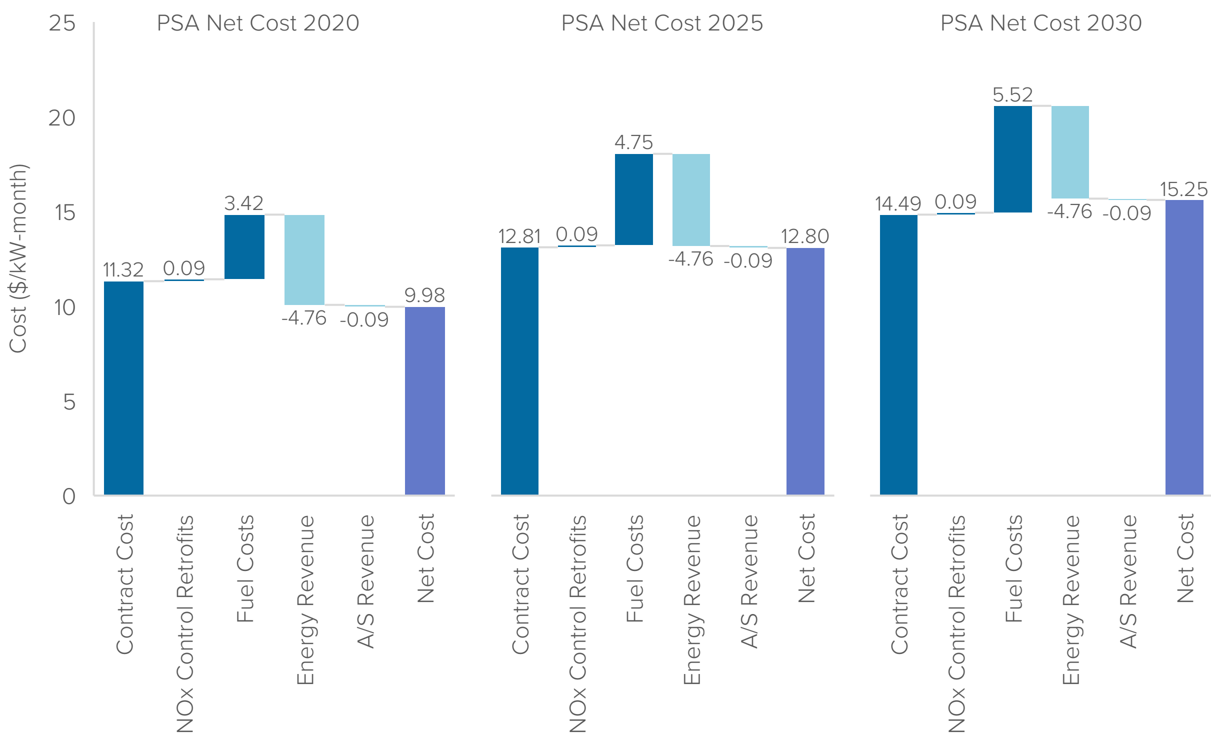

Figure 30. PSA Net Cost 2020 to 2030

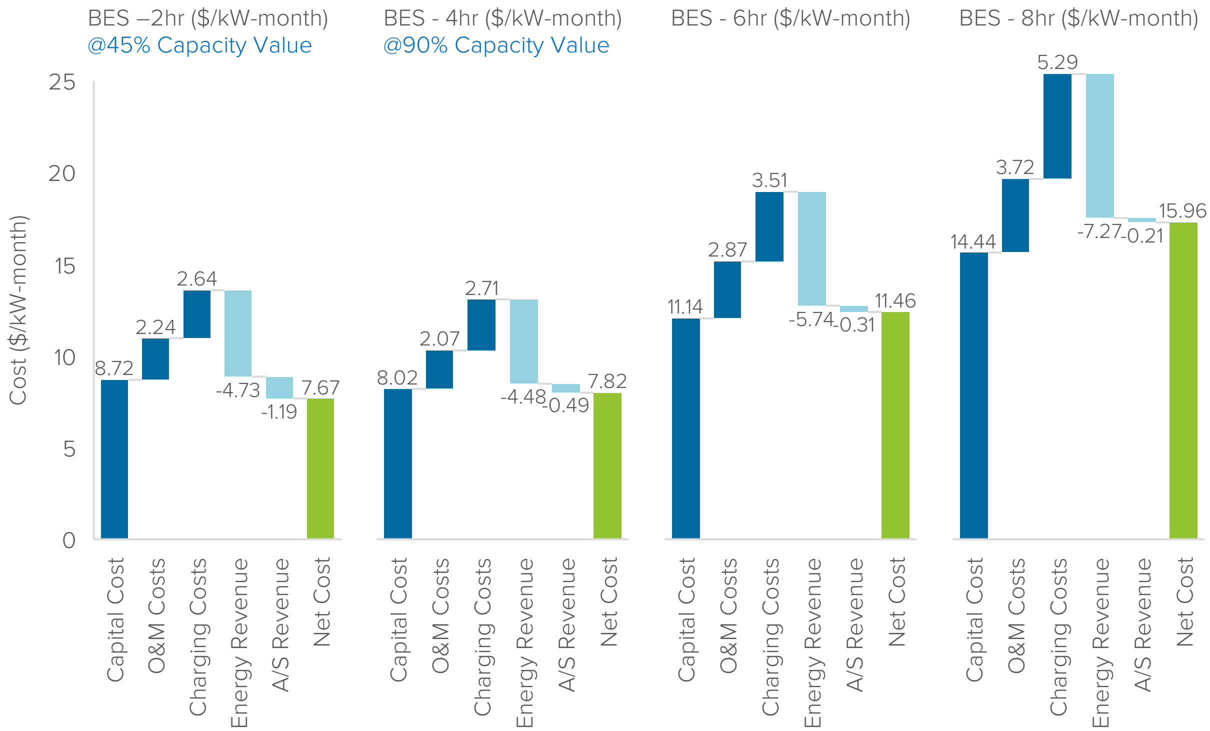

Figure 31. Energy Storage Net Cost in 2020

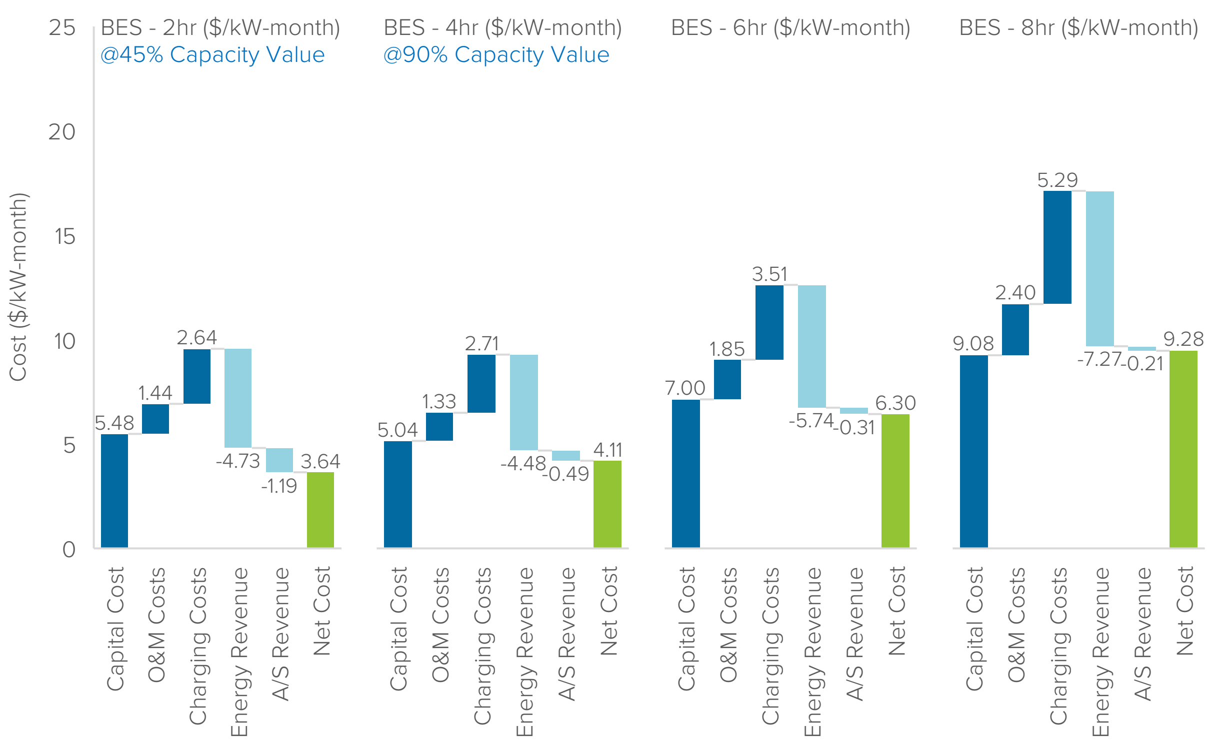

Figure 32. Energy Storage Net Cost in 2030

3.3 Energy Storage Benefits Not Included in Cost-Benefit Analysis

3.3.1 Grid Benefits of Storage

The addition of storage capacity to the New York grid provides additional benefits which are not quantified in this net cost of storage analysis, which focuses on direct monetizable value streams that can be captured for LIPA customer benefit.

