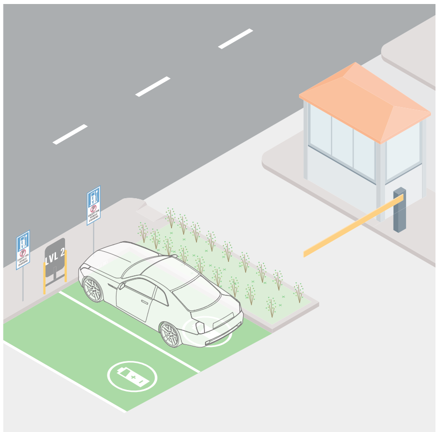
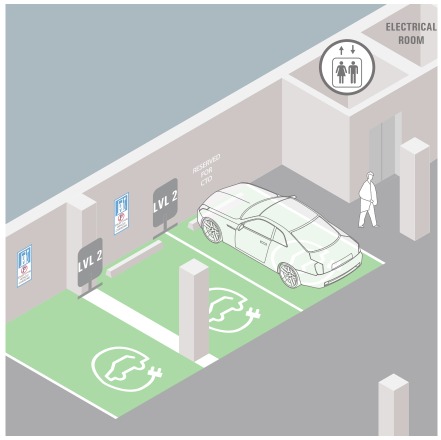
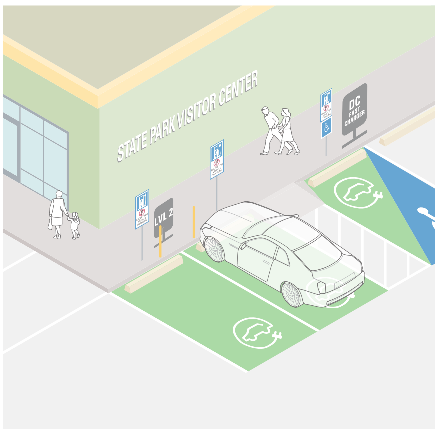




ACCOMMODATING GARAGE ORPHANS



in Boston, Cambridge, and Somerville

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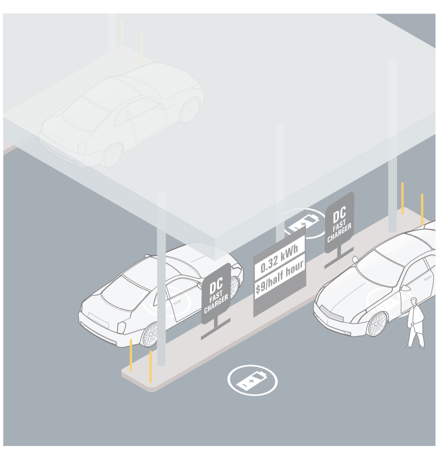

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SECTIONS

EXECUTIVE SUMMARY

As the nascent electric vehicle (EV) market has developed in the United States, urban areas are emerging as an unexpected soft spot in the market's growth. The inability of urban areas in the U.S. to accommodate charging station installations represents a key impediment to the growth of the larger EV industry and market; one that should be discussed alongside cost concerns and range limitations. In 2015, the U.S. is likely to fall short of its goal to put one million EVs on the road by year's end, one of many indicators of EV's market penetration difficulties.

The Boston Metropolitan area exhibits a similar pattern of weak EV adoption in urban areas. The regional hot spots for EV ownership are the wealthier suburban communities in Middlesex, Essex, and Norfolk counties. Since 2014, these counties have seen 371 EVs purchased. By contrast, Boston, Cambridge and Somerville residents have registered 38 EVs during the same period.[1]

Challenges to installing EV charging infrastructure in urban areas are manifold. They stem from the more complicated scenarios around providing charging for garage orphans: those car owners not in full possession of a parking space, in contrast to single-family home garages or driveways. Garage orphans must rely on condo associations, property and lot managers, or municipalities to dependably provide access to charging. Increasing access in these contexts will require initiative where there is a lack of viable business models for private participation.

Cities are ideal locations for owning and operating EVs. City drivers make fewer and shorter trips by vehicle than their suburban counterparts. The environmental justice benefits for urban communities include reduced auto emission and noise pollution, as EVs are significantly cleaner and quieter than internal combustion engines. Moreover, higher population density, as found in cities, translates to more residents benefiting from each EV replacing a gasoline-powered vehicle.

Several European cities, more akin to older cities of New England and Mid-Atlantic states than American cities developed prior to the automobile age, understood the urban charging challenge early on. They have planned and implemented successful strategies to place

1 https://mor-ev.org/program-statistics Accessed: June 8, 2015.

charging stations (EVSE) in alternative contexts: on their streets and parking lots.[2] Many of these cities have gone farther in incentivizing EV ownership, pairing EVSE with low-emission zones and congestion charging policies.

Unlike the challenges of EV cost and range limitations; solving the urban charging question requires policy commitment rather than improvements in technology.

This report presents several strategies for providing charging opportunities for garage orphans. These strategies have been interrogated through multiple lenses for their applicability to the different land use contexts of the report study area, encompassing the study area cities of Boston, Cambridge, and Somerville. This methodology can be applied to cities across the region and the country.

Through this layered investigation, several key findings arise:

- Implementing any of the charging station strategies will require encouragement through policy, including the lowest-hanging fruit: installing EVSE at multi-family residential parking garages and lots. Bringing policy, market, and infrastructure stakeholders together will help ensure their greater success.

- The densest, mixed-use neighborhoods are most likely to be inadequately supplied by multi-family residential parking and will require alternative strategies for providing charging supply. Whether on-street, in neighbor's parking space, or in nearby lots, all of these will require specific programs enabling their use.

- The continued development of the sharing economy and parking market can better optimize the use of existing resources and can assist in the success of alternative strategies. Investigating how restrictions on these new economic developments alongside alternative charging strategies can be lifted without impinging on other policy goals is a worthwhile municipal endeavor.

2 26% of charging stations in France and at least 17% in the United Kingdom via http://chargemap.com/stats/

KEY TERMS AND DEFINITIONS

EV
Electric vehicle

EVSE
Electric vehicle supply equipment, i.e. charging stations

Garage Orphan
Any EV owner who does not have full ownership of a parking spot and the associated space for necessary electrical infrastructure. Generally this is any owner not in a single-family home with garage or driveway

Study Area
The municipal boundaries of Boston, Cambridge, and Somerville, which are the three stakeholder communities interviewed and analyzed for this report

Framework
The three lenses by which this report examines garage orphan solutions; Policy & Politics, Technology & Infrastructure, and Market Feasibility & Viability

Demand
Existing parking preferences of vehicle owners

Supply
All types of parking solutions that exist within the study area

On-Site
Parking supply that is attached or adjacent to the resident's dwelling

Off-Site
Parking supply in a garage or lot that is separated from the resident's dwelling

Home-Centric
Parking supply or strategies that provide charging opportunities to EV owners at their place of residents or within close proximity (This study determines a quarter-mile radius as the boundary of close proximity)

Non-Home Centric
Parking supply or strategies that provide charging opportunities to EV owners while they are away from their dwelling

Kilowatt (kW)
A unit of power equal to 1,000 watts. It expresses the rate of energy conversion or transfer with respect to time. Kilowatt-hour (kWh) is a unit of energy equivalent to 1 kW of power expended for one hour.

Amps (A)
Also referred to as 'ampere'. Expresses flow rate of electric charge.

Volts (V)
The electrical potential that could be released if electric current is allowed to flow. Volts can be calculated as Amps x Kilowatts.

(Electrical) Conduit
Used to protect and route electrical wiring.

1. SCOPE OF GARAGE ORPHAN CHALLENGES

1.1 Introduction

In the growing world of electric vehicles (EVs), it is estimated that 80 to 90% of EV owners charge their vehicles in single-family homes with garages.[1] The remaining 10 to 20% of EV owners are identified as "garage orphans," who lack dedicated off-street parking with full ownership rights.

Parking in Boston, Cambridge and Somerville takes place in a variety of non single-family home garage spaces. The majority park their vehicles in off-street parking lots, shared driveways, and on-street spaces. In these contexts, providing electricity to a parking space must overcome additional challenges, including but not limited to dealing with multiple stakeholders, identifying fee structures, and assigning liability.

Guiding Principles

Developing a process in which improving access to Electric Vehicle Service Equipment (EVSE) for existing and potential EV owners is a critical step in reducing petroleum consumption and utilizing sustainable and locally produced sources of energy. The reduction of carbon emissions in cities through increased adoption of EVs will result in quality of life enhancement through cleaner air, less noise, and improvements in soil and water quality.

EVs are well-suited for urban vehicle owners, who average shorter daily driving distances and experience the negative impact of stop and go traffic on MPG efficiency of internal combustion engine (ICE) vehicles. The goal of this study is to identify solutions for garage orphans in an urban context that address the framework of Policy, Technology & Infrastructure, and Market Feasibility & Viability. In pursuing this, the study has identified three guiding principles:

1. Owning an EV should be as convenient as owning a non-EV, within the boundaries of not encouraging EV ownership and use at the expense of alternative modes of transport.

2. Solutions should be targeted to the local level to ensure they relate to fine-grained, on-the-ground conditions, as well as providing opportunities for local or neighborhood management and ownership.

3. Solutions should be scalable to the extent possible in order to maximize their utility and long-term applicability in a growing and evolving market of EV owners.

Figure 2. Single-family home with garage: The non-garage orphan

1 California Plug-In Electric Vehicle Collaborative, pg 3.

Summary of Local Parking Demand

The first step toward understanding how EV charging infrastructure can be adapted to an urban environment is to understand existing parking options. While garage orphans exist within most parking contexts outside of single-family homes, for EV owners to have a similar level of convenience as non-EV owners, a review of parking conditions was undertaken. In the Boston Metropolitan Area, encompassing Boston and six surrounding counties, 40% of households have a garage or driveway included with their home, 44% park their vehicle in a multi-family garage or lot, and 15% rely upon on-street parking.[2]

In the study area, there are a range of challenges that arise from integrating new technologies into existing infrastructure that may not have adequate electrical capacity or be sited in a less than optimal location. In addition, parking remains constrained, even with decreasing numbers of registered vehicles and parking permits issued since at least 2002.[3]

Where an on-site parking space exists, easy access to electricity is often not available. Separate driveways and off-site lots have an added level of complexity as the owner of the site has little incentive to invest in EV equipment and infrastructure.

2 U.S. Census Bureau, 2013 American Housing Survey

3 Data provided by the City of Boston indicate a decrease of 32,907 or 9.5% in registered vehicles from 2002-2013. City of Cambridge data indicates a decrease of 3,163 or 7.6% parking permits from 2002-2014.

On-street parking has a different and potentially more challenging set of obstacles arising from differentiating access to public use.

Summary of Local Parking Supply

Analyzing existing parking supply identifies opportunities and challenges within the neighborhood context for EV garage orphans. Options include traditional overnight parking opportunities as outlined in the demand summary, as well as non-traditional options that may provide a similar level of convenience and access to EV owners with fewer barriers to implementation.

