Climate Change, Energy, and Energy Insecurity in New York City

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Abstract:

This chapter of the New York City Panel on Climate Change 4 (NPCC4) report provides an overview of energy trends in New York City (NYC) and the State of New York, as well as accompanying challenges and barriers to the energy transition – with implications for human health and wellbeing. The link between energy trends and their impact on health and well-being is brought to the fore by the concept of 'energy insecurity', an important addition to the NPCC4 assessment.

Keywords:

Climate Change, Energy Insecurity, Health & Wellbeing, Energy Transition, NPCC4

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1 Chapter Summary

In the local pursuit of sustainable development and addressing global climate change challenges, it is crucial to not only focus on improving energy efficiency and lowering carbon intensity but also to consider how these processes affect the accessibility and use of energy by all who live and work in the city. Energy insecurity (EI) refers to the inability to meet, or stresses involved in meeting, household or community-level energy needs that are essential for health and wellbeing. Assertively addressing the issue of energy insecurity as New York City (NYC) pursues these challenges helps to bring this tension to the forefront of climate policy as it integrates energy, health, and social inequities.

1.1 Key Messages

Key Message 1: *While recognizing the urgency to reduce energy use and GHG emissions to meet the City and State's ambitious climate goals and mitigate the impacts of climate change, actions must be approached deliberately, considering energy insecurity and health. Challenges – including reducing fossil fuel use, acquiring renewables, adapting the grid to meet higher demand, and securing sufficient dispatchable generation to ensure reliability during peak periods when solar and wind generation is low – can all have implications for energy affordability and reliability. While the transition offers opportunities for economic growth, improved air quality, and promoting active transport, equitable implementation, and reliable energy supply particularly during extreme weather events are important considerations for NYC.*

Key Message 2: *Energy is not only vital for economic growth, but also for human health and well-being – a connection that the concept of energy insecurity (EI) highlights. EI can be caused by high energy costs relative to income, by frequent energy outages and unreliability, or both. Addressing EI both influences, and is influenced by, various domains such as public health, transportation, energy, and housing sectors – all compounded by climate change as a threat multiplier.*

Key Message 3: *EI can harm public health directly – via inadequate heating or cooling, indoor air pollution, and reduced ability to reliably use medical devices and refrigeration necessary for health needs – and indirectly when high energy costs reduce spending on other essential items like healthcare and food. Populations most vulnerable to EI include those of any citizenship and immigration status with lower incomes, people who have experienced systemic racism, people with underlying health conditions, disabilities, or dependent on electric powered medical equipment, and renters, who are less able to access energy subsidies.*

Key Message 4*: Climate resilience investments in energy infrastructure and mitigation plans for the transition from fossil fuels to renewable energy and the electrification of buildings and transportation could impact future energy reliability and costs. Vulnerable populations are most at risk from any potential increases in power outages or energy costs, which may be exacerbated by projected climate extremes in NYC, such as extreme heat, cold, and flooding. Equitable and just policies and investments in the energy and housing sectors can reduce future health risks from energy insecurity and shape a more resilient and equitable future.*

2 Introduction

2.1 Chapter Scope and Context

Reducing global greenhouse gas (GHG) emissions to mitigate climate change, coupled with implementing local adaptation measures, is essential for effectively minimizing local climate-related health risks. This approach underscores the critical need to improve energy trends, such as increasing renewable energy capacity. NYC, which already has much lower per-capita GHG emissions than the state and surrounding suburbs, has made significant strides towards a more sustainable future with less GHG emissions and reduced indoor and outdoor air pollution through policies, and projects that advance electrification, energy efficiency, and renewable energy generation for both city government operations and in the private sector. However, focusing solely on these positive trends without addressing energy insecurity would be an incomplete and shortsighted approach. For instance, as climate change worsens and energy transition plans take effect, electricity demands will increase as we use more energy to cool our buildings and electrify the building and transportation sectors, potentially overwhelming the electricity grid and local distribution infrastructure in the absence of advanced planning. This may cause more frequent blackouts and brownouts during peak periods of energy use, often associated with extreme weather events like heat waves and cold snaps, – an issue we have already witnessed in the Texas storms of February 2021 (Flavelle et al., 2021). Electricity demand will also change as the city and state work toward achieving the GHG emissions and clean energy targets of New York State's Climate Leadership and Community Protection Act (CLCPA) and Local Law 97 of 2019 (LL97) (CLCPA, 2019; Local Law 97, 2019). These policies will result in buildings and transportation shifting from fossil fuel combustion in buildings and vehicles to electric vehicles, heat, hot water, and cooking appliances utilizing an electric grid that is anticipated to be increasingly supplied with renewable and low- or zero-carbon sources. As heating systems electrify, peak energy demand in NYC will shift from summer to winter in the coming decades (New York Independent System Operator, 2023c; Urban Green Council, 2021). As new renewable energy sources come online, the city and state must balance decommissioning fossil fuel infrastructure that contributes to air pollution and disproportionately harms low-income and communities of color in NYC while maintaining reliability and addressing energy insecurity. Energy insecurity reveals the stark disparities in the ability to meet daily energy needs – both impacting, and impacted by, existing inequities. Under-resourced communities, including low-income communities and communities of color, often bear the brunt of energy insecurity facing challenges such as limited access to reliable and affordable energy supply, high energy cost burden, and higher energy use due to inefficient heating and cooling, systems, appliances as well as poorly insulated buildings.

BOX 1. Local Law 97 (LL97)

In 2019, the NYC Council passed Local Law 97 (LL97), which amended the city charter and NYC administrative code to achieve reductions in greenhouse gas emissions by 2050. The law set goals such as a 40% reduction of greenhouse gas levels by 2030 compared to baseline 2005 levels and carbon neutrality by 2050. LL97 applies, with some exceptions, to buildings larger than 25,000 gross ft^2 as well as to two buildings that together exceed 50,000 ft^2 which are either on the same tax lot or governed by the same board of managers of a condo association. Building types that are exempted from LL97 or have delayed compliance timelines include industrial power generation facilities, city buildings, houses of worship, and buildings on land owned by the New York City Housing Authority (NYCHA) or that are rent-regulated accommodations.

LL97 incentivizes large buildings to reduce emissions in several ways, such as through investment in energy efficiency, electrification, and renewable energy. Other mechanisms such as offsets and credits may also help buildings meet allowable emissions targets. The compliance period begins in 2024 and sets emissions limits per ft^2 that differ by type of property, or occupancy group. Under the law, large buildings may face penalties for exceeding emissions limits, or also for failing to report emissions annually or making false statements.

The law also established a LL97 advisory board and required reports on the law's adaptation and implementation, the first of which was submitted to the Mayor and City Council in December 2022. The advisory board is responsible for making recommendations for implementation of the law such as regarding owner and tenant responsibilities, incentives for reduced energy use at peak times and for electrification, and to assist properties with compliance through mechanisms like offsets and credits, with special attention to buildings in environmental justice areas.

For More Information, please see Local Law 97 of 2019, §28-320 and §28-321 of the NYC Administrative Code, and the December 2022 Local Law 97 Advisory Board Report, available at https://www.nyc.gov/assets/sustainablebuildings/downloads/pdfs/ll97_ab_report.pdf.

2.2 Chapter Organization

This assessment will provide an overview of energy trends in NYC and New York State, as well as accompanying challenges and barriers to the energy transition – with implications for human health and wellbeing. The link between energy trends and their impact on health and well-being is brought to the fore by the concept of 'energy insecurity' (EI), an important addition to this assessment. Energy insecurity includes dimensions of individual energy cost burden and the potential for outages at the household or community level[1]. Furthermore, energy insecurity has human health consequences and increased financial burdens on government. For instance, inadequate heating or cooling can contribute to respiratory illnesses, which can impose significant costs on healthcare systems and further harm those without access to health care. This topic must be considered alongside energy trends in the context of NYC's climate action planning as it highlights fissures that could otherwise be overlooked. A large and growing body of evidence demonstrates how energy insecurity can amplify overall climate impacts on health and their inequitable distribution among communities and populations (Hernández, 2013, 2016a; Hernández & Siegel, 2019; Lane et al., 2022). In

[1] Using data from the 2017 American Community Survey, the City conducted an energy cost burden analysis and found that 41% of low-income families (<200% FPL) in New York City are energy cost burdened compared to only 7% of non-low-income families. https://www.nyc.gov/assets/sustainability/downloads/pdf/publications/EnergyCost.pdf

addition, protecting public health requires that local, state, and national energy transition policies and investments reduce energy insecurity and preserve and enhance the reliability and resilience of NYC's energy system. Concerns for energy insecurity must therefore complement city- and state-level policymaking to ensure that neither progress in energy trends nor likely scenarios of increased future demand result in worse outcomes for those already facing challenges in meeting everyday energy needs.

3 Energy in New York City: Trends, Challenges and Opportunities

According to the US Department of Energy (US Energy Information Administration, 2023), New York State has the third largest and one of the most energy efficient state economies in the nation. New Yorkers consume less total energy per capita than the residents of all but two other states (Hawaii and Rhode Island) (US Energy Information Administration, 2023). Importantly, per capita energy consumption in New York's transportation sector is lower than in all other states; only the District of Columbia uses less. The state's energy efficiency results in part from the use of mass transportation in New York's densely populated urban areas, especially in NYC. In 2019, nearly three-tenths of state residents used public transit to commute to work, six times the national average (US Census Bureau, 2010, 2019). Given the state's energy efficiency, in 2020, New York's per capita energy-related CO_2 emissions were lower than those of any other state in the nation (US Energy Information Administration, 2023).

NYC was ranked 2nd most energy-efficient city in the USA[2], behind Boston(Samarripas et al., 2021). It has also been identified as a low GHG emitter among 100 US metropolitan areas (Brown et al., 2009; Sovacool & Brown, 2010). It should be noted, however, that in a global study of urban GHG emissions, North American cities were the largest contributors and had the mean highest per capita emissions (Marcotullio et al., 2013). In an analysis of global urban carbon footprints, NYC was estimated to be the third largest total GHG contributor, behind Seoul and Guangzhou, but was the 91st largest urban emitter per capita (Moran et al., 2018).

Notwithstanding high energy efficiency, New York State has committed to strong reductions in GHG emissions through the Climate Leadership and Community Protection Act (CLCPA), as has NYC, reflected in the city's commitment to the Climate Mobilization Act (New York City Council, 2019), the centerpiece of which is Local Law 97 (BOX 1). New York State has committed to an energy transition through a decrease in the use of fossil fuels (lower carbon intensity) and the increase in generation of renewable energy, while at the same time, electrifying transportation and building energy and creating greater energy efficiencies (lowering energy intensity) where possible. Given the substantial share of NYC in the state's overall energy use (30% of total electricity use of the state (New York State Energy Research and Development Authority, 2023e)), success in meeting the state's goals depends upon how successfully the city addresses the energy transition.

NYC faces challenges in meeting its goals, particularly as climate change is shifting essential energy needs. For example, as summers have become warmer, cooling demand has increased. In the future, as the city electrifies, peak demand is expected to shift from summer to winter, and the demand is also expected to increase. At the same time, extreme weather events are increasingly causing power outages (Horton et al., 2010; U.S. Government Accountability Office (GAO), 2021). While the shift from natural gas to wind, solar, and other clean forms of energy and accompanying electrification (homes, businesses, vehicles) will take place, there is concern over keeping up with energy demand and providing adequate dispatchable generation (e.g. from battery, thermal, or other forms of storage) and the risk of grid failure especially during times when most people are using electricity (Clack et al., 2017; Fekete et al., 2023; Mideksa & Kallbekken, 2010; Nierop, 2014).

An important challenge in meeting the goals is to do so in an equitable manner. For example, heat waves are affecting New York residents disproportionally, with Black and low-income residents more affected than their White and upper-income counterparts (City of New York Department of Health and Mental Hygiene, 2023b). When power outages occur, those in under-resourced communities are more affected than others (Casey et al., 2020) and currently, 311-calls for power outages are significantly higher in these under-resourced communities compared to others (Marcotullio, Diko, et al., 2023). The costs of a more resilient grid infrastructure and of decarbonizing energy generation, which will be collected in utility rates, could further strain low-income household budgets, therefore increasing energy insecurity. As renewables come online the ability for all New Yorkers to benefit could be undermined by differences in neighborhood hosting capacities.

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[2] Urban areas in North America are typically more energy efficient than suburban and rural areas. Hence, not only is NYC one of the most energy efficient cities, but it also is made up of some of the most energy efficient counties in the country.

3.1 New York City's Energy System

This section outlines the city's energy system and the challenges of creating an equitable transition. It first outlines the basics of NYC's energy system and how the system is changing. Importantly, current equity issues and implications of the energy transition on environmental justice are highlighted. NYC's energy system

NYC's energy system is intricately connected to the larger state, regional, and national energy system. This section attempts to outline the city's energy system through infrastructure including electricity generation, transmission, distribution, gas, steam and liquid fuels systems, and energy end use for buildings, transportation, and industry. In describing the current system and future transition we point out energy-related environmental justice issues.

Figure 1 visualizes the flows of energy from sources to end uses in NYC. Although simplistic, the figure attempts to demonstrate the size and complexity of the energy system within the city. According to the (City of New York Mayor's Office of Climate & Environmental Justice, 2022), the city consumed approximately 1.04 Quad Btu in four sectors (residential, commercial, industrial and transportation) in 2022. Another 430 TBtu was used for electricity production.

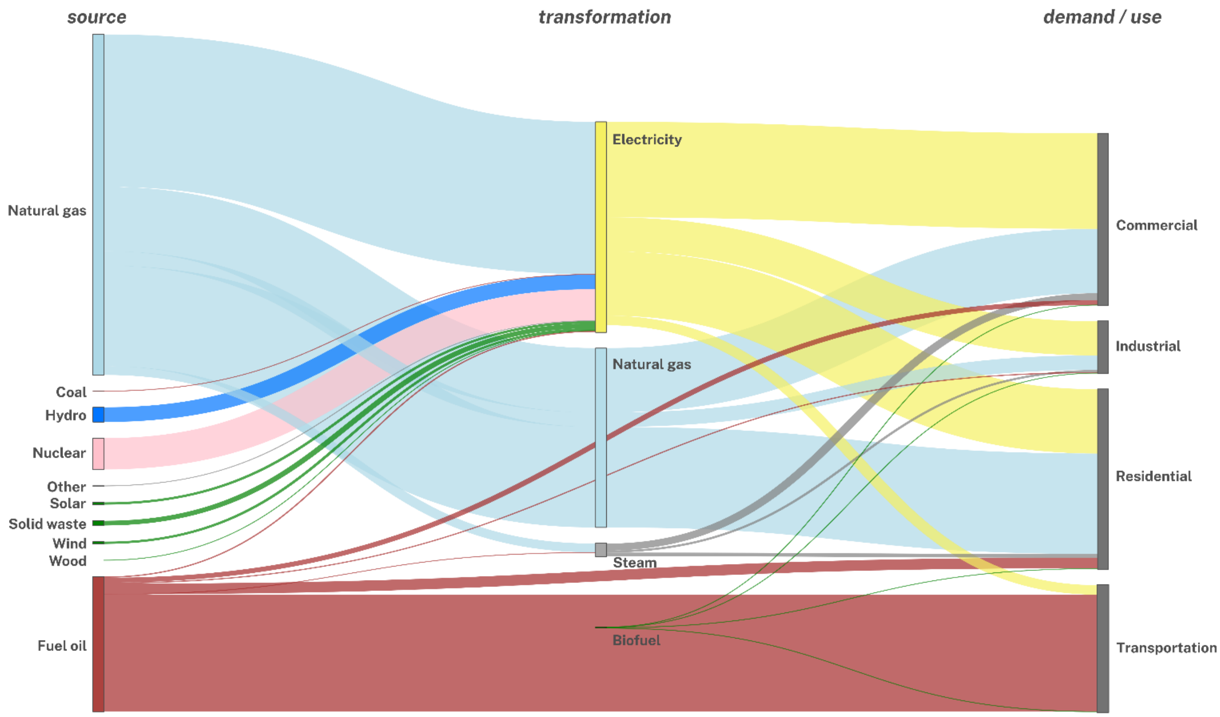

Figure 1. Sankey diagram of NYC energy end use 2022 (1.04 Quad Btu total). Note: the figure does not show rejected energy or waste heat. Data Source: (City of New York Mayor's Office of Climate & Environmental Justice, 2022)

3.1.1 Electricity system infrastructure

While the electricity system is integrated with larger systems, there are specific infrastructures that are critical to its performance. These infrastructures can be categorized in terms of three main elements: generation, transmission, and distribution.

3.1.1.1 Generation

Multiple companies and a state public authority own and operate 24 thermo-electric generation plants with a total capacity of over 9,000 MW of power in NYC (New York Independent System Operator, 2023b) . About 70% of the fleet is more than 50 years old and runs on inefficient and high-emitting technologies (City of New York Office of the Mayor, 2013b; Rueb, 2017). The in-city power plants rely primarily on fossil fuels—nonrenewable resources like natural gas and oil which emit high levels of pollutants when burned, including the GHGs responsible for warming our planet and sulfur and nitrogen oxides, particulate matter and heavy metals (Johnson et al., 2020). There has been an increase in the use of natural gas in the generation system as the Indian Point nuclear power plant was taken offline in 2021. The pollutants from fossil fuel use damage natural ecosystems, degrade water and air quality, enhance climate risks, and harm public health.

The generation system is working at 50% during a typical day, when the city is able to import cheaper electricity generated largely upstate to meet demand (City of New York Office of the Mayor, 2013a). Within New York State, approximately 91% of the electricity from upstate is from renewable resources, while approximately 89% from in-city sources is from fossil fuels (New York Independent System Operator, 2023d). The entire in-city generation runs, however, during hot summer days when upstate generation is not available at competitive prices and demand is high (demand can reach 11,000 MW during heat waves). During periods of high demand, an arsenal of 14 clusters of “peaker” plants may be used to keep the grid powered, the number that are dispatched depends on the capacity needed (Rueb, 2017). Approximately 50% of peaker plant generation runs when temperatures are 50°F (PSE, 2020). These plants can ramp up quickly but emit more criteria pollutants and GHGs than other base load plants (NYC Environmental Justice Alliance et al., 2020) and are expensive to use (City of New York Office of the Mayor, 2013b). These plants are largely located in the South Bronx, Sunset Park, and other under-resourced communities and environmental justice (EJ) communities (City of New York Office of the Mayor, 2023). As a result, EJ communities have developed health disparities and vulnerabilities from the air pollution emitted by these fossil-fuel energy infrastructures (NYC Environmental Justice Alliance et al., 2020).

Due to commitments to the CLCPA, the city is currently undergoing a transition in energy generation. An important component in this transition is distributed generation (DG). This includes combined heat and power (CHP or cogeneration) and smaller renewable generation infrastructure, including solar, offshore wind, and geothermal energy. CHP are found in certain large residential and industrial complexes, hospitals, and universities. Many of these systems are used consistently, while others are only for backup power (i.e., during power outages) (City of New York Office of the Mayor, 2013b). There are over 200 CHP systems in New York, with the biggest being the Brooklyn Navy Yard plant which can generate approximately 322 MW (Power Technology, 2022) and Con Edison’s 500 MW East River plant (City of New York Office of the Mayor, 2013b). Excluding these larger utility-scale systems, there exists approximately 150 MW of CHP within NYC (New York State Energy Research and Development Authority, 2023f).

To meet its goal of 70% of its electricity from renewable resources by 2030, New York State must add 20 GW over the next eight years, which will almost triple current levels (New York State Office of Budget and Policy, 2023; Office of the New York State Comptroller, 2021). In 2019 NYC consumed about a third of the State total and nearly all was generated by fossil fuels (New York State Department of Public Service, 2020). Therefore, increasing renewable generation in the city is a necessary part of meeting the State’s goals. NYC has set a target to deploy 1,000 MW of solar citywide by 2030. . Thus far, the city has installed 476 MW of solar generation (New York State Energy Research and Development Authority, 2023f). The city also has a goal of installing 100 MW of solar on city-owned buildings by 2025. As of 2022, 22 MW of solar PV panels were installed across 110 buildings, fulfilling 16% of the city's goal (NYC DCAS, 2023).

Community solar includes solar panels at offsite locations and therefore allows apartment renters, who may have no say about solar panels on their buildings, to benefit from solar energy. It also is beneficial to property owners, who can then split installation and maintenance costs for solar infrastructure. Currently, there are 43 MW generated by community solar in NYC (New York State, 2023a).

Not all communities may be able to take advantage of these technologies, however. Hosting capacity, or an estimate of the amount of distributed energy resources (such as solar) that may be accommodated without adversely impacting power quality or reliability under current configurations and without requiring infrastructure upgrades, varies across the city. Figure 2 demonstrates that hosting capacities of the grid in Manhattan are different from that of the Bronx and parts of Brooklyn.