As New York procures increasing amounts of renewable energy to reach CLCPA targets, the state will require energy storage to integrate these clean resources to their full advantage. New York's North Country, for example, is already experiencing consistent curtailment of wind resources when supply outpaces demand.[67] The region's transmission system is constrained which is limiting the grid's ability to transmit renewable energy.

Historically, addressing grid issues such as load growth, rising peak demand, network congestion, and system reliability has been accomplished by building out additional transmission and distribution (T&D) infrastructure which is expensive and time-consuming, but instead, energy storage can play an important role in the balancing act of matching supply and demand and help to create a more flexible and reliable grid system thus deferring the need for costly T&D upgrades while significantly reducing renewable energy curtailment.[68]

Additionally, battery storage resources can provide voltage control, a valuable ancillary service which would benefit grid reliability. Storage also adds diversity to the electric system, so the grid is less exposure to single points of failure, such as reliance on a single fuel source.

3.3.2 Health and Environmental Benefits from Reduced Emissions

Further, the economics in this report do not account for environmental or social benefits such health benefits, greenhouse gas emission reductions from reduced peaker usage, or improved conditions in Potential Environmental Justice Areas.

The counties that compose Long Island – Kings, Queens, Nassau, and Suffolk – currently and historically have nonattainment status regarding 8-hour ozone levels set by the National Ambient Air Quality Standard (NAAQS).[69] Further, according to the New York State Department of Health and Mental Hygiene, exposure to ozone above background levels causes New Yorkers to suffer annually from about 400 premature deaths, more than 800 asthma related hospital visits, and over 4,500 asthma related emergency room visits.[70] Additionally, it has been estimated that a reduction in ozone levels by just 10% could prevent more than 80 premature deaths, 180 hospital admissions and 950 emergency department visits annually.[71]

Beyond health impacts, emissions from peaker plants are also harmful for New York's economy. Peaker emissions cost the state an estimated $163 million annually based on

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[67] NYISO, *Unbottling Wind: How We Can Expand Clean Energy*. https://www.nyiso.com/view-blog/-/asset_publisher/5397qT1ac7HE/content/unbottling-wind-how-we-can-expand-clean-energy
[68] California Energy Storage Alliance, *Why Storage.* https://www.storagealliance.org/about/why-storage
[69] EPA, *New York Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants* https://www3.epa.gov/airquality/greenbook/anayo_ny.html
[70] New York City Department of Health and Mental Hygiene, *op. cit.* p. 4.
[71] *Ibid.,* p. 4.

average annual peaker emissions between 2016-2018, the morbidity and mortality of NOx and SOx as precursors to PM 2.5,[72] and the social cost of carbon.[73]

Table 12. Annual Economic Impact of Peaker Emissions

Criteria Pollutant	Economic Value ($/ton)	LIPA Peaker Emissions, 2018 (tons)	Annual Economic Impact (million $)
CO_2	42	2,650,000	111
NO_x	12,000	1,910	2.3
SO_x	78,000	639	50
Total			***163.3***

4. Recommended Replacement Pathway

Collectively, the peaker retirements proposed in this report represent a reduction of just over 2,300 MW of fossil fuel capacity on Long Island, and an addition of over 1,540 MW of new energy storage resources. If this pathway is followed, LIPA has the opportunity to halve the fossil fuel power plants operating in Long Island over the course of the next decade. As shown below, these reductions would put LIPA on a "glide path" towards meeting the CLCPA mandate of carbon neutral electricity generation by 2040, and also represents a significant step forward for Long Island's clean energy future.

