Curb Enthusiasm:

Report for On-Street Electric Vehicle Charging

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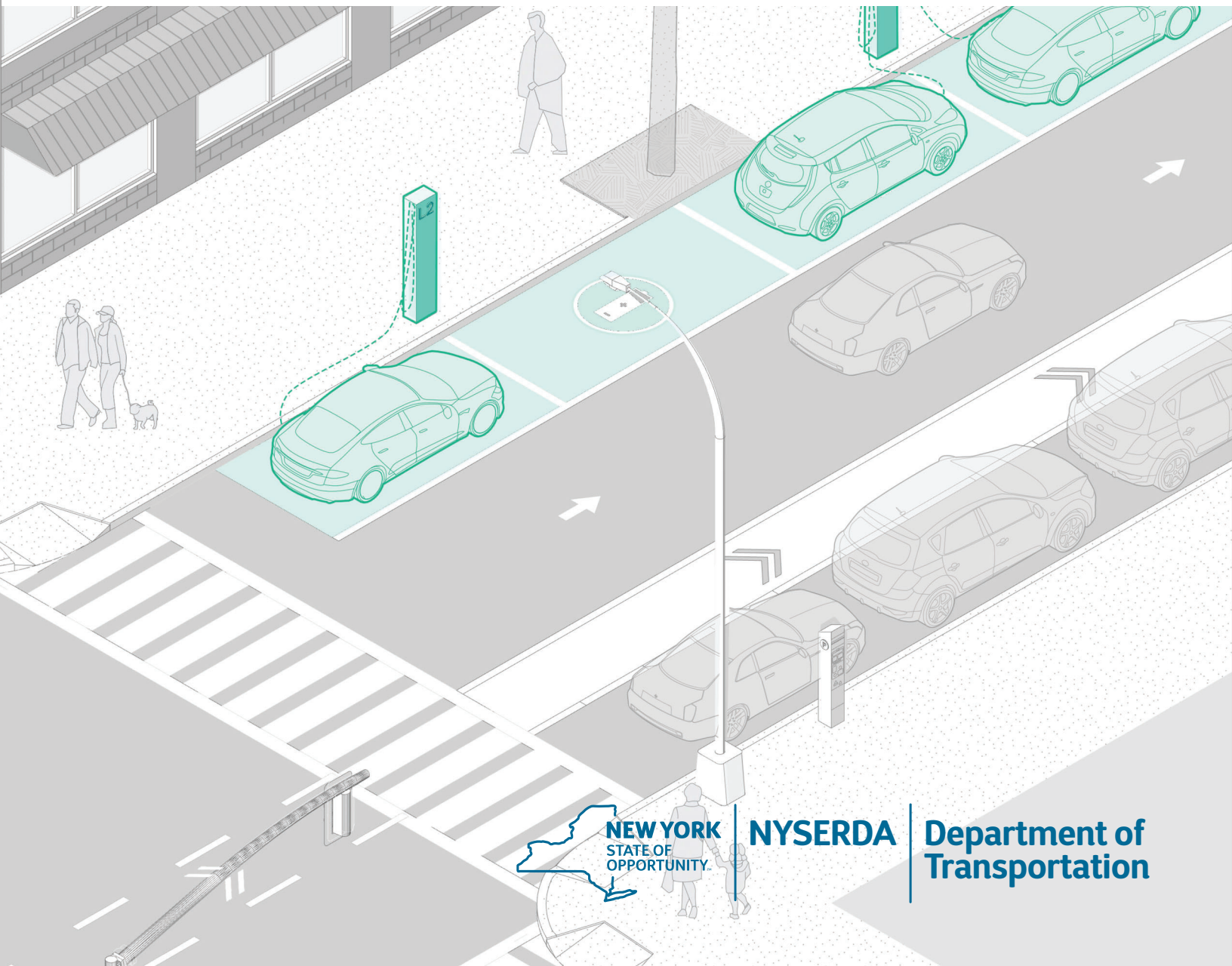

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Curb Enthusiasm: Report for On-Street Electric Vehicle Charging

Final Report

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Abstract

A critical barrier to the successful large-scale adoption of battery electric vehicles in metropolitan areas is the availability of public access charging infrastructure. Charging electric vehicles in areas with limited off-street parking, where charging equipment is typically installed, becomes a perceptual and logistical barrier for prospective electric vehicle drivers who primarily park on-street. The targeted deployment of curbside Level 2 charging stations is one of the most cost-effective and catalytic ways that local government can support a shift toward electric vehicles in cities.

Through original research, analysis, and case studies, this report seeks to define the potential for curbside Level 2 charging station implementation in New York City and to establish guidelines to ensure success. The report and its accompanying guidebook are intended to be a resource for New York City agencies as well as local governments looking to pilot curbside charging as the first step in a broader strategy to build an electric vehicle ecosystem. Visit: http://wxystudio.com/projects/urban_design/curb_enthusiasm_deployment_guide_for_onstreet_electric_vehicle_charging for the guidebook Curb Enthusiasm: Deployment Guide for On-Street Electric Vehicle Charging.

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Acronyms and Abbreviations

ACS	American Community Survey
BEV	battery-electric vehicle
CO_2	carbon dioxide
CTTP	Census Transportation Planning Products
EV	electric vehicle
EVSE	electric vehicle supply equipment
ft.	feet
GHG	greenhouse gas
ICE	internal combustion engine
PEV	plug-in electric vehicle
PHEV	plug-in hybrid electric vehicle
RFID	Radio-Frequency Identification Cards
RFP	request for proposals
sq. ft.	square foot, square feet
VMT	vehicle miles traveled
ZEV	zero emission vehicle

Agencies and Entities

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
BID	Business Improvement District
CAPA	City Administrative Procedure Act
Con Edison	Consolidated Edison
DCAS	Department of Citywide Administrative Services
DOF	New York City Department of Finance
DPW	Department of Public Works
DSNY	Department of Sanitation of the City of New York
eds and meds	education and medical institutions
EVAC	Electric Vehicle Advisory Committee
EVCROW	Seattle Electric Vehicle Charging in the Right-of-way
FDNY	New York City Fire Department
GM	General Motors
IDPW	Indianapolis Department of Public Works
MTA	Metropolitan Transportation Authority
LADOT	Los Angeles Department of Transportation
LADWP	Los Angeles Department of Water and Power
NEC	National Electric Code

NYCDCA	New York City Department of Consumer Affairs
NYCDCP	New York City Department of City Planning
NYCDEP	New York City Department of Environmental Protection
NYCDOB	New York City Department of Buildings
NYCDOE	New York City Department of Education
NYCDOT	New York City Department of Transportation
NYC Parks	New York City Department of Parks and Recreation
NYCMOS	New York City Mayor's Office of Sustainability
NYPA	New York Power Authority
NYPD	New York City Police Department
NYSDOT	New York State Department of Transportation
ODOT	Ohio Department of Transportation
PDC	New York City Public Design Commission
PSL	Public Service Law
SAE	Society of Automotive Engineers
SCL	Seattle City Light
SDOT	Seattle Department of Transportation
TfL	Transport for London

Key Terms

1. **Level 1:** A basic charge standard (120 volts) that provides a slow charge of 2–5 miles of electric range per hour. Slow charge limits this charger's application to uses with long charge times.
2. **Level 2:** A more powerful electrical current (208 or 240 volts) that can charge 10–20 miles of range per hour. The faster charge rate and affordability of hardware and installation make Level 2 a viable option for all settings, including, curbside, commercial and public access.
3. **DC Fast Charging Stations:** The highest and most powerful widely available charge option (480 volts) can provide an 80% recharger for most vehicles in 30 minutes or less. DC Fast Charging Stations are well-suited for public, commercial and fleet settings. However, high hardware and installation costs will limit curbside deployments.
4. **Cohort:** A collection of people who share an experience or characteristic over time. For the purposes of this study, cohort is used to describe people who share a workplace or a vocation (e.g. healthcare workers, municipal employees).

Executive Summary

A critical barrier to the successful, large-scale adoption of plug-in electric vehicles (PEV) in metropolitan areas is the availability of accessible public charging infrastructure. The targeted deployment of on-street electric vehicle supply equipment (EVSE) offers one pathway forward for space constrained urban areas seeking to encourage electric-drive transportation.

With mounting public and private sector support for clean transportation alternatives, there has never been a more opportune time to develop a comprehensive electric vehicle (EV) charging ecosystem in New York City. Building out a robust curbside charging network could meaningfully advance the City's efforts to achieve an EV registration benchmark of 20% for all new car registrations by the year 2025.[1] This goal has been established in two guiding policy documents: The Mayor's Office 1.5° Climate Action Plan and the New York City Department of Transportation (NYCDOT) Strategic Plan, which also champions sustainable mode share and congestion mitigation.

Since private passenger vehicles alone are responsible for roughly 90% of NYC's transportation-related greenhouse gas (GHG) emissions, even a small increase in EV adoption can create significant benefit. As a guiding principle, this study assumes that policymakers should seek out opportunities to replace passenger internal combustion engine (ICE)[2] miles driven with EV miles, while also prioritizing a broader shift toward public transit, biking, and walking. Further, any new EV infrastructure program should be in alignment with a strategy to reduce the number of cars on the road and overall vehicle miles traveled (VMT) in the City. Such a strategy will relieve congestion, reduce GHG emissions, and set NYC on track to reach an 80% sustainable mode share by 2050.[3]

To this end, Mayor de Blasio recently committed to invest $10 million in fast-charging stations citywide, with plans for 50 stations citywide by 2020. Governor Andrew M. Cuomo has also announced a $250 million initiative to expand electric vehicle supply equipment (EVSE) statewide.

Leading the charge from the private sector, Consolidated Edison (Con Edison), NYC's largest utility, has earmarked up to $20 million for demonstration projects that will support EV adoption in the region. Perhaps most catalytic in the near-term is Con Edison's three-year pilot program in partnership with NYCDOT to install up to 60 dual-port Level 2 curbside charging stations across the city starting in 2019. This opportunity for supporting changes in consumer behavior is significant for NYC, which has yet to deploy any charging infrastructure in the public right-of-way.

Even with rapid market growth and supportive initiatives, EVs represented less than 2% of all vehicles in New York State in 2017. As EVs approach price-parity with conventional vehicles, the EV cost-savings case is likely to resonate with cost-conscious consumers and these vehicles will increasingly enter the mainstream.[4] And while owning an EV has never been more affordable, with new models rapidly entering the market at lower price points and with greater range, continued EV market growth will hinge on the availability of adequate charging infrastructure.

Level 2 charging is a cost-effective way to catalyze EV adoption. Level 2 stations offer an advantage over other charging options in that they require less power than fast charging alternatives and align with typical parking habits, enabling users to receive an adequate charge in diverse contexts. While curbside charging models have been piloted in several North American cities—including Los Angeles, Indianapolis, Montreal, and Jersey City—and many more international cities, NYC faces unique challenges to a curbside strategy. The high premium for physical space—at the curb, on the sidewalk, and below the streets—as well as regulatory issues, liability concerns, installation costs, and the City's deep and abiding interest in congestion mitigation add a layer of complexity less present in other cities.

Despite NYC's curbside complexities, determining the optimal pilot deployment zones, street sites, and design guides for EVSE infrastructure will help to overcome planning and implementation challenges and support pilot success. Taken alone, the value proposition of offering EV-only access to the curb, in a city where residents often lack off-street parking and compete for limited on-street parking spaces, creates a powerful incentive for prospective EV owners.

This study has addressed these complexities while crafting potential deployment models that are supportable at current levels of EV market penetration and informed by the unique market conditions, policy imperatives, and limitations imposed by the environment in NYC.

The report is structured in two parts:

- **Section 1** presents examples and case studies from national and international leaders in curbside Level 2 deployments.
- **Sections 2 to 6** present a planning framework and EVSE siting approach to guide curbside Level 2 rollout in NYC, an overview of key policy actors and regulators for a pilot program, and a discussion of local impediments to successful deployments.

The report concludes with recommendations and estimated GHG impacts associated with a curbside pilot program. This study also produced the guidebook Curb Enthusiasm: Deployment Guide for On-Street Electric Vehicle Charging, an illustrated guide that synthesizes guidelines for site selection and recommends technical and urban designs for seamlessly integrating charging infrastructure on typical NYC streets (for details see the acknowledgement section of this report).

1 Introduction

The recommendations and case studies in this report are the culmination of a year-long feasibility study that included examples research, stakeholder interviews, geographic analysis, urban design analysis, and technical feasibility research. Original research and conversations with domestic and international decision-makers who have guided EVSE deployments, with EVSE manufacturers and network operators, and with local NYC policymakers have informed these recommendations for introducing Level 2 charging at the curb. The findings are intended to be a resource for NYC agencies as well as other local governments looking to pilot curbside Level 2 as part of a broader strategy to build an EV ecosystem.

In order to develop an approach to identifying suitable locations for curbside EVSE, the study team set out to accomplish the following goals:

- Identify and support multiple user groups.
- Identify and support multiple use cases.
- Develop strategies to replace ICE miles with PEV miles rather than inducing additional VMT.
- Plan for an EVSE ecosystem that achieves maximum inclusivity and broad distribution across NYC.
- Develop a data-driven methodology for identifying siting conditions for Level 2.
- Craft an approach that creates BEV-exclusive spaces with a minimum of disruption to overall inventory of available parking.

A curbside Level 2 charging network in NYC would support:

- Current and future EV drivers living in NYC without access to private parking in garages, lots, or driveways and who currently store their vehicles on street.
- Car-dependent commuters to outer borough workplaces and visitors to NYC.
- Current and future public fleet vehicles that either rely on in-the-wild charging (charging while away from a depot) and/or that cannot be accommodated in EVSE-equipped municipal parking facilities or depots.
- Future private fleet vehicles and commercial passenger vehicles that have in-the-wild charging needs and/or who typically store their vehicles on street (i.e., taxis, carshare, rideshare).

2 Curbside Charging Examples

Municipal governments and public agencies around the U.S. and across the globe have launched curbside deployment pilots that may offer New York City a path forward as it plans its own pilot program. As detailed in the case studies below, the array of approaches to curbside charging infrastructure reflects the great diversity of policy imperatives, market conditions, and even political concerns that have informed transportation policymaking in each profiled jurisdiction.

2.1 Domestic Markets

2.1.1 Case Study: Los Angeles, California

Figure 1. BlueLA Electric Carshare in Los Angeles, CA

Photo Credit: BlueLA

Note: The section is based on a telephone interview with Marvin Moon, Director of Engineering and EV Program Manager, Los Angeles Department of Water and Power, November 16, 2017. See Appendix A for interview notes.

The Los Angeles Department of Water and Power (LADWP) and Los Angeles Department of Transportation (LADOT) have jointly managed the installation of 85 curbside charging stations, including 82 Level 2 units mounted on street light poles, two on wood power poles, and one curbside direct current fast charge station. An LADOT partnership with Bolloré subsidiary BlueLA will yield an additional 200 EVSE units to serve a projected 100 carshare EVs stationed throughout downtown Los Angeles, Echo Park, Boyle Heights, East Hollywood, Chinatown, Pico-Union, Westlake, MacArthur Park, and parts of Koreatown.

The power pole installations have highlighted some unanticipated challenges for shared infrastructure approaches to curbside deployments. The multiple users of power poles present several operational challenges—linemen need to be retrained about navigating around EVSE units and new protocols need to be adopted by cable and telecom companies, both of which have expressed concerns about perceived limitations to power pole access posed by EVSE installations. LADWP is working to secure their buy-in and cooperation in advance of a broader rollout.

The lack of an industry standard for charge port location has also presented a challenge for LADWP planners who must ensure that a charge cord is long enough to reach either a driver's side or the passenger side port in a typical parallel parking deployment. Other challenges have been posed by retail business owners who fear that curbside installations will result in displacement of customer parking spaces for conventional vehicles. To address their concerns, the department favors curbside installations on side streets rather than main avenues, because they are less likely to create friction over perceived loss of spaces adjoining retail frontage.

Lastly, because charging stations will displace parking meters in a number of typical deployment scenarios, LADOT and LADWP are weighing solutions that can partially offset the average $30,000 in annual revenues per parking meter collected by LADOT. The two solutions under consideration include meter removal accompanied by revenue sharing with the city. The revenue sharing would include parking and charging fees or parking meter retention and equipment reprogramming for the collection of a blended parking and charging fee.

2.1.2 Case Study: Seattle, Washington

Figure 2. On-street Fast Charging in Seattle, Washington

Photo credit: Shannon Walker, City of Seattle

Note: Robin Gold & Kimberley Kline, Western Washington Clean Cities, Authors' Interview, 10/23/2017. See Appendix B for interview notes.

Seattle, Washington's Electric Vehicle Charging in the Right-of-way (EVCROW) program was launched in mid-July 2017 and seeks to deploy charging equipment in the public right-of-way, especially in areas that lack off-street parking. Since its launch, Seattle has installed two curbside charging stations operated by Seattle City Light (SCL) and several additional applications are in process. Seattle's citywide target of 30% EV car registrations by 2030 is driving much of the city's long-term EVSE planning efforts. In partnership with SCL, the EVCROW program seeks to assemble a network that will eventually include 20 utility-owned curbside stations across the city. Eluminocity, a BMW Group subsidiary, has plans for six to eight charging locations, while Greenlots, a California company, is pursuing permits for several dozen charging stations—although the final number of stations is contingent upon future funding. Seattle has also committed to installing curbside EVSE for carshare EVs.

The EVCROW program targets dense, transit-rich districts along major roadways—called *urban centers* and *urban villages*—and favors locations with low penetration of EVs and EVSE, as well as sectors burdened with poor air quality. The initiative also provides guidance on street tree protection, lighting, ADA compliance, coordination with other city projects, and metering.

To streamline the review process and remove obstacles to EVSE installation, Seattle is piloting a collaborative permitting strategy. All EVSE street use permit applications are evaluated and conceptually approved by Seattle Department of Transportation (SDOT) staff prior to an applicant's formal submission. While this approach is meant to ease the applicant's glidepath, it does not lessen its obligations under the street use permit. The city has, for example, set stringent terms regarding public access that are embedded in the terms of the permit/carshare companies that install EVSE must, for instance, pledge to make curbside charging available to non-members.

2.1.3 Case Study: Indianapolis, Indiana

Figure 3. BlueIndy Carshare in Indianapolis, IN

Photo credit: Herve Muller, Bolloré

Note: Hervé Muller, VP & General Manager, Bolloré Group, Authors' Interview, 10/31/2017. See Appendix C for interviewnotes.

Under a 2015 contract negotiated by Mayor Greg Ballard's administration, a Bolloré subsidiary BlueIndy agreed to install 100 charging locations across Indianapolis and Bolloré itself committed to a $41 million investment in the project. Infrastructure development to support the BlueIndy initiative also garnered $6 million in public investment from the city and $3 million from Indianapolis Power & Light. Since the program's 2015 rollout, the Indianapolis Department of Public Works (IDPW) has overseen BlueIndy's deployment of 425 curbside charge points at 85 different locations across the city. The EVSE units are available for use by both BlueIndy carshare members as well as other Indianapolis drivers. BlueIndy's plan is to install 1,000 curbside stations to serve 500 carshare EVs by 2019.