The primary categories of supplyinterrogation are divided between home-centric and non-home centric charging infrastructure. Home-centric options refer to sites that provide access to overnight charging within close proximity to an EV owner's home. Non-home centric options seek to address the charging needs of EV owners away from the home, where charging mechanisms may not be viable.

Summary of Study Area Analysis

In Section 3, a review of each neighborhood, based on the expanded framework introduced in the preceding section, examines supply solutions within different types of neighborhood contexts that exist within the study area.

Based on the analysis, two neighborhoods are selected as case studies: Cambridgeport and

The study inputs comprise four major components:

1. Literature Review
A comprehensive review of EV literature was conducted with a focus on charging equipment, business models, and market studies.

2. Stakeholder Interviews
Interviews were conducted over the phone and in-person with EV experts and local stakeholders during workshops.

3. Neighborhood Typology
A geospatial analysis focused on specific neighborhoods that were identified as high potential for future EV adoption, in order to determine applicability of available strategies.

4. Strategy Interrogation
A matrix was developed in order to rank opportunities based on their feasibility in the selected neighborhoods.

Jamaica Plain. These are used to highlight demand constraints and potential impacts of the strategies and recommendations. Strategies for providing EVSE for garage orphans in the study area are detailed in the final section.

The research and analysis performed for this study establishes a framework for future investigation of the study area along with neighborhoods in other urban areas with garage orphan challenges.

1.2 Methodology

The methodology of this study is based on an understanding that the parking contexts of Boston, Cambridge, and Somerville are varied and challenging for EV owners. Unique to this study, is a focus on an urban context of older, dense communities such as those in the study area.

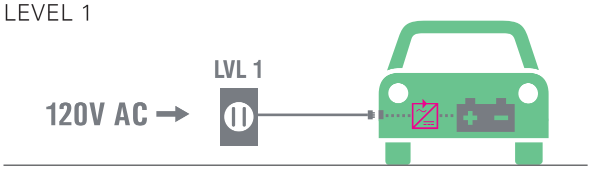
This study interrogates parking demand to determine preferences of vehicle owners within the study area and this is contrasted with an interrogation of supply, to review all types of parking and the opportunity to expand EVSE in each context. Data indicating (directly or indirectly) parking supply and demand were obtained for each municipality as possible. Where absent, the study utilized assumptions based on best available data and then cross-checked results through other inspections for reliability.

In determining the appropriate scale of analysis, city, neighborhood, and ZIP code were considered. Analysis at the neighborhood scale was found to be the most useful given its consistency with service schedules and parking permit assignment data.
The neighborhood provides a platform for understanding local characteristics that determine potential EV adoption and the extent to which the garage orphan problem exists. An important consideration was the accessibility of recommendations to the study area. Neighborhood characteristics, population demographics, and intangibles that can only be contextualized by local residents are an important component of a long-term EV strategy. The recommendations are meant to be adaptable based on community input and future planning concerns that are not available at the scale of the ZIP code or city boundary.

The analytical framework comprises three lenses to determine applicable recommendations: Policy & Politics, Market Feasibility & Viability, and Technology & Infrastructure. By investigating each opportunity through this framework, the study developed strategies that adequately address the goal of this study.

LEVELS OF CHARGE: DIAGRAMS AND ATTRIBUTES

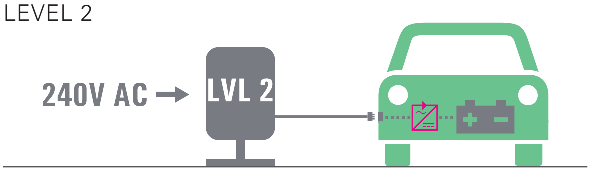
LEVEL 1



8–20+ HOURS CHARGE TIME

- A standard outlet provides 1.44kW at 12A
- 2 to 5 miles of range per hour of charging
- 8 to 12 hours for full charge of most vehicles
- Equipment cost ranges from $300 to $500

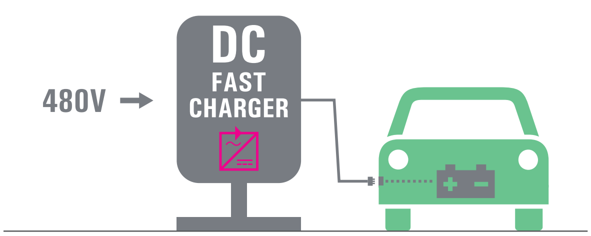
LEVEL 2



4 - 8 HOURS CHARGE TIME

- A low power Level 2 EVSE provides 2.88kW at 12A
- The standard Level 2 EVSE used for public charging provides 7.2kW at 30A
- 10 to 20 miles of range per hour of charging
- 4 to 6 hours for full charge of most vehicles
- Equipment cost ranges from $500 for basic home charging equipment to $6,000 for a public outdoor model with on-board billing system.

DC FAST CHARGE



30 MINUTES CHARGE TIME

- Reaches 40 to 65kW at 70 to 200A, requiring three-phase power
- 50 to 70 miles of range in 20 minutes of charging
- 80% battery charge in 20 to 30 minutes
- Equipment cost ranges from $15,000 to $50,000

Figure 1. Levels of Charge

2. MARKET INTERROGATION

Market interrogation investigates parking challenges and opportunities through the lenses of supply and demand. **Demand encompasses existing parking preferences of vehicle owners and how they translate for garage orphans. Supply includes the range of parking solutions including and beyond those identified in the demand interrogation.** Through the supply lens, we will examine possibilities for providing charging capacity to each parking type. This evaluation process identifies new and existing opportunities to help select the most feasible solutions for garage orphans.

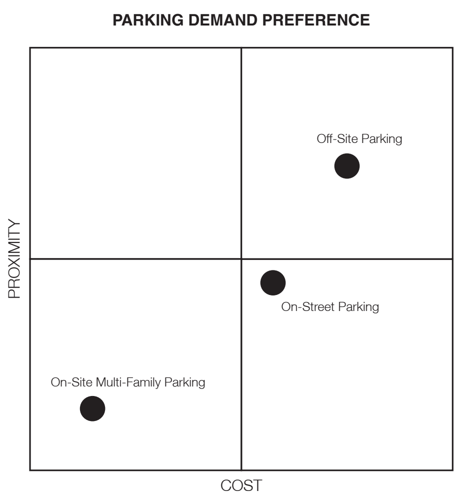


Figure 3. Demand preference matrix


Figure 4. On-site multi-family property

2.1 Parking Demand

The overwhelming majority of vehicle owners strongly prefer being able to park their vehicles at home. However, on-site parking is not always the most prevalent option. In Cambridge, detailed parking data indicate less than 40% of all vehicles have access to an on-site garage or driveway.[1] Most residents rely upon on-street parking, which can accomodate up to 80% of vehicles registered in the city. Together these can theoretically meet 100% of Cambridge residential parking needs, though on-street parking is definitely a second best option. At the neighborhood scale, on-street parking capacity varies from 45% in Mid-Cambridge to 200% in Cambridge Highlands. For several neighborhoods, combining capacity of on-site and off-site parking suggests insufficient capacity for local demand.

Parking preferences of vehicle owners not living in single-family homes can be placed into three categories: on-site multi-family properties, on-street parking, and off-site/ad-hoc designated parking. These are assumed to represent the primary parking options for potential garage orphans.

On-Site Multi-Family Properties

Small multi-family properties categorized as buildings with 2 to 8 units make up a majority of the housing stock in the study area. There are multiple ways each property addresses the parking needs of its residents. Some provide on-site lots and garages, others have guaranteed access to parking lots nearby. Buildings that don't have on-site parking were generally constructed before the creation of parking requirements, which may include single-family homes as well. For areas with housing stock built in the 19th and early 20th century, parking

1 Figure calculated by estimating the number of driveway and garage spaces attached to residential properties and divided against the number of vehicles registered. Source: GIS City of Cambridge.