The deployment of storage (and other clean energy resources), can be appropriately staged to ensure that 1) all reliability needs can be identified and addressed in a timely manner, 2) near-term deployments are able to address "low hanging fruit" opportunities to deliver immediate cost savings to LIPA customers, while scaling the market for energy storage, 3) medium and long-term deployments benefit from market maturity and declines in energy storage technology costs. By using a staged approach, we recommend that different targets be applied for replacing LIPA's peaker portfolio over the Near Term, Medium Term, and Long Term.

[72] EPA, *Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors.* https://www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-17-sectors
[73] EPA, *The Social Cost of Carbon.* https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html

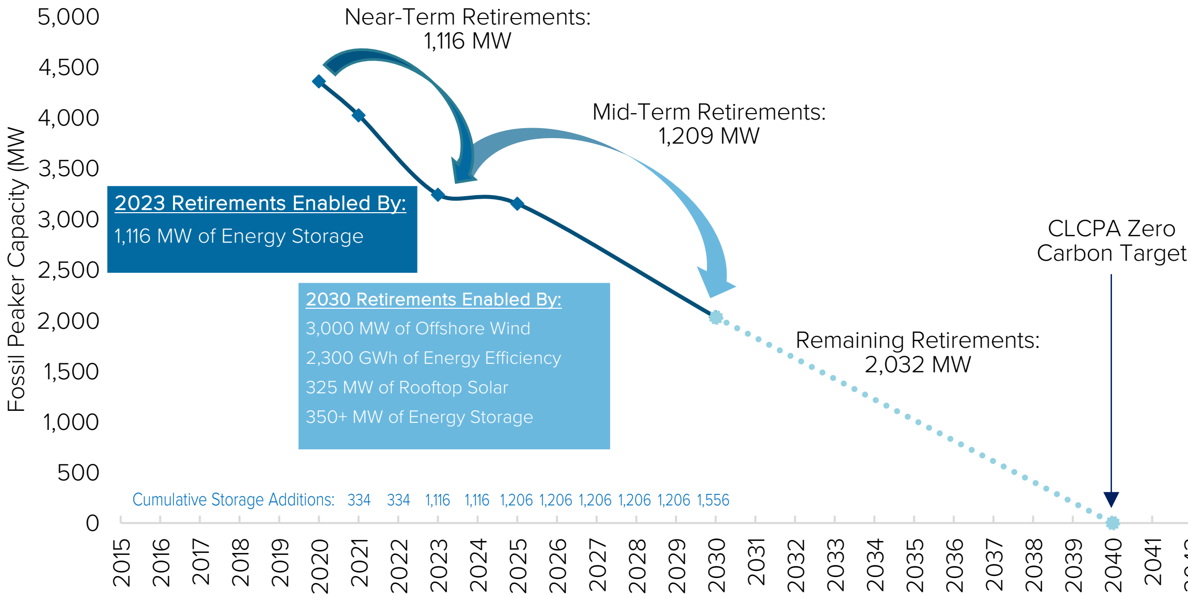

Figure 33. Peaker Retirement Pathway

4.1 Near Term (2020 – 2023)

There is a significant amount of peaking generation capacity (about 334 MW) that is "low hanging fruit" and could be feasibly and cost effectively replaced immediately. In addition to that initial set, over the next 3 years, LIPA could retire just over 1,100 MW of fossil fuel capacity and replace it with a portfolio of storage with similar capacity. While much of this near-term portfolio would consist of relatively short duration (i.e. <4 hours) storage resources, some portion may need to meet longer dispatch needs in the 6- to 8-hour duration range. On average, we estimate that the near-term storage portfolio duration would be around 5.5 hours, or about 4,700 MWh of storage capability.

4.2 Medium Term (2024-2030)

In the second half of the decade, LIPA has an opportunity to retire additional 1,200 MW of fossil fuel resources. As replacement resources are considered, energy storage is poised to play a key role. Retirement of fossil peakers could be enabled by the addition of offshore wind, distributed solar, and energy efficiency, and the addition of energy storage for a cumulative total of 1,556 MW or more. Moreover, this storage will play a critical role in supporting the integration of these new, clean resources through the provision of time shifting capabilities, operating reserves, and improving the deliverability of large-scale off-shore wind.

