ENHANCING THE FEASIBILITY OF ELECTRIC VEHICLES IN NEW YORK CITY

COLUMBIA UNIVERSITY | SCHOOL OF INTERNATIONAL AND PUBLIC AFFAIRS
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FACULTY ADVISOR

Professor Steven A. Cohen

AUTHORS

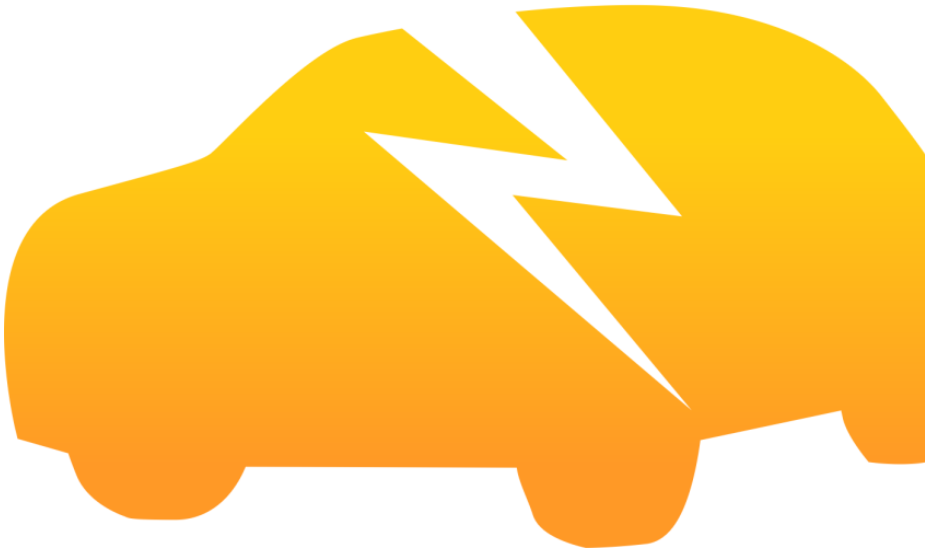
Lena Bansal
Wini Chen
Luke Clause
George Gatta
Andrea Karpati
Joseph Katz
Alison Miller
Todd Miner
Asaf Selinger
Dmitriy Shvets
Janelle Sommerville
Michelle Thompson

MANAGEMENT

Todd Miner, Manager
Andrea Karpati, Deputy Manager

REPORT

Wini Chen, Chief Editor
Dmitriy Shvets, Designer



Preface

This report is the culmination of the Workshop in Applied Earth Systems Policy Analysis, a core course for the Master of Public Administration in Environmental Science and Policy (MPA ESP) at Columbia University's School of International and Public Affairs. The MPA ESP program provides students with the theoretical knowledge and practical skills necessary to address environmental policy and management issues. The core curriculum focuses on innovative, systems-based thinking to environmental issues, encouraging students to think systemically and act pragmatically. In the fall and summer semesters, students acquire the skills necessary to analyze an environmental problem and create an implementation plan to address an issue. In the spring semester, students apply these skills by conducting policy analysis on environmental or management issues for clients in government and non-profit agencies. The Mayor's Office of Long-Term Planning and Sustainability requested a study of electric vehicle deployment and methods enhancing electric vehicle feasibility in New York City.

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Executive Summary

New York City recently incorporated electric vehicle adoption into its strategy to fulfill the objectives of PlaNYC 2030, the City's long-term sustainability plan. Electric vehicles contribute to PlaNYC's sustainability goals by improving local air quality and reducing greenhouse gas emissions contributing to global climate change.

Despite New York City's goal of facilitating electric vehicle use, the City faces unique barriers that may prevent its widespread adoption. Auto-manufacturers market electric vehicles to homeowners with access to personal garages and driveways for recharging, but nearly half of New York City drivers depend on street parking. Additionally, New York City's electricity rates are among the highest in the nation, reducing the savings offered by an electric vehicle. In this setting, the Mayor's Office of Long Term Planning and Sustainability commissioned a report to examine two issues: (1) how Con Edison, New York City's electric utility, should form electric vehicle policy, and (2) where the City should encourage the installation of public electric vehicle charging infrastructure in order to meet future consumer demand.

The report divided its analyses, findings, and subsequent recommendations into two primary segments: (1) geo-spatial analyses identifying areas with anticipated electric vehicle public charging demand and (2) utilities best practices encouraging electric vehicle use.

Within the geo-spatial analyses, key demographic variables associated with electric vehicle ownership were identified: education, income, hybrid vehicle ownership, ownership of more than one vehicle, and job density. Using these variables, our analyses identified targeted "hotspots" for public charging infrastructure in Northwest Brooklyn, North Brooklyn, and Western Queens. These areas are expected to show significant interest in electric vehicles but lack fundamental access to home garages for charging. Therefore, in these hotspots, we recommend electric vehicle charging station installations in public parking garages for potential owners to park overnight for recharging. While other locations in New York City also exhibit hotspots for electric vehicle demand, a robust public charging infrastructure is already developing throughout Manhattan. Additionally, areas in Staten Island and Eastern Queens have substantial access to home charging. Therefore, New York City can focus its planning efforts on the identified areas within Northwest Brooklyn, North Brooklyn, and Western Queens. Public charging infrastructure should be implemented quickly, within the next few years, to take advantage of federal funding for free charging stations.

For the utility analyses, a set of five best practices were developed from interviewing utilities with advanced electric vehicle programs. These five guiding principles broadly apply to New York City as well as other municipalities:

(1) Offer customers a range of electric vehicle rate options including time-of-use rates, which provide reduced prices overnight and higher prices during the day;

(2) Focus on consumer education and outreach to increase consumer understanding of electric vehicle technology and create a resource for electric vehicle information;

(3) Participate in partnerships and collaboration with other market stakeholders to share knowledge and operate more efficiently;

(4) Offer complementary programs, such as the option to purchase 100% renewable energy, to further incentivize potential consumers and;

(5) Encourage electric vehicle data collection and smart charging as a means of understanding future demand distribution and to make necessary upgrades to the electric grid.

Given the significant emphasis on reduced electricity rates, a subsequent cost analysis demonstrated the role of electricity rates impacting lifetime costs of vehicles: reducing New York City electricity rates significantly impacts the lifetime cost of an electric vehicle. After applying tax credits, the purchase price of an electric vehicle is over $3,000 more than a hybrid. For electric vehicles to be cost-effective, the annual savings, from maintenance and fuel costs, must recoup that purchase premium. The cost analysis found current New York City electricity rates require eight years to recover the premium, while a reduced electricity rate significantly lowers this payback period. These findings suggest that Con Edison should implement an electric vehicle-specific rate, separate from its regular Time-of-Use rate.

Implementation requires policy changes from New York City to allow installation of second electric meters, enabling Con Edison to bill the electric vehicle at its own rate separate from the rest of the home. Second meters are currently prohibited to prevent illegal apartments, it is recommended that New York City review and consider changing this building code to allow for an electric vehicle exception. In the meantime, Con Edison is researching smart dual channel metering to allow two rates within a single primary meter, cutting costs and complexity. We recommend the City help Con Edison in moving forward with an EV-rate and new metering technology for approval by the New York State Public Service Commission.

Experts within the field continually stress the importance of collectively engaging market participants and a wide variety of stakeholders to enable broad adoption. With the ultimate goal of moving beyond early adopters, local governments can effectively encourage electric vehicle adoption by working with utilities and other stakeholders. Similarly, an electric vehicle partnership between Boston, Philadelphia, and New York City demonstrates an approach for municipalities to share information, lessons learned, and resources to support the electric vehicle movement across the Northeast.

Background: New York City and Electric Vehicles

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Purpose of the Report

Both rising gasoline prices and growing environmental concerns attribute to the increasing availability of electric vehicles (EVs) offered by major automakers. EVs offer New York City (NYC) an opportunity to reduce vehicle exhaust emissions, improving local air quality while reducing the city's impact on global climate change. While significant technological improvements brought EVs into the mainstream automobile market, barriers to its widespread adoption remain. In NYC, many residents lack access to home garages where EVs are intended to recharge overnight. Additionally, NYC residents are subject to high electricity rates—rendering other types of vehicles more cost-effective than EVs. To overcome these two city-specific barriers, NYC Mayor's Office of Long-Term Planning and Sustainability (the Mayor's Office) seeks answers to a central question: "How can New York City promote the feasibility of electric vehicles throughout the five boroughs?" The purpose of the report is identifying strategies to overcome barriers relating to (1) charging infrastructure accessibility and (2) electricity rate structures.

The Environmental Problem: Vehicle Traffic in New York City

With widely accessible public transit, it is not surprising that only 23% of New Yorkers own automobiles.[1] However, NYC's traffic congestion is one of the worst in the nation, which exacerbates the region's air pollution.[2] Vehicle exhaust deteriorates local air quality and accounts for 17% of NYC's greenhouse gases (GHG) emissions.[3]

The Solution: PlaNYC and Electric Vehicles

In 2006, the Mayor's Office launched PlaNYC—a sustainability strategy for NYC, which includes the goal of a 30% reduction in its GHG emissions (relative to 2005 levels) by 2030. The

PlaNYC Initiatives and Goals

PlaNYC uses a portfolio of initiatives to achieve sustainability goals. These initiatives are categorized by ten general goals: Housing and Neighborhoods, Parks and Public Space, Brownfields, Waterways, Water Supply, Transportation, Energy, Air Quality, Solid Waste, and Climate Change.

Electric Vehicle Supply Equipment (EVSE) Charging Levels 1 – 3

There are three levels of EVSE charging time capability:

Level 1 uses a 120-volt AC circuit from a standard wall outlet and extension cord to power the vehicle's onboard charger. Level 1 is the slowest of the charging levels, taking 20 hours to recharge a fully depleted Nissan Leaf.

Level 2 uses a 240-volt AC circuit, requiring EVSE installation in facilities equipped to provide this level of power. The charge time is faster than Level 1, typically charging a fully depleted Nissan Leaf battery in 6 – 8 hours. It is well suited for an overnight recharge. Level 2 EVSE can be used for both public and home charging.

Level 3 is the fastest charging option using 400 – 500 volt DC power to recharge the battery. Depending on the battery depletion, recharging ranges from 15-30 minutes. Level 3 charging has the potential to rapidly charge EVs but there are battery-related limitations—such the extent it can fully recharge (80%) and the reduction in battery life from frequent use.

Note: While it requires time, most EVs will not recharge from fully depleted batteries. Battery depletion will impact charging time.

Source: "FAQ." Plug In America: We Drive Change. Web. 16 Apr. 2011. <http://www.pluginamerica.org/faq/general-question>.

plan also calls for significant improvements in local air quality through the reduction of smog causing pollutants. PlaNYC employs a portfolio of initiatives to fulfill this objective—including a 44% reduction in transportation emissions.[4] Improving and expanding the city's mass transit infrastructure will achieve a majority of these reductions by decreasing the total number of vehicles in NYC.

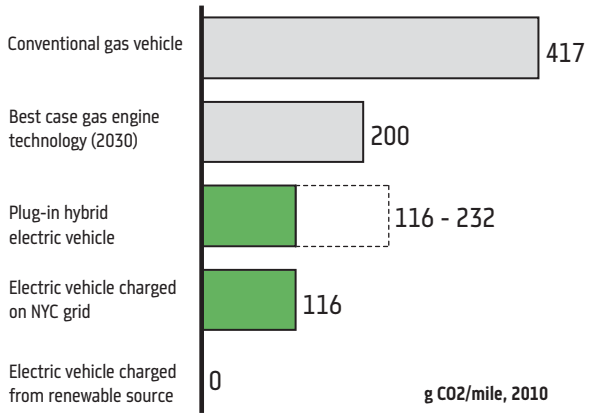
As zero-emission passenger vehicles, the Mayor's Office considers electric vehicles as a strategy for reducing the negative impact of the current vehicles within NYC by improving air quality and reducing NYC's carbon footprint. Solely operating on electricity, plugging the EV into a charging unit, or outlet, recharges its batteries. In comparison, hybrid and plug-in hybrids vehicles use conventional internal combustion engines, which distinguish them from EVs.

Mayor Michael Bloomberg July 15, 2010: Unveiling New York City's first public electric vehicle charger in Manhattan.

Environmental Benefits of Electric Vehicles

Converting 75% of batteries' chemical energy into power, electric motors in EVs offer drastic energy efficiency improvements over conventional gasoline vehicles, which converts only 20% of gasoline's potential energy.[5]

Figure 1: Wheel-to-Well Emissions Comparison for Combustion Engine and Electric Driving in New York City[6]



Source: IEA, IAEA, AG Energiebilanzen, U.S. Dept. of Energy, McKinsey, Oak Ridge National Laboratory

In a "wells-to-wheels" comparison (Figure 1), EVs emit roughly 25% of conventional vehicles' total carbon dioxide emissions. This value is not 0% because EVs are powered by emissions-producing electricity grids. Carbon neutral sources—such as nuclear and hydroelectric power—generate 40% of NYC's electricity,[7] and the addition of more such energy resources would further reduce EVs' wells-to-wheels emissions. Along with carbon dioxide emissions, other air pollutants will experience a net reduction.

Electric Vehicle Early Adopters

Early adopters only comprise a segment of NYC's new car buyers, but are eager to purchase EVs.[8] As aficionados for new technologies or green products, EV early adopters have a higher willingness-to-pay than other market participants and are ready to deal with the difficulties of using new technologies. Additionally, they play an important role by shaping other consumers' views on electric vehicles. Key obstacles must still be overcome to effectively encourage non-early adopters to purchase EVs.[9]

Barriers to Adopting Electric Vehicles in New York City

EVs are designed for recharging overnight in a home garage during "off-peak" electricity hours, taking advantage of reduced electricity rates. However, NYC does not fit this model, posing two specific barriers: (1) most residents lack access to personal garages for home charging, and (2) high electricity rates reduce the cost-effectiveness of EVs.

Charging Accessibility

A sizable percentage of NYC residents lack access to personal garages. Roughly 50% of all vehicles in NYC park on the street or in public parking lots throughout Manhattan,

Brooklyn, Queens, and the Bronx.[10] (See "Appendix 10: New York City's Home and Public Parking Spots" for detailed statistics on NYC parking.) Accessing alternative charging options is crucial for encouraging EV usage. NYC offers few options, presenting a serious obstacle for EV adoption and reflecting the need for policy intervention.

Electric Vehicle Charging Infrastructure

Installing public charging units within parking facilities is one solution to the charging accessibility issue. As recharging requires several hours, overnight parking (near EV owners' homes) and workplace parking present potential charging spots. To effectively entice EV adoption, it is necessary to strategically locate public chargers in the vicinity of expected future demand. Other potential charging unit locations include traditional gas stations and government parking lots.

High Electricity Rates

In November 2010, the average U.S. electricity rate was 9.6¢ per kWh.[11] With volatile gasoline prices, this rate incentivizes EV adoption as it costs less to operate than conventional vehicles. Varying by location, however, NYC's current electricity rate is 27.0¢ per kWh[12]—rendering EVs more expensive to operate than hybrid vehicles.

Electric Vehicle Off-Peak Charging Rate

To become cost-competitive in NYC, a reduced rate for recharging EVs is necessary. Con Edison, NYC's elec-

Range Anxiety

The range limitations of EVs, coupled with sparse public charging options, may cause potential consumers to believe EVs will run out of power before returning home for recharging. This is known as "range anxiety", and it complicates EV adoption initiatives. Under optimal conditions, most EVs today have a maximum range of roughly 100 miles per charge. Variables, including driving speed, terrain and road conditions, cold weather and air conditioner usage cause the range to fluctuate. In some conditions, the range could decrease to 50 miles per charge. Although range limitations are important, the majority of commuters in the U.S. drive only 20 total miles per day. As this distance is within the EV's range, the misinformed perception of range requirements is the underlying cause of range anxiety. This perception is likely to dissipate once a greater number of people drive EVs, demonstrating that range anxiety fears are unfounded.

Source: NYC Mayor's Office. PlaNYC. *Exploring Electric Vehicle Adoption in New York City*. New York: City of New York, 2010.

tricity supplier, currently does not offer EV-specific rates. However, an optional Time-of-Use (TOU) rate or reduced off-peak (overnight) rate is available. Using the TOU rate exclusively for EV charging (while the standard rate applies for all other use) potentially resolves the high NYC electricity rate barrier.

Study Methodology

The methodology of this study is comprised of three phases: Literature Review (Phase 1), Expert Interviews (Phase 2), and Study Analyses (Phase 3). The Study Analyses consists of two parts to evaluate the two barriers facing electric vehicle adoption.

Phase 1: Literature Review

Conducting an extensive literature review developed the broad understanding of the EV industry, relevant stakeholders, and pertinent policy issues. Additionally, research informed and shaped the analyses methodology.

Phase 2: Expert Interviews

Key informant and expert interviews embody the second phase of the study. Using a uniform interview guide—containing both general as well as industry-specific questions—interviewers gathered qualitative information in a standardized (*See "Appendix 2: Summary of Expert Interviews" and "Appendix 3: Expert Interview Questions."*) Analyzing interview summaries unveiled patterns and data relevant to the Study Analyses (Phase 3).

Phase 3: Study Analyses

Track 1: Charging Infrastructure

Relevant case studies from the Literature Review (Phase 1) structured the Charging Infrastructure Analyses. Employing geo-spatial methods, several potential EV adoption patterns emerged from juxtaposing current NYC charging unit locations with five demographic datasets. The demographic dataset selection is based upon frequently cited socio-economic variables predicting EV adoption.

Track 2: Utilities Best Practices

The Utilities Best Practices Analyses draws from case studies ascertained in the Literature Review (Phase 1) and expert interview summaries (Phase 2). Comparing and contrasting the EV-focused efforts of utilities nationwide unveiled common practices encouraging EV adoption. Additionally, this exercise sheds light on obstacles for utilities implementing EV initiatives. Lastly, employing a cost model demonstrates the different variables impacting the payback period of the EV's purchase premium relative to hybrid and conventional gas vehicles.

Charging Infrastructure Analyses

Charging Infrastructure Analyses Findings

As the market expects additional EVs, municipalities are mobilizing to establish charging infrastructure. To accelerate adoption, the government provides financial incentives for EV purchases and charger installation (*See "Appendix 1: Existing Policy Efforts"*). Funding the majority of NYC's existing public charging infrastructure, Federal stimulus money is available—though limited—for additional units (*See "Appendix 7: Current Electric Vehicle Charger Infrastructure"*) The limited funding emphasizes the importance of installing subsequent chargers in areas most effectively encouraging adoption. The Charging Infrastructure Analyses aims to identify such locations. As infrastructure development is time-sensitive, the recommendations are meant for implementing within the next five years.

The Charging Infrastructure Analyses draws upon studies commissioned by other municipalities preparing for EV demand. The Greater London Authority,[13] Puget Sound Regional Council,[14] and the Victoria Department of Transportation[15] identified similar demand predictors based on demographic information. The recurrent socio-economic indicating variables include education, income, hybrid vehicle ownership, multiple vehicle ownership, and job locations (*See "Appendix 4: Spatial Analyses Methodology" for variable details*). The following five datasets form the basis of the spatial analyses: (1) education level, (2) median household income, (3) job density, (4) households with 2 or more vehicles, and (5) hybrid-vehicle registrations.

Based on key informant interviews, most NYC public charging unit installations occur in response to parking garage owners' requests. Thus, demand shaped most of NYC's existing charging infrastructure. The study juxtaposes the aforementioned datasets with these locations to reveal any patterns or "hotspots" (*See "Appendix 4: Spatial Analyses Methodology"*).

Spatial Analyses Findings

Maps 1-5 are included in Appendix 5

Maps 1 & 2: Educational Attainment and Median Household Income

The distribution of individuals with at least a bachelor's degree closely mirrors median household income levels. Highest levels of income and educational attainment appear in downtown and midtown Manhattan. Areas in Brooklyn and Queens (directly across the East River from Manhattan) show similarly high levels for both variables. Additional hotspots are distributed in bands running from northern to southern Brooklyn, and from western to easern

Queens. Within Queens, the areas bordering Nassau County also show high education and income levels. Staten Island exhibits a band of higher median household income levels, bisecting from the northeast to the southwest. However, a similar counterpart band for education levels does not appear in the same area. Additionally, Staten Island appears more homogeneous than the other boroughs. The lower resolution level from larger area census tracts could explain this issue. The hotspots in the northwestern and eastern portions of the Bronx are less prevalent than other boroughs.

Map 3: Job Density

The highest job density areas appear in downtown and midtown Manhattan. A small section of downtown Brooklyn displays the second highest job density. Relatively low to medium job density spots are scattered throughout areas of Queens and Brooklyn, closer to the East River and directly across from Manhattan. Of all the boroughs, Staten Island displays the lowest job density.