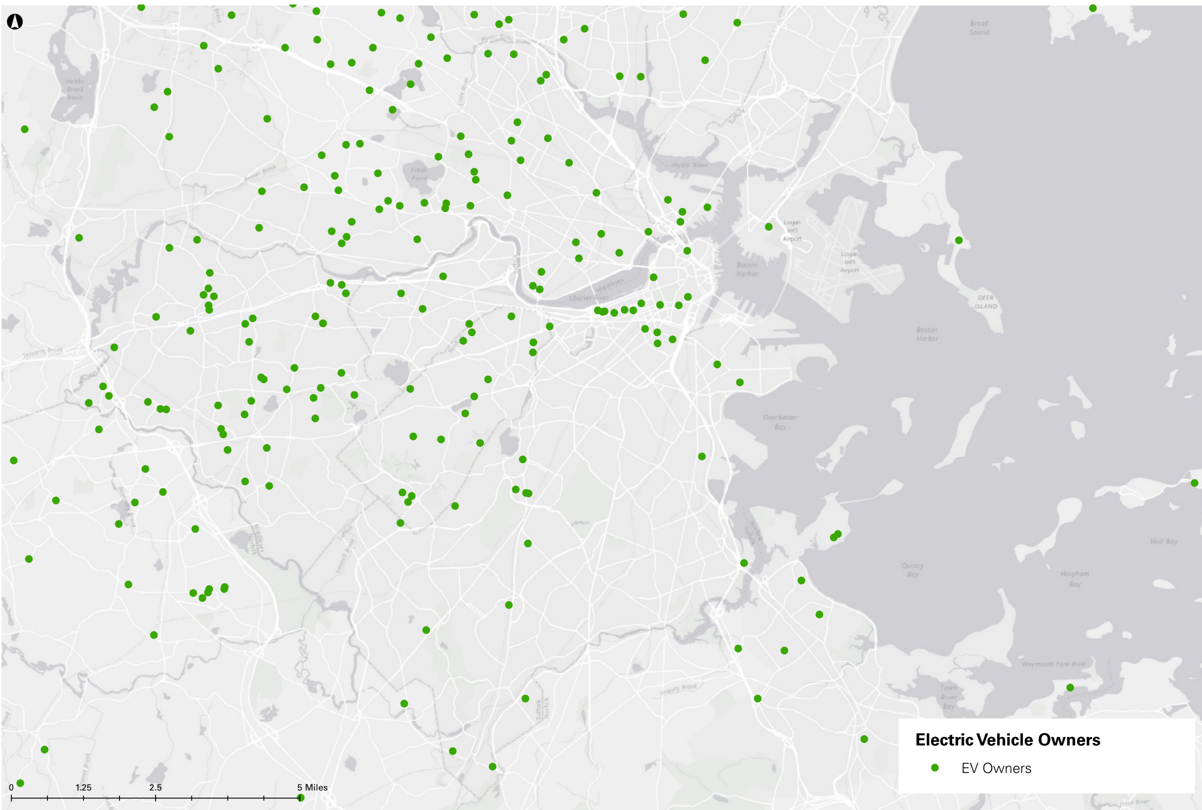


Figure 5. Electric Vehicle Owners

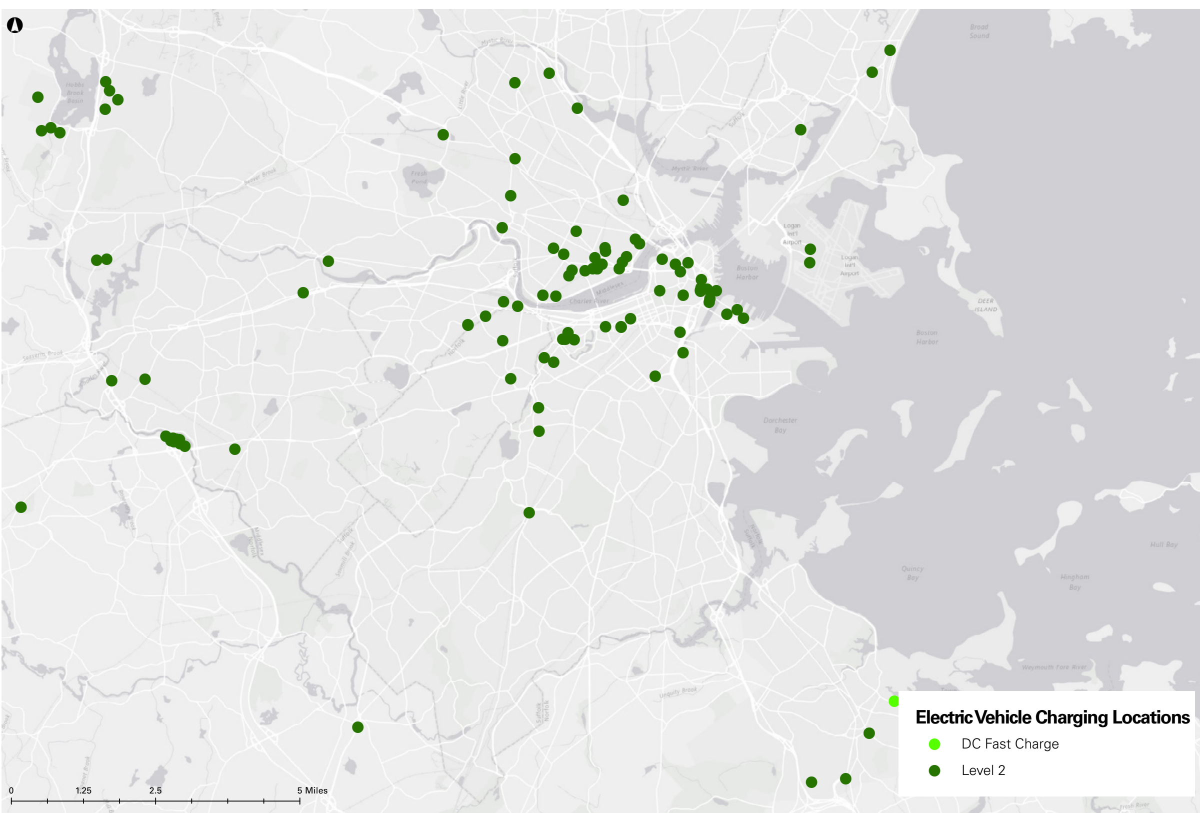


Figure 6. EVSE Locations

Figure 7. On-street parking

Figure 8. Off-site/ad-hoc designated parking

Parking Permits

Boston
Fee: Free to residents
Neighborhood Restrictions: Only valid within chosen neighborhood

Cambridge
Fee: $25/year
Neighborhood Restrictions: Only valid within chosen neighborhood

Somerville
Fee: $30/year
Neighborhood Restrictions: None

capacity can become inadequate due to increases in vehicle ownership.

Even when a vehicle owner has access to on-site parking, several barriers may exist to installing an EVSE. Access to electricity, is often challenging, especially for older garages and open lots not wired for sufficient electrical capacity. Providing electrical access at these locations may either be cost prohibitive or disruptive if located too far away from electrical panels, particularly when electrical capacity upgrades are required.

In these cases, the EV owner is assumed responsible for acquiring and installing the equipment and associated electrical infrastructure, maintaining it and accepting liability. For rental apartments, the economics of EVSE installation is often too great to overcome. Lastly, permission to install an EVSE is not guaranteed from building owners or condo boards.

On-Street Parking

On-street parking is the most common parking type in the study area, accounting for two-thirds of parking demand in Cambridgeport and East Cambridge. It can be subdivided into two categories: residential permit parking and metered parking. Permit parking schemes exist in all three of the cities, requiring minimal fees if any. Permits are granted on a per-vehicle basis for residents' use throughout the municipality. Boston and Cambridge assign parking permits at the neighborhood level, whereas Somerville permit holders have no area restrictions. Perhaps due to low fees, certain districts' parking is oversubscribed such that some neighborhoods have five permits for each available space. On-street parking spaces are especially valuable, because parked vehicles need only to be moved once or twice per month for street cleaning.

Metered parking serves commercial areas, and therefore may be less proximate to residences. Meters in the study area are generally in operation during business hours, e.g. 8am – 8pm, and become available for residential use during overnight, with the exception that in many cases, these spaces have overnight street cleaning daily or weekly. Metered spaces have been the predominant context for installing EVSE on-street, including in Boston, and represent potential synergies for multiple EV owners and user types.

Off-Site/Ad-Hoc Designated Parking

Those unable to park on-site or on-street seek alternative parking solutions. These may include commercial parking garages and lots, shared driveways and other residential parking spaces unaffiliated with the vehicle owners dwelling. These options are generally the most costly and furthest from home of the three demand types and thus, the least preferred.

Several commercial parking garages and lots, clustered in Boston's Downtown, offer monthly parking spaces. Interestingly, based on a recent search of parking rates on **Spothero.com**, many offer monthly rates to reverse

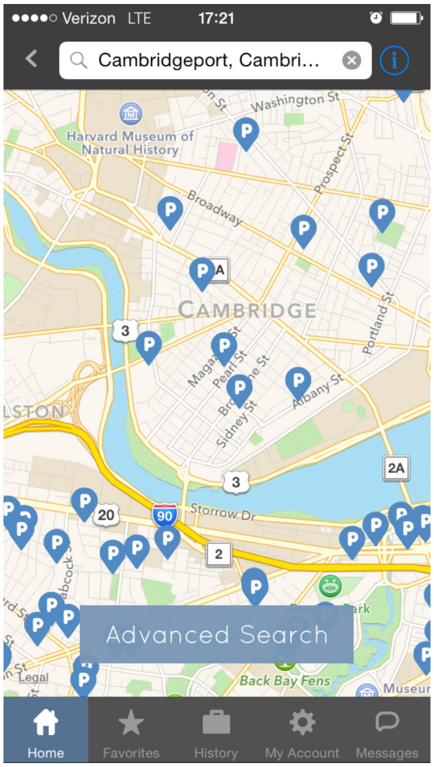


Figure 9. Screenshot of parking app, Spot

Figure 10. Managed parking

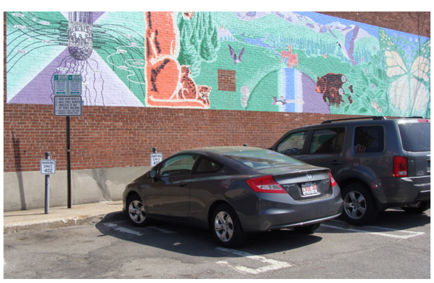


Figure 11. Assigned parking


Figure 12. Sheltered outdoor parking

commuters at approximately a third of what it costs to have fulltime access. This likely attests to complementary demand for daytime and nighttime parking in the Downtown area.

Shared driveways and other residential parking spots not associated with the vehicle owners dwelling refer to a sub-market for parking spaces that has emerged from entrepreneurial residents. Property owners, including condo owners with rights to a particular space, will lease it to a vehicle owner presumably without on-site parking access of their own. The extent of this practice is further evidenced by the popularity of smartphone apps such as Spot, which connects vehicle owners to available parking space rentals.

For garage orphans relying on shared driveways, accessing an EVSE can be a daunting task. Unless an outlet already exists near the shared space or the parking space owner allows an extension cord to be pulled through a window or door to the shared driveway, there can be few alternatives to providing charging in this context.

There have been efforts by some EV-friendly driveway owners to identify themselves through aggregating websites like Plugshare.com; however, they currently represent a small fraction of shared driveways.

Variables

Beyond the constraints outlined above, there are specific challenges that may have an impact on the ability of a garage or lot to accommodate charging access.

1. Does the site have assigned or common parking?

Where parking is assigned, an EV owner may be located away from the electrical panel which can significantly increase the installation cost. Reassigning parking spaces can be a challenge, especially if the EV-suitable space is in a superior location, causing resentment among other drivers. In parking lots without assigned spaces, installing an EVSE will either require a policy to create EV-only spaces or change their parking policies to avoid providing unreliable access to multiple EVs that resutls from sharing an EVSE.

2. Is the site sheltered or open to the elements?

Open sites risk being damaged from severe weather or vandalism. Further, installation costs may be greater if the site is outside, requiring floor rather than wall-mounted EVSE, bollards to protect from cars and snow plows, and electrical conduit to be buried or otherwise protected.

3. Is the site managed or self-service?

For EV drivers handing over their keys to parking attendants, the expectation is that the valet will charge the vehicle and move it into an available space after completion. The EVSE is provided as an amenity and included in existing monthly dues or as a surcharge.

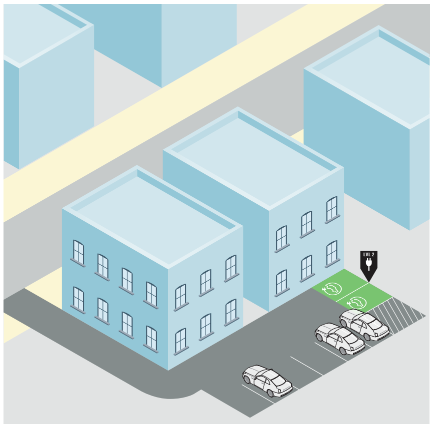


Figure 13. Multi-family residential parking

California Civil Code 4745 and 6713

A common interest development, including a community apartment, condominium, and cooperative development, may not prohibit or restrict the installation or use of EVSE in a homeowners designated parking space.

The homeowner and each successive homeowner of the parking space equipped with EVSE is responsible for the cost of the installation, maintenance, repair, removal, or replacement of the station, as well as any resulting damage to the EVSE or surrounding area. The homeowner must also maintain a $1 million umbrella liability coverage policy and name the common interest development as an additional insured entity under the policy.

Source:
http://www.afdc.energy.gov/fuels/laws/ELEC/CA

2.2 Parking Supply

The supply interrogation takes a look at each available parking type, including those not typically considered for residential overnight parking and some that provide charging during the day. This study examines the potential for each parking type to address the challenges facing garage orphans, and a review of leading practices within the context of each supply type informs the discussion.

There are two general charging strategies for EV owners: overnight and daytime charging. Although overnight charging is always preferred from an electrical demand perspective, daytime charging serves as an important alternative for those unable to meet their charging needs at home. These two strategies are encompassed by home-centric and non-home centric solutions.