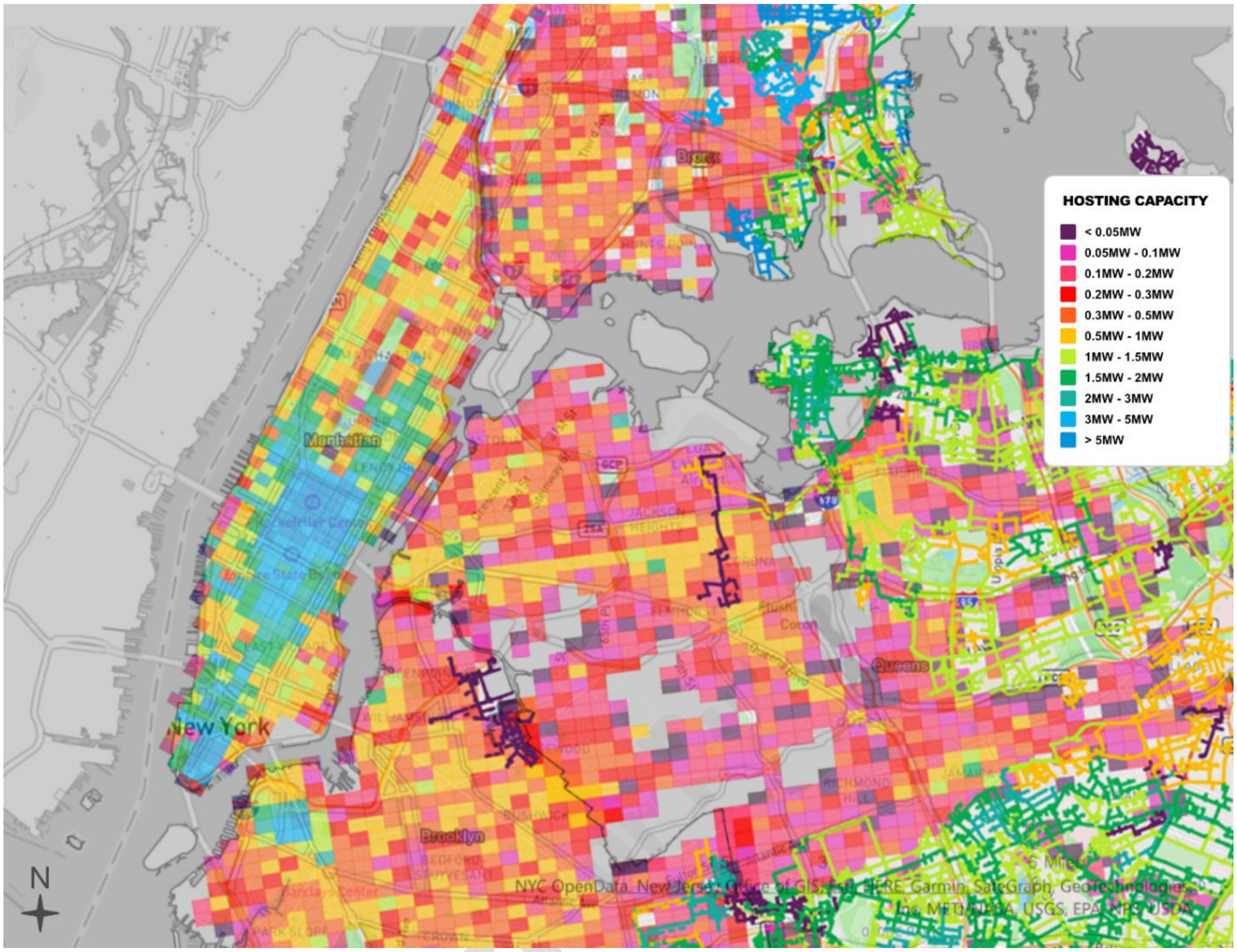

Figure 2. Hosting capacity differences across parts of NYC (14:00, 31 August 2023). Source: NYSERDA (2023c)

The city is also seeking to procure offshore wind energy. Wind projects are projected to reduce NYC's fossil fuel use for electricity by over 80% by 2030 (New York City Economic Development Corporation, 2021; New York State Energy Research and Development Authority, 2023d). Offshore wind projects that will serve NYC are under development in the New York Bight (Figure 3). The State issued competitive solicitations for offshore wind energy and contracts with offshore wind developers to purchase offshore renewable energy certifications (ORECs). There have been three solicitations to date. In 2018 two projects were awarded; Empire Wind (Equinor US Holdings, Inc.) and Sunrise Wind (Bay State Wind LLC, a joint venture of Ørsted A/S and Eversource Energy). These projects total 1,696 megawatts (MW) and are slated for Empire Wind 1. In 2020, two more projects were awarded, Empire Wind 2 and Beacon Wind, both with Equinor Wind US LLC (Equinor). Combined, the projects will deliver 2,490 megawatts (MW) of renewable energy. Empire Wind 2 is slated for a location near Empire 1, but Beacon Wind will be located south of Martha's Vineyard and Nantucket Island. In 2022, the most recent solicitation was awarded to three new offshore wind projects, representing 4,032 megawatts (MW) of clean, locally produced energy. The winders include Attentive Energy One (1,404 MW) developed by TotalEnergies, Rise Light & Power, and Corio Generation; Community Offshore Wind (1,314 MW) developed by RWE Offshore Renewables and National Grid Ventures; and Excelsior Wind (1,314 MW) developed by Vineyard Offshore (Copenhagen Infrastructure Partners). The Excelsior project will be located close to Empire 1 & 2 (within 22 miles of NYC). Both Attentive Energy One and Community Offshore Wind are located further south (located between 54 and 64 miles from NYC) in New York Bight. PSEG-LIPA has also been awarded a project. The proposed points of interconnection where the wind power will be brought into the State grid, are located across Long Island and NYC. There are also several planned port facilities, located throughout the lower New York State area where cutting-edge technologies, including the nation's first offshore wind tower manufacturing plants, will be located (New York State Energy Research and Development Authority, 2022b, 2022c, 2023b). Con Edison is developing the Brooklyn Clean Energy Hub to host the future offshore wind interconnection infrastructure for up to 1,500 MW of renewable wind energy (Consolidated Edison Company of New York, Inc, 2022b).

The city's Offshore Wind Vision plan includes the creation of 13,000 green jobs and generation of $1.3 billion in average annual investment (City of New York, 2021). Across the USA, energy technology innovation, private- and public-sector investments, and state, local, and federal energy and climate policies have propelled economic development and supported the creation of millions of jobs. An analysis of these data suggests differential opportunities for employment by race and ethnicity (National Association of State Energy Officials & Clean Energy Initiative, 2021). For example, benefits have not been equally available by gender and race particularly within the skilled trades, technology innovation and commercialization, and upper-level management of high-growth industries such as renewable energy development (IREC, 2022; Kapor Center, 2021; Keyser & Tegen, 2019; Muro et al., 2019). However, the city has secured commitments from offshore wind developers to direct 40% of job and investment benefits toward women, minorities, and environmental justice communities (New York City Economic Development Corporation, 2021).

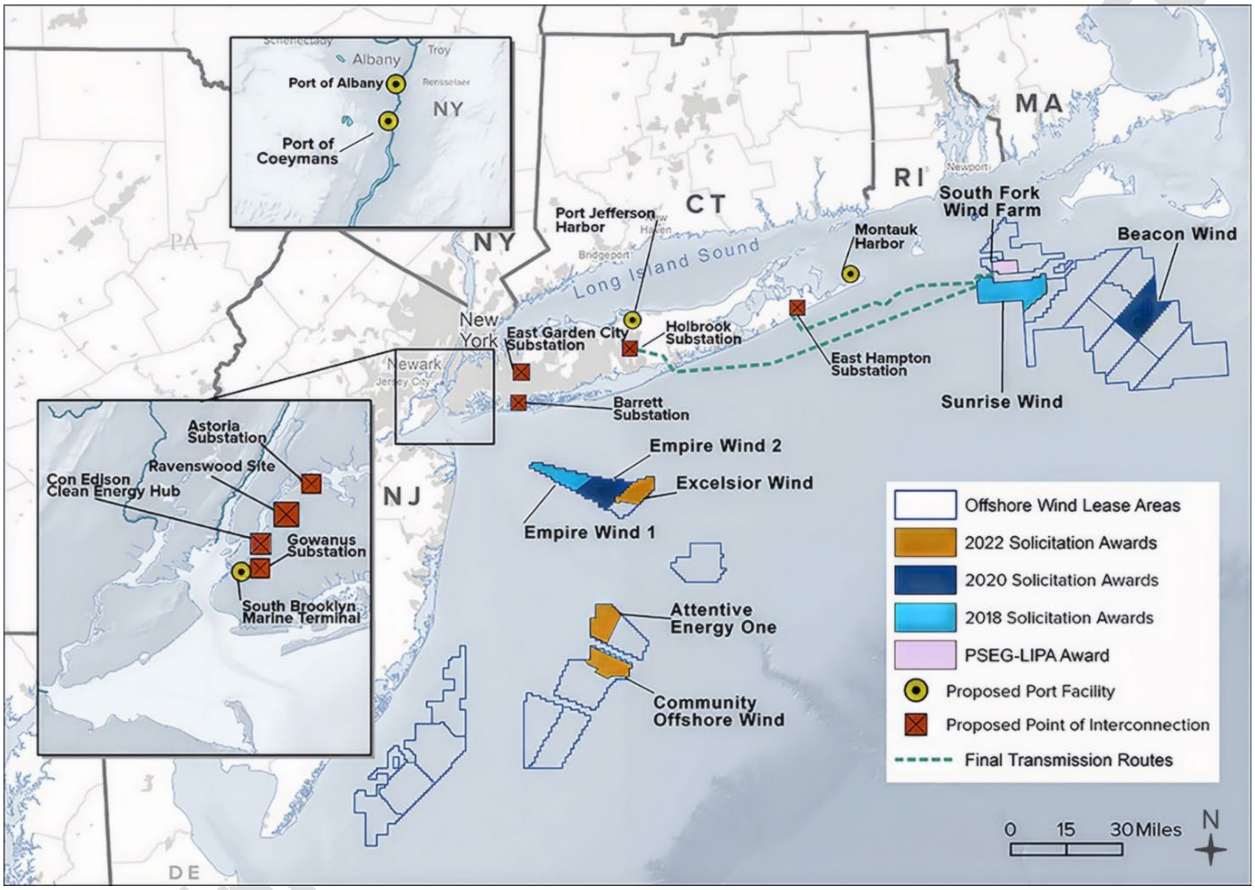

Figure 3. Offshore wind projects close to NYC. Source: NYSERDA (2023d). The New York State Energy Research and Development Authority (NYSERDA) has five offshore wind projects in active development, totaling more than 4,300 megawatts. In July 2022, NYSERDA launched a third offshore wind solicitation to procure at least 2,000 additional megawatts of offshore wind energy for New Yorkers.

Solar or wind power will produce output that is variable over time and imperfectly predictable, making it difficult to match generation and load at every instant. Battery energy storage systems complement variable renewable resources; and therefore, the city is planning for battery storage and thermal energy network development. However, these infrastructures have not yet been built. The city has established a goal of developing 500 MW of energy storage capacity within the city by 2025 and 1,000 MW by 2030. Currently, however, there are limited amounts of storage. For example, the NYC Department of Citywide Administrative Services has 10MW of energy storage projects in development (City of New York Mayor's Office of Climate & Environmental Justice, 2023c). Con Edison is about to begin operating a 7.5 MW battery system in Staten Island (Larson, 2023). According to the NYC Mayor's Office of Climate and Environmental Justice, there is approximately 400 megawatts (MW) of storage potential on City-owned unused vacant land and parking lots that could be used to deploy battery storage projects of greater than 1 MW. Currently, 300 MW of energy storage projects have passed initial review by relevant City agencies (City of New York Mayor's Office of Climate & Environmental Justice, 2023c).

Battery storage has important implications for environmental justice. On the one hand, there are safety concerns. A fire at a battery storage facility in Monterey County, California designed, constructed and operated by Pacific Gas & Electric (PG&E) and Tesla broke out in 2022, which brought national attention to large battery storage facilities (Ciampoli, 2022). NYC also has had experiences with battery fires, but these are from unregulated batteries used in e-bikes and scooters. For example, by the end of August 2023, there were 108 fires and 13 fatalities related to lithium-ion batteries in the city, many associated with low-income delivery service employees (Ly & Murphy Kelly, 2023). On the other hand, battery storage can reduce the need for in-city peaking plants to operate or may eventually replace them altogether, improving local air quality for affected under-resourced communities while still providing energy reliability (PSE, 2020). Batteries and energy storage projects also have the potential to provide local good paying jobs and workforce training opportunities for environmental justice communities (City of New York Mayor's Office of Climate & Environmental Justice, 2023b). To address fires concerns, the city requires energy storage systems authorized for installation to undergo rigorous safety testing (e.g., UL certification), have required project design and equipment reviews and inspections by permitting authorities (e.g., FDNY), and are equipped with built-in safety precautions (City of New York Mayor's Office of Climate & Environmental Justice, 2023d). The city also is pursuing strategies to regulate and improve the safety of e-bike and micro-mobility batteries (Hu, 2023).

The city is also committed to pursuing a district-scale geothermal demonstration project (New York Independent System Operator, 2023d). Geothermal heat pumps, or ground-source heat pumps, rely on the constant temperature beneath the Earth's surface to provide clean and efficient heating and cooling, while using less electricity than other types of heat pumps. NYC has already built building-level geothermal projects, including at the FDNY Rescue Company 2 facility in Brooklyn (Arch Daily, 2022) and at PS 62 on Staten Island (Wang, 2016). The city is now evaluating the feasibility of district-scale systems that connect multiple buildings to shared infrastructure, which can realize further efficiencies and maximize environmental benefits through balanced loads and a diversity of thermal sources and sinks.

3.1.1.2 Transmission

Long-distance high voltage transmission lines currently bring up to 6,000 MW of electricity from different parts of New York State, northern New Jersey, and Pennsylvania. These lines connect to 24 high-voltage transmission substations within the city that also receive energy from in-city generation sources, which decrease the voltage of the electricity and direct the electricity to either customers or the hub of smaller "area substations." There, smaller transformers decrease voltage once again and feed the local distribution system. Area substations typically serve one or two neighborhood-level "networks" or "load areas" of customer demand, each of which includes tens of thousands of customers.

A substantial amount of electricity is imported from outside NYC's generation system. On a typical day, about 50% of NYC's electricity is imported from New Jersey and locations in New York, which is carried into the city by various transmission cables (Rueb, 2017). Given the need for large amounts of renewable energy to meet state mandates, the city will need to increase its imports of energy. Therefore, two infrastructure projects are being implemented (New York State Energy Research and Development Authority, 2021). In December 2022, work began on the longest stretch of a transmission line that would bring renewable energy from Canada to NYC, the Champlain Hudson Power Express (CHPE), which is expected to deliver 1,250 MW of hydropower energy, about 20% of the city's electricity demand (Lisa, 2022). Cable lines will be installed underground and underwater for an estimated cost of $2.2 billion. The transmission line is expected to start full operations in the spring of 2026 and reduce the city's carbon emissions by 37 million metric tons in its first 10 years (Transmission Developers and CHPE LLC, 2023). The second project is called the Clean Path NY. This $11 billion infrastructure project includes more than 20 wind and solar generation projects located in New York State and a new 175-mile, underground transmission line that will deliver more than 7.5 million megawatt-hours of emissions-free energy into NYC every year (Clean Path NY, 2023).

According to the NYISO, however, as the grid transitions to intermittent renewable generation and electrification of buildings and transportation, at least 17,000 MW of fossil-fuel generating capacity may be needed in order to reliably supply electricity on high demand "peak" days (New York Independent System Operator, 2022). The NYISO argues that there will be a reliability need before the CHPE project is scheduled to be in service and starting as soon as 2025 (New York Independent System Operator, 2023e) and will grow over time and over the medium-term (past 2031) exist even with the CHPE (Figure 3). Moreover, the CHPE was already delayed from its originally anticipated in-service date of late 2025 due to several factors, including a longer than anticipated regulatory review process and supply chain logistics for key construction components. These concerns are particularly important for under-resourced communities, as these are the neighborhoods that are currently suffering from the highest number of electricity interruptions in the city (Marcotullio, Braçe, et al., 2023). Another concern is that if CHPE is delayed, the absence of this resource could contribute to projected energy deficits forcing NYC's electricity system to continue using fossil fuels.

Other concerns include claims from environmental advocates that the CHPE project will impact river and lake biodiversity (Riverkeeper, 2022; Sierra Club, 2022) while other claims that the price for energy delivered over CHPE is likely to be above market rate (EnergyZT Advisors, 2020).

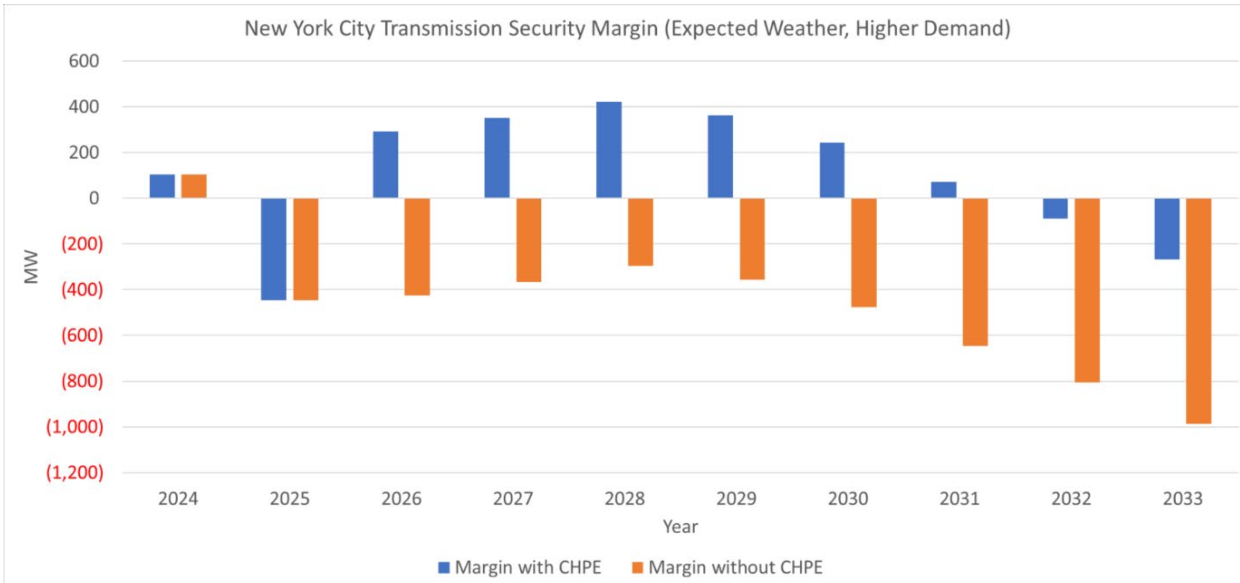

Figure 4. NYC Transmission Security Margin: With and Without CHPS. Source: New York Independent System Operator (2023e, p. 6)

3.1.1.3 Distribution

The electricity distribution system carries power between transmission substations and consumers. From area substations, electricity is distributed to end users through an underground transmission system or overhead loop systems and radial lines. In NYC, distribution infrastructure is primarily underground, however overhead lines carry 14% of the electrical load in areas of the outer boroughs. The underground system works as a network with multiple paths to any one customer. The overhead system is simpler and has fewer redundant pathways in which energy can get to customers. At the same time, it is cost prohibitive to bury all electrical lines throughout the city (Office of Long-Term Planning and Sustainability Office of the Mayor, City of New York, 2013). The distribution service lines are then connected to building electrical equipment. In many cases, high-rise buildings or campus-style complexes have dedicated transformer equipment, located beneath sidewalks, which serves these individual customers.

The Energy of Information Administration (Energy Information Administration, 2021) estimates approximately 5% loss of electrical energy between generators and customers in New York State and generally most of that loss occurs in the distribution system (MIT, 2011). Research suggests that the number and duration of large-scale electricity interruptions in the US are changing. The average U.S. electricity customer experienced nearly 20 more minutes of power interruptions in 2020 (the warmest year on record) than in 2017 (National Centers for Environmental Information, 2021). When major events are excluded, however, the average duration of interruptions customers experienced was consistently around two hours annually (U.S. Energy Information Administration, 2021f). More than 80% of interruptions were due to problems in the distribution system (Chowdhury & Koval, 2009; MIT, 2011).

In NYC, 311-calls reporting power outages are clustered in under-resourced communities and often occur during the warm season (June, July and August) (Marcotullio, Diko, et al., 2023). An important consideration is that with electrification of residential energy, the peak load on the electric grid will shift from the summer to the winter as building heating systems are electrified and we start to use more electricity in the winter than the summer. Currently, the city's peak power demand is 42% higher in the summer than in the winter (Urban Green Council, 2021). The shift is projected to occur around 2035-2040 (Figure 5) (New York Independent System Operator, 2023d). As building heating systems are electrified, the risk of winter outages during peak demand or during winter storms could lead to a new set of challenges related to keeping people safe in their homes. Given the impact of electricity interruptions on the health of the population (Anderson & Bell, 2012a; Casey et al., 2020; Dominianni, Lane, et al., 2018) addressing these challenges in an equitable way is essential (National Centers for Environmental Information, 2021).