Map 4: Vehicle Availability

Manhattan shows the lowest levels of vehicle availability per housing unit. Vehicle availability increases while moving outward from Manhattan. Eastern portions of Queens and the Bronx, and the southern portions of Brooklyn display the highest levels of vehicle availability per housing unit. As an entire borough, Staten Island exhibits the highest vehicle availability levels. The distribution of vehicle ownership data mirrors that of education and income level data, with the exceptions of Manhattan and downtown Brooklyn.

Map 5: Hybrid Vehicle Registration Density

Hybrid vehicle registration in downtown and midtown Manhattan, downtown Brooklyn, and western Queens exhibit greater densities. The pattern of hybrid vehicle registration density closely mirrors educational attainment levels and median household income levels in areas near downtown and midtown Manhattan, downtown Brooklyn, and western Queens. Hybrid vehicle registration densities decline the further the distance from these areas. The low population densities associated with the city outskirts could explain this trend.

A caveat with Map 5 regards the dataset used. The hybrid vehicle data contains some addresses with multiple hybrid vehicle registrations—perhaps a fleet owned by a government agency or business. Thus, residential hybrid vehicle registration may not be accurately reflected—possibly comprising Map 5's ability to anticipate potential EV demand.

Relative Distribution of Electric Vehicle Charging Units

Public charging units are primarily located in downtown and midtown Manhattan—an area of higher in-

come, education, and job density. These three variable patterns align with current charging spots, supporting their relationship with potential EV demand. On July 14,th 2010, this area housed NYC's first public EV charging station at 451 9th Avenue Edison Properties.[16] Since then, surrounding parking facilities installed their own Coulomb charging stations—resulting in the cluster of EV charging stations displayed today. On the contrary, the locations of charging spots in the Bronx, Queens, and Brooklyn do not display any particular pattern. These charging spots are located at several participating

A Coulomb Charging Station

Stations like this are currently installed in Manhattan garages.

Nissan dealership locations—scattered throughout these outer boroughs—explaining the absence of any patterns. The borough of Staten Island does not have any public EV charging stations.

Potential Locations of Future Electric Vehicle Charging Infrastructure

Although Manhattan contains the majority of NYC's public charging units, the EV market is merely budding. The increasing EV demand will likely expand public charging infrastructure to the other four boroughs in similar installation patterns—locating to areas of higher income, education, hybrid vehicle density, multiple vehicle density, and job density.

Indicated by dark green areas in Map 6, downtown Brooklyn (neighborhoods of DUMBO, Brooklyn Heights, Cobble Hill, Carroll Gardens, Gowanus, Park Slope, Prospect Heights, Clinton Hill, Fort Greene, Boerum Hill and Downtown Brooklyn), northern Brooklyn (neighborhoods of Greenpoint and Williamsburg), and western portions of Queens (neighborhoods of Long Island City, Hunters Point, Sunnyside, and Woodside) appear to be prime candidates for the next wave of public EV charger units.

Downtown Brooklyn contains a high number of parking facilities—offering opportunities for housing additional EV charging stations. These areas

both address the demand of local residents and individuals commuting to downtown Brooklyn. Exhibiting the highest vehicle availability levels, more residential and sprawled areas (light blue and dark blue areas in Map 6) are likely to fulfill initial EV demand by installing charging units in home garages.

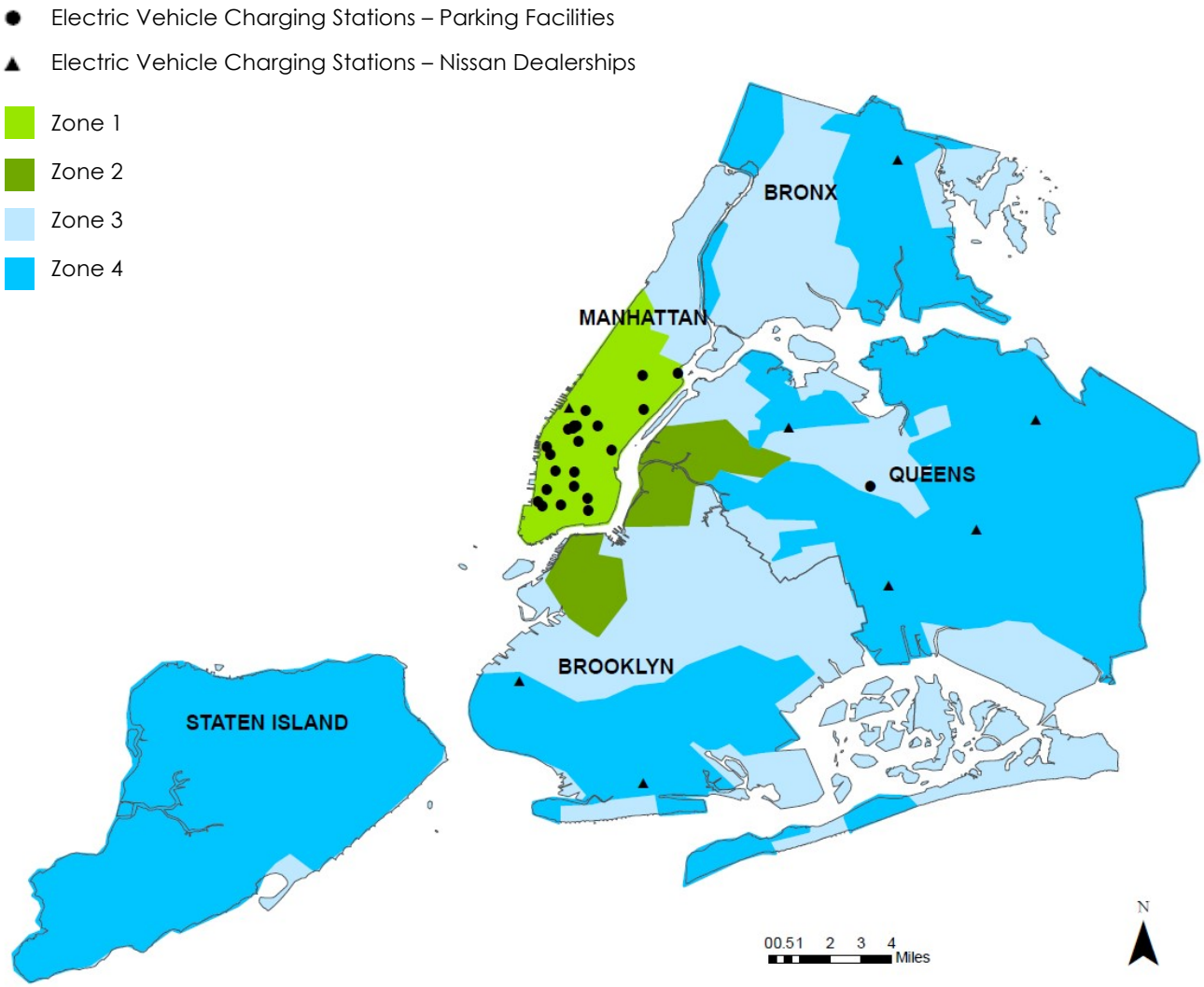
As the demand grows and installation costs fall over time, public institutions, office parking lots, shopping districts, and transportation hubs are likely to install charging units—joining the expanding EV charging network. Additionally, innovative approaches, such as private-public partnerships can garner support to encourage EV adoption. Seattle demonstrates the effectiveness of private-public partnerships in the role of encouraging EV adoption (See "*Appendix 14: Seattle Case Study*").

Providing chargers to individuals without access to home garages or parking facilities remains a challenge in enhancing widespread EV adoption. On-street chargers could resolve this obstacle but the option is costly. Additionally, concerns with vandalism and liabilities arise from damaged charging units. While there is no clear solution, technological innovations will probably resolve this issue over time. This could render on-street units safer and financially feasible. For now, individuals without access to charging infrastructure are marginalized in the EV adoption movement, and equity issues to access will need to be addressed.

As early adopters are associated with higher incomes and educational levels, locating charging sites to these "hotspots" inherently precludes residents of lower incomes and educational levels. Over time, a market for used EVs will eventually emerge and become accessible to individuals of all socio-economic backgrounds. Partnering with local environmental justice groups and engaging community members is one approach to ensure an equitable EV charging infrastructure.

Map 6: General Trends and Recommendations

To interpret Map 6, the subsequent tables include descriptions and recommendations for each zone.



Zone 1 (Light Green): Midtown and Downtown Manhattan

Education/ Income	Job Density	Vehicle Availability	Hybrid Density
Medium to High	Medium to High	Low	Medium to High

Description: Zone 1 exhibits most characteristics associated with EV early adopters: medium to high levels of education, income, and hybrid density. Having medium to high job density, Zone 1 is ideal for installing charging units to service EV commuters. While Zone 1 exhibits low levels of vehicle availability, the presence of numerous charging units reflects the area's demand for such infrastructure. Given the existing charging infrastructure, it is likely Zone 1 will continue to experience demand for additional charging units.

Policy Focus: With the high job density and existing charging units, Zone 1 should continue to develop charging infrastructure in parking facilities. Incorporating the demand of Zone 1's residents and commuters (parking in garages, lots, or off-street parking) into planning charger locations is key.

Zone 2 (Dark Green): North Brooklyn, Northwest Brooklyn, and Western Queens

Education/Income	Job Density	Vehicle Availability	Hybrid Density
Medium to High	Low to High	Low	Medium to High

Description: While exhibiting similar characteristics with Zone 1, the factors in Zone 2 are lower in magnitude. Zone 2 possesses lower job densities and lacks charging units.

Policy Focus: Prioritizing the installation of charging units throughout Zone 2 is important. One method is encouraging parking facility companies, with charging spots in Zone 1, to apply the EV charger business models to their (if any) Zone 2 facilities. This approach assumes that the needs of Zone 2 EV users are similar as those in Zone 1.

Zone 3 (Light Blue): Select Areas in Brooklyn, Queens, and the Bronx

Education/Income	Job Density	Vehicle Availability	Hybrid Density
Low to Medium	Low to Medium	Low to Medium	Low to Medium

Description: All four EV adopter indicators exhibit relatively low to medium levels in Zone 3. With only low to medium levels of education, income, vehicle availability, and hybrid vehicle density, the EV demand in Zone 3 will likely be lower than other zones.

Policy Focus: Facilitating home charger installation in Zone 3 is the predominant strategy for expanding charging infrastructure. Launching pilot programs enhances this strategy by installing charging units at shopping centers, business improvement districts, cultural and government institutions throughout Zone 3.

Zone 4 (Dark Blue): City Outskirts

Education/Income	Job Density	Vehicle Availability	Hybrid Density
Low to High	Low to Medium	Medium to High	Low to Medium

Description: Possessing relatively medium to high levels of vehicle availability, Zone 4 has relatively higher levels of income and education than areas in Zone 3. The higher levels of vehicle availability suggest this zone is better suited for adoption of EVs than those in Zone 3. Families owning more than one vehicle are likely to purchase an additional vehicle for limited range driving.

Policy Focus: Zone 4's policy strategy is similar to Zone 3.

Further Research

Additional Variables

Introducing additional variables could strengthen the spatial analysis and improve its capacity to anticipate areas of greater EV demand. Possible variables include new vehicle purchases, daily commuting distance, parking accessibility (i.e., street parking, home garage parking or non-home garage parking, etc.), environmental awareness and interest in new technology. Conducting a thorough field survey of each neighborhood could verify the model. Although time did not allow the addition of a statistical analysis into this report, a full geographically weighted regression is included in Appendix 6.

Implement Parking Facility Survey

Surveying representatives of parking facility companies could provide insight on the supply side of charging infrastructure. A survey would aim to understand parking companies' stance on EV charger installation in their facilities. Additionally, the survey seeks to identify potential challenges for developing EV charging infrastructure from the perspective of parking facility companies.

A sample questionnaire that may be used to conduct this research is included in the report (*see "Appendix 9: Sample Questionnaire for Parking Facility Representatives"*).

Transportation for London: "Success depends on stakeholder buy in"

While New York and London are different in many ways, the two cities wish to compete for the title of EV capital of the world, " EVs are a good fit for London's system, from our surveys we see that most drivers drive about 10 miles a day, which is in perfect EV range. The bigger issue is charging, since many residents do not have home charging access. This was the prime issue we targeted, since if you have a car and no where to plug it into, what good does that do?" Said Sean Conroy, Stakeholder & Partnership Manager at Transportation for London (TFL), the city agency responsible for the London EV project.

"The key to unlocking the charging issue was to bring in the business sector, such as retail stores where you will spend more than two hours, or public garages that serve both residents and commuters". Since the majority of these locations, are located off street, TFL has focused on creating a large-scale awareness campaign, which includes exposing all the incentives available to EV customers, " We believe that price and range anxiety are the two biggest barriers, and we're working on both fronts. Today, charging infrastructure is subsidized by the central government to increase the number of locations. On the incentives side, EV drivers will be exempt from the congestion charge, as well as other discounts. For instance in some boroughs of the city reduced parking rates are offered to zero emission vehicles, and these savings do add up."

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Charging Infrastructure Recommendations

Drawing upon the findings of the spatial analyses, we propose the following recommendations to enhance the EV adoption in NYC:

1. *Prioritize the installation of public charging infrastructure in Northwest Brooklyn, North Brooklyn and Western Queens*

Current efforts for public charging infrastructure have been focused on lower Manhattan, and should continue to be encouraged, but future efforts should prioritize the target areas in Brooklyn and Queens. These target areas should expect similar demand for electric vehicle as lower Manhattan and currently have no charging infrastructure. Other areas, in the outer boroughs, where electric vehicle ownership is predicted should be areas where consumers will have personal-private parking.

2. *Encourage the installation of chargers at major transportation hubs for EV drivers parking at train or bus stations for their daily commute.*

3. *Run a pilot program installing EV chargers at shopping centers, business improvement districts, cultural and government institutions.*

The Mayor's Office should encourage local businesses and the EV private sector to launch pilot programs within the recommended target areas. Parking garage companies, shopping centers, business improvement districts are all viable options for potential pilot programs. The Mayor could take advantage of his visibility to launch pilot programs in each of the target areas. This recommendation is based on Manhattan garages requesting charging stations after seeing the Mayor launch a program. Hopefully, this will stimulate demand from parking garages in the same manner occurring in lower Manhattan.

4. *Focus policy on facilitating the placement of chargers in parking facilities within the center of the city and home garages around the outer areas of the city.*

5. *Share information with primary stakeholders*

Share the findings with both private sector actors installing EV charging infrastructure as well as garage owners within these target areas. The goal is connecting these two actors, so parking garages receive free EV charging infrastructure while federal stimulus money is still available.

6. *Track EV registrations to identify demand patterns and meet EV adopter needs.*

7. *Conduct a voluntary study to collect data on the commuting/charging patterns of participating EV owners.*

8. *Partner with counties in the New York metropolitan region to create a comprehensive regional wide plan to integrate EVs.*

Utilities Analyses

Utilities Best Practices Findings

The Utilities Best Practices Analyses used findings from expert interviews (*See "Appendix 2: Summary of Expert Interviews" and "Appendix 3: Expert Interview Questions"*).

Key informant interviews provided in-depth qualitative information to develop the study approach in the utilities analyses. Additionally, information gathered from the interviews established the following Utilities Best Practices (*See "Appendix 12: Quick Matrix of Utilities Best Practices"*).

Utilities Best Practices

Widespread EV adoption not only impacts the transportation sector but also electric utilities. Anticipating these effects, several utilities are preparing for EV usage. To maximize infrastructure efficiency while maintaining customer relations, these utilities are mobilizing EV-focused efforts. Launching these initiatives, some utilities are also introducing complementary programs —such as smart-grid technologies. Without preparation, utilities risk overtaxing grids—potentially causing blackouts.[17]

As several major automakers begin to sell EVs, several utilities nationwide already established EV-specific programs. Based on key informant interviews, the following best practices demonstrate how utilities are preparing for electric vehicles. These guiding principles enable utilities to engage in EV adoption.

Best Practice #1: Electric Vehicle Time-of-Use Rates

Instead of standard flat rates for electricity usage, time-of-use (TOU) rates are associated with a specific time period. A TOU rate incentivizes EV charging during off-peak periods, when electricity demand is low, by

Grid Impact

A cause for concern with EV use in NYC is increased electricity loads demanded of EV charging, and its impact on New York's grid. EVs have the potential of increasing a household's energy demand by 10-20%, and such an increase may lead to system failures in certain neighborhoods. If communities of early adopters recharge simultaneously, the increased demand may result in substation failures. According to Con Edison, simulations have shown that 230,000 EVs charging off the grid will create supply shortages impacting all of New York. While addressing this issue is important to ensuring reliable electricity delivery in NYC, it is less likely to influence consumers' decisions when considering EVs. The issue may, however, influence the utilities' decision whether to offer reduced electric rates for EV owners. As such, the potential impacts on the electric grid may be viewed as a barrier to adoption that must be addressed.

reducing rates. On the contrary, peak hours have higher rates to discourage use during increased demand. Off-peak periods typically occur between midnight and 6:00AM. While most EV customers have the option to remain entirely on the standard rate, some utilities—such as California's PG&E—mandate TOU rate usage.

For most utilities offering EV-specific rates, there are generally two options for customers. The first option is a "whole-home TOU rate" where TOU rates apply to the entire home's electricity usage. Designed to encourage broad energy savings, the whole-home TOU option benefits customers with the majority of their energy consumption occurring during these off-peak periods.

The second option is an "EV-only TOU rate" requiring the installation of a separate meter for billing EV electricity usage under TOU rates. Initial installation costs and effort—such as permitting and other related upgrades—are higher under this option. However, unlike the whole-home TOU rate, the EV-only metering option provides flexibility by applying the standard rate for all other electricity use. This alternative is appealing for customers reluctant to commit their entire electricity consumption under TOU rates.

It is difficult to generalize if utilities prefer the whole-home TOU rate option or the EV-only metering TOU rate option, as no clear pattern emerges. Utilities may prefer customers using the whole-home option to improve energy utilization. Other utilities may prefer EV-only metering rates to obtain data about EV charging behavior. Utilities offering free EV charging infrastructure, such as Michigan-based DTE Energy and Consumers Energy, require customers to use a separately metered rate option (see "*Appendix 13: Michigan Case Study*").

Best Practice #2: Consumer Education & Outreach

Nearly all interviewed utilities consider consumer education a crucial component in the role of utilities in the EV market. Many utilities developed websites, brochures, call centers, and online chat functions to engage consumers on EV issues. Outreach efforts include educating local dealerships about special utility rates to direct involvement with automakers. The following describes three common areas of focus for utilities' consumer education and outreach efforts:

Electric Vehicles 101

Utilities' websites often provide basic information about electric vehicles, including the different categories of EVs, charging protocols, available incentives, and the installation and permitting process. Many include external sources of information, providing users with additional resources.

Rates and Options

Utilities' primary role as an educator is making rate options clear and helping customers decide which rate plan is most appropriate. One method is direct interaction with customer representatives. Another approach is providing energy or rate calculator tools on a website, allowing potential EV owners to understand the vehicle fuel costs and to determine which rate is suitable for their electricity use.

Environmental & Social Benefits

Some outreach efforts focus on the social and environmental benefits of electrified transport. For example, this may include information about how off-peak charging enables the system to avoid building new power plants. Another environmental benefit discussed could be the advantage of wind energy and its evening optimization. This type of information is particularly enticing to early adopters and market participants motivated primarily by environmental concerns.

Best Practice #3: Collaboration and Partnerships

Collaborations, partnerships, and task forces are widely cited by interviewees as successful approaches for initiating utilities' EV-programs. These collaborations are noted for their importance in data collection, outreach, and knowledge of regulatory issues. Further, partnerships are increasingly important as customers move between utility boundaries. Stakeholders such as local municipalities, automakers, charging unit manufacturers, and environmental groups are working closely with their respective Public Utility Commission, utilities and their other partners to successfully expedite charging infrastructure processes and establish EV rate structures. Examples of successful statewide partnerships include the Michigan Plug-in Electric Vehicle Preparedness Taskforce and the California Plug-In Electric Vehicle Collaborative.

Best Practice #4: Complementary Programs

Utilities across the U.S. are offering complementary programs to advance EV adoption. These programs especially help utilities that are unable to lower rates or offer financial incentives. The following describe some of the program options utilities offer:

Financial Incentives

Some utilities provide financial incentives for EV consumers. For example, Consumers Energy and DTE Energy both offer $2,500 reimbursements toward Level 2 home charging stations for up to 2,500 participants[18]. Their programs require participants to sign up for a separately metered rate[19]. Lansing Board of Water & Light, a municipally-owned utility in Michigan, offers a program to match the federal incentive up to $7,500 and provides two free charging stations to each participant: one for the

home and one for the workplace. Their program requires participants to answer surveys and collect charging data for 3 years. The Department of Energy (DOE) provides funding each of these programs.

