Assessment of Backup Diesel Generators in New York City

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Applied Economics Clinic

Prepared on behalf of
Bloom Energy

Authors:
Joshua R. Castigliego
Tanya Stasio
Sagal Alisalad
Elizabeth A. Stanton, PhD

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Economic and Policy Analysis of Energy, Environment and Equity

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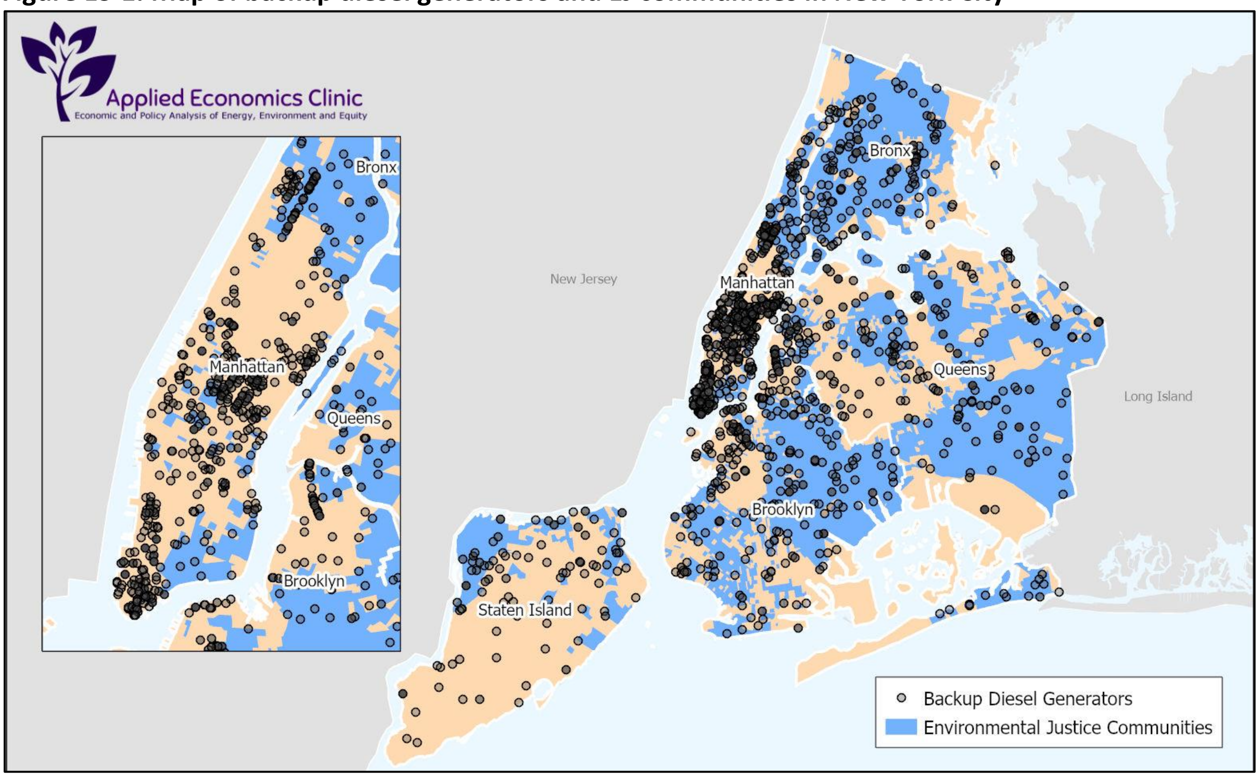
Executive Summary

Largely excluded from emissions inventories and often unreported to state and local authorities, New York City's vast and poorly documented fleet of backup diesel generators makes our air dirty, contributes to climate change, and is disproportionately sited in our most vulnerable communities. Diesel generators, or diesel generating sets, consist of a diesel engine and an electric generator that produce electricity. Emergency, or backup, diesel generators are used to supply electricity when power from the grid is unavailable during a power outage or other service disruption. Reliable backup power is important to electric customers—especially hospitals, fire stations, and other essential buildings/services—and will become more important as climate change increases the frequency of severe weather events that lead to power outages.

While reliable, uninterrupted power is increasingly indispensable for businesses and residents, backup diesel generators are currently one of the dirtiest remaining electricity generating technologies in New York City. Alternative technologies exist, such as clean distributed energy resources that provide the same essential service, without the high costs associated with releasing harmful pollutants into the air.

Figure ES-1. Map of backup diesel generators and EJ communities in New York City



Data sources: Environmental Justice Communities: U.S. Census. 2019. ACS 5-Year Estimated Detailed Tables [Tables: B02001, B17021]. Backup Diesel Generators: NYC Department of Environmental Protection. Accessed on April 11, 2021. NYC Open Data. Available at: https://data.cityofnewyork.us/Environment/CATS-Permits/f4rp-2kvy

This Applied Economics Clinic (AEC) report—prepared on behalf of Bloom Energy—compiles an inventory of emergency diesel generators based on publicly available data from the New York City Department of Environmental Protection (NYC DEP), and assesses the number, capacity, proximity to environmental justice (EJ) communities, and emissions impact of backup diesel generators in the City.

More than 2,600 of New York City's backup diesel generators are registered with NYC DEP, amounting to a combined capacity of roughly 2,900 megawatts (MW); for comparison, this is roughly one and a half times the size of the 2,050 MW oil- and gas-fired Ravenswood Generating Station located in Queens. While backup diesel generators are widespread across the City, many are located within or close to EJ communities (see Figure ES-1 above).

More than three-fifths of New York City residents live in EJ communities. These communities (home to many of New York City's minority and low-income households) are disproportionately burdened by higher concentrations of air pollutants due to their proximity to industrial facilities, highways, airports, and other polluting sources. This report finds that almost 40 percent of New York City's backup diesel generators (nearly 870 generators) are located within an EJ community, while nine out of ten backup diesel generators are located within a 0.5-mile radius of EJ communities.

Using conservative assumptions, we estimate that the New York City backup diesel generators that we have been able to identify emit between 104,300 and 127,500 metric tons of CO_2e per year and represent a considerable source of local air pollutants. These emissions result in at least 162 additional workdays lost, 48 additional upper and lower respiratory cases, and a total increase of $9.6 to $21.5 million in healthcare costs for New York City. Requirements outlined in New York City's building code suggest that there could be around 10,000 backup diesel generators with a combined capacity of 11,000 MW deployed across the City, which would result in the amount of emissions and associated impacts to be nearly four times higher. Furthermore, due to their disproportionate siting in EJ communities, these emissions cause the most harm to New York City's most vulnerable residents.