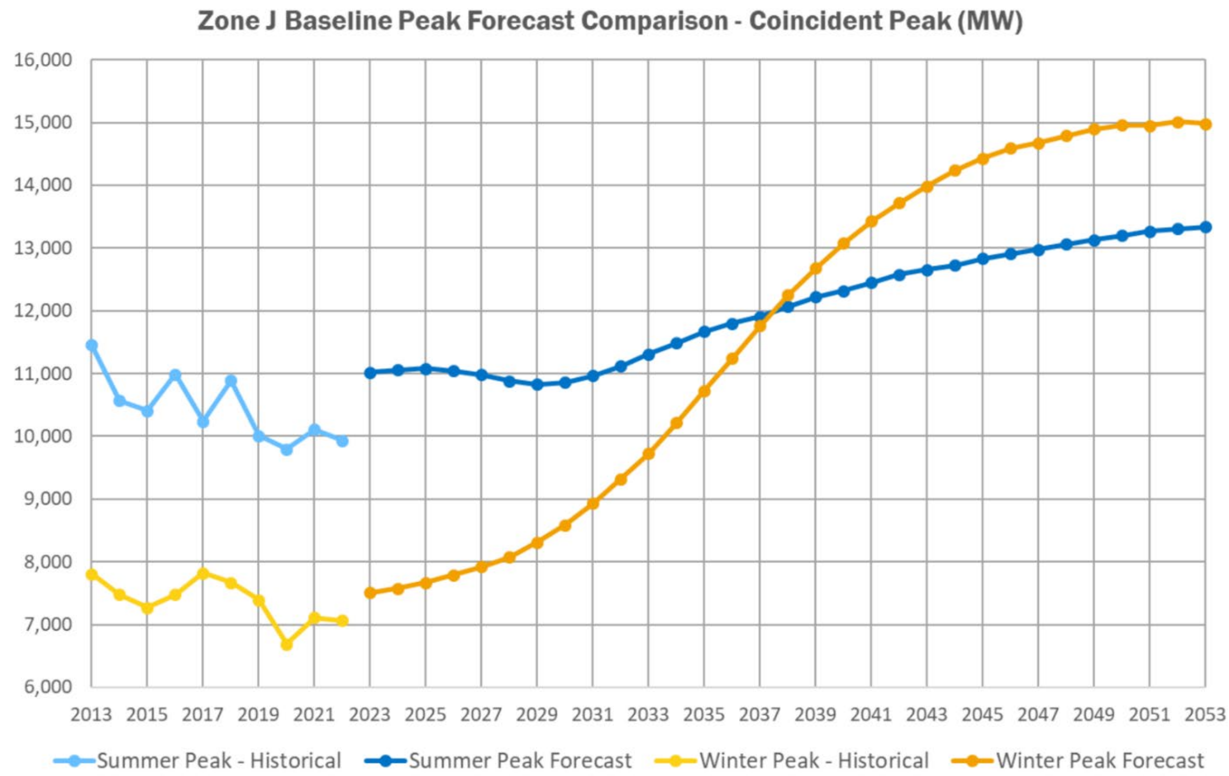

Figure 5. Zone J (NYC) Baseline Peak Forecast Comparison – Coincident Peak (MW). Source: New York Independent System Operator (2023a)

The increased penetration of renewable distributed generation also will pose challenges for the design and operation of the distribution system. The distribution system will need the integration of new communications infrastructures, sensor technologies, and advanced information technology that enable new system capabilities such as distribution automation (automated fault detection, isolation and restoration and optimization of system voltages and power flows) and advanced metering that stores and communicates energy consumption as a function of time (MIT, 2011).

3.2 Natural Gas System

Natural gas is transported from the Gulf Coast, Western Canada and other production regions to NYC through four private interstate pipelines.[3] The pipelines reach numerous interconnection stations called "city gates." From the city gates, high-pressure gas comes via an intra-city transmission system called the New York Facilities (City of New York Office of the Mayor, 2013b). Much of the natural gas that comes into the city is used for power generating and building heating systems in the city. For individual consumers, the gas pressure needs to be reduced, which is performed at regulator points, before it enters into the main distribution structures underground (City of New York Office of the Mayor, 2013b). The gas travels throughout the city through approximately 117 miles of pipelines that transport natural gas within the five boroughs (U.S. Department of Transportation Office of Pipeline Safety, 2023). On typical days, 98% of the in-city electricity generation is powered by natural gas and used for approximately 65% of heating for the 1 million buildings in the city (City of New York Office of the Mayor, 2013b).

The city's natural gas demand usually peaks on cold winter days, when it can exceed the capacity of the four interstate pipeline connections. On those days, utilities ask electric generating plants and other large users subject to interruptible utility rates to switch to liquid fuels (City of New York Office of the Mayor, 2013b).

Natural gas use in NYC has increased dramatically over the past two decades. In 2005, the total natural gas energy use exceeded 764 TBtu and by 2021, it was over 1,000 TBtu, or a 33% increase during that period. Much of this

[3] See DOE EIA https://www.eia.gov/naturalgas/archive/analysis_publications/ngpipeline/interstate.html

increase was in the buildings sector, although the industrial sector also experienced an increase. Gas utilities in New York are increasing their investments in their high fixed-cost pipeline networks despite the growing risk that those networks will become obsolete due to competition and climate policies. Over the past 10 years, the undepreciated balance of New York's gas utilities' investments in gas distribution infrastructure has more than doubled, from $13 billion to $29 billion (Walsh & Bloomberg, 2023). Con Edison suggests a continuation of providing natural gas to customers over the long run but at a lower level by replacing fossil methane gas with a mix of renewable natural gas (RNG) and hydrogen (Con Ed & Orange & Rockland Utilities, 2023). Decisions about natural gas transitions have equity considerations, as the costs of replacing pipelines will be borne by remaining ratepayers, who might see their bills increase (Walsh & Bloomberg, 2023).

3.3 Steam System

NYC's steam system, owned and maintained by ConEd, is one of the largest district steam systems in the world, providing heat and hot water to over 1,500 customers in Manhattan—including hospitals and many of the city's largest institutions---as well as air conditioning to a portion of those customers. Steam systems free customers from owning and maintaining boiler systems and require them to maintain on-site steam traps and condensate pumps.

Six natural gas- and fuel oil-fired steam generating facilities in Manhattan, Brooklyn, and Queens can collectively produce over 10 million pounds of steam per hour, either cogenerating this steam along with electricity, or producing steam alone. A network of 105 miles of underground pipes transports this steam to customers.

Since 2005, however, the energy generated by ConEd's steam plants available to end use sectors has decreased. In 2005, the city was generating approximately 67 TBtu, but by 2021, steam energy use dropped to approximately 35 TBtu or a 48% decrease (City of New York Mayor's Office of Climate & Environmental Justice, 2022). The decrease in steam use has been due to customer attrition, energy efficiencies and changing customer behaviors as a result of the COVID19 pandemic (see also section 3.4.3 'Industry' below).

3.4 Liquid Fuel System

There are more than 190,000 miles of liquid fuel pipelines in the United States. These pipelines connect oil-producing areas to refineries and chemical plants. A separate network of pipes then brings the refined petroleum products to retailers and consumers. Annually, the Northeast receives over 1 billion barrels of crude oil and petroleum products through pipelines, although some of the flow is redirected to other areas (U.S. Energy Information Administration, 2023a).(U.S. Energy Information Administration, 2023a). Two of the largest pipelines within the New York Area are the Colonial and Buckeye Pipelines. The Colonial Pipeline system, the largest in the US, can move 2.7 million barrels a day of refined petroleum products from refineries in the Gulf Coast (PADD 3) to the East Coast (PADD 1). The system provides states along the eastern seaboard about half of their total requirements for fuels such as gasoline, jet fuel, and heating oil, which accounts for about one-third of America's total petroleum product consumption (Medlock III, 2021). The Buckeye pipeline carries approximately 3.6 million gallons of jet fuel to JFK Airport. In addition, another 660,000 gallons per day of jet fuel runs through a branch pipeline to LaGuardia Airport. The pipeline also moves 2.7 million gallons of gasoline, diesel fuel and home heating oil to Long Island City daily. A total of nearly 10 million gallons of turbine fuel, gasoline, diesel fuel and home heating oil, 4.2 million for airports and 5.6 million for NYC consumers, are transported every day through pipelines from 62 storage tanks Buckeye owns in Linden, New Jersey, across the Arthur Kill to Staten Island, Brooklyn, Queens and Nassau County (Gentilviso, 2007). Most of the petroleum fuel supply arrives through ports under the jurisdiction of the Port Authority of New York and New Jersey. The downstate area is one of the world's largest fuel trading hubs and serves as a regional node for fuel distribution across the Northeast. Infrastructure includes 117 storage terminals with more than 25 million barrels of storage capacity, equating to 49 percent of the State's total (Hallman & Wei, 2016; ICF International, 2014).

Use of fuel oil in residential and commercial sectors has dropped over time. In 2005, the residential sector used 61 TBtu and the commercial sector used 17 TBtu, but by 2021, these figures dropped to 19.6 TBtu and 8.6 TBtu, respectively (City of New York Mayor's Office of Climate & Environmental Justice, 2022). This drop is in part due to the city's Local Law 38 (City of New York Department of Environmental Protection, 2021, p. 38), which required the phase out of No. 6 and No. 4 fuel oil, and conversion to either No. 2 fuel oil or other power sources. NYC established the Clean Heat Program to eliminate the use of residual heating oil which was a major source of air pollution in the city and linked to multiple adverse health outcomes, including cardiovascular disease (Columbia University Mailman School of Public Health, 2021). This policy led to significant improvements in NYC that were experienced in both low- and high-income neighborhoods (L. Zhang et al., 2021).

3.5 End Use Sectors

3.5.1 Buildings (residential and commercial)

There are over 1 million buildings in NYC (Table 1). The vast majority of these structures are strictly residential (approximately 950,000 buildings accounting for over 52% of the total building floor area in the city). There are another 65,000 buildings that are mixed residential and commercial structures (6% of total structures and about 18% of the total building floor area of the city). Commercial buildings account for about 2% of all buildings (24,000 buildings and about 14% of total building floor area). The remaining buildings are a mix of public, industrial, open space, transportation and miscellaneous structures (City of New York Department of City Planning, 2023b).

According to the NYC Mayor's Office of Climate and Environmental Justice (2023), in 2021, NYC buildings used 1.2 Quad Btu or 77% of the total energy used in the city that year. This energy use included approximately 11.6% of the fuel oil, 78.9% of the electricity, and 92% of the natural gas and 83.7% of the steam used during that year. The building sector is a major source of energy use for the city. Buildings also contribute about 70% of the city's GHG emissions.

Table 1. Building statistics for NYC, Source: (City of New York Department of City Planning, 2023b)

Building Type	Number of buildings	Total floor area (million sq. ft.)	Share of buildings (%)	Share of floor area (%)
One family	431,642	519	39.8	9.2
Two family	325,170	585	30.0	10.3
Multi-family walkup	175,404	736	16.2	13.0
Mixed residential/commercial	64,762	998	6.0	17.6
Commercial & Office	23,734	784	2.2	13.8
Multi-family elevator	17,398	1,131	1.6	20.0
Public & institutions	17,212	554	1.6	9.8
Industrial & manufacturing	11,903	196	1.1	3.5
Transport & utility	7,623	82	0.7	1.4
Parking	5,743	29	0.5	0.5
Open space & outdoor rec	3,309	37	0.3	0.7
Miscellaneous	1,740	14	0.2	0.2

Given that residential buildings account for a large percentage of the number of buildings and total floor area of all city buildings, energy use in these structures is of high interest. Common residential uses of energy include space heating, water heating, air conditioning lighting, refrigeration, cooking, and operation of a variety of other appliances (U.S. Energy Information Administration, 2021a). In 2020, energy consumption in the U.S. residential sector exceeded 12 quads Btu, which represented approximately 17% of total energy consumption and 20% of total carbon emissions for the nation (U.S. Energy Information Administration, 2021d, 2021e). A recent study of the residential energy use in the NYC metropolitan area suggests that between 1993 and 2009, residential energy use per household decreased, but that this decrease was due to declines in space heating, while energy use for water heating, cooling, and appliances all increased (Rio et al., 2022). This study also demonstrated that household energy use in the metropolitan core (5 boroughs of NYC) was lower than those in the outlying suburban areas.

Electrification of the city's housing stock will bring reductions in air pollution (Urban Green Council, 2021). However, there are important energy use differences between multi-unit and single and two-family buildings. The Department of Energy collects residential energy consumption data regularly at about 4-year intervals in the Residential Energy Consumption Survey (RECS). The data are divided into census regions and averaged. The Northeast Region includes New York State. The most recent survey presents data on the average energy consumption by housing type, both by household and square footage demonstrates differences in energy use between single family (detached and attached) housing and other types of buildings and also between owned and rented users. For example, within the Northeast region, average household energy use for single family detached housing is approximately 120.7 million Btu annually (

Table 2). Alternatively, the average energy use for households living in apartments buildings with 5 or more units is 36.2 million Btu, or over 3-fold less. On the other hand, among all household types, energy use per floor space is larger for units in apartment buildings with 2-4 units. While the energy use of renters is less than that of building owners, the lower use of energy in apartment versus single family households remains similar across these categories.

Table 2. Summary of annual household energy consumption in the Northeast USA, 2020. Source: DOE EIA RECS (2023b).

All homes	Total Northeast	Total (trillion Btu)	Per household (million Btu)	Per household member (million Btu)	Per ft^2 (thousand Btu)
Housing unit type					
Single-family detached	11.23	1,355	120.7	45.6	47.9
Single-family attached	1.95	167	85.4	31.7	47.4
Apartments in buildings with 2-4 units	3.15	214	68.0	27.2	65.4
Apartments in buildings with 5 or more units	5.10	184	36.2	19.9	41.6
Mobile homes	0.50	36	72.1	31.4	66.7
Ownership of housing rent					
Owned	13.77	1,526	110.8	43.0	47.9
Single-family	11.89	1,402	117.9	45.3	47.3
Apartments	1.50	96	64.0	26.7	54.6
Mobile homes	0.38	28	74.1	31.8	63.9
Rented	8.15	430	52.7	24.2	52.5
Single-family	1.29	120	92.9	30.2	55.8
Apartments	6.74	302	44.8	22.3	50.8
Mobile homes	0.12	8	65.6	29.8	79.0

Major trends in the NYC building sector include policy driven efficiencies, but there are environmental justice concerns about these efforts. Most NYC residents (more than 60%) live in multi-family buildings. While multifamily buildings in general tend to use less energy per capita than other residential buildings, most of the existing residential building stock in NYC pre-dates energy codes, uses inefficient, centralized fossil-fuel based heating systems, primarily steam, and has little insulation. Electrification and deep decarbonization is especially challenging for several reasons: (1) heat pumps may require additional electrical service, (2) electricity costs may be higher than fossil-fuels so that even when equipment efficiency is improved, utility costs could rise, and (3) insulating the building to compensate for rising costs is especially difficult for lot-line and masonry buildings typical in NYC. Furthermore, heat pumps provide both heating and cooling, which can introduce a shifting of utility costs from owners to tenants and is difficult to regulate. Electrification at scale will result in increasing grid demand which could lead to power outages in the winter. Current laws are targeting large buildings, including residential buildings, which already demonstrate high levels of efficiency rather than targeting single and 2-family buildings. Over 30% of building emissions are from these smaller residences and they house about half of the those living in larger apartment buildings. Moreover, the evaluation of energy uses the ENERGY STAR evaluation technique (U.S. Environmental Protection Agency, 2021). Including floor area may not demonstrate the same significant differences as per person. Using floor area can misrepresent the relative energy consumption in heating large floor areas, particularly for small households (and pied-à-terre investments). Even if heating the large space per floor area was equal to that of something smaller, the overall energy use would be higher than the smaller space. A more equitable comparison, therefore, would be per person. Finally, it can be more difficult to retrofit (e.g., to electrify or complete energy-efficient projects in) multifamily buildings than private homes because of the way the building is managed, or the way costs are allocated across owners, tenants, and shareholders. Efforts to electrify building systems may increase the cost of heat, hot water, and cooking for residents, and the consequence of electrifying buildings at scale may result in increasing demand in the winter, when extreme weather and storms present challenges to reliability distinct from summer heat waves.

3.5.2 Transportation

NYC has a massive transportation network comprised of several discrete but interconnected systems, including private and public vehicles and ferries, subways and heavy rail systems, and a growing bicycle and micro-mobility infrastructure.

Roads and private passenger vehicles: In 2021, there were over 2 million registered motor vehicles in NYC (Komanoff, 2023). On an average day, 34.6 million vehicles use bridges and tunnels, and 715,000 cars enter Manhattan. Prior to the pandemic, approximately 100,000 Taxi and for hire vehicles made approximately 315.9 million annual trips (NYC DOT, 2019).

Of the 3.1 million households in the city, approximately 1.4 million households (45 percent) own a car. About 3 percent of households own three or more cars. Ownership is lowest in Manhattan (22 percent) and highest in Staten Island (83 percent). Queens ownership (62%) is also above the city average, while the Bronx (40 percent) and Brooklyn (44 percent) look more like the city as a whole (NYC EDC, 2018).

In 2021, on-road vehicles used approximately 14.1 percent of the city's total final energy use (City of New York Mayor's Office of Climate & Environmental Justice, 2022) possibly an underestimation as energy used in segments of trips outside the city boundaries may be excluded). At the same time, on-road vehicles use over 83.4 percent of the liquid fuel (petroleum) used in the city. The total energy from fuel oils in the on-road transport sector declined from 244 TBtu in 2005 to 226 TBtu in 2021. During this period, private passenger car energy use declined from 229 TBtu to approximately 214 TBtu (City of New York Mayor's Office of Climate & Environmental Justice, 2022).

The city is currently installing congestion pricing infrastructure for Manhattan's Central Business District. Scholars debate environmental justice with congestion pricing focused on whether there are disproportionate burdens on low-income drivers. Studies have demonstrated that wealthy drivers are less burdened than those that spend a larger share of their income on transportation energy use (Chronopoulos, 2012; Hosford et al., 2021). While congestion pricing can have regressive effects, these can be balanced through the redistributed benefits to public transit (Eliasson & Mattsson, 2006; Levinson, 2010). Increased public transit and reduced car traffic also have health benefits through reduced air pollution, which disproportionately affects the urban poor (Levinson, 2010; Manville & Goldman, 2018) depending upon how the improvements are geographically distributed (Anas & Lindsey, 2011) A review of the impacts of congestion pricing found greater benefits inside tolling zones than outside, but there is a lack of studies on the relative socio-demographic makeup of beneficiaries (Hosford et al., 2021). Congestion pricing should be designed with clear equity objectives such as directing funding to improve transit in EJ transit-desert communities, which is currently part of the fund split among involved transportation agencies (Litman, 2023; Slevin, 2019).

Public transit: The New York City Transit Authority (NYCTA, publicly known as MTA New York City Transit as part of the Metropolitan Transportation Authority) operates roughly 5,900 buses within NYC. These buses move 2.2 million people on an average weekday or about 678 million people annually across 234 local, 20 Select Bus Service and 73 Express Bus Routes in the city. All of the MTA buses are wheelchair accessible. NYC's bus system carries more passengers than Los Angeles, Chicago and San Francisco's systems (the 2nd, 3rd and 4th largest in the country) combined. The MTA Bus Company was created in early 2005 to take over routes from private bus operators; plans are to eventually merge the MTA New York City Transit buses with MTA Bus (MTA, 2022).

NYC is known for its subway that operates on a 24 hour-7 day a week schedule. The subway system includes 6,684 subway cars, 472 stations and 248 miles (399 km) of routes (Foran & Kane, 2019). The system moves approximately 1.7 billion people annually. The NYC system has the world's largest number of stations (CityMetric, 2015). The subway system operates largely on electricity. Generally, the system used approximately 15 TBtu which has been stable from 2005 to 2021. There was a significant drop during COVID19 (2020) when the subway electricity energy fell to 12.6 TBtu for the year. It rebounded in 2021 to 13.6 TBtu (City of New York Mayor's Office of Climate & Environmental Justice, 2022; CityMetric, 2015).

Freight: Freight arrives in NYC through air, ship, rail, truck or combination any of the modes and moves through a system of highways, marine terminals, rail lines and yards, airports and distributions centers. In 2016, 198 million tons of freight passed through NYC, including industrial inputs and various manufactured products (26%), followed by consumer products (22%), construction materials (17%) fuels (16%), food (10%) and waste and scrap (9%) (New York City Economic Development Corporation, 2018). There are 8 freight hubs and three marine terminals in the city. The hubs are located within each borough with 2 in Queens and Staten Island. Some freight hubs directly connect to the national rail network and others, like the freight hub in the Bronx, connect to USDOT's marine highway network via the East River and Long Island Sound. The marine terminals include GCT New York in Staten Island, Red Hook Container Terminal in Brooklyn, and the South Brooklyn Marine Terminal also in Brooklyn. About 8 percent of the city's freight arrives through these terminals annually.

NYC has over 90 miles of rail freight track and 9 railyards that connect the city to the national rail network. The freight rail network runs through the Bronx and connects to Queens and Brooklyn. A separate railway runs in Staten Island. Approximately 70,000 freight rail cars move through NYC each year (equivalent to 280,000 trucks). Total rail freight handles about 2% of the city's total freight (New York City Economic Development Corporation, 2018).

Most freight movement (90%) is across the road network, through the use of trucks. An average of 120,429 trucks crossed into or out of NYC every day. At the borough level, the most trucks cross the Queens boundary (130,300), followed by Manhattan (125,600), the Bronx (103,600), Brooklyn (73,500), and Staten Island (26,400). The top three zip codes for daily freight deliveries and shipments are located in Midtown Manhattan, next to the Lincoln Tunnel (City of New York Department of Transportation, 2021). A significant proportion of the freight traffic is destined to residential buildings. Approximately 45 percent of New Yorkers received a delivery of some kind at their home at least once a week with the top five orders categories of groceries and gourmet food, home and kitchen, health and beauty, electronics and accessories, and apparel and accessories (City of New York Department of Transportation, 2021).

3.5.2.1 Transportation trends

As the city is working towards a transportation energy transition, two different but important trends are emerging. First, trends in motor vehicle ownership and use are shifting. Both passenger car and truck volume have increased in NYC. Passenger car registration has increased, as automobile-ownership increase can be seen across boroughs. From 2012 to 2021, the number of registered vehicles grew by 52,000 in the Bronx (22%), 59,000 in Queens (8.4%), 66,000 in Brooklyn (13%), 23,000 in Manhattan (13%) and 23,000 in Staten Island (10%). At the same time, the share of city households reporting zero motor vehicles in 2021, 53.9 percent, was down from 56.5 percent in 2012. Three boroughs — Bronx, Brooklyn and Manhattan — are still majority-car-free, but the share of car-free households dipped by two to three percentage points in every borough (Komanoff, 2023). Overall, traffic volumes have grown by 12% between 2015-2018. (Komanoff, 2023).

Increasing vehicle ownership and use has been encouraged by lower gas prices over the course of several years and Uber and Lyft's ascendency in the shared ride industry. Uber's ascendancy more than doubled for-hire drivers from 47,000 in 2013 to 103,000 in 2018 (Hu, 2018) likely accounting for a percentage of the overall 223,500 rise in five-borough registered vehicles during the seven-year period (Komanoff, 2023). Government policies have encouraged car ownership, such as the Bus rapid transit program that never took flight, the 7-line extension and the new Second Avenue Subway together contributed only a few miles of track and curbside parking pricing that never was implemented in the city (Komanoff, 2023).

