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Hon. Costa Constantinides, Chair

**February 11, 2019**

# OVERSIGHT - THE ASTORIA TRANSFORMER EXPLOSION AND THE TRANSITION TO A GREEN GRID

**INT. NO. 1318:** By Council Members Constantinides, Cabrera, Rosenthal, Cohen, Rodriguez and Menchaca

**TITLE:** A Local Law to amend the administrative code of the city of New York, in relation to replacement of gas-fired power plants

**ADMINISTRATIVE CODE:** Adds a new subdivision e to Section 24-803

## I. Introduction

On February 11, 2019, the Committee on Environmental Protection, chaired by Council Member Costa Constantinides, will hold an oversight hearing on "The Astoria Transformer Explosion and the Transition to a Green Grid." The Committee will also hold a first hearing for Int. No. 1318, sponsored by Council Member Constantinides, which would require the city to prepare and submit a report on the feasibility of replacing existing in-city gas fired power plants with renewables that use battery storage. The Committee expects to hear testimony from Con Edison, the New York City Department of Environmental Protection, energy experts, public health and environmental advocates, and interested members of the public.

## II. Background

On December 27, 2018, an equipment malfunction at the Con Ed substation in Astoria caused a sustained arc flash discharge that momentarily lit the sky a brilliant blue.[1] Dubbed the "Astoria Borealis," this accident caused a temporary loss of power at Riker's Island, LaGuardia Airport, on the 7 train line,[2] and in residential neighborhoods in Northern Queens. Although power was mostly restored within a 30 minute time frame,[3] questions have been raised about whether grid scale battery storage facilities would have been able to mitigate these outages.

The cost of producing energy from wind and solar technologies is now competitive with fossil fuel based methods, however, the intermittent nature of power generation from these sources

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[1] Matt Stevens, Rick Rojas and Jacey Fortin, "NY Sky Turns Bright Blue After Transformer Explosion" NEW YORK TIMES (December 27, 2018), https://www.nytimes.com/2018/12/27/nyregion/blue-sky-queens-explosion.html?module=inline

[2] Id.

[3] Id.

remains an obstacle to wide scale implementation.[4] Because the grid requires a consistent supply of energy that can be scaled along with demand, grid scale battery storage is an integral component of ensuring an uninterrupted supply of electricity during periods where wind and solar plants are not producing at peak efficiency.[5]

Prior to the 1990's, there is no record of any United States experimentation with grid scale battery energy storage.[6] The period from the 1990s to the late 2000s had limited experimentation due to significant financial and technological hurdles, but a combination of technological advances and increased public funding resulted in a marked increase in rollout and implementation during the period from 2009 to 2014.[7] Currently, lithium ion battery technology is the most widely implemented for grid scale use, however relatively high installation cost and short battery life has limited much of its utility to peaker plant type operations. [8]

Designed to run strictly during periods of high demand, peaker plants are often gas powered due to a gas facility's ability to be quickly deployed and run continuously as long as supplied with fuel.[9] Unfortunately, this flexibility comes at significant cost, as gas peaker plants have been shown to emit 30% more carbon dioxide per megawatt hour than natural gas combined-cycle plants.[10]