BlueIndy selects sites based on proximity to institutions, large employers and commercial activity. Its share members include: service workers who cannot afford to own a car, families that require a second car for occasional local travel needs, and mid- to low-level managers who drive locally for a variety of needs. In addition, 225 municipal fleet EVs also use the curbside units.

One significant challenge for the program has been jurisdictional; members of the Indianapolis City Council objected to what was perceived as the Ballard administration's unilateral action in contracting with Bolloré. A subsequent 2016 franchise agreement negotiated with the Council requires BlueIndy to pay the city $45,000 per year to compensate for lost meter revenue. The franchise agreement also gives businesses a one-time opportunity to contest the location of exclusive BlueIndy parking spaces by documenting, "demonstrable substantial economic harm or obstruction of customary access or obstruction of the ability to conduct normal business," caused by displacement of customer parking.[5]

In 2017, Napolese, an artisanal pizzeria, claimed that monthly sales at its 49th Street location slipped by as much as 10% from 2014 to 2016 after BlueIndy installed stations nearby. Another business, SoBro Cafe, stated that its sales dropped between 12% and 20% "for no apparent reason other than parking became more difficult."[6] Such early friction during BlueIndy's rollout resulted in 24 complaints to the Indianapolis's action center in 2015 and 28 in 2016 but have dropped to zero in 2018.

In addition to concerns voiced by some members of the business community, a recently approved rapid transit bus route may also require relocation of some EVSE units.[7]

2.1.4 Case Study: San Francisco, California

Figure 4. Green Vehicle Showcase, San Francisco, CA

Photo credit: Felix Kramer, https://www.flickr.com/photos/56727147@N00/3292002910/

Note: Barbara Hale, Assistant General Manager, Power, San Francisco Public Utilities Commission, Authors' Interview, 11/7/2017. See Appendix D for interview notes.

While San Francisco's curbside presence is very modest, the city does offer an innovative greenhouse gas (GHG) metric that drives deployment planning. The city's municipal utility sources its power from hydroelectric powerhouses, biogas co-generation facilities, and solar arrays positioned around the Bay Area, so its power has a zero GHG profile. As such, city planners have a pronounced preference for EVSE deployment in locations that the city controls, so GHG-free power is used. San Francisco's other priorities for siting include: equitable distribution, interconnection/electrical capacity, Americans With Disabilities Act (ADA) accessibility, and achieving a balance between fast charge and Level 2 as well as likely daytime use versus likely overnight use. While parking is fee-based, curbside charging was offered at no charge from the program's inception but is now transitioning to a fee-based system.

2.1.5 Case Study: Jersey City, New Jersey

Figure 5. GM Maven Electric Carshare, Jersey City, NJ

Photo credit: Michael Mazur, Greenspot

Note: Michael Mazur, Director of Operations, Greenspot, Authors' Interview, 1/17/2018.

In June 2014, the Jersey City, New Jersey municipal government approved a plan to install up to 20 curbside Level 2 units in front of a new residential building in its downtown Powerhouse Arts District. Six parking spaces were set aside for EV carsharing, while the other four spots were allocated to the public but restricted to use by EV drivers. Under Jersey City's franchise ordinance, real estate development firm Shuster Management (with residential property alongside the designated curb) was granted a 20-year license to install EV charging infrastructure and collect fees for charging and other related uses. Shuster Management created a subsidiary, Greenspot, to manage the pilot and develop a business strategy for curbside charging. Greenspot partnered with ChargePoint to operate and maintain the charging equipment and subsequently designated Maven, General Motors' carshare service, as its EV carshare vendor. Maven leases six dedicated spaces from Greenspot for its fleet of six Chevy Volts. According to Greenspot, Jersey City is currently Maven's highest-performing market in the U.S.

While Greenspot also charges individual EV owners for space and power, the firm cites Maven's participation as key to the model's profitability, since there are few privately-owned EVs in the city. Without a carshare partner, a developer who bears all costs and assumes all risk for EVSE deployment is, according to Greenspot, unlikely to see a return on investment at current levels of EV penetration. Robust enforcement is one additional element that the Greenspot model requires. While spaces were dedicated for EV parking under the Greenspot franchise agreement, at present no mechanism exists under the city charter to enforce this restriction.

2.1.6 Case Study: Berkeley, California

Figure 6. ADA Accessible Level 2 Curbside Charging in Berkeley, CA

Photo Credit: Sarah Moore, City of Berkeley

Note: Sarah Moore, Sustainability Planner, City of Berkeley, Authors' Interview,11/9/2017

The City of Berkeley has played a pivotal role in shaping and leading the disability rights movement since the early seventies and in the passage of the federal ADA and continues to be at the forefront in advocacy today. In May 2017, the City of Berkeley installed a dual-port, ADA compliant, on-street charging station in front of the LEED (Leadership in Energy and Environmental Design) Certified and net zero waste Branch Berkeley Library. The installation took advantage of an existing curb cut and on-ramp to make the space fully ADA compliant.

Federal accessibility requirements set in the ADA stipulate that EVSE available for use by the general public must be accessible for people with disabilities in State and Local Government Facilities, Public Accommodations, and Commercial Facilities. While there are no Federal standards specific to EVSE design, accessibility is still required as per legal examples that, "lack of explicit scoping or technical requirements does not relieve ADA Title II and Title III entities from obligation to provide access."[8] The 2016 California Building Code, effective in January 2017, sets California's accessibility regulations for EVSE.[9]

The municipality charges $1.50 per hour for charging, plus applicable parking fees (the space is a 4-hour metered zone). The charging station is partially powered by solar rooftop panels. The station was partially funded by grants from the California Energy Commission.

2.1.7 Case Study: Sacramento, California

Charging in the public right-of-way has garnered a significant attention from the Sacramento City Council and has yielded both plans for a pilot and new policymaking with implications for other urban markets around the U.S. In the pilot's first phase, three ADA-compliant fast charging stations were deployed in angled parking spots adjoining a city park.[10] EVSE provider EVGo sought locations with angled spaces, free parking, and a two-hour time limit. The city assessed a licensing fee of $6,000 over a ten-year license term. In phase 2 of the pilot, the city will designate locations for three more fast charge units, moving Sacramento closer to its goal of 20 curbside chargers citywide. For units deployed adjacent to currently metered spaces, the city determined that an EVSE vendor would need to compensate Sacramento for lost parking revenue based on past performance of the subject meters.

For additional fast charge locations, the city's Department of Public Works (DPW) is recommending time-limited, high-turnover spots in Sacramento's downtown. Because local policymakers have expressed concerns about excessive dwell time, busy locations where parking is at a premium are preferred. A DPW representative stated, "If anything is going to be in the right-of-way, it better be a DC [direct current] fast charger."

2.1.8 Case Study: Columbus, Ohio

Columbus, Ohio has set a goal of installing 800 publicly accessible EVSE units and 30 curbside chargers citywide. Norman *Bud* Braughton, Senior Project Manager for Smart Columbus, Columbus' federally-funded clean mobility initiative, describes efforts to assemble an EV ecosystem as "trying to grab this as a culture."[11] Policy initiatives in the city seek to stoke both consumer and fleet adoption of EVs, while addressing the infrastructure challenge with a broad and multi-pronged strategy. More than 780 public and private fleet EVs, including 100 city-owned PHEVs provide baseload demand for charging stations.

While Columbus' siting strategies consider the condition and availability of underground infrastructure, parking meter revenue information has been used to gauge potential demand. High-utilization parking meters point to high visibility and are likely used by EV drivers. A significant infrastructure project aimed at reducing accidents at freeway exit ramps near the heart of downtown has sparked a collaboration between Smart Columbus and the Ohio Department of Transportation (ODOT), which has launched its own EVSE planning initiatives. East Fulton Street, which connects to eastbound exit ramps from I-71, is slated for curbside EVSE units to serve motorists exiting the interstate as well as visitors to nearby German Village and its thriving dining scene. This explicit link between EVSE placement and local economic development is unusual for a North American city and indicative of the ecosystem-wide approach that the city has adopted.

ODOT's $75 million freeway project has, however, caused considerable delays in the launch of the Smart Columbus curbside pilot. Resurfacing of two major freeways, shoring of retaining walls, streetscaping and the installation of new public art along exit ramps must be completed before charging station installation can begin, so the pilot is unlikely to commence before the spring of 2019.

Meanwhile, the Smart Columbus team is drafting a Request for Proposals (RFP) to select a vendor to install and operate a network of charging stations across the city. The Columbus Public Service Department has weighed in regarding design considerations and AEP Ohio, the area's principal utility, has offered guidance on technical specifications. Modeled in part on the Virginia Department of Environmental Quality's RFP to establish a statewide EVSE network and informed by AEP Ohio's own charging station program, the RFP is likely to be circulated in early 2019.

2.2 Overseas Markets

2.2.1 Case Study: London, United Kingdom

Figure 7. Lamp Post Charging in London, UK

Photo credit: Liv Colell, Ubitricity

Note: David Metcalfe, Transport for London, Authors' Interview, 11/22/2017.

In the Spring of 2011, Transport for London (TfL) sparked the city's earliest efforts to plan and implement an EV charging network for London. Under the Source London program, TfL oversaw an initial rollout of 1,200 publicly-accessible chargers and subsequently launched a procurement

process to identify private sector vendors for future EVSE deployments. In September 2014, Bolloré, already the operator of a carshare program and charging network in Paris, was awarded the TfL contract and assumed operational responsibility for the Source London network that the transportation agency had catalyzed three years earlier.

While Bolloré won *good will* and a significant concession from the agency, it did not secure exclusivity. The company still must negotiate with each of the city's borough councils for curb space and, like other EVSE vendors, pay a license fee to each borough in order to operate. Despite these challenges, Bolloré quickly doubled the size of the city's charging network to over 2,000 EVSE units. While Bolloré currently manages the TfL EVSE network, any vendor can petition the boroughs to install curbside Level 2 chargers and a number of competing vendors are active across the city. There is, however, no interoperability between London's multiple charging networks, which limits ease of use for drivers.

In 2017, TfL and the Office of the Mayor issued Electric Vehicle Charging Infrastructure: Location Guidance for London, a blueprint for London's EVSE rollout, especially new DC Fast Charging Stations units.[12] New curbside DC Fast Charging Stations installations are targeted to locations where taxis queue and other commercial EVs cluster. TfL is also developing an off-street strategy for DC Fast Charging Stations focused on leased sites, including former petrol stations. TfL and the municipal government have not, however, offered network operators much in the way of direction around the design and functionality of EVSE units, other than basic guidance related to pedestrian safety and sidewalk access. Some borough authorities have issued their own design guidelines—Westminster, for instance, requires that every EVSE unit be black.

TfL's reluctance to embrace an overly prescriptive approach coupled with the city's decentralized decision-making have yielded a number of market-driven solutions to EVSE network-building. One initiative that gained traction in several boroughs is the upfitting of streetlight poles for EV charging via user-supplied power cords. OVO Energy and its technology partner, Berlin-based Ubitricity sell their subscribers a metered power cable that can plug into any one of 300 converted streetlights for a 3 kW *trickle charge* appropriate for overnight charging. Such slow charging solutions work well for residents who park in their home neighborhoods, but they are ill-suited to addressing a range of daytime use cases that require faster charging speeds and that facilitate steady turnover (See Appendix A for a case study on lamp post charging.)

In the early years of EVSE deployment, the United Kingdom central government underwrote 75% of the cost of charging station installation; boroughs were responsible for remaining 25%. At present, high EV usage in London has heightened the demand for EVSE units and largely eliminated the need for a public subsidy for Level 2 units. Subsidies are, however, available for local grid upgrades to support new fast charge installations—capital costs that are unlikely to be borne by network operators since they limit profitability and disrupt the operator's business model. While a recent market study identified these costs as a principal barrier to increased fast-charge availability, the large size of Fast Charging Stations has also created zoning and public review challenges.

2.2.2 Case Study: Copenhagen, Denmark

Figure 8. Public Access Curbside Charging in Copenhagen, Denmark

Photo credit: Kåre Albrechtsen, The Capital Region of Denmark, Center for Regional Development

Note: Kare Albrechtsen, Copenhagen Electric, Authors' Interview, 11/11/2017

Copenhagen Electric, a hybrid regional/municipal authority financed largely by the Capital Region of Denmark (the easternmost region of the country) and the national government, encourages the adoption of electric vehicles through knowledge-sharing, procurement, and project implementation. The authority has facilitated the installation of approximately 300 curbside, Level 2 units and 20 Fast Charging Stations across the Capital Region. The regional government's goal is a carbon-free transport sector by 2050.

Copenhagen's municipal government has a limited role in network planning. The siting process is left to private sector vendors and guided in part by local stakeholder requests. While still not profitable, the two EVSE operators active in the market—Clever and E.ON—identify locations and then apply for a concession at those locations. For residents and institutions, an initial call to the municipality is required to request a charging station. While the municipality is typically very supportive of EVSE requests, some locations are inevitably denied due to issues such as physical barriers and cost constraints, and the requesting entity/individual must then identify alternative locations. The municipality provides incentives for curbside deployments at hospitals and taxi charging hubs but does not typically subsidize *less commercially-interesting* locations.

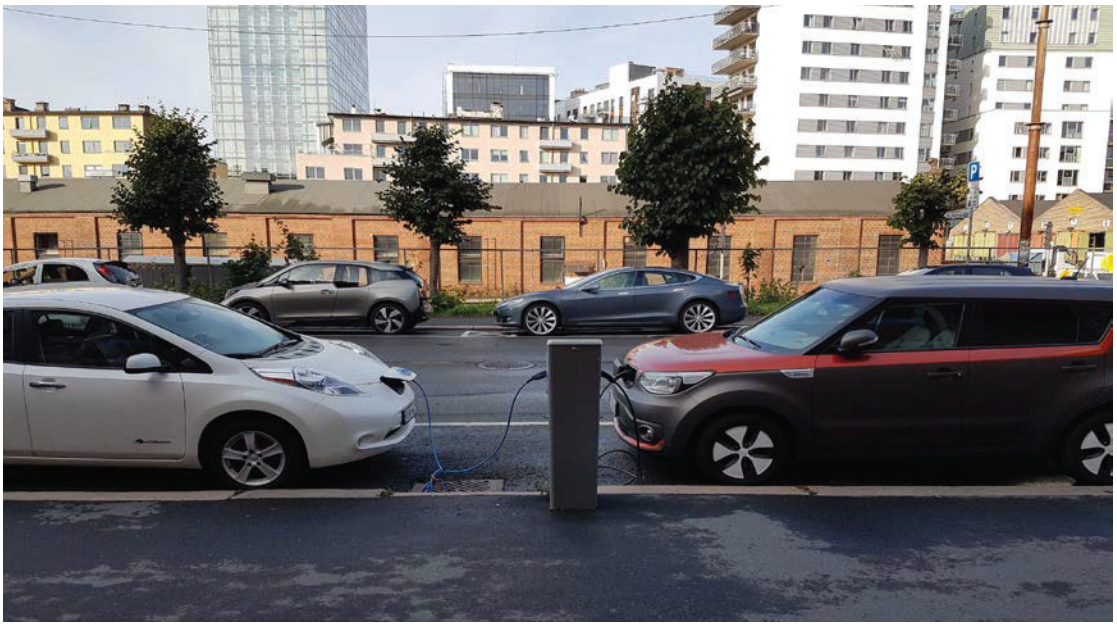
Baseload demand for charging is highly diversified. Copenhagen boasts two public carshare programs—400 battery-electric BMW i3s are available to residents through DriveNow's carsharing initiative while the Green Mobility carshare fleet features an additional 400 EVs. While DriveNow vehicles are largely charged curbside, Green Mobility charging is conducted largely at hot spots off the street. Both the Danish postal service and the Copenhagen municipal fleet include EVs which utilize curbside stations, as well. EV drivers pay a bundled parking and charging fee when they park in an EVSE-equipped spot.

The city also uses residential parking permit fees as policy instruments to incentivize EV ownership. In dense residential areas, car owners are issued parking permits for the right to park on the street. Owners of an ICE vehicle typically pay $200 per year to park in their own residential zone. The comparable rate for an EV parked in a residential zone is $10–$15 per year.

2.2.3 Case Study: Oslo, Norway

Figure 9. Public Access Curbside Charging in Oslo, Norway

Photo credit: Sture Potvik, Agency for Urban Environment, City of Oslo



Note: Sture Portvik, Project leader, Electrical Vehicles, Agency for Urban Environment, City of Oslo, Authors' Interview, 11/7/2017

Oslo, Norway has set a long-term goal of carbon neutrality for transportation. To advance that policy objective, the city has deployed 1,200 curbside chargers, 80% of which are Level 2 and 19% Level 1. The city has also installed five curbside fast chargers and has a mobile Fast Charging Stations unit that can be deployed at the curb. In 2018, Oslo plans to install an additional 200 Level 2 chargers and 400 fast charging stations curbside.

The Oslo region is home to more than 35,000 electric vehicles and Norway has today become the world's first mass market for zero emission cars. Passenger EVs, electric taxis, electric scooters and motorcycles all contribute to EVSE demand in a city where half of all new vehicles sold in 2017 were electric-drive. Rapid real estate development in the region has, however, reduced the amount of suitable space for EVSE installations. Other challenges to further expansion of the region's public charging network include a time-consuming review process and added cost associated with weather-proofing curbside units. Harsh winter weather and high snow drifts necessitate non-standard installations, with EVSE units placed on higher pedestals than in other markets and additional bollards required to protect the equipment from snow removal equipment. In some installations, EVSE units are sheltered to protect them from the elements, adding to the deployment cost.

3 Planning Framework: Curbside Charging in NYC

3.1 Benefits of Curbside EVSE

To achieve long-term goals and assemble a truly robust, highly visible, and supportive EV ecosystem will require the strategic deployment of curbside charging units in and near the public right-of-way. Such an agenda is likely to prove defensible from both a carbon mitigation and an efficacy perspective. Strategic electric vehicle supply equipment (EVSE) siting in NYC holds great promise to simultaneously reduce emissions, build a robust curbside charging network, maximize public investment, and advance public initiatives.