Truck traffic volumes have grown faster than passenger car volumes. Truck use in NYC has grown by 21% between 2015 and 2018. During this period, small, single unit 2-axle trucks accounted for more than 50 percent of the growth in truck volumes. The increase in truck volume can been seen in the major bridge and tunnel crossings between New York and New Jersey, where truck volume increased at a faster rate than automobile volumes (New York City Economic Development Corporation, 2018).

Truck freight traffic has experienced an increase due to the dynamics of the e-commerce sector, which has exploded over the last decade with consumer demand for online goods surging by over 33% between 2019 and 2020 alone (Brewster, 2022). E-commerce has grown, on average, 15 percent annually since 2009 and will account for 15 percent of all retail commerce by 2020. Market researchers estimate that more than 500 million packages were delivered to NYC in 2018, up 13 percent from 2017 (City of New York Department of Transportation, 2021). Increasing demand for online goods and retail same- or next-day services have encouraged the development of "last-mile" warehouses. These structures are for the final stage of delivery, from which items are shipped to the customer's doorstep. High concentrations of last-mile warehouses impact air quality, GHG emissions, and noise pollution due to high numbers of truck trips, the use of diesel fuels by these trucks (which emit high levels of particular matter and nitrous oxides) (U.S. DOT, 2023). the large square footage needed to house items and the hours of operation (sometime 24 hours a day, 7 days a week). These structures are disproportionately located within lower income communities and communities of color (Nowlan, 2023). In NYC last-mile warehouses can currently be built directly adjacent to residential neighborhoods predominantly communities of color and lower-income communities, without any review or mitigation of traffic, public safety, or air quality impacts (Last Mile Coalition, 2023).

Industrial traffic is also important. Within industrial business zones (IBZs), the busiest truck destinations include JFK Airport, Hunts Point, North Brooklyn, Maspeth, and Southwest Brooklyn with seven industries (retail, wholesale, accommodation and food services, modal transportation, construction, and health care) accounting for 84 percent of freight deliveries. The exact type of industrial traffic, however, varies by borough (City of New York Department of Transportation, 2021). The highest number of truck volumes during morning and evening peak periods are the Goethals Bridge (connecting Staten Island to New Jersey), the Major Deegan Expressway (connecting the Bronx to Yonkers), the Cross-Bronx Expressway, and the Throgs Neck Bridge. Many of the communities in these parts of the cities are under-served, communities of color.

The city has under-invested in rail, maritime, and distribution infrastructure while freight volumes are projected to grow 68 percent by 2045 (New York City Economic Development Corporation, 2018).

As the city intends to electrify transportation, including these new trends will put additional demand on the grid, which may affect reliability during periods of peak demand, particularly in load pockets where local electric distribution infrastructure is insufficient.

While passenger car travel and freight have increased, there have also been positive trends in transit and non-motorized vehicle transport. From 2010 to 2017, subway ridership also increased from 1.60 to 1.73 million; bus ridership dropped from 817 to 724 million during the same period. During 2020, however, due to COVID19, subway ridership plunged to 640,000 people, or a drop of a third, from pre-pandemic levels in 2020 (Metropolitan Transportation Authority, 2020). Ridership increased to 760,000 for 2021, which was about 48% of pre-pandemic levels. A 2023 snapshot found that subways ridership was at 67% of pre-pandemic levels as of February of 2023, suggesting that some pandemic trends will persist into the future (NYC Comptroller, 2023). The bus system has undergone a similar trend with a drop of121 million rides in 2019 to 66,000 in 2020 or 46% of pre-pandemic levels. Ridership increased to 71,000 in 2021 and a 2023 snap shot showed an increase to 65% of pre-pandemic levels (Metropolitan Transportation Authority, 2020; NYC Comptroller, 2023). Generally, NYC has an enormous and effective mass transit system. (NYC Comptroller, 2023). This system is conducive to lowering transportation energy use, increasing air quality and improving health. How the transit system evolves in the future will help to determine efforts to reduce emissions and improve air quality and health for all New Yorkers, but particularly for middle- and low-income residents that depend upon these relatively cheap transportation modes.

Another important trend related to non-motorized traffic is the dramatic increase in micromobility. E-Bikes now crisscross New York Streets as riders deliver goods, including food, drink, and other services. Micromobility trends are new, in part, to new EV bike laws. As of November 23, 2020, all e-bikes (Classes 1-3) are legal. Moreover, the city has expanded the number and safety of bike lanes. NYC DOT is on track to install a record number of protected bike lanes in 2023, to harden more than 10 miles of existing bike lanes, and to use sturdier materials in new bike lanes. NYC DOT will also launch a public awareness campaign on the safe operation of e-bikes (NYC DOT, 2023). Bicycle ridership grew from 250,000 a day to 490,000 a day from 2010 to 2017 (NYC DOT, 2019).

3.5.3 Industry

New York's industrial energy use ranks 30th among states (U.S. Energy Information Administration, 2021c). In 2021, in NYC, industrial energy use accounted for approximately 8.7% of total energy use (City of New York Mayor's Office of Climate & Environmental Justice, 2022) while the share of industrial energy use for the nation was 32.4% (U.S. Energy Information Administration, 2021c). After decades of employment losses in the NYC industry, however, the sector has stabilized and is growing again. Between 2011 and 2014, the city registered a net gain of 880 manufacturing jobs (a 1.2% increase) while New York State lost 6,615 manufacturing jobs (a 1.4 percent decline) (Bowles, 2015). While NYC lost 83,100 jobs, due in large part to COVID19. (Bowles, 2015), by 2021, the city gained 349,800 jobs in manufacturing (NYS BLMI, 2021). Thus, as many cheaper and lower-paying manufacturing jobs continue to relocate overseas, NYC has seen a corresponding rise in technical manufacturing. This includes computer products, mobile devices, video games, 3-D printing, and general software engineering tools. These jobs tend to pay well above the average state wage (Ross, 2021).

A recent study of the city's economy states that there are 11 significant industries[4] in NYC and most are in business services (NYS BLMI, 2021). They include heavy and civil engineering construction; couriers and messengers; warehousing and storage; other information services; securities, commodity contracts, investments; professional, scientific and technical services; administrative and support services; educational services; ambulatory health care services; social assistance'; and food service and drinking places. Most of the jobs in these industries are in service or the tertiary economic sector. Many of these activities take place in commercial buildings and are therefore accounted for in the commercial sector. Second, while manufacturing industries such as food manufacturing, apparel, fabricated metal product manufacturing, furniture and related product manufacturing, nonmetallic mineral product manufacturing, and plastics and rubber product manufacturing are still important employers, they make a small percentage of the total city labor force; 1.2% (City of New York Department of Labor, 2023). In 2021, the commercial sector in NYC used approximately 33% of total final energy use for the city, while manufacturing was responsible for only 8.7% of total final energy use. During that year, industry used 16.7% of all electricity, 8% of natural gas, 16.3% of

[4] An industry was designated as "significant" by the US Bureau of Labor Statistics with reference to the following characteristics: 1) The industry experienced above-average job growth (in either net or percentage terms); or 2) The industry had more than 150,000 jobs; or 3) The industry's projected employment growth for 2018-2028 was above average in the region (+12.2%); or 4) The industry paid above-average annual wages for the region ($106,300).

steam and less than 1% of liquid fuel use (City of New York Mayor's Office of Climate & Environmental Justice, 2022).

The New York economy is globally oriented, encouraging the concentration of global business and other services (e.g., financial markets). The service sector is a lower energy-consuming sector than manufacturing. Consequently, New York State accounted for about 6% of the U.S. population in 2016, but it consumed only 1% of the country's industrial energy (U.S. Energy Information Administration, 2021b).This is also a reason why NYC's emissions per capita are among the lowest among cities in the nation (Berger, 2019).This is not to suggest that manufacturing is not an important component of the labor market. Manufacturing offers avenues for low-skilled workers to gain employment and skills as well as jobs for middle-class workers (Bowles, 2015). In terms of environmental justice, the challenge is to secure equitable job opportunities in these industries for low-income and under-served community residents.

Energy policies for these industries have environmental justice implications as there are many jobs in commercial industries that are low-wage, low-skills (i.e., janitorial, fast-food service, hotel housekeeping service, etc.). Policies to reduce energy in these industries must consider how costs will be borne for these employees. Manufacturing, alternatively, provides opportunities for the middle class and skilled work.

3.6 Summary

New York State has a large economy significantly driven by activities in NYC. At the same time, however, it is also an energy efficient state, again helped by high energy efficiency in NYC. The energy system in NYC is massive and complex, providing reliable energy for residential, commercial, transportation and industrial uses. The system is also undergoing a transition, driven by the need to provide clean energy and reduce climate change. The energy transition, however, does not guarantee that the future energy system will be sustainable, as there is a need to be mindful of institutionalized environmental injustices.

Electrifying our buildings and transportation, building new renewable energy and storage infrastructure, and emphasizing energy efficiencies must be approached with consideration of the current inequitable access to the benefits, and burdens of the energy system on some communities and the projected impacts of climate change. This is all the more important as those communities that contribute the least to climate change are burdened the most by its effects.

Electrification of the energy system with clean renewable energy, the use of heat pumps in homes and apartments, and the proliferation of clean electric vehicles will go a long way to reducing GHG emissions, improving air quality and improving the general health and well-being of the city residents. The transition is necessary to fight the existential threat of climate change. However, the transition must also include attention to the inequitable access to resources, burdens, and opportunities across NYC neighborhoods. For example, as pointed out trends in the transportation sector are moving away from the city's climate goals. Bringing transportation trends back into line should be accomplished equitably, allowing all who want electric vehicles access to charging stations, and all who desire other modes of mobility the ability to do so safely (i.e., walking, biking, using public transit). Abrupt changes or hasty decisions in energy policy can inadvertently exacerbate energy insecurity and health disparities, particularly for those already marginalized. For instance, the closing of Indian Point without a viable alternative energy source for electricity disproportionately impacted low-income households and underserved communities through increased prices of energy.

The next section provides an overview of 'energy insecurity' that captures these conditions and challenges and demonstrates why a holistic approach, taking into account energy insecurity and health implications is warranted to ensure a just and sustainable energy transition that benefits all.

4 Opportunities and Challenges to achieving the city's CLCPA and LL97 Goals

NYC and State, with their commitment to the CLCPA and Local Law 97 (LL97), are positioned to lead the nation in transitioning to a more sustainable energy system. This shift includes a strategic move from gas to electricity in buildings, underscored by the city's building electrification law (Local Law 154, 2021), and heightened building efficiency driven by LL97 (Local Law 97, 2019). Fuel power sources can be replaced with renewables including solar, wind, and hydropower. Annual fuel oil energy use is over 7% of total residential energy fossil fuel use and natural gas use is over 75% of total residential fossil fuel use for NYC. Together these account for over 212 trillion Btu of residential energy use annually. To achieve the goal of total electrification, the current grid will need to dramatically change. By 2030, New York will need to more than double the share of the electricity generated from wind, sun, and water to 70% (Barnard & Ashford, 2021). However, one estimate suggests that solar alone could only power up to 14% of the city's current total annual electricity use (Murphy et al., 2019; Navarro, 2011). Moreover, renewable generation projects have tradeoffs. For example, certain stakeholders argue that the energy brought to NYC by CHPE is not clean (has associated GHG emissions) and the CHPE project will impact river and lake biodiversity and take land from indigenous people (Center for Biological Diversity, 2020; Deng, 2023; New York Independent System Operator, 2022; Riverkeeper, 2023). According to the NYISO, reliability concerns emerge as early as 2025, as 'peaker' plants are scheduled to close and these issues will increase if the CHPE project is delayed (Energyzt Advisors, LLC, 2020; New York Independent System Operator, 2022; New York State Energy Research and Development Authority, 2022a).

Why should NYC's energy transition be approached with caution? This transition offers a unique opportunity for NYC to become a model for energy efficiency with a focus on equity, particularly considering the CLCPA's requirement that disadvantaged community groups receive 40% percent of overall benefits of spending on clean energy and energy efficiency programs, projects or investments (CLCPA, 2019). To realize this equity-oriented goal, electrifying our buildings, transportation and building new renewable energy infrastructure as outlined in the above sections should be approached with caution and a mindful consideration of the potential inequitable access to the benefits, or possibly overall improvements at the cost of marginalized populations, who may be further disenfranchised in the process. For example, as NYC has gotten warmer, the essential energy services needed to protect health have changed, while the inequitable access to energy services has not. Access to adequate air conditioning has grown to become nearly ubiquitous in commercial establishments, and highly prevalent in middle- and upper- income households, while low-income households, communities and people of color continue to be much more likely to lack air conditioning or the means to pay to turn it on (City of New York Department of Health and Mental Hygiene, 2022d; Cong et al., 2022a; Consolidated Edison Company of New York, Inc, 2022a, 2022c; Dominianni, Lane, et al., 2018; Jessel et al., 2019; Madrigano et al., 2018; Maldonado, 2022; Mukherjee et al., 2018; New York State Energy Research and Development Authority, 2023a; Ortiz et al., 2022; Stone et al., 2021; Zimmerman et al., 2019). While the resilience of electricity grids varies regionally and generally has improved in the northeast in recent years (Shen et al., 2018), in June 2021, a major electricity outage during a heat wave was narrowly averted, and many neighborhoods, the majority of which were in Brooklyn with the largest outage occurring in Williamsburg, were affected by localized outages and voltage reductions (Noor, 2021). At times when electric demand is high and could threaten overall grid reliability, utilities may intentionally reduce customer supply voltage to reduce the overall electric load. In July 2019, at the tail end of a severe heat wave, ConEd cut off power to more than 30,000 customers in a high heat vulnerability index neighborhood to avert a wider blackout in the city from high demand and grid strain (Perper, 2019).

The urgency to transition to renewable energy cannot be overstated. The adoption of renewable energy is crucial not only to mitigate the impacts of climate change but also to rectify the longstanding injustices of the current energy system. A transition to renewable energy offers an opportunity to address systemic inequities laden in the current energy system, improving health outcomes and economic stability for those most affected by the existing disparities. However, this crucial transition must be done in a manner that considers both the possible scenarios brought about by worsening climate change, as well as the reality of inequitable access to resources across marginalized populations. Abrupt changes or hasty decisions in energy policy can inadvertently exacerbate energy insecurity and health disparities, particularly for those already marginalized. For instance, sudden increases in energy prices or the closure of traditional energy sources without viable alternatives can disproportionately impact low-income households and underserved communities. The next section provides an overview of 'energy insecurity' that captures these possibilities, and demonstrates why a careful and holistic approach, considering energy insecurity and health implications is warranted to ensure a just and sustainable energy transition that benefits all. A carefully considered approach does not mean a slow transition. Instead, it implies a thoughtful, inclusive strategy that rapidly advances adoption of renewables while ensuring equitable benefits and mitigating risks for marginalized populations.

5 Energy Insecurity (EI): Health Impacts and Vulnerabilities

5.1 Introduction: EI at Household and Community Levels

The World Health Organization (WHO) notes the underappreciated importance of energy to global health: "Energy is essential to meet our basic needs: cooking, boiling water, lighting, and heating. It is also a prerequisite for good health -- a reality that has been largely ignored by the world community" (Rehfuess & World Health Organization, 2006). In the US, one in three households have energy insecurity[5], meaning they are unable to adequately meet their energy needs. The three main dimensions of household energy insecurity are physical (due to substandard built

[5] For an in-depth discussion about the differences between various terminology used to characterize energy-related hardship, such as 'fuel poverty', 'energy burden', and 'energy poverty', please refer to Hernández et al., 2022.

environment of the household), economic (financial burdens that high energy expenditures impose), and behavioral (strategies to cope with the economic and physical dimensions of energy insecurity), all of which are associated with environmental, health, and social consequences (Hernández, 2016a; Yoon & Hernández, 2021) (**Error! Reference source not found.** 6). The context for energy insecurity's influence on health in NYC and in the US is different from that in countries where many lack access to reliable, modern energy services for basic needs (IEA et al., 2022). In countries with more extensive physical infrastructure and for many decades in the US, widely available household energy services have provided telecommunications, refrigeration, air conditioning, and plumbed hot water. However, even when these appliances are available, not everyone may be able to access or use them. For example, if a household owns an air conditioner but cannot afford to run it, its health benefits will not be realized, and negative health impacts could occur (City of New York Department of Health and Mental Hygiene, 2023a). Researchers have also recognized that more widespread adoption of AC will further increase electricity demand (see NPCC4, Balk et al (Balk et al., 2024), and so policies to expand air conditioning ownership and use could also be accompanied by measures to reduce the need to use AC in both residential and commercial buildings. Households may also experience utility disconnections for non-payment, which can be life threatening (Haag, 2018). In the context of climate change impacts on vulnerable US populations, the need for more research and interventions to address energy insecurity has long been recognized (Hernández, 2013).

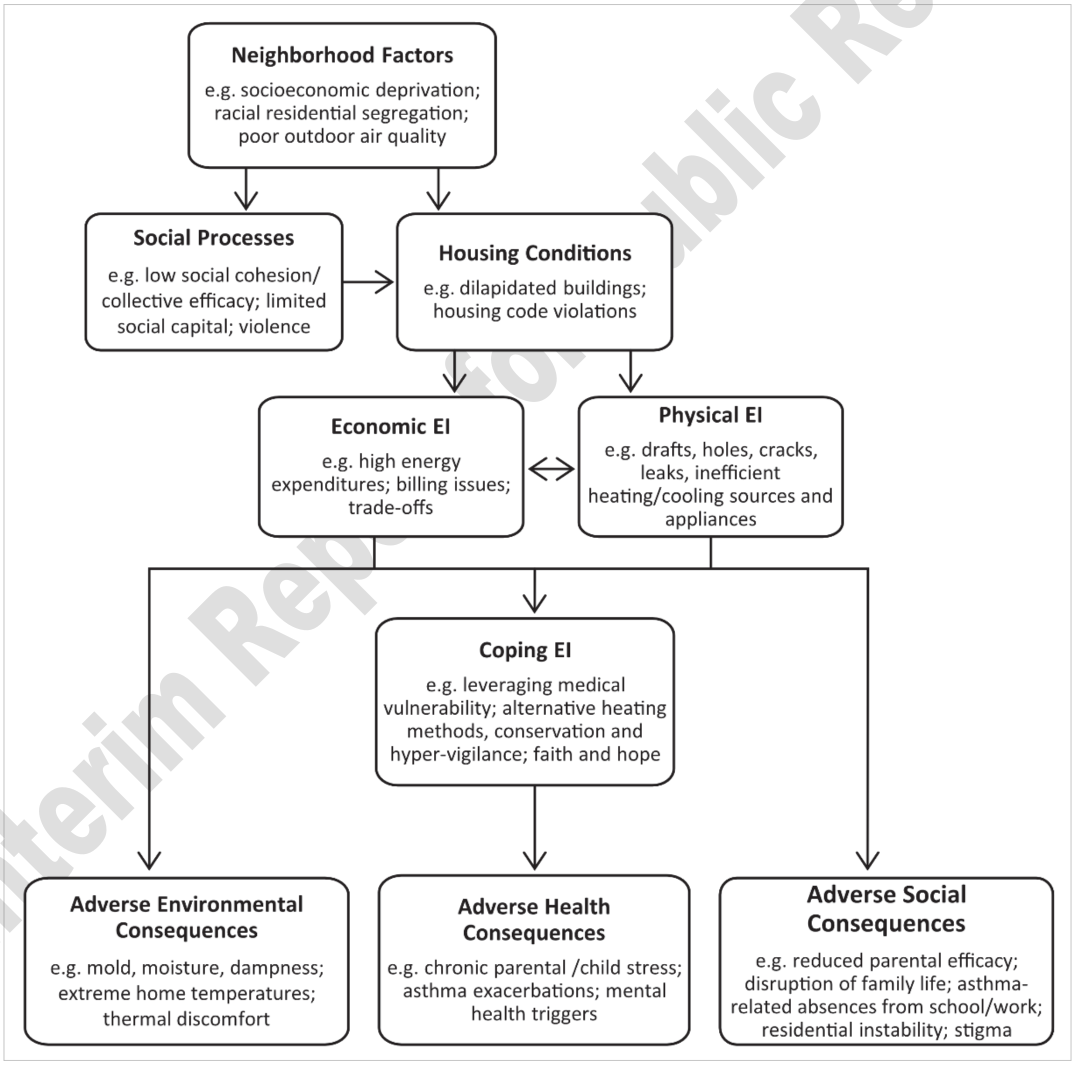

Figure 6. Energy insecurity: a pathway to disease and disadvantage. Source: (Hernández, 2016b, fig. 1)

This assessment also considers community-level energy insecurity in NYC, meaning energy infrastructure and energy services in buildings that do not reliably meet essential community needs. Analogous to household energy insecurity, community energy insecurity has physical, economic, and behavioral dimensions. These relate, respectively, to the physical robustness of the energy supply, local distribution infrastructure, and vulnerability to outages caused by extreme weather or equipment failure; the economic dimensions of energy markets and regulations that affect the distribution of costs among energy uses and communities; and behavioral factors that influence energy consumption, costs, and reliability at the community level.

For under-resourced NYC households and communities, energy insecurity often reflects not a lack of access, but high cost burden, inefficient housing and appliances, and infrastructure prone to outages (Hernández, 2018; Hernández & Siegel, 2019; Kontokosta et al., 2020) - despite living in a state and country where most have had modern, affordable energy for generations.

Research about household and community-level energy insecurity and its implications for health is still developing. More information on the national and international dimensions of energy insecurity and power outages can be found in some recent scholarly reviews which helped inform this assessment (Casey et al., 2020; Hernández, 2016a; Hernández & Siegel, 2019; Jessel et al., 2019). More on the global and historical context of energy insecurity is Annex A.