In New York City and across the country, data on the prevalence, operation and impacts of small-scale and other backup generators is difficult to come by. For this analysis, AEC accessed a partial set of data on backup diesel generators in New York City through NYC Open Data. Better and more accessible data on emitting generators of all sizes would improve the accuracy of emissions measurement and the targeting of social health investments.

In order to lessen the burden on EJ communities in particular and account for the harmful but overlooked emissions from backup diesel generators across the City, recommended state and local policy interventions include:

- **Overcome the false assumption that diesel generators are indispensable.** New zero- and low-emissions alternatives together with public policy can ensure the same level of reliability—or greater—without continuing to rely on one of the dirtiest remaining electricity generating technologies in New York City. The current regulatory landscape appears to perpetuate widespread, and often unknown, deployment of diesel backup generators. Alternatives exist that address reliability concerns without worsening the air quality crisis and its inherent inequities.
- **Improve data availability and access.** Data on backup diesel generators is limited and difficult to access. This has allowed a substantial source of emissions to go relatively unscrutinized even as climate and EJ initiatives have taken center stage.

- **Strengthen reporting standards.** Emissions from small stationary sources, such as backup diesel generators, need to be included in local air pollution permitting and greenhouse gas inventories. Annual reporting requirements should include: hours for readiness testing and operation, air pollutant and greenhouse gas emissions, energy output, and fuel consumption.
- **Stricter standards for locally polluting energy sources in EJ communities.** With EJ communities already facing disproportionate exposure to local air pollution, more oversight and stricter standards on the siting and operation of backup diesel generators (and other locally polluting energy sources) is essential to protect the health of the most vulnerable. Stricter standards would also highlight the availability of alternative zero- or low-emissions options.

This report demonstrates that there is an abundance of backup diesel generators throughout New York City that are commonly sited near EJ communities and represent a considerable—and largely avoidable—source of air pollution and greenhouse gas emissions that threatens public health and the environment.

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I. Introduction

Diesel generators (also referred to as diesel generating sets) consist of a diesel engine and an electric generator, which are used to produce electricity under either emergency or non-emergency conditions. Emergency diesel generators (also referred to as backup diesel generators) are used as a backup source of electricity when power from the grid is unavailable to customers during a power outage or other service disruption. Non-emergency diesel generators are used to support the grid during times of peak demand and may also be deployed in areas where grid connection is unavailable.

Reliable backup power is important to electric customers—especially hospitals, fire stations, and other essential buildings/services—and will become more important as climate change increases the frequency of severe weather events that lead to power outages.[1] Moreover, the COVID-19 pandemic has redefined essential services to include buildings previously overlooked, such as grocery stores. Between periodic maintenance testing and operation in emergency conditions, New York City's backup diesel generators are assumed for this study to run for 51 hours per year (see the Methodology Appendix below).[2] When running, backup generators release local air pollutants and greenhouse gas emissions into the atmosphere. These public health hazards are of particular concern to Environmental Justice (EJ) communities, which already face disproportionate exposure to local air pollution and the impacts of climate change.[3] EJ communities include minority and low-income populations that face a disproportionate burden from environmental hazards.

Due to their infrequent operation for power generation, backup diesel generators are often overlooked in reporting and registration requirements, and are commonly omitted from energy and emissions inventories gathered by local, state and federal agencies (e.g., U.S. EIA, U.S. EPA, and state energy and environmental agencies). Ignoring these emissions leaves local residents, and EJ communities in particular, vulnerable to the negative health impacts of air pollution, undercounts emissions responsibility, and overestimates progress towards climate goals.

In this report, the Applied Economics Clinic (AEC) reviewed publicly available data from the New York City Department of Environmental Protection (NYC DEP) to assess the quantity, location, combined capacity, and emissions impact of backup diesel generators in the City. Section II presents an inventory of backup diesel generators in New York City. Section III examines the proximity of these generators to EJ communities. Section IV estimates the quantity (in metric tons) of local air pollutant and greenhouse gas emissions from the backup diesel generators captured in the inventory. Section V offers policy recommendations based on

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[1] Davis, M. and S. Clemmer. April 2014. "Power Failure: How Climate Change Puts Our Electricity at Risk—and What We Do." *Union of Concerned Scientists.* Available at: https://www.ucsusa.org/sites/default/files/2019-10/Power-Failure-How-Climate-Change-Puts-Our-Electricity-at-Risk-and-What-We-Can-Do.pdf

[2] Testing frequency and duration for backup generators varies depending on local, state, or federal mandates. As a general rule, backup generators should be exercised at least once monthly with a load for a minimum of thirty minutes. Source: National Fire Protection Association. 2019 edition. *NFPA 110: Standard for Emergency and Standby Power Systems – Chapter 8: Routine Maintenance and Operational Testing.* Available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=110

[3] Mikati, I., Benson, A.F., Luben, T. J. Sacks, J.D, and Richmond-Bryant, J. 2018. "Disparities in Distribution of Particulate Matter Emission Sources by Race and Poverty Status." *American Journal of Public Health*, 108, 480-485. *https://doi.org/10.2105/AJPH.2017.304297*

this analysis. The Appendix presents AEC's methodology for this analysis, including data sources, assumptions, and calculations.

II. Inventory of backup diesel generators in New York City

More than 2,600 of New York City's backup diesel generators have been confirmed by AEC as registered with NYC DEP (see Table 1 below). AEC assembled this inventory of backup diesel generators using data from NYC DEP's Clean Air Tracking System (CATS).[4]

NYC DEP's CATS database requires owners to register emergency and portable generators with a capacity of 40 kW or greater. As part of the filing requirements, owners must provide the following information on their generator: equipment make/model, serial number, fuel type, maximum heat input (million Btu/hr), output (HP), capacity (kW), EPA Tier, and emission control technology. However, only a subset of the information gathered by NYC DEP's CATS is publicly available; the remainder of the data can only be acquired by filing a Freedom of Information Law (FOIL) request with NYC DEP.[5] This analysis is based only on the CATS publicly available data.

Since the publicly available CATS database on NYC Open Data does not list generator sizes, AEC assumed an average generator capacity of 1,102 kW for the purposes of estimating air pollutant and greenhouse gas emissions.[6] Based on this assumption, the estimated combined capacity of New York City's emergency diesel generators amounts to roughly 2,900 MW; for comparison, this is roughly one and a half times the size of the 2,050 MW oil- and gas-fired Ravenswood Generating Station located in Queens (see Table 1 below). Of the confirmed backup generators in the CATS database approximately 385 listings do not include a specific address—these are shown as "Various Locations" in Table 1 below. (For a detailed discussion of the data used in this analysis, refer to the Methodology Appendix below.)