3.1.1 Reduce Transportation-Related GHG Emissions

As part of its commitment to the Paris Climate Agreement of 2016, NYC has committed to reducing citywide emissions by 80% by 2050. Achieving this goal will require reducing transportation emissions, which represent nearly a third of NYC's greenhouse-gas (GHG) emissions—about 15 million metric tons per year.[13] More than 90% of emissions come from on-road vehicles. In order to achieve the City's sustainability goals, New Yorkers will need to further embrace EVs. While NYC has a relatively efficient transportation system compared to other North American cities and other sections of the State, electric drive transportation holds the promise of making meaningful reductions in overall GHG emissions, especially since EVs powered by NYC's grid emit only 30%–43% of the GHGs emitted by conventional internal combustion engine (ICE) cars.[14]

3.1.2 Promote Replacement of Internal Combustion Engines Miles with Electric Miles

Building a robust and visible curbside charging network can reduce range anxiety and remove perceived barriers to EV ownership. Dedicated curbside parking for EVs creates a powerful incentive for prospective EV owners. In fact, studies show that the availability of public access charging correlates to EV adoption. Building a charging network will support a growing regional cohort of EV drivers.

3.1.3 Maximize Public Investment

A 2016 white paper on the effectiveness of various state-level electric vehicle incentives found that public EVSE deployment offered the highest ratio of consumer benefit-to-state-cost among all the forms of support that government is positioned to provide to EV owners. Conducted by four Cornell and SUNY Stony Brook economists, the study determined that public charging station installation had more than twice the benefit-cost ratio of high-occupancy vehicle (HOV) lane access.[15] In NYC, with its more than three million curbside parking spaces and relative scarcity of HOV lanes, a carefully considered strategy for curbside deployment may prove especially compelling to current and prospective EV drivers.

3.1.4 Advance Public Initiatives

Through the Charge NY program, Governor Cuomo has set an ambitious goal of deploying 3,000 EV charging stations to power an expected 30,000 EVs on the State's roads by the end of 2018 and 1 million by 2025. Since its 2013 launch, the Charge NY program has brought about the deployment of over 800 EVSE units statewide. The New York State Zero Emission Vehicle (ZEV) mandate requires that auto manufacturers active in the NYS market meet specific sales goals for cleanest models available.

NYC's Local Law 160 (enacted in December 2016) established an Electric Vehicle Advisory Committee and a charging station pilot program that requires the City to install at least 25 EVSE in publicly accessible locations, with at least two stations in every borough.[16] The EV Advisory Committee will monitor the pilot, scheduled to run from Spring 2018 to Spring 2020, will make recommendations regarding the broader deployment of EVSE in the city, including the feasibility of on-street EV charging.[17]

3.2 Planning Principles

In order to support the planning and design of a curbside charging pilot program in NYC, the team undertook a strategic planning process that draws on the following planning principles. These principles represent the best practices demonstrated in other cities with successful curbside charging networks, as well as the specific constraints, opportunities, and planning objectives found in NYC.

In a dense urban setting with limited curb space, a high volume of commercial activity, and a public policy imperative to reduce congestion, installing a new technology curbside and offering preferential parking for a specific vehicle type will likely provoke a vigorous debate. The planning framework that follows presents an approach for curbside Level 2 charging station siting and street integration that seeks to minimize impact on residents and businesses while expanding charging opportunities citywide.

3.2.1 Support Multiple User Groups and Use Cases

By identifying and supporting multiple user groups, public sector decision-makers can optimize the utilization of new curbside infrastructure and designated EV parking spaces and minimize the likelihood that Level 2 charging goes unused.

Intelligently calendared on-street infrastructure can also support the carbon mitigation efforts of other users of the curb, including EV delivery fleets, food trucks, and emergency vehicles with onboard power requirements, and refrigerated grocery delivery services that employ a hub and spoke service model.

3.2.2 Replace Internal Combustion Engines Miles with Zero-Emission Vehicle Miles Traveled

This study seeks to identify several cohorts of downstate commuters who are typically auto-dependent, especially resistant to mass transit incentives and access, and whose daily travel is within the operational range of commercially available EVs. Instead of simply micro-targeting current or past EV drivers, this strategy offers the greatest likelihood of replacing ICE miles with battery-electric vehicle (BEV) miles among what is likely the next wave of EV owners. This approach enables NYC to facilitate EV uptake *without inducing additional vehicle use* for local travel. Across each proposed deployment scenario, the objective is to never induce driving but to replace ICE miles with BEV miles.

3.2.3 Identify Street Conditions that Optimize Level 2 Utilization

In order to avoid extended dwell times at an EVSE-equipped parking space, the study seeks to identify typologies in which regulations encourage regular vehicle turnover and likely demand ensures optimal utilization. Once weekly alternate side parking rules could, for example, result in week-long furloughs in a designated space by a single BEV. In contrast, regular street cleaning, metered curbside spaces, and other time-limited zones can help support favorable charging turnover. Vehicle turnover and optimization amplify the public benefit of EVSE and accelerate the return on investment for the city and the EVSE operator.

3.2.4 Plan for Maximum Inclusivity and Broad Distribution

To ensure that access to public EVSE infrastructure is not limited to small clusters of early adopters, the study seeks to identify deployment scenarios in underserved areas, environmental justice communities, and neighborhoods that have low levels of BEV ownership but a significant share of inbound car commuters. Recognizing that any charging station deployment can and should confer benefits to the broader public and not simply to the immediate user, the study highlights approaches that maximize air quality benefits near vulnerable populations (e.g., medical centers, public schools).

3.2.5 Use Data-Driven Methods to Identify Deployment Zones

While stakeholder interest, local consensus-building, and even online request forms can drive the site selection process in some jurisdictions examined by the project team, this study seeks to provide decision-makers with a data-driven approach to supplement other qualitative considerations.

3.2.6 Minimize Overall Disruption

In locations where on-street parking is at a premium, any repurposing of existing parking inventory can be disruptive to local stakeholders. Deployment scenarios should prioritize installations that local residents, businesses, and institutional stakeholders support.

3.1 State of EV and EVSE Markets

Public access charging stations are a powerful incentive that policymakers can use to encourage EVs adoption. As of August 2018, there were 739 public access charging stations in NYC, all in garages or surface lots.[18] Researchers have found that availability of public access infrastructure is significantly correlated with EV adoption. A 2014 study exploring factors influencing the uptake of alternative vehicles found that every additional charging station per 100,000 people increased the national share of EVs to passenger ICE cars by 0.12 %.[19] Researchers Peter Slowik and Nic Lutsey found that in the U.S.'s 50 largest metropolitan areas, the relationship between workplace charging infrastructure and EV adoption was even more compelling, with correlations as high as 94%.[20] Given the important role charging infrastructure plays in promoting EV adoption, and the low EVSE availability relative to car ownership in NYC, even a small investment in charging infrastructure stands to have great impact.

3.1.1 Interoperability and Industry Standards

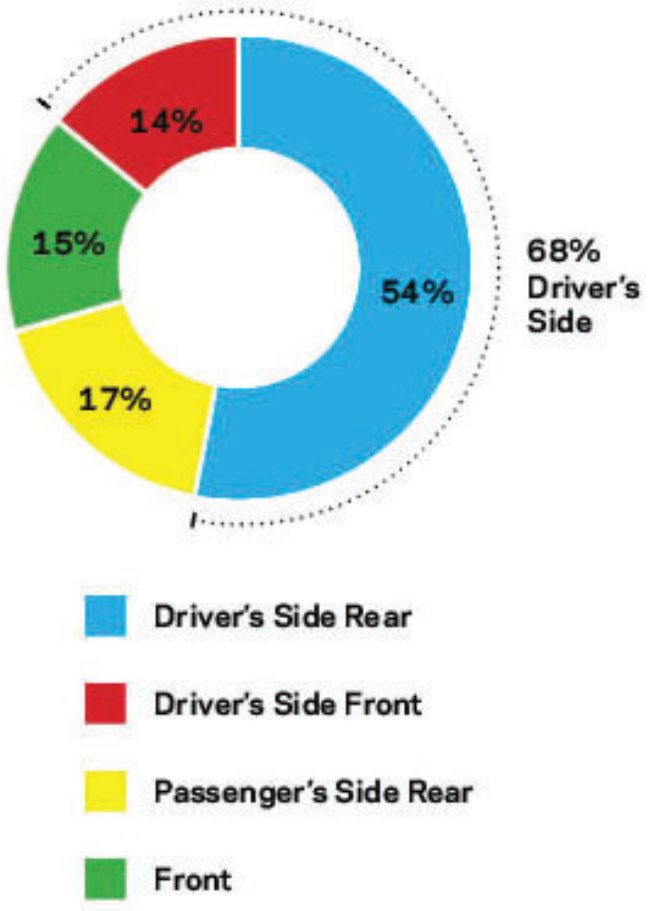
Planning for maximum interoperability in a curbside public access network requires careful consideration of industry standards, including type of charge specified, plug configuration, and charging port location on vehicles. The Society for Automotive Engineers (SAE) J1772 (Type 1) is the most commonly used charging standard in North America, compatible with Level 1 and Level 2 charging stations. All EV models with this standard can use the same charging infrastructure. All EV manufacturers selling in North America are compatible with this standard with the exception of Tesla, who uses a proprietary plug type and has built an exclusive Fast Charging Stations network across the U.S. Despite using its own plug standard, Tesla sales include an SAE-J1772 compliant adapter cable (adapters for CHAdeMO and SAE J1772 Combo are also available). There are several charging standards used in North America:

- **Society for Automotive Engineers (SAE) J1772 (Type 1)**: The most commonly used charging standard in North America, compatible with Level 1 and Level 2 charging stations.
- **SAE J1772 Combined Charging System (SAE J 1772 Combo)**: Combo connector allows interoperability with DC fast charging stations.
- **CHAdeMO**: A specialized connector for DC fast charging developed by Tokyo Electric Power Company and a consortium of Japanese automakers.
- **Tesla:** A proprietary plug type and an exclusive DC fast charge network across the U.S.

There is no fixed port location for auto manufacturers in North America or abroad: Nissan and Audi place ports on the front and center of the vehicle; Tesla places ports on the rear drivers' side; Ford and General Motors ports are all on the front drivers' side; and still others, such as BMW, place ports on the rear passenger side.

Variability in charge port location means that planning for curbside EVSE must consider accessibility and safety for plugging into all sides of a vehicle. That said, approximately 68% of BEV units sold in 2016 and 2017 in the U.S. have charge ports on the driver's side,[21] indicating that a curbside strategy for EVSE should prioritize planning for driver's side ports in order to minimize drivers from entering the right-of-way (Figure 10).

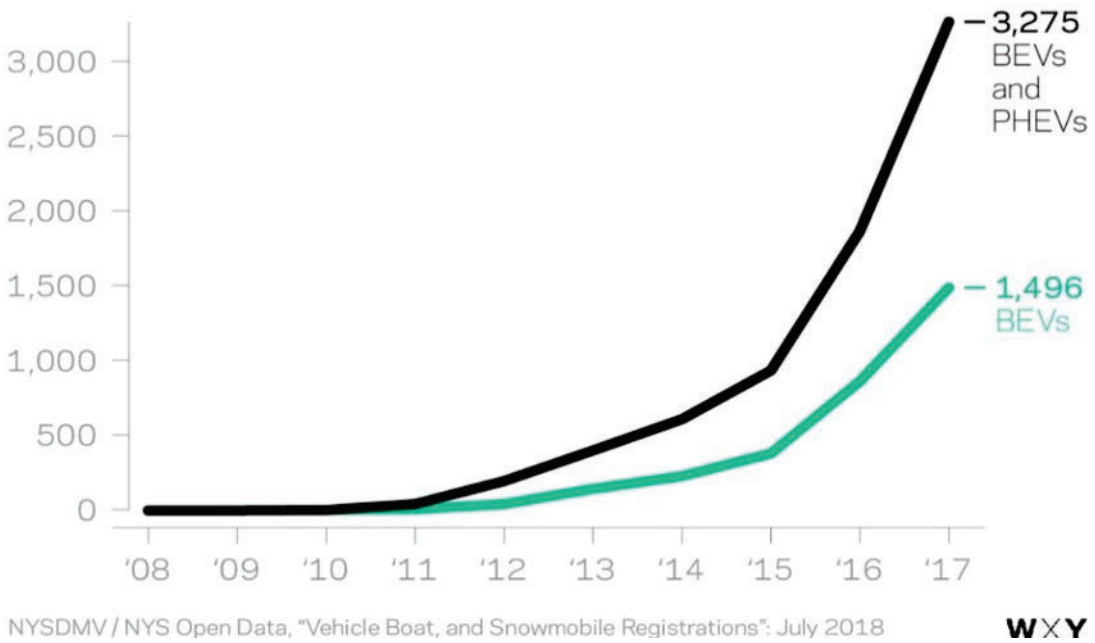
Figure 10. Port Location for Battery Electric Vehicles Sold in the U.S. from 2016–2017



The EV and EVSE markets, however, are dynamic and current conditions may not reflect near-term or medium-term market penetration efforts by new entrants in the BEV space or current players in the process of introducing new models. Nonetheless, the EV industry still needs to overcome significant challenges related to battery capacity and charging infrastructure. Adopting a common standard for EV charging, deepening the collaboration between auto manufacturers and EVSE suppliers, and leveraging renewed incentives and subsidies will all support continued market growth.

3.1.2 Electric Vehicle Growth in New York City

Figure 11. EV Growth in New York City (2008–2017)



As of August 2018, there were an estimated 5,888 electric vehicles (EVs) registered in NYC, including an estimated 2,637 battery electric vehicles (BEVs).[22] Of the total EVs, 1,700 were registered to the Department of Citywide Administrative Services (DCAS), making New York City the cleanest municipal government vehicle fleet in the country. Roughly half (1,500) of these are likely to be new car sales, as approximated, based on model year vehicles added within the same calendar year.[23] Among EVs registered, 50% were registered to addresses in Manhattan, while Brooklyn and Queens each had approximately 20% registered. Year-on-year growth of EV registrations in NYC has averaged at 169% over the last four years, with 175% growth between 2016 and 2017 (Figure 11).[24]

EV adoption is expected to accelerate further in the coming years with continued support from public incentives, new EVSE networks, and improved battery technology. While estimates vary widely, it is predicted that EVs will achieve mass adoption in the United States within the next 15 years and will soon cost the same as their ICE counterparts.

Sales of light passenger EVs in 2017 hovered around 1% of national auto sales,[25] although it is likely that aggregate sales of these vehicles will total more than 1.5% of the market by the close of 2018.[26] EV registrations in NYC over the same period represented about 0.7% of all passenger vehicles.[27] Forecasts of when electric models will achieve mass adoption in the U.S. vary from 2025 to 2040[28] and beyond. However, the growth of the EV's market share of total U.S. auto sales is a trend that is likely to continue.

Leading automakers have responded to this opportunity and are rapidly expanding their EV offerings. General Motors, Toyota, and Volvo have all declared a target of 1 million in EV sales by 2025. BMW has also stated that it will offer 25 electrified vehicles, of which 12 will be fully electric, by 2025. Other luxury auto manufacturers have committed to shifting to all-electric fleets in the next few years. These newer models tend to feature longer driving ranges, faster charging rates, and lower sticker prices. Of the passenger EVs registered in NYC, Tesla's Model S and Model X are the most popular models, followed by the Kia Soul EV and Chevrolet Bolt (Table 1).

Table 1. Top BEV Models in NYC as of July 2018

Make and Model	Count	Port Location
1. Tesla Model S	698	Drivers Side Rear (left)
2. Tesla Model X	626	Drivers Side Rear (left)
3. Kia Soul EV	86	Front
4. Chevrolet Bolt	74	Drivers Side Front
5. Nissan LEAF	56	Front
6. Smart ForTwo EV	38	Passengers Side Rear (right)
7. BMW i3	10	Passengers Side Rear (right)
8. Tesla Roadster	10	Drivers Side Rear (left)

3.2 EV User Characterizations

Publicly available industry data on current and likely EV drivers is scant. In June 2017, used car retailer CarMax partnered with online news site CleanTechnica to survey EV and hybrid buyers about their lifestyles and vehicle preferences. The survey addressed consumers who drive both new and used hybrid and electric vehicles. Based on more than 2,300 responses, the study found that hybrid and EV drivers have higher levels of education than the average American consumer. Over 70% of survey respondents

had a bachelors or post-graduate degree. Respondents were also more likely to be newcomers to alternative fuel technologies—more than 60% of those surveyed reported that they had never owned an EV or hybrid before their current purchase and most of these drivers had owned their vehicles for less than six years.[29]

In addition, in 2017, management consulting firm Altman Vilandrie & Company profiled more than 2,500 auto buyers in the U.S. to assess attitudes toward EVs and offer insights into the likely early adopter demographic. The study found that those most likely to purchase an EV rate both younger and more affluent than the average American consumer. Among consumers earning $100,000 or more, 17% plan to purchase an EV for their next vehicle; among 25–34-year-olds, 18% stated that their next car would be an EV.[30]

While high levels of education, relative affluence, and youth tend to characterize current and likely EV adopters, they are not altogether predictive. A January 2017 McKinsey report *Electrifying Insights* identified a next wave of potential adopters with more modest household incomes and different residential dispersion patterns. For these consumers, more affordable utilitarian vehicles with relatively small battery packs will address their daily mileage needs, which are typically 20% to 30% lower than those reported by suburban drivers.[31] Household income is, according to McKinsey, already fading as a key determinant of likely EV adoption in other markets across the globe. In fact, EV drivers in China already mirror the predicted profile of next generation consumers cited in the McKinsey study–budget-conscious consumers with household incomes lower than that of other vehicle buyers.[32]

4 Cluster-Based Targeting

A cluster-based approach to EVSE siting, described in Figure 12, prioritizes car-dependent users and incorporates a geographic understanding of where EVSE demand converges with potential partnerships that will increase the likelihood of a successful pilot.

While geography is likely a meaningful determinant of EV adoption (and, of course, car ownership), vocation, workplace location, and work shift also converge to create especially rich clusters of opportunity to identify both current and prospective EV drivers. And since slightly more than 30% of all charging in the U.S. occurs at the workplace,[33] a close examination of employment centers with auto-commuting employees can serve as an important site-selection filter for curbside EVSE deployment.

Certain vocational cohorts are especially car-dependent and may therefore create offer opportunities for efficient calendaring, predictive demand, and optimal utilization at specified curbside locations near their workplaces. A cohort is a group of people who share an experience or characteristic over time. In this case, the shared characteristic is workplace or vocation. These cohorts of commuters include the following:

- Healthcare workers
- Higher education workers
- NYC municipal employees, especially from NYC Department of Education (NYCDOE)

The three cohorts include significant numbers of auto commuters commuting from areas outside of the five boroughs and/or areas far from mass transit. The workers also tend to work non-standard work shifts that make public transportation less convenient. Drivers in these groups typically take advantage of restricted parking zones, extended-time meters sited near places of work, and other parking privileges—such as city-issued placards.

Figure 12. Optimal Clusters of Institutions and User Cohorts for Curbside Level 2 Deployments

Optimal Clusters of Institutions and User Cohorts for Curbside Level 2 Deployments

MEDICAL CAMPUS

Healthcare workers
Hospital visitors and services

Medical campuses tend have a largely car-dependent workforce amplified by shift workers who have fewer and less frequent off-hours public transit options. Often, parking for visitors and employees spills out of garages onto the curb.