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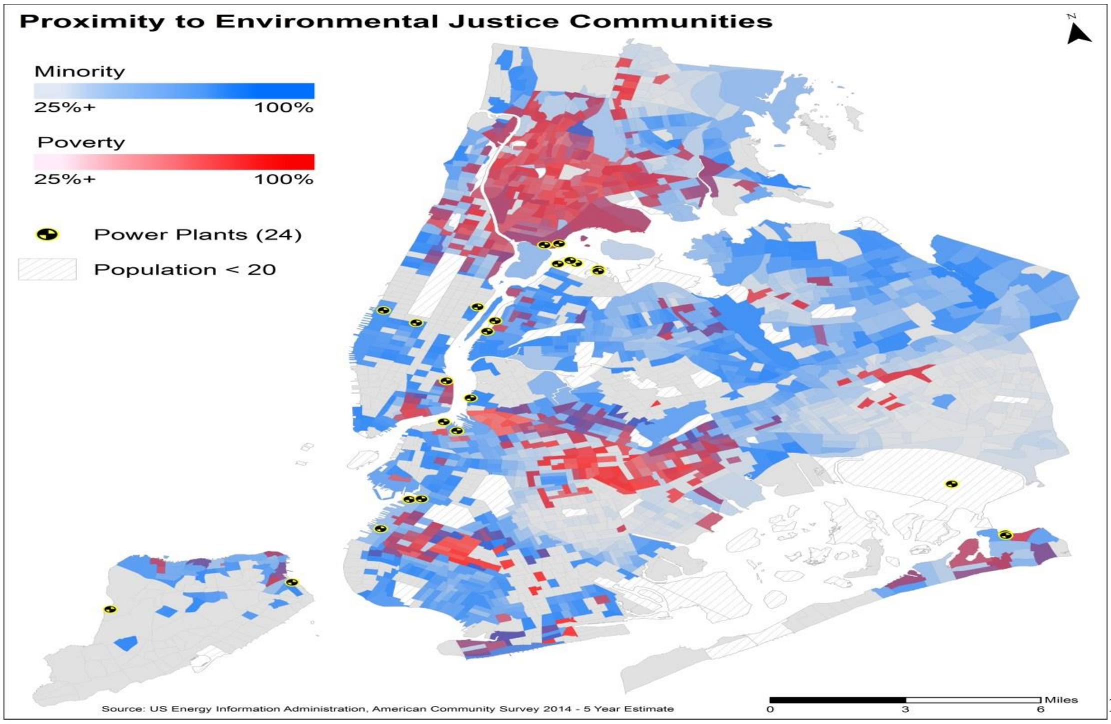
[4] Earl J. Ritchie, "The Cost of Wind and Solar Intermittency" FORBES (January 24, 2017), https://www.forbes.com/sites/uhenergy/2017/01/24/the-cost-of-wind-and-solar-intermittency/#73f516b068de
[5] Id.
[6] David Hart and Alfred Sarkissian "Deployment of Grid Scale Batteries in the United States" GEORGE MASON UNIVERSITY (June 2016), https://www.energy.gov/sites/prod/files/2017/01/f34/Deployment%20of%20Grid-Scale%20Batteries%20in%20the%20United%20States.pdf
[7] Id.
[8] James Temple, "The $2.5 trillion reason we can't rely on batteries to clean up the grid" MIT TECHNOLOGY REVIEW (July 27, 2018), https://www.technologyreview.com/s/611683/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/
[9] Charles Newbery, "Energy Storage Poses A Growing Threat to Peaker Plants" GENERAL ELECTRIC (October 1, 2018), https://www.ge.com/power/transform/article.transform.articles.2018.oct.storage-threat-to-peaker-plants
[10] Physicians, Scientists, and Engineers for Healthy Energy "Natural Gas Power Plants in California's Disadvantaged Communities" (April 2017), https://www.psehealthyenergy.org/wp-content/uploads/2017/04/CA.EJ_.Gas_.Plants.pdf

Moreover, statistical analysis in California[11] and New York[12] show that these plants may be disproportionately sited in economically vulnerable communities (see Map 1).

Map 1: Proximity of Environmental Justice Communities to in-City Power Plants



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Pursuant to a reliability requirement imposed by the New York Independent System Operator, local power plants are capable of meeting roughly 86% of the city's power demands.[14] However, these plants generally only provide approximately 50% of the electricity that is

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[11] Id.
[12] Based on data illustrated in Map 1
[13] This map shows the location of in-City power plants, and their proximity to environmental justice communities, which are defined by the percentage of each community that identifies as belonging to minority groups, and the percentage of each community that is at the federal poverty guidelines. Source of Data: US Energy Information Administration and the American Community Survey (2014).
[14] PlanNYC "New York City's Pathways to Deep Carbon Reductions," at 54 https://s-media.nyc.gov/agencies/planyc2030/pdf/nyc_pathways.pdf (December 2013)

consumed in the city annually, with the other 50% of the city's electricity needs being met with cheaper energy imported from Upstate New York and New Jersey.[15] Of the 24 power plants located within the bounds of New York City, the bulk are powered by natural gas.