The exact scale of unreported generators across the New York City is unknown. New York City's building code[7] requires high-rise buildings (over 75 feet) to be equipped with an emergency power source, which accounts for nearly 11,500 buildings.[8] In New York City, only residential buildings with multiple units—those classified as "R-2"—are permitted to utilize gas as the sole fuel supply for emergency power systems, leaving approximately 87 percent of the City's building stock to utilize another fuel (e.g., diesel).[9] Combining these two data points leads to a rough estimate of 10,000 backup generators with a combined capacity of

[4] NYC Department of Environmental Protection. *Clean Air Tracking System*. Available at: https://www1.nyc.gov/site/dep/environment/clean-air-tracking-system.page

[5] NYC DEP acknowledged AEC's FOIL request on April 6, 2021 and stated that a response should be expected by September 30, 2021.

[6] The New York State (NYS) Department of Environmental Conservation (DEC) estimated the average nameplate capacity for emergency generators in the City to be 1,102 kW based on 226 sources in New York City. Source: NYS DEC. October 2020. *State Implementation Plan (SIP) revision to incorporate revisions to Title 6 of the New York Codes, Rules, and Regulations (NYCRR) Part 222 and Part 200*. Available at: https://www.dec.ny.gov/docs/air_pdf/siprev222.pdf

[7] NYC Building Code. 2014. *Section 2702.2.14 High-Rise Buildings*. Available at: https://up.codes/viewer/new_york_city/nyc-building-code-2014/chapter/27/electrical#27

[8] Emporis. n.d. "Buildings in New York City (existing)." Available at: https://www.emporis.com/city/101028/new-york-city-ny-usa/status/existing/574

[9] NYC Building Code. 2014. *Section 2702.1.1 Fuel Supply*. Available at: https://up.codes/viewer/new_york_city/nyc-building-code-2014/chapter/27/electrical#27

11,000 MW that are most likely run using diesel fuel, which is nearly four times greater than the generators confirmed in the publicly available CATS database. Therefore, this report provides only a partial picture of the scale of diesel generator deployments and emissions across the City, highlighting the lack of focus on this widespread and dirty energy source.

Table 1. Inventory of backup diesel generators in New York City

Borough	Number of Generators	Total Capacity (MW)	% of Total Capacity
Bronx	198	218.2	7.5%
Brooklyn	354	390.1	13.4%
Manhattan	1,029	1134.0	38.9%
Queens	536	590.7	20.3%
Staten Island	140	154.3	5.3%
Various Locations	385	424.3	14.6%
TOTAL	**2,642**	**2,911**	**100%**

Data source: NYC Department of Environmental Protection. Accessed on April 11, 2021. NYC Open Data. Available at: https://data.cityofnewyork.us/Environment/CATS-Permits/f4rp-2kvy

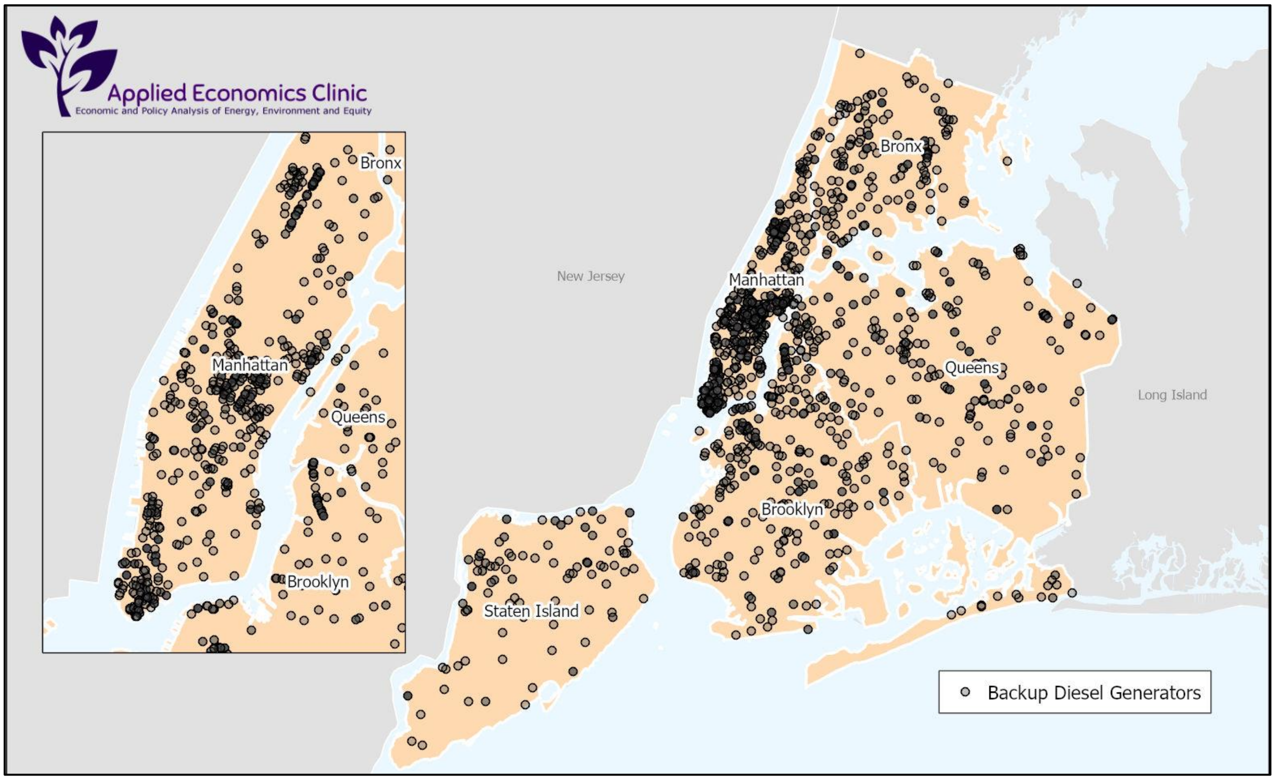
Note: AEC assumed an average generator capacity of 1,102 kW. Source: NYS DEC. October 2020. State Implementation Plan (SIP) revision to incorporate revisions to Title 6 of the New York Codes, Rules, and Regulations (NYCRR) Part 222 and Part 200. Available at: https://www.dec.ny.gov/docs/air_pdf/siprev222.pdf

Almost two-fifths of New York City's backup diesel generators are located in Manhattan, the City's smallest and most densely populated borough housing about one-fifth of the City's population (Figure 1).[10] Another one-third of the generators are located in Brooklyn and Queens, which are home to nearly three-fifths of New York City's residents.[11]

[10] U.S. Census. 2019. ACS 5-Year Estimates [Table: Total Population - B01003]. Available at: https://data.census.gov/cedsci/table?q=population&g=0500000US36005,36047,36061,36081,36085&y=2019&tid=ACSDT5Y2019.B01003&hidePreview=true

[11] Ibid.