HIGHER EDUCATION

Higher education personnel and students
School visitors and services

Post-secondary education is a significant driver of New York City's economy and draws employees and students from across the region. Outer borough campuses isolated from public transit have high proportions of auto commuters.

PUBLIC SECTOR

Municipal workers and visitors (e.g. DOE, FDNY, NYPD)

Municipal employees in New York City drive at higher rates than private sector employees. 30% of municipal workers live outside the City and that this sector has the third longest average commute time (according to Fast City, Slow Commute, a March 2016 report on NYC commuting patterns). Many municipal employees work shifts at workplaces far from transit options, contributing to their car dependency.

NEIGHBORHOOD CENTER

Residential "Garage Orphans"
Local commercial visitors and employees

Neighborhood centers are the most prevalent neighborhood type in NYC, with a mix of commercial and residential uses. Drivers in neighborhood centers with high car ownership, especially those without substantial new residential construction, tend to store their vehicles on-street. "Garage orphans" have fewer opportunities for EV ownership without charging where they park: on street.

LEISURE DESTINATION

Employees and visitors
Fleet needs

Parks, public pools, cultural institutions (museums and science centers), stadiums and other major institutions are examples of leisure destinations that offer a good opportunity for EVSE exposure and top-off charging. These destinations may also have EV fleet charging needs. While some of these destinations have dedicated garages or lots, many visitors, especially in denser areas of the city, spill over to the curb.

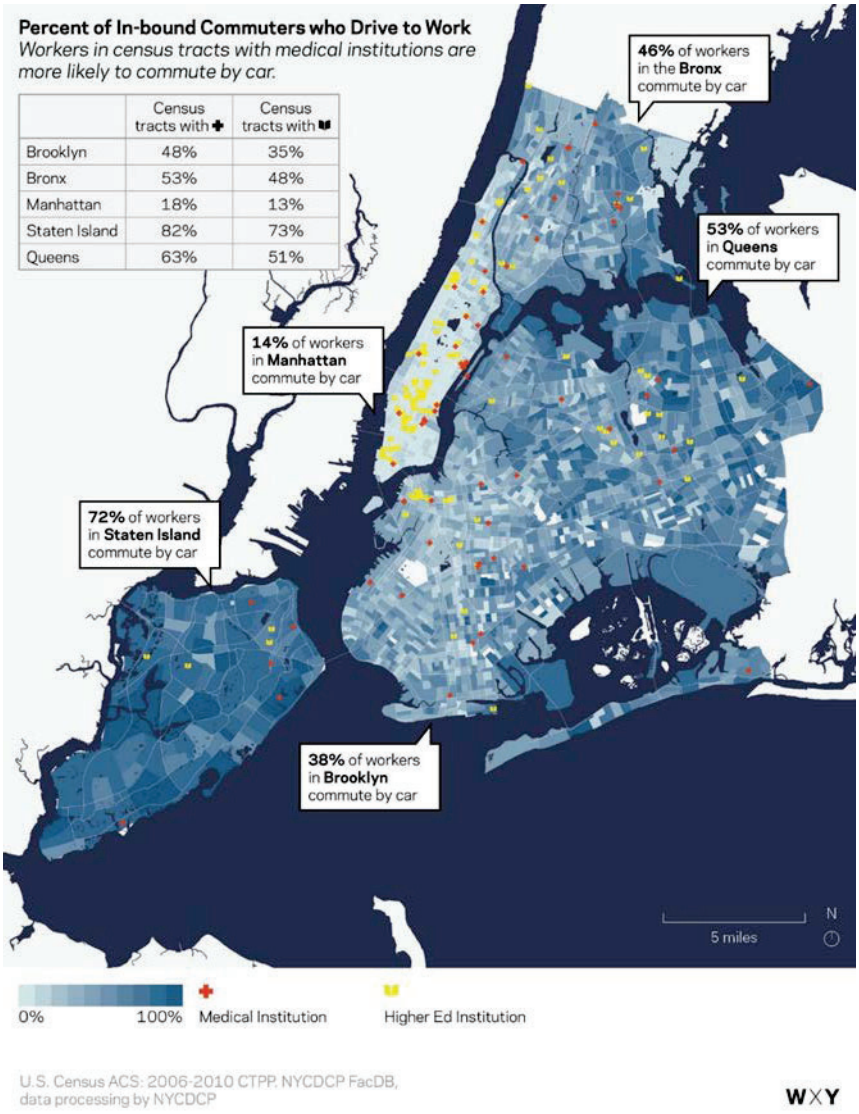
WXY

Figure 13 shows the percent of inbound, car commuters to NYC based on census tracts. Overlaid on top are education and medical institutions (eds and meds). Such analysis shows that workers commuting to workplaces in Queens disproportionately commute by car.

4.1 Baseline Data: NYC Workforce and Auto Commuting

- In Queens and Staten Island, the majority of workers use cars for commuting within their borough of residence and to other boroughs.[34]
- Most workers who reside outside NYC and work in the outer boroughs commute by car.[35]
- Among NYC residents, most workers commuting to the Bronx, Brooklyn, Queens, and Staten Island commute by car.[36]

Figure 13. Percent of In-Commuters Driving to Work



	Census tracts with ✚	Census tracts with
Brooklyn	48%	35%
Bronx	53%	48%
Manhattan	18%	13%
Staten Island	82%	73%
Queens	63%	51%

4.1.1 Cohort: Healthcare Workers

A January 2018 study by The Center for an Urban Future documented the commuting challenges of workers in the healthcare industry in NYC—which has 209, 677 hospital jobs. An Unhealthy Commute: The Transit Challenges Facing New York City's Healthcare Sector identified significant transit gaps for workers in the sector. The study's authors observed that 21 NYC hospitals and major medical centers as well as 32% of the large healthcare employers studied are located more than eight blocks from a subway stop.[37]

According to the study's analysis, census districts with the highest concentration of residents working in healthcare are themselves typically underserved by subways. The study identified 11,235 healthcare workers who commute to jobs from their homes in Queens Village, Cambria Heights, and Rosedale, Queens—neighborhoods without a single subway stop. Another 17,721 healthcare workers were counted in Canarsie and Flatlands, two neighborhoods served by a single subway stop located at the northern edge of their community, too remote for most to use for their daily commute.[38]

Workers who live in one outer borough but work in another is an increasingly typical pattern for workers in the sector. Additionally, 15% of NYC healthcare workers commute to their jobs from outside the City.[39] Such residential clustering in peripheral communities has, not surprisingly, yielded a largely car-dependent workforce. This pattern is only amplified for shift workers who have fewer and less frequent off-hours public transportation options.

4.1.2 Cohort: Higher Education Personnel

Post-secondary education is a significant driver of the NYC economy. In 2007, the sector employed 110,000 people, representing nearly 2.5% of all NYC jobs. By 2009, the New York State Comptroller reported that higher education jobs in NYC constituted between 3.2–5% of total employment.[40] The Educational Services sector, which includes Higher Education, draws employees from throughout the downstate region and from as far away as Eastern Pennsylvania. In 2014, 21% of employees in the sector resided outside NYC.[41]

According to citywide data furnished by the NYC Department of City Planning, 20% of commuters in NYC census tracts containing higher education institutions are auto commuters.[42] In some outer borough tracts containing higher ed institutions, the proportion of auto commuters is significantly higher. For instance, the northeast Bronx census tract containing the Albert Einstein College of Medicine, part of

Montefiore Health Systems, is the commute destination for 2,187 workers, of which 1,580 drive; 72% of that tract's workers commute by car. In Jamaica, Queens, the tract containing York College draws 1,711 inbound commuters, of which 1,191 are auto-commuters or nearly 70% of the total.[43]

Higher education institutions across Queens draw a heavily car-dependent workforce—58% of commuters to Queens tracts with colleges and universities travel by car. The equivalent figure for the Bronx is 52.9%; for Brooklyn, 37.6% of commuters to tracts with higher ed institutions are auto-commuters.[44]

4.1.3 Cluster: Higher Education and Healthcare

Because higher education institutions are often co-located with other institutional anchors, intersecting labor pools and institutional partnerships will often yield an even denser cluster of inbound commuting in certain areas. Figure 14 highlights clusters of eds and meds with high numbers of in-commuters by car.

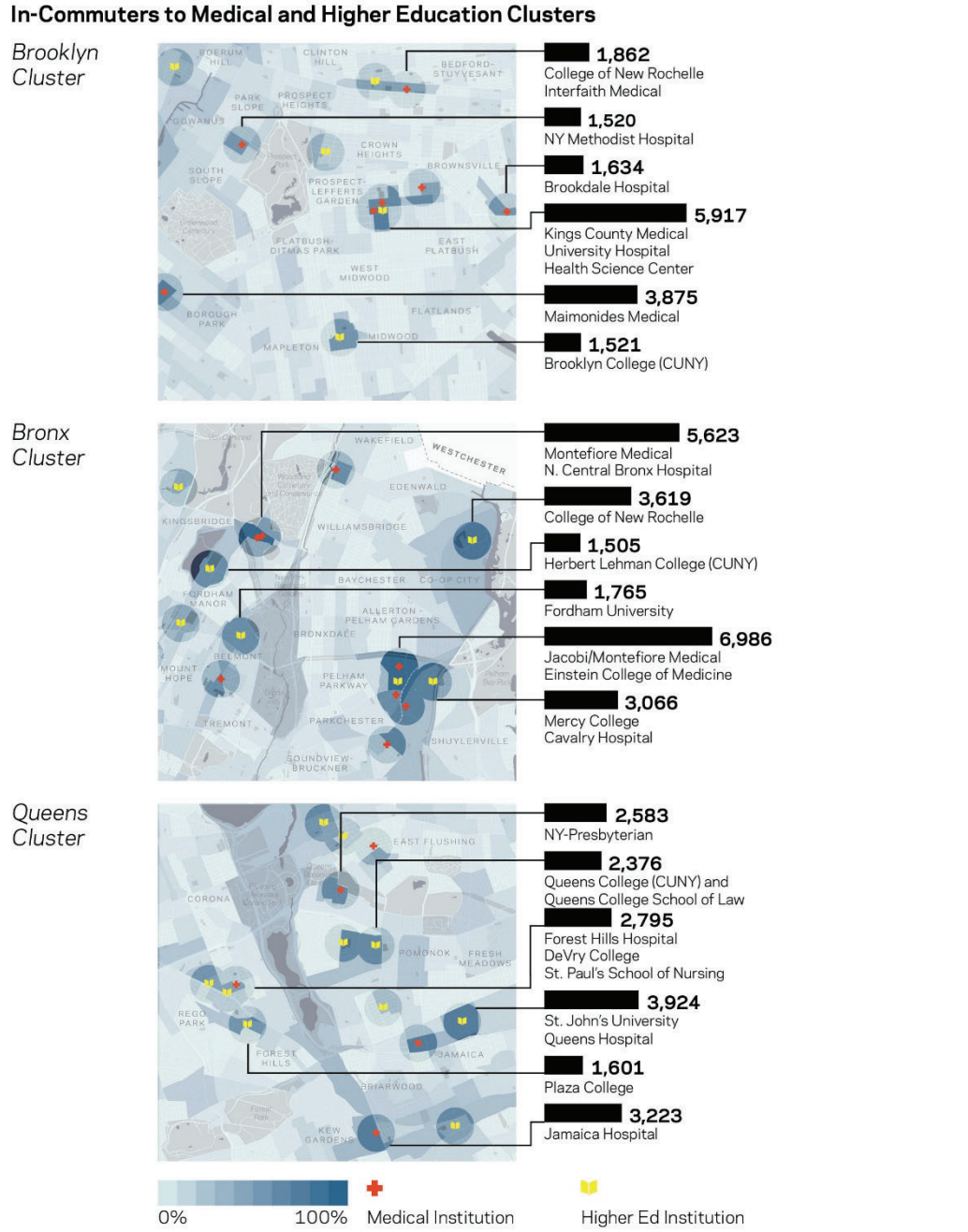
4.1.3.1 Select High Receiving Healthcare Institutions

- Fifty-four percent of 6,220 commuters in the census tract with Health Science Center at Brooklyn (SUNY) commute by car.[45]
- Sixty percent of 4,259 commuters in the tract with Kings County Hospital in Brooklyn commute by car.[46]
- Fifty percent of 8,136 commuters in the tract with Jacobi Medical Center in the Bronx commute by car.[47]
- Sixty-three percent of 2,187 commuters in the tract with Albert Einstein College of Medicine and Montefiore Medical Center—Jack D Weiler Hospital in the Bronx commute by car.[48]
- Eighty percent of commuters in the tract with Long Island Jewish in Queens commute by car.[49]
- Seventy percent of 3,585 commuters in the tract with New York Hospital Medical Center of Queens commute by car.[50]

4.1.3.2 Select High Receiving Education Institutions

- Fifty-four percent of inbound commuters in the census tract with SUNY Downstate College of Medicine (3,381 auto commuters) commute by car; 59% of commuters to adjacent tract with Kings County Hospital Center commute by car (2,536 auto commuters).[51]
- Nearly 70% of the inbound commuters in the census tract that includes York College in Jamaica, Queens are auto commuters.[52]
- Sixty-five percent of 3,674 commuters to tract with Queens College (CUNY) commute by car.[53]

Figure 14. Inbound Commuters to Medical and Higher Education Clusters



4.1.4 Cohort: NYC Municipal Employees and NYCDOE Personnel

A 2007 study completed by transportation analyst Bruce Schaller for the advocacy group Transportation Alternatives found that of the 177,300 government employees working south of 59th Street, 47,400 drove to work each day, a rate twice that of private sector employees.[54] Non-standard shifts and residential dispersion to communities without adequate transit access are two possible explanations for elevated rates of commuting by car. According to Fast City, Slow Commute, a March 2016 report on NYC commuting patterns, 30% of municipal workers live outside of NYC.[55] And the average commuting time in 2014 for employees engaged in public administration was 48 minutes, the third longest commute of any vocational group.[56]

4.1.4.1 NYC Municipal Employees

- A 2007 Transportation Alternatives study found that 47,400 government employees drove to work each day, a rate twice that of private sector employees.[57]
- Of drivers entering NYC's central business district who parked on-street, a Transportation Alternatives survey identified 6% who used a government-issued placard.[58]
- Twenty-three percent of public sector employees commuting into Manhattan used private autos in 2009.[59]
- Seventy-three percent of city employees reside in Nassau County.[60]

Further, according to a 2007 report from NYC's Independent Budget Office, one-fourth of the government employees in Manhattan who drive to work are NYCDOE employees who take advantage of on-street parking spaces designated for their use.[61] The NYCDOE employs nearly 135,000 people full time. In addition to teachers, these positions include administrators, teacher assistants, counselors, nurses, custodians, clerical staff, and security. Salaries range from about $25,000 to over $150,000 for full-time employees. Members of this cohort tend to commute during non-traditional travel times as many of these employees must arrive prior to 8:00 a.m. and end their day by 3:30 p.m.

A potential case study of this especially car-dependent cohort of NYC commuters can help model a methodology for micro-targeting EVSE deployment and calculating environmental benefit. NYC has over 3.4 million parking spaces on public streets, including 10,033 spots near schools that are designated for daytime (7:00 a.m.–4:00 p.m.) use by public school teachers.[62] Because parking availability is a significant consideration for teachers who drive to work, designated EVSE-equipped spaces may have

significantly more value as an EV purchasing incentive for this cohort than it might be for other types of car commuters. If only 1% of NYCDOE spaces were equipped with smart charging infrastructure, it would enable the annual displacement of as much as 461 metric tons of carbon dioxide (CO_2) by incentivizing the regular utilization of up to 100 EVs with NYCDOE personnel.[63]

Michael Sill, the United Federation of Teachers Director of Personnel cautioned against any approach that ultimately reduced the inventory of available spots for teachers but saw promise in exploring deployments near environmentally-themed schools and as well as at other schools that currently lack on-street parking designated for NYCDOE personnel. Sill emphasized that gauging the interest of UFT members at a given school and gaining their buy-in will be key to the success of any proposed EV strategy.[64]

4.1.4.2 NYC NYCDOE Personnel and Auto-Commuting

Key Takeaways:

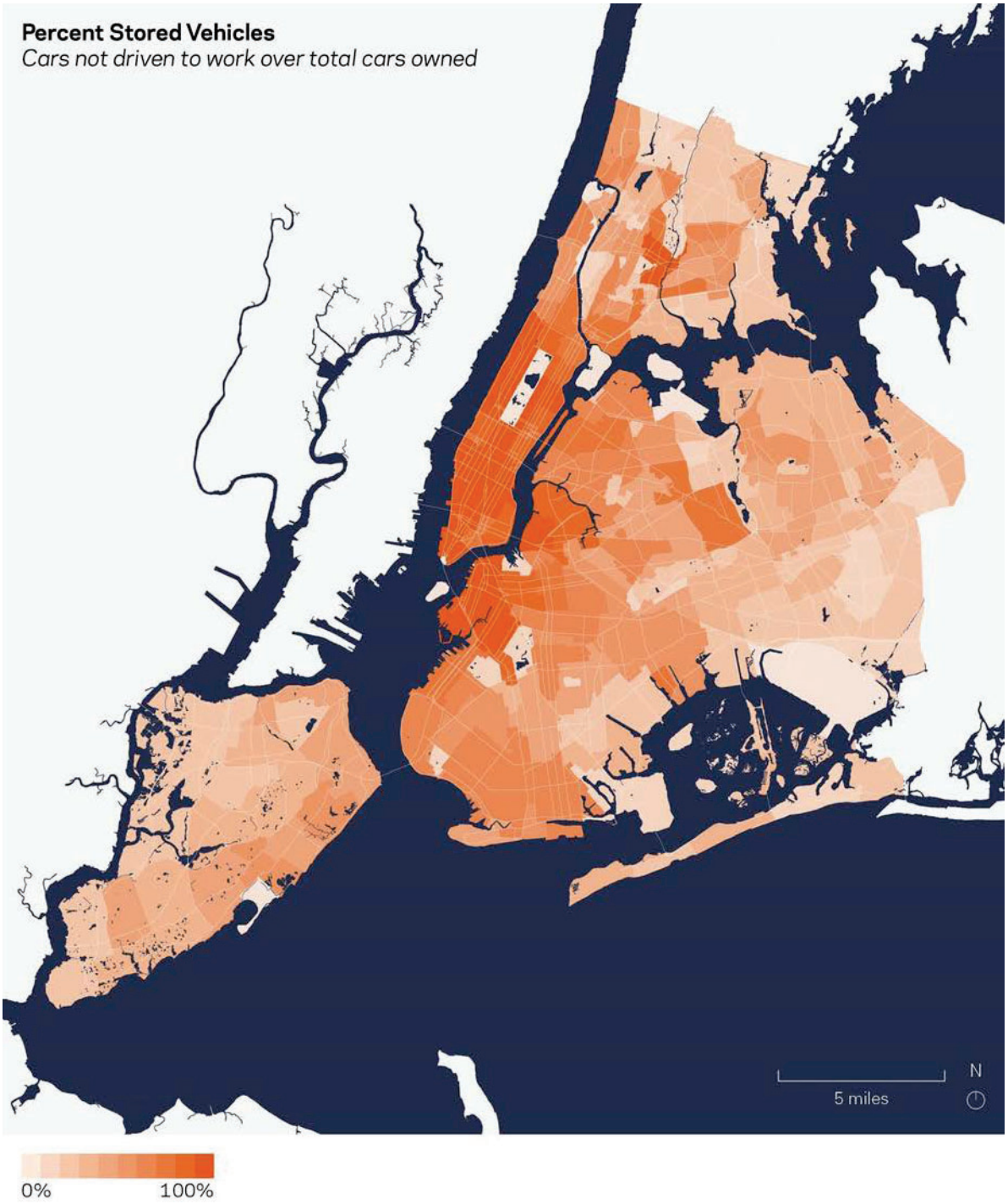
- Approximately 61,000 placards were issued to NYCDOE personnel (effective May 2017).
- NYCDOE permits are limited to assigned school, unless employee *floats* between schools.
- NYCDOE issues permits, but NYCDOT designates curb space.