Below is a list of 24 in-City power plants[16], including information about their location, and capacity (in Megawatts).

| Power Plant name | Owners | Address | County | Zip | Primary Fuel Used | Capacity (Megawatts) |
|---|---|---|---|---|---|---|
| Ravenswood | TC Ravenswood LLC | 38-54 Vernon Blvd, Long Island City | Queens | 11101 | natural gas | 2246 |
| Astoria Generating Station | U S Power Generating Company LLC | 18-01 20th Avenue, Astoria | Queens | 11105 | natural gas | 1320 |
| Arthur Kill Generating Station | NRG Arthur Kill Operations Inc | 4401 Victory Blvd, Staten Island | Richmond | 10314 | natural gas | 858 |
| East River | Consolidated Edison Co-NY Inc | 801 East 14th Street, Manhattan | New York | 10009 | natural gas | 629 |
| Gowanus Gas Turbines Generating | U S Power Generating Company LLC | 420 2nd Avenue, Brooklyn | Kings | 11232 | natural gas | 549 |
| Astoria Energy | Astoria Energy LLC | 17-10 Steinway Street, Astoria | Queens | 11105 | natural gas | 540 |
| Astoria Energy II | Astoria Energy II LLC | 17-10 Steinway Street, Astoria | Queens | 11105 | natural gas | 540 |
| Astoria Gas Turbines | NRG Astoria Gas Turbine Operations I | 31-01 20th Avenue, Astoria | Queens | 11105 | natural gas | 515 |
| 500MW CC | New York Power Authority | 19-51 20th Ave, Astoria | Queens | 11105 | natural gas | 454 |
| Narrows Gas Turbines Generating | U S Power Generating Company LLC | 4 Whale Square, Brooklyn | Kings | 11232 | natural gas | 283 |
| Brooklyn Navy Yard Cogeneration | Brooklyn Navy Yard Cogen PLP | 63 Flushing Ave., Building 41, Brookl | Kings | 11205 | natural gas | 250 |
| JFK Airport Cogen | KIAC Partners | JFK Airport, Building 49, Jamaica | Queens | 11430 | natural gas | 126 |
| Vernon Boulevard | New York Power Authority | 42-30 Vernon Blvd, Long Island City | Queens | 11427 | natural gas | 80 |
| Joseph J Seymour Power Project | New York Power Authority | 23rd &3rd Ave, Brooklyn | Kings | 11232 | natural gas | 80 |
| Hell Gate | New York Power Authority | 910 E 134th St. Locust Ave, Bronx | Bronx | 10454 | natural gas | 80 |
| Harlem River Yard | New York Power Authority | 680-780E 132nd St, Bronx | Bronx | 10454 | natural gas | 80 |
| Jamaica Bay Peaking | Jamaica Bay Peaking Facility, LLC | 14-25 Bay 24th St, Far Rockaway | Queens | 11691 | petroleum | 54 |
| Bayswater Peaking Facility LLC | Bayswater Peaking Facility LLC | 14-25 Bay 24th Street, Far Rockaway | Queens | 11691 | natural gas | 54 |
| Pouch | New York Power Authority | 143 Edgewater Street, Staten Island | Richmond | 10305 | natural gas | 46 |
| North 1st | New York Power Authority | North 1st & Grand 47-79 River, Brool | Kings | 11211 | natural gas | 45 |
| Hudson Avenue | Consolidated Edison Co-NY Inc | 1-11 Hudson Avenue, New York | Kings | 11201 | petroleum | 42 |
| 74th Street | Consolidated Edison Co-NY Inc | 506 E 75th Street, New York | New York | 10021 | petroleum | 38 |
| 59th Street | Consolidated Edison Co-NY Inc | 850 12th Avenue, New York | New York | 10019 | natural gas | 15 |
| Hilton NY Co Gen Plant | UTS Project Company HNY-1 LLC | 1335 Avenue of the Americas, New Y | New York | 10019 | natural gas | 2 |

Source: Data and information from the United States Energy Information Administration, webpage on New York "State Profile and Energy Estimates," available at http://www.eia.gov/state/?sid=NY

Studies have found a significant correlation between rates of hospitalizations for respiratory diseases and individual proximity to a fuel-fired power plant.[17] This pattern persists

[15] New York City Mayor's Office of Sustainability, "New York City's Roadmap to 80 x 50," (September 2016) at 34, https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New%20York%20City's%20Roadmap%20to%2080%20x%2050_Final.pdf