Figure 1. Inventory of backup diesel generators in New York City



Data source: NYC Department of Environmental Protection. Accessed on April 11, 2021. NYC Open Data. Available at: https://data.cityofnewyork.us/Environment/CATS-Permits/f4rp-2kvy

III. Proximity of backup diesel generators to EJ communities in New York City

More than three-fifths of New York City's residents live in an EJ community.[12] These communities are home to minority and low-income households that have been disproportionately burdened by poor air quality due to their close proximity to traffic congestion and polluting facilities.[13] To assess the potential burden from backup diesel generators on EJ communities in New York City, AEC conducted a co-locational analysis using GIS software; this analysis includes only the 2,600 backup diesel generators confirmed in the CATS database and not the additional 7,400 units that may also be in operation in the City. AEC calculated the distance of each generator to the nearest EJ community using (1) an inventory of New York City's backup diesel generators from data provided in NYC DEP,[14] and (2) EJ community boundaries as defined by the New York

[12] U.S. Census. 2019. ACS 5-Year Estimated Detailed Tables [Tables: B02001, B17021].

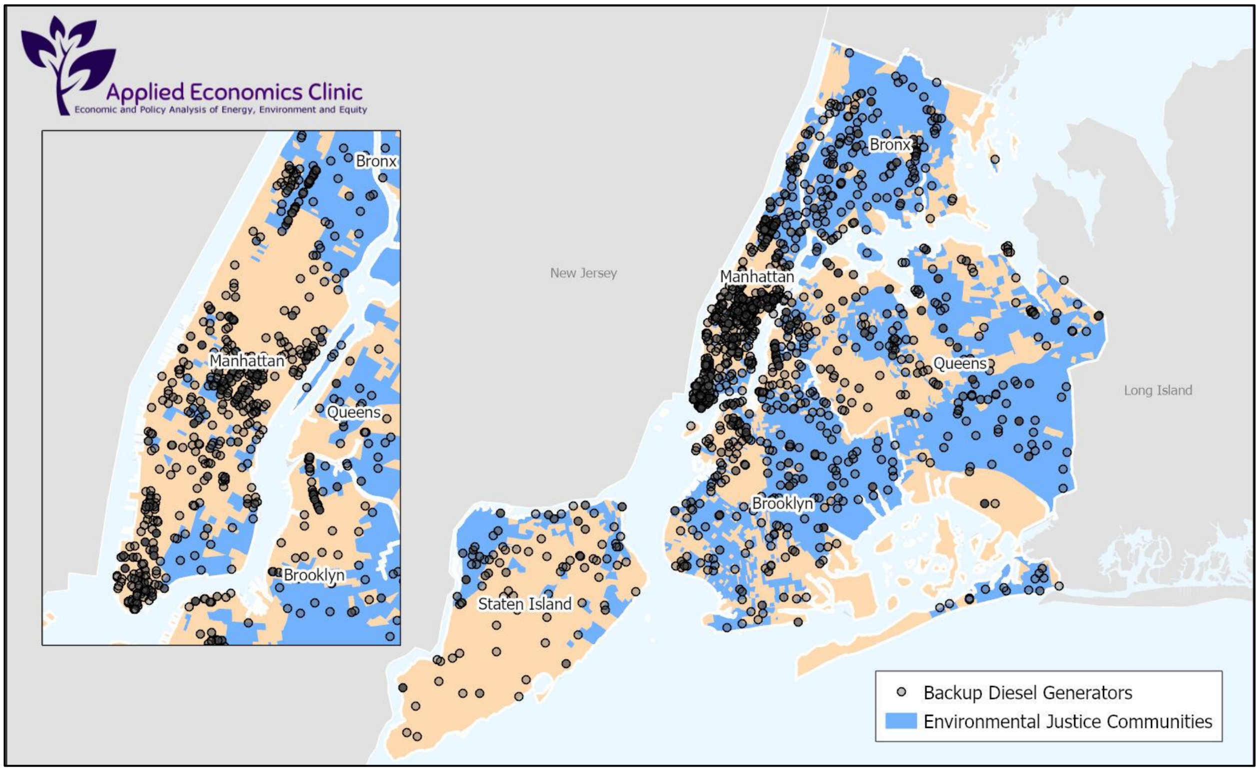
[13] WE ACT. 2017. *Unequal air and care: Federal impact on pediatric asthma disparities in 4 US cities.* Available at: https://www.weact.org/campaigns/asthmadisparities/

[14] NYC Department of Environmental Protection. Accessed on April 11, 2021. NYC Open Data. Available at: https://data.cityofnewyork.us/Environment/CATS-Permits/f4rp-2kvy.

State,[15] updated with 2019 data from the American Community Survey (ACS).[16]

Most backup diesel generators in New York City are located within or near at least one EJ community (see Figure 2). The Bronx, Queens, and Brooklyn are home to most of the City's EJ communities, which account for two-fifths of backup diesel generators in AEC's inventory.

Figure 2. Map of backup diesel generators and EJ communities in New York City



Data sources: Environmental Justice Communities: U.S. Census. 2019. ACS 5-Year Estimated Detailed Tables [Tables: B02001, B17021]. Backup Diesel Generators: NYC Department of Environmental Protection. Accessed on April 11, 2021. NYC Open Data. Available at: https://data.cityofnewyork.us/Environment/CATS-Permits/f4rp-2kvy

Almost 40 percent of the backup diesel generators (nearly 870 generators) in AEC's New York City inventory are located directly within an EJ community, representing a combined capacity of 957 MW (see Table 2). Backup diesel generators within a 0.25-mile radius of an EJ community account for 71 percent of AEC's inventory (nearly 2,000 generators). When the radius is extended to 0.5 mile of an EJ community, backup diesel generators account for 89 percent of AEC's inventory with almost 2,000 generators. (See the Methodology Appendix below for a more detailed discussion of the development of these estimates.)