4.1.5 Cluster: Medium to High-Density Communities

There is currently a market limitation for charging at home for New Yorkers who live in medium- to high-density residential zones with limited off-street parking. To meet the needs of *garage orphans*, or drivers without access to off-street parking in private driveways, building garages, or lots where charging infrastructure is typically installed, infrastructure needs to be installed where most drivers store their vehicles: on-street, at the curb. Since car owners make decisions about where to park based on parking availability in their neighborhoods, dedicating EV-only parking spaces in dense residential areas with high car ownership would be an incentive that could spur EV adoption.

According to NYCDOT's Citywide Mobility Survey, 53% of NYC car owners reported parking a least one car on the street.[65] Drivers who live in Northern Manhattan, Brooklyn, and the South Bronx are even more likely to store their vehicles on the street,[66] as seen in Figure 15, which shows the percent of stored vehicles (cars not driven to work over total cars owned) by neighborhood tabulation area. While street cleaning rules and a variety of use cases will inform vehicle turnover patterns in many communities, in neighborhoods such as Forest Hills—where 69% of households have at least 1 vehicle and 28% of commuters drive to work[67]—it is likely that regular usage will help ensure routinized turnover and preclude long-term furloughing of vehicles in EVSE-equipped spots.

Figure 15. Percent Stored Vehicles (Cars Not Driven to Work over Total Cars Owned)



4.1.6 Cluster: Leisure Destinations

NYC's many outer borough leisure destinations also present a ripe opportunity for EVSE deployment. Pools, parks, sports facilities, and cultural institutions with curbside frontage offer policymakers highly-visible locations. Destinations with ample nearby curb space—such as the Astoria Park Pool, the Red Hook Pool and Recreation Area, and the Brooklyn Children's Museum—also offer opportunities to address multiple use cases and efficient calendaring at the same location. The angled parking adjoining the Children's Museum, for instance, abuts a public school and is located across St. Marks Avenue from single and multifamily homes, largely without dedicated off-street parking. The Red Hook Recreation Area, meanwhile, offers a four-season menu of indoor and outdoor activities, including soccer, baseball, track, and basketball, as well as swimming. While several playing fields are currently closed to the public for an environmental cleanup, Little League baseball, youth soccer, several adult leagues, and a 44-year-old food truck marketplace still draw hundreds of visitors to the area evenings, weekends, and throughout the day in the summer months.

Curbside EVSE deployment near NYC Parks facilities like Red Hook and Astoria Park Pools can also augment the City's own off-street infrastructure by offering in-the-wild charging for municipal fleet vehicles. By positioning these units at strategic curb locations across the boroughs, NYC can ensure that its agency vehicles are never more than a short distance from charging opportunities when out in the field.

5 Complementary Uses

Optimizing the use of infrastructure associated with EVSE deployment will help build public support for curbside charging and avert the likelihood of failure. By identifying multiple use cases and user groups for a given deployment, public sector decision-makers can also address diverse mobile source emissions challenges with the same conduit infrastructure. A number of vocational, service, and delivery fleets, including emergency service vehicles, food trucks, and refrigerated hub vehicles used for home delivery of groceries are likely users of curbside power. In each case, NYC has an abiding policy interest in reducing fossil fuel consumption by these fleets, providing designated zones for them, or facilitating grid connections to power essential onboard functions.

Further, because it is assumed that uptake on light and medium duty EVs will continue to proceed slowly in the near term, additional users of curbside power will help accelerate return on public and private infrastructure investment and improve the business model for utilities and others engaged in power provision. While these complementary use cases would be unlikely to require a traditional Level 2 with a standard SAE J1772 connector, the work required to pull power to the curb and install a stub can be leveraged to support an array of diverse emissions-reduction applications and can future-proof the curb for emergent technologies.

5.1 Public and Private Fleet Range Extension

For medium duty electric vehicle fleets, range extension will serve an important function when typical route lengths are in excess of 70 miles per day. As UPS, FedEx, DHL, and national brands such as Frito-Lay increasingly integrate plug-in technologies into their fleets, their ultimate utility and cost-effectiveness will largely be determined by battery density and EVSE availability. Until the range of a medium duty EV with a full payload comfortably exceeds a typical route length, en route charging will provide a margin of comfort to drivers and help address variations in range owing to outside temperature, topography, and route-recalculating due to congestion or construction.

For public agency vehicles domiciled in NYC, curbside charging is especially crucial to a broader use of fleet EVs since few city and state agencies have sufficient off-street parking resources to accommodate their light-duty fleets. While an estimated 75% of all public fleet EVs statewide are deployed by NYC agencies, the contingent of EVs in the New York State fleet is expected to grow significantly to meet Governor Cuomo's Clean Fleets New York mandate as well as the Zero Emission Vehicle Action Plan's 2025 light-duty EV target of 25% of all State vehicle purchases. Due to the anticipated growth in the

count of State government EVs and the already significant and growing number of NYC fleet EVs, charging infrastructure near city and State offices will have to grow accordingly. As noted in the previous section, charging *in-the-wild* is one tactic for addressing the lack of depot infrastructure and safeguarding against battery depletion due to route changes, weather conditions, or other unforeseen circumstances. Curbside infrastructure deployment represents the only viable strategy to support in-the-wild charging and compensate for the scarcity of off-street parking for fleet EVs.

5.2 Auto Dealerships

In other U.S. markets—notably, Indianapolis—conflicts have emerged between EVSE operators and local businesses fearful of losing valuable parking spaces.[68] Auto dealerships that sell and service EVs are a notable exception and are among the business district stakeholders most likely to embrace and benefit from curbside charging infrastructure. Such siting can offer customers convenient charging and, importantly, offer the dealership a highly visible marketing tool for its plug-in vehicles. "It's almost a necessity for all dealerships to have electric charging facilities for use by the customers and the public at-charge," observed Steve Dorn, Senior Vice-President, Milea Auto Group. "If I have chargers curbside, I'll have people that will come inside the showroom, people who appreciate that they're coming to a facility that can accommodate their needs."[69] As the number of different new EV models on the market continues to increase, so will the number of used all-electric and plug-in hybrid models, making them more affordable. A fair number of these models, especially model years 2015–2019, will be taken to dealers for parts and service. This development presents additional demand for curbside charging.

5.3 Emergency Vehicles

Leveraging power provision infrastructure for use by emergency vehicles can mitigate impacts of idling by emergency vehicles with onboard power requirements. One NYC emergency medical provider, Northwell Health's (formerly North Shore-LIJ hospital system) Center for Emergency Medical Services has been under contract with the New York City Fire Department (FDNY) since 1998 and today responds to over 7,000 emergency calls each month, transporting over 4,500 patients to hospitals throughout the New York Metropolitan area.[70] Northwell reports that its vehicles can idle for up to 12 hours per day at various staging locations around the City, which include designated street corners, locations in Central Park, and emergency bays at hospitals.[71]

Idling impacts from ambulances can be substantial, reported Paul Power, Director of Workforce Safety Operations for Northwell.[72] The trade magazine *Fire Apparatus* reports that an ambulance discharges an estimated 45 tons of particulate matter annually due to idling. For every hour it idles, a typical ambulance consumes an estimated 1.5 gallons of fuel and produces 33 pounds of carbon dioxide.[73] Discharging exhaust into high-density residential areas and or in the vicinity of emergency rooms or ambulatory care facilities presents a public health challenge for a healthcare organization but ambulances that do shut off their engines run the risk of degrading temperature-sensitive blood products and medications stored in onboard refrigeration units. Further, keeping an ambulance in *ready-mode* and its communications fully operational are essential to minimizing response time. Plugging into curbside power sources would reduce environmental impacts, minimize fuel consumption, and enhance driver health by limiting exposure to exhaust and engine vibration.

Both private and public emergency service providers pre-position ambulances at strategic locations citywide. In 2013, Northwell reported that it had 100 emergency vehicles with systems that could plug in to a curbside 110V, 20–40A service.[74] FDNY, meanwhile, stations its ambulances at *atoms*, or sectors within a police precinct but these locations are regularly re-evaluated based on the volume of service calls and are typically modified accordingly.[75] MOVE Systems, a supplier of power provisioning equipment to emergency vehicle fleets, entered into a contract with the City in 2016 to install 30 ambulance charging pedestals in Brooklyn, Queens, and The Bronx.[76] While FDNY favors a grid connection since it provides longer run time than battery packs, the dynamic nature of the atoms siting process may complicate efforts to identify permanent locations for such infrastructure.

5.4 Food Carts and Food Trucks

Food trucks offering prepared foods and beverages to curbside patrons typically rely on diesel or gasoline generators to power onboard appliances and refrigeration systems. Food trucks operate throughout the City but in recent years have proliferated in neighborhoods with large numbers of office workers and tourists. Simply Grid, a MOVE Systems subsidiary, launched a food truck electrification pilot in Union Square in 2013 and has installed similar technology at food truck parks in Atlanta and Austin.

Absent the development of EVSE units with a separate outlet for 120V and 220V appliances, new conduit for curbside charging stations could nonetheless be leveraged to provide a dedicated grid connection for food trucks. Such food truck pedestals could offer NYCDOT a point of leverage to incentivize vendors to shed their diesel generators. By establishing *green* criteria for prime locations, NYCDOT could

encourage vendors to meet their onboard power needs via shore power rather than liquid fuels. And by collocating grid-connected food trucks and carts in an EVSE-equipped curb, NYCDOT could optimize the spread the cost of grid connectivity over multiple users and use cases.

The challenge of separately metering these diverse customers in this and other multi-user scenarios may, however, prove difficult to overcome. One possible solution would be the master metering of the EVSE operator and submetering of non-EV uses.

5.5 Grocery Home Delivery

A fifth category of vehicles that could benefit from curbside power provision are refrigerated *depot* vehicles, such as those used by grocery home delivery services. These vehicles function as curbside distribution hubs for FreshDirect, NYC's leading online grocer, serving teams of handcart-equipped *runners* who execute last-mile delivery within a 10-block radius of the stationary truck. Typically, used in Manhattan, the depot model utilizes designated—but not guaranteed—spots that are occupied throughout the delivery day by multiple 24-foot refrigerated trucks. "All parked trucks are placed strategically throughout the City, serving as hubs to reduce side street congestion," stated David Helfenbein, a spokesperson for FreshDirect, in a 2016 prepared statement to an Upper West Side community board that had expressed concerns about engine noise and emissions from the parked truck.[77]

These depots on wheels are the catalyst for regular noise and air quality complaints by New Yorkers living and working near these hubs.[78] According to FreshDirect's fleet management team, quiet, zero-emission refrigeration systems are crucial to improving community relations and reducing quality of life complaints in the communities the company serves.[79] A time-limited loading zone equipped with a grid connection could provide safe harbor for such refrigerated delivery vehicles, a deep reduction in fossil fuel consumption and associated air quality impacts, and an elimination of noise from diesel-powered truck refrigeration units (TRUs). Conduit infrastructure could provide both shore power for TRUs during loading-zone hours and distribution to EVSE units on the same block, enabling a potential time-sharing system serving passenger vehicles in the overnight hours and delivery trucks during the business day.

5.6 Carshare Vehicle Charging

A number of carshare services have incorporated EVs into their vehicle fleets, including General Motors's Maven, Daimler's Car2Go, and BMW's ReachNow. For free-floating services—those that station vehicles in the public right-of-way within a designated *home area*—the presence of a reliable and accessible charging network is key to viability and growth.[80] Curbside charging for these services offers another path to building EV infrastructure prevents Level 2 infrastructure from going unused.

In Seattle, Portland, Indianapolis, and especially Los Angeles, free-floating car services have yielded curbside deployments that support carsharing services. While some carshare models require exclusive access to their curbside infrastructure, others like BlueIndy in Indianapolis are open to other EV drivers who become *charging members* of the program.[81] While the carshare service provides critical baseload demand, the growing cohort of other EV drivers can fill gaps in utilization and help optimize the asset.

5.7 Pedal-Assist eBike Charging

In June 2018, the NYC Council legalized the use of Class 1 pedal-assist electric bicycles on NYC streets. In other cities where they have been piloted, *eBikes* are typically recharged by roving battery swap teams or dropped at a neighborhood charging center. JUMP Bikes, a dockless eBike service based in the Brooklyn Navy Yard, offers riders in some of its host cities incentives to deposit bikes at charging locations.

CitiBike, which will be rolling out its own electric bicycle to coincide with the April 2019 L train service stoppage, will utilize eBike *corrals* at either end of the Williamsburg Bridge to collect bikes for recharging.[82] JUMP, CitiBike, and other new entrants into the pedal-assist eBike market will all require electrified hubs for charging battery packs—pairing these hubs and EVSE units can offer the City economies of scale for running power to the curb and cost-sharing between vendors.

6 Policy Actors and Regulators

A number of City, State, and even non-governmental entities have oversight or regulatory authority over the installation of curbside charging stations in NYC. Table 2 summarizes agencies, entities, and guidance documents with significant oversight. The streamlined and expedient deployments of curbside EVSE will require that utilities, NYC, and NYS agencies work together. Key stakeholders include NYCDOT, Con Edison, the Public Design Commission (PDC), and the Mayor's Office. Site-by-site deployments may trigger review by NYSDOT, NYC Parks, and NYC Department of Buildings.

Table 2. Policy Actors and Regulators

	Entity	Regulation	Function
City	**City of New York**	City Administrative Procedure Act (CAPA)	City agencies are empowered to adopt rules necessary to carry out the powers and duties delegated to it by or pursuant to federal, state, or local law.
	NYC Department of Buildings	NYC Charter, Section 643 (6 and 7); NYC Electrical Code (Local Law 39 of 2011)	Enforces NYC electrical code (as well as national model codes and standards) and approves major electrical installations; inspects completed electrical installations performed by private electricians.
	NYC Department of Finance	Official Compilation of Rules of NYC (Title 19, Chapter 39)	Adjudicates and collects fines from parking tickets.
	NYC Department of Transportation	Section 4 of Title 34 of the Rules of New York; Parking Rules of NYC [4-08(p)(3)]; Revocable Consents	Responsible for the safe, efficient, and responsible movement of people and goods; sets restrictions on hospital and school zones; sets framework for the issuance of permits and revocable consents.
	NYC Public Design Commission	Rules of the City of New York (RCNY)	A binding design review agency with jurisdiction over permanent structures proposed on or over City-owned land.
State	**NYS Department of Transportation**	Region 11	Jurisdiction over highway viaducts and entrance/exit ramps; sets standards on signs and street markings.
	NYS Public Service Commission	Public Service Law	Maintains jurisdiction over transactions between utilities, owners, and operators of charging stations.
Federal	**Federal Highway Administration**	MUTCD under 23 U.S.C. 109(d) and 402(a)	Provides general guidance to ensure that design and placement of signage is in substantial conformance with FHA standards.
	U.S. Department of Justice	2010 ADA Standards for Accessible Design	Sets enforceable accessibility standards required for all new construction and alterations (adopted March 15, 2012).
Other	**AASHTO**	A Policy on Geometric Design of Highways and Streets	A standards setting body that coordinates among DOTs nationwide. ("The Green Book")
	Con Edison	Specifications for Electric Installations	Provides electrical utility service and connection to the grid; reviews and approves meter installation and electric service.

6.1 NYC Agencies

6.1.1 New York City Department of Transportation

The New York City Department of Transportation (NYCDOT) is responsible for the safe, efficient, and environmentally responsible movement of people and goods. The department enforces regulations related to passenger and commercial vehicles and their use of City streets. The City Charter enables NYCDOT to regulate these activities with extensive authority. Enumerated powers include rulemaking authority for the conduct of traffic,[83] design, installation, location and maintenance of street signs,[84] providing recommendations and proposals to the mayor on policies regarding street improvements and establishing parking areas,[85] establishing parking meter zones,[86] enforcing parking laws, rules, and regulations,[87] controlling construction, maintenance and repair of public streets,[88]and regulation of the use and transmission of electricity over, under, and across streets and public places.[89] Although these provisions do not mention terms such as sidewalk or curb, NYCDOT defines sidewalk as the following:

> That portion of a street, whether paved or unpaved, between the curb lines or the lateral lines of a roadway and the adjacent property lines intended for the use of pedestrians. Where it is not clear which section is intended for the use of pedestrians, the sidewalk will be deemed to be that portion of the street between the building line and the curb.[90]

Thus, NYCDOT jurisdiction over streets includes curbs and sidewalks. Given this regulatory framework, NYCDOT has broad authority to plan and implement a pilot curbside EVSE deployment, as well as a more expansive curbside EVSE program.

NYCDOT's guidance documents include: DOT Street Design Manual (SDM), Manual on Uniform Traffic Control Devices (MUTCD), AASHTO Policy on Geometric Design of Highways and Streets and ADA Standards for Accessible Design.