Green Power

A major impetus for purchasing an electric vehicle—for potential EV owners and especially the early adopters—are the associated environmental benefits. Providing green electricity options enhances this choice. For example, New York's Con Edison offers customers the option to buy 100% renewable energy from the New York region.[20]

Fleet Demonstrations

Many utilities are committed to EV fleet purchases or participating in automaker demonstration programs. By 2020, Duke Energy commits to have all new vehicle purchases be electric vehicles.[21] Progress Energy, located in Florida, is a participant in both the Ford Escape PHEV and the Chevorlet Volt Demonstration projects.[22]

Best Practice #5: Electric Vehicle Data Collection and Smart Charging

Utilities are participating in a number of deployment and demonstration programs to gather data about EV consumers' charging behavior as well as anticipated locations of clustering. This information allows utilities to prepare for grid investment as adoption spreads to other cities and regions. With a $200 million grant from the DOE, Progress Energy will deploy hundreds of smart charging stations to gather real-world data in preparation for large-scale adoption of EVs.[23] This data can help utilities leverage their involvement in the EV market into a smart grid. Utilities incorporating smart charging may be better equipped in avoiding future grid problems while retaining greater information and control of infrastructure upgrades.[24] Smart charging issues undergoing investigation and pilot projects include:

Distributed Intelligence

Communications are embedded along the distribution chain allowing for charging management. For example, a transformer could control when the connected EVs charge, avoiding overloading and failing.[25]

Advanced Metering Infrastructure Integration

Allows the utility to separate EV charging from the primary meter. Utilities can use advanced metering infrastructure data to predict local reliability issues, and help utilities forecast future demand.[26]

Demand Response Integration

A utility can adjust the electricity load by lowering air conditioners or stopping EV charging as needed.[27]

The California Public Utilities Commission and the Michigan Public Service Commission both launched studies to explore the utilities' potential role in this type of demand management.

Barriers to Applying Utilities Best Practices in New York City

Our analysis found five nation-wide best practices for Con Edison to adopt and fully engage in the EV market. While some best practices are already implemented, two NYC-unique barriers prevent Con Edison from fully adopting the identified best practices.

Barrier to Adoption: NYC Building Code

Current building codes in NYC prohibits the installation of a second meter to prevent illegal apartments in the city. Additionally, this prohibition prevents landlords from charging different electricity rates to different units within a building. Unfortunately, this restriction also prevents utilities like Con Edison from offering an EV-only rate.

Barrier to Adoption: New York State Public Service Commission (NYSPSC)

Regulated utilities require approval by their State Public Utility Commission (PUC) or Public Service Commission (PSC) before changing their rates or implementing metering changes. Regulators must balance the interests of utilities with ratepayers. Rate requests may require substantial time and financial resources on the part of the utility. Furthermore, initially obtaining a correct rate may be critical in obtaining approval—as defending rates or re-filing rate requests often subjects utilities to greater regulatory scrutiny.[28] Utilities obtaining approval for EV rates found the process similar to other rate requests, taking approximately 4 – 10 months.

In addition, some utilities note current or forthcoming restrictions on education and outreach efforts by their Public Utility Commission. In these cases, education is limited to off-peak charging and rate options information, excluding environmental and social benefits. Since ratepayers fund these educational programs, the restriction stems from concerns with ratepayers subsidizing EV programs.

Recommendations for Applying Utilities Best Practices in New York City

Recommendation to NYC Government: Change Building Code for Second Meter Exception for Electric Vehicles

The New York City government should amend the local building code restriction on second meter installations. Utilities from other states

note that second meters do not pose serious problems as they are easy to monitor: the load from an electric vehicle is drastically different from an apartment load—making it detectable when the second meter is inappropriately used. Requiring an EV proof of purchase for a second meter permit should reduce instances of illegal use.

Recommendation to Con Edison: Invest in Dual Channel Smart Meter Technology

Some utilities including, Con Edison, are researching dual channel meters. These are advanced technology smart meters allowing for separate billing for the EV within the primary meter—removing the need for a second meter. These dual channel meters are expected to be more cost-effective than second meters—costing a few hundred dollars instead of thousands of dollars. Currently, there are no approved dual channel meters. Utilities are conducting studies and piloting these meters, but the technology requires further research and development before deployment begins. Moreover, these meters require the Public Utility Commission's approval. Con Edison could pursue this option while also working with NYC on the second meter building code change.

Recommendation to both NYC Government & Con Edison: Collaborate on Regulatory Efforts with NYSPSC

Collaborative efforts by Con Edison, the NYC government, and other relevant stakeholders provide added resources and allies in the regulatory approval process for an EV-accommodating rate structure and dual channel meters. This partnership could collectively appeal to the NYSPSC to approve of utilities practices accommodating EV use.

Next Steps for Future Analysis

In addition to the NYC-specific recommendations derived from the best practices analysis, key informant interviews also unveiled additional findings. These findings pose additional questions to be addressed before EV adoption occurs beyond early adopters.

Notification Standardization

Utilities do not have a standardized notification system to track customers who purchase EVs. In some areas, electricians are required to notify the utility when any upgrade or new load is added to a home. In other areas, utilities are notified by customers on a voluntary basis. Sometimes automakers provide data on new EV owners to utilities. While adequate for now, these notification modes are neither sustainable nor efficient with the anticipated sales of EVs. Utilities prioritize standardizing this process as it enables them to prepare adequately for load increases. Considering customer privacy concerns, utilities such as

PG&E, ensure information obtained is solely used for grid preparation, not for marketing purposes.

Third-Party Charging Station Regulation

Public Utility Commissions are investigating and discussing regulations of third-party charging station operators. A primary concern focuses on operators "re-selling" electricity—an action prohibited throughout most of the country. Entities selling electricity are subject to utility regulation. The California Public Utilities Commission issued a preliminary ruling that these operators are not utilities and will not be regulated. According to several interviewed utilities, a way to overcome this issue is making explicit business models, such that the charging station operator is not selling electricity. Instead, the operator is selling parking or charging services, for which customers pay a separate fee. The electricity price and all other fees associated with the charging operator are delineated clearly in the receipt.

Electric Vehicles Cost Analysis Findings

Electric Vehicle Costs

Currently, electric vehicles cost more to purchase than comparable hybrid and conventional vehicles. However, in comparison to its alternatives, electric vehicle usage presents substantial annual savings in two ways: (1) lower vehicle maintenance costs and (2) fuel savings. A vehicle's lifetime cost is probably considered during the decision-making process surrounding its purchase. For electric vehicles to be cost-effective its annual savings must recoup the purchase premium or the extra initial costs paid.

Discovering that an EV-only TOU rate is a best practice amongst utilities nationwide, the analysis subsequently examines the impact of a reduced EV rate in NYC. A cost analysis model is used to illustrate how different variables, such as electricity price, gasoline price, and miles traveled, impact the payback period of the purchase premium. This analysis also illustrates the sensitivity of variable changes in comparison to hybrid and conventional vehicles.

Cost Model Analysis

The electric vehicle in this model is a standard 2011 Nissan Leaf, the hybrid vehicle is a 2011 Toyota Prius II, and the conventional vehicle is a 2011 standard Toyota Camry. All assumptions in the model are detailed in "Appendix 11: Electric Vehicle Cost Model Assumptions."

Based on the model, the electric vehicle has a purchase premium of $3,330 over the hybrid and $6,560 over the conventional vehicle, after adjusting for eligible tax credits. The calculations for these premiums are detailed below:

Leaf: $32,780 (base price of Leaf[29]) + $2,200 (charging unit estimate[30]) -

$7,500 (tax credit) - $1,100 (tax credit) = **$26,380**

$26,380 (Leaf) - $23,050 (Prius[31]) = **$3,330 Purchase Premium over Prius**

$26,380 (Leaf) - $19,820 (Camry)[32] = **$6,560 Purchase Premium over Camry**

Table 1 illustrates the various payback periods associated with differing electricity prices, gasoline prices, and driving distances. This exercise reveals that lowering electricity prices substantially lowers the payback period. In fact, without a TOU or reduced rate in NYC, it would take over 13 years for an EV owner to recover the upfront costs, relative to the Prius (at a gasoline price of $3.50/gallon). However, with a discounted rate of 13.5 cents/kWh and $4.00/gallon gasoline, the payback period reduces to less than 4 years, approximately the average turnover period of a new vehicle. Another cost model result supports the finding of electricity price sensitivity and payback periods. While maintaining the current price of 27 cents/kWh but lowering the gasoline price to $2.50/gallon, it still costs more to fuel the EV in NYC than the hybrid car.

By comparing NYC, Boston, and Philadelphia—the three largest cities of Northeastern United States—NYC faces high electricity prices. However, Boston and Philadelphia may not find electricity prices as barriers to EV adoption since their electricity rates are fairly low.

Table 1: Payback Period for EV Premium in Northeast U.S. Cities

New York City - Flat Rate $0.27/kWh			Comparison to Hybrid Vehicle: EV Premium: $3,330		Comparison to Conventional Vehicle: EV Premium: $6,560	
Electricity Price	*Cost per Gallon Gasoline*	*Miles Driven per Day*	*Cost Savings per Year*	***Payback Period (Years)***	*Cost Savings per Year*	***Payback Period (Years)***
$0.27	$3.50	40	$255.18	**13.05**	$1,567.15	**4.19**
$0.135	$3.50	40	$728.22	**4.57**	$2,040.19	**3.22**
$0.0675	$3.50	40	$964.74	**3.45**	$2,276.71	**2.88**
$0.27	$4.00	40	$398.32	**8.36**	$1,898.97	**3.45**
$0.135	$4.00	40	$871.36	**3.82**	$2,372.01	**2.77**
$0.0675	$4.00	40	$1,107.88	**3.01**	$2,608.53	**2.51**
$0.27	$2.50	40	($31.09)	**N/A**	$903.51	**7.26**
$0.135	$2.50	40	$441.95	**7.53**	$1,376.55	**4.77**
$0.0675	$2.50	40	$678.47	**4.91**	$1,613.07	**4.07**
$0.135	$3.50	20	$463.76	**7.18**	$1,115.34	**5.88**
$0.135	$3.50	40	$728.22	**4.57**	$2,040.19	**3.22**
$0.135	$3.50	80	$1,257.14	**2.65**	$3,889.87	**1.69**

Boston - Flat Rate $0.07718/kWh			Comparison to Hybrid Vehicle: EV Premium: $3,330		Comparison to Conventional Vehicle: EV Premium: $6,560	
Electricity Price	*Cost per Gallon Gasoline*	*Miles Driven per Day*	*Cost Savings per Year*	***Payback Period***	*Cost Savings per Year*	***Payback Period***
$0.15882	$3.50	40	$644.76	**5.16**	$1,956.72	**3.35**
$0.07941	$3.50	40	$923.01	**3.61**	$2,234.97	**2.94**
$0.15882	$4.00	40	$787.89	**4.23**	$2,288.54	**2.87**
$0.07941	$4.00	40	$1,066.15	**3.12**	$2,566.79	**2.56**
$0.15882	$2.50	40	$358.48	**9.29**	$1,293.09	**5.07**
$0.07941	$2.50	40	$636.73	**5.23**	$1,571.34	**4.17**
$0.15882	$3.50	20	$422.03	**7.89**	$1,073.61	**6.11**
$0.15882	$3.50	40	$644.76	**5.16**	$1,956.72	**3.35**
$0.15882	$3.50	80	$1,090.21	**3.05**	$3,722.94	**1.76**

Philadelphia- Flat Rate $0.0999/kWh			Comparison to Hybrid Vehicle: EV Premium: $3,330		Comparison to Conventional Vehicle: EV Premium: $6,560	
Electricity Price	*Cost per Gallon Gasoline*	*Miles Driven per Day*	*Cost Savings per Year*	***Payback Period***	*Cost Savings per Year*	***Payback Period***
$0.0999	$3.50	40	$851.21	**3.91**	$2,163.18	**3.03**
$0.050	$3.50	40	$1,026.06	**3.25**	$2,338.03	**2.81**
$0.0999	$4.00	40	$994.35	**3.35**	$2,495.00	**2.63**
$0.050	$4.00	40	$1,169.20	**2.85**	$2,669.85	**2.46**
$0.0999	$2.50	40	$564.94	**5.89**	$1,499.54	**4.37**
$0.050	$2.50	40	$739.79	**4.50**	$1,674.39	**3.92**
$0.0999	$3.50	20	$525.26	**6.34**	$1,176.84	**5.57**
$0.0999	$3.50	40	$851.21	**3.91**	$2,163.18	**3.03**
$0.0999	$3.50	80	$1,503.12	**2.22**	$4,135.86	**1.59**

1 http://www.coned.com/customercentral/calculators/EC_res_Appliance_Calculator.html
2 http://www.nstaronline.com/residential/rates_tariffs/basic_service.asp
3 http://www.papowerswitch.com/shop-for-electricity/shop-for-your-home/by-distributor/peco-energy/rs/

Con Edison: "EVs are a clear opportunity."

From a utilities perspective electric vehicles present a clear opportunity for increased efficiency and a gateway to a smart grid age. "For us EV's present a clear advantage in terms of load management, energy efficiency and smart metering", states John Shipman, head of Con Edison's EV program," If a substantial fleet of cars plugs into the grid, we believe we will see a reduced need for capital investment, which means we can save our rate payers money".

In order to promote use of EVs, Con Edison, is currently exploring a special EV rate, that allows customers to enjoy a low overnight charging rate," We want to incentivize this behavior, of charging at night. In our calculations we see that even without smart charging we're the grid can handle the excess EV load until about 2018, and with smart charging we can go even further out".

Since Con Edison, is a regulated utility, any rate change requires approval from the Public Utilities Commission, which we believe should be coordinated with city policymakers. In terms of city government policies, the biggest stumbling block to EV implementation is the ban on second meter, which inhibits the ability to get the aforementioned EV rate.

Cost Model Analysis Conclusion & Recommendation

Based on these findings, a reduced electricity rate is essential to the widespread adoption of electric vehicles as the lifetime cost likely dictates the decision to purchase an EV. This finding supports the recommendations for Con Edison and NYC government to collaborate and implement a solution for NYC residents to charge EVs. Whether a second meter building code amendment or dual channel meter, enhancing the feasibility of EV adoption depends on electricity rate structure options available to NYC residents.

Summary of Recommendations for New York City

Charging Infrastructure
1. Prioritize installation of public charging infrastructure in Northwest Brooklyn, North Brooklyn and Western Queens
2. Encourage the installation of chargers at major transportation hubs for EV drivers parking at train or bus stations for their daily commute.
3. Run a pilot program installing EV chargers at shopping centers, business improvement districts, cultural and government institutions.
4. Focus policy on facilitating the placement of chargers in parking facilities within the center of the city and home garages around the outer areas of the city.
5. Share information with primary stakeholders.
6. Track EV registrations to identify demand patterns and meet EV adopter needs.
7. Conduct a voluntary study to collect data on the commuting/charging patterns of participating EV owners.
8. Partner with counties in the New York metropolitan region to create a comprehensive regional wide plan to integrate EVs.

Utilities Best Practices
1. Change building code for second exception for electric vehicles.
2. Invest in dual channel smart meter technology.
3. Collaborate on regulatory efforts with New York State Public Service Commission.

The recommendations in the utility and infrastructure analyses are intended to be actionable next steps in removing the barriers identified through this research. Developed through our literature review and key

informant interviews, below are noteworthy recommendations that don't fall under the Utilities Best Practices or Charging Infrastructure categories.

1. Coordination of Electric Vehicle Policy and Progress

Taking significant steps in bringing together governmental actors, market participants, and stakeholders, New York City is coordinating and organizing electric vehicle initiatives. The Department of Planning, Department of Transportation, Citywide Administrative Services, the Department of Buildings, and Con Edison are key participants in developing a robust electric vehicle policy. The participation of Ecotality, Coulomb, Clipper Creek, various local EV charging station distributors, and parking garage owners is vital for bringing electric vehicles to the mainstream market. The Mayor's Office of Long-Term Planning and Sustainability is developing an electric vehicle website to serve as a portal for different sectors providing resources and information.

2. Organize and Streamline Electric Vehicle Purchasing Process for Consumers

Purchasing an EV and installing the charger at home may require more time and effort than desired. Minimizing the costs and processes relating to electric vehicle purchases may incentivize selecting an electric vehicle over a hybrid-electric. Another approach in organizing electric vehicle purchases is developing a database of customers managed by Con Edison:

- Develop process for auto-manufacturers or the Department of Motor Vehicles to collect electric vehicle registrations;
- Develop standard procedures for permitting, installation and inspection process for EV chargers;
- Possibly grant second meter waiver to electric vehicle owners upon vehicle registration.

3. Promotion of Electric Vehicle Fleets for Government Sector

We recommend that the City consider purchasing electric vehicles as it replaces older fleet vehicles, which total over 26,000 vehicles.[33] Currently, NYC's fleet includes 339 electric vehicles. The Department of Citywide Administrative Services (DCAS), the agency charged with implementing a cleaner fleet, committed to purchasing at least 60 additional electric vehicles and installing 42 chargers with DOE funding.[34] We advise the City to continue and expand these efforts.

The City receives its electricity from New York Power Authority (NYPA), a New York State public agency, at a discounted rate. This reduced rate significantly lowers the cost of owning and operating an EV fleet. How-

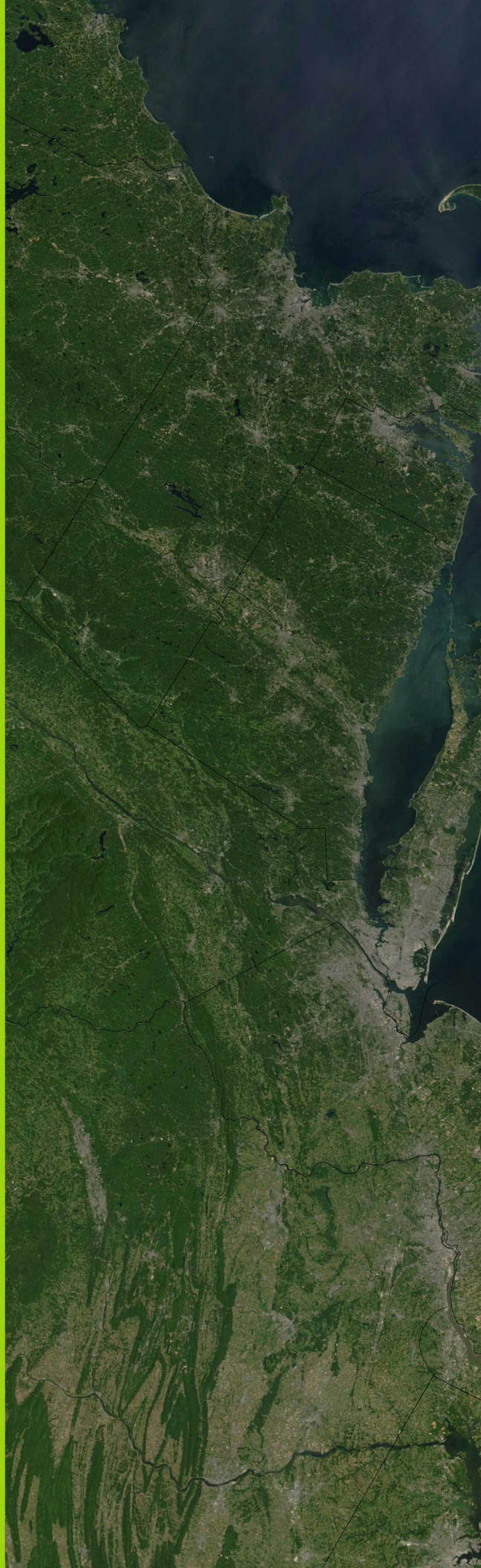
ever, municipal government purchases are not typically eligible for tax incentives offered by the federal government, which would increase the EV payback period. More analysis on the payback period should be conducted as the City also receives a reduced gasoline price.

Nevertheless, the public sector is typically more willing to accept a longer payback period than private consumers. Even without the tax credits, municipal fleets are still an option for EV adoption—especially since nearly all fleet vehicles have predetermined parking lots or garages to park overnight. This provides the ideal matchup of charging accessibility with low electricity prices—an option NYC's private car owners do not have. City agencies with substantial fleets include:

- Department of Transportation
- Department of Sanitation
- NYC Taxis & Limousines
- New York Police Department
- New York City Housing Authority

Chevrolet Volt in Times Square

North East Regional Vehicle Partnership



Electric Vehicles and the Northeast Partnership

The public and private sectors agree that cities and municipalities must play a vital role in expediting electric vehicle adoption into the mainstream. Major cities create partnerships around shared policy goals, such as electric vehicles, to learn from common best practices—advancing solutions effectively and efficiently. Policy consortiums, like the Urban Sustainability Directors Network, seek to formalize partnerships between cities and to define the Northeast region as the nation's sustainability leader.