[16] Note: in addition to this, there are distributed generating facilities that also produce power

[17] Xiaopeng Liu, Lawrence Lessner, and David O. Carpenter, "Association between Residential Proximity to Fuel-Fired Power Plants and Hospitalization Rate for Respiratory Diseases" NIHS, available at Environ Health Perspect 120:807–810 (June 2012) http://dx.doi.org/10.1289/ehp.1104146

even after adjusting for age, sex, race/ethnicity, and urban/rural residence.[18] Taken in concert with the potential likelihood that a gas fired power plant in New York City may be sited in an economically disadvantaged community or a majority minority community,[19] the evaluation of transitioning towards a system based on renewable energy and grid scale battery storage should also be considered for its environmental justice impacts.

## III. Potential Battery Technologies For Grid Scale Energy Storage

- **Lithium Ion Batteries** – Between 2010 and 2015, lithium ion batteries accounted for 95% of the grid scale battery market.[20] They are comparatively energy dense, and costs have come down significantly due to aggressive research and development in related sectors such electric car production.[21] They are attractive to consumers because the batteries can be purchased as off the shelf units, which can then be scaled together in temperature regulated storage tanks and easily coupled with controlling units.[22] Unfortunately, they are currently only capable of providing four hours of energy storage, and have a limited cycle life, meaning that their performance degrades with repeated charging and discharging of electricity.[23] There are also concerns regarding the sustainability of the mining practices surrounding necessary

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[18] Id.
[19] Based on data illustrated in Map 1
[20] David Hart and Alfred Sarkissian, "Deployment of Grid Scale Batteries in the United States" George Mason University (June 2016), https://www.energy.gov/sites/prod/files/2017/01/f34/Deployment%20of%20Grid-Scale%20Batteries%20in%20the%20United%20States.pdf
[21] Id.
[22] Peter Drown, "Implications of a Lithium Ion Storage Transformation" Power Engineering (November 15, 2017), https://www.power-eng.com/articles/print/volume-121/issue-11/features/implications-of-a-lithium-ion-storage-transformation.html
[23] Jingyuan Zhao et al, "Cycle Life Testing of Lithium Batteries: The Effect of Load Leveling" International Journal of Electrochemical Science (December 28, 2017), http://www.electrochemsci.org/papers/vol13/130201773.pdf

components, limited infrastructure and technology in place for the recycling of spent batteries, and the high cost, estimated at $270-$600 per megawatt hour of storage.[24]

- **Liquid Air Energy Storage Batteries** – Liquid air energy storage batteries use the phase change between liquid and gas of super cooled liquid nitrogen to power turbines and generate electricity on demand.[25] The technology is extremely scalable, capable of over 100 megawatts of storage, and well suited to long term storage applications.[26] The systems can be built with readily available mature technologies that would be familiar to most power generation professionals, simply configured in a novel way.[27] The levelized cost of this method is roughly $250 per megawatt hour of storage.[28] The pertinent disadvantages of this system relate to the necessity to cold store the liquid air at low pressure, and the fact that while the systems can be built with readily available mature technologies, the novel configuration results in higher costs in the interim period, as this technology has yet to be widely implemented.[29]
- **Sodium Sulfur Batteries** – Sodium sulfur batteries are attractive for grid scale use because they are a relatively mature technology that results in energy dense and stable batteries that can be made from abundant and low cost source materials.[30] A standard sodium sulfur battery makes use of a molten sulfur positive electrode, and a molten sodium negative electrode,

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[24] Id. at 20
[25] Energy Storage Association " Liquid Air Energy Storage (LAES)" http://energystorage.org/energy-storage/technologies/liquid-air-energy-storage-laes (Last accessed on 2/8/19)
[26] Id.
[27] Id.
[28] Robert Morgan et al, "An Analysis of a Large Scale Liquid Air Energy Storage System" INSTITUTION OF CIVIL ENGINEERS PUBLISHING (March 2, 2015), http://eprints.brighton.ac.uk/14982/1/ener1400038.pdf
[29] Id.
[30] Zhaoyin Wen et al "Research on Sodium Sulfur Battery for Energy Storage" Solid State Ionics (September 2008) https://www.researchgate.net/publication/257005361_Research_on_sodium_sulfur_battery_for_energy_storage

separated by a layer of solid ceramic that functions as the electrolyte.[31] This configuration is capable of high energy storage efficiency in the 90% range, can provide 6 hours of charge, and is already widely used for grid scale storage at over 190 sites in Japan.[32] Unfortunately, because proper functioning requires both the sodium and sulfur to be molten, the batteries must be heated to 300 to 350 degrees Celsius in order to work.[33]