5.2 What Are the Health Impacts of EI In New York City?

5.2.1 Household EI

Essential daily life activities such as cooking food, lighting a home, staying warm in the winter and cool in the summer, and sleeping and working in adequate thermal comfort are only possible when a household is energy secure. A compromise to any of these activities brings health consequences.

Inadequate heat is one of the leading causes of 311 calls from low-income communities across the city (Donavan, 2022; Office of the New York City Comptroller, 2023). Living in a cold home has pervasive adverse health effects for people of all ages, including respiratory problems in children, arthritis and rheumatism, and mental health challenges (Dear & McMichael, 2011) as well as indirect long-term effects such as negatively affecting educational attainment, emotional resilience, and forcing nutritional and other compromises to alleviate the financial burden of heating a poorly insulated home (University College et al., 2011). Energy insecurity is associated with household food insecurity, and for children, poorer overall health and greater risks of developmental problems and hospitalizations (Cook et al., 2008).

Locally, a study in Washington Heights found that energy insecurity was significantly associated with poor respiratory health (e.g., asthma, pneumonia), mental health, and sleep outcomes (Hernández & Siegel, 2019). Energy Insecurity may harm respiratory health through coping mechanisms such as using gas stoves for heat, releasing indoor air pollutants, including nitrogen dioxide and potentially deadly carbon monoxide. Candles (Schwirtz & Vadukul, 2013), stoves, and space heaters create fire risks. Heating equipment is the leading national cause of home fires (R. Campbell, 2021); a malfunctioning space heater ignited a devastating Bronx apartment fire in January 2022, killing 17 New Yorkers (Hernández, 2022). A study of low-income households in the South Bronx showed the complex ways energy insecurity interacts with other factors to harm health; overlapping economic hardship, poor quality housing, and physical health challenges contributed to stress and coping behaviors that increased cost and exacerbated stress (Hernández et al., 2016).

Energy insecurity is a national issue that has received growing media attention in recent decades, often associated with climate change coverage, considering adverse health impacts from both extreme heat as it was with extreme cold, and variation in emphasis by region (Yoon & Hernández, 2021).

5.2.2 Community EI: power outages

In the 2021-2022 heat season (October 1, 2021 to May 31, 2022), utility outages, including power, gas and water, have increased to 3605 compared to 2872 from the previous heat season (Cerro, 2023). Whether caused by extreme weather events, infrastructure failures, or inadequate supply, utility outages have adverse and deadly health impacts. For example, prolonged gas outages in NYCHA complexes in Red Hook forced residents to forego meals or spend hundreds of dollars on take-out food on already tight budgets (Sandoval, 2021). While all utility outages can have adverse health impacts, most prominently researched among them are power outages. An August 2003 blackout affecting the northeast – during warm but not extremely hot weather – and lasting less than two days, caused a 25% increase for non-accidental cause deaths and an overall increase of 28%, or roughly 90 excess deaths in NYC alone (Anderson & Bell, 2012b).

Hurricane Maria likely caused more than 5,000 excess deaths in Puerto Rico during the months after storm impact; massive infrastructure damage, a prolonged lack of access to electricity, and interruption of medical care caused many more deaths than the official direct count of 64 (Kishore et al., 2018). On average, households went 84 days without electricity, which had wide detrimental impacts, such as the inability to use medical equipment that required electricity (Kishore et al., 2018). These large-scale power outages highlight all the more the existing environmental justice issues disproportionately burdening certain communities, such as those experiencing economic hardship, chronic health conditions, and rural populations (Andrade et al., 2022; Niles & Contreras, 2019).

The Texas power outage of February 2021 – the worst in the state's history – demonstrated how deadly cold weather blackouts can be (while also illustrating aspects unique to the Texas system, such as energy landscape and housing infrastructure). An initial estimate of deaths directly caused by the outage – 246 (Hellerstedt, 2021) – was much lower than a more complete estimate of 702 excess deaths (Aldous et al., 2021; Buchele, 2022). NYC's very different housing stock would mitigate some of the risks faced in Texas and amplify others. For example, while carbon monoxide (CO) poisoning from portable generator use constitutes the majority of adverse health outcomes linked to power outage (Johnson-Arbor et al., 2014; Worsham et al., 2022), NYC may see less CO poisoning and cold-related mortality as high-density multi-unit residential building residents are less likely to have, and run, a portable generator and are better able to retain heat during a power outage (Urban Green Council, 2014). However, urban dwellers – particularly the elderly, the chronically ill and the poor – nevertheless face challenges in accessing safe, backup power (Mango et al., 2021).

In addition to deaths from widespread outages, a range of health outcomes have been linked to power outages of various sizes. Limitations of available data on small outages likely mean health impacts are missed or underestimated. Nonetheless, localized power outages in NYC were associated with increased mortality from all causes and with more cardiovascular disease hospital admissions when they occurred during cold weather and with renal disease hospitalizations during the warm season (Dominianni, Lane, et al., 2018). Power outages in New York State have been linked to increased chronic obstructive pulmonary disease (COPD) hospitalizations, gastrointestinal illness (Marx et al., 2006), respiratory illness (Prezant et al., 2005), and food and water-borne diseases, comorbidity and medical costs (Lin et al., 2021; W. Zhang et al., 2020). One review found evidence that power outages of various scales can cause carbon monoxide poisoning, temperature-related illness, gastrointestinal illness, as well as increases in natural cause mortality and hospitalizations (Casey et al., 2020). Following Super Storm Sandy, there was a large increase in calls to the New York poison center for carbon monoxide poisoning, with indoor grilling and generator use accounting for a substantial share of cases (Chen et al., 2013). This and other power outage-related exposures may have contributed to excess mortality in the weeks following the storm, which increased up to 30% compared to the same period in 2010-2011 (Howland et al., 2015).

5.2.3 Individual and social vulnerability

5.2.3.1 Household energy insecurity

Energy insecurity has been recognized as a 'mediator' between structural conditions of disadvantage, environmental exposures, and poor health (Figure 7) (Hernández, 2016a; Jessel et al., 2019). Individual, social, and physical environmental factors all influence one's ability to access and afford essential energy. Energy insecurity disproportionately affects those marginalized along race and class lines through mediating factors of poverty, discrimination, and structural neglect resulting from a history of segregation, redlining, and housing disinvestment (Lewis et al., 2019). Economic and social barriers to investment in housing and energy efficiency contribute to disproportionate energy cost burdens for people of color across income levels. Those with disabilities or existing conditions that necessitate reliance on electric medical equipment are also rendered at disproportionate risk (Friedman, 2022). As such, many face intersecting and compounding burdens, such as those with worse baseline or lack of access to healthcare who are unable to refrigerate their medication during a power outage (Mango et al., 2021).

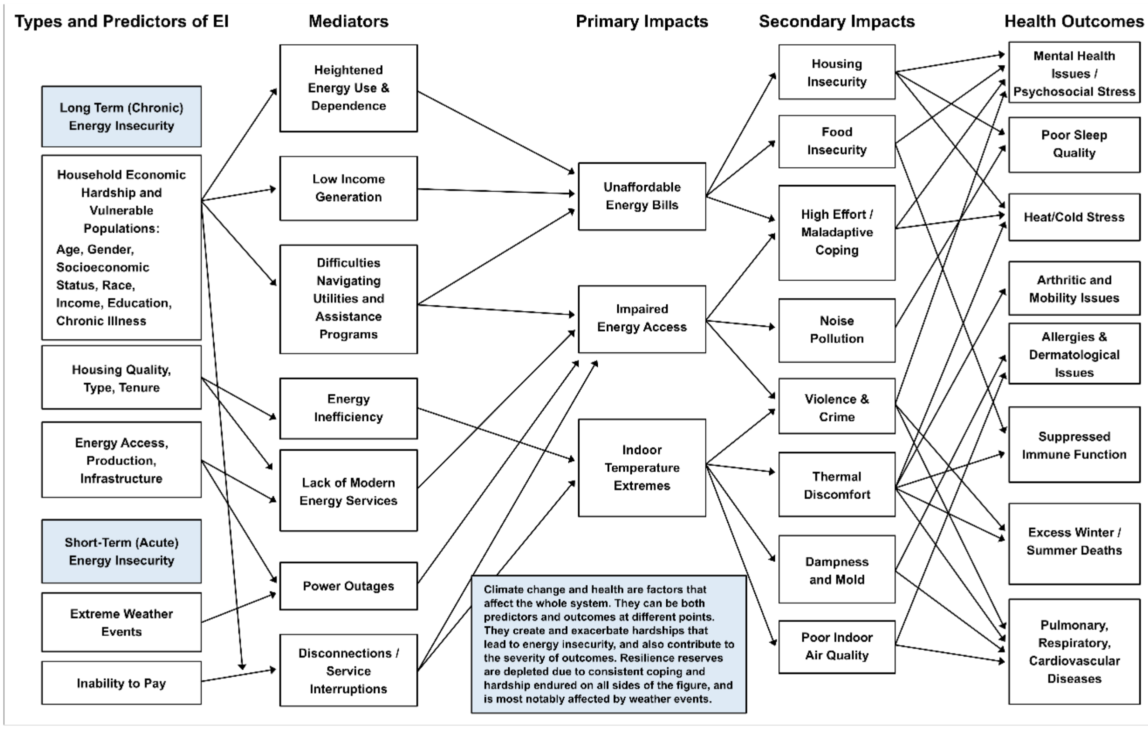

Figure 7. Connection Between Household Energy Insecurity (EI) and Health. Source: (Jessel et al., 2019, fig. 2)

Strong associations of social and economic disadvantage with energy insecurity are consistent; absolute estimates can vary with definitions and methods. Nationally, energy insecurity is patterned by socioeconomic status, race, age, and housing condition (U.S. Energy Information Administration, 2020); 82% of those 50% under the federal poverty line experience energy insecurity (Hernández et al., 2014). Energy insecurity is more common among Black and Hispanic households compared to white households, households with young children, those with a person using an electronic medical device, and low-income households - all for whom disparities were exacerbated by the COVID-19 pandemic (Memmott et al., 2021). Additionally, energy insecurity is more prevalent among renters than owners, and Black and Hispanic New Yorkers are also overrepresented in rental units (City of New York, 2018; Lyubich, 2020). Lyubich (2020) found that Black households spend more in energy expenditures in absolute terms than white households in the U.S., even after controlling for income, household size, homeowner status, home type, and city of residence. A recent study of two U.S. cities found a racial effect distinct from income, with non-white city block groups in the lowest-income stratum reporting about 40% higher annual energy costs than block groups with more white residents (Tong et al., 2021).

The unequal burden of energy insecurity is also seen in NYC, where an estimated 18% of residents were energy cost burdened in 2017, paying significantly more than the Governor's commitment to ‘no more than 6% of household income going towards energy bills’ (NYC Mayor’s Office of Sustainability & Mayor’s Office for Economic Opportunity, 2019). In New York State, households in the lowest quintile (20%) of income spend an average of 9.5% of pretax income on home energy and nearly 18% when vehicle fuel and public transit costs are included. This compares to just 1.5% and 4% of pre-tax income, respectively, for the most affluent (top 20%) of households (Figure 8) of pre-tax household income, by income quintile (U.S. Bureau of Labor Statistics, 2021).

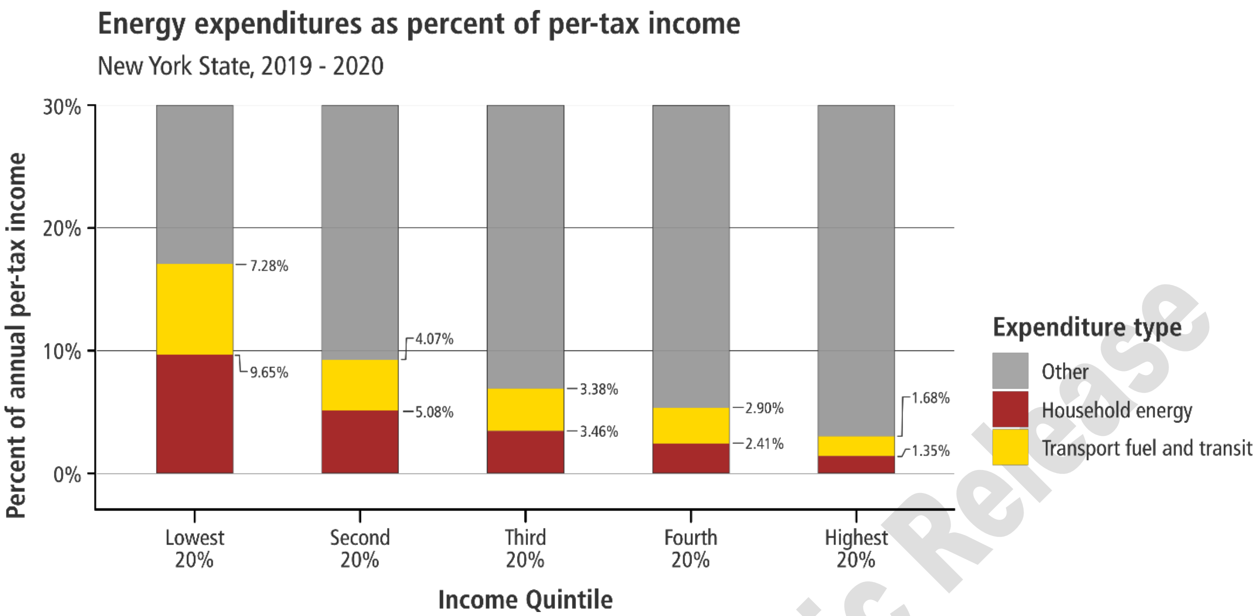

Figure 8. Energy expenditures, percent of pre-tax household income, by income quintile, New York State, 2019-2020. Data Source: U.S. Bureau of Labor Statistics (2022a).

The NYC housing code sets standards for indoor temperature during the heating season, but inadequate heat is one of the most common reasons for calling 311. Such complaints rose 25% between October 1st, 2022 to January 10th, 2023 and are most frequent in low-income communities of the Bronx, Northern Manhattan, and parts of Brooklyn (RentHop, 2023). While there are no existing requirements around cooling in summer, PlaNYC 2023 sets out an agenda to establish a maximum indoor temperature policy during summer months (City of New York Office of the Mayor, 2023).

Utility disconnections are more common in the Northeast than other regions of the US (Hernández & Laird, 2021). Currently, New York State only offers protection from utility disconnection from November 1 to April 15 when there is a threat of hypothermia, but no statewide equivalent exists during the summer months (National Center for Appropriate Technology, 2022). In NYC, electric service for any residential customer may not be disconnected for non-payment just before, during, and for two days after hot days using the 90°F heat index criteria, and on any day with a minimum windchill reaching 32°F or lower (City of New York Mayor's Office of Climate & Environmental Justice, 2023c).

Among a sample of primarily low-income and older New Yorkers in NYC, Black New Yorkers were nearly three times more likely to experience disconnections than non-Latinx white New Yorkers (Lane et al., 2022). They are also more likely to face the 'heat or eat' dilemma, having to choose between spending on essential food and medicine and paying their energy bills (Bansah et al., 2011; Cook et al., 2008), and to cope by using the stove or oven for heat. For vulnerable populations, power disconnections can be especially deadly. For example, 68-year-old New Jersey woman Linda Daniels – who was on an electric-powered oxygen tank she used to breathe – died after Public Service Electric and Gas Company shut off her power (Haag, 2018).

5.2.3.2 Power outages

Power outages, like power disconnections experienced by households with energy insecurity, are life threatening for vulnerable people that depend on electric-powered medical devices (Casey et al., 2020), have health conditions that are exacerbated by heat or cold stress, take medications requiring refrigeration, have mobility limitations, or need help with daily activities. 7.6% of all NYC households use electric medical equipment, with the figure as high as 16% in some low-income and racialized neighborhoods such as East Harlem (City of New York Department of Health and Mental Hygiene, 2022c, 2023c). Following Super Storm Sandy, when power was out for much of lower Manhattan, ED visits and hospital admission at a nearby hospital that remained open increased the most among older patients (Gotanda et al., 2015). Among older adults (≥ 65 years) in NYC, and study respondents with household members who require assistance with daily activities or depend on electric medical devices, only 58% reported being prepared for an outage and only 40% those with electric-dependent medical equipment reported being enrolled in the power outage notification program (Dominianni, Ahmed, et al., 2018), a service offered by Con Ed and other energy utilities. Residents of facilities like nursing homes are nearly all at risk from power outages if backup systems fail or if outages occur during extreme heat. Backup systems are currently not required to be powerful enough to run air conditioning, presenting an additional layer of risk during extreme heat events.

In September 2017, Hurricane Irma made landfall in Florida as a category 4 storm. The storm caused extensive damage, including leaving 6.7 million utility customers without power (Issa et al., 2018; State of Florida Division of Emergency Management, 2017). Local health officials documented at least 17 heat stress deaths among people who lacked air conditioning, of which 14 were residents of a nursing home that was unable to run its air conditioning because of the outages (Dosa et al., 2020; Issa et al., 2018). Outdoor temperatures were in the 80s and heat indices in the mid-90s but conditions inside the nursing home were much hotter and the facility could not maintain the federally required safe temperature maximums without air conditioning (Dosa et al., 2020; Minority Staff of the US Senate Committee on Finance, 2018). A study of nearly 55,000 Florida nursing home residents found that power outages were associated with increased odds of death at one week and at 30 days following the storm (Williams, 2019). In addition to the deaths, more than 200 residents were evacuated and treated for dehydration and heat-related illnesses (Minority Staff of the US Senate Committee on Finance, 2018). Following Irma, Florida passed a law requiring nursing homes and assisted living facilities to have generators that can keep comfortable temperatures for four days after power loss (Walters, 2018).

5.2.4 Physical environment factors

5.2.4.1 Household energy insecurity

Energy, the built environment, and health are connected, all of which influence and are influenced by social inequities (Hernández, 2013). Socioeconomic deprivation is associated with substandard housing conditions, such as: having cold drafts through holes and cracks; leaks and mold; and malfunctioning heating and cooling sources and cooking appliances – all of which leads to inefficient energy use and increased costs. Energy insecurity plays a key role in pathways linking housing deficiencies, economic hardship, health, and chronic stress (See Figure 9). Physical environment and energy insecurity linkages are further echoed in studies that identify older, substandard, and inefficient housing as a leading contributor to energy insecurity in the US and disproportionate impacts on Black Americans and others marginalized by race and income (Dubois, 2012; Hernández & Siegel, 2019; Memmott et al., 2021; Min et al., 2010; Reames, 2016b; Santamouris et al., 2007). High energy costs or compromised ability to meet daily energy needs, in turn lead to adverse physical and mental health outcomes (Lewis et al., 2019).

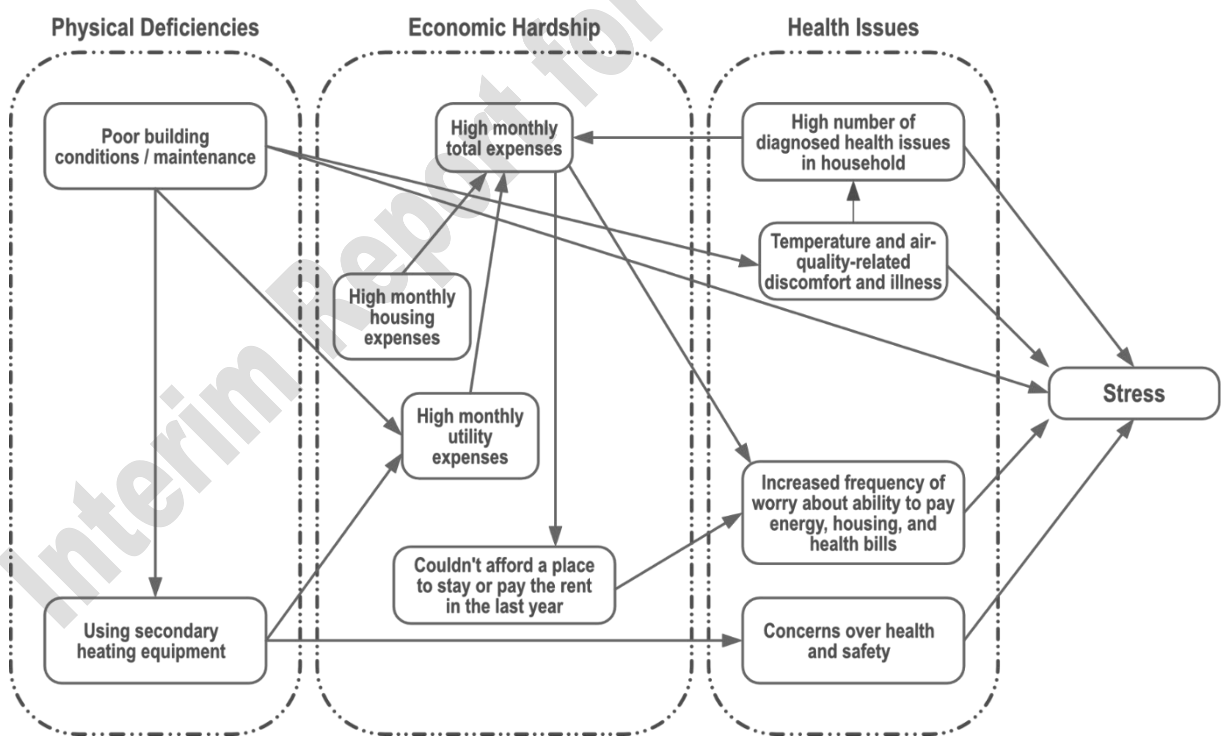

Figure 9. Housing, energy and health pathways to stress. Source: (Hernández et al., 2016, fig. 1)

Locally, a study in the Washington Heights neighborhood found that energy insecurity was not limited to the lowest-income households (annual household incomes ≤ $20,000); nearly 25% of those who earn $60,000-$80,000 annually experienced energy insecurity at least episodically (Hernández & Siegel, 2019). Renters face particular challenges and may have limited ability to regulate indoor temperature or cope with older appliance failures. They may experience high rent burdens as rising energy costs for heat and hot water are priced into rents and considered in affordable housing rent regulation, compounded by COVID-related price hikes and other subsequent financial burdens (Rent Guidelines Board | City of New York, 2019).