This study provides a thorough analysis of the key issues New York City faces in becoming better-suited for electric vehicles. Other large U.S. cities face similar barriers in educating their citizens and bringing EVs onto their roads. Furthermore, New York City's policies affect its neighbors' and vice versa. Increased demand for electric vehicles creates economies of scale, leading to reduced costs and more extensive charging infrastructure. Thus, EV policies in one city potentially aid adoption in neighboring cities. New York City recognizes this potential and released an updated PlaNYC 2.0 in April 2011, announcing a partnership with Boston and Philadelphia known as "the Northeast Regional Electric Vehicle Partnership (NREVP)."

Due to their proximity, comparable geography, demographics, and infrastructure, Boston, Philadelphia and New York City must consider similar issues with EV feasibility. Each city should address how local electricity prices affect vehicle payback periods and how drivers can charge electric vehicles without their own parking spots or driveways. These problems differ across the cities in frequency and in degree, but not in kind. With the shared vision of the NREVP, the analysis completed for New York City can apply to Boston and Philadelphia, and facilitate EV adoption in each respective city.

Boston

Charging Infrastructure

The greater Boston metropolitan area is estimated to have approximately 4.5 million residents,[35] of which roughly 600,000 are located within Boston-proper. The majority of residents are located within an area surrounding Interstate 95, and a less dense population within the boundary of Interstate 495. Residents living in the greater Boston area generally have private parking spaces attached to their housing unit, thus the city will not require as much public charging infrastructure when compared to New York City. However, Boston has its share of residents that park on the street, and who could not easily drive an electric vehicle.

As this study has demonstrated, Boston should seek to understand location and driving needs of these residents. As previously concluded, high income and education are strongly correlated with EV interest. In Boston, high income and education are most prevalent along Interstate 90[36] (The Massachusetts Turnpike) in a line that ends in the downtown Boston area. Census data showing housing units with attached parking may be plotted geographically showing where income, education and lack of parking for housing units correlate, more accurately predicting where public charging infrastructure should be focused. Hybrid vehicle ownership data[37] generally supports the conclusion that downtown areas are likely to have high demand for electric vehicles but lack charging options in parking facilities; these areas should be primary target areas for public infrastructure. There are also pockets of hybrid ownership in Jamaica Plain, Allston/Brighton, Roslindale and the South End; these areas should be secondary target areas for charging infrastructure.

Utility Policy

Boston's electric utility, NSTAR, offers a flat rate for electricity of $0.159 per kWh, which is close to half of the rate offered in New York City. Although currently there is no Time-Of-Use rate offered for individual households, as of March 2010, NSTAR has partnered with Tendril[38] to build the capacity to use smart metering, and is exploring dynamic rates. As the cost model shows, and assuming an average of 40 driving miles per day, the $0.159 per kWh rate will already offer electric vehicle consumers a payback period of 5.16 years over a hybrid and 3.35 years over a comparable gasoline vehicle.

Should NSTAR cut the electricity rate in half and offer $0.079 per kWh, and assuming gasoline prices remain high, the payback period of an EV over a hybrid is only 3.61 years, which is well within the policy window to incentivize consumers. That reduced rate also offers a payback period of 2.94 years over a comparable gasoline vehicle. There are no known restrictions of second meters, but approving dual metering technology will ease electric vehicle electricity rates.

The current major policy initiative for electric vehicles is a promotional-pilot program of electric vehicle chargers outside City Hall in downtown Boston. It is recommended that the city collaborate with colleges and universities in the greater Boston area as well. Boston is well poised to increase the rate of electric vehicle adoption, leveraging commercial entities as they are already receiving reduced electricity rates between $0.037 and $0.058 per kWh.

Philadelphia

Charging Infrastructure

The greater Philadelphia area has roughly 6.1 million people, with approximately 1.5 million living within the proper city boundaries.[39] As with Boston, it appears that Philadelphia has fewer areas in need of public electric vehicle charging. Much of the greater Philadelphia population has parking attached to housing units. This census data needs to be plotted, along with hybrid ownership, in order to confirm this projection. High income and education converge in an east-west swath in Center City along Market, Chestnut and Walnut Streets. The highest convergence of income and education occurs along the eastern waterfront area and in Old City.[40] Public charging infrastructure should focus on these three streets in Center City and along the waterfront.

Utility Policy

PECO, Philadelphia's electric utility offers a flat rate of $0.163 per kWh, but does not offer a Time-Of-Use rate to either individuals or commercial entities. Assuming an average of 40 driving miles per day, the payback period for the premium of an electric vehicle, over a hybrid, is 5.28 years and for a comparable gasoline vehicle is 3.38 years.

As part of the Exelon 2020 program and following Pennsylvania regulations, PECO will begin offering a Time-Of-Use rate in 2012. Currently there are no plans to establish a rate specific to electric vehicles. Assuming the Time-Of-Use rate is half of the current flat rate, a rate of $0.081 per kWh will decrease the payback period of the electric vehicle premium over a hybrid to 3.64 years. Using Time-Of-Use pricing, the payback period for a comparable gasoline vehicle would decrease the payback period to 2.94 years. Using this model, current and projected pricing for electric vehicles will not incentivize early adopters to purchase electric vehicles. It is strongly recommended that PECO offer electric vehicle specific rates, which provide EV customers a wide range of options, enhancing the EV purchase.

Currently, private vehicle sharing companies (PhillyCarShare and Zipcar) are planning to add a total of 18 electric vehicles to their collective fleets. These vehicles will be supported by charging stations paid for by the American Recovery and Reinvestment Act of 2009 (commonly known as "the stimulus"). At this time only small pilot programs exist, consisting of one or two electric vehicles (PECO will add two Chevrolet Volts to its fleet).

Next Steps

The Northeast Regional Electric Vehicle Partnership is still nascent, but it is clear these three cities and other municipalities will benefit from this type of benchmarking. The more these types of analyses are applied to other cities the more feasible it will become to understand the barriers and to ascertain whether these barriers should be addressed by government policy or should be left to the private sector. This allows cities and municipalities to make more informed, efficient and cost-saving policy decisions for electric vehicles.

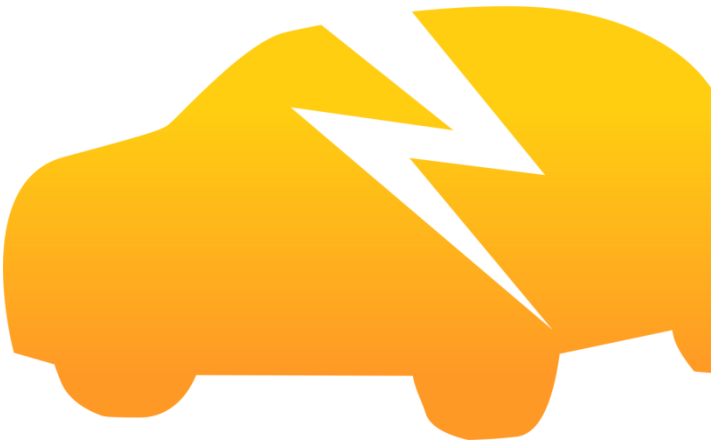
Project get ready: "EVs require long term planning and commitment."

Project Get Ready is an electric car coalition working out of the Rocky Mountain Institute. The organization seeks to facilitate a knowledge-sharing network, from which cities can learn best practices and benchmark their progress. In interviews we conducted with Project Get Ready, the following issues arose as critical factors:

- Ease of use, if a transition to EV is complicated people will stick with current technology
- Incentives: Is cheap electricity enough, should we use tax credits or rebates?
- Education: Cities and utilities need to expose this technology
- Charging Solutions for all residents: private garages, apartment homes, and public garages
- EV coalition: Bringing in all stakeholders, and creating a 5 year work plan.

Conclusion

Electric vehicles represent a great opportunity for New York City to meet its sustainability goals outlined in PlaNYC. By facilitating the electrification of its transportation sector, New York City demonstrates to the nation how a modern, cutting-edge city enhances electric vehicle feasibility. Promoting business partnerships, utility best practices, the expansion of public charging infrastructure, and cost-effective electricity rates, New York City enables its residents to take full advantage of electric vehicles' unique benefits. With growing consumer interest, private companies and non-profits are mobilizing to ensure electric vehicles and charging technologies enter the market. New York City must reach out to these stakeholders to facilitate cooperation and spur interest in electric vehicle demand. Additionally, as partnerships across municipalities offer access to additional resources and information, the Northeast Regional Electric Vehicle Partnership will serve to bolster each city's electric vehicle initiatives. As demonstrated by successful regional electric vehicle partnerships in the Seattle Puget Sound region and the San Francisco Bay Area, the partnership between Boston, Philadelphia, and New York City shows great promise in the Northeast—reflecting the country's growing interest not only in electric vehicles but also long-term urban sustainability.



Appendices

Appendix 1: Existing Policy

Introduction

In his State of the Union Address on January 25, 2011, President Obama pledged to "break [America's] dependence on oil…and become the first country to have a million electric vehicles on the road by 2015."[41] President Obama's plan echoes the growing interest of government agencies, consumers, and industries across America in promoting electric vehicles in the United States. [42] Various federal programs and policy initiatives already encourage and support EV use.[43]

Federal Policy Efforts

Federal efforts to promote EV adoption target both consumers and industry. Presently, a federal tax credit of up to $7,500 is available for the purchase of qualifying plug-in electric drive motor vehicles. This credit will phase out after the sales of qualifying vehicles in the United States reach 200,000 units.[44] In addition, federal legislation such as the American Recovery and Reinvestment Act of 2009 promotes EV adoption through manufacturing investments, financial incentives, and consumer education.[45] Stimulus funds are also available for supporting the installation of charging infrastructure. The ChargePoint America program is supported by $15 million in stimulus funding granted by the Department of Energy; this program is responsible for the installation of a planned 200 free chargers within New York City. [46]

State Policy Efforts

From financial assistance to special privileges, the State of New York is developing additional programs and incentives to encourage EV use. Under the Clean Pass Program, the State provides non-commercial EV drivers with unrestricted access to "high occupancy vehicle (HOV)" lanes.[47] In October 2010, the NY State Power Authority announced its partnership with Ford Motor Company to render the State of New York "EV-ready"—by developing consumer outreach strategies as well as coordinating efforts with utilities.[48] In addition, the New York State Energy Research and Development Authority (NYSERDA) administers the Alternative-Fuel Vehicle Program. The goal of this program is to encourage both public and private fleets to purchase alternative-fuel vehicles (electric vehicles included) and to install the supporting fueling or charging stations. To do so, NYSERDA provides financial assistance and technical information to program participants.[49]

New York City Efforts

Currently, there are nearly fifty charging stations in publicly accessible parking garages mainly in lower Manhattan, the first of which was publically announced by Mayor Bloomberg in July 2010. These charging stations have primarily been installed by Ecotality and Coulomb

Technologies under the Federal Stimulus Act of 2010, which is aimed at incentivizing the implementation of infrastructure for electric vehicles in order to meet President Obama's goal of one million electric vehicles on the road by 2015. Under the stimulus act, the cost of installing charging stations in public facilities is paid by the federal government through distributors and manufacturers of electric vehicle charging stations.

Private Sector Efforts

The private sector is also utilizing EVs in various ways. In January 2011, Hertz unveiled Chevy Volt rentals from an Upper East Side location.[50] Likewise, Edison Properties LLC's has invested in chargers at over 21 of their 40 'Edison Park Fast' locations in New York and New Jersey.[51]

Appendix 2: Summary of Expert Interviews

Between February and March 2011, the group conducted nearly forty interviews to develop general knowledge of electric vehicles while answering key questions formulated from the study's methodology. Interviewees were categorized into the two research tracks: Utilities Best Practices and Charging Infrastructure. Scholarly works and policy writings found in the literature review identified interviewees. The interview process also identified additional references and interviewees. Respondents tend to be directly involved with EVs or companion technologies. The interviewees are not a comprehensive sample of experts in the EV field—rather people with relevant knowledge relating to our study.

Charging Infrastructure

Interviewees generally agree population density presents difficulties to EV adoption, as potential owners may not have private parking attached to their house or apartment. Overcoming range anxiety with proper charging infrastructure is a primary concern, as range limitations remain an issue for the general public. Pilot projects and awareness campaigns are consistently mentioned as possible tools for increasing EV demand and public charging infrastructure. Several interviewees mention electrifying NYC's vehicle fleets as a way to reduce range anxiety amongst New Yorkers. Congestion is consistently identified as an issue for NYC. Additionally, EV initiatives should strive to replace existing gasoline cars, rather than add new vehicles to NYC. Interviewees believe multi-dwelling unit residents face the largest infrastructure barrier due to lack of available parking. Some buildings have parking garages, while others do not. There is no clear solution to this issue.

Utilities Best Practices

Interviewees identified electricity rates as the key issue related to utilities. There are varying opinions of implementing EV-specific rates or Time-of-Use rates. Both solutions present additional issues for NYC. Currently, NYC does not allow second meter installation—a necessity for having EV-specific rates. Upgrades to NYC's electric grid are likely to occur as demand for EVs increase. However, Con Edison claims they are prepared.

Appendix 3: Expert Interview Questions

I. CHARGING INFRASTRUCTURE QUESTIONS

1. INTRODUCTORY QUESTIONS

a. Why have electric vehicles not yet been widely adopted?
b. From a consumer's perspective, what are the most important factors influencing the decision to purchase an electric vehicle?
c. How can the adoption of the electric vehicle be accelerated in New York City?
(Alternatively Asked: What is Nissan doing to bring the leaf to NYC?)
d. What are the most important factors to adopting electric vehicles in New York City?

2. SPECIFIC CHARGING INFRASTRUCTURE QUESTIONS

a. In your opinion, what is the most critical factor for implementing electric vehicles in New York City, related to charging EVs?
b. In your opinion, will the placement of charging stations in private parking garages increase the feasibility of EV in New York City?
c. How can the implementation of this charging infrastructure be accelerated?
d. Other than home charging and private parking garages, what alternative parking locations do you feel should be considered?
e. Who would you consider the most relevant stakeholders for charging infrastructure?
f. When might electric vehicles become competitive with conventional forms of transportation?

II: UTILITY RATE STRUCTURE

3. INTRODUCTORY QUESTIONS

a. Why have electric vehicles not yet been widely adopted?
b. From a consumer's perspective, what are the most important factors when choosing to purchase an electric vehicle?
c. How can the adoption of the electric vehicle be accelerated in New York City?
d. What are the most important issues to adopting electric vehicles in New York City?
e. When could electric vehicles become competitive with conventional forms of transportation?
f. Is it better to incentivize the consumers, or producers of electric vehicles; both?

4. SPECIFIC UTILITY RATE STRUCTURE QUESTIONS

a. In your opinion, what is the most critical factor for implementing electric vehicles in New York City, related to electric utility rates? Other factors?
b. In your opinion, will a reduced off-peak electricity rate, specific to electric vehicles, increase the possibility of widespread adoption in New York City?

c. Other than an off-peak electricity rate, what other alternative policies do you feel deserves consideration?
d. Who would you consider the most relevant stakeholders for charging electric vehicles?
e. When might electric vehicles become competitive with conventional forms of transportation?

III: SUB-CATEGORIES

5. CHARGING INFRASTRUCTURE

a. Currently, one hour of an open gas pump can provide 8,000 miles of driving. When will electricity be able to meet that standard? What are the barriers to providing this standard in electricity?
b. If there is a lower rate for charging electric vehicles, is it possible to alter the charging station to power other devices?
c. How will Level 3 480 volt quick-charging technologies be utilized?
d. How would battery-swapping affect charging technology?
e. To bring further insight to our study, would you be able to recommend any colleagues with pertinent experience with electrical infrastructure and integration with EV charging technology? EV charging in general?

6. UTILITIES

a. Will an off-peak electric vehicle charging rate change regular electricity rates in New York City?
b. Will upgrades to the New York electric grid be necessary if electric vehicles are widely adopted?
c. With existing technology, can an electric vehicle charging rate be applied only to electric vehicles?
d. Are there sufficient safeguards, against misuse, incorporated in current charging technology?
e. To bring further insight to our study, would you be able to recommend any colleagues with pertinent experience within electrical infrastructure and utilities?
f. Are there sufficient safeguards, against misuse, incorporated in current charging technology?
g. What Factors or data would you use to gauge the potential location of EV charging Stations (relating to the locations of likely EV adopters)?

7. CAR MANUFACTURERS

a. What are the expected lifetime maintenance costs for the electric vehicle?
b. Are there specific technological breakthroughs you foresee that will accelerate the popularity of electric vehicles?
c. What other types of transportation are the biggest competitors for electric vehicles in New York City? (public transport, bike-renting, etc.)?
d. To bring further insight to our study, would you be able to recommend any colleagues with pertinent experience within EV manufacturing?
e. How important is public charging away from home? Where does it fit into Nissan's model (vs. overnight)?
e. What happens to an EV's range when in congestion?

8. BATTERIES

a. What is the expected lifespan of a typical electric vehicle battery?
b. Does the type of charging affect the lifespan of the battery?
c. What are the expected maintenance costs for a typical battery?
d. Do existing recycling programs in New York City cover electric vehicle batteries?
e. When will battery technology be advanced enough that range and mass will no longer be constricting factors?
f. Do you expect a breakthrough in the battery technology? Is it necessary for the popularity of electric vehicles?
g. To bring further insight to our study, would you be able to recommend any colleagues with pertinent experience with EV batteries or charging?

9. POLICY

a. What can New York City learn from your city's experience implementing electric vehicles?
b. What program and/or policies were particularly helpful in encouraging electric vehicles?
c. How has a commitment to electric vehicles benefitted your city?
d. To bring further insight to our study, would you be able to recommend any colleagues with pertinent experience related these policy or management issues?

IV. INTERVIEWS OF OTHER STAKEHOLDERS

10. CURRENT EV CONSUMERS

a. How would you convince another consumer that this car can work?
b. What initially attracted you to an electric car?
c. What are the biggest benefits of purchasing an electric car?
d. What are the added operating costs that you experience?
e. What are the expected costs to EV owner for installing/maintaining home charging units?
f. How many EVs do you expect to sell in coming years?
g. What's your opinion of stop and go traffic in NYC; does it help or hurt the EV?

11. GARAGE OWNERS

a. What are your biggest concerns about installing electric vehicle chargers in your garage?
b. What are your suggestions to Mayor Bloomberg for alleviating these concerns?
c. Do you believe the installation of EV charging stations will increase revenue at your garage?
d. Do attendants receive training to operate stations?
e. Do EV drivers pay a premium to the garage owner for charging service?
f. Is there a combined tariff?

12. ELECTRIC VEHICLE FLEETS

a. Would you consider transitioning your fleet to electric?

b. What internal obstacles are there to this?
c. How would your physical plant need to change?
d. Would you invest in high speed DC charging?

Addendum to Interview Guide: Utility Analysis Questions

SECTION 1.A: Offering specific Electric Vehicle Electricity Rate

a. Is this rate distinct from a broadly offered Time of Use rate?
b. How was the actual EV rate(s) determined?
c. What were the driving factors in adopting the rate?
d. Can you provide a brief overview of the process to implement the EV-rate? What was the timeline? Key milestones?

i. What were the obstacles to implementation of the EV rate?
ii. What stakeholders were the most important in the process?
iii. What was the involvement of the Public Utility/Service Commission in the process?
iv. Have you seen an increase in EV owners due to the rate?
v. Is there a minimum number of consumers opting into the EV rate required to make it economical from the utility perspective?

e. How has (or how will) the EV rate affect other ratepayers? If infrastructure upgrades, such as replacing a neighborhood transformer, are necessary, will the costs be spread to all ratepayers?
f. Are you concerned at all with the charging station model and re-selling electricity?

SECTION 1.B: NOT offering specific Electric Vehicle Electricity Rate

a. Do you anticipate adopting an EV-rate in the future?
b. What are the driving factors in your decision-making process to adopting an EV rate?
c. Do you see any obstacles to implementation of the EV rate?
d. Do you expect there is a minimum number of consumers who need to opt into the EV rate to make it economical from the utility perspective?
e. How will an EV rate affect other ratepayers? If infrastructure upgrades, such as replacing a neighborhood transformer, are necessary, will the costs be spread to all ratepayers?