4.3 Long Term (2031-2040)

In the decade beginning in 2031, LIPA will need to retire just over 2 GW of existing fossil fuel capacity to be compliant with the electric sector zero carbon targets of the CLCPA. These remaining 2 GW represent the peakers understood to be the most "challenging" from the standpoint of having typically longer start durations. However, they will still need to be addressed as part of the transition towards CLCPA goals. To enable this transition, LIPA will need to continue on a trajectory of developing clean, integrating resources to balance renewable generation and meet net peak demand. While some of these resources could theoretically be retired sooner, we believe the plan laid out in this report presents a reasonable "glide path" for meeting the CLCPA goals, while still giving sufficient time to plan and procure the appropriate portfolio of replacement resources, including energy storage. Meanwhile, LIPA will be able to gain critical experience operating storage resources as a means to better understand their performance and contribution to system reliability.

Appendix A

Table 13. Detail of Peaker Selection by Generating Unit

Unit	Ultimate Parent	Town	Nameplate Capacity (MW)	Unit Type	Capacity Factor	PSA	Age (years)	Fuel	2019 Net GWh	Replacement Phase	Peaker Rule	Duration @90% (hours)
E.F. Barrett Jet GT01	National Grid	Island Park	18	GT	2.47%	Yes	50	NG/ FO2	3.9	Phase 1 (2020-2023)	Non-Compliant	N/A
Freeport GS CT1	J Power	Freeport	60	GT	7.59%		16	NG/ FO2	39.9	Phase 1 (2020-2023)	Compliant	8
Glenwood CT GT02	National Grid	Glenwood	55	GT	0.06%	Yes	48	FO2	0.3	Phase 1 (2020-2023)	Non-Compliant	8.4
Holtsville 03	National Grid	Holtsville	56.7	JE	0.34%	Yes	46	FO2	1.7	Phase 1 (2020-2023)	Non-Compliant	3.9
Jamaica Bay GT2	Hull Street Energy	Jamaica Bay	60.5	JE	1.60%		17	NG/ FO2	8.5	Phase 1 (2020-2023)	Compliant	11
Northport CT GT	National Grid	Northport	16	GT	0.00%	Yes	53	FO2	0.0	Phase 1 (2020-2023)	Non-Compliant (Black-start)	3.9
Port Jefferson Peaking GT1	National Grid	Port Jefferson	16	GT	0.07%	Yes	54	FO2	0.1	Phase 1 (2020-2023)	Non-Compliant (Black-start)	3.6
West Babylon 4	National Grid	West Babylon	52.4	GT	0.65%	Yes	49	FO2	3.0	Phase 1 (2020-2023)	Non-Compliant (Retiring)	8.4
E.F. Barrett Jet 03	National Grid	Island Park	18	GT	1.78%	Yes	50	NG/ FO2	2.8	Phase 2 (2020-2023)	Non-Compliant	8
E.F. Barrett Jet 05	National Grid	Island Park	18	GT	1.65%	Yes	50	NG/ FO2	2.6	Phase 2 (2020-2023)	Non-Compliant	8