Among housing types, for a given household income, average energy cost and cost burden is substantially higher in single family homes than it is for units within multi-family buildings (US Department of Energy Office of State and Community Energy Programs, 2022). Single family homes may be less able to retain heat during a cold weather power outage (Urban Green Council, 2014). Although relatively infrequent in NYC, cold-related (i.e. hypothermia) deaths with indoor exposures occur and are likely linked to being unable to pay for home heating. Most of these deaths involve people aged 60 or older, with mental health or cognitive conditions who live in single family or row homes, all without heat (Lane et al., 2018).

Other health and climate risks can be compounded by energy insecurity. Environmental justice neighborhoods in particular are already dealing with these interacting exposures. For example, residents who live in the Mott Haven-Port Morris area of the South Bronx face a variety of environmental and health challenges such as poor housing quality, air pollution health impacts, multiple climate risks, and a high prevalence of health conditions that make people more vulnerable (City of New York Department of Health and Mental Hygiene, 2022a).

A lack of access to household air conditioning is another important dimension of energy insecurity. In NYC, between 2012 and 2021, all heat stroke deaths among people exposed at home did not have air conditioning or were not using it (City of New York Environment and Health Data Portal, 2023). Households in low-income communities, and non-Hispanic Black people are more likely to lack air conditioning or report being unable to pay the added electricity cost (City of New York Department of Health and Mental Hygiene, 2022d; Lane et al., 2014; Madrigano et al., 2018) (City of New York Department of Health and Mental Hygiene, 2022b). Air conditioning and other cooling technologies are considered in more depth in Section 6.1. Data on adults with air conditioners (City of New York Environment and Health Data Portal, 2007), household air conditioning (City of New York Environment and Health Data Portal, 2017) and older adults with air conditioners (City of New York Environment and Health Data Portal, 2013) by boroughs are available on the Environmental and Health Data Portal.

5.2.4.2 Power outages

Power outages in NYC disproportionately affect marginalized communities, as shown by ConEd data (Figure 10). From 2017 through 2021, networks with more outages appear to have disproportionately impacted environmental justice neighborhoods (defined using the Climate Justice Working Group's draft disadvantaged community criteria) in the outer boroughs.

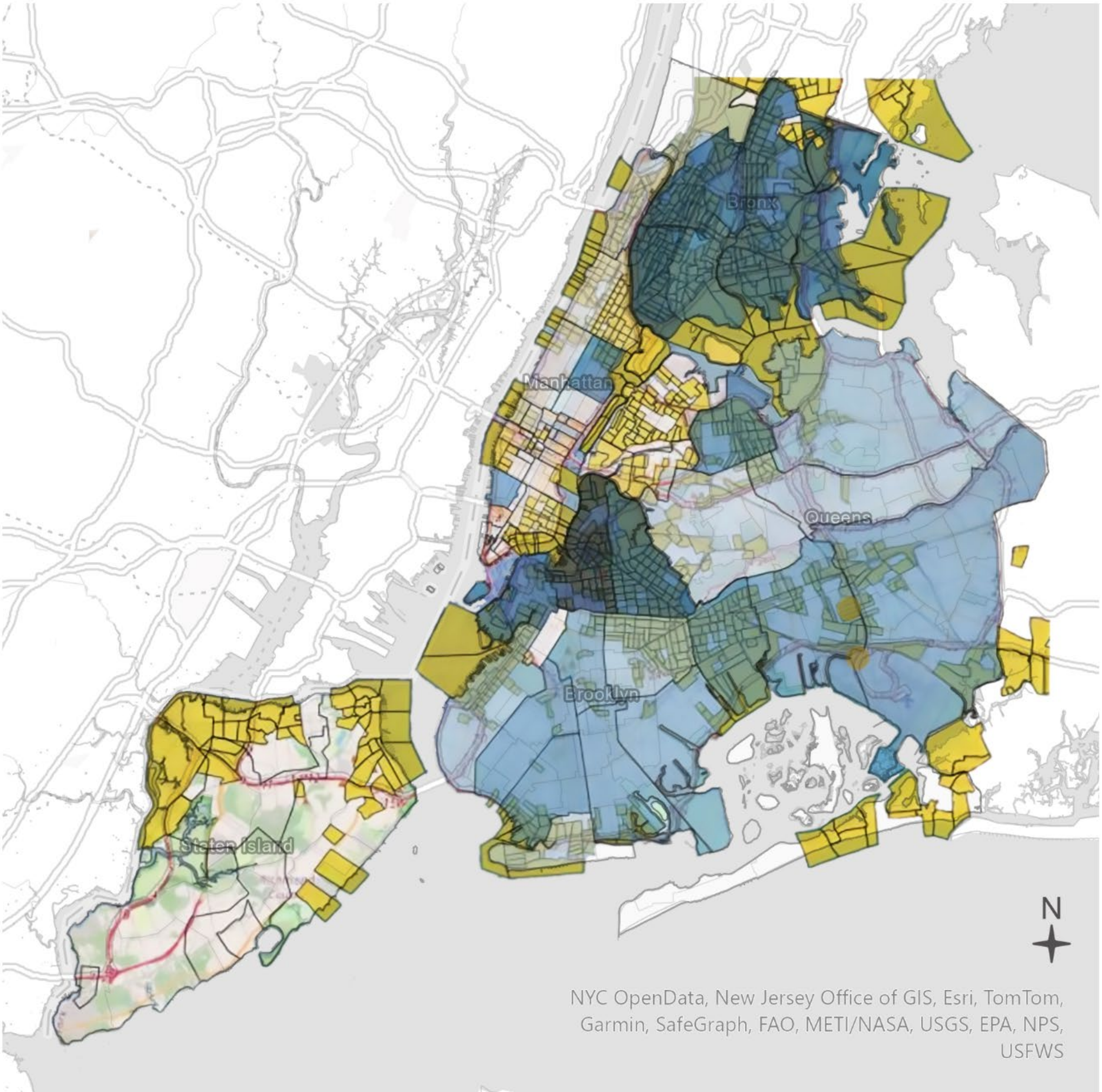

*Figure 10. Census tracts identified as disadvantaged communities by the Climate Justice Working Group (yellow) and upper decile of outage incidents, or most customers affected by outages from 2017 to 2021 (blue) as reported by Con Edison. The network outage data were taken from responses to City 19-292 and City 19-298. (Source: Adapted from City of New York testimony to PSC (*Prepared Direct Testimony of New York City Policy Panel before the New York State Public Service Commission: In the Matter of Consolidated Edison Company of New York, Inc. Case 22-E-0064 and Case 22-G-0065*, 2022).*

Calls to 311 for power outages from 2014 through 2022 (NYC311, 2023) during the summer rise sharply on extremely hot days. Their spatial distribution is largely consistent with the outage data. Power outage calls were most frequent in neighborhoods in northern Manhattan, much of the Bronx, central Brooklyn, and other places with more low income, Black or Hispanic households (Figure 11). More details on an analysis of 311 calls for power outages and their relationship to weather, neighborhood demographics, energy cost burden and heat health risks are in Annex

B(Marcotullio, Braçe, et al., 2023).

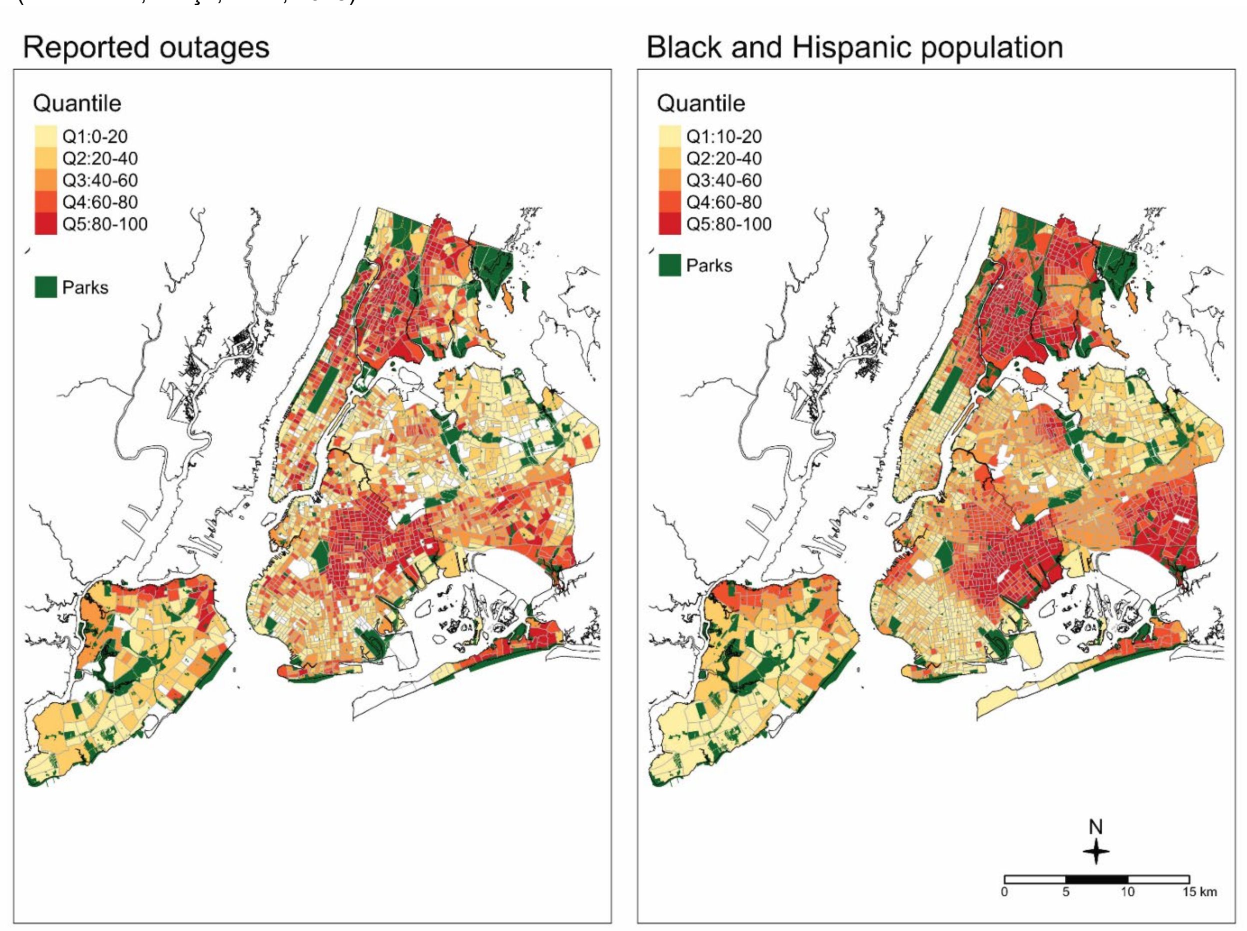

Figure 11. (left) Quantiles of the distribution of absolute numbers of 311 calls for "electric supply" or "power outage" in NYC from 2014-2021 by census tract: (right) Percent of households that are Black or Hispanic.

Assessing how infrastructure influences these disparities is beyond the scope of this assessment. But the findings call for the need to prioritize investments in grid- and building-level resilience measures in the most vulnerable neighborhoods. As NYC addresses its climate change mitigation and energy transition ambitions, there will be a growing need for technology and infrastructure that can improve efficiency and reliability for all communities. This challenge is discussed in more detail below, in NPCC4, Balk et al (Balk et al., 2024), as well as in Annex C.

6 Reducing Future Impacts

6.1 Current Policies

In the near term, energy insecurity and its health impacts can be reduced through a range of strategies: direct, need-based, subsidies for energy costs and home energy efficiency improvements; reducing energy prices; considerations for building codes; targeted investments in clean energy infrastructure and backup energy systems within NYC; and community-led renewable energy programs. The provision of subsidies and reductions in electricity rates would have to be undertaken at the state level by the Public Service Commission. The strength of evidence supporting effectiveness of different implementation approaches varies, but proven approaches can be expanded, and promising ones further tested and evaluated. It should be noted that many benefit programs designed to help address energy insecurity are not available to people who are not US citizens due to existing state and federal policy.

Household disconnection prevention: Disconnection protections vary by jurisdiction and circumstance but can offer important protections during extreme weather. Most states, including New York State (New York State Department of Public Service, 2023), provide some protections from utility disconnections to vulnerable customers during dangerously hot or cold weather. In NYC, residential disconnections for non-payment for all residential customers are suspended just before and after hot days using criteria based on the heat index and on cold days using criteria based on wind chill. In Los Angeles, on the other hand, a motion passed in 2022 that prohibits the Department of Water and Power from practicing water or power shutoffs as a debt collection tool for income-qualified residents and seniors (Smith, 2022).

Many states also provide time-limited disconnection protection for those with certain medical or other vulnerabilities. Some social services agencies provide one-time emergency grants to help people avoid disconnection; the NYC Human Resources Administration or HEAP emergency assistance programs are examples (City of New York Department of Human Resources Administration, 2023). Early in the Covid-19 pandemic, the New York State Public Service Commission prohibited disconnection of residential or small business customers for non-payment. In a May 2022 testimony of the NYC Policy Panel to the NYS Public Service Commission, city practitioners advocated for stronger protections against disconnections, and submitted that customers need greater protections than shareholders (Berkman et al., 2022).

Residential cooling: Ability to afford home air conditioning and energy to run it is the main driver of indoor temperature. Air conditioning can lower indoor temperatures and, in some cases, can increase ventilation. Increasing home AC access can also reduce health inequities by race and income (Madrigano et al., 2018). In place of AC, split heat pumps are another cooling technology that are typically more efficient than a standard AC and also provide electric heating (U.S. Department of Energy, 2023). Some types of facilities housing at-risk people are already required to maintain safe indoor temperatures during hot weather. For example, federal legislation requires long-term care facilities to provide comfortable and safe temperatures, and facilities certified after 1990 are required to keep temperatures in a range from 71 to 81°F (National Archives, 2023). Some jurisdictions, such as Dallas, Tucson, and Tempe, require that rental properties have cooling equipment (The Times Editorial Board, 2022).

In addition to increasing AC prevalence for communities without access, NYC has taken measures to reduce the need for AC consumption through temperature setpoint policies and cooling strategies. In 2023, NYC announced plans to develop maximum indoor temperature policies to protect all residents by 2030 and require cooling in all new construction by 2025 (City of New York Office of the Mayor, 2023; Ostapiuk, 2023). Advocacy groups have also proposed a minimum temperature setpoint for larger buildings, such as commercial or office buildings (WE ACT for Environmental Justice, 2023a). Energy efficiency measures can help reduce cooling cost burdens, as can cool roofs that are painted with white reflective paint to reflect rather than absorb heat, which can reduce indoor temperatures (Bock et al., 2021; Sun et al., 2021). Green roofs (i.e. roofs covered in vegetation) and other forms of green infrastructure that can provide shade and cooling also have benefits to the indoor environment and stormwater maintenance but are more expensive to install and maintain.

Utility subsidies: The federally funded Low-Income Home Energy Assistance Program (LIHEAP) provides financial assistance to households that meet income and other criteria to help with energy costs. Examples of health benefits from LIHEAP for households include reduced prevalence of undernutrition in young children (Frank et al., 2006). New York, like other states, receives a block grant and establishes its own guidelines for distribution within a set of federal policies. In complement to LIHEAP, the NYS Public Service Commission can approve subsidies for utility costs. During the Covid-19 pandemic, at the request of the city, the NYS Public Service Commission approved a small monthly subsidy, roughly $35 per month, to assist 440,000 low-income families in NYC and Westchester with costs of operating air conditioners in summer 2020 (City of New York, 2020). Limitations of the current LIHEAP program in New York State include not reaching 46% of qualifying households, limited assistance to renters who have heat included in their rent, limited funds available for air conditioning purchase, and currently there are no funds for summer utility assistance (Office of Community Services, 2022). A New York State extreme heat action plan proposed increasing LIHEAP cooling assistance funding and potentially providing summer utility assistance (Hochul et al., 2022). National legislation to greatly increase LIHEAP and weatherization funding has been proposed (Ed Markey: United States Senator for Massachusetts, 2022).

Energy efficiency and weatherization assistance: The New York City Department of Housing Preservation and Development (HPD) launched its HomeFix program in November 2019, which provided financial assistance and individualized support for home repairs. As of the time of this writing the program us not accepting new applicants (City of New York Department of Housing Preservation and Development, 2024). The state-administered Weatherization Assistance Program (WAP) provides energy efficiency audits and weatherization for qualifying low-income households. Nationally, in addition to reduced energy use and costs, multiple health benefits have been tied to WAP including reductions in asthma morbidity, better prescription adherence, less illness from cold and heat stress, reduced fire and CO poisoning risk, less need for food assistance, and increased productivity from improved sleep (Tonn et al., 2014).

Locally, a pilot evaluation of 20 low-income Bronx households receiving energy efficiency upgrade assistance found that participants experienced greater thermal comfort and temperature control, reduced energy costs, and less need for supplemental heating (Hernández & Phillips, 2015). As with LIHEAP, WAP funds are not sufficient to reach most qualifying households, and often considered inaccessible and underused particularly by renters. Reaching more households and renters may require a community-based and context-dependent approach based on the needs of individual communities (Reames, 2016a). Older households with lead, mold, or other contaminants may be denied access to weatherization upgrades and there is no current state funding for this type of pre-weatherization remediation (New York State Division of Housing and Community Renewal, 2023; WE ACT for Environmental Justice, 2023a). One recommendation that has been offered is that the state create and fund pre-weatherization remediation programs (WE ACT for Environmental Justice, 2023a). There is a 'split-incentive barrier' to energy efficiency, as those (i.e. landlords) who decide and pay for energy efficiency improvements do not necessarily benefit from the investment (Bednar & Reames, 2020; Bird & Hernández, 2012). Given the pervasive, inequitable harms from inefficient housing on energy insecurity and health among people of color and low-income households (Jessel et al., 2019) – and in particular Black Americans (Lewis et al., 2019) - expanding access to energy efficiency and weatherization assistance can contribute to restorative justice.

Reducing energy prices and debt forgiveness: NYC households have long been burdened by high energy costs. In 2016, the New York State utility regulator, the Public Service Commission, set a target energy cost burden for low-income households at 6 percent. Even before the Covid-19 pandemic, more than half a million NYC residents had costs above this threshold, and 460,493 low-income families in NYC are still paying over 6% of their pre-tax income toward their energy bills (NYC Mayor's Office of Sustainability & NYC Mayor's Office for Economic Opportunity, 2019). The economic damage from the COVID-19 pandemic, spikes in natural gas prices caused by war in Ukraine, and an increase in natural gas use for electricity after the Indian Point nuclear plant closed in 2021 further raised energy cost burdens. By March 2022, one in eight residential energy customers in the state were in arrears, the majority in NYC and Long Island (New York State Office of the New York State Comptroller, 2022). In response, the state and the Public Service Commission announced programs to help customers with these unprecedented levels of debt (New York State Office of the New York State Comptroller, 2022). In January 2023, the PSC approved financial assistance for past-due utility bills that accrued during the COVID-19 pandemic (New York State, 2023b). Because this path forgives the debt through a combination of state tax money and customer subsidization through electric rates, it does not result in a long-term reduction of energy prices. Other states have different rate structures, for example, using tiered rates based on income. Currently, programs for rate subsidies are only available to individuals who pay their energy bills, and not when operators of multifamily buildings pay the bill and roll those energy costs into rent. Given recent instability in energy markets due to the volatility in wholesale electricity prices from national and global factors (e.g., COVID pandemic, Russian invasion of Ukraine, increased electricity demand during heatwaves and winter storms, coal labor shortages that caused increased demand for natural gas), ongoing monitoring and evaluation of these programs are needed (New York ISO, 2022; Wholesale U.S. Electricity Prices Were Volatile in 2022, 2023).

Community clean energy ownership: The clean energy transition provides opportunities to sustainably reduce energy costs while providing more benefits to local communities. Community-owned clean energy typically refers to clean energy projects where a community can exercise control over the generation, use, and/or sale of energy resources and where the community plays an active role in decision-making. These projects may use different clean energy sources, such as wind or solar, at varying scales and capacities (Berka & Creamer, 2018). An example is WE ACT for Environmental Justice's 'Solar Uptown Now' campaign that has organized residents of upper Manhattan to buy and install solar power in multifamily housing together, sharing the up-front costs and longer-term energy savings (WE ACT for Environmental Justice, 2022). These types of projects have been implemented or proposed in other geographic contexts, for example, community-owned wind farms across Scotland (Community Energy Scotland, 2021) and community solar rooftops in Delhi, India (Kumar, 2023). For other examples of community clean energy and climate resilience projects in NYC, see *NPCC4 Advancing Climate Justice in Climate Adaptation Strategies for New York City* (Foster et al., 2024, sec. 2.2 and 5.1).