Dispersion of air pollutants occurs due to meteorological conditions, terrain, and many other complex parameters. The effects of air pollutants on humans are not only felt locally, but are dispersed around the

[15] Any block group that meets any of the following criteria: at least 24 percent of households have an annual mean income below the 2019 federal poverty level; or 51.1 percent or more residents identify as a race other than white. New York State. 2000. "Maps and Geospatial Information System (GIS) Tools for Environmental Justice." Available at: https://www.dec.ny.gov/public/911.html

[16] U.S. Census. 2019. ACS 5-Year Estimated Detailed Tables [Tables: B02001, B17021].

county, state and even country. Although it is impossible to tell how the air pollutants will disperse in a specific area without completing complex modeling, it is known that the negative effects of air pollutants are experienced beyond the immediate perimeter of the emissions source. Increased air pollution leads to an increased number of respiratory symptoms, infant mortality, heart attacks, and work loss days, and these all results in an increase in healthcare costs for residents living near an emissions source.[17] Backup diesel generators are also unable to effectively disperse air pollutants due to their short exhaust stacks, which leads to larger impacts on the residents and workers in the area.[18]

Table 2. Proximity of backup diesel generators to New York City's EJ communities

Proximity to an EJ Community	Number of Generators	Percentage of Generators	Combined Capacity (MW)
Within community	868	39%	957
Less than a 0.5-mile	1,991	89%	2,194
Less than 1-mile	2,141	95%	2,359

IV. Estimates of air pollutant and greenhouse gas emissions

Backup diesel generators—while providing an important service—release local air pollutants and greenhouse gas emissions that go largely unaccounted for in public health and climate data. In 2006, the U.S. Environmental Protection Agency (EPA) adopted the *New Source Performance Standards [NSPS] for Stationary Compression Ignition Internal Combustion Engines* to regulate various pollutants from stationary diesel engines, including: carbon monoxide (CO), particulate matter (PM), nitrogen oxide (NO_x), sulfur dioxide (SO_2).[19] These standards did not develop new emission limits for stationary engines, but instead required stationary engines to meet previously established emission standards for mobile nonroad diesel engines.[20] The emission standards for nonroad compression ignition engines (including stationary diesel generators) are determined by both the generator size and an EPA Tier Rating that is based on the generator's year of manufacture.[21]

EPA's Ratings were established for Tiers 1 through 4, with each Tier phased in over time and having stricter emission limits than the previous Tier. The NSPS rule required stationary engines to use ultra-low sulfur (15

[17] U.S. EPA. (n.d.). "Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)." Available at: https://cobra.app.cloud.gov/

[18] New York State Energy Planning Board. 2015. *New York State Energy Plan*. Volume 2: Impacts & Considerations. Available at: https://energyplan.ny.gov/-/media/nysenergyplan/2014stateenergyplan-documents/2015-nysep-vol2-impacts.pdf

[19] U.S. EPA. November 2019. "Standards of Performance for Stationary Compression Ignition Internal Combustion Engines." 40 CFR Part 60 Subpart IIII. Available at: https://www.govinfo.gov/content/pkg/FR-2019-11-13/pdf/2019-24335.pdf

[20] U.S. EPA. March 2016. Nonroad Compression-Ignition Engines: Exhaust Emission Standards. EPA-420-B-16-022. Office of Transportation and Air Quality. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OA05.pdf

[21] US EPA. March 2016. Nonroad Compression-Ignition Engines: Exhaust Emission Standards. EPA-420-B-16-022. Office of Transportation and Air Quality. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OA05.pdf

ppm) diesel fuel by October 2010. Table 3 shows an example of required emission rate limits for local air pollutants and greenhouse gas emissions—provided in carbon dioxide equivalents (CO_2e)—for a 250 kW, Tier 3 backup diesel generator, on a per megawatt-hour (MWh) basis.[22]

Table 3. Example emission rate limits (kg/MWh) for a 250 kW, Tier 3 backup diesel generator

Power source	Emission Rate Limits (kg/MWh)				
	CO	PM	NO_x	SO_2	CO_2e
Tier 3 Backup Diesel Generator, 250 kW	3.5	0.2	3.8	0.007	786.8

AEC estimated the annual local air pollutant and greenhouse gas emissions from backup diesel generators in New York City. AEC made conservative assumptions for the EPA emission factors used in the emissions calculations, as not all the relevant information to make a correct emission factor determination were available. This results in emission estimates that are mostly likely lower than actual emissions. These emission estimates are provided as a 10 percent sensitivity range above and below an assumed annual operation of 51 hours. (See the Methodology Appendix below for a more detailed discussion of the development of these estimates including data limitations and assumptions.) Our findings based on the 2,600 backup diesel generators confirmed in the CATS database show that just the New York City's backup diesel generators that we included in our partial inventory emit between 104,300 and 127,500 metric tons CO_2e per year and represent a considerable source of local air pollutants (see Table 4). Based on AEC's estimated emissions, the U.S. EPA's Co-Benefits Risk Assessment (COBRA) screening tool calculates the following health impacts in New York City: 162 additional work days lost, 48 additional upper and lower respiratory cases, and a total increase of $9.6 to $21.5 million in healthcare costs.[23]

Table 4. Air pollutant and greenhouse gas emissions for backup diesel generators in New York City

Backup Diesel Generators in NYC	Annual Emissions (metric tons)				
	SO_2	PM	CO	NO_x	CO_2e
Low-end Estimates	1.0	5	470	470	104,300
High-end Estimates	1.2	33	570	790	127,500

With the requirements outlined in New York City's building code for high-rise buildings which increase the possible number of back up diesel generators to 10,000 with a combined capacity of 11,000 MW, the air pollutant and greenhouse gas emissions for backup diesel generators in New York City could be nearly four times as great as the amounts shown in Table 4 above. For CO_2e emissions this would be 394,500 to 482,100 metric tons CO_2e per year.

Backup diesel generators, although a source of vital electric reliability, release substantial emissions each year. Alternative backup power options, such as distributed energy resources, provide the same essential

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[22] The emission factors for CO, PM, and NO_x vary by generator size and EPA Tier rating. However, the emission factors for SO_2 and CO_2e rely solely on the fuel consumption of the generator.