Home-Centric Solutions

Home-centric supply solutions include parking types that are near to residences for overnight parking. These types include (1) multi-family residential parking, (2) shared driveways, (3) retail, office, and municipal garages and lots, and (4) on-street parking. Each home-centric supply case is investigated based on the opportunities they present to garage orphans to accomplish their charging needs overnight.

Multi-Family Residential Parking

As mentioned previously, multi-family residential parking is the preferred form of parking for vehicle owners without sole ownership of private garages. Policymakers, especially on the West Coast, have embraced the strategy as the next-best alternative to the single-family home garage, where the ability remains to pair EVSE with individual EV owners, along with lower equipment cost and installation in comparison with public charging infrastructure. However, many of these parking facilities do not have electrical access at parking spaces. This together with the potential involvement of multiple stakeholders, makes EVSE installation in this context more complicated than at single-family homes.

Several states have prioritized increasing access to EVSE in multi-family properties by establishing regulations that clearly outline the roles and responsibilities of stakeholders in those parking scenarios. Some have even established policies to encourage multi-family property managers to take advantage of economies of scale by installing multiple EVSE themselves, significantly reducing the average installation cost per station. For example, Maryland instituted a tax rebate amounting to 20%, or up to $5,000, of the total equipment and installation cost for an unlimited number of EVSE, while California implemented a lending program that allows property owners to leverage their properties up to 15% to finance equipment and installation.[2,3,4] San Diego Gas & Electric is currently undertaking a large-scale

2 http://energy.maryland.gov/Transportation/evserebate.html
3 http://industry.traveloregon.com/content/uploads/2015/01/GCC-Supporting-PEV-Market-December-2014.pdf Page 7
4 http://www.afdc.energy.gov/laws/all?state=CA "Residential Electric Vehicle Supply Equipment Financing Program."

Figure 14. Shared driveways

Retail Lot Parking Example

In Cambridge, Massachusetts, EVSE were installed at the Porter Square shopping center parking lot for its EV customers. Soon nearby residents began utilizing the EVSE overnight. While this was not the intended purpose, the organic result is a positive indicator of user-acceptance of such a format.

Source: Transportation and Climate Initiative. "Lessons From Early Deployments of Electric Vehicle Charging Stations." March 2013.

Parking Garage EVSE	1 Space	5 Spaces
Charging Station Hardware	$3,250	$3,250
Electrician Materials	$50	$30
Conduit & Wire	$50	$30
Electrician Labor	$1,150	$230
Mobilization	$300	$60
Permitting	$125	$25
Total:	$4,875	$3,595

Savings per EVSE	$1,280 26.3%

Curbside EVSE Additional Expense	1 Space	5 Spaces
Other Materials	$150	$30
Trenching/Boring	$100	$20
Mounting/Signage/ Protection	$50	$10

Savings per EVSE	$1,400 27.9%

Table 1: Potential cost savings from installing multiple EVSE per site

network build out for multi-family residential and workplace utility installations.[5] In such a scenario, costs can be averaged over thousands of installations. Further, these costs are borne by ratepayer increases other then by individual users, which may be a benefit depending on one's perspective.

A key reason this supply solution can be so attractive is the low cost of Level 1 or Level 2 EVSE in the residential setting, in comparison to public charging equipment, because it requires less on-board capabilities. Installation costs can vary substantially though. Some costs associated with the installation of charging equipment in residential parking garages can be reduced by instituting pre-wiring requirements in new and renovated parking garages. In existing garages, cost reductions can be achieved by installing low-power Level 2 chargers that enable multiple EVSE to be installed on a single panel, while still providing sufficient overnight charging.[6] The California Plug-In Electric Vehicle Collaborative recommends installing surface-mounted conduit in parking garages as an alternative to boring through walls or concrete, as a means of reducing installation costs.[7]

Shared Driveways

Shared driveways, which satisfy a major portion of existing demand within off-site/ad-hoc designated parking, occur within nearly every neighborhood of the study area. Indicative of the high demand, even this type of parking faces supply constraints. Recently, third-party apps such as "Spot" have made the process easier for some neighborhoods.

There are significant questions about the best practices for establishing charging access on residential driveways unaffiliated with a vehicle owner's residence. It is also generally not realistic to expect users of shared driveways to invest in EVSE installation because of the lack of ownership stake, low-commitment level of relevant use-contracts, and uncertainty of installation costs. Therefore, EVSE installation is an unlikely outcome in most circumstances. Possible solutions to unlock this parking supply to some garage orphans include: (1) embracing technology to assist with identifying and rating EV-ready driveways and (2) creating a legal framework to recognize the transaction and include a provision for access to electricity.

Retail, Office, and Municipal Garages & Lots

Retail, office, and municipal parking garages and lots represent an unexplored resource which may be available for overnight parking. Excess parking supply at these sites is possible during business hours as well, posing an opportunity for further study.

Where these sites are located within or near residential areas,

5 http://www.utilitydive.com/news/how-sdge-wants-to-power-the-electric-vehicle-market/315887/
6 US Department of Energy. A Guide to the Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects. January 2014.
7 California Plug-In Electric Vehicle Collaborative. "Plug-in Electric Vehicle Charging Infrastructure Guidelines for Multi-unit Dwellings." November 2013. Page 10.

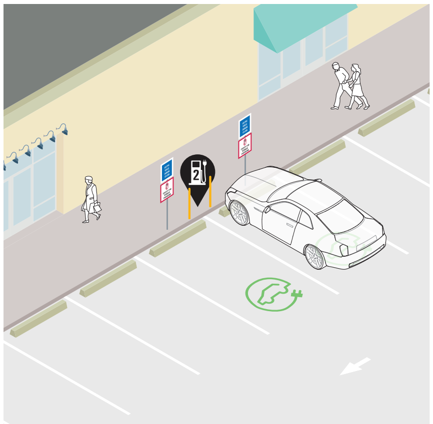


Figure 15. Retail parking lot

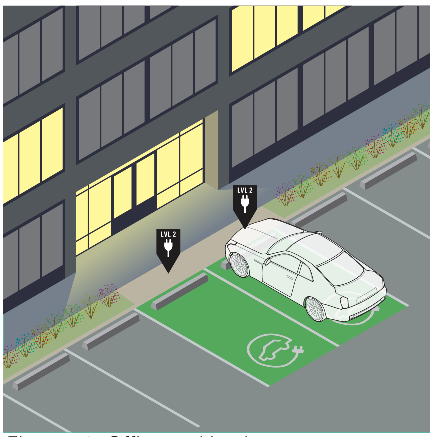


Figure 16. Office parking lot

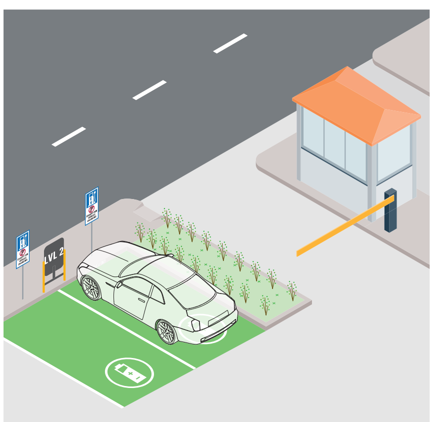


Figure 17. Municipal parking lot

there is potential to increase EV charging opportunities in non-contentious locations.[8,9] Installing EVSE at these lots incur fewer hurdles than in other supply scenarios, as lot operators have few stakeholders to consult. From a market perspective, lot operators have shown a willingness to install EVSE in order to attract customers during operating hours. Office parking garage and lot operators have considered EVSE to be an amenity for their employees and as a way to project a green-conscious image. Further, opening up this supply to residents may establish additional revenue streams by leasing spaces overnight.

Considerations for lot operators seeking to install EVSE include enforcement and safety. Parking restrictions for EV-only spaces may come into conflict with a desire not to upset customers or clients. Safety measures, including surveillance equipment may need to be put in place to allow for overnight charging.

Existing policies may also hinder utilizing this parking resource. New constructed parking must be associated with residential or workplace use, and is specifically not available for the general public, i.e. "commercial" parking. Parking offerings have been limited through a parking cap because of clean air concerns in three districts of Boston: South Boston, East Boston, and Downtown ("Boston Proper").[10] In Cambridge, because of PTDM policies, those who construct parking must pay impact fees.

On-Street Parking

On-street parking exists within every study area neighborhood and is the most common parking type. It represents an attractive opportunity for municipalities, who own the spaces, to burnish their "green" image. Dedicated EVSE have been installed at on-street locations in Boston (in front of City Hall and the Lenox Hotel), Washington DC, Seattle, and San Francisco, among others.[11,12] Policymakers in these cities have considered installing curbside EVSE as a public good in support of zero-emission vehicle adoption. Other cities, such as Philadelphia, have instituted an application form through the parking authority in order to systematize the process of installing on-street EVSE in residential areas.[13]

For the most part, these EVSE on-street installations are in metered spaces, which, similar to retail, office, and municipal lots, are most useful for regular car commuters.

Non-metered parking can serve long-term parking needs, including irregular schedules and weekend users. Installing EVSE

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8 California Plug-In Electric Vehicle Collaborative. "Plug-in Electric Vehicle Charging Infrastructure Guidelines for Multi-unit Dwellings." November 2013. Page 10.
9 Seattle Office of Sustainability & Environment. "Removing Barriers to Electric Vehicle Adoption by Increasing Access to Charging Infrastructure." October 2014.

10 http://www.epa.gov/region1/topics/air/sips/ma/MA_7_33.pdf
11 Transportation and Climate Initiative. "Lessons from Early Deployments of Electric Vehicle Charging Stations." March 2013.
12 Seattle Office of Sustainability & Environment. "Removing Barriers to Electric Vehicle Adoption by Increasing Access to Charging Infrastructure." October 2014.
13 http://philapark.org/wp-content/uploads/2014/03/EVPS-Application.pdf Accessed: May 26, 2015.

On-Street Parking Example

The experience of EV-Box, a Dutch firm which runs the largest EV charging network in the world, suggests on-street EVSE can achieve market viability with 360 kWh of usage per month. EVSE in un-metered residential parking permit areas are unlikely to meet this usage threshold. On average, EV-Box's public stations achieve this rate of usage three months after installation.

Source: Conversation with Tim Kreukniet, EV-Box. April 28, 2015

Figure 18. On-street parking

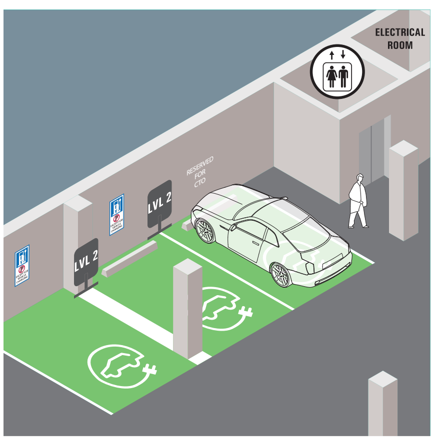

Figure 19. Workplace charging

at curbside locations requires extensive municipal planning and upfront costs. As a supply solution, it also suffers from uncertain turnover rates and, as evidenced during recent winter storms, remains susceptible to severe weather. Installing EV infrastructure in these locations may come up against several barriers including outdated policy and permit procedures, street-by-street variability in utility electrical service, and push-back from non-EV owning residents around the dispensation of public space, especially where parking demand is high and EVSE utilization is low.