E.F. Barrett Jet 06	National Grid	Island Park	18	GT	1.59%	Yes	50	NG/ FO2	2.5	Phase 2 (2020-2023)	Non-Compliant	6
E.F. Barrett Jet 09	National Grid	Island Park	41.8	JE	3.55%	Yes	49	NG/ FO2	13.0	Phase 2 (2020-2023)	Non-Compliant	8
E.F. Barrett Jet 10	National Grid	Island Park	41.8	JE	3.09%	Yes	49	NG/ FO2	11.3	Phase 2 (2020-2023)	Non-Compliant	7
E.F. Barrett Jet GT02	National Grid	Island Park	18	GT	1.59%	Yes	50	NG/ FO2	2.5	Phase 2 (2020-2023)	Non-Compliant	7
Edgewood GT1	J Power	Brentwood	50	GT	7.35%		18	NG	32.2	Phase 2 (2020-2023)	Compliant	14
Edgewood GT2	J Power	Brentwood	50	GT	6.48%		18	NG	28.4	Phase 2 (2020-2023)	Compliant	12
Glenwood Landing GT01	National Grid	Glenwood	16	GT	0.07%	Yes	53	FO2	0.1	Phase 2 (2020-2023)	Non-Compliant (Retiring)	3.9
Holtsville 01	National Grid	Holtsville	56.7	JE	0.26%	Yes	46	FO2	1.3	Phase 2 (2020-2023)	Non-Compliant	5
Holtsville 02	National Grid	Holtsville	56.7	JE	0.12%	Yes	46	FO2	0.6	Phase 2 (2020-2023)	Non-Compliant	4.6
Holtsville 04	National Grid	Holtsville	56.7	JE	0.40%	Yes	46	FO2	2.0	Phase 2 (2020-2023)	Non-Compliant	5.2
Holtsville 05	National Grid	Holtsville	56.7	JE	0.26%	Yes	46	FO2	1.3	Phase 2 (2020-2023)	Non-Compliant	5
Holtsville 06	National Grid	Holtsville	56.7	JE	0.44%	Yes	45	FO2	2.2	Phase 2 (2020-2023)	Non-Compliant	8
Holtsville 07	National Grid	Holtsville	56.7	JE	0.58%	Yes	45	FO2	2.9	Phase 2 (2020-2023)	Non-Compliant	8
Holtsville 08	National Grid	Holtsville	56.7	JE	0.70%	Yes	45	FO2	3.5	Phase 2 (2020-2023)	Non-Compliant	6
Holtsville 09	National Grid	Holtsville	56.7	JE	0.42%	Yes	45	FO2	2.1	Phase 2 (2020-2023)	Non-Compliant	6.6
Holtsville 10	National Grid	Holtsville	56.7	JE	0.40%	Yes	45	FO2	2.0	Phase 2 (2020-2023)	Non-Compliant	7
Bethpage 3	Calpine Corp (Volt Parent)	Hicksville	96	CC	13.21%		15	NG	111.1	Phase 3 (2024-2030)	N/A	20.2
Bethpage CT GT4	Calpine Corp (Volt Parent)	Hicksville	60	GT	8.62%		18	NG	45.3	Phase 3 (2024-2030)	N/A	16
Brentwood	New York Power Authority	Brentwood	47	GT	13.04%		19	NG	53.7	Phase 3 (2024-2030)	Compliant	13
E.F. Barrett Jet 04	National Grid	Island Park	18	GT	2.98%	Yes	50	NG/ FO2	4.7	Phase 3 (2024-2030)	Non-Compliant	9
E.F. Barrett Jet 08	National Grid	Island Park	18	GT	1.20%	Yes	50	NG/ FO2	1.9	Phase 3 (2024-2030)	Non-Compliant	9.5
E.F. Barrett Jet 11	National Grid	Island Park	41.8	JE	6.53%	Yes	49	NG/ FO2	23.9	Phase 3 (2024-2030)	Non-Compliant	9
E.F. Barrett Jet 12	National Grid	Island Park	41.8	JE	4.78%	Yes	49	NG/ FO2	17.5	Phase 3 (2024-2030)	Non-Compliant	9

