GRID READINESS: CREATING A CLEAN, CLIMATE RESILIENT, AND RELIABLE ENERGY GRID

ABSTRACT

New York City's (NYC or City) strategy to meet city and state climate policy targets relies heavily on electrification. Local Law 154 of 2021 requires the City to study the readiness of NYC's electric grid to accommodate anticipated customer demand given increased levels of electrification. To assess the readiness of New York City's grid, this research geospatially allocated anticipated citywide electrification to each Con Edison distribution network. This network-level geospatial forecast of load impacts was used with publicly available data from Con Edison to determine where additional investment or analysis may be necessary to avoid issues of resource reliability and grid readiness in the future. This research evaluates electrification load impacts and interactions with the Con Edison distribution system under several load management scenarios to assess the value of increased load management and exporting technologies.

While the analysis finds that Con Edison is already planning upgrades in several networks expected to face electrification accommodation challenges accommodating electrification, additional investments and upgrades may be required. Many upgrades may have substantial lead times, and the analysis suggests that the City and Con Edison should conduct additional distribution planning in the near-term to prevent the grid from becoming a bottleneck to electrification and achievement of City climate targets.

RESEARCH AREA OVERVIEW AND OBJECTIVE

As a result of New York State and NYC's climate goals and electrification targets, the City anticipates reaching high levels of both building and transportation electrification over the next three decades. New York City's Local Law 154 requires the City conduct a "grid readiness study" focused on the impacts of electrification on both transmission and distribution systems. This research area is part of the PowerUp study and satisfies the Local Law 154 requirement.

The expansion of transmission lines into NYC to support increased electrification is evaluated qualitatively and draws upon related work from NYISO and NYSERDA.

The distribution system is evaluated quantitatively in the study. Electrification impacts were evaluated on Zone J annual and peak load as well as impacts on the local grid. The research examined a range of plausible electrification futures in the City from 2030 through 2040. The study team partnered with Integral Analytics to use their Forecasting Anywhere tool to develop a granular (distribution network level) forecast of the impacts of building and transportation electrification in NYC. This study built upon previous work conducted for the City that evaluates the impacts of electrification. Notably, Urban Green Council has conducted an evaluation of building electrification impacts at the distribution network level in NYC. This study leveraged the Urban Green Council evaluation and additional transportation electrification metrics to offer a comprehensive evaluation of electrification impacts on New York City's grid. Forecasts of annual and peak load added at the distribution network level were used to determine where additional upgrades will be needed.

The outputs of this study can be used to identify potential grid or resource reliability issues throughout the City that will occur absent further investment, given expected energy supply and demand factors in different plausible scenarios. Using projected electricity demand, transmission flows, and resource adequacy needs, this research area identified ways to adapt placement of certain electrification end uses (such as fleet charging stations) and areas that require further investment in the electrical grid, distribution system, or transmission system. Additionally, the outputs of this study can indicate topics that require further research and how flexible resources, and emerging technologies can be used contextually to address grid readiness moving forward.

METHODOLOGY

This study used the Forecasting Anywhere tool to geospatially allocate building and transportation electrification across NYC networks. Building electrification was represented as the adoption of electric building appliances, including electric heat pumps for space heating, electric water heating, cooking, clothes drying. Transportation electrification was represented as the number of EV chargers necessary to serve EVs, since EV chargers are the point of transportation electric demand.

The Forecasting Anywhere tool inputs a variety of datasets with use of information regarding location, size, and other characteristics of buildings, parking spaces, and roads. These datapoints inform the technical potential, or the availability to electrify given physical constraints of New York City. A backbone to building the technical potential was the Primary Land Use Tax Lot Output (PLUTO) dataset.i The PLUTO dataset contains tax lot level data for all five City boroughs from the data files maintained by the Department of City Planning (DCP). The study used a version of the PLUTO dataset updated in August 2022.

Forecasting Anywhere also used historic data and forecasted adoption trends to determine the likelihood that each building and vehicle in NYC will electrify in the modeling horizon. This included past electrification trends and of existing electrification trends with key parameters like median household income and existing building fuel type. Forecasting Anywhere also used adaptation forecast trends that capture patterns of electrification that may be different than those observed to date. For example, Forecasting Anywhere can capture anticipated trends in building electrification from the implementation of Local Law 97 starting in 2024. Both historic and anticipated future trends in electrification were used to inform the electrification uptake. Each building or parking space data point was given a numeric propensity, or likelihood, of electrification. Numeric propensities are relative (i.e., the numbers derive meaning from comparisons to other data set numbers) and are derived by assigning each data point a number based on parameters that affect relative likelihood of electrification. The parameters used to assign propensities are customizable and were selected for NYC based on historic and anticipated trends in electrification. More detail on the trends and propensities used is provided in each of the subsequent "Buildings" and "Transportation" subsections.

The modeling horizon for this study is 2030 through 2040, with results shown for snapshot years of 2030, 2035, and 2040. Although the modeling horizon is 2030 through 2040, electrification from 2023 up to 2030 were captured in results shown for 2030 and onward. The milestones of 2030 and 2035 were selected to depict the timing at which the City's electric grid will start to become constrained by electrification, as informed by other studies of electrification in NYC like the Urban Green Council's Grid Ready report. By 2040, high levels of electrification are anticipated given the City's electrification and climate targets. Including 2040 in the modeling horizon offers insights into grid constraints once penetration levels of building and transportation electrification technologies are higher.

Scenarios

This study modeled three scenarios in each of the modeled years (2030, 2035, 2040). Scenarios varied based on levels of load management. The "Unmanaged Load Scenario" evaluates electric load that is entirely unmanaged. For buildings, unmanaged load has no peak shaving (i.e. raw electric demand for heating, even at grid peak times, are met). For transportation, unmanaged load is charging that begins immediately upon arrival of a vehicle at a charging location. Most EVs are personal light-duty vehicles that use residential chargers. Therefore, unmanaged charging tends to occur in early evening hours when many drivers arrive at home.

The "Managed Load Scenario" depicts electric loads managed to avoid incremental electrification load adding stress to the grid at peak times. For buildings, managed load included peak shaving of 10% of load at peak times. This was achieved through either demand response of space heating loads (i.e., a customer reduces their temperature setpoint at times of grid peak) or through dual fuel heating systems. To achieve a 10% reduction at peak times, customers must reduce temperature setpoints for heating by 2.5 degrees in 100 hours (with hours determined based on grid peak times). A dual-fuel heating system would switch use to natural gas or fuel oil for space heating instead of electric heat pump at times of grid peaks. Both demand response and dual fuel heating systems are needed whenever the temperature goes below 10 degrees Fahrenheit in order to achieve a 10% reduction in demand at peak times.

The "Managed Load with Exporting Technologies Scenario" leveraged the capability of buildings and EVs to provide energy back to the grid, building on the load management performed in the "Managed Load Scenario." Buildings were modeled with behind-the-meter battery storage that charges the battery during off-peak times and discharges energy back to the grid at peak times. Vehicles were modeled with vehicle-to-grid (V2G) capability enabling vehicle batteries to discharge stored energy back to the power grid during peak times.

The levels of building and transportation electrification remained the same across all scenarios. Given the different levels of load management, the same level building electrification and EV penetration result in different grid impacts. A comparison of grid impacts across these three scenarios offers an assessment of the value of load management strategies.

Disadvantaged Communities

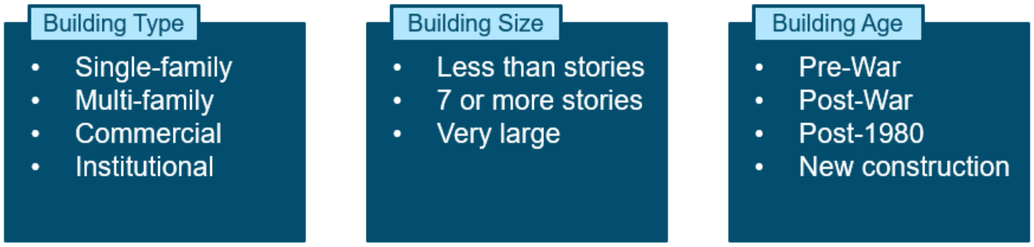
In addition to showing citywide results at the network levels, this study also isolates results for network levels classified as “disadvantaged.” Network levels were classified as disadvantaged if 50% or more of the network level areas were within a disadvantaged community, as defined by New York State. At the time of this analysis, New York State was using the interim criteria developed by the Climate Justice Working Group (CJWG) to define disadvantaged communities statewide, which was also used for this analysis. The interim criteria defined disadvantaged communities using indicators like land use and facilities associated with historical discrimination, potential climate change risks, and potential pollution exposure.ii

BUILDINGS

Typologies

Building typologies represented in this study were aligned with the building typologies used in the “Pathways to Carbon-Neutral NYC” study (referred to as Pathways Study) iii￼ detailed in ￼Figure ￼ below.