If third-party provided on-street charging is desired by the municipality, a citywide lease contract for all such spaces is an attractive option, and can be achieved through an RFP process. Multi-year lease terms are necessary to entice private partnership. Significantly longer terms are necessary for DC Fast-Charge (to compensate for greatly increased equipment and installation costs) though no DC Fast-Charge rollout of this type has been attempted in the US. Larger numbers of EVSE, number of spaces and contract length can be negotiated to attract more interest by averaging installation costs and spreading risk.

Non-Home Centric Solutions

Non-home centric supply solutions differ from home-centric solutions in that they seek to provide charging during the day, usually for shorter periods, and support multiple users. These solutions may either be a viable primary strategy or complement a home-centric strategy acknowledged to not address all of the charging needs of a city's garage orphans, especially those vehicles not regularly used for commuting.

Major challenges for non-home centric charging include identifying the sufficient number of stations to meet demand, appropriate siting, achieving minimum required investment returns for private operators, and in not encouraging vehicle trips where other transportation alternatives may exist. The three main opportunities for non-home charging include workplace charging, destination charging, and DC Fast-Charging.

Workplace Charging

According to the US Department of Energy, workplace charging currently represents the second most common charging location.[14] Nationwide, policymakers have sought to incentivize workplace charging, and in Massachusetts MassEVIP provides incentives to employers for installing Level 1 and Level 2 EVSE.[15] Workplaces have the advantage of being able to site EVSE close to electrical panels to reduce time and cost of installation, and can rearrange employee parking as needed. A study conducted by the National Research Council estimated that workplace charging infrastructure would be more cost-effective than installing public EVSE.[16]

Relying on place of work to provide charging infrastructure has

14 US Department of Energy. "Plug-In Electric Vehicle Handbook: for Workplace Charging Hosts." August 2013. Page 8.
15 http://www.mass.gov/eea/agencies/massdep/air/grants/workplace-charging.html
16 National Research Council. "Overcoming Barriers to Deployment of Plug-in Electric Vehicles." 2015.

Existing EVSE Incentives in Massachusetts

The Massachusetts Electric Vehicle Incentive Program (MassEVIP), a program established by the Massachusetts Department of Environmental Protection in 2013, provides incentives for the acquisition and installation of ESE through two current programs:

1. Grants of up to $13,500 for the purchase or lease of Level 2 EVSE for Massachusetts cities, towns, state agencies, public/private colleges & universities, and public/private driving schools.

2. Grants for up to 50% of the cost of Level or Level 2 workplace EVSE, up to $25,000, to employers with 15 or more employees in non-residential place of business.

Source: http://www.mass.gov/eea/agencies/massdep/air/grants/massevip.html

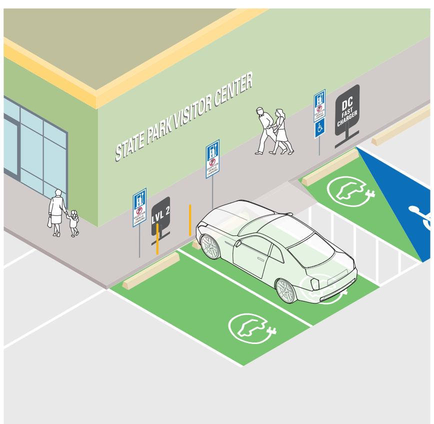

Figure 20. Destination charging

the benefit of leveraging private sector involvement to respond to market demand. Several pricing models have emerged, including providing the service for free to employees.

Workplace-focused EVSE strategy is not without its own risks, such as shifting charging habits from off-peak hours to daytime peak demand periods. Another issue arising from free charging is it becoming attractive to workers who have charging available at home, potentially blocking those who rely on it.[17]

Finally, there is a strong possibility for workplace charging to induce driving, where viable alternative transportation options exist, which is counter to the study area municipalities' stated Parking and Transportation Demand Management requirements.

Destination Charging

Destination charging is a potential solution for those vehicle owners who do not regularly use their EV for commuting, and instead use them for occasional excursions. Destinations may include concert and sports venues, large retailers such as Costco or IKEA, museums, and recreation centers and parks. This solution would likely require regional agency or State support for destinations outside the municipality. An extensive destination charging network would benefit all EVs and also be complemented well by DC Fast-Charging along key routes.

DC Fast-Charging

DC Fast-Charging, which can charge an EV battery to 80% in 20 to 30 minutes, is an essential component of any comprehensive charging infrastructure ecosystem, facilitating longer-distance travel. The substantial reduction in charging time changes the siting strategy from a parking issue into an idling issue. In DC Fast-Charging scenarios, EV owners standby or stop at a service area, convenience store, or other short-term destination as their EV charges.

Though DC Fast-Charging stations in the US are primarily located along highways and other major routes, another strategy might see them distributed across the study area — a gas station model alternative to home-centric EVSE provision. DC Fast-Chargers face significant hurdles in the urban environment: high equipment and installation costs for which no successful standalone business model exists; a less convenient user experience compared to overnight charging solutions; and especially the challenge of accessing the three-phase power necessary to operate.

Three-phase power is not available in many locations, especially residential areas served by radial systems rather than network systems.[18] A radial system is arranged like the branches of tree, providing each customer with one source of supply. A network system has multiple redundancies, providing the opportunity to draw power at greater currents if required. As older municipalities, portions of Boston and Cambridge are served

17 Plug In America. "Workplace Charging: The Goldilocks Approach." February 20, 2015.

18 Eversource – DC Fast Charging Working Draft. June 6, 2015

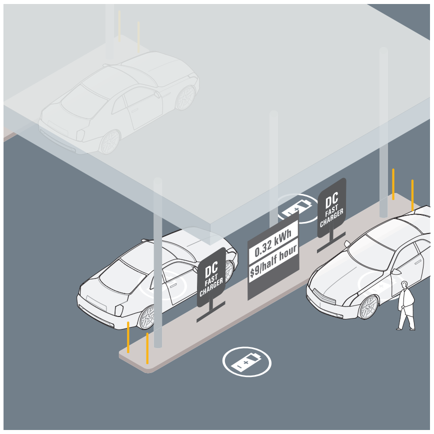

Figure 21. DC fast-charging

Tesla Supercharger Business Model

Cost of equipment and installation of four to six Tesla Supercharger stations: $100,000 - $175,000 (depending on site modification needs). Entire process takes between 12 and 20 weeks, of which only 2 to 4 weeks is actual site-work)

Real Estate: Landowner sets aside 200 to 600 sq. ft. for the Supercharger and equipment and four to six parking spaces.

Contract: Land is leased for a minimum of 5 years and usually 10 years. Landowner receives high profile landmark and Tesla retains the right to install and operate their EVSE. No money is exchanged between Tesla and Landowner.

Sites: 204 locations in North America
3 locations in Massachusetts

Source: http://insideevs.com/tech-crunch-what-it-takes-to-be-a-tesla-supercharger-partner/

by the more robust network system. For either system, adding or interfacing with high-powered charging capacity requires assistance from the local utility.

Compared to Level 2 stations, equipment and installation for DC Fast-Charging can cost upwards of $50,000 per station.[19] There are currently three common standard variants, two of which are open standards: the Japanese developed CHAdeMO standard and the International J1772 Combo standard. While both provide equivalent charging capability, the plugs themselves are incompatible. Recent DC Fast Charging station installations have incorporated plugs for both standards. Tesla Motors has developed a proprietary charging platform provided at no fee to Tesla Model S and later model owners. Tesla has recently incorporated other DC Fast Chargers in their Supercharger installations, though of fewer number than Tesla-only chargers.

The Dutch company Fastned has set out to install the densest DC Fast-Charging infrastructure in the world by 2016. The company aims to provide a DC Fast-Charging station within 31 miles of any user,[20] densities far too low to support as a primary means of charging. Japan meanwhile, has DC Fast-Charging as the main focus of their charging infrastructure strategy. The country, which is roughly the size of California with three-times the population, currently has over 1,400 DC Fast-Charging stations,[21] in contrast to the United States, which has installed less than a thousand to date.[22]

In spite of the positive implications for DC Fast-Charging, a study conducted by the EV Project and the Idaho National Laboratory discovered that despite the shorter charge times, DC Fast-Charging infrastructure was utilized at half the rate of Level 2 chargers: between 4 to 7 times per week as opposed to a median average of 9 to 38 charging events per week for Level 2.[23] Conversations with officials working on EVSE programs suggest the underutilization of DC Fast-Charge equipment is due to poor location selection, in particular the use of retail centers not immediately adjacent to highways. Commercial centers and new gas stations continue to be promoted as ideal places, regardless of location, where retailers can take advantage of the 30-minute wait times.[24, 25]

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19 National Research Council. "Overcoming Barriers to Deployment of Plug-in Electric Vehicles." 2015. The basic cost of a DC fast-charging station is about $10-15,000, but the total equipment cost of the Washing State stations averaged $58,000 reflecting the auxiliary services and features needed for a publicly accessible unit…

20 Palet, Laura Secorun. "Fast Food Stops for Electric Cars." USA Today. May 27, 2014. Accessed: May 26, 2015. http://www.usatoday.com/story/money/cars/2014/05/27/ozy-charging-stations-electric-cars/9624017/

21 International Energy Agency. "Global EV Outlook: Understanding Page 14.

22 Alternative Fuels Data Center, http://www.afdc.energy.gov/locator/stations/

23 The EV Project. "Analyzing Public Charging Venues: Where are Publicly Accessible charging Stations Located and How Have They Been Used?" Idaho National Laboratory. September 2014.

24 Conversation with Ashley Horvat, Oregon Department of Transportation, March 23rd, 2015

25 Turco, Andrew. "After the Gas Station: Redevelopment Opportunities from Rethinking America's Vehicle Refueling Infrastructure." Massachusetts Institute of Technology. June 2014.