- **Flow Based Batteries** – Also known as redox flow batteries, flow batteries are comprised of two chemical components dissolved in liquids, held in separate tanks, and pumped past a membrane that allows for ion exchange and the flow of an electric current.[34] Batteries utilizing this technology are capable of storing electrical charges long term, and are also capable of potentially unlimited charge discharge cycling. [35] These batteries have been in use since the 1940's and are already widely implemented for the purposes of grid scale storage.[36] The most pertinent drawback of this technology is the correlation between total battery capacity and the volume of electrolyte in the storage tank, meaning an increase in storage capacity requires a correlating increase in the size of the storage tank.[37]
- **Lead-Acid Batteries** – Lead acid batteries are a very well established technology, widely used in many applications, including automotive and industrial applications.[38] They are generally

[31] Energy Storage Association "Sodium Sulfur NAS Batteries" http://energystorage.org/energy-storage/technologies/sodium-sulfur-nas-batteries (Last accessed on 2/8/19)
[32] Id.
[33] Id.
[34] Sukhvinder P.S. Badwal et al. "Emerging Electrochemical Energy Conversion and Storage Technologies" Frontiers in Chemistry (September 24, 2014) https://www.frontiersin.org/articles/10.3389/fchem.2014.00079/full
[35] Zhaoxiang Qi and Gary M. Koenig Jr. "Flow Battery Systems With Solid Electroactive Materials" Journal of Vacuum Science and Technology (May 12, 2017) https://avs.scitation.org/doi/10.1116/1.4983210
[36] Id.
[37] Id.
[38] Geoffrey J. May, Alistair Davidson, and Boris Monahov, "Lead Batteries for Utility Energy Storage: A Review" Journal of Energy Storage (February 2018) https://www.sciencedirect.com/science/article/pii/S2352152X17304437

comprised of positive and negative plates separated by a poorly conductive material, and stacked within the body of the battery.[39] They are comparable to lithium ion batteries in terms of lifespan, though they are capable of fewer charge discharge cycles, and are slightly less energy efficient, with an efficiency percentage of 85%, compared to 90% for lithium ion batteries.[40] The cost of installation however, is significantly lower at four to six hundred dollars per kilowatt hour, as opposed to $1250 to $1500 for lithium ion batteries.[41] While they are susceptible to dry-out, leakage, vent failure, and mechanical damage, and overheating, which can all significantly affect performance, they are a fully mature technology with a well-established, highly efficient recycling protocol approaching a 99% recycling rate.[42]

- **Zinc Batteries** – Zinc batteries are another mature technology that has enjoyed wide commercial use in their non-rechargeable form.[43] While traditionally beset with significant complications limiting their potential for recharging,[44] recent technological advances have resulted in rechargeable batteries that are already being implemented for micro-grid use across Africa.[45] Zinc air batteries are less prone to overheating than lithium ion batteries, and do not generally require external cooling.[46] They also do not trigger the same ethical concerns regarding mining practices of rare elements, and do not require as many polluting components

[39] Id.
[40] Id.
[41] Id.
[42] Id.
[43] Kevin Clemens "The Challenges of Zinc Air Batteries" Design News (May 3, 2018) https://www.designnews.com/electronics-test/challenges-zinc-air-batteries/8902498758539
[44] Id.
[45] Nadia Krieger "NantEnergy's Zinc-Air battery Crosses the $100/kWh Barrier" Engineering.com (October 8, 2018) https://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/17776/NantEnergys-Zinc-Air-Battery-Crosses-the-100kWh-Barrier.aspx
[46] Id.

in their construction.[47] At this time however, only one company has claimed to achieve rechargeable zinc battery technology, and it remains to be seen whether their claims hold true.[48] Beyond that, even in the event that they have achieved easily rechargeable zinc air batteries, the relatively young age of the technology means there is scant information pertaining to the longevity and durability of the technology.[49]