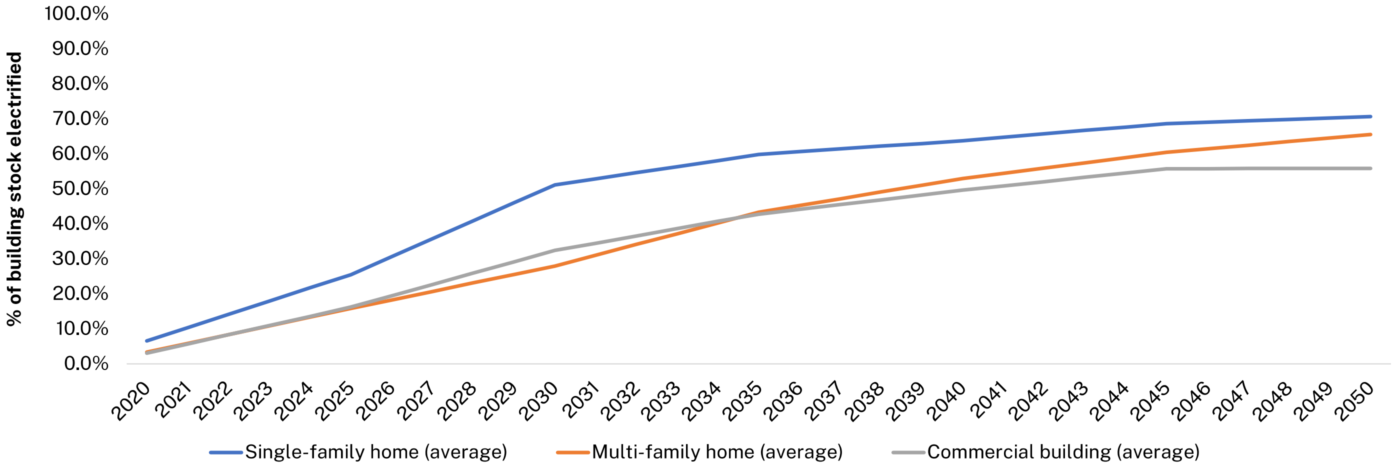
Figure 1. Building typology characteristics



Citywide adoption forecast

The citywide levels of building electrification were geospatially allocated to networks and were informed by forecasts of the portion of building stock electrified as identified in the Pathways Study. This study used the detailed Pathways study breakdown of electrification forecasts by building typology and the building typology-level sum to determine the total forecasted building electrification for NYC. Figure 2 below shows the forecast of building stock electrified, grouped by building type (i.e. single-family, multi-family, and commercial) for simplicity.

Figure 2. Building stock electrification forecast, 2022-2050



Adoption propensities

The propensities, or likelihoods, for a given datapoint to adopt electric building appliances are based on several factors. The first was Local Law 97 (LL97). Starting in 2024, buildings over 25,000 square feet are required to meet GHG emissions limits and will face penalties if emissions are above the set limit.[iv] Therefore, an anticipated electrification trend for LL97-compliant buildings holds that buildings with higher emissions, which will face higher penalty costs for exceeding emissions limits, will be more likely to electrify.

Another factor considered when developing propensities was the baseline fuel type. Based on findings from the Building Electrification research which analyzed the relative cost-effectiveness of electrification by baseline fuel type, this study assigned building propensities based on cost-effectiveness. Per that Chapter, electrification of buildings that currently use fuel oil is more cost-effective than the electrification of those that use natural gas. Additionally, buildings that use steam have been identified as harder to electrify than other baseline fuel types. To reflect this, buildings that use steam have a lower associated propensity to electrify than other fuel types.

Building propensity to electrify also incorporates a slight correlation with income.[1] Income data used for this study was derived from the United States Census Bureau.[v] Income data was mapped from census tracts to the local and network levels using Federal Information Processing Standards (FIPS) codes, which include identifiers necessary for mapping.

There was also some randomization introduced into the numeric propensity assignments to reflect uncertainty and the likelihood that electrification will not precisely follow cost-effectiveness trends. To inform the geospatial locations of where new construction will occur, this study used [vi]￼ Permit data includes information on the type of permit requested. Permits requested or issued for new construction, demolition, or boiler replacements were used to inform where and when new construction will occur across the city. The likelihood of new construction to electrify is aligned with City requirements for all-electric new construction. Starting in 2024, new construction of buildings less than 7 stories must be all-electric. B[vii]￼

Load shapes

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[1] Given a limited amount of historical heat pump adoption, trends have indicated that adoption is more likely in higher-income households. Although programs and incentives are helping to increase adoption in lower-income households, it is assumed that there will remain a slight correlation of building electrification with income given the projection for continued higher upfront costs of electric appliances. Study on historical correlation of heating adoption with income from Shen et al.: https://www.researchgate.net/publication/360752972_The_Effect_of_Rebate_and_Loan_Incentives_on_Residential_Heat_Pump_Adoption_Evidence_from_North_Carolina.

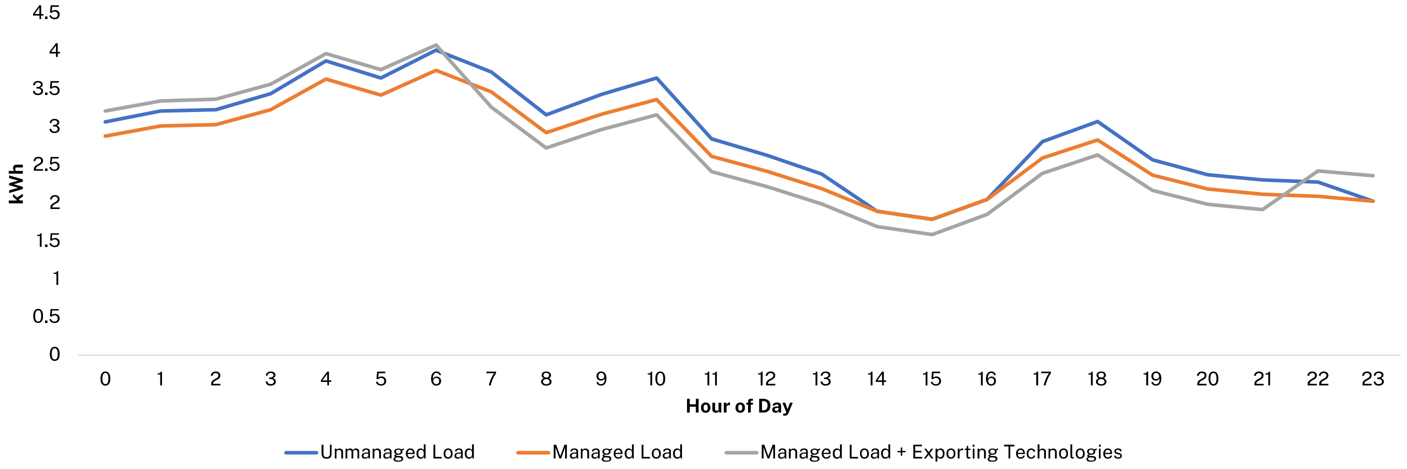
Building load shapes for each of the three scenarios were input into Forecasting Anywhere to determine the grid impacts of buildings electrified in each network level. Building load shapes for the Managed Load Scenario were derived from the Pathways Study. The Pathways Study developed separate baseline (pre-electrification) and electrification (post-electrification) load shapes by building typology. Electrified building load shapes for Pathway Scenario 1b were used for this study. Load shapes for Pathways Study Scenario 1b include an assumed 10% load reduction at peak times, which aligns with the management assumed for building load in the Managed Load Scenario. Electricity demand for electrified buildings was derived by blending the measure combinations specified by the Pathways Study for Pathways Scenario 1b. More detail on the measure combinations for each building typology can be found in the Pathways Study Technical Appendix. The analysis applied an adjustment to the electrified building load shapes used in the Pathways Study to reflect updated assumptions on achievable energy efficiency penetration.[2] The incremental impact of electrifying buildings was derived by calculating the hourly difference between the baseline and electrification load shapes.

To derive building load shapes for the Unmanaged Load Scenario, the study back calculated the load shape that would have resulted from no reduction at peak times. One option to achieve the 10% reduction in space heating load during peak times was to implement a setpoint temperature adjustment of 2.5-degrees in the top 100 hours of winter grid demand. Therefore, this analysis calculated the load shape that would result from space heating demand for an additional 2.5 degrees in those top 100 hours.

Building load shapes for the Managed Load + Exporting Technologies Scenario were calculated to include a behind-the-meter 4-hour battery storage system sized to meet 20% of each building typology's peak load. To represent the aggregated charging and discharging that would result from an entire building population's 4-hour battery storage systems, each building was modeled to have charging spread evenly over peak times. Discharging was then spread evenly over off-peak times. Peak and off-peak times were defined based on a currently offered Con Edison time-of-use rate. In the summer months (June 1-September 30), peak hours are 2 to 6 p.m. and off-peak hours are all other times. In the winter months (all other months), peak hours are 8 a.m. to 10 p.m. and off-peak hours are all other times.[viii]

Building load shapes for each of the three scenarios is shown for a representative day in Figure 3 below.

Figure 3. Building load shapes for each scenario for a single-family detached home for a representative day



TRANSPORTATION

Typologies

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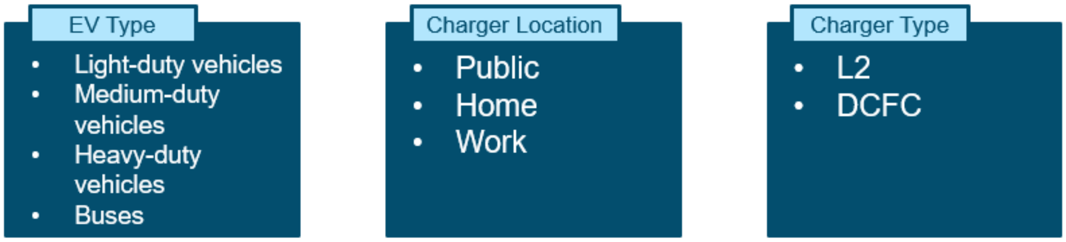
[2] The Pathways study assumed levels of energy efficiency that are higher than what is currently estimated to be realistically and cost-effectively achieved. Therefore, E3 reduced the energy efficiency (EE) assumptions so that Pathways building load shapes could not achieve greater than 27% for measures with "Low Effort EE", 30% for measures with "Low Effort EE + High Effort EE" and 32% for measures with "Low Effort EE + High Effort EE + Recladding".