Market Interrogation	Opportunities	Challenges
Home-Centric Solutions: Parking types that are near garage orphan residence for overnight parking.		
Multi-Family Residential Parking	(1) Already the preferred parking option of residents who have access to it. (2) Leverages private-sector demand which insures EVSE utilization. (3) Utility provider can install and own EVSE at these locations to achieve large scale cost-savings.	(1) Acess to electricity may not be available at older properties (2) Apartment renters do not have an ownership stake. (3) Permission to install an EVSE is not guaranteed.
Shared Driveways	(1) Exists within nearly every study area neighborhood. (2) Third party apps are making locating parking spaces easier for consumers.	(1) Little incentive for small private lots to install EVSE. (2) Most shared driveways do not have electricity access except from within the associated building. (3) Cambridge and Somerville do not allow leasing of residential parking.
Retail, Office, and Municipal Lots	(1) May be an underutilized parking supply. (2) EVSE installation is less demanding than in other contexts.	(1) Current regulations do not allow office parking spaces to be utilized by residents without a commercial variance. (2) Lots and garages are likely to be more distant to an EV owners home than other options. (3) Private lots may have difficulty with enforcing parking restrictions and ensuring the safety of EVs overnight.
On-Street Parking	(1) The most common parking type within the study area. (2) Exists within every neighborhood. (3) Owned by the municipality.	(1) Parking permits are already oversubscribed. (2) Low turnover rates. (3) EVSE are susceptible to damage from vandalism and severe weather. (4) Variability in electrical service. (5) Pushback from non-EV owners for reducing public access for EV only parking.
Non-Home Centric Solutions: Provide charging solutions during the day, usually for shorter periods of time than home-centric solutions, and seek to accomplish multiple charges during the day.		
Workplace Charging	(1) Massachusetts policy already exists to incentivize workplace charging (MassEVIP). (2) Can site EVSE close to electrical panels. (3) More cost-effective than installing public EVSE.	(1) Can shift charging habits from off-peak hours to daytime peak electrical usage periods. (2) Can result in non-garage orphans being primary users if EVSE is not reliably available to those who need it. (3) Can induce additional driving where other transportation alternatives exist.
Destination Charging	(1) Provides charging for EV owners whose primary use is infrequent trips. (2) Would compliment intracity solutions and DC Fast-Charging networks.	(1) Locations are generally outside of study area jurisdiction, requiring regional agency of State support.
DC Fast Charging Network	(1) Charges a battery in 20 to 30 minutes. (2) Can reduce the ratio of EVSE to EV owners below 1:1.	(1) Significantly more expensive to acquire and install. (2) Existing model requires 3-phase power, not available in many locations.

Table 2: This tables summarizes the opportunities and challenges of the parking supply solutions discussed in the market interrogation.

3. FRAMEWORK FOR DEVELOPING EV CHARGING

3.1 Analytical Framework
The study utilized three lenses to evaluate potential solutions: Policy & Politics, Market Feasibility & Viability, and Technology & Infrastructure. Each lens focuses on a set of constraints that determine applicable solutions from the Supply Interrogation for a given neighborhood characteristic. In this chapter, the primary considerations are outlined for each neighborhood to identify typologies that favor specific solutions. The next section identifies two neighborhoods where potential solutions are evaluated using geospatial analysis and the results of the results of this analysis.

Policy & Politics addresses the political viability and policy feasibility of a given supply solution. Political viability addresses the anticipated attractiveness based on electorate perceptions of a city's 'green' image, public equity, and resource allocation; and policy feasibility questions the existing regulatory environment, and the ease by which it can be changed if necessary. From this standpoint, critical questions include: are there legal obstacles to overcome, and are they substantial? At which level of government do they need to be addressed? Can stakeholders be incentivized or required to participate?

Technology & Infrastructure reviews technical hurdles to implementation of a garage orphan charging network. It asks: is the technology scalable? Is it adaptable to different environments? Can existing infrastructure support the supply solution over the near-term or only in the long-term? What infrastructure improvements need to be in place, and are they realistic? Are there current technologies that would facilitate or ease implementation?

Market Feasibility & Viability correlate to the Demand and Supply interrogations in the previous chapter. Market feasibility asks, given a particular solution; If we build it, will they come? Will the solution make owning an EV as convenient as owning a non-Electric Vehicle? And would the assumed installers and operators in fact take on such an effort? Market viability takes the supply perspective: Do parking lot and garage owners have incentives to participate? Is there a viable business plan for the supply solution, including a sufficient supply of sites? Are incentives to install charging equipment market driven or policy driven, and if so, are they sustainable or otherwise replaceable?

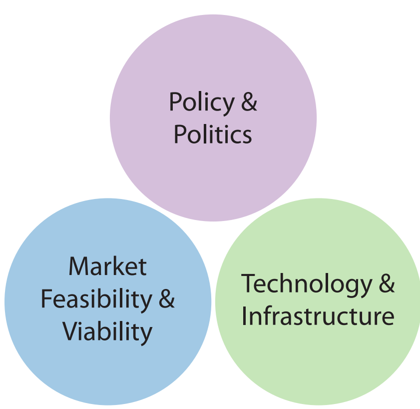

Figure 22. Framework lenses

No.	Strategy	Market Demand	Market Supply	Technical Feasibility	Infrastructure Feasibility	Political Viability	Policy Feasibility	Total	Rank
1	Install EVSE at on-site Residential Parking Garages and Lots	Very High	Adequate	High	High	Very High	Very High	26	1
2	Create 'shared parking' legal framework that includes regulation on electricity access	High	Low	Low	Adequate	Adequate	Very Low	15	8
3	Promote Overnight Charging at Commercial, Office, and Municipal Lots	Adequate	High	High	High	High	Adequate	22	3
4	Create Special EV Curbside Parking Permits in Neighborhoods and Planning Districts	High	Adequate	Adequate	Low	Adequate	Adequate	16	5
5	Install High-Profile EVSE at Metered On-Street Parking	Low	Low	High	Low	High	High	16	5
6	Create Robust Workplace Charging Outreach Strategy	High	Very High	High	High	High	Adequate	24	2
7	Create Robust Destination Charging Outreach Strategy	Adequate	High	High	Adequate	High	Adequate	21	4
8	Support DC-Fast Charging Network	High	Very Low	Adequate	Very Low	High	Adequate	16	7

Table 3: Strategy Matrix

1	Very Low
2	Low
3	Adequate
4	High
5	Very High

Strategy Scoring Guide

Out of these questions a supply matrix was developed to compare solutions against one another on a scale of 1, meaning 'Very Low' and 5, meaning "Very High"

Neighborhood Typology

As outlined in the methodology, this study tested strategies against neighborhood typologies. Because Cambridge parking and relevant data was more readily available, our analyses concentrated in its neighborhoods, and approximations based on best available data were then translated to typologies for neighborhoods in Boston and Somerville. For the purposes of this analysis, Area 2/MIT was not considered as its metrics were outliers due to the university's near universal presence inside the neighborhood boundaries.

Neighborhood typologies were determined based on three metrics: availability of retail, office, and industrial areas within the neighborhood; density of residential units; and the context of parking supply based on availability of preferred parking types and the number of registered vehicles.

Although no two neighborhoods are identical, in many cases, shared attributes point toward common solutions. Relying on specific metrics to determine the type of parking needs and opportunities within each neighborhood, three general typologies emerged:

1. Mixed-use, high-density neighborhoods with parking demand constraints
2. Residential, high-density neighborhoods with parking demand constraints
3. Mid/Low-density, residential neighborhoods with adequate on-site and on-street parking

The list of neighborhoods within all study areas and the most applicable typology are listed below. The following detailed analysis of Cambridge neighborhoods is provided as an example.

Neighborhoods By Type

Type 1
East Cambridge
Cambridgeport
Cambridge Highlands
Black Bay/Beacon Hill
Dorchester
Roslindale
West Roxbury
Hyde Park
Davis Square
East Somerville
Ward Two/Cobble Hill

Type 2
Wellington-Harrington
Area Four
Mid-Cambridge
Riverside
East Boston
Charlestown
South Boston
Central
South End
Fenway/Kenmore
Roxbury
West Somerville
Tufts
Powder House
Magoun/Albion
Central Hill
Prospect Hill
Spring Hill
Winter Hill
Ten Hills

Type 3
Agassiz
Neighborhood 9
West Cambridge
North Cambridge
Strawberry Hill
Allston/Brighton
Jamaica Plain
Mattapan

Neighborhood Typology 1: Mixed-Use, High-Density Neighborhood with High Parking Demand

This group includes Cambridgeport and Black Bay/ Beacon Hill and Davis Square. They are characterized by their high proportion of retail, office, and industrial areas relative to other neighborhoods. This group is also of higher residential density, with a range of multi-family building sizes.

These neighborhoods can be assumed to have substantial daytime parking needs due to the retail and business activity within their boundaries. From a supply perspective, there are opportunities for retail, office, and municipal parking to provide overnight charging needs for local residents while also being utilized by commuters during the day.

It should be noted that Cambridge Highlands is a unique case in that the majority of its housing is single-family. Despite this, the neighborhood was included in this category because many of the Supply solutions are still relevant from a commuter perspective,

Neighborhood Typology 2: Residential, High-Density Neighborhood with High Parking Demand

With its strongly residential character, Type 2 includes Wellington-Harrington, Area Four, Mid-Cambridge, and Riverside. Analysis of these neighborhoods indicate a greater reliance on shared driveways, garages and lots. These neighborhoods have a higher proportion of on-site parking than those in Type 1, and inadequately provided on-street parking. Supply-side solutions for garage orphans in this typology are focused on shared driveways, on-street parking, and residential lots and garages.

Neighborhood Typology 3: Residential, Mid/Low-Density Neighborhood with Adequate Parking

Neighborhoods in this group have a strong residential character with medium- to low-density housing stock. Unlike the previous two typologies, these neighborhoods have a sufficient supply of on-site and on-street parking. Even though access to parking is adequate, on-street parking does not necessarily align with proximity to individual residences. From a garage orphan perspective, the largest challenge in this context is enabling charging capacity in multi-family buildings and on-street residential parking. Where these supply solutions are not feasible, non-home centric charging may be the best alternative.

Gaps in the Data

Cambridge GIS has extensive data available including land use, traffic, parking, residential permits, and landmark information along with base layers for building footprints, parking lots, streets, sidewalks, driveways and driveways. Data collected from Cambridge GIS, along with US Census data provided much of the information necessary for a comprehensive spatial analysis of the city and Cambridgeport's parking and EV charging supply and demand.

Figure 24: Neighborhood typology map. Type 1 are mixed-use, high density neighborhood with parking demand constraints. Type 2 are residential, high-density neighborhood with parking demand constraints. Type 3 are mid/low-density residential neighborhoods with adequate on-site and on-street parking.