Although this feasibility study involves a pilot deployment, a formal process for expanded deployment of curbside EVSE—as well as specifications regarding locations and space allocation, and limits and manner of operation—can be codified in a municipality's official rules and regulations. In NYC, new rules take effect by following the requirements of the City Administrative Procedure Act (CAPA).[91] Each City agency is empowered to adopt rules necessary to carry out the powers and duties delegated to it by or pursuant to federal, state, or local law.[92] Under CAPA, an agency identifies an issue, drafts a rule to address it, and then notifies the public of the draft rule along with related hearings to be held.[93]

The agency must give notice to the members of the City Council, the office of the Corporation Counsel, local media, community boards, and civic organizations.[94] The proposed rule is subject to review by the Corporation Counsel and the Mayor's Office.[95] The agency follows a public hearing process that allows for public comment on the proposed rule.[96] After governmental review and public comment, if there are no complications with the rule drafting process or delegated authority to adopt the proposed rule, the agency publishes and formally adopts the final rule.[97]

6.1.2 New York City Department of Buildings

The New York City Department of Buildings (NYCDOB) and its electrical unit enforce the requirements of the NYC Electrical Code and applicable national regulations. For installation by a private electrician or firm, NYC requires a permit for new installations that require 600 or more volts,[98] which exceeds the 240 volts needed for a Level 2 charger. However, lower voltage installations may be subject to an inspection by a NYCDOB electrical inspector.[99]

Service equipment must bear the approval label of a testing laboratory, such as Underwriters Laboratories UL, acceptable to the NYCDOB Commissioner or approved by the NYCDOB Electrical Advisory Board.[100] In some cases, the model codes defer to local code enforcement authority for such approval. For example, the 2017 National Electric Code (NEC) edition section on flexible cords states the following:

> 404.4 Types. Flexible cords and flexible cables shall confirm to the description in Table 400.4. The use of flexible cords and flexible cables other than those in Table 404.4 shall require permission by the authority having jurisdiction.

Therefore, deviations from UL, SAE and NEC standards should be approved by NYCDOB Electrical Advisory Board (see also Con Edison section).

Generally, a private electrician's permit application to NYCDOB would include the proximate address to the curb location for the proposed EVSE. However, if locations are near street corners, the address of the nearest building may be insufficient. Therefore, using latitude and longitude coordinates would provide more accurate information. Additional questions about waivers, streamlining the application process, or novel issues should be referred to the NYCDOB Chief Electrical Engineer.

Under the NYC Charter, section 643 Items 6 and 7 give NYCDOB broad authority to regulate, inspect and test the EV charger. These sections state that NYCDOB is responsible for the following:

> (6) the regulation, inspection and testing of gas and electricity used for light, heat and power purposes, electric, gas and steam meters, electric wires and all lights furnished to the city; and
>
> (7) the regulation, inspection and testing of electric wires and wiring apparatus and other appliances used or to be used for the transmission of electricity for electric light, heat, power, signaling, communication, alarm and data transmission in or on any building or structure in the city…

NYCDOB has indicated that if NYCDOT infrastructure is used for curbside charging, such as streetlights, then no permit is necessary. However, NYCDOB has not taken a position on what is required for curbside EVSE that draws electricity from sources other than the lines that power streetlights.

6.1.3 New York City Department of Finance

The NYC Department of Finance (NYCDOF) adjudicates summonses and collects parking fines and also acts as the City's chief civil law enforcement officer, among other tasks. It is presumed that NYCDOT has and will continue to confer and coordinate with DOF on the curbside EVSE pilot program regarding articulation with muni-meter system, averting loss of parking revenues, and crafting strategies for bundling fare collection and charging fees.

6.2 NYS Agencies

6.2.1 New York State Department of Transportation

The New York State Department of Transportation (NYSDOT) has jurisdiction over highway viaducts and entrance/exit ramps. NYSDOT is responsible for maintaining and repairing this infrastructure. As a result, NYSDOT requires access under such infrastructure for routine maintenance as well as necessary repairs. Therefore, any EVSE considered for deployment under such infrastructure would need the approval and input of NYSDOT.

NYSDOT also provides the guidelines and standards for traffic control devices and street signs (see discussion of federal Manual on Uniform Traffic Control Devices). Therefore, any street signs or pavement markings within NYSDOT Right of Way that accompany curbside EVSE would need to meet NYSDOT standards.

6.2.2 New York State Public Service Commission

New York State Public Service Commission (PSC) ensures the safe, secure, and reliable access to electric services for New York State's residential and business consumers at just and reasonable rates. Under the Public Service Law (PSL), the PSC's jurisdiction extends to the manufacture, conveying, transportation, sale, or distribution of electricity for light, heat, or power to electric plant and to the entities owning, leasing, or operating electric plants. Thus, the PSC regulates Con Edison, NYC's main utility, and a key player in the deployment, installation, and powering of curbside EVSE.

In 2013, the PSC ruled that it does not have jurisdiction over publicly available EV charging stations. Specifically, it ruled that the Public Service Law does not provide the commission with jurisdiction over (1) publicly available electric vehicle charging stations, (2) the owners or operators of such charging stations, so long as the owners or operators do not otherwise fall within the PSL's definition of *electric corporation*, or (3) the transactions between the owners or operators of publicly available electric vehicle charging stations—which do not otherwise fall within the PSL's definition of *electric corporation*—and members of the public. [101]

The PSC followed the recommendations of responders it solicited such as NYSERDA, NYPA and NYC, who suggested that the PSC refrain from asserting jurisdiction over publicly accessed charging stations. These responders also acknowledged the need for utility test piloting projects involving EVs to better determine rates for consumers.[102] The PSC determined that charging stations do not fall within the definition of *electric plant* because charging stations are not used for or in connection with or to facilitate the generation, transmission, distribution, sale, or furnishing of electricity for light heat or power. Instead, and as urged by several comments, charging stations are used to provide a service, specifically, charging services. This service requires the use of specialized equipment and allows the customer to do only one thing—charge a PEV's battery. The primary purpose of the transaction between charging station owners/operators and members of the public is the purchase of this service and the use of this specialized equipment. While the customer is using electricity, this is incidental to the transaction.

The PSC qualified its ruling by stating it acknowledged the recommendation in some of the submitted comments which specified the PSC should maintain its ability to respond to the market as it evolves. The commission also (1) underlined that the ruling does not diminish its ability to respond to changes in markets where charging stations operate, (2) maintained continuing jurisdiction over the transactions between electric distribution utilities and the owners and operators of charging stations, and (3) noted that other entities may assert oversight of safety issues, such as installation and connection.

6.2.3 New York State Department of Agriculture and Markets

The New York State Department of Agriculture and Markets regulates devices used to sell commodities, such as fuel through its Bureau of Weights and Measures. The Bureau also oversees municipal programs, such as the New York City Department of Consumer Affairs' regulation of weights and measures. The Bureau has incorporated the national standards for specifications, tolerances, and regulations for commercial weighing and measuring devices adopted by the 98th National Conference on Weights and Measures 2013 as published in the National Institute of Standards and Technology Handbook 44, 2014 edition.[103] The handbook is currently a non-enforceable code, but NYS may change its approach to regulating EVSE. For example, it has recently purchased a testing standard for EVSE.

6.3 Federal Agencies

6.3.1 Federal Highway Administration

The implementation of EV-only parking will require appropriate signage to ensure safety, efficiency, and maximized benefits. The U.S. Secretary of Transportation, under authority granted by the Highway Safety Act of 1966, decreed that traffic control devices on all streets and highways open to public travel in accordance with 23 U.S.C. 109(d) and 402(a) in each state shall be in substantial conformance with the standards issued or endorsed by the Federal Highway Administration (FHWA). The Manual on Uniform Traffic Control Devices (MUTCD) is administered by the FHWA and serves as the national standard for all traffic control devices installed on any street, highway, bikeway, or private road open to public use. States or other federal agencies that have their own MUTCDs must be in substantial conformance with the FHWA administered MUTCD and must maintain such substantial conformance.[104] NYS adopted the MUTCD 2009 Edition in 2010 and promulgated the NYS Supplement to the Manual for Uniform Traffic Control Devices for Streets and Highways in 2011.[105] NYCDOT rules require that all permittees comply with the most recent version of the MUTCD and the NYS Supplement.[106]

6.4 Other Policy Actors and Regulatory Factors

A number of non-governmental entities are positioned to play roles in NYC's curbside EVSE implementation strategy, including Con Edison, Business Improvement Districts (BID), and local merchants' associations.

6.4.1 NYC Electric Vehicle Advisory Committee

NYC's Electric Vehicle Advisory Committee (EVAC) is tasked with reporting on the progress of the curbside EVSE pilot deployment. The EVAC was established in 2013 to make recommendations on strategies to promote EV use, including methods to enhance the availability of EVSE.[107] The members of EVAC consist of the (1) NYCDOT Commissioner, who serves ex officio and appoints a chairperson and an industry representative, (2) Commissioners of NYCDOB and the New York City Department of Environmental Protection (NYCDEP) and the Director of the Office of Long Term Planning and Sustainability, or their respective designees, (3) Speaker of the City Council or his or her designee, (4) five borough presidents or their designees, and (4) transportation and environmental advocates appointed by the NYCDOT commissioner.[108] The committee is also tasked with compiling a database of EVSE locations for dissemination to the public, engaging with employers on workplace charging, and enhancing regional data collection.[109] The EVAC could have a significant impact on the early evolution of curbside EVSE and interagency coordination because its members represent agencies that oversee regulation, enforcement, funding, and policy related EV and EVSE deployment.

6.4.2 Con Edison

Con Edison is the main electric utility for NYC's metropolitan area. The curbside EVSE deployments contemplated by this study will need to be closely coordinated with Con Edison and adhere to all the utility's connection protocols. Furthermore, Con Edison will invest up to $25 million on demonstration projects that will test strategies for increasing the number of EVs in the region, including a pilot program that will install up to 60 dual-port Level 2 charging stations on NYC streets. As such, Con Edison is an indispensable partner in the planning and development of curbside EVSE in NYC.

In a curbside EVSE installation, charging equipment can be connected to the grid under several different scenarios. Two potential pathways for electrical service to a curbside Level 2 include the following methods:

- Adding a second 208V leg through a street light
- Extending service from an adjacent metered property housing a receiver, such as a retail location

Although there is no precedent for curbside charging in NYC, the typical approach for obtaining a new service connection is for an electrical contractor to submit a load letter to Con Edison's online project center.[110] *Electric Vehicle Supply Equipment* is listed on the utility's website as one of its service requests.[111] The load letter triggers an engineering review of what size service is needed and an order of magnitude cost estimate for the service. Because EVSE would be placed in the public right-of-way, charging stations would be deemed as temporary services that are paid for by the customer.

Con Edison has also suggested an *adopt a charger* model that would rely on other non-governmental actors such as outdoor advertising firms seeking advertisement placement and co-branding opportunities or on merchant associations seeking to differentiate their commercial districts. Private contractors are required under NYCDOT rules to provide a public service corporation such as Con Edison at least 48 hours' notice prior to breaking ground where its pipes, mains, or conduits are located.[112]

6.4.3 Business Improvement Districts and Merchants Associations

While NYC Business Improvement Districts (BIDs) have no official oversight authority over curbside activity, their services typically include street and sidewalk cleaning and sanitation, landscaping, security, and capital projects that all may impact conditions at the curb. BIDs and their leadership typically exercise *informal authority* in their catchment areas and are key channels for engagement with local businesses and institutions. Achieving consensus for EVSE deployments and promoting their use in and around BIDs will rest in part on addressing the concerns of BID leaders and members.

While fears about parking availability inevitably arise in commercial districts where EVSE deployment is contemplated, some BIDs and merchant associations may be especially disposed to the implementation of curbside EVSE, both for marketing purposes and to help meet internal sustainability objectives.

7 Local Impediments to Successful Deployment and Utilization

The relatively low levels of EV penetration among even environmentally savvy New Yorkers represents the single most significant barrier to wider deployment and acceptance of EV charging infrastructure in the public right-of-way. According to *The Los Angeles Times*, battery electric and plug-in hybrid cars sales represented a little more than 1% of the 17 million cars and light trucks sold in the U.S. in 2017.[113]

The culture of car ownership and parking in NYC also presents significant challenges to optimization of infrastructure and efficient calendaring of curbside EVSE. NYC car owners who do not use their vehicles to commute typically incur long dwell times in the same parking space, moving a vehicle only to comply with alternate side regulations. In neighborhoods with one day alternate side regulations, this use pattern can result in vehicles furloughed for up to seven days at a time. Under such circumstances, an EV driver could maintain a virtual monopoly of an EVSE-equipped parking space, limiting the broad utility of curbside deployment and undercutting its usefulness as an incentive to replace an internal combustion engine (ICE) vehicle with an EV.

Beyond these foundational challenges, the potential barriers to success for curbside deployment can be segmented into three broad categories:

- Public perceptions and aesthetic concerns
- Technical and jurisdictional challenges
- Technological change

7.1 Public Perceptions and Aesthetic Concerns

Impediments associated with public perceptions include concerns among business owners and residents about parking availability in both residential neighborhoods and along commercial corridors. Based on research conducted in The Hague, residents who rely on street parking will likely be resistant to a change perceived as limiting or reducing the inventory of available parking spaces.[114] Similarly, merchants who depend on ready access to on-street parking to drive retail traffic may fear that EV-designated spaces will increase parking pressures and result in a decline in sales and other business activity.

Both residents and other community stakeholders will also likely have concerns about perceived hazards associated with EV charging. Certain concerns—such as tripping hazards—will be more justified, while others will likely be overstated, such as danger of electrocution, fire, and attracting criminal mischief. Concerns about energy usage and impacts on the grid may likewise cause some to question the value of public charging infrastructure. Fears that EV charging will compete with other electrical uses, result in brownouts or drive up utility costs have been especially pronounced in the U.K., where publicly accessible charging infrastructure is common.[115]

Concerns about congestion are also a likely point of contention. Because the presence of EVSE units may attract EVs to a spur street or commercial corridor, residents, business owners, and certain institutional stakeholders may fear that curbside deployments will increase congestion in a community.

Finally, merchants, institutional stakeholders, and residents may have aesthetic concerns about the appearance of EVSE units, especially in or around historic districts, and the visual clutter that any new street furniture or infrastructure introduces to the curb.

7.2 Technical and Jurisdictional Challenges

In busy commercial districts, the proximity of proposed EVSE units to CitiBike docking stations, LinkNYC kiosks, and Select Bus Service fare collection machines could complicate installations and prove disruptive to the flow of pedestrian traffic. In other settings, such as under expressway viaducts, the availability of 3G cellular and Wi-Fi service or grid access may be limiting factors, adding cost and complexity to installations. Adding to the complexity of under-viaduct deployments are jurisdictional issues between NYSDOT and NYCDOT which share joint responsibility for many such locations.

In other non-standard deployments, such as angled parking and highway off-ramps, cord management and associated risks are likely to surface as both technical concerns and matters of safety for motorists and pedestrians. For deployments near highway exit ramps, EV drivers entering a travel lane to plug in or disengage a power cord on a vehicle's street-side may be at risk from cars exiting the highway. Angle parking on more conventional streets creates similar cord management and safety challenges, especially for vehicles with front charge ports—such as the Nissan LEAF and Audi e-trons—utilizing back-in only spaces. Pedestal-mounted EVSE units in reverse angle parking settings may also be more likely to sustain damage from vehicle impacts.

Technical issues around signage, including visual symbols selected and foreign language translation, will also need to be addressed. Some communities are likely to advocate for signage in multiple languages due to the prevalence of drivers from three or more distinct linguistic groups. Additional signage in commercial districts may also be subject to scrutiny by BIDs and merchant associations seeking to reduce curb clutter as well as community organizations concerned about distracted driving.

7.3 Technological Change

As noted earlier, EV technology and the technical specifications for traction batteries and associated charging infrastructure continue to evolve. Changes in the size, weight, and energy density of battery packs, improvements to charging equipment, and the emergence of wireless charging, as well as enhancements to the grid and connectivity will all likely transform the process of EV charging, reducing charge times, and enhancing ease of use for the motorist. Dynamism in the battery market and the rate of overall change in the transportation sector may prove disruptive to near-term efforts at EVSE deployment, as fast charging and wireless solutions become increasingly viable and more energy dense batteries result in longer intervals between charges.

8 Estimated Impacts

8.1 Charging Pilot Impacts

The study team estimates that every curbside charge port installation will enable 1.2–3.8 new EVs in NYC. An investment of up to 120 charge ports in 60 dual-port Level 2 charging stations, as proposed by the NYCDOT and Con Edison charging station pilot, would prompt an estimated 165 to 461 car owners to switch to an EV. Assuming that EV vehicle miles traveled will replace existing ICE vehicle miles traveled, such an investment would result in annual emissions offset of 145 to 406 tons of carbon dioxide (CO^2) per year, summarized in Table 3.

Table 3. Estimated Greenhouse Gas Offset

Inputs		*Low*	*High*
Investment	EV Charging Ports	120	120
Utilization Assumptions	Charge Port Occupancy Rate (percent)	20%	40%
	Charging Hours per Day per EV	3.50	2.50
Results			
Electric Vehicles	Additional EVs per Charging Port	1.2	3.8
	Cumulative EVs Added	165	461
Emissions Reduction (tons of CO^2 emissions)	Yearly	145	406
	After Three Years	435	1,217
	After Five Years	724	2,028

Analysis suggests that the shorter charging events result in greater GHG emissions savings, since higher turnover allows for charge ports to accommodate a greater number of EVs. Thus, co-locating EVSE in time-limited parking zones—ideally 2-hour to 4-hour zones that can accommodate two to four short-charging events during the day and one long-charging event at night—is a strategy that supports favorable charging station turnover and GHG emissions reductions. Siting charging stations on metered spur streets where parking is typically limited to under four hours offers the greatest opportunity for offsetting GHG emissions.

8.2 Model and Assumptions

There is a considerable amount of uncertainty in predicting the impact that curbside charging infrastructure will have on GHG emissions offsets given that there is very little precedence or historical data that analyzes the relationship between curbside EVSE, EV adoption, and EVSE utilization—largely because the curbside charging programs in North America are still in infancy. To be cautious in terms of accounting for the uncertainty, the model tests low- and high-utilization scenarios to create a range for GHG impacts associated with new curbside ports.

Calculating GHG emissions offsets is largely a factor of each port's utilization rate, which is made up of two inputs that change in the two scenarios. The *low* scenario assumes that charging ports will be actively charging 20% of the time, with the EVs charging an average of 3.5 hours daily. The *high* scenario assumes 40% occupancy (twice that of the low scenario), with EVs charging an average of 2.5 hours daily.[116]

8.2.1 Utilization Scenario Inputs

8.2.1.1 Port Occupancy Rate

The percent of time an EV is actively charging at a port.

According to NYSERDA's 2016 Data Summary, the charging stations monitored had an average occupancy rate of 6.5%. However, the best performing stations, all located in the NYC Metro area in university or medical center parking lots, had an average occupancy rate of 20%.[117] If charging stations are installed according to the guidance set forth in this report, policymakers can expect a similar port occupancy rate for the *low* scenario. Given EV sales trends, improvements in EV technology and affordability, and 24-hour use case for curbside charging in NYC, this occupancy rate stands to be much higher, conservatively set as twice the base rate in the *high* utilization scenario.

8.2.1.2 Charging Hours Per Day

Average number of hours each EV spends charging (daily).

New Yorkers and commuters driving into NYC drive an average of 9 miles per day.[118] Given the energy needs for such driving patterns, it is reasonable to expect that an EV owner will require three 6-hour to 8-hour charge events per week (or 2.5 to 3.5 hours per day) at a Level 2 port.