Four separate vehicle types were modeled in this study, consistent with the vehicle types modeled in the Pathways Study. [ix] Each vehicle type was also assumed to have charging access to one or several types of charging technology. Charging access is defined by charger location and charger type. Figure 4 below outlines the types of vehicles and charger locations and types modeled in this study.

Figure 4. Vehicle types modeled

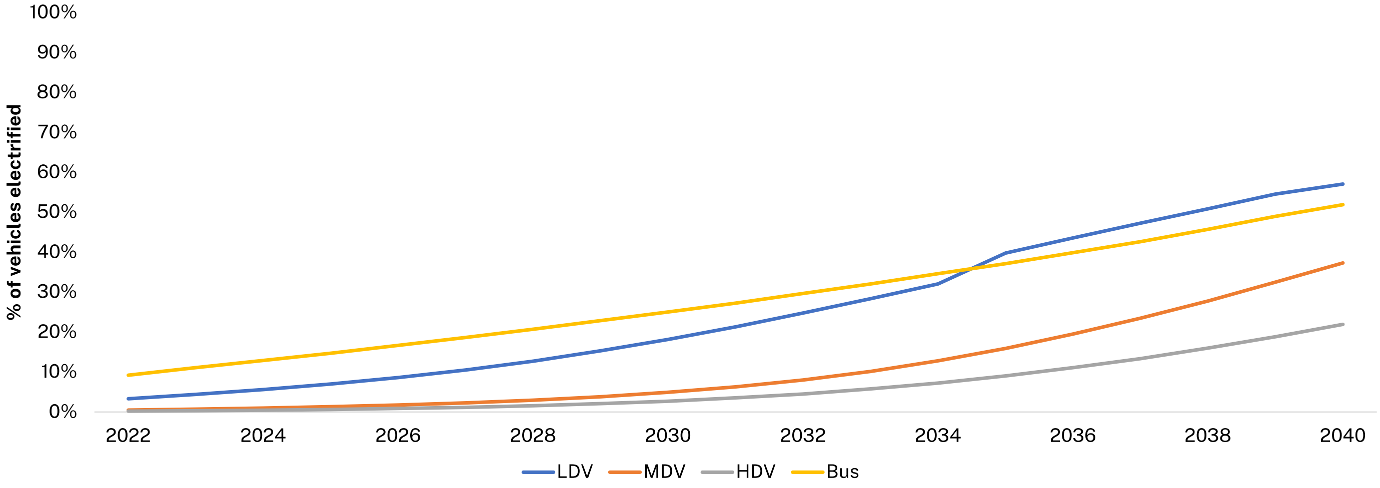


Most vehicles are expected to meet their charging needs with L2 and/or DCFC (Direct Current Fast Charging) by 2030.[x] This study did not model L1 chargers, as any L1 chargers that are used have a relatively minimal impact on the grid given their smaller charging level (i.e., 1 kW for an L1 charger compared to 7.7 kW for an L2 charger).

Citywide adoption forecast

Citywide levels of transportation electrification were based on the electric vehicle adoption forecasts developed in the Pathways Study. Since the Pathways Study was published in April 2021, New York State has passed legislation to require 100% of passenger cars, pickup trucks, and SUVs sold in the state to be zero-emission by 2035.[xi] While the Pathways Study forecast assumed electrification of 80% of light-duty vehicles (LDV) by 2035, this study adjusted assumptions to reflect the 100% light-duty vehicle electrification starting in 2035. Although there are other non-electric options for zero-emission vehicles, like hydrogen-powered fuel cell vehicles, these alternatives are more likely to be used for medium- and heavy-duty vehicle applications rather than to LDVs [xii]Therefore, the 100% zero-emission sales target for light-duty vehicles is assumed to be met through all electric vehicles. The forecast for each vehicle type as a percentage of total vehicles on the road electrified is shown in Figure below.

Figure 5. Vehicle stock electrification forecast, 2022-2050



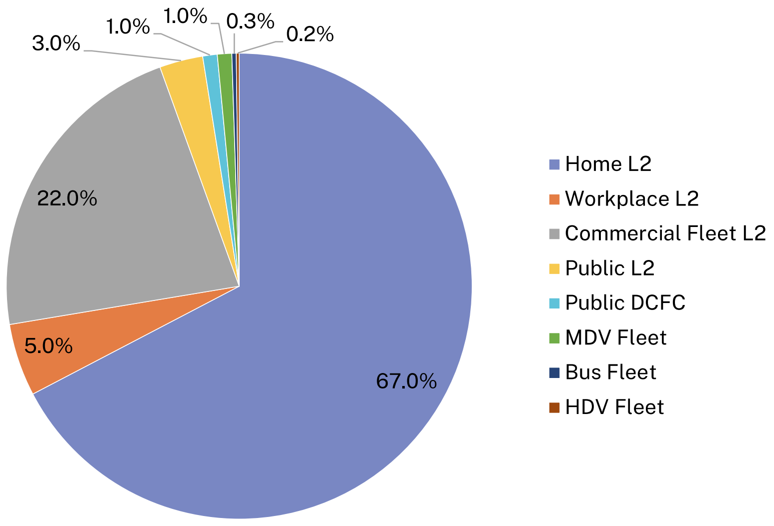
Forecasting Anywhere input a forecast of EV chargers rather than vehicle counts to determine electrification impacts. EV adoption forecasts were translated to charger adoption forecasts based on the EV-to-EV charger ratios derived from the "New York State Clean Transportation Roadmap"[xiii] (Clean Transportation Roadmap) and study assumptions. Residential chargers are assumed to have an EV-to-EV charger ratio of 1 across the modeling horizon, indicating that each personal LDV will have access to a residential charger. The EV-to-EV charger ratio for depot locations also remain constant over the modeling horizon, with one charger for every two or three vehicles depending on the vehicle type. Workplace and public EV to EV charger ratios vary slightly over time, with fewer vehicles per charger later in the modeling horizon to reflect higher levels of charger buildout over time.

Table 1. EV to EV charger ratios

Charger Type	2030 EV: EV charger ratio	2035 EV: EV charger ratio	2040 EV: EV charger ratio	Source
Residential L2	1	1	1	Study assumption
Workplace L2	13.4	13.3	12.9	“New York State Clean Transportation Roadmap”
Public L2	19.9	18.9	17.3	“New York State Clean Transportation Roadmap”
Public DCFC	97.1	80.5	71.4	“New York State Clean Transportation Roadmap”
Fleet depot L2	3	3	3	Study assumption
MDV depot L2	2	2	2	Study assumption
HDV depot DCFC	2	2	2	Study assumption
Transit bus depot L2/DCFC[3]	4	4	4	Study assumption

The resulting proportion of chargers added throughout New York City by charger type in 2040 is shown in Figure 6 below.

Figure 6. 2040 proportion of each charger type in New York City



EV Adoption Rate

The propensities, or likelihoods, for a given datapoint to adopt a light-duty EV charger are informed by a combination of income-based trends and random apportionment. Historic trends provide that higher-income households are more likely to adopt personal light-duty EVs. This trend is expected to fade over time as the upfront costs of light-duty EVs reach cost parity with comparable internal combustion engine (ICE) vehicles. Therefore, there is some correlation in modeled years between income and likelihood to adopt an EV. There is also some

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[3] The study assumes that half of school bus chargers are L2 and half are DCFC. The EV to EV charger ratio of 4 applies across both charger levels.

randomization to EV adoption applied on top of the income-based correlation to reflect future EV adoption trend uncertainty. Propensities for LDV charger adoption also reflect some citywide roadmaps, such as the Clean Transportation Roadmap.xiv For example, the Clean Transportation Roadmap identifies a need for additional DCFC at airports to support ridesharing vehicles that heavily traffic airports, and this is reflected in increased propensities for airport parking spots to adopt DCFC.

The propensities for a given datapoint to adopt a medium- or heavy-duty (MD/HD) EV charger were informed by characteristics of organizations or businesses, like business type. Data for this study was provided by the North American Industry Classification System (NAICS)[xv] and was used to predict MD/HD charger adoption based on organization/business characteristics. The electrification of school buses, classified as MDVs, is informed by City requirements to reach 100% electric school bus sales by 2027 and a fully electrified school bus fleet by 2035. Data on each school bus in New York City was obtained from the Department of Education (DOE). School bus age was used to estimate when each bus will be electrified; older school buses more likely to retire are estimated to electrify first. Transit bus electrification is aligned with the depot-level deployment plan for electric buses outlined in the MTA Zero-Emission Bus Transition Plan released in May 2022.[xvi]