SECTION 1.C: Questions for Public Utilities Commissions/Policymakers

a. Does your utility offer an EV – specific rate? Is that distinct from a broad or whole home Time of Use rate?
b. How does your utility feel about sub-metering?
c. Do you believe an Electric Vehicle electricity rate will encourage EV adoption?
d. What is your involvement, if any, in the process of implementing such rates? Was there collaboration with

utilities in establishing the rate structure?

e. Have you seen an increase in EV owners where utilities offer an EV rate?

f. Is there a minimum number of consumers opting into the EV rate required to make it economical from the utility perspective?

g. How has (or how will) the EV rate affect other ratepayers? If infrastructure upgrades, such as replacing a neighborhood transformer, are necessary, will the costs be spread to all ratepayers?

Appendix 4: Spatial Analyses Methodology

Hybrid Vehicle Ownership

Studies conducted by the Greater London Authority[52] and the Puget Sound Regional Council[53] suggest there is a relationship between hybrid-vehicle ownership and possible EV adoption. In London, current EV owners and hybrid-vehicle owners tend to cluster in the same neighborhoods.[54] Additionally, the Seattle region reveals a strong association between Nissan Leaf registrations and current hybrid-vehicle owners.[55]

Socio-Economic Factors

Assuming early EV adopters share characteristics with early hybrid-vehicle adopters, the Victoria Department of Transportation reviewed various hybrid-vehicle studies to identify relevant socio-economic factors.[56] The Victoria Department of Transportation references studies supporting a common theme: early hybrid-vehicle adopters were more likely to have higher education and income levels. [57] The Greater London Authority study supports this hypothesis as London's current EV and hybrid owners tend to be wealthy and educated. [58]

Job Density

The Greater London Authority[59] and the Puget Sound Regional Council[60] both consider workplace localities and commuting patterns in their studies. As workers spend several hours at their job sites, workplace parking locations present potential EV charging sites.

Households with More than Two Vehicles

The Greater London Authority,[61] the Puget Sound Regional Council,[62] and the Victoria Department of Transportation[63] all use datasets with multi-vehicle owning households. All three studies cite the increased likelihood of an EV replacing a vehicle in a multi-vehicle household.

Conducting Spatial Analyses

Geographic Information Systems (GIS) is the method of spatial analyses used in the present study.[64] All spatial analyses were performed using the ESRI ArcMap 10 Software (ArcMap Software). The spatial methodology section offers a detailed description of the procedures used for conducting the Charging Infrastructure Analyses.

The maps displayed use graduated colors—ranging from blue (lowest values), to yellow (medium values), and to red (highest values). The data is categorized with ten classes. Class ranges use the natural breaks (Jenks) classification in the ArcMap Software. Light grey areas indicate census tracts with unavailable data.

Creating the Base Maps

The NYC Counties and the Census 2000 Census Tract shapefiles form the layers of the base maps. Both shapefiles were obtained from the Columbia University Spatial Data Catalog.

Current Electric Vehicle Charging Infrastructure Data

Websites for ChargePoint America,[65] Beam Charging LLC,[66] and Electric Car Stations[67] provide information regarding the locations of existing EV chargers in NYC. Using BatchGeo,[68] a program converting addresses to XY coordinates, the EV charger addresses were converted to a compatible GIS format and mapped using the ArcMap software.

Median Household Income Data

The median household income map is based on the 2005-2009 American Community Survey 5-Year Estimates "Median Household Income" Data for the counties of NYC: Bronx County, Kings County, New York County, Queens County, and Richmond County. Gathering the income data from the United States Census Bureau American FactFinder[69] and linking it with the census tract numbers in the Census 2000 Census Tract shapefile generated the median household income map.

Education Data

The education level map uses the 2005-2009 American Community Survey 5-Year Estimates "Sex by Age by Educational Attainment for the Population 18 Years and Over" dataset obtained from the United States Census Bureau American FactFinder.[70] The information collected is limited to NYC residents age 18 or older. Additionally, this information only includes individuals with at least a Bachelor's degree within NYC's five counties.

Since the educational data presents information for males and females separately, the number of educated females and educated males are first combined to find the "general" number of educated individuals. This combined gender education data is then used to calculate the percentage of educated individuals. The number of educated individuals is divided by the general population data within a census tract. Linking this education population data with the Census 2000 Census Tract shapefile generated the education map.

Job Density Data

The job density map is based on the U.S. Census Bureau's Longitudinal Employer-Household Dynamics (LEHD) data obtained from the LEHD OnTheMap website.[71] This data details the number of workers and their respective work locations (per census tract) in 2009. Using the census tract numbers, these values are linked to the Census 2000 census tract shapefile. To determine the number of jobs per square mile, these values were divided by the areas of the census tracts.

Vehicle Availability Data

The vehicle availability map was generated using the 2005-2009 American Community Survey 5-Year Estimates "Tenure by Vehicles Available" data. This data was obtained at the United States Census Bureau American FactFinder website[72]. Combining the owner occupied housing units data and renter occupied housing unit data created one index of occupied housing units. Data categories for two vehicles, three vehicles, four vehicles, and five or more vehicles available were combined to create the two or more vehicles category. The number of occupied housing units with two or more vehicles was divided by the total population of occupied housing units within a census tract. This generated the percentage of occupied housing units with two or more vehicles available. These values were linked to the Census 2000 census tract shapefile using the census tract numbers.

Hybrid Vehicle Registration Data

Due to its confidential nature, it was necessary to file a Freedom of Information Act request[73] to obtain the addresses of NYC's hybrid vehicle registrations from the New York State Department of Transportation. The data contains roughly 23,000 registration addresses (2011) of all hybrid vehicles in NYC. The hybrid vehicle types ranged from small hatchbacks (i.e., the Toyota Prius, etc.) medium-sized sedans (i.e., the Toyota Camry hybrid, etc.), to large SUVs (i.e., GMC Yukon Hybrid, etc.) BatchGeo[74], an online tool that converts addresses to XY coordinates, converted the EV charger addresses to a GIS-compatible format, which were then mapped using the ArcMap software. A spatial location join command is used to calculate the number of registered hybrid vehicles located within each census tract. To determine the number of hybrid vehicle registrations per square mile, this calculated value was divided by census tract areas.

Appendix 5: Spatial Analysis Maps

Maps used in the Spatial Analysis are presented on the following pages

Map 1: Educational Attainment
Map 2: Median Household Income
Map 3: Job Density
Map 4: Vehicle Availability
Map 5: Hybrid Vehicle Ownership

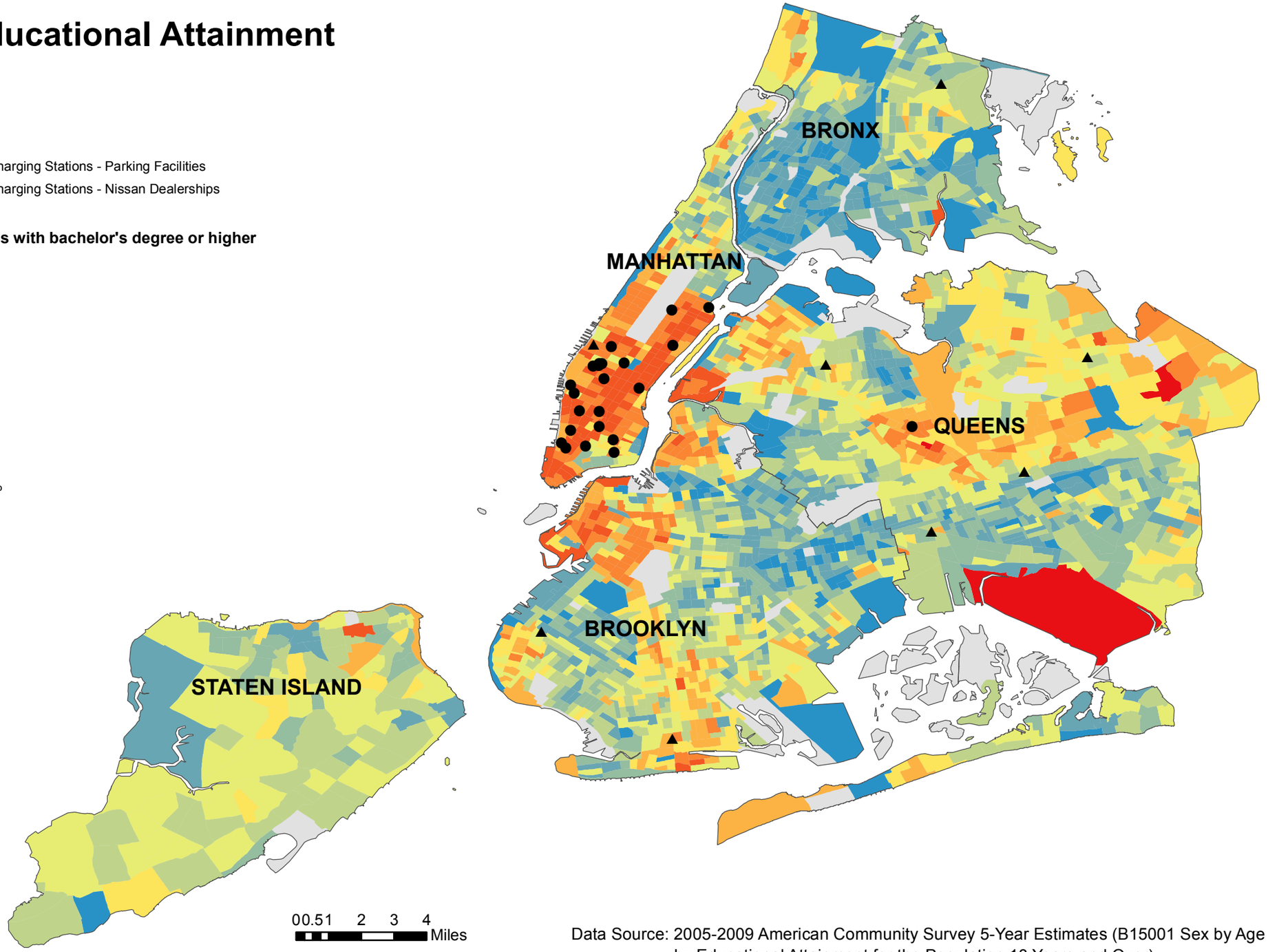
Map 1: Educational Attainment

LEGEND

- ● Electric Vehicle Charging Stations - Parking Facilities
- ▲ Electric Vehicle Charging Stations - Nissan Dealerships

Percent of invididuals with bachelor's degree or higher

- 0.00% - 5.10%
- 5.10% - 9.46%
- 9.46% - 13.23%
- 13.23% - 17.07%
- 17.07% - 21.25%
- 21.25% - 26.14%
- 26.14% - 32.04%
- 32.04% - 40.69%
- 40.69% - 64.19%
- 64.19% - 100.00%
- No data available



Data Source: 2005-2009 American Community Survey 5-Year Estimates (B15001 Sex by Age by Educational Attainment for the Population 18 Years and Over)

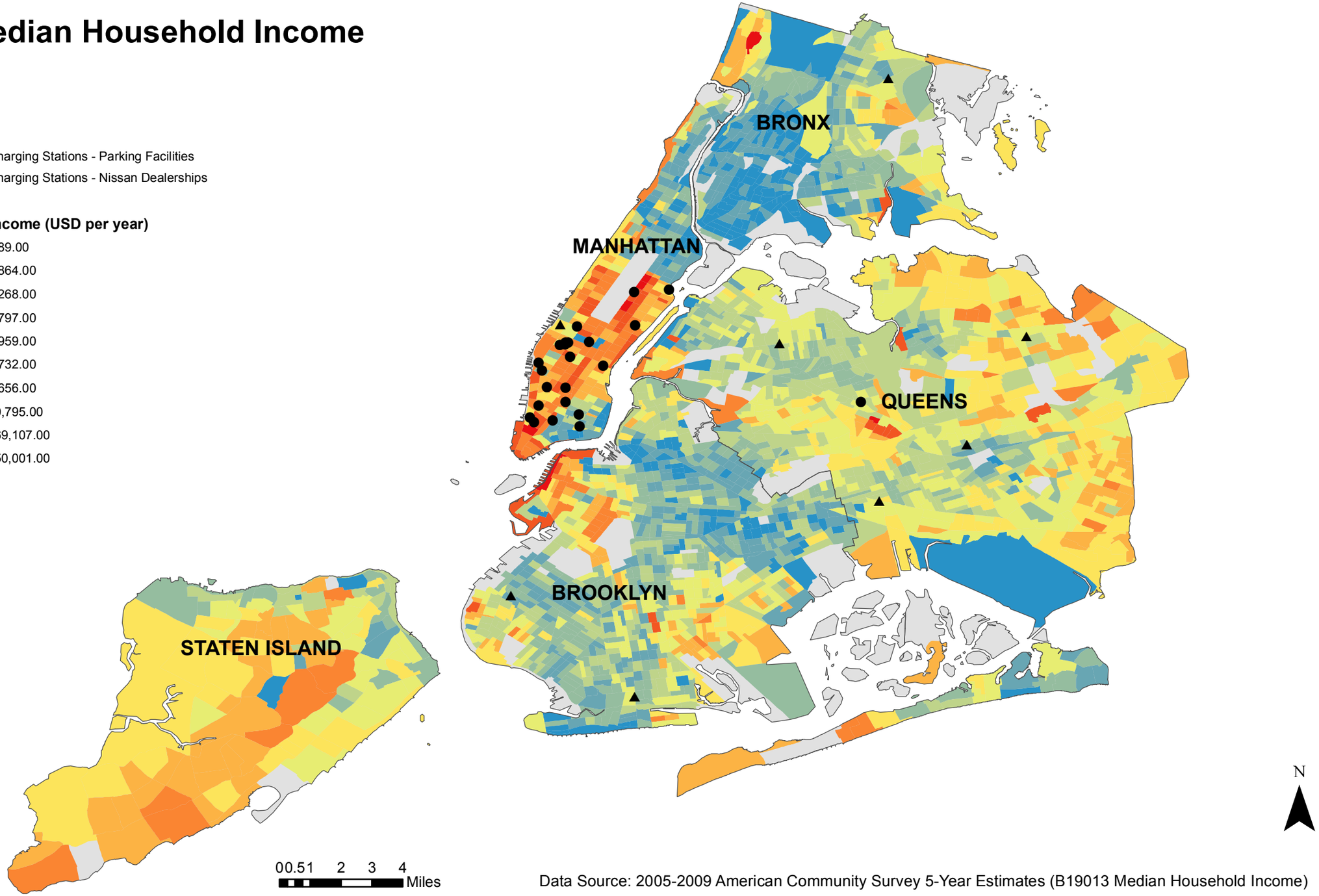
Map 2: Median Household Income

LEGEND

- ● Electric Vehicle Charging Stations - Parking Facilities
- ▲ Electric Vehicle Charging Stations - Nissan Dealerships

Median household income (USD per year)

- $2,499.00 - $23,889.00
- $23,889.00 - $34,864.00
- $34,864.00 - $45,268.00
- $45,268.00 - $55,797.00
- $55,797.00 - $66,959.00
- $66,959.00 - $79,732.00
- $79,732.00 - $96,656.00
- $96,656.00 - $120,795.00
- $120,795.00 - $169,107.00
- $169,107.00 - $250,001.00
- No data available



Data Source: 2005-2009 American Community Survey 5-Year Estimates (B19013 Median Household Income)

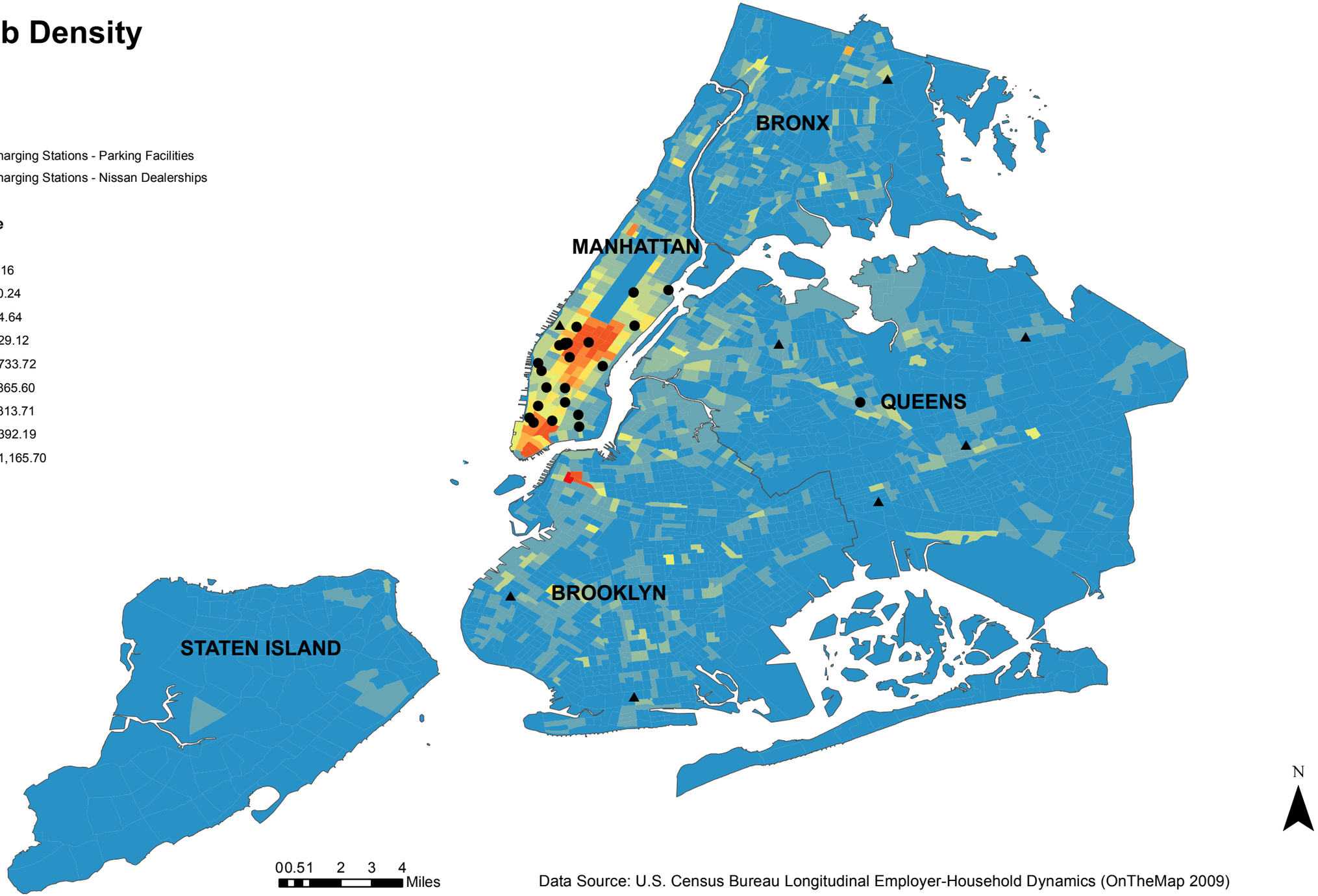
Map 3: Job Density

LEGEND

- ● Electric Vehicle Charging Stations - Parking Facilities
- ▲ Electric Vehicle Charging Stations - Nissan Dealerships

Jobs per Square Mile

- 0.00 - 6,595.89
- 6,595.89 - 19,114.16
- 19,114.16 - 39,890.24
- 39,890.24 - 72,274.64
- 72,274.64 - 123,629.12
- 123,629.12 - 217,733.72
- 217,733.72 - 311,865.60
- 311,865.60 - 466,313.71
- 466,313.71 - 930,392.19
- 930,392.19 - 3,201,165.70



Data Source: U.S. Census Bureau Longitudinal Employer-Household Dynamics (OnTheMap 2009)