[23] The following inputs were used to generate these results: (1) Location: New York City—including Bronx, Kings, New York, Queens, and Richmond counties; (2) Sector/Subsector: Fuel Combustion: Other, Commercial/Institutional Oil; (3) $PM_{2.5}$ emissions increase by 5 tons; (4) SO_2 emissions increase by 1 ton; (5) NO_x emissions increase by 470 tons. Source: U.S. EPA. (n.d.). "Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA)." Available at: https://cobra.app.cloud.gov/

service, without the high costs associated with releasing harmful pollutants into the air.

V. Conclusions and recommendations

Although the thousands of backup diesel generators in New York City, including those not captured in this report, provide electric customers with reliable power in the event of a power outage or other service disruption, they represent an important and largely uncounted source of local air pollutants and greenhouse gas emissions that pose a threat to public health and contribute to climate change. Backup diesel generators provide an important service in ensuring that power continues to flow to essential buildings during service interruptions, but alternative reliable power sources exist that emit less or no pollution into the atmosphere. The infrequent operation of backup diesel generators during service interruptions—about 1 hour, on average, in New York City—leads to these locally polluting energy sources to be overlooked and omitted from energy and emissions inventories gathered by local and state governments. We find, however, that between operation during outages and for generator testing these pollution sources, which are overwhelmingly located in or very near to the City's most vulnerable communities, are adding unreported emissions of both local pollutants and greenhouse gases.

Our findings show that nine out of ten New York City backup diesel generators are located within a 0.5-mile radius of EJ communities, which are already disproportionately affected by exposure to local air pollution and the impacts of climate change. Without state and local intervention, these locally polluting energy sources will continue to be overlooked—leaving EJ communities vulnerable to the negative health impacts of air pollution, undercounting emissions responsibility, and overestimating progress towards climate goals.

In order to lessen the burden on EJ communities in particular and account for the harmful but overlooked emissions from backup diesel generators across the City, recommended state and local policy interventions include:

- **Overcome the false assumption that diesel generators are indispensable.** New zero- and low-emissions alternatives together with public policy can ensure the same level of reliability—or greater—without continuing to rely on one of the dirtiest remaining electricity generating technologies in New York City. The current regulatory landscape appears to perpetuate widespread, and often unknown, deployment of diesel backup generators. Alternatives exist that address reliability concerns without worsening the air quality crisis and its inherent inequities.

- **Improve data availability and access.** Data on backup diesel generators is limited and difficult to access. This has allowed a substantial source of emissions to go relatively unscrutinized even as climate and EJ initiatives have taken center stage.

- **Strengthen reporting standards.** Emissions from small stationary sources, such as backup diesel generators, need to be included in local air pollution permitting and greenhouse gas inventories. Annual reporting requirements should include: hours for readiness testing and operation, air pollutant and greenhouse gas emissions, energy output, and fuel consumption.

- **Stricter standards for locally polluting energy sources in EJ communities.** With EJ communities already facing disproportionate exposure to local air pollution, more oversight and stricter standards on the siting and operation of backup diesel generators (and other locally polluting energy sources) is essential to protect the health of the most vulnerable. Stricter standards would also highlight the availability of alternative zero- or low-emissions options.

Our research demonstrates that there is an abundance of backup diesel generators throughout New York City that are commonly sited near EJ communities and represent a considerable—and largely avoidable—source of air pollution and greenhouse gas emissions that threaten public health and the environment.

Methodology Appendix

Inventory of backup diesel generators in New York City

To compile an inventory of backup diesel generators in New York City, AEC utilized NYC DEP's CATS database for engines, generators, and turbines through NYC Open Data. This database is limited to generators registered in New York City that are 40 kW or greater.[24] In addition, only a subset of the information gathered by NYC DEP's CATS is publicly available through NYC Open Data; the remainder of the data can only be acquired by filing a Freedom of Information Law (FOIL) request with NYC DEP.[25] The following information can only be obtained through a FOIL request: maximum heat input (million Btu/hr), output (HP), capacity (kW), EPA Tier, and emission control technology. This analysis is based only on the CATS publicly available data.

Of the over 3,700 currently registered generators in the CATS database, 2,642 use distillate fuel oil no. 2 (i.e., diesel fuel), the focus of this study, as the primary fuel.[26]

New York City's building code[27] requires high-rise buildings (over 75 feet) to be equipped with an emergency power source, which accounts for nearly 11,500 buildings.[28] The City's building code also states that only "R-2" occupancies (i.e., residential buildings with more than two units) and standby power systems in New York City are permitted to rely solely on gas as a fuel source.[29] By calculating the share of buildings not classified as "R-2", AEC estimates that roughly 87 percent of New York City's buildings **are not permitted** to utilize gas as the sole fuel supply for emergency power systems.[30] AEC assumes that buildings over 75 feet have the same share of "R-2" buildings as the City's entire building stock. With this information, AEC estimates that there are at least 10,000 backup generators in the City that are most likely run on diesel fuel, which is nearly four times greater than the diesel generators accounted for in the CATS database.

Environmental justice analysis

To identify EJ communities in New York City, AEC utilized the New York State's EJ designation,[31] which is

[24] NYC Department of Environmental Protection. Revised August 2016. "Engines, Generators, Turbines, Determination of NYC DEP Filing Requirements". *The City of New York Department of Environmental Protection.* Available at: https://www1.nyc.gov/assets/dep/downloads/pdf/air/cats/cats-engines-generators-turbines-determination-filing-requirements-nyc.pdf

[25] NYC DEP acknowledged AEC's FOIL request on April 6, 2021 and stated that a response should be expected by September 30, 2021.

[26] NYC Department of Environmental Protection. Accessed on April 11, 2021. NYC Open Data. Available at: https://data.cityofnewyork.us/Environment/CATS-Permits/f4rp-2kvy.

[27] NYC Building Code. 2014. *Section 2702.2.14 High-Rise Buildings*. Available at: https://up.codes/viewer/new_york_city/nyc-building-code-2014/chapter/27/electrical#27

[28] Emporis. n.d. "Buildings in New York City (existing)." Available at: https://www.emporis.com/city/101028/new-york-city-ny-usa/status/existing/574

[29] NYC Building Code. 2014. *Section 2702.1.1 Fuel Supply*. Available at: https://up.codes/viewer/new_york_city/nyc-building-code-2014/chapter/27/electrical#27

[30] NYC OpenData. 2014. "Historical DOB Permit Issuance." Available at: https://data.cityofnewyork.us/Housing-Development/Historical-DOB-Permit-Issuance/bty7-2jhb/data.