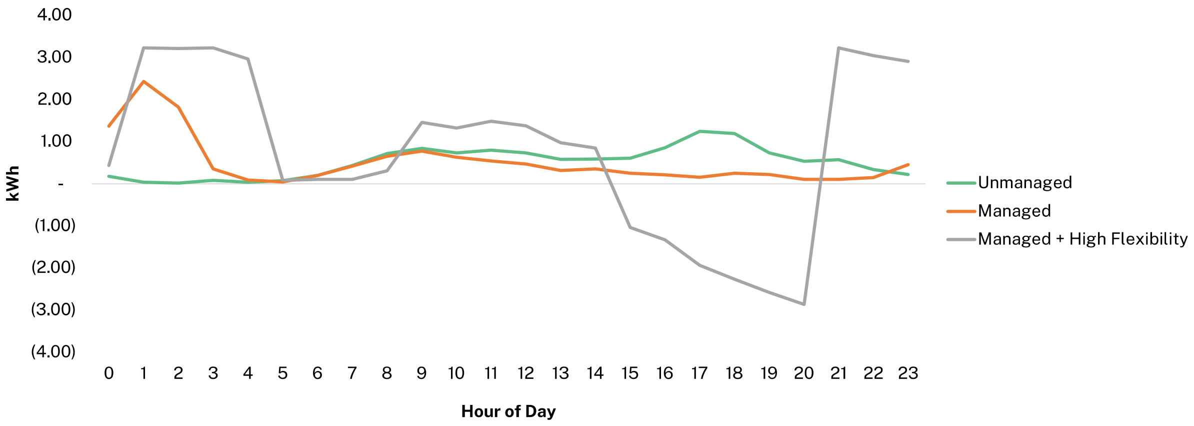
Load shapes

Load shapes for EV charging were also input into Forecasting Anywhere to determine the grid impacts of electrifying transportation. Load shapes for the Unmanaged and Managed Load Scenarios were developed based on load shapes used in the Pathways Study. The Pathways Study includes separate charging profiles for LDVs, MDVs, HDVs, and transit buses. This study modified the Pathways Study load shapes for each vehicle type to account for vehicle efficiency losses due to temperature. EVs have been observed to have lower efficiency in extreme hot and cold temperatures and therefore require more charging to drive the same distances at times of extreme temperature. In New York City, cold winter months have a particularly large impact on charging demands. Temperature adjustments were applied based on findings from a real-life study conducted by Geotab.[xvii] Temperature data for a New York State Typical Meteorological Year (TMY) was used to adjust the 24-hour load shape used in the Pathways Study for each hour in the year.

Load shapes for the Managed Load + Exporting Technologies Scenario were developed to capitalize on the capability of vehicles to discharge stored energy back to the grid and also charge to satisfy driving requirements. V2G (vehicle-to-grid) load shapes were only developed and used for residential L2 charging for LDVs and for school bus charging since these are the use cases that are most likely to be able to participate in V2G charging. Other vehicle types and charging locations, such as LDV public charging or HDV depot charging, are less likely to have the time and flexibility given driving needs to participate in V2G charging. Therefore, these vehicles type were modeled to have managed charging rather than V2G charging in the Managed Load + Exporting Technologies Scenario. Residential L2 charging V2G charging profiles were developed based on V2G profiles that the study developed using a real-time NYISO rate. School bus V2G charging profiles were aligned with those developed for the PowerUp School Bus Electrification study. V2G charging profiles for residential L2 and school bus charging were designed so as to still satisfy the same driving requirements as vehicles in the Unmanaged and Managed Scenarios.

Light-duty vehicle charging load shapes for each of the three scenarios is shown for a representative day in Figure 7 below.

Figure 7. LDV charging load shapes for each scenario for a sample day in April



Grid Impacts

Assumed electrification levels based on the Pathways Study were compared to Con Edison data to assess the readiness of New York City's grid to accommodate forecasted levels of electrification. Forecasting Anywhere used Con Edison hourly peak load data for 2022 by network level, derived from Con Edison's hosting capacity website,[xviii] to determine how peak loads change in each network level once electrification is added. Grid impacts are relative to today's network. Given data limitations, changes to Con Edison's grid, either planned or anticipated, are not reflected in the comparison of electrification to grid capacities.

Key Findings

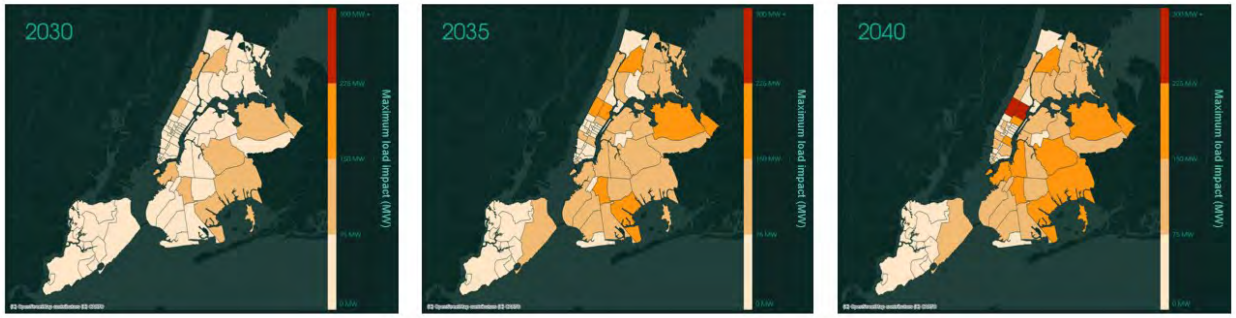
Shown below are key findings from each of the three scenarios studied (Unmanaged Load, Managed Load, and Managed Load + Exporting Technologies). Results from the Managed Load Scenario are presented first and represent a baseline set of results in which the findings from the Unmanaged Load and Managed Load + Exporting Technologies Scenarios are compared.

Managed Load Scenario

Maximum Incremental Load Impacts from Electrification

The results of the Managed Load Scenario maximum incremental load impacts from combined building and transportation electrification are shown in Figure 8 below. These results show the maximum incremental load, in MW, from electrification without consideration of the baseline load peak or the timing of the baseline load peak. Maximum incremental loads shown below represent the maximum hourly load from electrification for each individual network level and therefore may be at separate times across different network levels.

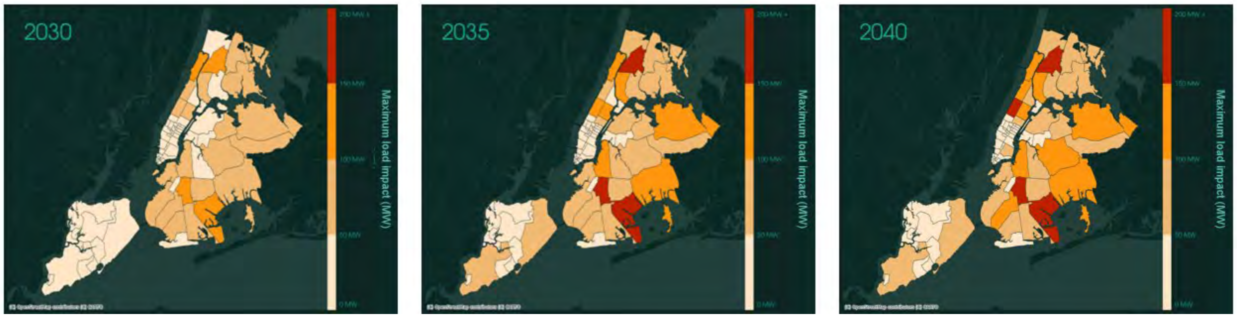
Figure 8. Maximum incremental load impacts, in MW, of building and transportation electrification combined (Managed Load Scenario)



Results in Figure 8 provide that some of the highest incremental load impacts from electrification will be in the outer areas of Brooklyn and Queens. Additionally, there are pockets of Manhattan and the Bronx that are forecasted to experience high incremental load impacts from electrification. These areas begin experiencing load impacts from electrification by 2030 and the impacts increase over time through 2040.

Figure 9 below shows the maximum incremental load impacts from building electrification for only the Managed Load Scenario.

Figure 9. Maximum incremental load impacts, in MW, of building electrification (Managed Load Scenario)



Maximum incremental load impacts from building electrification as shown in Figure 9 are highest in Brooklyn, Queens, and the Bronx. Maximum incremental load impacts from building electrification are aligned with where building electrification is projected to occur, shown below in Figure 10 in terms of square feet electrified.

Figure 10. Building electrification adoption, in million square feet electrified

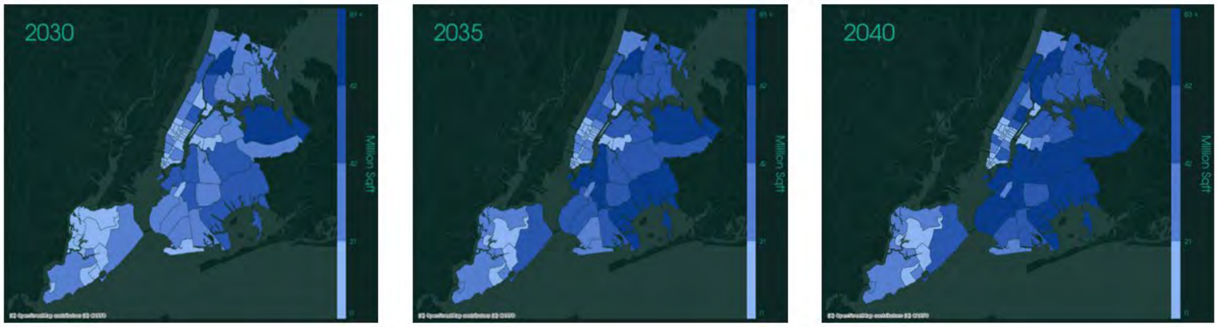
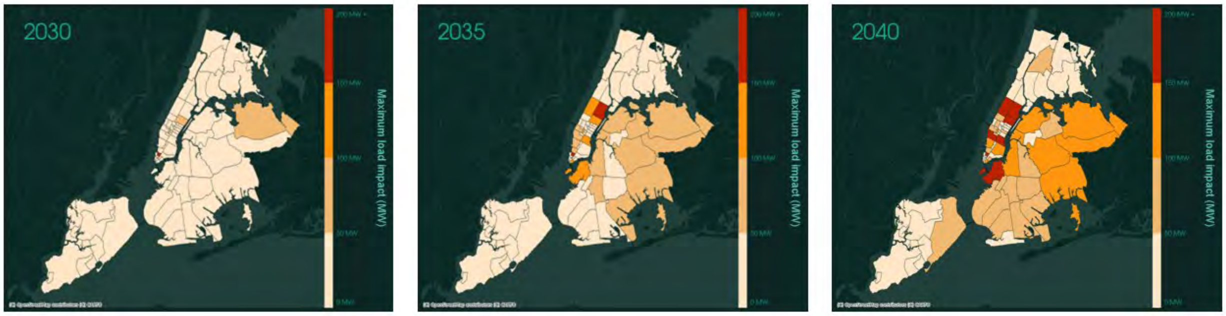