8.2.2 Assumptions

- There is a linear relationship between charging station installation and EV growth.
- There is a strong relationship between curbside EVSE and EV adoption, as mentioned previously and documented in research.[119]
- Each new EV will replace an existing ICE, yielding a net zero increase in total vehicles.[120]

A more complex model could estimate the marginal effect of each charge port on EV adoption, occupancy rate, and charging demand. The rise of EVs as a mass-market good is a relatively recent trend; though growth has been robust in NYC, NYS, and nationwide since 2012, this does not constitute enough historical data to build a more dynamic model. Estimates of EVSE infrastructure investments on EV adoption exist at the national level,[121] but even these are variable. At the local level, they are often just as variable.[122]

9 Recommendations

The following recommendations are based on models and best practices for Level 2 planning from other jurisdictions, conversations with NYC policymakers, utilities, arbiters of public space, and others. The recommendations herein are tailored towards the proposed NYCDOT and Con Edison curbside pilot program that will install up to 60 dual-port Level 2 charging stations, scheduled to launch in 2019. Additional recommendations related to on-street deployments can be found in Curb Enthusiasm: Deployment Guide for On-Street Electric Vehicle Charging (for the URL to the guidebook, see the abstract for this report).

9.1 Planning and Siting

1. NYCDOT should be responsible for location approval for siting.
2. NYCDOT should pursue a citywide EVSE siting approach that plans for a broad distribution of Level 2 units.
3. Limit the number of Level 2 clustered in one NTA until there is proven demand for multiple deployments.
4. Establish opportunities for stakeholder EVSE site requests, such as through an online portal, 311 requests, and requests through Community Boards. Encourage bulk EVSE requests from Business Improvement Districts, universities, medical institutions and other workplaces or other groups of community members. Policymakers and EVSE operators should factor in stakeholder requests for charging stations whenever possible.
5. Outreach to institutions adjacent to proposed Level 2 locations should be performed prior to final site selection.
6. NYCDOE and United Federation of Teachers representatives should be consulted regarding potential installations in select school parking zones.
7. NYCDOT should consult with NYSDOT on proposed curbside Level 2 to be located under NYSDOT-managed elevated highways, under viaducts, or highway ramps.
8. Prioritize sites close to an electrical panel, as trenching and laying new conduit can greatly increase costs and render sites financially unfeasible.
9. Evaluate the social equity benefits to and burdens on communities of color, low- and medium-income communities, and individuals with limited-English proficiency due to deployment of charging stations permitted through curbside pilot programs or permanent installations.
10. Design siting plans for Level 2 stations in accordance with NYCDOT guidance documents:
    - The NYCDOT Street Design Manual
    - Manual on Uniform Traffic Control Devices
    - AASHTO Policy on Geometric Design of Highways and Streets
    - ADA Standards for Accessible Design

11. Adhere to ADA accessibility standards for station design and installation. Curbside Level 2 should be sited so that people with mobility impairments can safely and comfortably navigate the sidewalk and at a height wherein the station's user interface is accessible.
12. Site selection should not interfere with upcoming projects in NYC's freight, transit, bicycle, and pedestrian master plans and capital projects that could impact deployment and operation. Applicants for all proposed curbside Level 2 sites should coordinate with NYCDOT's project construction and maintenance operations to identify future paving project conflicts, and with NYCDOB to mitigate conflicts with permitted construction projects.
13. Locating charging stations on metered blocks should be prioritized where possible. Such siting will support top-off charging in short metered zones where frequent daytime turnover is necessary for local business success.
14. The following street conditions and settings may present deployment challenges and should be avoided:

    - Along current or planned transit priority streets
    - Locations that interfere with bus layovers
    - Locations adjacent to protected bike lanes
    - Locations with frequent street closures for community activities (e.g., street festivals)
    - On peak-period restricted parking blocks
    - Locations in historic districts or close to a registered landmark may trigger additional design review

9.2 Permitting

1. Proposed sites should have a mandatory site survey in coordination with utilities (Con Edison) to determine financial feasibility of bringing power to the site and to avoid conflicts that might increase project complexity prior to initiating permitting.
2. Con Edison's online load letter request form should allow for GPS coordinates rather than address locations when submitting requests for power reviews. Such a strategy will lead to a more accurate assessment of the feasibility of supplying power to the site since many curbside locations may not have an associated address. See Appendix D for a case study on stakeholder request mechanisms.
3. NYCDOT should consult with the NYCDOB to ensure electrical code compliance, identify any appropriate waivers or exemptions from the electrical code, and maximize interagency coordination.

9.3 Signage and Enforcement

Curbside Level 2 should be signed as *electric vehicle parking while charging only*. NYCDOT should consult with NYSDOT on proposed signage and street markings related to curbside Level 2.

1. EVs should be prohibited from parking if the EV is not actively charging.

2. Non-EVs should be prohibited from parking in a space designated as *electric vehicle parking while charging only*. Penalties for violating this regulation should be consistent with NYCDOT parking regulations and enforcement should be in cooperation with NYPD.
3. Clear explanatory signage, street painting, and pricing schemes should be considered to reinforce turnover and minimize added burden for enforcement on law enforcement. Whenever possible, Level 2 should be sited in already regulated zones.

9.4 Level 2 Infrastructure

All proposed Level 2 infrastructure should:

1. Be UL certified.
2. Be PDC approved.
3. Fit within NYCDOT's approved family of street furniture.
4. Vendors bidding for contracts as providers for curbside Level 2 demonstrate substantial compliance with the manufacturing specifications found in National Conference on Weights and Measures 2017.
5. Be made of low-maintenance durable materials that are vandal-proof to the extent possible and operational in extreme weather conditions (including low and high temperatures).
6. Deploy a cord management system that minimizes pedestrian trip hazard.
7. Curbside Level 2, including all auxiliary loads, should be metered in accordance with electric utility requirements.

9.5 Program and Operation

1. Curbside Level 2 should be publicly available 24-hours a day, 365 days a year. Periodic street closings (for construction, street festivals, etc.) and other unforeseen circumstances, emergency suspensions of alternate side parking and other parking regulations for weather events should minimize impeding access to charging.
2. Station operators should ensure access during snow accumulation and plow build-up or secure a third party to provide snow removal services. Design considerations that serve to protect curbside Level 2 from snowplows and ensure continuous and safe operation during snow events should be considered.
3. A longer-term strategy should build parking space use into the payment structure for charging use.
4. A curbside pilot program should be evaluated within 12 months of its launch and program requirements should be updated accordingly.

9.6 Post-Pilot Tasks

1. Explore the feasibility of developing proprietary NYC charging station sheathing for a unified charging network that fits within NYC's existing street furniture family.
2. Collect data on station utilization.
3. Design a network provider framework that allows for maximum interoperability.

10 Conclusion

A diminished federal role in promoting clean fuel technologies necessitates an agile and localized approach to broadening EV adoption at a crucial point of inflection for the electric vehicle market. In this political climate, the role of municipal governments in identifying and implementing viable and cost-effective clean transportation strategies will only grow. Cities have a menu of policy alternatives at their disposal to incent the adoption of electric vehicles and replace ICE miles with EV miles by passenger and fleet vehicles. Setting aside EVSE-equipped curb space at this early stage of adoption offers policymakers a promising and relatively cost-effective strategy for encouraging zero-emission transport while preparing New York State for the emergence of mass market EVs.

A growing number of domestic and overseas models offer NYC glimpses of a path forward for charging in the public right-of-way and its potential role in an unfolding EV ecosystem. For policymakers in other metros, approaches that yield meaningful levels of EVSE deployment but are not overly reliant on direct public subsidies have proven especially appealing. Of course, enormous variations in density, transportation patterns, political consensus, and private vehicle utilization suggest hyper-local and bespoke strategies for meeting public policy goals regarding charging station deployment. But some extremely useful lessons apply across markets—identifying use cases and likely user cohorts prior to site selection, collaborating with a utility at the inception of a planning process, and leveraging private sector investment to reduce public sector exposure—can eliminate or diminish the risk in EVSE network-building for municipal policymakers.

Deployment of electric vehicle charging infrastructure well in advance of critical mass for the EV does, however, pose efficiency challenges for those entrusted with managing the public right-of-way. Urban transportation agencies typically face competing economic and social drivers to balance public and private interests while managing the flow of traffic. The effort to achieve the right balance requires careful and well-informed decision making by agency staff, elected officials, and certain non-governmental entities with a stake in management of the curb. Making targeted investments in public right-of-way charging will similarly require a thoughtful balancing of market considerations, environmental equity, technical feasibility, and the public's appetite for disruptions to long-established parking protocols.

The return on these investments will be a meaningful reduction in NYC's fossil fuel consumption as well as the GHG emissions associated with mobile sources across the City. Building a network of curbside charging stations will only add to the operational advantages of EVs over ICE vehicles by offering both opportunistic and routinized charging for commuters, residents, and visitors to NYC, as well as for public and private fleet operators. The emergence of smart charging may also enable municipal governments to better manage, monitor, and even monetize the curb. By bringing power to the curb, policymakers can facilitate an array of clean transportation solutions, including range extension for electric delivery trucks, charging for eBikes, and even the powering of electric refrigeration units, appliances on food trucks, and lifesaving equipment on standby emergency vehicles.

Even the best informed and timely policymaking can, however, be rapidly overtaken by the pace of technological change. The technologies and technical specifications for EVs are still evolving. Changes in the size, weight, and energy density of EV traction batteries, improvements to charging equipment, emerging wireless charging capability, as well as enhancements to the grid and connectivity will all impact policymaking in the future and will likely transform the policy debate several times over in the years ahead. But the revolution at the curb—the electrification of an array of emissions mitigation solutions—is likely to endure.

Appendix A: London Borough of Kensington Lamp Column Charging

London's Borough of Kensington and Chelsea installed 57 Ubitricity SimpleSockets onto lamp posts in areas where residents do not have access to off-street parking for a pilot that kicked off in February 2017.[123] To access the network, users must purchase a discounted Ubitricity SmartCable (subsidized by Transport for London (TfL). There are two pricing options:[124]

- Option 1: buy a cable for £199 and join Ubitricity's monthly subscription (£7.99 per month; 15 pence per kWh for electricity used).
- Option 2: buy a cable for £299 with no monthly subscription (19 pence per kWh for electricity used).

Wherever possible, SimpleSockets were mounted onto light poles next to Pay & Display parking bays, where parking charges and maximum stay requirements will apply during controlled hours. Officials expect that most electric vehicle users will use the lamp column chargers at night, when parking is free. Since the parking is not exclusive for EVs, no change in traffic orders were required.

The pilot is part of a larger TfL initiative that is developing a multi-supplier framework contract that will cover user supplied cord options and that looks at existing street assets and seeing if they can be dual-purposed as a charge point (e.g., street lighting, parking meters, wayfinding).[125]

Pros	Cons
• Quick and minimally disruptive installation • No groundwork or new electricity connections required • Less street clutter • Allows charge points to be installed closer to where residents live	• Slow charge: the power that can be delivered is limited by the capability of the street lighting circuit, which can be slow (London generally seeing 3-7kW available through lamp posts) • Interoperability: Ubitricity socket does not work with all charging cables • User must buy a special charging cable • Required utility upgrades to fuses

Appendix B: Overseas Markets

B.1 Case Study: City of London[126]

B.1.1 Managing or Oversight Entity: Transport for London (TfL)

Curbside Penetration:

Current: An initial 1,200 chargers were installed by TfL during the first three years of London's EVSE rollout. In 2014, a procurement process was launched to identify private sector vendors for future EVSE deployments. Bolloré, already the operator of a carshare program and charging network in Paris, ultimately won the TfL contract. Bolloré also assumed responsibility for the charging network that TfL had already developed. While Bolloré won *good will* and a significant concession, it did not secure exclusivity and still must negotiate with each borough council for curb space. Despite these challenges, Bolloré quickly doubled the size of the city's charging network to over 2,000 EVSE units. While Bolloré manages the TfL EVSE network, any vendor can petition the boroughs to install curbside Level 2 chargers and a number of other vendors are active across the city.

Long term goal: 8,000 units by 2020 is Bolloré plan; 300 DC Fast Charging Stations units installed by TfL by 2020.

Equipment Types:

Mostly 7 kw Level 2 (Level 2) units, newer 3 Kw *trickle-charge* units for overnight charging.

Principal vendors:

Bolloré, Chargemaster, Podpoint, Ubricity (3 kw trickle chargers); Fast Ned (Netherlands-based network of DC Fast Charging Stations stations with solar canopies), ESB (Irish national energy provider); British Gas; and Chargemaster

Siting Process:

In 2017, TfL and the office of the Mayor issued Electric Vehicle Charging Infrastructure: Location Guidance for London, a blueprint for London's EVSE rollout. Curbside DC Fast Charging Stations installations have targeted locations where taxis queue and other commercial EVs cluster. A DC Fast Charging Stations off-street strategy focused on leased sites, including former petrol stations, is under development by TfL. Each designated site is leased for a minimum of eight years and can accommodate four to six rapid chargers.

Incentives:

In the early years of EVSE deployment, the UK central government was providing 75% of the cost of charging station installation; boroughs were responsible for remaining 25%. At present, high EV usage in London has heightened the demand for EVSE units and largely eliminated the need for a public subsidy for Level 2 units. Demand for EVs has been driven by grants for plug-in vehicles, excise duty waivers for EVs, congestion charge exemptions, and free parking for EVs in many areas across London. While subsidies for Level 2 units have largely been withdrawn, public subsidies to strengthen the local grid to accommodate new DC Fast Charging Stations units have been made available.

License/Concession Terms:

Bolloré agreed to manage and operate TfL infrastructure; Bolloré pays a license fee to each borough, as do other EVSE operators.

Required Approvals and Design Guidelines:

Design guidelines are limited and generally related to pedestrian safety and access to the sidewalk. TfL offers streetscape guidance and has established a setback requirement of 450 mm from edge of curb and a 2-meter minimum sidewalk width for pedestrians. Some boroughs have issued design guidelines (e.g., Westminster requires that every EVSE unit be black) but all are required to ensure access for the disabled and legible text on the EVSE touchscreen.

Demand Drivers/Baseload Demand:

A 200% year over year increase in EV sales in London has generated significant demand for EVSE. Surcharges on driving older diesels in London’s congestion zone and on parking permits for polluting vehicles have also bolstered by the rate of EV adoption. The taxi market may prove to be the most robust market segment going forward since new legislation has been introduced to require that all cars-for-hire

must become all-electric. In anticipation of new and proposed restrictions on ICE vehicles, *London Electric Vehicle Company* has introduced a taxi model with a pure electric range of 70 miles; with a range extender engine, its range increases to 200 miles. The freight market also has a significant use case for curbside EVSE. A large increase in *light goods* delivery vehicles in London has accelerated calls for fleets to electrify both vehicle drivetrains and refrigeration units.

Enforcement:

Enforcement policy is determined at the borough level, but all boroughs have relatively robust penalties for parking ICE vehicles in EV-only spaces. Some boroughs specify the daytime and night-times uses for chargers in residential neighborhoods, with some stations open to the public during the day and restricted to residents at night. Dedicated signage must meet UK government standards.

Role of Utility:

Scottish Southern Energy is the power provider to chargers, providing renewable energy to them. TfL will subsidize demand charges for DC Fast Charging Stations units.

Payment Protocols:

Under the Bollorée model, charging and parking is bundled into one fee. For rapid charging, parking is free and user pays for EV charging only.

Operational and Regulatory challenges:

While London permits multiple vendors to install EVSE infrastructure, there is no interoperability between the networks, which limits ease of use for drivers. Operational barriers to fast charge deployments are significant. A recent market study identified the cost of upgrading power networks as a principal barrier to increased deployment of DC Fast Charging Stations units. Such costs limit profitability and destroy the operator's business model. The large size of DC Fast Charging Stations units created zoning and public review challenges, but local authorities are generally supportive. In addition, private ownership of vehicles is dropping in London and city government is promoting cycling, walking, and public transport.

B.2 Case Study: Copenhagen[127]

Managing or Oversight Entity:

Copenhagen Electric is a hybrid regional/municipal authority financed through funds allocated by the Capital Region of Denmark as well as through grants from the national government and other sources. Copenhagen Electric encourages conversion to electric vehicles in the Capital Region through knowledge-sharing, procurement opportunities, and communication as well as by convening parties in the region to develop projects that increase the deployment of electric vehicles. The authority serves the 29 municipalities that compose the Capital Region.

Curbside Penetration:

Current: Approximately 300 Level 2 and 20 DC Fast Charging Stations curbside in Capital Region.

Long term goal:

The Capital Region's goal is for the transport sector to be 100% free of fossil fuels by 2050.

Equipment Types:

11, 22, and 44 kW; many three corded units with both Level 2 and fast charge capability.

Principal Vendors:

Clever (Danish utility) and E.ON (German-Swedish utility).

Siting Process:

City government does not plan or drive rollout for EVSE deployment. The siting process is left to private sector vendors and guided in part by local stakeholder requests. While still not profitable, both companies—Clever and E.ON—identify locations and then apply for a concession at those locations. For residents and institutions, an initial call to the municipality is required to request an EVSE unit. While the municipality is typically very supportive of EVSE requests, some locations are inevitably denied due to issues such as physical barriers and cost constraints, and the requesting entity/individual must then identify alternative locations.

Incentives:

Public sector only subsidizes deployments at hospitals and taxi charging hubs. No incentives available for *less commercially-interesting* locations.

License/Concession Terms:

Companies receive 10-year license agreement at no cost.

Required Approvals and Design Guidelines:

Approvals from the following public sector agencies are required before charging stations can be installed: Police (to review concerns about lines of sight and traffic/pedestrian safety); Planning Department (to review other uses have been approved nearby); and the City/State Architect (to review design—the State Architect has objected to siting large DC Fast Charging Stations units in historic districts).

Demand Drivers/Baseload Demand:

Copenhagen boasts two public carshare programs—400 BMW battery-electric i3s are available to residents through DriveNow's carsharing initiative while an additional 400 carshare EVs are part of the Green Mobility fleet. While DriveNow vehicles are largely charged curbside, Green Mobility charging is conducted largely at hot spots off the street. The Danish postal service also has EV delivery vehicles and has permission to use curbside charging stations, as well. Municipal fleet vehicles also use curbside EVSE.

Enforcement:

No uniform policy on enforcement exists. Each municipality in the capital region sets its own enforcement policies. In most cases, ICE cars are fined for parking in an EVSE-equipped space and patrol officers issue summonses regularly. EVs can also be obliged to charge as per posted regulations but the Danish government limits enforcement of charging requirements and gives municipalities the option of setting limits based on congestion or environmental factors.[128] Enforcement is efficient because parking enforcement teams in dense areas are well-staffed and technology facilitates their work. As an example, scanner cars inspect each parking space and an enforcement parking app displays locations of all cars in a given area. Enforcement personnel must, however, be conversant in different EV models because there are no EV-specific plates or badges.