## IV. NEW YORK STATE ENERGY STORAGE GOALS

The Public Service Commission ("PSC") is mandated by New York State Public Service Law (PLS) §74 to establish a statewide energy storage goal for 2030, and a deployment policy to support that goal.[50] In the 2018 State of the State address, New York Governor Andrew Cuomo announced a target to deploy 1,500 MW of energy storage by 2025, to help achieve the Clean Energy Standard goal of getting 50% of New York's electricity from renewable sources by 2030.[51] This commitment will provide roughly $2 billion in benefits to New Yorkers and avoid more than one million metric tons of CO2 emissions.[52]

In June 2018, the New York State Department of Public Services along with New York State Energy Research and Development Authority ("NYSERDA") filed a roadmap to provide the PSC with a range of recommendations to meet the goals established in PLS §74.[53] On December

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47 Id.
48 Id.
49 Id.
50 PLS §74 was enacted on November 29, 2017 by Chapter 415 of the Laws of 2017, was subsequently amended on November 5, 2018 and December 11, 2018, and was enacted on December 21, 2018 by Chapter 417 of the Laws of 2018.
51 New York State Energy Research and Development Authority, "New York State Energy Storage" https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Storage *(last accessed on February 7, 2019)*
52 Id.
53 See New York State Energy Research and Development Authority, Energy Storage in New York, https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Storage

13, 2018, the PSC, NYSERDA and the Long Island Power Authority ("LIPA") issued the resulting *Order Establishing Energy Storage Goal and Deployment Policy* ("the Order"),[54] a comprehensive strategy to enable deployment of 1,500 MW of energy storage by 2025 and expanding to 3,000 MWs by 2030.[55] The Order also adopts a package of energy storage deployment policies, and authorizes bridge incentive funds to be deployed by NYSERDA, bringing total authorized funds to $350 million outside Long Island, and requires NYSERDA to work with LIPA to develop equivalent set of incentives on Long Island.[56]

## V. LEGISLATION

Int. No. 1318 would mandate a report by the Mayor's Office of Sustainability or such other office as the mayor may designate on the feasibility of the utilization of renewables with battery storage to replace in-city gas fired power plants. Such report shall include time frames indicating when such replacement can take place, should replacement of existing in city power plants with renewables battery storage be found to be feasible. The report shall also provide a review of the battery storage potential of lithium ion batteries; liquid air energy storage batteries; sodium sulfur batteries; flow based batteries; lead-acid batteries; and zinc batteries. It would take effect immediately.

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[54] State of New York Public Service Commission, "Case 18-E-0130 - In the Matter of Energy Storage Deployment Program" (December 13, 2018), http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BFDE2C318-277F-4701-B7D6-C70FCE0C6266%7D
[55] Id.
[56] Id.

Int. No. 1318

By Council Members Constantinides, Cabrera, Rosenthal, Cohen, Rodriguez and Menchaca

A Local Law to amend the administrative code of the city of New York, in relation to replacement of gas-fired power plants.

Be it enacted by the Council as follows:

Section 1. Section 803 of title 24 of the administrative code, as amended by local law number 22 for the year 2008, is amended by adding a new subdivision e to read as follows:

e. Report on the feasibility of utilization of renewables with battery storage to replace in-city gas fired power plants. By December 30, 2019, an office or agency designated by the mayor or the mayor's office of sustainability shall prepare and submit a report to the mayor, the speaker of the council and the New York state public service commission on the feasibility of replacing existing in-city gas-fired power plants with renewables that use battery storage in a manner that is consistent with the public service commission energy storage deployment policy developed pursuant to public service law section 74. Such report shall include:

1. Expedited time frames indicating when such replacement can take place if the replacement of existing in city power plants with renewables battery storage is found feasible;

2. A review of the battery storage potential of lithium ion batteries;

3. The battery storage potential of liquid air energy storage batteries;

4. The battery storage potential sodium sulfur batteries;

5. The battery storage potential of flow based batteries;

6. The battery storage potential of lead-acid batteries; and

7. The battery storage potential of zinc batteries.

§ 2. This local law takes effect immediately.

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