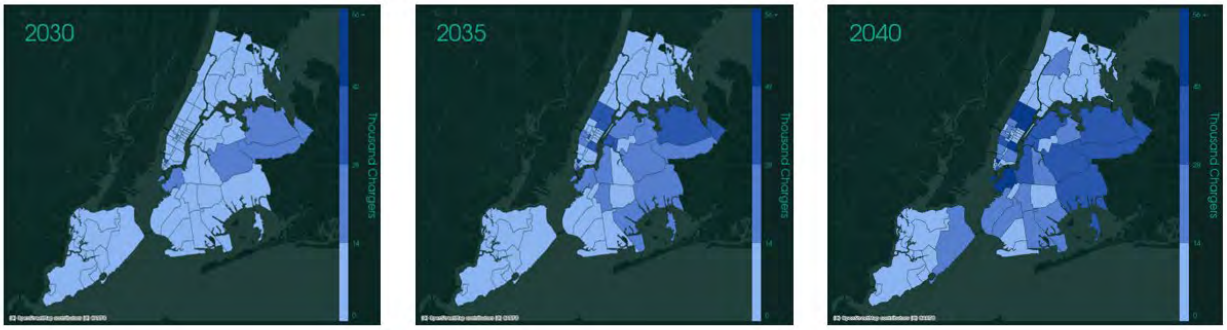
Figure 11 below show the maximum incremental load impacts from transportation electrification only for the Managed Load Scenario.

Figure 11. Maximum incremental load impacts, in MW, of transportation electrification, in Managed Load Scenario



Maximum incremental load impacts from transportation electrification are highest in Manhattan and Queens. The findings suggest incremental load impacts from electrification in Manhattan are driven more by transportation loads whereas load impacts in Brooklyn and the Bronx are more so driven by building electrification. Maximum incremental load impacts from transportation electrification are aligned with where transportation electrification is projected to occur, shown below in Figure 12 in terms of the number of chargers built.

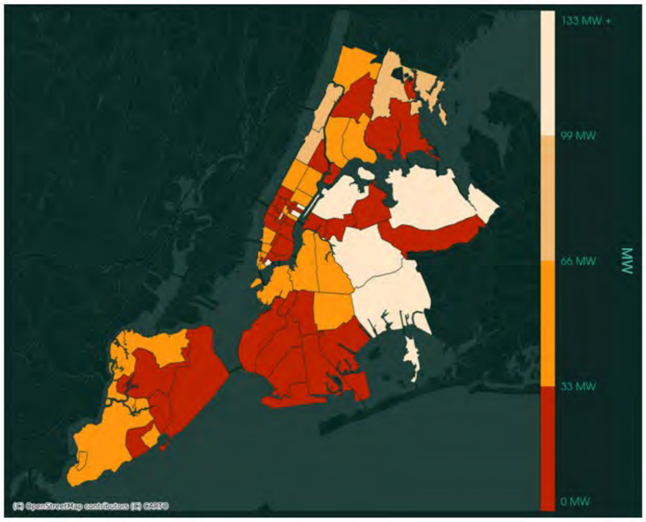
Figure 12. EV charger buildout, in thousands of chargers built



Available Headroom on Con Edison Network

Figure 13 below shows Con Edison's current headroom on each of its New York City networks based on Con Edison's hosting capacity website.[xix] The darker, red shading indicates that a network has a lower amount of headroom available.

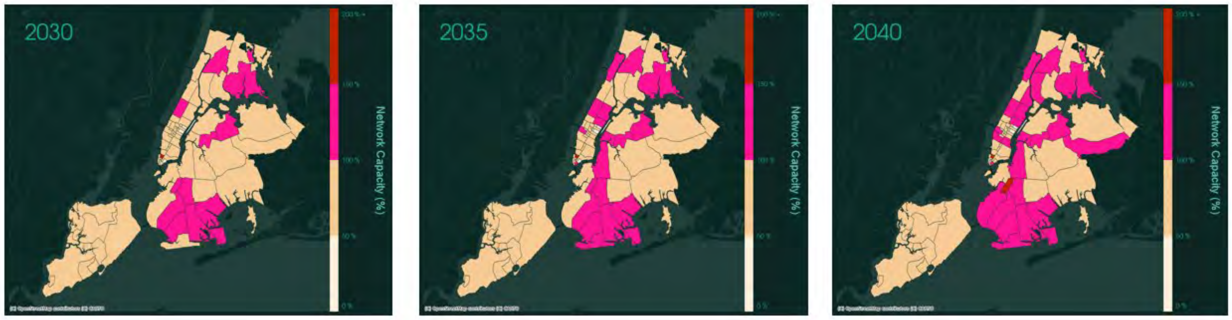
Figure 13. Current available headroom on Con Edison's networks



If electrification load impacts were spread evenly throughout New York City, the areas with less headroom available would be expected to be most impacted by increased electrification. However, results from this study indicate varying load impacts by network level. Therefore, networks with less headroom currently available may not necessarily be those that exceed capacity from increased electrification. The following results of the Managed Load Scenario show the remaining available headroom in each of Con Edison's networks after building and transportation electrification.

Figure 14 below shows the available headroom of each network with electrification relative to Con Edison's current headroom in percentage of capacity exceeded. A percentage of less than 100% indicates that network peak load remains below network capacity after electrification while percentages greater than 100% indicates that network peak load exceeds current available capacity.

Figure 14. Network capacity, in % of total network capacity, after electrification on Con Edison's networks in Managed Load Scenario



As illustrated in Figure 14, several networks throughout New York City begin to exceed capacity by 2030. Several more, concentrated more heavily in Brooklyn and the Bronx, exceed capacity by 2035. These networks have strong overlap with the networks with low amounts of current available headroom as shown in Figure 13.

To accommodate electrification, distribution-level upgrades would be needed in 11 networks by 2030 and 25 networks by 2040, respectively. Of the eleven networks that exceed available capacity by 2030, Con Edison has planned upgrade projects for three networks. Of the 25 networks that exceed capacity by 2040, Con Edison has planned upgrade projects for seven identified networks. Con Edison has identified projects in a total of 14 networks citywide, all of which have 30% or less available headroom by 2030 with projected electrification. A summary of results for the number of networks that exceed capacity and networks with planned Con Edison projects is shown in Table 2 below. A full list of results by network is given in Appendix A.

Table 2. Summary of networks exceeding capacity with electrification in Managed Load Scenario versus networks with Con Edison planned projects

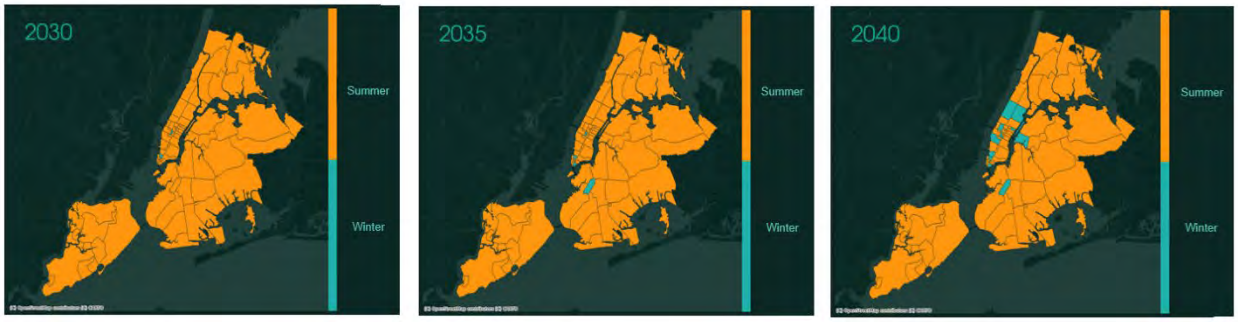
	# of networks in New York City		
	2030	**2035**	**2040**
Exceed capacity after electrification	11	19	25
Con Edison planned project	14	14	14
Exceed capacity with Con Edison planned project	3	6	7
Exceed capacity without Con Edison planned project	8	13	18

Results indicate that, while Con Edison has made progress in planning for projects that will help enable anticipated electrification levels, eight networks are likely to exceed capacity by 2030 which do not have planned upgrades. Moreover, there are 18 networks that exceed capacity by 2040 that do not yet have published plans for upgrades.

Summer versus Winter Peaking

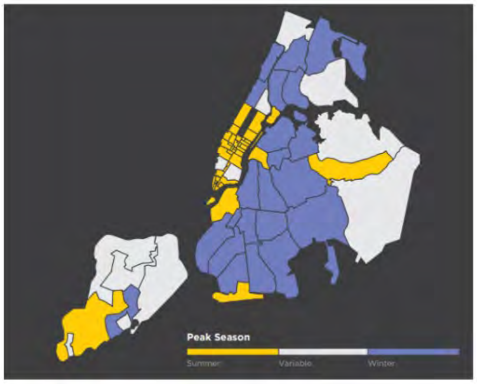
A key impact of electrification is the transition from summer to winter peaking for New York City's grid. NYC is currently a summer peaking system due to high air conditioning loads in summer afternoons. Once New York City has high levels of building electrification, space heating loads are expected to cause a shift toward a winter peaking system. Each network level will experience the switch from summer to winter peaking; the snapshot years modeled demonstrate the differences in timing across network level for the transition to winter peaking.