[31] New York State. 2000. "Maps and Geospatial Information System (GIS) Tools for Environmental Justice." Available at: https://www.dec.ny.gov/public/911.html

assigned to U.S. Census block groups that meet at least one of the following criteria:

- At least 24 percent of households have an annual mean income below the 2019 federal poverty level;[32] or
- 51.1 percent or more residents identify as a race other than white.

New York State's GIS layer for EJ communities was constructed according to the criteria above using data from the 2000 U.S. Census. AEC created an updated version of this EJ layer by using data on race and income from the U.S. Census' 2019 ACS 5-year estimates[33] to identify EJ communities.

Using GIS software, the locations of the backup diesel generators were mapped using the addresses listed in the CATS database. Out of the 2,642 backup diesel generators in the inventory compiled from the CATS database, 390 were not included in the EJ analysis due to incomplete address information. For each diesel generator, the distance to the nearest EJ community was calculated. Using these distances, AEC calculated the number and capacity of generators located inside EJ communities and within particular distance bands. Since the publicly available CATS database on NYC Open Data does not list generator sizes, AEC assumed an average generator capacity of 1,102 kW.[34]

Estimating emissions from backup diesel generators

To conduct the emissions analysis for backup diesel generators, AEC estimated the annual generation (kWh) by multiplying the assumed average capacity of each generator (1,102 kW) by the assumed annual operation time range (hours) for outages and testing.[35] AEC also estimated the annual fuel consumption (MMBtu) of each generator by multiplying the calculated annual generation (kWh) by an assumed heat rate of 10,500 Btu per kWh.[36]

Due to the uncertainty in the annual operation time for generator testing, AEC assumes that backup diesel generators in New York City operate, on average, for 50 hours per year to perform maintenance and

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[32] The U.S. Census sets poverty thresholds for households depending on: size of family, number of children, and, for one- and two- person families, age of the householder. See: U.S. Census. American Community Survey and Puerto Rico Community Survey: 2019 Subject Definitions. Available at: https://www2.census.gov/programs-surveys/acs/tech_docs/subject_definitions/2019_ACSSubjectDefinitions.pdf. p. 110-112 and p. 149

[33] U.S. Census. 2019. ACS 5-Year Estimated Detailed Tables [Tables: B02001, B17021].

[34] The New York State (NYS) Department of Environmental Conservation (DEC) estimated the average nameplate capacity for emergency generators in the City to be 1,102 kW based on 226 sources in New York City. Source: NYS DEC. October 2020. *State Implementation Plan (SIP) revision to incorporate revisions to Title 6 of the New York Codes, Rules, and Regulations (NYCRR) Part 222 and Part 200*. Available at: https://www.dec.ny.gov/docs/air_pdf/siprev222.pdf

[35] Generator testing (also referred to as "exercising") is a form of routine maintenance where operators periodically run their generator with and without load to ensure that it is fully operational and ready in the event of a power outage. Source: National Fire Protection Association. 2019 edition. *NFPA 110: Standard for Emergency and Standby Power Systems – Chapter 8: Routine Maintenance and Operational Testing.* Available at: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=110

[36] Based on the average heat rate (9,000 to 12,000 Btu per kWh) for reciprocating engines between 500 and 2,000 kW. Source: U.S. Department of Energy. July 2011. *Hospitals Discover Advantages to Using CHP Systems*. Available at: https://www1.eere.energy.gov/buildings/publications/pdfs/alliances/hea_chp_fs.pdf

readiness testing.[37,38] AEC estimated the annual operation time due to power outages by averaging the U.S. EIA's System Average Interruption Duration Index (SAIDI) across New York City's electric utilities over the 7-year period between 2013 and 2019, which resulted in an annual average of 1.1 hours per customer served (see Table 5).[39] With these two components, AEC formulated a range of operating hours by taking the average operating time of 51 hours as the midpoint and applying a 10 percent sensitivity above and below this value.

Table 5. Average outage duration per customer served in New York City

Outage Duration per Customer Served (hours)	2013	2014	2015	2016	2017	2018	2019	Annual Average
New York City Average	0.6	0.5	0.7	0.8	0.7	3.1	1.2	**1.1**

Source: U.S. EIA. 2013–2019. Annual Electric Power Industry Report, Form EIA-861 detailed data files [Reliability]. Available at: *https://www.eia.gov/electricity/data/eia861/*

To estimate the amount of air pollutants (including CO, PM, and NO_x) emitted by these backup diesel generators, AEC multiplied the annual generation (kWh) of each generator by the corresponding emission rate limits (kilograms per kWh)—shown in Table 6 below—established by the U.S. EPA's *New Source Performance Standards for Stationary Compression Ignition Internal Combustion Engines*.[40,41] Some of the emission standards for NO_x are reported as a combined emission standard with non-methane hydrocarbons (NMHC)—referred to as NMHC+NO_x. To separate NO_x from this combined emission standard, AEC assumed that NO_x represents a 75 percent share of the NMHC+NO_x standard based on the Ohio Environmental Protection Agency's assumed NO_x to NMHC ratio.[42]

[37] General testing requirements call for generators to be tested monthly for a minimum of 30 minutes with load and weekly for a minimum of 30 minutes without load; however, the frequency and duration of testing varies among generator operators based on personal preference and manufacturer guidelines.

[38] Emergency generators in New York City are allowed to operate for up to 500 hours each year. This limit applies to operation during emergency conditions, routine maintenance, and routine exercising. As of February 2021, NYS DEC has revised its definition of emergency backup generators to allow for operation in excess of 500 hours during a declared state disaster emergency. Source: NYS DEC. February 2021. *Adopted Part 201 Permits and Registrations, and Part 200 General Provisions*. Available at: https://www.dec.ny.gov/docs/air_pdf/adopted201.pdf

[39] U.S. EIA. 2013–2019. *Annual Electric Power Industry Report, Form EIA-861 detailed data files [Reliability]*. Available at: https://www.eia.gov/electricity/data/eia861/

[40] U.S. EPA. November 2019. "Standards of Performance for Stationary Compression Ignition Internal Combustion Engines." 40 CFR Part 60 Subpart IIII. Available at: https://www.govinfo.gov/content/pkg/FR-2019-11-13/pdf/2019-24335.pdf

[41] These emission standards are defined by EPA Tier Ratings were established for different size generators and phased in over specified time periods that are applicable to a diesel generator's model year. Source: U.S. EPA. March 2016. *Nonroad Compression-Ignition Engines: Exhaust Emission Standards.* EPA-420-B-16-022. Office of Transportation and Air Quality. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OA05.pdf