Resilient and clean energy infrastructure: Reducing secondary impacts due to infrastructure failure will be beneficial during multiple hazards, including heat waves, hurricanes, and flooding events. As the transition to low-emissions energy supply advances, the need for and development of technology and infrastructure that can improve efficiency and reliability, such as battery storage and demand response, is growing. High-efficiency technologies for buildings such as ground source heat pumps can also serve to lower peak electric demand (Buonocore et al., 2022). Following the passage of Local Law 2 in 2022, the city is evaluating the technical feasibility of district-scale geothermal systems (City of New York Mayor's Office of Climate & Environmental Justice, 2023a). These clean energy technologies have the potential to provide substantial health and equity co-benefits if they are deployed and sited using a framework that explicitly prioritizes these goals (Krieger et al., 2016). One potential solution to improve efficiency and reliability while increasing the uptake of renewables is to increase energy storage. In addition to large utility scale batteries for storage, another need in NYC is for resilient energy backup systems suitable for multi-family dwellings, which have a different permitting structure than large-scale outdoor batteries. Such systems are being developed to provide electricity during blackouts to common refuge areas for powering life-sustaining equipment, heating, cooling, lighting, and refrigeration of perishables (Clean Energy Group, 2022; Mango et al., 2021). Such systems can use rooftop solar, including community-owned systems that help reduce peak load grid strain and energy costs. The city of Toronto, Canada now mandates resilient building energy systems in all new mid- and high-rise developments (City of Toronto Planning and Development, 2023). In the aftermath of prolonged building-side outages following Super Storm Sandy, NYCHA has retrofitted 73 buildings with flood protected backup generators (New York City Housing Authority, 2021). Achieving NYC's targets for reducing GHG emissions by 2050 could avoid 160 and 390 premature deaths and 460 hospitalizations and emergency department visits for respiratory and cardiovascular disease each year, with a societal benefit of $3.4 billion (Johnson et al., 2020).

7 Opportunities for Future Research

7.1 Summary of Knowledge Gaps

In the context of climate change impacts on vulnerable US populations, the need for more data, research, and interventions to address energy insecurity has long been recognized (Hernández, 2013). Below we outline a few prominent gaps in research that warrant attention.

7.1.1 The need for more household energy use and outage data

There is an opportunity to enhance our understanding of energy use at the household level if data are available. Understanding how households use and do not use energy can help provide vital information to stakeholders. For example, Cong et al. (Cong et al., 2022b) used residential electricity consumption data to identify energy use behaviors in comparison to income-based measures of energy poverty, uncovering a previously hidden gap in energy equity. In addition, timely, spatially granular power outage data is not currently available in NYC. Over the past 9 years over 50,000 calls for power outages have been collected by the 311-call service, but why these claims have been made (why the household experienced a power outage) remains unknown. In addition, relying on 311 calls includes shortcomings such as differential reporting based on socio-demographics and the historical exclusion of NYCHA residents (Marcotullio, Braçe, et al., 2023). More information on the details of the circumstances would help stakeholders to identify outage hotspots, housing and electrical infrastructure or other problems and allow for tracking of outages with an equity lens at the community and individual level. Utilities also have data on outages but are not required to publicly share historical records of power outage data, which can include the cause of outages and their duration.

7.1.2 Equity implications of electrification and transition to renewable energy in the context of energy insecurity and health

As the city electrifies and transitions away from fossil fuels and to renewable energy, there are questions about whether communities will be able to benefit equitably, and how benefits and burdens will be distributed. There are also questions about whether hosting capacity differences will pose challenges across different neighborhoods. Low-income households in the NYC metropolitan area have a median energy burden of 9.3%, compared to 2.9% city-wide, and 25% of low-income (≤200% FPL) households have an energy burden greater than 16.8% compared to 3.4% for non-low-income households (Drehobl et al., 2020). The implications to the energy cost burden of transitioning away from fossil fuels to renewables and increasing electrification of the building sector are not yet fully understood or accounted for. Ensuring equitable access to building electrification and the indoor air quality benefits it can provide will require identifying and implementing strategies to address barriers to building electrification, particularly in older buildings and NYCHA-owned and affordable housing, such as high upfront or ongoing costs, access for renters, cost shifting concerns for tenants, a lack of skilled labor for installations, and upgrades to electricity infrastructure and other building modifications for new wiring (Cohn & Wang Esram, 2023; WE ACT for Environmental Justice, 2023b). NYCHA has a goal to reduce its greenhouse gas emissions 80 percent by 2050, which will require rehabilitation of its buildings so they can undergo energy retrofits and electrification. The quality of NYCHA's building stock has been challenged by deferred maintenance and underinvestment in public housing (Campion, 2023), which complicates the achievement of its GHG reduction goals. In addition to the benefits of building electrification to indoor air quality, the transition away from polluting peaker plants to cleaner forms of energy can improve outdoor air quality. NYPA commissioned a study in consultation with the PEAK coalition that assessed options for replacing NYPA's existing peaker plants (NYPA, 2022). However, as NYISO attempts to maintain reliability standards, they have warned that peaker plants may need to stay on for longer than planned (New York Independent System Operator, 2023c). The distribution of benefits and burdens related to exposure to poor outdoor air quality and grid reliability challenges will depend on the ability to introduce alternatives like demand response, rooftop solar, and battery storage and balance the pace of increasing renewables and efficiency with decreasing fossil fuels.

7.1.3 Transportation

The expansion of public transit, including Select Bus services in areas such as Eastern Queens holds the potential to improve employment, education, shopping, and other opportunities for local communities. By providing efficient and reliable transportation options, expanded public transit services can enhance mobility and connectivity, enabling easier access to job opportunities, educational institutions, and commercial centers, particularly for individuals who may have faced challenges in commuting to distant locations (Heyward & Khalifeh, 2023). Additionally, improved access to shopping areas can enhance the availability of goods and services, contributing to economic development and community well-being. However, further research is needed to assess the actual impact of the public transit expansion on employment rates, educational attainment, local economic growth, and overall community development. Addressing this knowledge gap will provide a better understanding of the potential benefits and inform decisions regarding public transit expansion to support equitable opportunities and enhance quality of life in these communities.

8 Traceable Accounts

Key Message 1	While recognizing the urgency to reduce energy use and GHG emissions to meet the City and State's ambitious climate goals and mitigate the impacts of climate change, actions must be approached deliberately, considering energy insecurity and health. Challenges, including reducing fossil fuel use, acquiring renewables, adapting the grid to meet higher demand, and securing sufficient dispatchable generation to ensure reliability during peak periods when solar and wind generation is low can all have implications for energy affordability and reliability. While the transition offers opportunities for economic growth, improved air quality, and promoting active transport, equitable implementation, and reliable energy supply particularly during extreme weather events are important considerations for NYC.
Description of Evidence	Currently, in NYC there are disparities in environmental burdens such as energy use, costs and electricity interruptions between Black and Hispanic and low-income communities and White and high-income communities (Drehobl et al., 2020; Marcotullio, Diko, et al., 2023; Ortiz et al., 2022) with significant health implications (City of New York Department of Health and Mental Hygiene, 2023a; Dominianni, Lane, et al., 2018). There are also significant differences in opportunities including access to energy-related jobs (National Association of State Energy Officials & Clean Energy Initiative, 2021). The Challenges of reducing energy-related fossil fuel emissions can further exacerbate these disparities if not addressed adequately. Inadequate solutions that exacerbate disparities include reducing grid reliability (NYISO, 2022), placement of infrastructure, such as last mile warehouses in low-income and Black and Hispanic communities and continued job opportunity exclusion (IREC, 2022; Muro et al., 2019).
New Information and Remaining Uncertainties	Remaining uncertainties include: the pace of the transition and its potential implications for energy insecurity; the identification of suitable locations and technologies for renewable energy generation; the development of energy storage solutions to address variability in renewable energy production; the precise economic and health benefits associated with the transition; the potential challenges related to energy equity and how they will be addressed; and strategies for ensuring energy supply reliability during extreme weather events.
Assessment of Confidence based on the Evidence	Given the evidence base, there is **high** confidence that New York State will reduce fossil fuel use and transition to renewables, although the precise pathway remains unclear. The confidence in the feasibility and timeline for achieving the state's climate goals accordingly is **moderate**, given the complexities involved in transitioning an entire energy system. The confidence in the potential economic and health benefits could also be **moderate** and depends on specific policy decisions and implementation. Confidence in equitable implementation and energy supply reliability during extreme weather events may also be **moderate** and require careful planning and policy development.

Key Message 2	Energy is not only vital for economic growth, but also for human health and well-being – a connection that the concept of energy insecurity (EI) highlights. EI can be caused by high energy costs relative to income, by frequent energy outages and unreliability, or both. Addressing EI both influences, and is influenced by, various domains such as public health, transportation, energy, and housing sectors – all compounded by climate change as a threat multiplier.
Description of Evidence	A growing body of literature around the concept of household and community energy insecurity inform its consideration as part of a sustainable development strategy, particularly as it relates to human health and well-being (Hernández, 2013, 2016a; Jessel et al., 2019). The prevalence and causes of energy insecurity, including high energy costs and energy outages, are documented (Energy Information Administration (EIA), 2017; NYC Mayor's Office of Sustainability & NYC Mayor's Office for Economic Opportunity, 2019; U.S. Energy Information Administration, 2020). Information on the measures, policies, and programs that have been implemented to address energy insecurity and other energy-related issues nationwide and in New York is available (Carley et al., 2021; Murray & Mills, 2014; NYC Mayor's Office of Sustainability & Mayor's Office for Economic Opportunity, 2019).
New Information and Remaining Uncertainties	Uncertainties remain about New York-specific strategies and initiatives aimed at reducing energy insecurity; effectiveness of existing policies and programs in alleviating energy insecurity; and how energy insecurity may evolve in response to changes in energy systems and costs.
Assessment of Confidence based on the Evidence	Given the strong body of evidence, confidence in the link between energy, human health and well-being is **very high.** Confidence in specific measures and policies to address energy insecurity **may vary** and depend on their effectiveness in practice. Confidence in the interconnections between energy insecurity and various sectors may also **vary** and require further research and analysis.
Key Message 3	EI can harm public health directly -- via inadequate heating or cooling, indoor air pollution, and reduced ability to reliably use medical devices and refrigeration necessary for health needs -- and indirectly when high energy costs reduce spending on other essential items like healthcare and food. Populations most vulnerable to EI include those with lower incomes, victims of systemic racism, people with underlying health conditions, disabilities, or dependent on electric powered medical equipment, and renters, who are less able to access energy subsidies.
Description of Evidence	There is a large body of evidence that documents the myriad ways in which energy insecurity directly impacts health, such as through fires from compromised thermal safety (J. Campbell, 2022; Hernández, 2022); dangerous coping strategies (Hernández, 2016a; Middlemiss & Gillard, 2015; Simes et al., 2023; Yoon & Hernández, 2021) and resulting respiratory issues such as indoor air pollution attributed to the use of unsafe heating or cooking methods and exposure to carbon monoxide (Ahrens, 2017; Dennekamp, 2001; Nicole, 2014; WE ACT for Environmental Justice, 2023b); interruption in life-supporting electrical-powered medical equipment (Casey et al., 2021; Mango et al., 2021). Research also documents indirect impacts of energy insecurity on health, such as compromised spending on other life essentials such as medication (Harker Steele & Bergstrom, 2021; Memmott et al., 2021; Simes et al., 2023); food-borne illnesses from lack of refrigeration (City of New York Department of Health and Mental Hygiene, 2022c; Gotanda et al., 2015; Lin et al., 2021); and foregoing other essential daily needs (Bansah et al., 2011; Hager et al., 2010). Statistics show that New Yorkers who are racialized and low-income (Frank et al., 2006; Murray & Mills, 2014; Reames, 2016b), rely on electric-powered medical equipment (Casey et al., 2021; Yoon & Hernández, 2021), living with existing medical conditions (Hernández, 2018; Simes et al., 2023), and renters (Bird & Hernández, 2012; RentHop, 2023) are disproportionately impacted by energy insecurity.
New Information and Remaining Uncertainties	Energy insecurity remains a complex and evolving issue with several key uncertainties. Measuring energy insecurity lacks a universal standard, making comparisons challenging. Data availability and quality vary, hindering precise assessment. Long-term health impacts and interactions with other determinants of health need further exploration. Assessing the effectiveness of interventions and policies is also an ongoing challenge. Advancements in energy technology and their impact on access and health outcomes require further monitoring, as does the long-term effect of policies.
Assessment of Confidence based on the Evidence	Given the evidence base and remaining uncertainties, there is **very high** confidence that without significant and equity-oriented policies targeted at reducing energy insecurity, the direct and indirect consequences for New Yorkers' health will continue to be exacerbated.

Key Message 4	Climate resilience investments in energy infrastructure and mitigation plans for the transition from fossil fuels to renewable energy and the electrification of buildings and transportation could impact future energy reliability and costs. Vulnerable populations are most at risk from any potential increases in power outage risks or energy costs, which may be exacerbated by projected climate extremes in NYC, such as extreme heat, cold, and flooding. Equitable and just policies and investments in the energy and housing sectors can reduce future health risks from EI and shape a more resilient and equitable future.
Description of Evidence	NPCC4, Balk et al(Balk et al., 2024) provides evidence on the challenges and opportunities of transitioning from fossil fuels to renewable energy sources. There is an existing evidence base for potential impacts of climate resilience investments for future energy reliability and costs particularly on the potential impacts of electrification of the building and transportation sectors on the energy system (New York Independent System Operator, 2023c). These new investments and plans' potential disproportionate impact on vulnerable populations is supported by studies that have evaluated existing disparities of the energy system (Drehobl et al., 2020; Lane et al., 2022; Lyubich, 2020; Marcotullio, Diko, et al., 2023; Ortiz et al., 2022) The support for equitable policies and investments in the energy and housing sectors towards reducing future health risks from energy insecurity can be found in Lewis et al, Kreiger et al, and Jessel et al (Jessel et al., 2019; Krieger et al., 2016; Lewis et al., 2019). In particularly on, data on the potential impacts of electrification of the building heating and transportation sectors on the energy system are derived from NYISO (New York Independent System Operator, 2023c).
New Information and Remaining Uncertainties	The effectiveness of climate resilience investments in mitigating energy infrastructure risks is an evolving field, and strategies and innovations in the transition from fossil fuels to renewables continue to emerge. Uncertainties remain regarding the exact impacts of electrification on energy reliability and costs.
Assessment of Confidence based on the Evidence	There is **very high** confidence in this finding based on 1) well-documented support for the close links between EI, human health, and well-being, and 2) strong evidence about the disproportionate impacts of EI on marginalized populations. Confidence in the specific impacts of electrification on energy reliability and costs **may vary** and depend on local factors and technologies.

9 Sustained Assessment

A sustained assessment of energy and energy insecurity in New York stands as a critical endeavor for both the present and the future. As the state strives to reduce its carbon footprint and transition toward renewable energy sources, an ongoing evaluation of energy systems and their resilience is imperative. This comprehensive assessment should not only encompass the reliability and costs of energy but also acknowledge the profound interplay between energy access, resource and economic sustainability, and human health and well-being. In a landscape where vulnerable populations are most susceptible to energy-related challenges, the pursuit of equitable and just policies and investments in the energy sector becomes paramount. Table 3 includes indicators and key metrics to track progress on impact, vulnerability, resilience, and interventions towards climate-friendly energy futures without compromising household or community energy security.

This sustained inquiry into New York's energy dynamics promises to shape a more resilient, equitable, and sustainable future for all its residents. These indicators should be considered alongside those from NPCC4 (Foster et al., 2024; Matte et al., 2024), recognizing that energy security and the health and well-being of all New Yorkers are intrinsically linked.

Table 3. Energy and energy insecurity-related indicators

Climate risk		Indicator	Indicator Portal or Report	Data source	Initiative, recommended by	Distributional equity stratification
Energy industry and infrastructure benefits		Hosting capacity	NYSERDA	Con Edison, NYSERDA		Race, ethnicity, poverty, housing tenure, income
	Interventions (& co-benefits)	Newly created jobs		NYS Department of Labor, NYC Comptroller		Race, gender, ethnicity, income
		Quality of the newly created jobs (e.g., prevailing wage, benefits, security)		NYS Department of Labor, NYC Comptroller		Race, gender, ethnicity, income
		Sustainable and accessible public transportation from all parts of New York, particularly parts that currently are in lack (e.g., Southeast Queens)		NYC DOT		Race, ethnicity, income
		New jobs specifically for marginalized populations		NYS Department of labor, NYC Comptroller		Race, ethnicity, income
		EV purchases (bikes, cars, scooters, etc.)		NYC DOT (registrations)		Income
	Interventions	More and better data availability				
Electricity interruptions	Identification and descriptions	Location, length, and extent of outage	311 calls, outage records	Open data Con Edison		Race, ethnicity, income
	Energy security	Lived experiences of power outages				Race, gender, ethnicity, income
	Health	Morbidity/mortality hospitalizations, l		DOHMH, Health and Hospitals		Race, gender, ethnicity, income

Energy Insecurity	Impact	Power outages			NPCC2, 3	Race, Poverty concentration, Housing tenure status
		Secondary hazards from power outages (e.g., adverse health effects from food spoilage, thermal discomfort, inability to use electric powered medical equipment)			NPCC2, 3	Race, Poverty concentration, Housing tenure status, Age, Existing health conditions
	Vulnerability	Energy cost burden: percent of households spending more than 6% of income on energy bills	U.S. Energy Information Administration	Residential Energy Consumption Survey	New to this assessment	Race, Poverty concentration, Housing tenure status
	% without heat	% without air conditioning		New York City Housing and Vacancy Survey		Race, Poverty concentration, Housing tenure status
		Fires due to self-made heat (e.g., candles)		FDNY		Race, Poverty concentration, Housing tenure status
		Lithium-ion battery-related fires		FDNY		Race, Poverty concentration
	Interventions	EI mitigation policies				Race, Poverty, Housing tenure status

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Figure List:

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Content

Disclaimer

This assessment does not represent the policy position of any agencies whose staff are co-authors.

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Annex A: Energy Insecurity - Global, National, and Historical Context

Energy or fuel poverty are terms that have been used internationally to describe a lack of access or means to afford modern energy services and products needed for health and development. In developing countries, a lack of clean household energy for cooking and heating[1] is a major cause of preventable illness and death. While energy access is improving in many developing economies, by one estimate 733 million people without access to reliable electricity and 2.4 billion people using dangerous and inefficient cooking systems.[2] Among this population, those that lack access to energy include those that simply cannot afford it. Access to electricity in the US is virtually universal, while in Malawi, for example, only about 11% of the population has electricity access[3] and more than 95% of people depend on solid household fuels. Globally, household air pollution from use of solid fuels for cooking and other needs caused an estimated 2.3 million deaths in 2019, from causes including childhood pneumonia, COPD, heart disease and strokes, diabetes, low birth weight and preterm birth.[4,5] Improving clean household energy access is a UN sustainable development goal (number 7).

A lack of energy access and excessive cost burden also exists in developed economies.[6] "Fuel poverty" was first studied intensively in the United Kingdom.[7] As with energy insecurity, fuel poverty considers all essential energy services (not just heating), what is needed (not only what is used), and housing energy inefficiency as a major cause.

In the United States, electricity came first to cities more than 100 years ago, and the need to expand access was recognized. The rural electrification program beginning in the 1930s improved electricity access in rural areas from less than 10% to near-universal. Among other benefits, a decline in infant mortality has been attributed to this program.[8] With modern energy connections becoming near universal in the US, excessive energy cost burden emerged as a major hardship for both urban and rural households. This concept has been the focus of many U.S. researchers who study the relative costs of energy to households. The energy burden focuses on the household energy bill as a percentage of the household's annual income.