Figure 15. Summer versus Winter Peaking for Con Edison Networks in Managed Load Scenario



Results in Figure 15 show that, through 2040, almost all of New York City remains a summer peaking system — even after electrification. By 2040 several networks, particularly in Manhattan, switch to winter peaking. This result is inconsistent with findings from other studies for New York City. The Urban Green Council found in its “Grid Ready: Powering NYC’s All-Electric Buildings” report that even with 20% citywide electrification, many networks will begin experiencing a switch to winter peaking. With 40% citywide electrification, even more networks will switch to winter peaking. The “Grid Ready” study identified Brooklyn, Queens, and the Bronx as transitioning to winter peaking.[xx] Results from the “Grid Ready” study for 40% citywide electrification are shown in Figure 16 below.

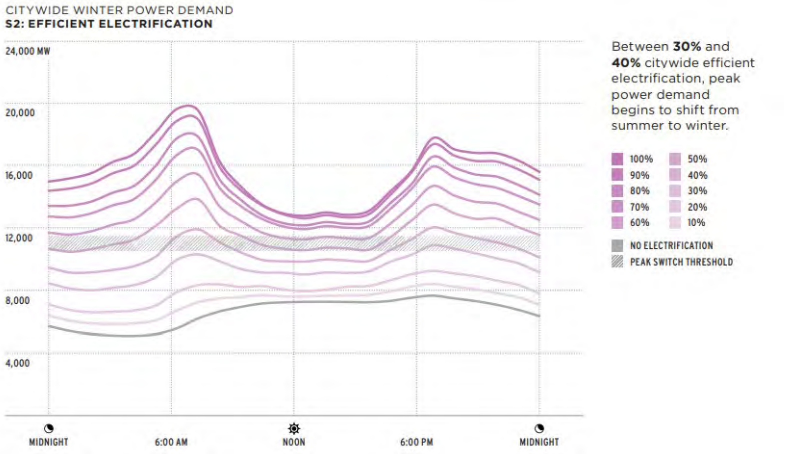
Figure 16. Results for Summer versus Winter Peaking for Con Edison Networks in Urban Green Council’s Grid Ready report’s 40% citywide electrification scenario[xxi]



Discrepancies between this study and the “Grid Ready” study results largely relate to the underlying inputs and assumptions used to forecast future electrification loads. This study leveraged current loads and load profiles for electrified buildings and vehicles from the “Pathways Study” whereas Urban Green Council generated its own baseline and building electrification load profiles for its “Grid Ready” study.

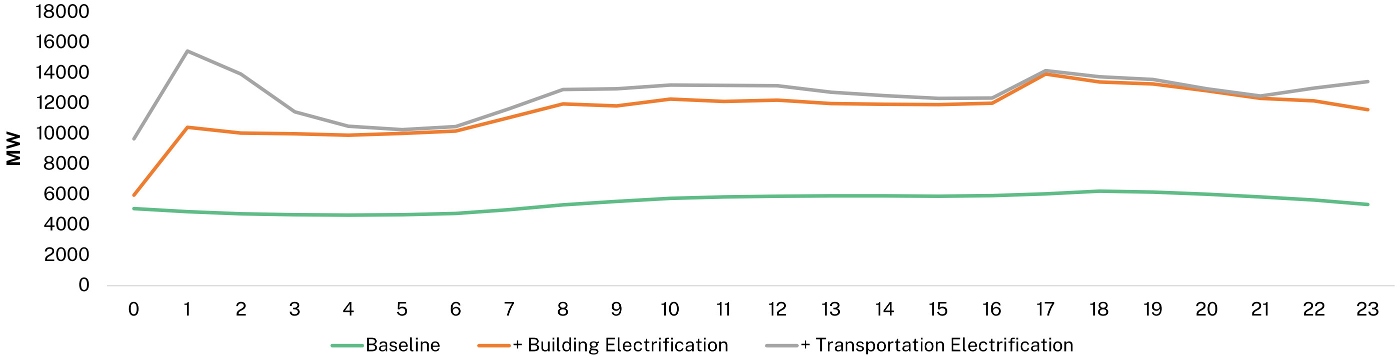
Building electrification load shapes used in the “Grid Ready” report predict much higher citywide loads with electrification as compared to loads used in this study. As shown in Figure 17 and Figure 18 below, there are fairly significant variations between winter load assumptions in the “Grid Ready” report and this study. The baseline load used in this study is roughly two-thirds that of the baseline used in the “Grid Ready” report, which significantly impacts peak load reached on winter days. The incremental load from electrification is also different, with load impacts from electrification in this study lower than the incremental load impacts from electrification. The “Grid Ready” report includes only building electrification, yet the loads are higher than those used in this study which includes both transportation and electrification.

Figure 17. Citywide loads for a winter day with different levels of building electrification from the “Grid Ready” report



Between **30%** and **40%** citywide efficient electrification, peak power demand begins to shift from summer to winter.

Figure 18. Hourly average January 2040 citywide loads with electrification from the PowerUp study

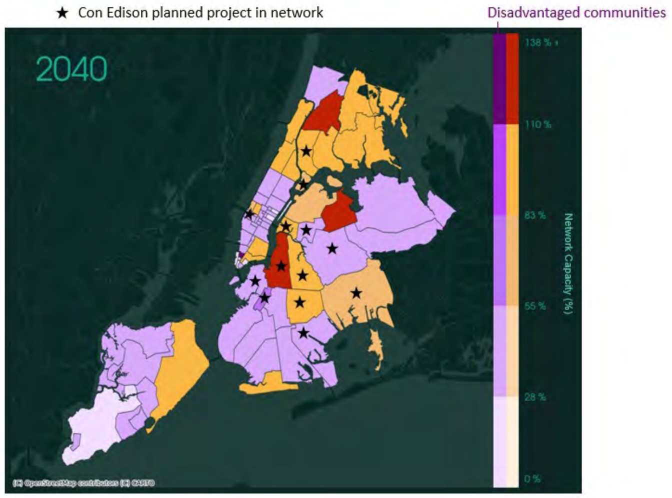


Therefore, more research and modeling may be necessary to accurately capture underlying inputs to ensure current load patterns and profiles from electrified building appliances and vehicles.

Grid Readiness in Disadvantaged Communities

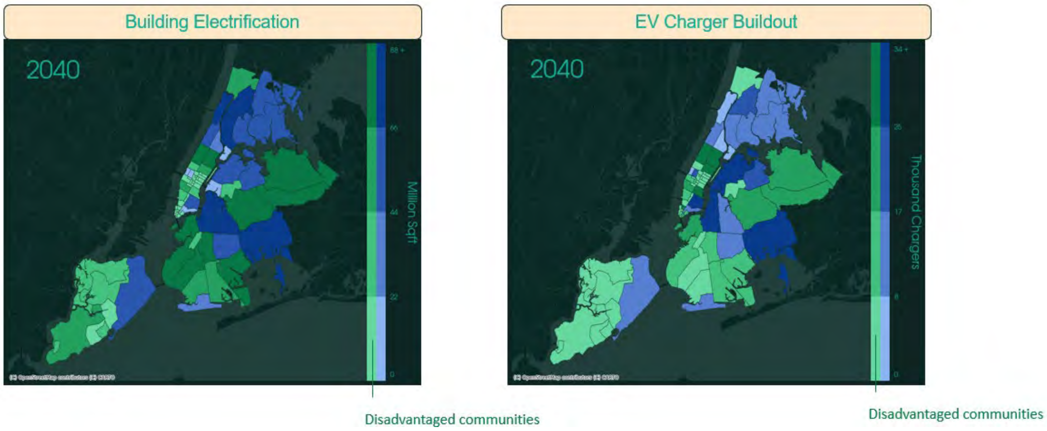
This study assessed how results for grid readiness compare between networks classified as disadvantaged versus those not classified as disadvantaged (“non-disadvantaged”). The same 2040 map of network capacity, as shown in Figure 14￼is shown below with separate color-shading to distinguish disadvantaged networks.

Figure 19. 2040 network capacity, in % of total network capacity, after electrification on Con Edison's networks in Managed Load Scenario with distinction for disadvantaged networks



There are no clearly discernible patterns to indicate there is a disproportionate number of networks that exceed capacity with electrification in disadvantaged versus non-disadvantaged networks. . Stars in Figure 19 indicate networks that have Con Edison planned projects. There are also no clear patterns indicating Con Edison projects disproportionately serve disadvantaged versus non-disadvantaged networks. A breakout of electrification adoption for disadvantaged versus non-disadvantaged networks is shown in Figure 20 below.