Freeport CT2	Village of Freeport	Freeport	60.5	GT	2.49%		16	NG/ KER	13.2	Phase 3 (2024-2030)	Compliant	12
Glenwood CT GT03	National Grid	Glenwood	55	GT	0.04%	Yes	48	FO2	0.2	Phase 3 (2024-2030)	Non-Compliant	10
Glenwood Landing GT04	National Grid	Glenwood	53	GT	8.42%		18	NG/ FO2	39.1	Phase 3 (2024-2030)	Compliant	13
Glenwood Landing GT05	National Grid	Glenwood	53	GT	8.81%		18	NG/ FO2	40.9	Phase 3 (2024-2030)	Compliant	12
Northport 1	National Grid	Northport	387	ST	9.86%	Yes	53	NG/ FO6	334.2	Phase 3 (2024-2030)	N/A	171.8
Pinelawn Power 1	J Power	Babylon	82	CC	9.58%		15	NG/ KER	68.8	Phase 3 (2024-2030)	N/A	17
Port Jefferson Peaking GT2	National Grid	Port Jefferson	53	GT	4.85%		18	NG/ FO2	22.5	Phase 3 (2024-2030)	Compliant	10
Port Jefferson Peaking GT3	National Grid	Port Jefferson	53	GT	4.63%		18	NG/ FO2	21.5	Phase 3 (2024-2030)	Compliant	10
East Hampthon 2	National Grid	East Hampthon	2	IC	4.00%	Yes	58	FO2	0.7	East End	Non-Compliant	N/A
East Hampthon 3	National Grid	East Hampthon	2	IC	5.14%	Yes	58	FO2	0.9	East End	Non-Compliant	N/A
East Hampthon 4	National Grid	East Hampthon	2	IC	5.14%	Yes	58	FO2	0.9	East End	Non-Compliant	N/A
East Hampthon GT1	National Grid	East Hampthon	21.3	JE	6.43%	Yes	50	FO2	12.0	East End	Non-Compliant	16
Greenport Hawkeye GT1	Hawkeye Energy Greenport	Greenport	54	JE	6.45%		17	FO2	30.5	East End	Compliant	14
Shoreham 1	National Grid	Shoreham	52.9	GT	0.15%	Yes	49	FO2	0.7	East End	Non-Compliant	5.4
Shoreham 2	National Grid	Shoreham	18.6	JE	0.18%	Yes	36	FO2	0.3	East End	Non-Compliant	4.5
Shoreham Peaking GT3	J Power	Shoreham	50	GT	0.55%		18	FO2	2.4	East End	Compliant	9
Shoreham Peaking GT4	J Power	Shoreham	50	GT	0.53%		18	FO2	2.3	East End	Compliant	6
Southampthon 1	National Grid	Southampthon	11.5	GT	2.08%	Yes	57	FO2	2.1	East End	N/A	N/A
Southold 1	National Grid	Southold	14	GT	1.39%	Yes	56	FO2	1.7	East End	N/A	N/A
Wading River 1	National Grid	Shoreham	79.5	GT	0.55%	Yes	31	FO2	3.8	East End	Non-Compliant	11
Wading River 2	National Grid	Shoreham	79.5	GT	0.43%	Yes	31	FO2	3.0	East End	Non-Compliant	7.2
Wading River 3	National Grid	Shoreham	79.5	GT	0.57%	Yes	31	FO2	4.0	East End	Non-Compliant	11
Northport 2	National Grid	Northport	387	ST	15.37%	Yes	52	NG/ FO6	521.1	Long Duration	N/A	405
Northport 3	National Grid	Northport	387	ST	16.00%	Yes	48	NG/ FO6	542.3	Long Duration	N/A	727.4
Northport 4	National Grid	Northport	387	ST	18.63%	Yes	43	NG/ FO6	631.6	Long Duration	N/A	509
Port Jefferson 3	National Grid	Port Jefferson	188	ST	6.62%	Yes	62	NG/ FO6	109.1	Long Duration	N/A	257.2
Port Jefferson 4	National Grid	Port Jefferson	188	ST	10.01%	Yes	60	NG/ FO6	164.8	Long Duration	N/A	246.2
Charles P Keller 10	Village of Rockville Centre	Rockville Centre	3.5	IC	0.00%		66	FO2/ NG	0.0	Back-up Generator	N/A	N/A
Charles P Keller 11	Village of Rockville Centre	Rockville Centre	5.2	IC	0.00%		58	FO2/ NG	0.0	Back-up Generator	N/A	N/A
Charles P Keller 12	Village of Rockville Centre	Rockville Centre	5.5	IC	0.00%		53	FO2/ NG	0.0	Back-up Generator	N/A	N/A
Charles P Keller 13	Village of Rockville Centre	Rockville Centre	5.5	IC	0.00%		46	FO2/ NG	0.0	Back-up Generator	N/A	N/A
Charles P Keller 14	Village of Rockville Centre	Rockville Centre	6.2	IC	1.47%		26	FO2/ NG	0.8	Back-up Generator	N/A	N/A
Charles P Keller 7	Village of Rockville Centre	Rockville Centre	2	IC	0.00%		78	FO2	0.0	Back-up Generator	N/A	N/A
Charles P Keller 9	Village of Rockville Centre	Rockville Centre	3.5	IC	0.00%		66	FO2	0.0	Back-up Generator	N/A	N/A
Freeport 1-2	Village of Freeport	Freeport	2.9	IC	0.00%		71	FO2	0.0	Back-up Generator	Compliant	N/A
Freeport 1-3	Village of Freeport	Freeport	3.1	IC	0.00%		66	FO2	0.0	Back-up Generator	Compliant	N/A
Freeport 1-4	Village of Freeport	Freeport	5.1	IC	0.00%		56	FO2	0.0	Back-up Generator	Compliant	N/A

Freeport 2-3	Village of Freeport	Freeport	18.1	GT	0.13%	47	KER	0.2	Back-up Generator	Compliant	N/A
Greenport IC4	Village of Greenport	Greenport	1.2	IC	0.00%	63	FO2	0.0	Back-up Generator	N/A	N/A
Greenport IC5	Village of Greenport	Greenport	1.8	IC	0.00%	55	FO2	0.0	Back-up Generator	N/A	N/A
Greenport IC6	Village of Greenport	Greenport	3.8	IC	0.00%	49	FO2	0.0	Back-up Generator	N/A	N/A

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