	Mixed Use Determinant		Density Determinant (% of Properties)			Demand			
Neighborhood	% Residential	% Retail, Office, Industrial	% SFH	% Small Multi-Fam	% Large Multi-Fam	On-Site: Vehicles	On-Street: Vehicles	% Unmet Demand	Neigh-borhood Type
East Cambridge	25%	23%	29%	68%	3%	0.12	0.67	21%	TYPE 1
Area 2/MIT	1%	5%	0%	0%	100%	0.05	10.05	NONE	N/A
Wellington-Harrington	60%	13%	27%	71%	7%	0.38	0.64	-1%	TYPE 2
Area Four	52%	12%	25%	72%	4%	0.35	0.78	-12%	TYPE 2
Cambridgeport	48%	21%	24%	73%	4%	0.26	0.67	7%	TYPE 1
Mid-Cambridge	62%	3%	25%	67%	8%	0.31	0.45	25%	TYPE 2
Riverside	45%	7%	25%	69%	6%	0.21	0.57	22%	TYPE 2
Agassiz	44%	1%	37%	59%	3%	0.45	0.90	NONE	TYPE 3
Neighborhood 9	61%	5%	44%	52%	5%	0.33	0.68	-1%	TYPE 3
West Cambridge	48%	4%	50%	48%	2%	0.60	1.36	NONE	TYPE 3
North Cambridge	46%	10%	35%	63%	3%	0.38	0.77	-15%	TYPE 3
Cambridge Highlands	12%	28%	63%	32%	4%	0.35	2.00	NONE	TYPE 1
Strawberry Hill	34%	0%	32%	67%	1%	0.66	0.80	NONE	TYPE 3

Table 4: Neighborhood typology matrix (Cambridge)

Data for Cambridge that would have further supported this study:

- Consistent parking data, as Land use, parking lot and commercial lot datasets offered conflicting parking lot and garage location information, including the number of parking spaces.
- Residential parking garage information, both for detached single-family homes as well as multi-family buildings.
- Information on on-street parking, such as street signage, or parking restrictions.
- Communiting patterns, to understand how parking spaces would be used, and therefore which supply solutions are viable.

The City of Boston, MassGIS and the city of Somerville have comparitively less data available regarding land use, streets, sidewalks, parking permits, MBTA parking lots, building footprints, and landmark locations. Further data was collected from Open Street Maps and other public entities, and used alongside U.S. Census data. The limitations of these data and layers led to gaps in the Jamaica Plain case study.

Data for Boston and Somerville that would further support this study:

- Commercial, municipal or institutional parking lot and parking garage data with parking space information.
- Driveway and residential parking garage geospatial locations and information.
- Any data regarding street parking and metered street parking.
- Street sign designations and parking restrictions.
- Data regarding public and private commercial, municipal and institutional lots.
- Updated parking permit and vehicle count estimates.
- Vehicle usage patterns

Cambridgeport, Snapshot

Population
12,220
23,057 people/square mile[1]

Parking
1,226 spaces in residential driveways
1,182 spaces in residential lots
3,166 unmetered street parking
290 metered parking spaces

Housing
4.4% single-family buildings
30% 2-4 unit buildings
65% 4+ unit buildings
5,391 housing units[2]

Vehicles
4,701 vehicles
4,253 parking permits[3]
70% of residents have 1+ vehicle

Land Use
48% residential
21% retail, office, industrial

Transportation/Commute
30% drive to work
70% walk, take public transport, bike or work from home[4]

1 American Community Survey, 2006-2011 5-year estimates, U.S. Census Bureau
2 Cambridge GIS, CDD, http://www.cambridgema.gov/GIS/gisdatadictionary/CDD/CDD_LandUse
3 CDD City of Cambridge, Neighborhood Statistical Profile, 2013.
4 American Community Survey, 2006-2011, 5-year estimates, U.S. Census Bureau

3.2 Case Studies

Summary and Demand Interrogation
Parking and EV charging demands vary by neighborhood, based on several factors, including land use typology, population demographics, and local policies and infrastructure constraints. Neighborhood case studies bring into relief the realities of each typology and its appropriate parking and EV charging supply solutions. Demand for parking may be met by the preferred solution on-site parking in driveways and home garages or alternatives, including on-street parking, or off-site parking. Cambridgeport and Jamaica Plain were chosen as they exemplify two different, but translatable, neighborhood land use, socioeconomic and parking supply and demand profiles, where EV usage is present, but has not yet taken hold.

Additionally, Cambridgeport showcases the analytical opportunities afforded through the city's extensive data collection.

Parking and EVSE supply solutions can be analyzed against the case study neighborhood typology through an understanding of the neighborhood demand and supply. On-site and on-street, as well as off-site solutions can be matched to the neighborhood characteristics based on in-depth geospatial analysis in Cambridgeport and Jamaica Plain.

Cambridgeport
Cambridgeport represents an area with mixed land uses of primarily residential, commercial and institutional users. It is home to areas of MIT campus, as well as the Boston Biomedical Corp., and other research facilities associated with the university. Its main commercial corridor Massachusetts Avenue defines its northern border, which includes commercial and residential activity, restaurants, and offices. The Charles River wraps around the southern edge of the neighborhood, with large-lot commercial and retail properties clustered in the south west. These properties, including Whole Foods Market, Trader Joe's, and Micro Center are accompanied by ample surface parking.[1] The neighborhood also features a significant residential area with a mixture of small multi-family homes, apartment buildings, and a small portion of single-family homes. Some housing units feature driveways and residential parking access, while many rely on on-street parking, encouraged by limited street cleaning restrictions. Based on the neighborhood density, mixed-use, and parking demands, it has been characterized as a Type 1 neighborhood: a mixed-use, high density neighborhood with high parking demand.[2]

Demand
Cambridgeport's population of 12,220 has a population density of 23,057 people per square mile. Just 30% of the population commutes to work by car, but 70% of households have one or more vehicles available to them.[3]

1 Google Maps, https://www.google.com/maps/place/Cambridgeport,+Cambridge,+MA/@42.3605092,-71.1137274,18z/data=!4m2!3m1!1s0x89e379fd099ea5bd:0x1a8d84d84b68093e
2 Neighborhood Typology Matrix
3 American Community Survey, 2006-2011 5-year estimates, U.S. Census Bureau

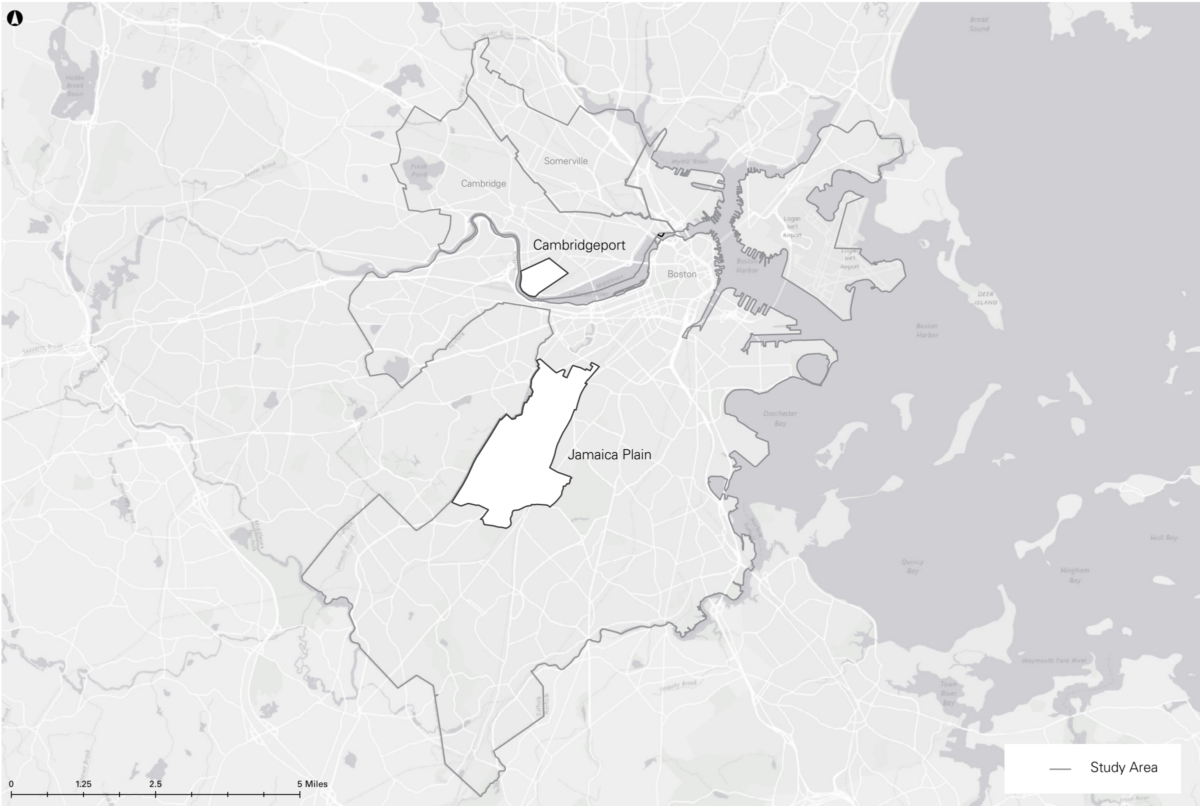

Figure 25: Case study areas

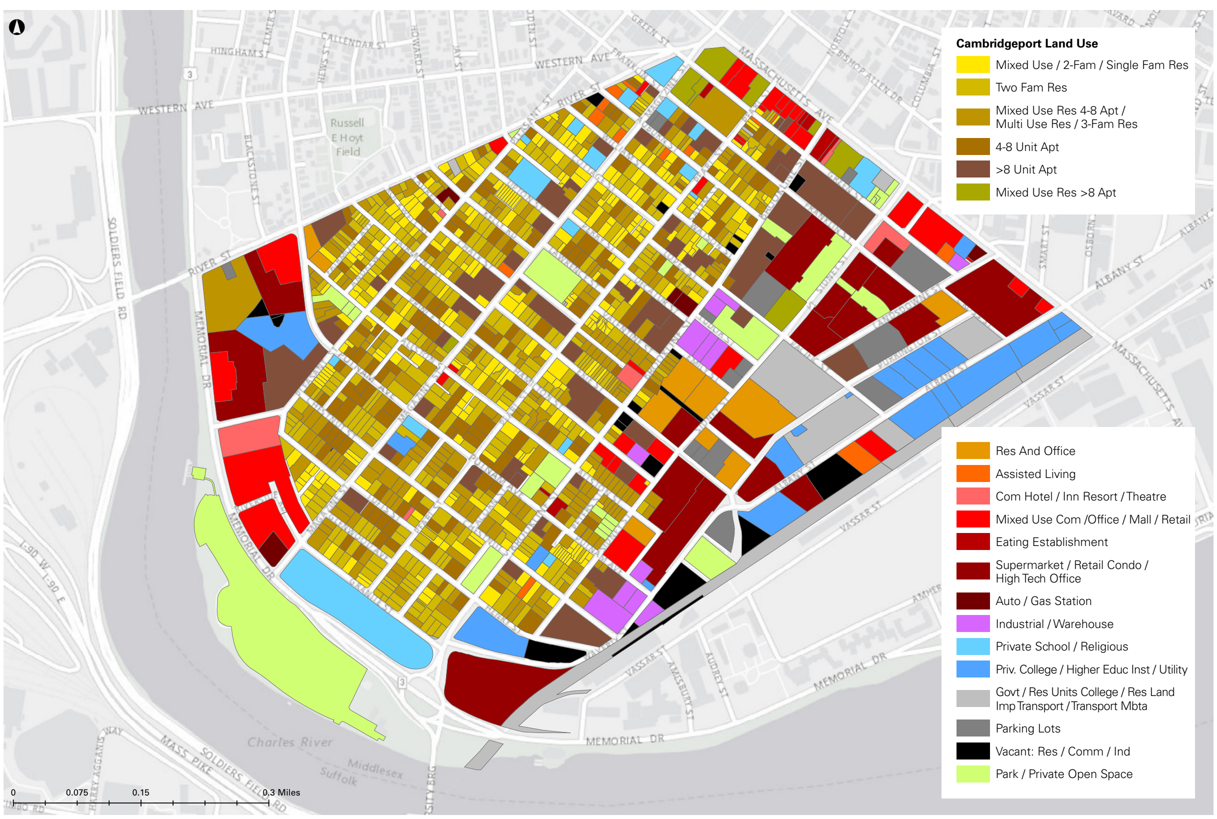

Figure 26: Cambridgeport land use

Many residential buildings in the neighborhood are detached homes featuring two to four units (30%), alongside small multi-family properties with four to twelve units and some larger apartment buildings (65%). Only 4.4% of homes are single-family.[4]

There are an estimated 4,701 vehicles owned by Cambridgeport residents, and 4,253 parking permits issued for the neighborhood.[5] Cambridgeport features 657 driveways within residential lots, (in 1601 buildings and 5,391 housing units), indicating a ratio of almost two-and-a-half buildings for every driveway. While detailed residential garage information is unavailable, spatial investigation indicates that the majority of Cambridgeport residents likely park on-street or at off-site locations. Most of Cambridgeport's on-street parking is permit parking, alongside 290 metered parking spaces located predominantly within the commercial and office area around Massachusetts Avenue and university facilities in the South-East.[6] These metered parking spaces are within a quarter mile of many homes.