Figure 20. Electrification adoption in disadvantaged versus non-disadvantaged networks in 2040



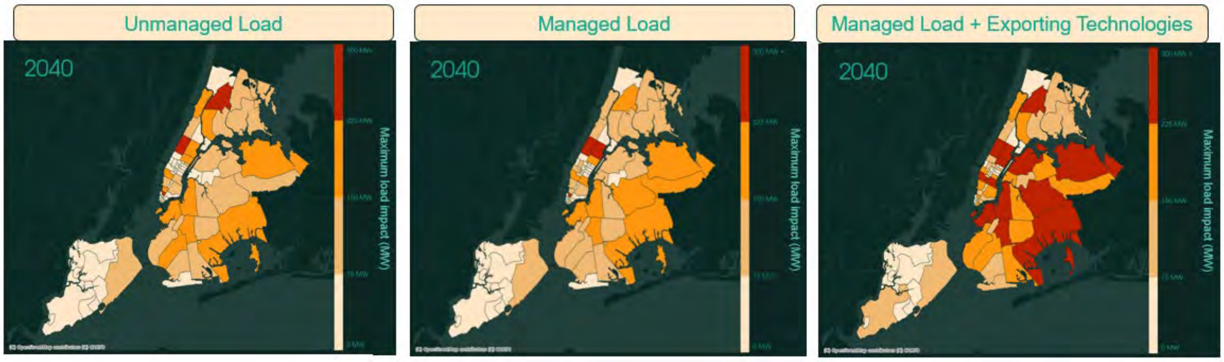
These results above suggest there is not a disproportionate amount of building or transportation electrification expected in non-disadvantaged networks.

Comparison of Unmanaged, Managed, and Managed +Exporting Technologies Scenarios

Maximum Load Impacts from Electrification

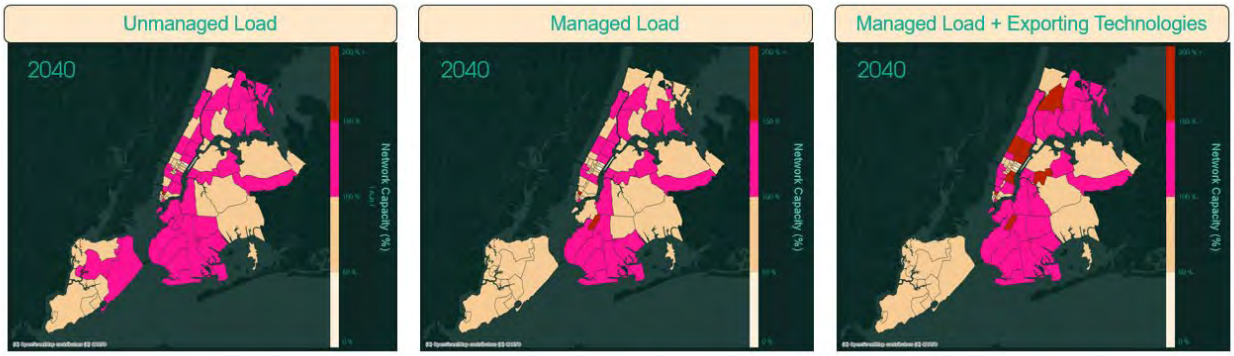
Previous sections focused on the managed load scenario; the following information compares these results to the other two scenarios. Figure 21 below shows the 2040 maximum load impacts from combined building and transportation electrification for each of the three scenarios analyzed. The maximum loads shown represent the maximum hourly incremental load from electrification for that specific network level and scenario, and therefore may occur at separate times across different network levels or for a given network level across scenarios.

Figure 21. Comparison of 2040 maximum load impacts, in MW, of building and transportation electrification across load management scenarios



Results indicate the greatest load impacts from electrification occur in the Managed Load + Exporting Technologies Scenarios. Higher load impacts result from the additional load required for charging battery storage systems and V2G charging. This result alone does not indicate whether exporting technologies benefit or harm the grid. Instead, results in Figure 22 which show network capacity in each scenario, are indicative of how each load management scenario interacts with the underlying baseline load.

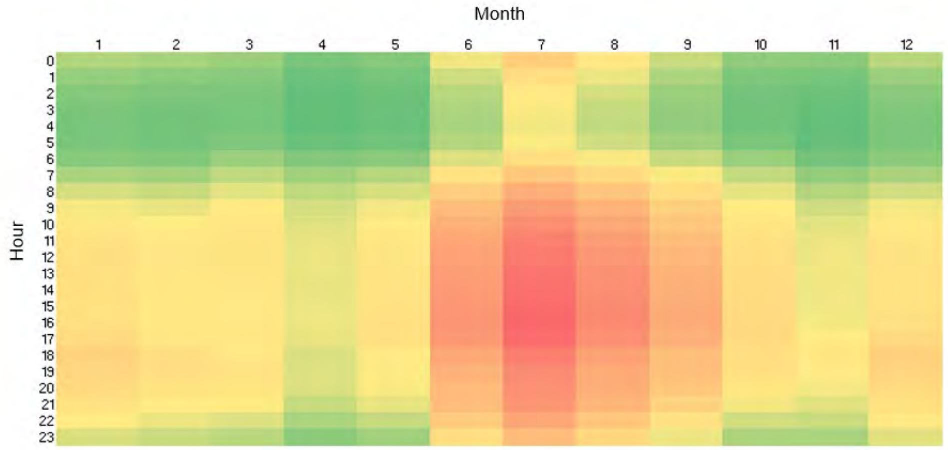
Figure 22. Comparison of 2040 maximum load impacts, in MW, of building and transportation electrification across load management scenarios



In comparing Unmanaged and Managed Load Scenarios, unmanaged loads tend to yield more networks that exceed capacity relative to when load is managed. This result is expected; load management shifts load from hours with high levels of baseline load into hours with lower levels and can therefore mitigate the contribution of electrified loads to network peak.

In comparing the Managed Load + Exporting Technologies Scenario to the Unmanaged and Managed Load Scenarios, results are less intuitive. Including exporting technologies was intended to further shift load from peak hours to off-peak hours. However, the Con Edison rate used to determine charging and discharging schedules for battery storage and V2G EV charging are not aligned with times of peak baseline load. The Con Edison TOU rate modeled has a peak period of 8 a.m. to 10 p.m. each day. However, there is still a substantial amount of baseline load at 10 p.m., particularly in summer months, shown in the month-hour average heat map of baseline load below. The darker red shading represents hours with higher average loads while darker green shading represents relatively lower average hourly loads.

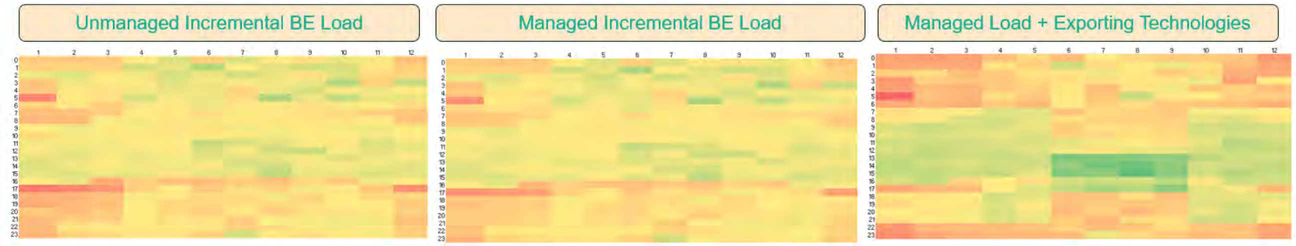
Figure 23. Month-hour average baseline load in the Yorkville network



Accordingly, shifting both managed loads and charging loads for exporting technologies actually causes an increase in network peak load around 10 p.m. in some networks.

Month-hour average heat maps are shown for incremental electrified load (broken out into building and transportation electrified loads) and total load (baseline + incremental electrified load) in Figure 24, Figure 25, and Figure 26, respectively.

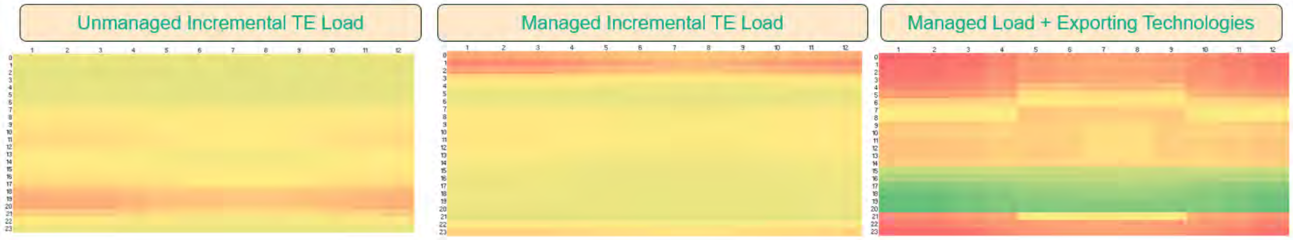
Figure 24. Month-hour average incremental load added from building electrification in 2040 in the Yorkville network for each load management scenario


Unmanaged Incremental BE Load

Managed Incremental BE Load

Managed Load + Exporting Technologies

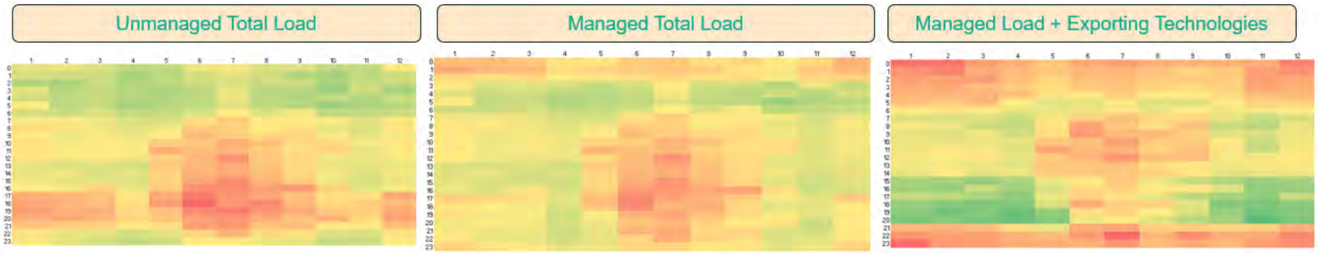
Figure 25. Month-hour average incremental load added from transportation electrification in 2040 in the Yorkville network for each load management scenario