[42] Ohio Environmental Protection Agency. *Calculation of NOx Emissions for Compression Ignition (CI), Internal Combustion Engines (ICE)*. Available at: https://www.epa.ohio.gov/portals/27/genpermit/CI.calcs.pdf

Table 6. Nonroad Compression-Ignition Engines: Exhaust Emission Standards

Rated Power (kW)	EPA Tier Rating	Model Year [Start]	Model Year [End]	NMHC (g/kWh)	NMHC+ NOx (g/kWh)	NOx (g/kWh)	PM (g/kWh)	CO (g/kWh)
kW < 8	1	2000	2004		10.5		1.0	8.0
	2	2005	2007		7.5		0.8	8.0
	4	2008			7.5		0.4	8.0
8 ≤ kW < 19	1	2000	2004		9.5		0.8	6.6
	2	2005	2007		7.5		0.8	6.6
	4	2008			7.5		0.4	6.6
19 ≤ kW < 37	1	1999	2003		9.5		0.8	5.5
	2	2004	2007		7.5		0.6	5.5
	4-Initial	2008	2012		7.5		0.3	5.5
	4-Final	2013			4.7		0.03	5.5
37 ≤ kW < 56	1	1998	2003			9.2		
	2	2004	2007		7.5		0.4	5.0
	4-Initial	2008	2012		4.7		0.3	5.0
	4-Final	2013			4.7		0.03	5.0
56 ≤ kW < 75	1	1998	2003			9.2		
	2	2004	2007		7.5		0.4	5.0
	3	2008	2011		4.7		0.4	5.0
	4-Initial	2012	2013		4.7		0.02	5.0
	4-Final	2014		0.19		0.4	0.02	5.0
75 ≤ kW < 130	1	1997	2002			9.2		
	2	2003	2006		6.6		0.3	5.0
	3	2007	2011		4		0.3	5.0
	4-Initial	2012	2013		4		0.02	5.0
	4-Final	2014		0.19		0.4	0.02	5.0
130 ≤ kW < 225	1	1996	2002	1.3		9.2	0.54	11.4
	2	2003	2005		6.6		0.2	3.5
	3	2006	2010		4		0.2	3.5
	4-Initial	2011	2013		4		0.02	3.5
	4-Final	2014		0.19		0.4	0.02	3.5
225 ≤ kW < 450	1	1996	2000	1.3		9.2	0.54	11.4
	2	2001	2005		6.4		0.2	3.5
	3	2006	2010		4		0.2	3.5
	4-Initial	2011	2013		4		0.02	3.5
	4-Final	2014		0.19		0.4	0.02	3.5
450 ≤ kW < 560	1	1996	2001	1.3		9.2	0.54	11.4
	2	2002	2005		6.4		0.2	3.5
	3	2006	2010		4		0.2	3.5
	4-Initial	2011	2013		4		0.02	3.5
	4-Final	2014		0.19		0.4	0.02	3.5
560 ≤ kW < 900	1	2000	2005	1.3		9.2	0.54	11.4
	2	2006	2010		6.4		0.2	3.5
	4-Initial	2011	2014	0.4		3.5	0.1	3.5
	4-Final	2015		0.19		3.5	0.04	3.5
kW > 900	1	2000	2005	1.3		9.2	0.54	11.4
	2	2006	2010		6.4		0.2	3.5
	4-Initial	2011	2014	0.4		3.5	0.1	3.5
	4-Final	2015		0.19		3.5	0.04	3.5

Reproduced from: U.S. EPA. March 2016. Nonroad Compression-Ignition Engines: Exhaust Emission Standards. EPA-420-B-16-022. Office of Transportation and Air Quality. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OA05.pdf

To estimate SO_2 emissions from backup diesel generators, AEC multiplied the annual diesel fuel consumption (MMBtu) of each generator by the U.S. EPA's emission factor for SO_2 of 0.001515 lbs per MMBtu.[43,44]

To estimate the greenhouse gas emissions (CO_2, CH_4, and N_2O) released by these backup diesel generators, AEC multiplied the annual fuel consumption (MMBtu) of each generator by the EPA's emission factors for each greenhouse gas for distillate fuel oil no. 2 (kilograms per MMBtu) as shown in Table 7.[45] The total greenhouse gas emissions in CO_2e were calculated by multiplying the emissions of CO_2, CH_4, and N_2O by their 100-year global warming potentials of 1, 25, and 298, respectively.

Table 7. U.S. EPA greenhouse gas emission factors for distillate fuel oil no. 2

Fuel Type	CO_2 kg per MMBtu	CH_4 g per MMBtu	N_2O g per MMBtu
Distillate Fuel Oil No. 2	73.96	3	0.6

Source: U.S. EPA. Last Modified 1 April 2021. Emission Factors for Greenhouse Gas Inventories. Available at: https://www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf

Due to the data limitations, several assumptions were made in this analysis to estimate emissions from backup diesel generators. The publicly available CATS database on NYC Open Data does not provide the manufacture year of the diesel generators registered in the City. In the absence of this information, AEC used the emission limits defined by EPA Tiers 2 and 4 to create a range of possible air pollutant emissions from CO, PM, and NO_x.[46] The range defined by the EPA Tiers was then combined with the range of operation time to result in the low- and high-end estimates of air pollutant emissions. Collectively, the conservative assumptions made for this study have resulted in calculated emissions that are likely on the lower range of what is actually occurring, since EPA emission factors are lower for newer models. The real magnitude of the emissions from diesel backup generators is likely higher and the impacts more widespread.

[43] The SO_2 emission factor is equal to 1.01S lbs per MMBtu, where "S" is the sulfur content as a percentage. Since ultra-low sulfur diesel contains 15 ppm of sulfur, "S" in the SO_2 emission factor would be equal to 0.0015 percent. Source: U.S. EPA. October 1996. "3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines." AP 42, Fifth Edition, Volume I Chapter 3: Stationary Internal Combustion Sources. Available at: https://www.epa.gov/sites/production/files/2020-10/documents/c03s04.pdf p.3.4-5

[44] AEC divided the SO_2 emissions by 2.205 to convert from lbs to kilograms.

[45] U.S. EPA. Last Modified 1 April 2021. Emission Factors for Greenhouse Gas Inventories. Available at: https://www.epa.gov/sites/production/files/2021-04/documents/emission-factors_apr2021.pdf

[46] Since it is unlikely that all backup diesel generators in New York City would be categorized as Tier 1, AEC assumed that the average EPA Rating across the city would fall between Tiers 2 and 4.