Role of Utility:

Orsted, the main utility in the capital region, is not directly involved in EVSE deployment so it assesses a significant fee for power upgrades. Orsted is a regulated utility and is 50% owned by the Danish government. As such, it does provide some discounts for power upgrades for that serve public purposes.

Payment Protocols:

EV drivers who park on the street now pay for both parking and electricity. Parking permit fees also apply to car-owners in dense residential areas. Drivers issued parking permits typically pay $200/year to park an ICE vehicle in their own residential zone. The comparable rate for an EV parked in a residential zone is $10—15/year.

Operational and Regulatory Challenges:

Private vehicle owners can be frustrated by Drive-Now vehicles using all the EVSE units on a residential street. Drive-Now dispatches runners to move vehicles when they become clustered to balance the distribution of EVs.

B.3 Case Study: Oslo[129]

Managing or Oversight Entity:

City of Oslo, Agency for Urban Environment

Curbside Penetration;

Current: The city of Oslo has deployed 1,200 curbside chargers. About 80% of these units are Level 2 and 19% are L1. The city has also installed five curbside DCFCs, as well as a mobile DC Fast Charging Stations that can be deployed at the curb. In 2018, Oslo plans to install an additional 200 Level 2 chargers and 400 DCFCs curbside.

Long-term:

The city of Oslo has set a long-term goal of carbon neutrality for transportation. The plan for the deployment of curbside EVSE for the next three years (2018-22) calls for:

- 200 Level 2 chargers (3 and 6 kW AC) installed per year for a total of 600 new EVSE units
- 1,200 semi-quick chargers (22 kW AC)
- Six new quick charging sites with 4 quick chargers and 12 semi-quick chargers each

- Expansion of six quick charging sites with minimum two new quick chargers each
- In addition, the city is planning to designate dedicated EVSE-equipped parking places and other customized curbside solutions for:
    - Mini-buses
    - Taxis
    - Freight Electric Vehicles (FEVs)
    - Vehicles used by tradespeople (plumbers, electricians, carpenters and other contractors)

Demand Drivers/Baseload Demand:

EVs, taxis, FEVs , scooters, and electric motorcycles all contribute to demand in a city where half of all new vehicles sold in 2017 were electric drive.

Key Partnerships:

The principal utility, Hafslun AS, is owned by the city of Oslo.

Operational and Regulatory challenges:

Limited space is a challenge, which has intensified with development. Approvals from the *grid inspector* can be time consuming. In addition, the harsh weather presents some siting and installation challenges. Chargers are placed higher for snow, with bollards to protect the equipment from vehicles. Other EVSE units are sheltered to protect them from the elements.

Appendix C: Domestic Markets

C.1 Case Study: Los Angeles[130]

Managing or Oversight Entity:

Los Angeles Department of Water and Power (LADWP) and Los Angeles Department of Transportation.

Curbside Penetration

Current: 82 L-2 EVSE mounted on street light poles, 2 on wood power poles, and one DC Fast Charging Stations unit at curbside; for BlueLA pilot, LADOT has partnered with BlueLA to install about 200 electric charging stations and distribute 100 electric vehicles throughout downtown L.A., Westlake, MacArthur Park, and parts of Koreatown.

Long-term goal:

Goal for publicly accessible EVSE installations is 10,000 units within 5 years, including 4,000 on city property. The goal for streetlight-mounted units is a minimum of 50 - 100 per year. (The LA Bureau of Street Lighting will install 100 charging units this next Fiscal Year). Future power pole installations are projected to total 850–50 in fiscal year 2018, then 200 per year for four years. In addition, where light and power poles are not present, underground electric vaults with vents will be used to place Level 2 and DC Fast Charging Stations units. According to LADWP, 12,000 such locations exist in the city.

Equipment types:

Level 2, DC Fast Charging Stations

Principal Vendors:

BlueLA (Bollorée), ChargePoint

Incentives:

Vehicle rebate program, workplace charging program, grants, carbon credits, federal and state tax incentives.[131] The BlueLa pilot has been underwritten with $1.67 million in grant funds from the California Air Resources Board and $1.82 million from the city.

Siting Process:

LADWP selects and prioritizes sites for installation. Bureau of Street Lighting installs the equipment. Communities selected for initial deployments were identified by the State as ranking in the bottom 10% for income and being the most vulnerable to pollution from traffic or industrial sources. BlueLA is also soliciting recommendations for charging hubs for its carshare vehicles

License/Concession Terms:

5-year pilot program

Required Approvals and Design Guidelines:

Standards for striping, signage, required dimensions, and accessibility are all set by the City of Los Angeles Department of Building and Safety.

Demand Drivers/Baseload Demand:

BlueLA EV carshare fleet, municipal vehicles, including LAPD EVs (largely BMW i3s), and public buses.

Enforcement:

LAPD will have jurisdiction over violations of EV restricted spaces.

Role of Utility:

LADWP sites, owns and maintains the curbside light, power pole and vault-mounted EVSE units.

Payment Protocols:

BlueLA subscription plans include standard ($5 per month and 0.15 per minute), Community ($1 per month and .10 per minute), and Trial ($0 per month and .20 per minute).

Operational and Regulatory Challenges:

For power pole installations, retraining linemen to adopt new protocols is one clear challenge. The multiple users of power poles present additional operational challenges regarding pole access. Cable and telecom companies, for example, have expressed concerns about perceived limitations to power pole access posed by EVSE installations. LADWP is working to secure their buy-in and cooperation in advance of a broader rollout.

The lack of an industry standard for charge port location has also presented a challenge for LADWP planners who must ensure that a charge cord is long enough to reach either a driver's side or the passenger side port in a typical parallel parking deployment. Other challenges have been posed by retail business owners who fear that curbside installations will result in displacement of customer parking spaces for conventional vehicles. To address their concerns, the department favors curbside installations on side streets rather than main avenues because they are less likely to create friction over perceived loss of spaces adjoining retail frontage.

Lastly, because charging stations will displace parking meters in a number of typical deployment scenarios, LADOT and LADWP are weighing solutions that can partially offset the average $30,000 in annual revenues per parking meter collected by LADOT. The two solutions under consideration include meter removal accompanied by revenue-sharing with the city of parking and charging fees or parking meter retention and equipment reprogramming for collection of a blended parking and charging fee.

C.2 Case Study: Seattle, Washington

Managing or Oversight Entity:

Seattle Department of Transportation

Curbside Penetration

Current: The *Seattle Electric Vehicle Charging in the Right-of-way* (EVCROW) program was launched in mid July 2017 and will pilot curbside charging, especially in areas that lack off-street parking.

Since its launch, the program has installed two curbside charging stations operated by Seattle City Light and several additional applications are in process. In May 2017, ReachNow—BMW Group's mobility service—announced plans to install 100 new Light & Charge electric vehicle charging locations, including 20 fast charge units, at 20 different locations across the city.

Long-term goal:

Seattle's citywide target of 30% EV car registrations by 2030 is driving much of the city's long-term planning efforts. In partnership with Seattle City Light, the EVCROW program seeks to assemble a network that will eventually include 20 utility-owned curbside stations across the city. The German charging station company eluminocity has plans for six to eight charging locations; Greenlots, a California company, is pursuing permits for several dozen charging stations, although the number of stations they ultimately install is contingent on future funding. Seattle has also committed to installing curbside EVSE for shared EVs.

Equipment types:

Level 2, DC Fast Charging Stations

Principal vendors:

ChargePoint and Blink; Greenlots for DC Fast Charging Stations

Incentives:

Utility incentives include subsidies for the DC Fast Charging Stations and residential charging installations. EV owners in the state are eligible for state tax incentives, a state emissions test exemption, and green driver insurance discounts.[132]

Siting Process:

The EVCROW program provides criteria for siting curbside EVSE. It allows for curbside EVSE in areas designated *Urban Centers* and *Urban Villages*—dense, transit-rich districts along major roadways—and favors locations with low penetration of EVs and EVSE, as well as those burdened with poor air quality. The initiative provides guidance on street tree protection, lighting, ADA compliance, coordination with other city projects, and metering.

License/Concession Terms:

Seattle features a *collaborative permitting* approach to regulation and siting to facilitate EVSE installation. Other terms are related to access policies—carshare companies that install EVSE must pledge to provide curbside charging access to non-members. The deployment of carshare vehicles is itself a matter of permitting rather than procurement. A 2015 City Council resolution allocated 500 permits to a carshare company and up to 750 if the service agreed to expand its home area to underserved areas of Seattle. Operators were required to provide citywide service after two years of business in Seattle.

Required Approvals and Design Guidelines:

The EVCROW program requires a number of permits and approvals prior to installing curbside EVSE. These include a public space management permit, street use utility permit for installing the infrastructure; electrical permit from the Seattle Department of Construction and Inspections to establish an electrical connection to each new EV charging station unit; Seattle City Light (SCL) service connection application; approval from the applicable Historic and Landmark District review board, written authorization from telecommunications utilities to permit connections to fiber or other telecommunications infrastructure; and a parking permit from Seattle Department of Transportation (SDOT). In addition, appropriate staff from SDOT's Transit and Mobility, Transportation Operations, and Project Development Divisions will assess and conceptually approve the selected EVSE locations. SCL, meanwhile, can exercise the right of first refusal for all privately-owned EV charging infrastructure locations. Finally, for every installation there is also a public notice requirement.

Demand Drivers/Baseload Demand:

55 ReachNow carshare EVs and municipal fleet vehicles, which include 80 fully electric vehicles and 17 plug-in hybrids. Demand is expected to grow, partly in response to a City Council resolution calling for 30% of all light-duty vehicles in Seattle to operate under electric power by the year 2030.

Enforcement:

The EVCROW program provides for parking restrictions related to propulsion type. Only EVs are permitted to park at one-hour DC Fast Charging Stations-equipped parking spaces, and two- or four-hour Level 2-equipped parking spaces. These spaces are open to the public and to shared vehicle fleets.

EVs that are not in the process of charging are prohibited from parking in an EVSE-equipped space that is marked as *electric vehicle parking while charging only.* SDOT defines the process of charging as a being plugged into an EVSE charger in the dedicated EV-only space within any applicable time regulations. The Seattle Police Department will chalk vehicle tires to enforce this regulation.

Role of Utility:

SCL has permit authority for street utility permits and service connection permits. SCL's electricity is completely carbon-neutral, 90 percent of it sourced from hydroelectric generation. In support of the city's efforts to increase EV utilization, in 2017 SCL committed to installing 20 publicly accessible DC Fast Charging Stations units on 15 sites, including in the public right-of-way. The utility conducts an initial vetting of potential sites and identifies those that meet the EVCROW's key criteria. The pilot program seeks out locations with low penetration of both EVs and of EVSE, as well as neighborhoods with poor air quality.

Payment Protocols:

For Seattle City Light fast charge units deployed in the public right-of-way, parking and charging fees are bunded in the same transaction.

Operational and Regulatory Challenges:

These issues have yet to manifest themselves as the program is still relatively new and most approvals and installations are still pending. Recent news coverage has, however, reflected concerns that the pilot program could be perceived as benefitting only those affluent enough to own EVs.[133]

C.3 Case Study: Indianapolis[134]

Managing or Oversight Entity:

Indianapolis Department of Public Works (installation), BlueIndy (operations)

Curbside Penetration

Current: 425 curbside charge points at 85 different locations, managed by BlueIndy and available to its carshare members, as well as other EV drivers. Also, a public curbside EVSE charger installed by the city downtown.

Long-term goal:

BlueIndy's plan is to install 1,000 curbside stations to serve 500 carshare EVs by 2019.

Equipment Types:

Level 2, DC Fast Charging Stations

Principal vendors:

BlueIndy (Bollorée); ChargePoint

Incentives:

$6 million in public investment from the city, $3 million from Indianapolis Power & Light for infrastructure deployment.

Siting Process:

BlueIndy selects sites based on location near institutions, employers and commercial activity. The city has the right to relocate up to 7 charging stations under a 2016 franchise agreement.

License/Concession Terms:

Under an initial 15-year contract with the city, BlueIndy agreed to install 100 charging locations across the city and its parent company, Bollorée, committed to a $41 million investment in the project. A subsequent 2016 franchise agreement negotiated with the city council requires BlueIndy to pay the city $45,000 per year to compensate for lost meter revenue. The franchise agreement also gave businesses a one-time opportunity to contest the location of restricted BlueIndy parking spaces by showing that the locations caused "demonstrable substantial economic harm or obstruction of customary access or obstruction of the ability to conduct normal business."[135]

Required Approvals and Design Guidelines:

Standards for striping, signage, required dimensions, and accessibility set by the Indianapolis Department of Transportation. Under a revised city contract, BlueIndy must provide a 16-day public notice before installing new stations. Required permits include a *right-of-way permit* and an *encroachment permit*, which enable the parking of cars and the installation of EVSE units.

Demand Drivers/Baseload Demand:

500 carshare EVs in the BlueIndy system. carshare members include: service workers who cannot afford to own a car, families that require a second car for occasional local travel needs, and mid to low-level managers who drive locally for a variety of needs. In addition, 225 municipal fleet EVs can also use the curbside units.

Enforcement:

EV-only restrictions prohibit ICE vehicles from utilizing designated EV spaces; illegally parked vehicles are subject to towing.

Role of Utility:

Indiana Power and Light is a deployment partner. IPL's plans for implementing a Vehicle-to-Grid (V2G) pilot are part of the BlueIndy franchise agreement with the city.

Payment Protocols:

In addition to providing carshare vehicles, BlueIndy offers curbside EV charging to other passenger EVs. To join as a *charging-only member*, an applicant can register online, download a mobile app, or visit an enrollment kiosk at select BlueIndy stations. The applicant is required to provide a valid U.S. driver's license, a credit card, and vehicle registration. Enrolled members then receive a membership badge which enables them to reserve, unlock and use the charging stations. At its launch, BlueIndy offered charging for $1.50/hour to its charging-only members.

The carshare service itself offers a range of subscription levels for its members. A driver may subscribe for a day and pay $8 for the first 20 minutes of vehicle use and 0.40 each additional minute. Other rates include a weekly subscription for $9.99 and $7 for the first 20 minutes of each trip, followed by $0.35 for each additional minute. The cost of a yearly subscription is $9.99 per month and $4 for the first 20 minutes per trip, and then $0.20 each additional minute.

Operational and Regulatory challenges:

The 2016 franchise agreement allows for relocation of up to seven charging stations at locations where business owners can show economic harm due to displacement of customer parking. In 2017, Napolese, an artisanal pizzeria, claimed that monthly sales at its 49th Street location slipped by as much as 10 percent from 2014 to 2016 after BlueIndy installed stations nearby. Another business, SoBro Cafe, stated that its sales dropped between 12 percent and 20 percent "for no apparent reason other than parking became more difficult."[136] Such early friction during BlueIndy's rollout resulted in 24 complaints to the city's Action Center in 2015 and 28 in 2016 but have dropped to zero in 2018.

In addition to concerns voiced by some members of the business community, a recently approved rapid transit bus route may also require relocation of some EVSE units.[137]

Appendix D: Estimating the Impacts of Curbside Charging Methods

Estimating the potential emissions reduction of an investment in curbside EVSE requires answering two questions:

1. How many EVs will one Level 2 charge port serve annually?
2. What is the emissions offset associated with replacing one ICE with one EV in NYC?[138]

Multiplying the answers to these questions together yields the annual GHG offset of each Level 2 charge port. In turn, multiplying this last figure by the number of charge ports built yields the total GHG offset resulting from the investment in charging infrastructure.

D.1 Estimating the Capacity of a Level 2 Charge Port

To estimate the number of EVs one Level 2 charge port can support, we take the average annual number of hours in a year a charge port will be occupied over the average annual on-street charging hours required by a single EV. How then to estimate the average annual on-street charging hours required by an EV?

According to NYSERDA's *2016 Data Summary*, the charging stations in New York State it monitored averaged an occupancy rate of 6.5% in 2016. However, the top 5% most performing stations, all located in the NYC Metro Area in university or medical center parking lots, averaged an occupancy rate of 20% in 2016. These occupancy rates have been steadily rising since 2014, with EV growth.[139]

As such, we take this as our base occupancy rate (see 'low'), given the close fit, geographically and in terms of institutional proximity, with the proposed use case in this report. For our high occupancy rate estimate, we estimate a 'high' occupancy rate to be twice as high, 40%. Given the demand for curbside parking in NYC and the additional overnight demands that would be placed on a curbside charging station (as opposed to one in a lot, likely only used during work-hours), we think this is a reasonable assumption for the high demand scenario.

With our estimated occupancy rate, we can now solve for the number of hours in a year a charge port will be occupied. To determine the number of EVs supported by this charge port, we take this last figure over the average annual hours required by a single EV. We estimate the average daily charge time of an EV in NYC to be between 2.5 and 3.5 hours. Given the typical daily VMT of a POV in NYC (discussed in greater detail below), 2.5 to 3.5 hours of charging per day at an Level 2 station would more than cover its energy demands. As such, we consider the demand for EV charging stations to be closer to that of a traditional parking spot. Given parking regulations that discourage or prohibit the use of charging stations by EVs that are not charging, we might reasonably expect an EV owner to require three six to eight-hour charge events per week (or 2.5 to 3.5 hours per day).

D.2 Estimating the Emissions Offset of Replacing One ICE POV with One EV in NYC

Having worked out the potential number of EVs supported by each Level 2 charge port, we now only need the emissions offset associated with the replacement of one ICE POV by one EV. Using a tool provided by the Union of Concerned Scientist, we estimate EVs in NYC to be about 67% more efficient than an ICE POVs in NYC getting 29 miles per gallon.[140] Their tool uses the EPA's eGRID tables for calculating the average emissions factor of NYC's grid, using this figure to estimate the efficiency of different EV models in NYC. Using these EV model efficiency figures, we produce a weighted average efficiency of all of NYC's existing BEVs based on registration data. Finally, according to Joe Cortright's *New York City's Green Dividend* report, daily VMT in NYC is 9 miles, or 3,285 miles annually. With this last figure and the emissions associated with a mile driven by an ICE POV,[141] we calculate the annual emissions of an ICE POV in NYC to be 1.32 tCO2e. As such, the emissions offset per ICE replaced by an EV in NYC is 0.88 tCO2e.

Appendix E: CityRacks Case Study

Residents can nominate a location for free sidewalk bicycle racks via a simple online form available on the NYC DOT website. While NYCDOT cannot reply to each individual request, all locations suggested by the public using the online portal are investigated by the agency through an on-site evaluation. DOT also encourages bulk requests from Business Improvement Districts, civic associations or other groups of community members.

Technical feasibility, cost and complexity of installation, and neighborhood planning considerations will ultimately drive much of the site selection methodology, but baseline demand should be at the core of any site selection model.

Copenhagen and other European cities rely on direct stakeholder engagement to guide the Level 2 siting process. The CityRacks request process, along with the nomination protocols for the CityBench and Street Seats programs, offers an analogue for community-scale engagement in the deployment of curbside infrastructure that can be applied to the Level 2 site selection process.

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