Unmanaged Incremental TE Load

Managed Incremental TE Load

Managed Load + Exporting Technologies

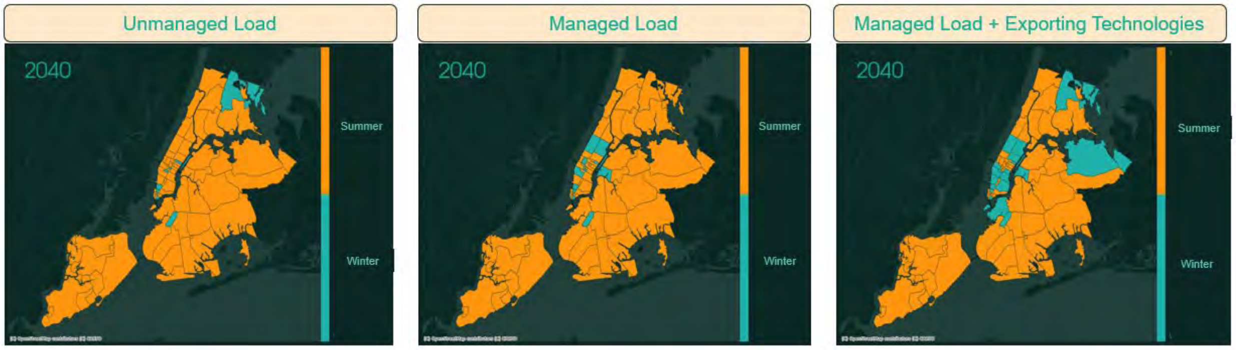
Figure 26. Month-hour average load (including baseline and incremental building and transportation electrification load) in 2040 in the Yorkville network for each load management scenario



Summer versus Winter Peaking

Figure 27 below provides the networks that transition from summer to winter peaking by 2040 in each load management scenario.

Figure 27. Comparison of 2040 networks that are summer versus winter peaking across load management scenarios



The results above indicate that more networks transition to winter peaking with increased load management. The Managed Load Scenarios have more networks that transition to winter peaking than the Unmanaged Load Scenario since load management can shift EV charging from summer evening peaks and therefore lower the peak that winter loads must surpass to shift to a winter peaking system. The Managed Load + Exporting Technologies Scenario has an even greater number of networks shift to winter peaking than the Managed Load Scenario. In addition to shifting EV charging from summer evening peaks, the Managed Load + Exporting Technologies scenario discharges battery storage and uses V2G to even further reduce summer peaks. Therefore, winter loads have an even lower peak they must exceed to switch to a winter peaking system.

Recommendations for New York City

Based on these findings, additional research that includes more robust Con Edison data may be necessary before decisions on upgrades are made. This study used publicly available data on Con Edison network load shapes, peaks, and planned projects; more updated or detailed data may be available from Con Edison that could improve the robustness of this type of analysis. While Con Edison already plans to make upgrades to some networks expected to exceed capacity after electrification, results suggest additional investments and upgrades may be required to prevent the grid from becoming a bottleneck to electrification. Many of the upgrades may have substantial lead times, and therefore, any further research and distribution planning should be considered in the near-term to allow for distribution upgrade lead times.

Although this study does not find any disproportionate electrification adoption in non-disadvantaged networks relative to disadvantaged networks, more research may be necessary to ensure financing and incentive programs are in place to make electrification accessible to low-income households.

APPENDIX A

Table 3. Networks exceeding capacity with electrification in Managed Load Scenario versus networks with Con Edison planned projects

Network	Borough	2030 Available Headroom (%)	2035 Available Headroom (%)	2040 Available Headroom (%)	Con Edison Has Planned Upgrade?
Battery Park City	Manhattan	52%	52%	52%	No
Bay Ridge	Brooklyn	94%	98%	101%	No
Beekman	Manhattan	49%	49%	49%	No
Borden	Queens	99%	101%	109%	Yes
Borough Hall	Brooklyn	92%	93%	94%	Yes
Bowling Green	Manhattan	59%	102%	114%	No
Brighton Beach	Brooklyn	98%	104%	108%	No
Canal	Manhattan	71%	75%	85%	No
Central Bronx	Bronx	83%	88%	92%	No
Central Park	Manhattan	101%	114%	132%	No
Chelsea	Manhattan	93%	95%	109%	No
City Hall	Manhattan	84%	87%	89%	No
Columbus Circle	Manhattan	86%	88%	90%	No
Cooper Square	Manhattan	90%	91%	95%	No
Cortlandt	Manhattan	58%	59%	59%	No
Crown Heights	Brooklyn	87%	94%	98%	Yes
Empire	Manhattan	79%	79%	82%	No
Fashion	Manhattan	70%	71%	90%	No
Flatbush	Brooklyn	105%	114%	117%	Yes
Flushing	Queens	76%	77%	78%	No
Fordham	Bronx	123%	133%	138%	No
Fox Hills	Staten Island	93%	94%	95%	No
Freedom	Manhattan	52%	52%	52%	No
Fresh Kills	Staten Island	84%	86%	86%	No
Fulton	Manhattan	49%	49%	52%	No
Grand Central	Manhattan	76%	76%	77%	No
Greeley Square	Manhattan	90%	91%	91%	No
Greenwich	Manhattan	89%	92%	94%	No
Harlem	Manhattan	84%	91%	96%	No
Herald Square	Manhattan	62%	75%	75%	No
Hudson	Manhattan	72%	73%	73%	No
Hunter	Manhattan	85%	85%	86%	No
Jackson Heights	Queens	106%	111%	114%	No
Jamaica	Queens	#N/A	#N/A	#N/A	Yes
Kips Bay	Manhattan	94%	96%	98%	No
Lenox Hill	Manhattan	87%	112%	120%	No
Lincoln Square	Manhattan	90%	92%	94%	No
Long Island City	Queens	51%	54%	55%	No
Madison Square	Manhattan	92%	95%	128%	No
Maspeth	Queens	71%	73%	75%	Yes

Network	Borough	2030 Available Headroom (%)	2035 Available Headroom (%)	2040 Available Headroom (%)	Con Edison Has Planned Upgrade?
Midtown West	Manhattan	82%	82%	82%	No
NorthEast Bronx	Bronx	76%	85%	89%	No
Ocean Parkway	Brooklyn	109%	117%	121%	No
Park Place	Manhattan	240%	353%	368%	No
Park Slope	Brooklyn	109%	116%	121%	No
Pennsylvania	Manhattan	99%	100%	100%	Yes
Plaza	Manhattan	88%	90%	91%	No
Prospect Park	Brooklyn	101%	109%	154%	Yes
Randall's Island	Manhattan	79%	79%	79%	Yes
Rego Park	Queens	94%	99%	101%	No
Richmond Hill	Queens	70%	73%	77%	Yes
Ridgewood	Brooklyn	82%	85%	88%	Yes
Riverdale	Bronx	85%	90%	92%	No
Rockefeller Center	Manhattan	85%	85%	85%	No
Roosevelt	Manhattan	30%	31%	35%	No
Sheepshead Bay	Brooklyn	112%	119%	123%	No
Sheridan Square	Manhattan	79%	81%	82%	No
SouthEast Bronx	Bronx	100%	106%	109%	No
Sunnyside	Queens	118%	127%	129%	Yes
Sutton	Manhattan	83%	84%	85%	No
Times Square	Manhattan	74%	74%	74%	No
Triboro	Manhattan	91%	97%	100%	No
Turtle Bay	Manhattan	90%	90%	90%	No
Wainwright	Staten Island	87%	91%	94%	No
Washington Heights	Manhattan	96%	105%	107%	No
West Bronx	Bronx	92%	98%	102%	Yes
Williamsburg	Brooklyn	99%	106%	110%	Yes
Willowbrook	Staten Island	87%	90%	93%	No
Woodrow	Staten Island	68%	69%	70%	No
Yorkville	Manhattan	99%	105%	127%	No

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[i] Source: City of New York
[ii] Source: "New York State's Disadvantaged Communities Criteria." New York State
[iii] Source: "Pathways to Carbon-Neutral NYC: Modernize, Reimagine, Reach." City of New York
[iv] Source: Sustainable Buildings NYC
[v] Source: United States Census Bureau
[vi] Source: City of New York

[vii] Source: The New York State Senate
[viii] Source: "Schedule for Electricity Service." Con Edison
[ix] Source: "Pathways to Carbon-Neutral NYC: Modernize, Reimagine, Reach." City of New York
[x] Source: New York State Energy Research and Development Authority
[xi] Source: New York State
[xii] Source: "Decarbonizing Medium- & Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis." National Renewable Energy Laboratory
[xiii] Source: New York State Energy Research and Development Authority
[xiv] Source: "Taxi Strategic Plan 2022." New York City Taxi and Limousine Commission
[xv] Source: United States Census Bureau
[xvi] Source: "MTA Zero-Emission Bus Transition Plan." Metropolitan Transportation Authority
[xvii] Source: Geotab
[xviii] Source: Con Edison
[xix] Source: Con Edison
[xx] Source: "Grid Ready: Powering NYC's All-Electric Buildings." Urban Green Council
[xxi] Source: "Grid Ready: Powering NYC's All-Electric Buildings." Urban Green Council