For New York State, the energy burden is defined as households that spend more than 6% of their annual income on energy.[9,10] According to the US DOE's Low-Income Energy Affordability Data (LEAD) Tool the national average energy burden for low-income households is 8.6%, three times higher than for non-low-income households which is estimated at 3%. In some areas, depending on location and income, the energy burden can be as high as 30%.[11] Nevertheless, the extent of the energy household burden has been a persistent if underappreciated problem in the United States.[12] For example, urban and rural low-income households (defined as 80% of area median income or 150% federal poverty level) spend roughly three times as much of their income on energy cost as compared to non-low-income households (7.2% and 9% versus 2.3% and 3.1%, respectively.[13,14] Moreover, low-income, African American, Latinx, multifamily and renter households are disproportionately impacted by high energy burdens.[13] Out of a total of 118.2 million US households, in 2015, the US Energy Information Administration (EIA) estimated that 17 million households received an energy disconnect/delivery stop notice and 25 million households had to forgo food and medicine to pay energy bills.[15]

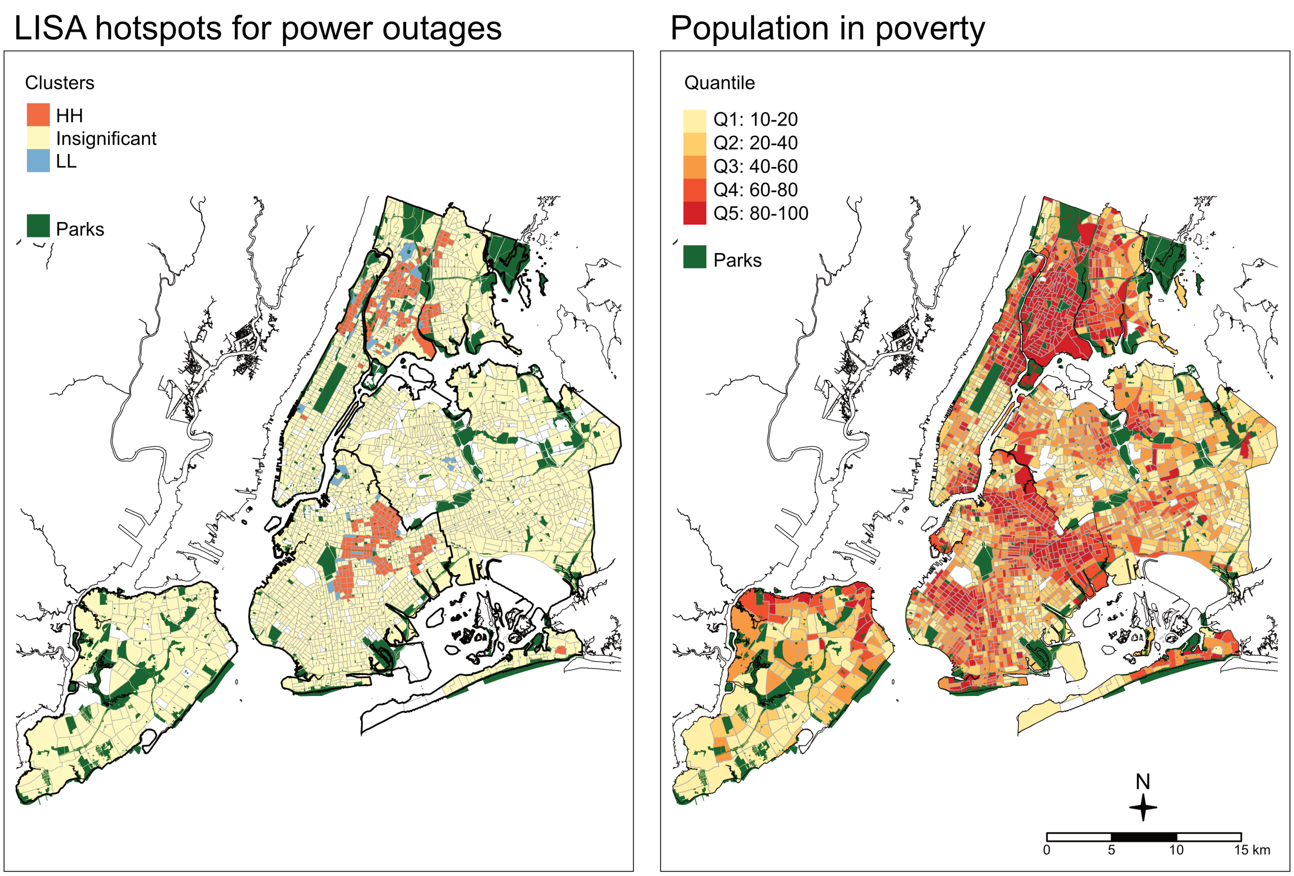
The results of the energy burden have been identified as energy insecurity, or the state in which households cannot meet their energy needs.[16] This term refers to the uncertainty that a household faces in being able to make utility bill payments.[17] The point emphasized from this concept is that the stress from insecurity creates significant health issues.[18] For example, the results of energy insecurity include extreme home temperatures, hazardous heating alternatives, and the constant threat of utility shut-offs or mounting arrears in utility bills because of nonpayment. This problem is especially acute for low-income residents such as single parents, the elderly, the disabled, and others with low or fixed incomes.[19,20] Those facing energy insecurity may be homeowners unable to invest in efficiency upgrades or may be renters living in housing units where landlords do not pay for the utilities and consequently have very little incentive to create more energy efficient units.[21] Energy insecurity is an important issue in the US. The DOE EIA Residential Energy Consumption Survey (RECS) data for 2015 suggest that 31% of U.S. households experienced some form of energy insecurity. That year, nearly seven million households had their access to heat interrupted at least once, and six million lost access to air conditioning at least once.[22] Adequate housing and income are central to energy justice. Energy justice is a branch of environmental justice[23,24] focused on the notion that all individuals should have access to energy that is affordable, safe, sustainable and able to sustain a decent lifestyle, as well as the opportunity to participate in and lead energy decision-making processes with the authority to make change.[25–27] Energy justice scholarship stresses that neither the adaptation to climate change nor the renewable energy transition is inherently just nor democratizing in terms of the distribution of technologies and benefits.[28] Energy justice is based upon disparities within energy systems closely associated with housing including, inter alia, notions concerning energy poverty, fuel poverty, energy burden and energy insecurity.

Annex B: 311 Calls for Summer Power Outages - Methods

Researchers tested whether the 311 calls were clustered, dispersed or randomly distributed throughout the city.[29] Using spatial statistical test, the research found that there is a clustering of high numbers of 311-calls made between 2013 and 2022. That is, high numbers of calls were spatially clustered together as were low numbers of calls. A specific test, called the Local Indicator of Spatial Autocorrelation (LISA) demonstrated the location of these different levels of calls. The results of this analysis are presented in Annex Figure B-1 (left panel). Across most of the census tracts in the city, there is no clustering of calls amounts, but high numbers of calls are clustered in Northern Manhattan, parts of the Bronx, central Brooklyn, and Southeastern Queens. Areas designated as High-High (HH) signal locations of high absolute numbers of 311-calls for power outages (i.e., above the mean level of 311-calls for power outages per census tract) and where the adjacent census tracts also had High absolute number of 311-calls for power outages. The HH designation indicates areas of spatially clustered high levels of 311-calls for loss of power. Alternatively, areas designated as Low-Low (LL) are areas of low absolute numbers of 311-calls for power outages (i.e., below the citywide mean for 311-calls for power outages per census tract) and the adjacent cells are also areas of low absolute numbers of 311-calls for power outages.

Selected socio-economic characteristics of the census tracts with different levels of 311 calls were also examined. The research identified that there is an association between the levels of calls and the level of poverty within the different clusters. The distribution of those in poverty is presented in Annex Figure B-1 (right panel). A statistical test (student's t-test) of the means of the percent poverty in census tracts in high call cluster areas and the percent of poverty in census tract of low call cluster areas is significant ($t = 3.5806$, $df = 84.929$, $p\text{-value} = 0.0006$).

The results suggest that there is a significantly higher percentage of the population in poverty within census tracts with high numbers of calls compared to the percentage of population in poverty in census tracts with low numbers of calls. The mean percent in poverty in census tracts with high cluster calls is 26.0% and the mean percent of poverty in the census tracts with low cluster calls is 19.3%.



Annex Figure B 1. Local Indicator of Spatial Autocorrelation (LISA) results for 311 calls for power outages by census tract from January 1, 2014-January 1, 2023 (left). The distribution of percent population in poverty by quantile and census tract in New York City 2020 (right)

Annex C: Energy Transition Plans, Reliability, and Affordability - Challenges for NYC

As NYC addresses consistency with the Climate Leadership and Community Protection Act (CLCPA) and the commitment to carbon neutrality, there will be a growing need for technology and infrastructure that can improve efficiency and reliability. Over the course of the next few decades, New York State has committed to an energy transition. The transition is slated to occur through a decrease in use of fossil fuels to generate electrical power, while electrifying transportation and building energy services including heating, hot water, and cooking. Plans call for replacing fossil fuels with renewables including solar, wind, and hydropower.[30] The role of nuclear power remains an open question.

NYC will play a significant role in the energy transition, as the city's energy use is a major share of state energy use (30%) and the city produces 40% of the state's GHG emissions. The City also has committed to carbon neutrality by 2050.[31] At the same time, the City faces significant challenges in reducing the use of fossil fuels, acquiring renewables and electrifying sectors. The City's commitment to carbon neutrality is envisioned through the use of increased renewable energy generation, battery storage, and renewable energy transmission from up-State and beyond. All transportation and building energy demand are slated to be met by renewable electricity, meaning that electricity demand will increase dramatically. In order to meet low carbon fuel goals and reduce emissions, the City plans three important strategies:

1. Transform the electricity system to deliver 100% zero-emission electricity to buildings and the capacity to provide the same for more than a million zero emission vehicles (ZEVs);
2. Transform the current natural gas system to deliver low carbon gas (e.g., such as hydrogen or renewable natural gas) for end uses too costly and complex to fully electrify; and
3. Provide low carbon steam system for heating and cooling to some of the largest and most difficult buildings to decarbonize.[32]

According to New York Independent System Operator (NYISO), given current trends and conditions, annual baseline energy use will increase from 49,230 GWh in 2023 to 68,810 GWh in 2050 (40% increase) and baseline peak demand is projected to increase from 11,023 MW to 13,200 MW over the same period.[33] Energy storage to allow for renewable energy use is currently 22 MW and is projected to increase to 704 MW by 2050, and this storage will increase energy provision from 3 GWh in 2023 to 686 GWh in 2050[33] (about 10% of annual electricity demand during that 2050 period). Two transmission lines will deliver renewable energy to NYC; the Champlain-Hudson Power Express (CHPE) project that will deliver hydropower from Canada directly to Queens, and the New York Power Authority (NYPA)-led proposal, known as Clean Path NY, which proposes to deliver renewable energy from upstate New York directly to NYC.

There are at least four concerns to meeting carbon neutrality given current plans. The first is that many of the technologies to meet carbon neutrality goals are not yet commercially available. As a NYC study states, additional innovation is needed as battery storage technology is untested and undeveloped at the scale required to decarbonize NYC.[32] For example, Fekete et al.[34] points out that current battery storage technologies have limited capacity that may not meet the need for base load given seasonal variation in renewable energy generation. Current research suggests that studies of net-zero decarbonization include carbon capture and sequestration (CCS).[35] In fact, many studies suggest that CO2 emission reductions of great than 50% will not be possible without CCS.[36] CSS was not considered in the City's plans, suggesting contrary to research that the City's transition could indeed reduce carbon emissions without it. New York State is currently in the process of defining what constitutes 'zero emissions' that meet CLCPA targets,[37] to which there have been environmental, equity and justice-related concerns about the implications of fuels and technologies that may be included (e.g., nuclear, biofuels, hydrogen).[38]

Second, there are reliability concerns with the transition to a larger role of the electricity grid. Recently, the New York Independent System Operator (NYISO) finds that thinning reliability margins over the next decade present increased challenges to reliability for NYC.[39] NYISO quarterly assessment of reliability of the bulk electric system found a deficit in reliability margins for the NYC area beginning in summer 2025. The deficit is as large as 446 MW, driven primarily by the combination of a forecasted increase in peak demand (through the electrification of the transportation and building sectors, continued economic growth following the pandemic) and the unavailability of certain generators (Peaker plants).

Third, the electricity costs and affordability are important concerns. New York State is among the top 10 states with the highest electricity costs in the country. In 2023, cost of residential electricity was 21.92 cents/KWh compared to 15.92 cents/KWh for the country.[40] Costs will be increasing, as in June 2023, Con Ed requested another increase in electricity rates resulting in a roughly 12% increase for customers over the next three years.[41] These increases will go towards financing upgrades to the company's electricity delivery system, funding renewable energy plans and improving overall infrastructure. Continual rate increases can be critical for some NYC residents as approximately 610,000 families (representing 18% of total families in the city) pay greater than 6 percent of their household income and are therefore considered energy cost burdened.[9] Moreover, as there are large areas in the city that have low hosting capacity there will be a need to further upgrade the electricity grid in these locations so as to provide equitable renewable energy access.

Finally, there is concern whether Con Edison will be able to provide enough electricity distribution necessary to meet the increased demand for heating and transportation during the transition and if this increase can be accomplished while keeping affordability in check.

Annex D: Overview of City and State-Level Energy Policy

Table D1:Overview of City and State-level Energy Policy

Local Policy Initiative	Policy Entities	Policy Mandates	Energy Implications	Justice Implications
STATE				
Climate Leadership and Community Protection Act (CLCPA)	New York State Public Service Commission (PSC), New York State Energy Research and Development Authority (NYSERDA), New York State Department of Environmental Conservation (DEC), Climate Action Council (CAC)	6,000 MW of distributed solar installed by 2025, 185 trillion BTU reduction in total energy consumption, including electrification to reduce fossil fuel use in buildings by 2025, 3,000 MW of storage installed by 2030, 70% of load supplied by renewable resources by 2030, 9,000 MW of offshore wind installed by 2035, 100% of load supplied by zero emissions resources by 2040.	Transformation of the power grid, necessitating changes in market structures, planning processes, flexible load, and investment in bulk power system infrastructure.	The Climate Act mandates that no less than 35% with a goal of at least 40% of our climate action benefits will go toward New York's disadvantaged communities. The aim is to address the challenges and barriers these communities are facing.
Tier 4	New York State, New York City, New York State Public Service Commission (PSC)	TIer 4 is an innovative approach to supporting the development of transmission infrastructure at the state level while also providing clean energy to the state's most challenging load center.	Tier 4 addresses the imbalance of renewable energy access within the state grid. Administered by the New York State Energy Research and Development Authority (NYSERDA), the program procures renewable energy attributes in the form of Tier 4 Renewable Energy Certificates (RECs), which are tied to the delivery of renewable generation in New York City.	After a thorough project evaluation and negotiation process, two contract awards were recommended for projects: Clean Path NY (CPNY), and Champlain Hudson Power Express (CHPE). This renewable energy will help increase grid reliability and provide clean energy to New York City.
"Peaker Rule" Ozone Season Oxides of Nitrogen (NOx) Emissions Limits for Simple Cycle and Regenerative Combustion Turbines	NYS DEC	Reduce ozone-contributing pollutants associated with New York State-based peaking unit generation. Compliance obligations phased in between 2023 and 2025.	Reduction of fossil fuel use.	The Peaker Rule was issued to remove the legacy environmental harms in environmental justice communities and has resulted in the pursuit of deactivation by some of the city's oldest and dirtiest Peaker plants, allowing these sites to be redeveloped for energy storage and renewable energy infrastructure.

Local Policy Initiative	Policy Entities	Policy Mandates	Energy Implications	Justice Implications
STATE				
NYS Accelerated Renewable Energy Growth and Community Benefit Act (AREA)	Office of Renewable Energy Siting (ORES) within the NYS Department of State, NYPSC, NYSERDA	Provides for an accelerated path for the permitting and construction of renewable energy projects other than the Article 10 power plant siting law, calls for a comprehensive study to identify cost-effective distribution, local and bulk electric system upgrades to support the state's climate goals, and to file the study with the New York State Public Service Commission. Calls for use of NYISO's competitive Public Policy Process to meet transmission needs to meet CLCPA goals.	Intended to help accelerate siting of eligible renewable resources and establish new transmission investment priorities to facilitate the achievement of state climate and energy policies.	This legislation aims at improving the siting and construction of large-scale renewable energy projects in an environmentally responsible and cost-effective manner. Communities have input on reviews and potentially can receive compensation benefits for hosting major renewable facilities. All project approvals include provision for host community benefits.
Indian Point Deactivation	Agreement between New York State and Entergy	Deactivate Indian Point units 2 and 3 by 2020 and 2021, respectively.	Remove this nuclear power plant from the grid. NYISO Deactivation Assessment found no reliability need with loss of 2,311 MW. Three gas powered plants were subsequently used to make up baseload.	Deactivation resulted in the replacement of energy by natural gas. The closure of Indian Point has resulted in higher electricity prices.
Regional Greenhouse Gas Initiative (RGGI)	New York and other RGGI states	Reduce carbon dioxide emissions cap by 30% from 2020 to 2030 and expand applicability to currently exempt "peaking units" below current 25 MW threshold.	The NYS DEC proposed to expand applicability in NYS to generators of 15 MW or greater, whereas currently rules do not apply to generators less than 25 MW.	Power sector carbon mitigation policies' focusing on aggregate emissions reductions have largely benefitted non-environmental justice communities and have not redressed the fundamental problem of disparities in pollutant burdens between EJ and non-EJ communities.
Offshore Wind development	New York State Public Service Commission (PSC) / New York State Energy Research and Development Authority (NYSERDA)	NYSERDA currently has five offshore wind projects in active development, totaling more than 4,300 megawatts – nearly half of the State's goal for 9,000 megawatts by 2030. In July 2022, NYSERDA launched a third offshore wind solicitation to procure at least 2,000 additional megawatts of offshore wind energy for New Yorkers.	In addition to greening the grid, the offshore wind industry can bring thousands of new jobs to NYC and help revitalize our working waterfronts–like the efforts currently underway to transform the South Brooklyn Marine Terminal into an offshore wind staging site.	New York has entered into agreements to provide new jobs to EJ communities. The New York City Public Design Commission (PDC) has approved Equinor's design for the offshore wind operations and maintenance building to be constructed at the South Brooklyn Marine Terminal (SBMT). The approval from the PDC allows for advancement of New York's first-ever, purpose-built offshore wind operations and maintenance facility, marking an important step in revitalizing a working waterfront at this historic port. Jobs from this operation can help residents from disadvantaged communities.

Local Policy Initiative	Policy Entities	Policy Mandates	Energy Implications	Justice Implications
CITY				
Local Law 43 (2010) and Local Law 32 (2023)	New York City	Eliminate combustion of fuel oil numbers 6 and 4 in NYC.	Removal of "dirty" oil fuel use in residential and commercial buildings.	The Clean Heat program, related to this effort, reduced air pollution emissions in both high and low-income neighborhoods.
Local Law 97 (2019)	New York City	Requires reduced building greenhouse gas emissions by 40% by 2030, with compliance starting in 2024, and 100% by 2050.	Mandate applies to any building in NYC 25,000 square feet or larger; the law was updated in 2020 to include buildings in which up to 35% of units are rent regulated, starting in 2026. Officials estimate the law would apply to roughly 50,000 of the city's more than one million buildings.	Local Law 97 focuses on NYC's large buildings, both residential and commercial. Large residential buildings, where about two thirds of the city's population live, are already more efficient than single and two-family homes. Moreover, measurement of efficiency is based upon square footage, and it would be more effective to focus on per capita or household level emissions. To address this NYC launched the ElectrifyNYC (Electrify New York City), a free program that helps NYC homeowners in 1-4 unit buildings with green and efficient home upgrades so they can save money, make their homes more comfortable, and clean the air.

Local Policy Initiative	Policy Entities	Policy Mandates	Energy Implications	Justice Implications
CITY				
Local Law 24 (2016)	New York City	To enhance public awareness of the city's efforts to install 100 MW of solar by 2025. The city is required to assess the solar PV potential of all City-owned buildings over 10,000 gross square feet once every two years. Special focus is given to identifying and quantifying potential capacity at solar-ready buildings, which are defined as buildings that have roofs that are no more than 10 years old and in fair or good condition. The City has initiated the "Solar 100" project goal to install 100 megawatts (MW) of solar photovoltaic (PV) electricity generation capacity across municipal buildings by 2025. The Department of Education (DOE) partners with Solar One (a 501(c)(3) organization fostering sustainability education, training and technical assistance), on programs that support climate education and climate-related workforce development opportunities for public schools.	Increase in renewable solar energy generation within NYC.	There is a difference in hosting capacity across NYC neighborhoods which brings up questions of whether this will affect solar installation and energy storage capacity in EJ communities.
Local Law 92 and Local Law 94 (2019)	New York City	These laws require all buildings undergoing roof decking replacement and any newly constructed buildings to have a sustainable roofing zone—a solar PV system, a green roof, or a combination of both.	Enhance the development and implementation of solar energy in NYC.	NYC Accelerator program provides resources, training, and one-on-one expert guidance to help building owners and industry professionals improve energy efficiency and reduce carbon emissions from buildings in NYC.
Local Law 2 (2022)	New York City	Requires the creation of a demonstration program for geothermal exchange systems, pending results of the ongoing feasibility study.	Geothermal heat pumps provide clean and efficient heating and cooling, while using less electricity than other types of heat pumps. The project can realize further efficiencies and maximize environmental benefits through balanced loads and a diversity of thermal sources and sinks.	Geothermal power can potentially provide EJ communities with clean and efficient heating and cooling.

Local Policy Initiative	Policy Entities	Policy Mandates	Energy Implications	Justice Implications
CITY				
Local Law 99 (2019)	New York City	Assessing the feasibility of replacing in-city gas fired power plants with battery storage powered by renewables, and assessing the readiness of NYC's electric grid to accommodate anticipated increases in customer electricity demand due to building electrification.	Providing background on replacing fossil fuel power plants with clean energy and battery storage.	Background material can be used to provide information one energy storage access in EJ communities.
Local Law 248 (2017)	New York City	A law that requires NYC to create a long-term energy plan in 2019, every four years after and also establishes a City energy policy advisory subcommittee.	Provides a plan for energy use, a review of the current energy supply and capacity; a summary of the current citywide energy demand and a projection of the future citywide energy demand over the next four years, or such longer period as the advisory subcommittee may deem appropriate, including (i) an identification of factors that may affect demand; (ii) specific recommendations regarding the capacity that could be added to the current energy supply to meet such projected demand after consideration of such factors; and (iii) actions the City could take in connection with such recommendations.	Background material can be used to provide information on availability of wind generation in EJ communities.
Local Law 104 (2018)	New York City	A Local Law to amend the administrative code of the City of New York, in relation to the creation of wind maps demonstrating wind energy generation potential within the city.	Promote wind generation in NYC.	Background material can be used to provide information on removing highly polluting plants from EJ communities.
Local Law 181 (2019)	New York City	Studying the feasibility of installing utility-scale energy storage on private buildings throughout the city.	Provision of utility scale storage systems to allow for use of renewable energy.	Background material can be used to provide information on energy storage availability to EJ communities and what is feasible to use in lieu of Peaker plants.
Local Law 17	New York City	To direct the mayor’s office of long-term planning and sustainability to study the feasibility of different types of renewable energy sources combined with battery storage on Rikers Island.	Provide background on renewable energy to Riker's Island.	Provide renewable energy to officers, staff and inmates at Riker’s Island facility.

Local Policy Initiative	Policy Entities	Policy Mandates	Energy Implications	Justice Implications
CITY				
Local Law 154	New York City	To amend the administrative code of the City of New York, in relation to the use of substances with certain emissions profiles.	No person shall permit the combustion of any substance that emits 25 kilograms or more of carbon dioxide per million British thermal units of energy, as determined by the United States energy information administration, within such building.	Reduction of carbon dioxide emissions and electrification of EJ community buildings.
Local Laws 60 and 64	New York City	Assess the environmental equity issues in NYC and develop a plan to incorporate environmental justice into the fabric of City decision making. The law covers Power plants, Substations, distribution, and transmission Citygate stations, High-pressure regulators stations over 300psi; any boilers burning fuel oil #4 or #6 with or without waivers from City agencies; renewable energy systems, including solar PV, wind, microgrids, and energy storage, Generators required to be registered with DEP.	A report, an online EJ portal, and a plan are available. This legislatively mandated work, known as Environmental Justice New York City (EJNYC), represents a historic investment from the City of New York to study environmental inequities affecting how and where low-income communities and communities of color live, and to provide all residents the tools to advocate for the best outcomes for their communities.	The report on future investment decisions includes energy infrastructure in and affecting EJ communities.

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