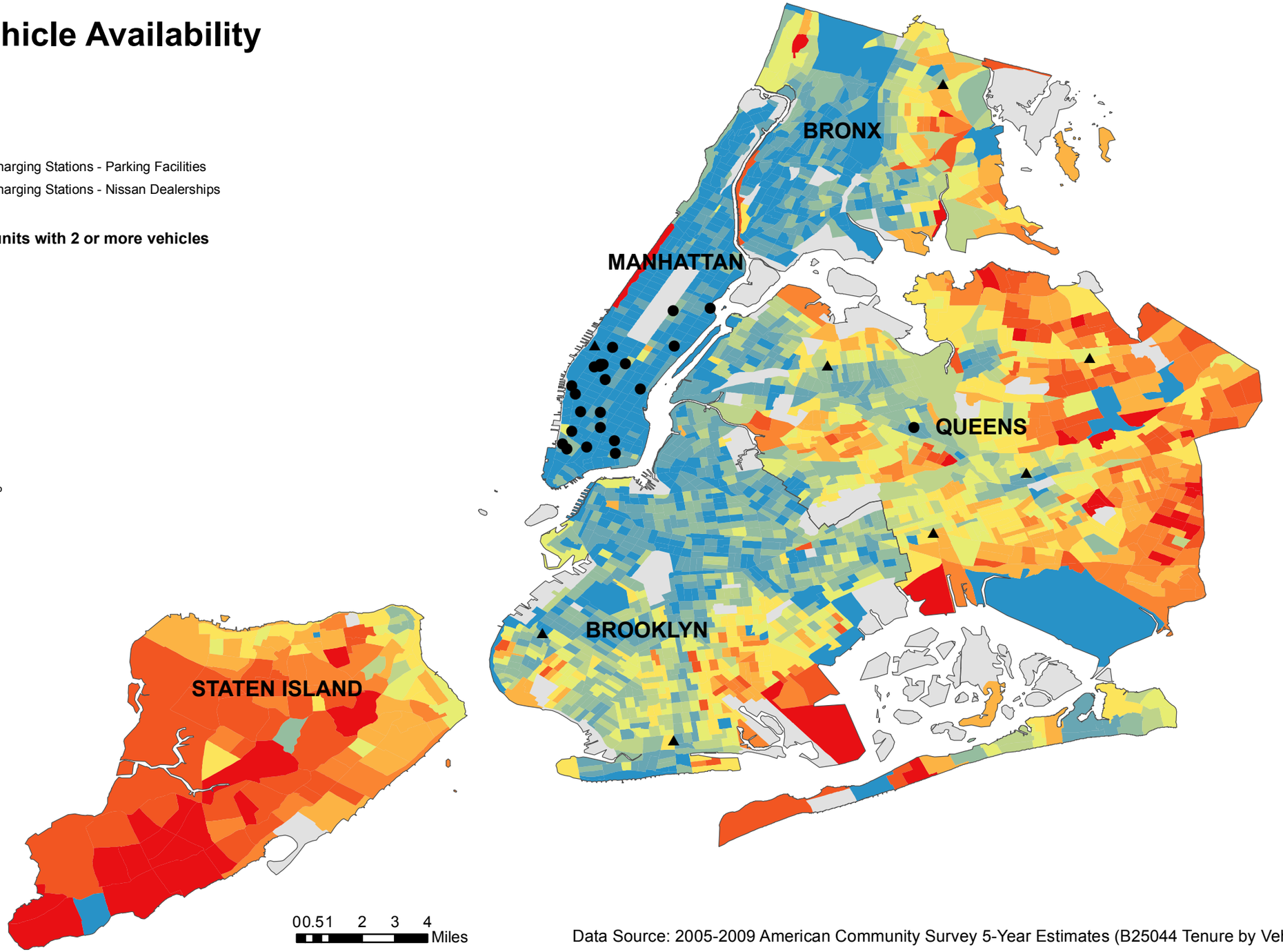
Map 4: Vehicle Availability

LEGEND

- ● Electric Vehicle Charging Stations - Parking Facilities
- ▲ Electric Vehicle Charging Stations - Nissan Dealerships

Percent of housing units with 2 or more vehicles

- 0.00 - 2.13%
- 2.13% - 4.49%
- 4.49% - 7.44%
- 7.44% - 11.60%
- 11.60% - 17.18%
- 17.18% - 24.18%
- 24.18% - 32.79%
- 32.79% - 43.28%
- 43.28% - 55.99%
- 55.99% - 100.00%
- No data available



Data Source: 2005-2009 American Community Survey 5-Year Estimates (B25044 Tenure by Vehicles Available)

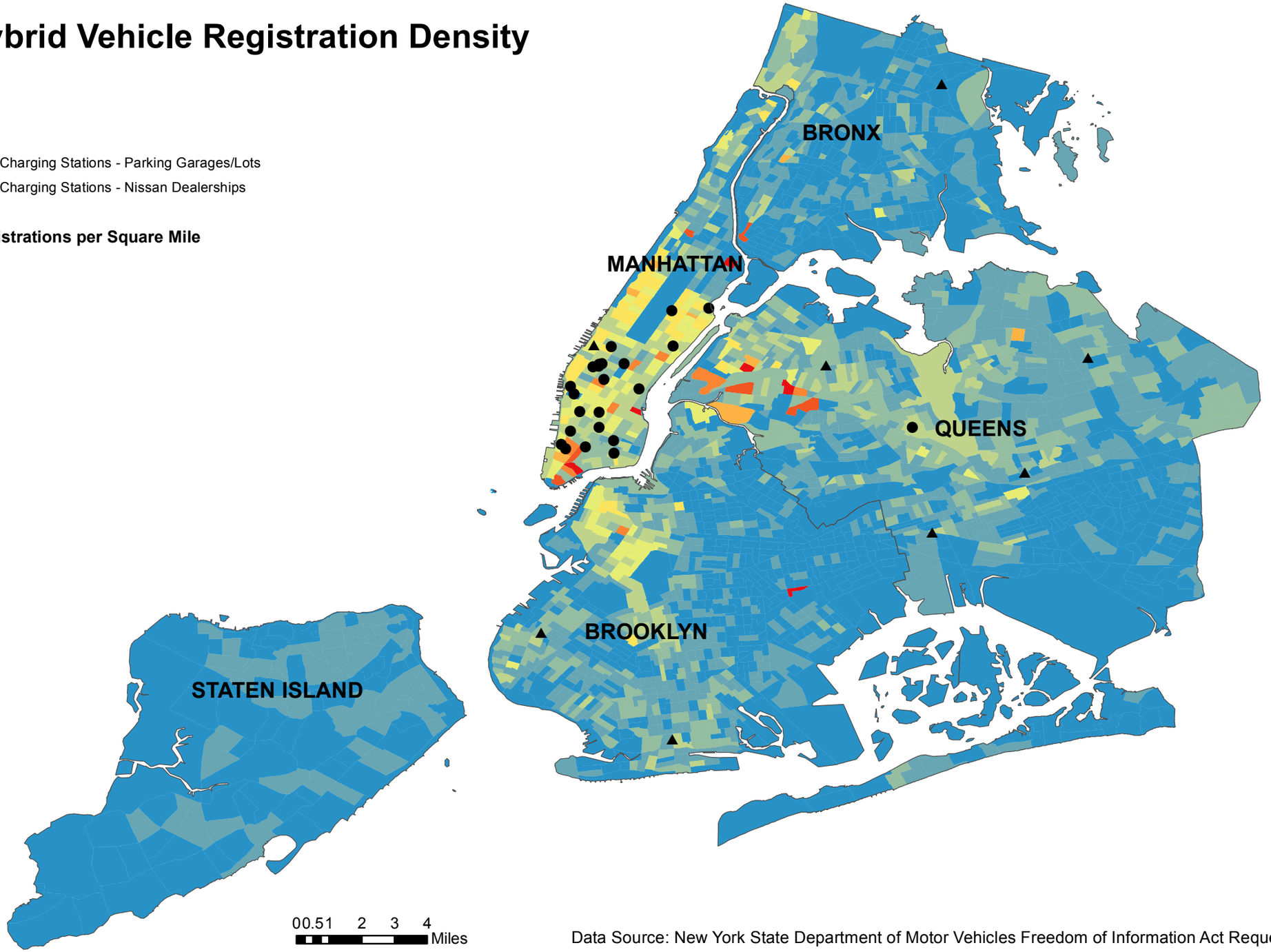
Map 5: Hybrid Vehicle Registration Density

LEGEND

- ● Electric Vehicle Charging Stations - Parking Garages/Lots
- ▲ Electric Vehicle Charging Stations - Nissan Dealerships

Hybrid Vehicle Registrations per Square Mile

- 0 - 33
- 34 - 80
- 81 - 156
- 157 - 277
- 278 - 479
- 480 - 816
- 817 - 1,402
- 1,403 - 2,142
- 2,143 - 3,537
- 3,538 - 8,714



Data Source: New York State Department of Motor Vehicles Freedom of Information Act Request

Appendix 6: Geographically Weighted Regression

The analysis provided in the report makes note that income and education and car availability are closely related to the hybrid ownership data. Hybrid vehicle ownership, as mentioned above in the qualitative analysis, is generally considered a good predictor of future electric vehicle ownership. As an example, London's 2009 "*Turning London Electric*," hypothesized that early adopters of electric vehicles share many characteristics with hybrid owners. In fact, different cities have used current hybrid ownership data to predict areas where there will be higher electric vehicle ownership.

Based on these two assumptions the predictions for the occurrence of electric vehicles in New York City have chiefly relied on income, education, households with 2 or more vehicles and job density. Job density has been dropped from the explanatory variables when computing the statistical analysis because we are focusing on at overnight charging. Manufacturers foresee electric vehicles being charged overnight near the owners' residence. For this reason, the Geographically Weighted Regression was done using income, education and households with 2 or more vehicles as predictors for electric vehicle ownership. This regression is statistically significant and robust, which supports the predictions made in this report's charging infrastructure analysis.

The results of the Geographically Weighted Regression are not comprehensive; as they do not show, with 100% accuracy, that these three explanatory variables alone can explain hybrid vehicle ownership. There could be other variables that could be used to reach even more accurate results The results confirm that these variables (income, education and multiple car ownership) are good predictors for future EV ownership and therefore provide a good estimation where electric vehicles will be located and what there relation is expected to be with respect to the average number of future EVs in the city. By using this regression the number of vehicles can be predicted, see Map 7. It is important to recognize relationship between the predicted numbers rather than their nominal value, as the latter may be influenced by information outside the model, i.e. inflation. The results of the regression analysis indicate hotspots for electric vehicles, where the predicted number of cars is at least 50% higher than the average number of vehicles throughout the city.

Detailed description of the GIS spatial analysis methodology

The statistical tool used for predicting concentration of EV ownership in New York City is the Geographically Weighted Regression of GIS. This regression uses data that reflects aggregated information on census level track. This provides a comparison between the different variables and prevents individual households from being identified. The variables follow those of the qualitative analysis. The dependent variable of the regression is hybrid vehicle ownership. The main assumption here is that hybrid vehicle ownership is a good indicator for future electric vehicle ownership. The same assumption was made in other cities planning for electric vehicles, as the interviews with experts show. The only difference between this quantitative and the previously explained qualitative analysis is that hybrid vehicle ownership data is presented in reflection to census track rather than per square mile for greater accuracy.

Following the assumptions from this report's analysis, the explantory variables for vehicle ownership in this model are median household income, educational attainment and vehicle availability (2 or more cars per housing unit). The explanatory variables are considered on an equal basis, meaning weighted the equally in the regression.

For greater statistical precision outliers were excluded from the analysis. Areas (census tracts) where more than 150 hybrid vehicles are registered are considered outliers, as explained above these areas probably reflect the presence of hybrid fleets (i.e. taxi cabs or other governmental or commercial fleets) rather than personal transportation vehicles. The exclusion of these areas is to ensure that current hybrid fleets do not create bias in the analysis.

The first step of the regression consist an Ordinary Least Squares regression (OLS) that verifies that explanatory relationship between the variables and shows statistical significance. When checking for Spatial Autocorrelation, the results show that "There is less than 1% likelihood that this clustered pattern could be the result of random chance". This means that there is a spatial bias is present in the OLS.

This shows that correct results can be provided only with Geographically Weighted Regression, that encounters with the spatial distribution of data in the dataset describing the model's variables throughout New York City. Running the Geographically Weighted Regression with the GIS software provides the following results:

Table 2: Results of geographically weighted regression

Item	Result
Neighbors	194
Residual Squares	224295.79737646185
Effective Number	151.8720343933817
Sigma	10.464826306011483
AICc	16658.634653650046
R2	0.3328618001864845
R2 Adjusted	0.28371814358024683

Checking for spatial autocorrelation, Global Moran's I analysis has to be run on the standard residuals of the regression results. This shows, that "The pattern is neither clustered nor dispersed". This means that the regression model run has no variable bias, and can be considered a statistically robust model.

Table 3: Spatial Autocorrelation: Global Moran's I summary

Item	Result
Moran's Index	-0.003718
Expected Index	-0.000455
Variance	0.000013
Z Score	-0.912530
p-value	0.361490

Map 7: Predicted Location and Number of Electric Vehicles in New York City

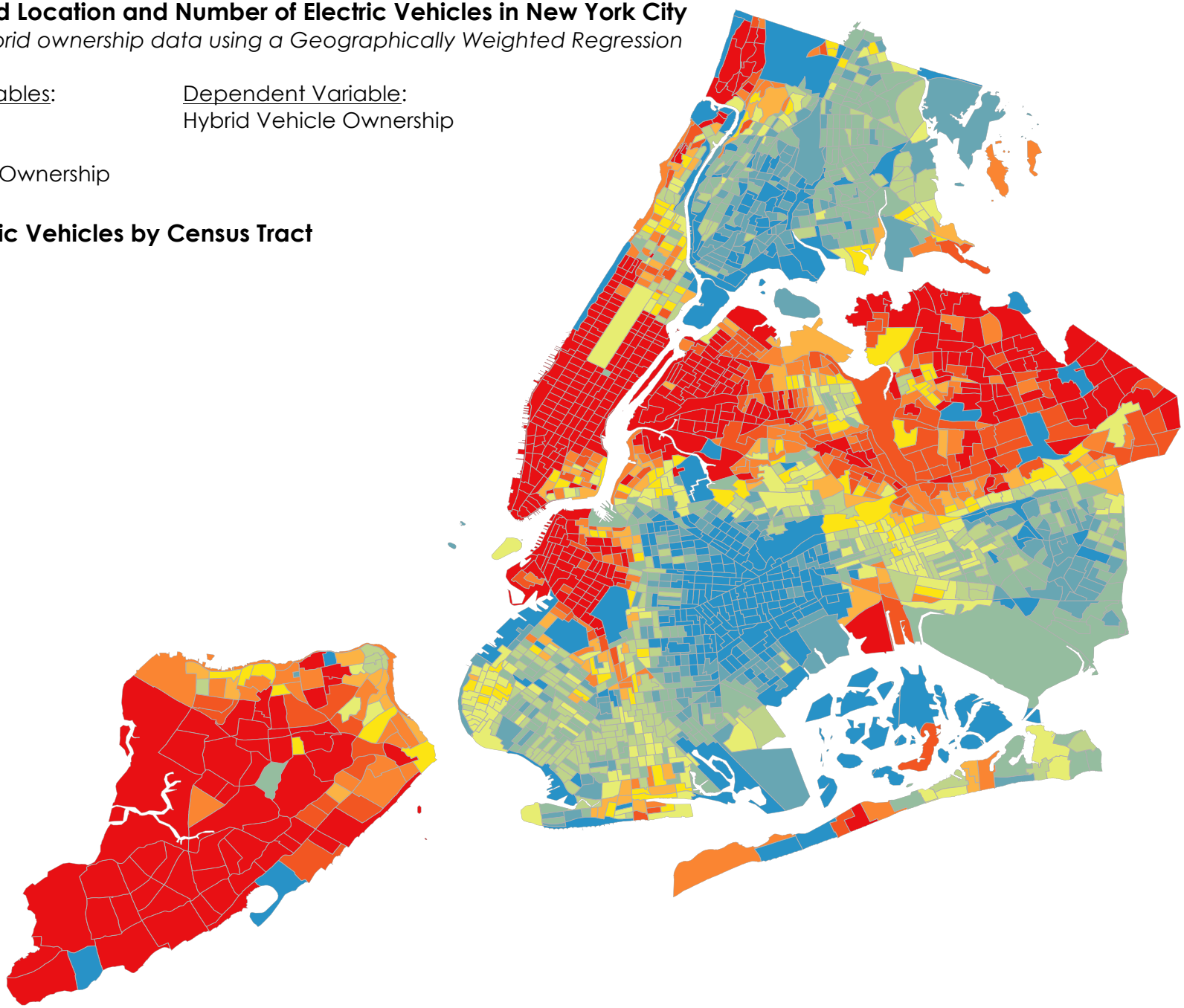
Based on 2010 hybrid ownership data using a Geographically Weighted Regression

Independent Variables:
Income
Education
2 or More Vehicle Ownership

Dependent Variable:
Hybrid Vehicle Ownership

Number of Electric Vehicles by Census Tract

- 0-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- 8-10
- 10-12
- 12 or more



Appendix 7: Current Electric Vehicle Charging Infrastructure

NYC's EV charging infrastructure is still nascent. Current NYC locations of EV charging sites are listed below, in Table 4, and displayed on all spatial analyses maps. With the exception of Nissan dealerships, the charging stations listed are known as "Coulomb Charge Point stations" as they are made by Coulomb Technologies. Each station contains both Level-1 120 volt and Level-2 240 volt charging positions. The listed Nissan dealerships house two Level-2 240 volt AeroVironment chargers.[75] While these chargers become available to Nissan customers, each dealership ultimately determines if non-Nissan EV users will have access. [76]

Several parking garages are accommodating EVs. From midtown to downtown Manhattan, nine garages of Edison Park Fast are equipped with a charging station. Beam Charging LLC installed four charge points in Manhattan and one in Forest Hills (Queens). Car Charging is under an agreement to install charge points in Icon Parking Systems-owned garages.

Apartment developers and managers are also emerging charging infrastructure providers. Glenwood Management provides 5 Manhattan charging locations for its luxury apartments. Seward Park Co-op contains 4 charging locations.

The rental car industry is mobilizing by offering EV rentals and installing the necessary charging infrastructure. Hertz Rent-a-Car plans to add 15 to 20 EVs to its fleet within the year. Additionally, Hertz currently has one charging location in Manhattan.[77]

While all care was taken to ensure that this data is complete and accurate, it is possible for some charging stations to be excluded in the analysis. The data presented here represents the information we consider to be the most easily accessible by the general public.

Table 4: Current Electric Vehicle Charging Stations in NYC

Location Name	Address	Chargers Available
BEAM CHARGING / BEAM NY 0001	300 East 34th St., NY, NY 10016	1x 120v, 1x 240v
BEAM CHARGING / BEAM NY 0002	142 East 31st St., NY, NY 10001	1x 120v, 1x 240v
BEAMCHARGING / BEAM NY 0003	160 West 10th St., NY, NY 10014	1x 120v, 1x 240v
BEAM CHARGING / BEAM NY 0004	21 East 12th St., NY, NY 10003	1x 120v, 1x 240v
BEAM CHARGING / BEAM NY 0005	112-01 Queens Blvd, Forrest Hills, New York, 11375	1x 120v, 1x 240v
BEAM CHARGING / BEAM NY 0006	8 East 83rd St., NY, NY 10028	1x 120v, 1x 240v
CARCHARGING INC / CCNY 00001	350 West 50th St., NY, NY 10019	1x 120v, 1x 240v
CARCHARGING INC / CCNY 00003	398 West 16th St., NY, NY 10011	1x 120v, 1x 240v
CARCHARGING INC / CCNY 00004	376 Greenwich St., NY, NY 10013	1x 120v, 1x 240v
CARCHARGING INC / CCNY 00005	310 West 39th St., NY, NY 10018	1x 120v, 1x 240v
CONNECTBYHERTZ / 327 E 64TH SPO3	327 East 64th St., NY, NY 10065	1x 120v, 1x 240v
EDISONPARKFAST THEATRE DISTRICT	50 West 44th St., NY 10036	2x 120v, 2x 240v
EDISONPARKFAST LOT 12	174 Centre St., NY, NY 10013	1x 120v, 1x 240v
EDISONPARKFAST LOT 250	451 9th Ave., NY, NY 10018	1x 120v, 1x 240v
EDISONPARKFAST LOT 280	260 Spring St., NY, NY 10013	1x 120v, 1x 240v

EDISONPARKFAST LOT 30	167 Essex St., NY, NY 10002	1x 120v, 1x 240v
EDISONPARKFAST LOT 37	375 Lafayette St., NY, NY 10012	1x 120v, 1x 240v
EDISONPARKFAST LOT 4	15 Worth St., New York, NY 10013	1x 120v, 1x 240v
EDISONPARKFAST LOT 89	161 10th Ave., NY, NY 10011	1x 120v, 1x 240v
GLENWOOD MGMT / 37TH ST. 1	326 West 37th St., NY, NY 10018	1x 120v, 1x 240v
GLENWOOD MGMT / EMERALD GREEN	330 West 38th St., NY, NY 10018	3x 120v, 3x 240v
GLENWOOD MGMT / THE BRITTANY 1	1775 York Ave., NY, NY 10128	1x 120v, 1x 240v
SEWARD PARK CO-OP	413 Grand St., NY, NY 10002	4x 120v, 4x 240v
NISSAN OF MANHATTAN	646 Eleventh Ave, NY, NY 10036	2 x 240v
KOEPPEL NISSAN	74 - 15 Northern Bl., Jackson Heights, NY 11372	2 x 240v
TEDDY NISSAN	3660 Boston Road, Bronx, NY 10469	2 x 240v
STAR NISSAN	206-02 Northern Blvd, Bayside, NY 11361	2 x 240v
NEMET MOTORS	153-03 Hillside Ave, Jamaica, NY 11432	2 x 240v
NISSAN OF QUEENS	93-25 Rockaway Blvd, Ozone Park, NY 11416	2 x 240v
KINGS NISSAN	2758 Coney Island Ave, Brooklyn, NY 11235	2 x 240v
BAY RIDGE NISSAN	6501 5th Ave, Brooklyn, NY 11220	2 x 240v

Sources: http://www.mychargepoint.net/find-stations.php, http://beamcharging.com/locations.html, and http://electric.carstations.com

Appendix 8: Traffic Analysis

Electric vehicle adoption poses implications on commuting patterns for New York City and the surrounding metropolitan region. The following traffic analysis provides a brief overview of commuting patterns, and presents approaches to incorporate EVs into the transportation portfolio of the NYC metropolitan region.

According to the New York Metropolitan Transportation Council (NYMTC), the greater NYC area population expects to increase from roughly 12.5 million people in 2010 to 14.4 million by 2035. The corresponding job growth is projected to increase by 1.5 million. As jobs and commuting are interrelated, many employees will travel from outside the five boroughs. Commuting rates from the surrounding areas are likely to increase, as the size of the labor force living within NYC is projected to increase at a slower rate that the supply of jobs (only 800,000 more residents will be present to fill 1.5 million additional jobs). This points not only to increased commuting from the boroughs outside Manhattan, but also a continued reliance on New Jersey, Southwestern Connecticut, Long Island, and various tri-state suburbs to supply workers to firms located within the NYMTC region.[78]
These projected labor and commuter patterns are a great opportunity for EVs in NYC. While public transit can alleviate the potential congestion resulting from the increases in commuter traffic, there is still a role for EVs to play. Many will use an electric vehicle as a 2nd or 3rd car (a "commuter car") to drive the 10-15 miles from home to a mass transit platform on the edge of the City – which will then transport them to their ultimate destination. Others will choose the EV to save money on increasing fuel costs as they make their way into the City.

With this in mind, we chose to look at existing traffic patterns and deduce where commuter destinations begin and end. In doing so, we can determine where initial charging stations should be introduced for maximum effectiveness and efficiency. There are two areas we have chosen to look at: Inter-City commuting (that is, within the five boroughs), and Regional commuting (those drivers who come from outside NYC to work, and then leave NYC once work is completed for the day).

Inter-City Commuting

While midtown and downtown Manhattan will continue to be the top destination for commuters due to its high job density, the City should focus initial charging infrastructure sitting efforts at public garages near large centers of employment in Brooklyn and Queens. When excluding Manhattan traffic, we see from Table 5 that the largest amount of commuters in the outer-boroughs are those travelling from Queens to

Brooklyn. The next highest number of automobile commuters live in Brooklyn and travel to work in Queens.

Table 5: Location of Residence and Location of Work, by Borough

Live	Work	Total # of workers
Queens	Brooklyn	83,722
Brooklyn	Queens	59,711
Staten Island	Brooklyn	28,173
Queens	Bronx	17,479
Bronx	Queens	17,155
Bronx	Brooklyn	16,772
Brooklyn	Bronx	10,813
Brooklyn	Staten Island	8,832
Staten Island	Queens	5,368
Queens	Staten Island	5,002
Bronx	Staten Island	2,049
Staten Island	Bronx	1,028

Source: New York City Department of City Planning Peripheral Travel Study, 2010

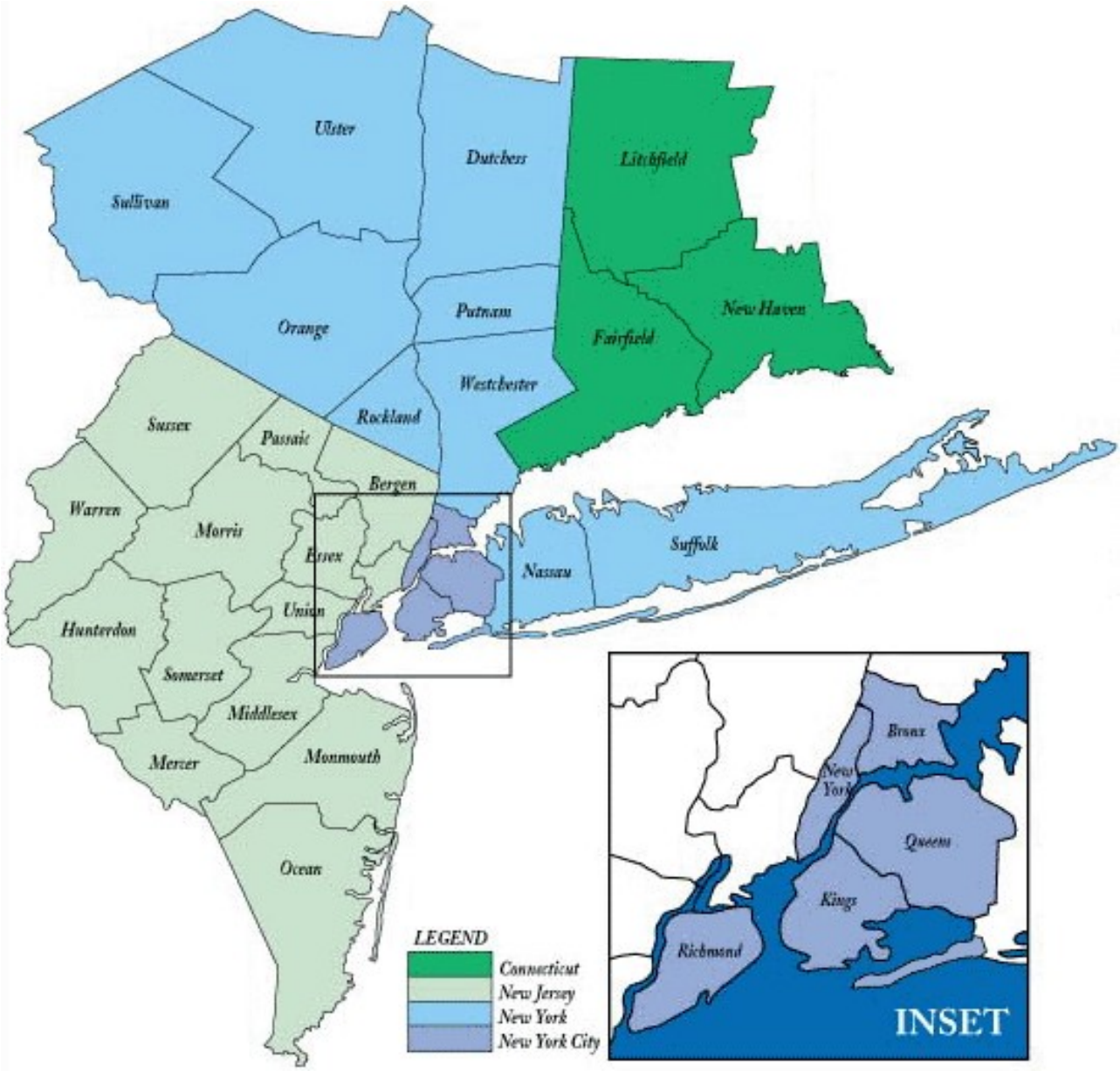
Along with previously known vehicle ownership rates (McKinsey, 2010), this leads to the conclusion that these boroughs (Brooklyn and Queens) should be primary targets for initial public charging infrastructure. A later focus can move to improving charging infrastructure in the Bronx and Staten Island. However, we do note that it appears the prevalence in single-family housing and household garages will lead to more at-home charging in Staten Island, and therefore public charging may not be as necessary as in the other boroughs.

External Commuting

As previously mentioned, the number of auto commuters has declined over the past decade, and this holds true for regional commuters as well. Among regional residents, just over 17 percent of commuters to Manhattan drove in 2000, while in 2007 the share was close to 13 percent. That said, demographic characteristics and optimal driving ranges lead us to believe a portion of this 13 percent of regional commuters will be prime candidates for purchasing and commuting with EVs. As Figure 1

illustrates, the formal NYC metropolitan region incorporates two states and includes 31 counties.

Figure 2: New York Metropolitan Region[79]



While not directly within NYC's purview, we believe the significant influence the City carries as a magnet for residents of the surrounding area can help influence these local governments to begin adoption and implementation of strong EV policies and infrastructure. By increasing re-

gional community acceptance and implementation of charging infrastructure for external commuters, we believe NYC and its EV owners receive a mutual benefit. NYC alleviates much of the congestion and pollution these commuters bring with them to the city, and City EV owners now extend their driving range when travelling throughout the greater metropolitan area.

One significant note we'd like to add, however, involves an on-going study that will prove invaluable to future sitting recommendations. Currently, the New York Metropolitan Transportation Council (NYMTC), the North Jersey Transportation Planning Authority (NJTPA), and their partners in regional transportation planning have begun collaboration and data collection on ***The Regional Travel Survey***.[80] The Regional Travel Survey will collect travel data from households in 28 counties in the tri-state area of New York, New Jersey and Connecticut.

This $4.5 million survey - required and funded by the federal government - will be used to weigh future transportation plans throughout the region, and help the region's transportation planning organizations answer important questions about travel in the region. Through targeted surveying, they are gathering data on how people of the area move around, reasons they travel, and who uses the transportation system today. We believe once this survey is complete (projected by next year – 2012), it will be essential for future EV planners to study the information and identify most likely areas for EV use and 2nd generation charging infrastructure sitting.

Appendix 9: Sample Questionnaire for Parking Facility Representatives

1. How many parking facilities does your company operate in NYC?

2. Approximately how many NYC customers do you serve annually?

3. In which boroughs are your facilities located? How many facilities are in each one? And are there plans to expand to other boroughs?

4. Are you in the process of (or have plans for) installing electric vehicle charging stations in any of your facilities?

If yes, which facilities are/will these installations take place?

a. Please describe how and why you made this decision.

b. What were the greatest obstacles for installing EV chargers in your parking facilities?

c. Are you partnering or thinking about partnering with an EV charging company? If so, which one(s)?

d. How many chargers are you planning to install in your parking facilities by in the next 5 years?

If not, could you please explain what is preventing you from installing an electric vehicle charging station (i.e., need more information, cost, complexity of installation, etc.)?

5. Several electric vehicles can be charged using a standard 110V outlet. Your customers may want to plug into a 110V outlet while parking their electric car at your facilities. Is this something you would be willing to do?

If yes, would you be willing to have your facility/facilities listed as "plug-in electric vehicle friendly" on a public website? If yes, which ones?

6. Have you heard about other companies installing EV chargers in their parking facilities? If so, which companies are they and how did you hear about this?

7. In your opinion, on a scale of 1-10 ("1" meaning this causes revenue loss; "5" meaning no impacts to revenue; "10" meaning it generates revenue) how would you rate the installation of electric vehicle chargers in parking facilities as a business proposition?

8. On a scale of 1-10 ("1" having absolutely no priority, and "10" being the highest priority) how important is the installation of electric vehicle chargers on your company's agenda?

9. In general, what are some questions or concerns you have about electric vehicle charging stations?

Appendix 10: New York City's Home and Public Parking Spots

Table 6: The Number of Home and Public Parking Spots in New York City 2009[81]

Borough	At Home (home garage or assigned lot)	Public (on street or unassigned lot)
Bronx	**44%** (approx. 78,760 parking spots)	**56%** (approx. 100,240 parking spots)
Brooklyn	**42%** (approx. 159,180 parking spots)	**58%** (approx. 219,820 parking spots)
Manhattan	**46%** (approx. 75,900 parking spots)	**54%** (approx. 89,100 parking spots)
Queens	**54%** (approx. 262,440 parking spots)	**46%** (approx. 223,560 parking spots)
Staten Island	**77%** (approx. 98,560 parking spots)	**23%** (approx. 29,440 parking spots)

Appendix 11: Electric Vehicle Cost Model Assumptions

The electric vehicle represented in the model is a standard model 2011 Nissan Leaf, the hybrid vehicle is a 2011 Toyota Prius II and the conventional vehicle is a 2011 standard Toyota Camry. The model has been built to enable comparison of any electric vehicle to any traditional vehicle. We chose these three as representative vehicles. All costs and fuel efficiencies for these vehicles are taken from the manufacturers' websites. We have assumed that Nissan's preferred partner, AeroVironment, will provide the charging unit. We have assumed federal tax credits of $7,500 for vehicle purchase and 50% of the cost of the charging unit (with a maximum of $2000). While we included the ability to add State subsidies or tax credits, we have assumed none in this analysis, as New York State currently does not offer any. Further, assumed that there are no service upgrade requirements or second meter installations. Though we have built the ability to account for these into the model, these costs will depend on each individual home and cannot be attributed generally to all EVs. We have assumed that the fuel efficiency of the electric vehicle is 4.17 miles per kWh (based upon the stated range of 100 miles and a battery capacity of 24 kWh). Finally, annual maintenance and repair costs for the Prius and Camry were determined from a Motor Trend analysis of the 2011 models, while the Leaf estimate is based on an economic study from Project EVIE. The maintenance costs were estimated at $169.50[82], $368.80[83], and $360.00[84], for the Leaf, Prius, and Camry, respectively. The base electricity rate for NYC is 27 cents/kWh as assessed from Con Edison's website in February 2011[85]. The Boston current base rate is 7.718 cents/kWh assessed on NSTAR's website for their residential basic service fixed rate in April 2011[86]. The Philadelphia base rate is 9.999 cents/kWh from PECO for residential service for the second quarter of 2011[87].

Appendix 11: Quick Matrix of Utilities Best Practices

Table 5: Summary of Utilities Best Practices

City / Region	Utility	Ownership	Best Practices	Electric Vehicle Rate Options	Rate Notes
Central, Coastal and Southern CA	Southern California Edison	Investor-Owned	EV Rates, Education & Outreach, Collaboration & Partnerships, Rate Assistance Tool (calculator), Renewable Energy Programs, Smart Grid Programs	**Two Time of Use (TOU) Rates:** TOU-D-TEV - Home & Electric Vehicle Plan - Single Meter (Summer Super off-peak: $0.11953/kWh, Winter Super off-peak $0.12136/kWh) TOU-EV-1 - Electric Vehicle Plan - Separate Meter (Summer Super off-peak: $0.16033/kWh, Winter Super off-peak $0.15948/kWh)	
San Diego, CA	San Diego Gas & Electric	Investor-Owned	EV rates, Education & Outreach, Collaboration & Partnerships, Renewable Energy Programs, Smart Grid Programs, Fleet Demonstration Programs	**Two Time of Use (TOU) Rates:** EV-TOU: Electric Vehicle Plan - Separate Meter (Summer Super off-peak $0.13719/kWh, Winter Super off-peak $0.13969/kWh) EV-TOU-2: Whole Home Plan - Single Meter (Summer Super off-peak $0.13719/kWh, Winter Super off-peak $0.13969/kWh)	Once a customer opts for an EV rate, the customer must stay on that rate for at least twelve consecutive months before changing back to the otherwise applicable tariff or any other optional rate.
San Francisco, CA & Northern CA	Pacific Gas & Electric	Investor-Owned	EV rates, Education & Outreach, Collaboration & Partnerships, Renewable Energy Programs, Smart Grid Programs, Fleet Demonstration Programs	**Experimental Time-of-Use Low Emission Vehicle Rate (E-9)** Option A - Whole Home Option - Single Meter (Summer off-peak $0.05/kWh, Winter off-peak $0.058) Option B - Vehicle Only Option - Separate Meter (Summer off-peak $0.056/kWh, Winter baseline off-peak $0.064)	The E-9 rate is mandatory for customers that are currently on a residential electric rate and who plan on charging an EV at home.
Southeastern MI	DTE Energy (Detroit Edison)	Investor-Owned	EV rates, Education & Outreach, EV Cost Calculator, Financial Incentives, Collaboration & Partnerships, Renewable Energy Programs, Fleet Demonstration Programs, Smart Grid Programs	**Two EV Rate Options:** Option 1: Electric Vehicle Rate (D1.9) - Time of Use - Separate Meter ($0.07695/kWh off-peak) Option 2: Flat-rate of $40 per month (limited to 250 customers/meters)	
Lansing, MI	Lansing Board of Water & Light	Publicly-Owned	EV Rate, Education & Outreach, Collaboration & Partnerships, Financial Incentives, Fleet Demonstrations	**One Option:** Residential Plug-In Electric Vehicle Charging Service 22 - Separate Meter **(**$0.0526/kWh off-peak)	
Los Angeles, CA	Los Angeles Department of Water & Power	Publicly-Owned	EV Rates, Education & Outreach, Collaboration & Partnerships, Fleet Demonstrations, Renewable Energy Programs	**Two EV Rate Options** Option 1: Electric Vehicle Time-of-Use - Separate Meter ($.095/kWh offpeak) Option 2: Whole Home Time-of-Use - Single Meter (500 kWh block receives $0.025 kWh discount off standard rate)	Solar customers with net metering must use Option 1 in order to take advantage of the EV discount.
Sacramento, CA	Sacramento Municipal Utility District	Publicly-Owned	EV Rate, Education & Outreach, Collaboration & Partnerships, Fleet Demonstrations	**Residential Time-of-Use Electric Vehicle (RTEV) Rate** Separate Meter ($0.0754/kWh winter off-peak, $0.084/kWh summer off-peak)	
MI	Consumers Energy	Investor-Owned	EV Rates, Education & Outreach, EV Calculator, Collaboration & Partnerships, Financial Incentives	**Three EV Options:** Option 1 - Residential Home and Plug-in Electric Vehicle Time-of-Day Rate (REV-1) - Single Meter (off-peak $0.06/kWh) Option 2 - Residential Plug-in Electric Vehicle Only Time-of-Day Rate (REV-2) - Separate Meter (off-peak $0.06/kWh) Option 3 - Residential Plug-in Electric Vehicle Only Monthly Rate (REV-3) - Monthly fee for up to 300 kWh - Separate Meter	The REV-3 Rate is limited to 250 customers.
TX	Reliant Energy	Investor-Owned	EV Rate, Education & Outreach, Collaboration & Partnerships,	**One Option:** Reliant EV Owner's Plan (Time-of-Use): Whole Home Option - Single Meter	Developing additional plans and options for EV owners

Appendix 13:
Utility Case Study: Michigan

In our search for best practices for New York City benchmark, through interviews with two Michigan electric utilities have created an EV rate through, we were able to learn how through collaboration with the Michigan Public Service Commission (MPSC), an EV rate has been created and implemented. The Lansing Board of Water & Light, a publicly owned utility, is currently working on the implementation of sponsoring a DOE funded program-funded by the DOE which has providing allocated for 27 EV customers a matching rebate of $7,500 incentive, matching the federal rebate. This provides funds for the purchase of two free charging stations per car, at the owner's home and workplace. The charging unit is installed on a separately metered circuit, allowing the EV to recharge using the lower rates offered by the utility. The Lansing Board of Water & Light launched the EV rate on March 1, 2011. This rate is a separate TOU rate designed specifically for the separate EV meter. The Board, not the MPSC, oversaw the process of creating an EV rate.[88]

DTE, another utility in Michigan utility, DTE has also recently created an EV rate. The EV rate is distinct from the broadly offered TOU rate and was created through a collaborative process with the MPSC. The rate offered by DTE is $0.08/kWh, about half the normal standard flat rate. After purchasing an EV, the owner simply contacts DTE and within 2-3 days, DTE will which coordinates the permitting and installation of a charger in the owner's home within two to three days. DTE also offers a financial incentive of $2,500 for the EV owner to offset the upfront purchase of the charger.[89]

Appendix 14:
Infrastructure Case Study: Seattle

In 2009, the City of Seattle developed a plan to introduce first-generation charging infrastructure throughout the city. Known as 'The Plug-In Project', the effort was coordinated by the City's Office of Sustainability and Environment, working with staff from Seattle City Light, Seattle Department of Transportation, Department of Planning and Development, Fleets and Facilities Department, and the Mayor's Office."[90] As a partner in The EV Project – a "$230 million public-private initiative funded with a $114.8 million grant from the U.S. Department of Energy,"[91] Seattle received financing and construction assistance to help facilitate the process.

Seattle analyzed current and projected traffic patterns from the Puget Sound Regional Council (PSRC), regional commuting corridors, locations of existing hybrid owners, and various related demographics to determine the ideal sitting locations for first generation public EV chargers. While the predominance of EV drivers in Seattle are likely to charge at single-family homes with an attached private garage, the city has opted to expand the locations of public chargers to local hotels, restaurants, sports venues, government buildings, tourist destinations, libraries, and similarly visible locations. Most of these first generation chargers have been placed at their current locations based on request from the private business owners and concurrence from charging network companies (Coulomb Technologies, etc). The city's primary role has been to identify potential problems and streamline existing laws, ordinances, or procedures that would discourage EV purchasing and use. They have also helped facilitate private investment through the sharing of public data analysis that help vested parties best plan where to install and maintain charging units. In doing so, Seattle has become a recognized leader in city-level EV policy and is well prepared to meet the increased demand for electric vehicles throughout the region.

Glossary

charging station: a public location with installed EVSE for plug-in electric vehicle recharging; most commonly uses Level 2 EVSE (see "Level 2 charging" and "electric vehicle supply equipment").

conventional gas vehicle: vehicle driven by an internal combustion engine powered by gasoline or diesel fuel.

dual channel smart meter: electricity billing meter capable of tracking two different levels of electricity usage at two different price rates.

early adopters: consumers purchasing new products or technology very early in its availability, willing to pay higher costs to have the product before it enters the mainstream market.

electric vehicle (EV): vehicle powered 100% by electricity, driven by an electric motor with electricity stored in rechargeable batteries (aka "plug-in" or "battery electric vehicle").

electric vehicle supply equipment (EVSE): electric appliance used to recharge plug-in electric or hybrid electric vehicles.

global climate change: changes in global weather patterns caused by increasing global temperatures as greenhouse gas emissions from energy production accumulate in the atmosphere (aka "global warming"; see "greenhouse gas" and "carbon dioxide").

greenhouse gas (GHG): gas which traps outgoing solar radiation in the atmosphere causing global temperature to rise (see "global climate change")

hybrid electric vehicle (HEV): vehicle powered partially by electricity; an electric motor and battery pack are used for low speed driving with a gasoline powered internal combustion engine for high speed driving (aka "hybrid").

kilowatt-hour (kWh): standard billing unit for electricity suppliers (see "utility")

Level 1 charging: plug-in electric vehicle recharging method using 120 volt AC electricity; the most simple and slowest charging method.

Level 2 charging: plug-in electric vehicle recharging method using 240 volt AC electricity; faster recharging method than Level 1, requires installed EVSE (see "charging station").

Level 3 charging: plug-in electric vehicle recharging method using 300 volt or higher DC electricity; fastest recharging method, requires installed EVSE (see "charging station").

off-peak: the time of day when electricity demand and costs are lowest; typically during the evening.

on-peak: the time of day when electricity demand and costs are highest; typically during the afternoon.

PlaNYC: a long-term sustainability plan for New York City instituted by Mayor Michael Bloomberg in 2006.

plug-in: an electric vehicle which recharges its batteries by taking electricity from the local electric grid (see "electric vehicles" and "plug-in hybrids").

plug-in hybrid electric vehicle (PHEV): vehicle powered partially by electricity; an electric motor drives the vehicle with electricity stored in rechargeable batteries with the option to recharge with electricity or with an onboard gasoline powered generator (aka "plug-in hybrid" or "range extender").

renewable energy: electricity generated from a naturally occurring resource and produces no direct emissions (wind, solar, tidal, geothermal).

smart-grid: electricity delivery technology designed to supply electricity to specific places on the grid in order to regulate on-peak demand loads.

time of use (TOU): electricity price structure which charges a reduced cost for off-peak electricity use and an increased cost for on-peak electricity use (see "on-peak" and "off-peak").

utility: an organization which delivers a public service, such as electricity.

wells-to-wheels emissions: a lifecycle analysis of vehicle emissions from fuel extraction to on-road emissions; for electric vehicles, includes the extraction of the electric fuel (coal, natural gas, nuclear) and the emissions produced by generating electricity used to recharge.

Image Sources

Cover Page:
Traffic Photograph. Web. 19 Apr. 2011.
<http://timenewsfeed.files.wordpress.com/2010/06/42-20216645.jpg%3Fw%3D455>.

Leaf Charger Photograph. Web. 19 Apr. 2011.
<http://www.cardotcom.com/photos/cars01/2011-nissan-leaf/nissan-leaf-11.jpg>.

Northeast Photograph. Web. 19 Apr. 2011.
<http://eoimages.gsfc.nasa.gov/ve/4864/NortheastUS.A2002251.1550.250m.jpg>.

Utilities Photograph. Web. 19 Apr. 2011.
<http://photogeek23.files.wordpress.com/2009/12/img_1235.jpg>.

EV Plug Photograph. Web. 19 Apr. 2011.
<http://myecoproject.org/wp-content/uploads/2010/11/plug-in+electric+vehicle.jpg>.

Coulomb Photograph. Web. 19 Apr. 2011.
<http://www.goodcleantech.com/2010/07/coulomb_technologies_to_instal.php>.

Mayor Photograph. Web. 19 Apr. 2011.
<http://articles.nydailynews.com/2010-07-15/local/27069979_1_electric-cars-electric-vehicles-lot>.

Chevrolet Volt Photograph. Web. 19 Apr. 2011.
<http://gm-volt.com/wp-content/uploads/2011/03/VoltUnpluggedNY01.jpg>.

New York Satellite Image. Web 24 Apr. 2011.
<http://earthobservatory.nasa.gov/images/imagerecords/3000/3678/aster_newyorkcity_lrg.jpg>

Works Cited

[1] *New York City's Green Dividend*. Rep. CEOs for Cities, Apr. 2010. Web. 25 Feb. 2011. <www.nyc.gov/html/dot/downloads/pdf/nyc_greendividend_april2010.pdf>.
[2] NYC Mayor's Office. PlaNYC. *Exploring Electric Vehicle Adoption in New York City*. New York: City of New York, 2010.
[3] Ibid.
[4] Ibid.
[5] "Electric Vehicles." *Fuel Economy*. US Department of Energy. Web. 16 Apr. 2011. <http://www.fueleconomy.gov/feg/evtech.shtml>.
[6] NYC Mayor's Office. PlaNYC. *Exploring Electric Vehicle Adoption in New York City*. New York: City of New York, 2010.
[7] Ibid.
[8] Ibid.
[9] Ibid.
[10] Ibid.
[11] United States. Department of Energy. Energy Information Administration. "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State." 14 Feb 2011. Web. 24 Feb. 2011. < http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html>
[12] "Con Edison - Appliance Calculators." *ConEd.com*. Con Edison of New York, Inc., Web. 21 Feb. 2011. <http://www.coned.com/customercentral/calculators/EC_res_Appliance_Calculator.html>.
[13] Greater London Authority. "London's Electric Vehicle Infrastructure Strategy." *Draft Electric Vehicle Infrastructure Strategy*. Greater London Authority, Dec. 2009. Web. 7 Mar. 2011. <http://static.london.gov.uk/electricvehicles/charging/>.
[14] Puget Sound Regional Council. "Electric Vehicle Infrastructure: Regional Station Siting Analysis." Puget Sound Regional Council, July 2010. Web. 8 Mar. 2011. <http://www.psrc.org/assets/4144/Station_siting_July2010.pdf>.
[15] Rorke, Justin, and Christina Inbakaran. *Potential Early Adopters of Electric Vehicles in Victoria*. Rep. Victoria Department of Transport, 2009. Web. 4 Mar. 2011. <www.patrec.org/web_docs/atrf/papers/2009/1755_paper143-Rorke.pdf>.
[16] Coulomb Technologies. *Coulomb Technologies Unveils ChargePoint Network Electric Vehicle Charging Stations in New York City*. Web. Coulomb Technologies, 2010. Web. 15 April 2011. <http://www.businesswire.ca/portal/site/ca-fr/permalink/?ndmViewId=news_view&newsId=20100714005555&newsLang=en>
[17] "How the Smart Grid Enables Utilities to Integrate Electric Vehicles." Silver Spring Networks. 2010. Web. 23 Mar 2011. Pg 10. <http://www.silverspringnet.com/pdfs/SilverSpring-Whitepaper-ElectricVehicles.pdf>
[18] "Plug-In Electric Vehicle Rates." DTE Energy. Web. 13 Mar 2011. <http://www.dteenergy.com/residentialCustomers/productsPrograms/electricVehicles/pevRates.html>
[19] "Plug-in Electric Vehicles Incentive Program." Consumers Energy. Web. 13 Mar 2011. < http://www.consumersenergy.com/content.aspx?id=3368>
[20] "Choose Green Power." ConEdison Solutions. Web. 29 Mar 2011.<http://www.conedsolutions.com/residential_green_power.html >
[21] "Duke Energy and PEVs." Duke Energy. Web. 26 Mar 2011. < http://www.duke-energy.com/plugin/pev-duke-and-evs.asp>
[22] "Electric Transportation." Progress Energy. Web. 26 Mar 2011. < http://progress-energy.com/environment/ras/hybrids.asp>

[23] Ibid.
[24] "How the Smart Grid Enables Utilities to Integrate Electric Vehicles." Silver Spring Networks. 2010. Web. 23 Mar 2011. Pg 14. <http://www.silverspringnet.com/pdfs/SilverSpring-Whitepaper-ElectricVehicles.pdf>
[25]Ibid.
[26] Ibid.
[27] Ibid.
[28] Stosser, Michael A. and Bobenski, Andew L. "What Will Fuel the Coming Electric Fleet?" The National Law Journal. 14 Feb 2011. Web. 6 Mar 2011. <http://www.law.com/jsp/nlj/PubArticleNLJ.jsp?id=1202481534912&What_will_fuel_the_coming_electric_fleet&slreturn=1&hbxlogin=1>
[29] "Nissan Leaf: Packages and Features." Nissan USA. Web. Mar 1 2011. <http://www.nissanusa.com/leaf-electric-car/feature/pricing_information>
[30] "Nissan Delivers Affordable Solutions for Purchase, Lease of All-electric Nissan LEAF." AeroVironment, Inc. Mar 30 2010. Web. Mar 1 2011. <http://investor.avinc.com/releasedetail.cfm?releaseid=455628 >
[31] "Toyota Prius." Toyota. Web. Mar 1 2011. <http://www.toyota.com/prius-hybrid/>
[32] "Toyota Camry." Toyota. Web. Mar 1 2011. <http://www.toyota.com/camry/>
[33] "Review Ideas: NYC Simplicity." The City of New York. 2011. Web. 13 Apr 2011. <http://www.nyc.gov/html/simplicity/html/ideas/review.shtml>
[34] "Fleet". The City of New York. Department of Citywide Administrative Services. Division of Energy Management. 2011. Web. 13 Apr 2011. <http://www.nyc.gov/html/dem/html/conservation/fleet.shtml>
[35] *Metropolitan Area Planning Council Promoting Smart Growth and Regional Collaboration*. Web. 20 Apr. 2011. <http://www.mapc.org/>.
[36] Bloch, Matthew, *Mapping America: Every City, Every Block*. The New York Times (2009).
[37] *Boston Redevelopment Authority*. Web. 20 Apr. 2011. <http://www.bostonredevelopmentauthority.org/Home.aspx>.

[39] *2010 Census*. Web. 20 Apr. 2011. <http://2010.census.gov/2010census/>.
[40] Bloch, Matthew, *Mapping America: Every City, Every Block*. The New York Times (2009).
[41] "Remarks by the President in State of Union Address." *The White House*. 25 Jan. 2011. Web. 20 Feb. 2011. <http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address>.
[42] One Million Electric Vehicles By 2015." *Analysis Shows Significant Advances in Electric Vehicle Deployment*. U.S. Department of Energy, 8 Feb. 2011. Web. 15 Feb. 2011. <http://www.energy.gov/media/1_Million_Electric_Vehicle_Report_Final.pdf>.
[43] Ibid.
[44] "Plug-in Electric Vehicle Credit (IRC 30 and IRC 30D)." IRS, 3 Jun. 2010. Web. 26 Feb. 2011. < http://www.irs.gov/businesses/article/0,,id=214841,00.html>.
[45] One Million Electric Vehicles By 2015." *Analysis Shows Significant Advances in Electric Vehicle Deployment*. U.S. Department of Energy, 8 Feb. 2011. Web. 15 Feb. 2011. <http://www.energy.gov/media/1_Million_Electric_Vehicle_Report_Final.pdf>.
[46] Schwartz, Ariel. "EV Early Adopters: Hybrid-Heavy Cities to Lead the Way | Fast Company." *FastCompany.com*. 15 Feb. 2011. Web. 21 Feb. 2011. <http://www.fastcompany.com/1727892/new-york-los-angeles-to-lead-electric-vehicle-adoption>.
[47] "New York's Clean Pass Program." New York State Department of Transportation, 24 Nov. 2010. Web. 15 Feb. 2011. <https://www.nysdot.gov/programs/clean-pass>.

[48] "FORD AND N.Y. POWER AUTHORITY TEAM UP TO PREPARE NEW YORK FOR ELECTRIC VEHICLES." Ford Motor Company, 5 Oct. 2010. Web. 15 Feb. 2011. <http://media.ford.com/article_display.cfm?article_id=33354>.
[49] "Alternative-Fuel Vehicle Program." NYSERDA, 26 Feb. 2011. Web. 26 Feb. 2011. <http://www.nyserda.org/programs/transportation/afv.asp>.
[50] *Edison Properties, LLC*. Web. 21 Feb. 2011. <http://www.edisonproperties.com/>.
[51] "We're Giving the Electric Cars in NYC a Jolt!" *Manhattan Mini-Storage*. 18 Feb. 2011. Web. 21 Feb. 2011. <http://blog.manhattanministorage.com/electric-cars-nyc/>.
[52] Greater London Authority. "London's Electric Vehicle Infrastructure Strategy." *Draft Electric Vehicle Infrastructure Strategy*. Greater London Authority, Dec. 2009. Web. 7 Mar. 2011. <http://static.london.gov.uk/electricvehicles/charging/>.
[53] Puget Sound Regional Council. "Electric Vehicle Infrastructure: Regional Station Siting Analysis." Puget Sound Regional Council, July 2010. Web. 8 Mar. 2011. <http://www.psrc.org/assets/4144/Station_siting_July2010.pdf>.
[54] Greater London Authority. "London's Electric Vehicle Infrastructure Strategy." *Draft Electric Vehicle Infrastructure Strategy*. Greater London Authority, Dec. 2009. Web. 7 Mar. 2011. <http://static.london.gov.uk/electricvehicles/charging/>.
[55] Puget Sound Regional Council. "Electric Vehicle Infrastructure: Regional Station Siting Analysis." Puget Sound Regional Council, July 2010. Web. 8 Mar. 2011. <http://www.psrc.org/assets/4144/Station_siting_July2010.pdf>.
[56] Rorke, Justin, and Christina Inbakaran. *Potential Early Adopters of Electric Vehicles in Victoria*. Rep. Victoria Department of Transport, 2009. Web. 4 Mar. 2011. <www.patrec.org/web_docs/atrf/papers/2009/1755_paper143-Rorke.pdf>.
[57] Ibid.
[58] Greater London Authority. "London's Electric Vehicle Infrastructure Strategy." *Draft Electric Vehicle Infrastructure Strategy*. Greater London Authority, Dec. 2009. Web. 7 Mar. 2011. <http://static.london.gov.uk/electricvehicles/charging/>.
[59] Ibid.
[60] Puget Sound Regional Council. "Electric Vehicle Infrastructure: Regional Station Siting Analysis." Puget Sound Regional Council, July 2010. Web. 8 Mar. 2011. <http://www.psrc.org/assets/4144/Station_siting_July2010.pdf>.
[61] Greater London Authority. "London's Electric Vehicle Infrastructure Strategy." *Draft Electric Vehicle Infrastructure Strategy*. Greater London Authority, Dec. 2009. Web. 7 Mar. 2011. <http://static.london.gov.uk/electricvehicles/charging/>.
[62] Puget Sound Regional Council. "Electric Vehicle Infrastructure: Regional Station Siting Analysis." Puget Sound Regional Council, July 2010. Web. 8 Mar. 2011. <http://www.psrc.org/assets/4144/Station_siting_July2010.pdf>.
[63] Rorke, Justin, and Christina Inbakaran. *Potential Early Adopters of Electric Vehicles in Victoria*. Rep. Victoria Department of Transport, 2009. Web. 4 Mar. 2011. <www.patrec.org/web_docs/atrf/papers/2009/1755_paper143-Rorke.pdf>.
[64] "GIS Working Group Home Page." *Columbia University GIS Working Group Home Page*. Columbia University, 2011. Web. 14 Mar. 2011. <http://www.gis.columbia.edu/>.
[65] ChargePoint America is a Coulomb Technologies Inc. sponsored program; (http://www.mychargepoint.net/),
[66] "Beam Locations." *Beam Charging*. 2011. Web. 14 Mar. 2011. <http://www.beamcharging.com/beam-locations.html>.
[67] "Electric Vehicle Charger Finder Map." *Electric Car Stations*. 2011. Web. 12 Mar. 2011. <http://electric.carstations.com/>.
[68] "Create Maps." Batchgeo, 2011. Web. 16 Mar. 2011. <http://batchgeo.com/>.
[69] "American Community Survey." *American FactFinder*. U.S. Census Bureau, 2011. Web. 14 Mar. 2011. <http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS>.

[70] Ibid.
[71] "OnTheMap." *OnTheMap*. U.S.Census Bureau Center for Economic Studies, 2011. Web. 12 Mar. 2011. <http://lehdmap.did.census.gov/>.
[72] "American Community Survey." *American FactFinder*. U.S. Census Bureau, 2011. Web. 14 Mar. 2011. <http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS>.
[73] "Freedom of Information Act (FOIA) Home Page." Federal Communications Commission, 2011. Web. 15 Mar. 2011. <http://www.fcc.gov/foia/>.
[74] "Create Maps." Batchgeo, 2011. Web. 16 Mar. 2011. <http://batchgeo.com/>.
[75] Nissan North America. "Nissan Dealers Install First Charging Stations for All-Electric Nissan" *P.R. Newswire*. United Business Media, 1 Nov. 2010. Web. 16 Mar. 2011. <http://www.prnewswire.com/news-releases/nissan-dealers-install-first-charging-stations-for-all-electric-nissan-leaf-106451463.html>.
[76] "Electric Cars." *Nissan*. Nissan USA, 2011. Web. 15 Mar. 2011. <http://www.nissanusa.com/leaf-electric-car-electric/index#/leaf-electric-car/index>.
[77] "Hertz Announces Electric Car Rentals : NPR." *NPR : National Public Radio : News & Analysis, World, US, Music & Arts : NPR*. Web. 16 Apr. 2011. <http://www.npr.org/2010/12/16/132101176/Hertz-Announces-Electric-Car-Rentals>.
[78] New York Metropolitan Transportation Council. *Planning in Times of Uncertainty, Annual Report*. Rep. New York Metropolitan Transportation Council, 2011. Web. 7 April 2011. < < http://www.nymtc.org/mainpage/2011_AnnualMeeting/ar2011_final.pdf >
[79]*Metroeast Climate*. Digital image. *CIESIN*. Columbia University. Web. 17 Feb. 2011. <http://metroeast_climate.ciesin.columbia.edu/images/mec_map.gif>.
[80] "*Regional Travel Survey*." New York Metropolitan Transportation Council. Web. 7 April 2011. < http://www.regionaltravelsurvey.org/welcome.aspx >
[81] NYC Mayor's Office. PlaNYC. *Exploring Electric Vehicle Adoption in New York City*. New York: City of New York, 2010.
[82] "Microeconomics of Electric Vehicles." 2010. Project EVIE. Web. Mar 1 2011. <http://www.project-evie.org/microeconomics.html>
[83] "2011 Toyota Prius Base Hatchback: Ownership Costs." Motor Trend. Web. Mar 1 2011. <http://www.motortrend.com/cars/2011/toyota/prius/base_hatchback/324/cost_of_ownership/index.html>
[84] "2011 Toyota Camry Base Sedan: Ownership Costs." Motor Trend. Web. Mar 1 2011. <http://www.motortrend.com/cars/2011/toyota/camry/base_sedan/341/cost_of_ownership/index.html>
[85] "Con Edison - Appliance Calculators." Con Edison of New York, Inc., Web. 21 Feb. 2011<http://www.coned.com/customercentral/calculators/EC_res_Appliance_Calculator.html>
[86] "Rates & Tariffs: Basic Service." *Nstaronline.com*. NSTAR. Web. 5 Apr. 2011 <http://www.nstar.com/residential/rates_tariffs/basic_service.asp>
[87] "Shop for Your Home." PApowerswitch.com. Pennsylvania Public Utility Commission. Web. 5 Apr. 2011. <http://www.papowerswitch.com/shop-for-electricity/>
[88] Malcoun, Joseph. Telephone interview. 15 Mar. 2011.
[89] Christensen, Kellee. Telephone interview. 14 Mar. 2011.
[90] "Getting Seattle Plug-In Ready." *Seattle.gov Home Page*. Web. 19 Feb. 2011 <http://www.seattle.gov/environment/EV-ready.htm>
[91] "ECOtality Issues EV Blueprints for Washington." *ECOtality.com*. Web. 19 Feb. 2011. <http://www.ecotality.com/pressreleases/10262010_Washington_EV_Infrastructure.pdf>