Supply
There are several supply opportunities for garage orphans because of their close proximity to a range of land uses. All residences are within a quarter mile of at least two of either municipal, commercial, institutional, or office parking spaces. Driveways, on-street parking spaces, and residential lots are also available to vehicle owners to varying degrees.

On-Site Multi-Family Residential Parking
There are an estimated 1,182 parking spaces in residential surface lots in Cambridgeport, fulfilling up to 25% of parking demand for vehicles. Cambridgeport has a further 1226 estimated parking spaces in residential driveways that have the potential to supply up to another 26% of the neighborhood's parking demands, though the usage of the full amount would require an extensive system of sharing.[7]

It should be noted that garages provide an additional, though unquantified source of on-site parking to residents in the neighborhood.

On-Street Parking
On-street parking accounts for the largest share of parking supply for Cambridgeport vehicle users. There are an estimated 3,166 un-metered parking spaces in the area, and another 290 metered spaces along Massachusetts Avenue and around MIT campus.[8] For those residents without access to residential driveways lots or garages, on-street parking provides the next-best option in terms of proximity and comfort. Cambridge streets are cleaned twice a month, one side each

4 CDD Cambridge Land Use Data "http://www.cambridgema.gov/GIS/gisdatadictionary/CDD/CDD_LandUse"
5 CDD City of Cambridge Neighborhood Statistical Profile, 2013.
6 Cambridge GIS, Traffic Data, http://www.cambridgema.gov/GIS/gisdatadictionary/Traffic/TRAFFIC_MeteredParkingSpaces

7 CDD Cambridge GIS, Basemap Data, http://www.cambridgema.gov/GIS/gisdatadictionary/Basemap
8 Calculation made based on U.S. Census Tigerline Geogrpahy 2010.

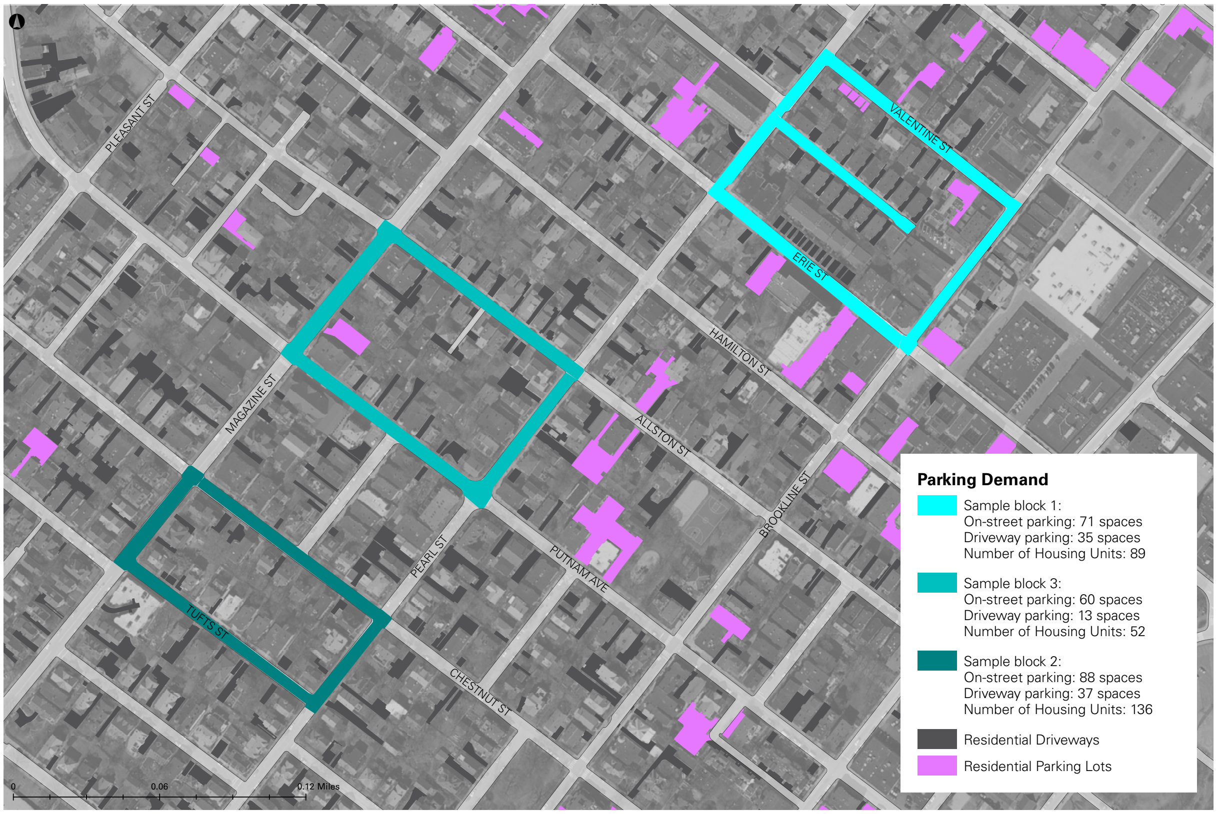

Figure 27: Cambridgeport sample block parking demand

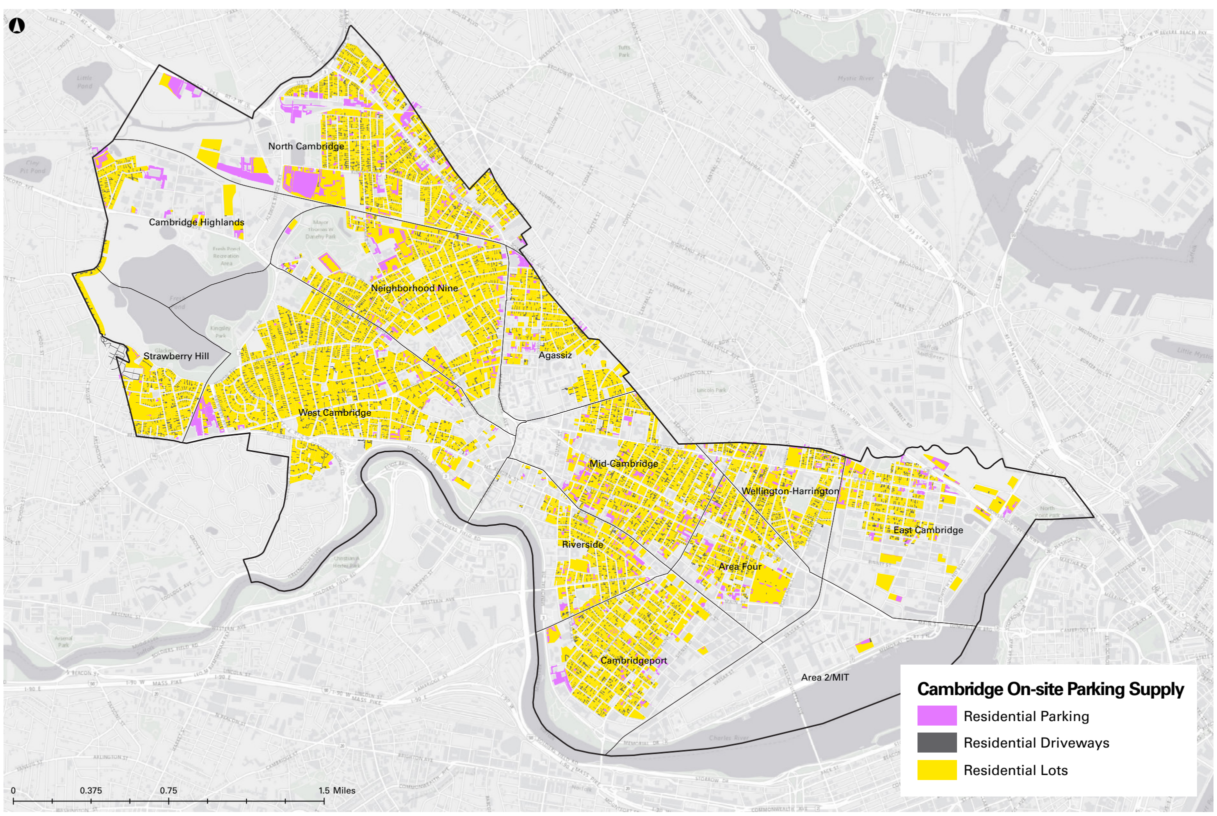

Figure 28: Cambridge on-site parking supply

cleaning; giving residents the possibility of leaving their vehicle parked on-street for up to a month at a time.[9]

Retail, Office, and Municipal Lots and Garages

The neighborhood contains a number of opportunities for off-site parking which could provide overnight parking for garage orphans. All residential buildings in the neighborhood are within a 5-minute walk of some form of off-site parking: commercial garages, retail or office surface lots, institutional surface lots, or religious/charitable facility parking. Based on the total number of parking spaces calculated in each of those lots, every residential property is within a quarter mile of two to five different types of off-site parking spaces.[10]

The commercial node in the Southwest corner of the neighborhood offers an example of an opportunity for off-site parking.[11] There are approximately 470 parking spaces in the lots associated with this mixed residential/commercial/office node. A sample of the businesses reveals an average 8:45 pm closing time.[12] Furthermore, there are 2,815 housing units within a quarter mile of this commercial and office parking area, which is over half of the total housing units in the neighborhood.[13] Whole Foods Market, one of the adjacent businesses, has a precedent of installing EVSE in its parking lots (e.g. Jamaica Plain) and the installation of EVSE could act as a way to attract customers and shoppers to the area.[14]

Commercial garages in Cambridgeport offer approximately 790 parking spaces, which provide another opportunity for off-site charging. Most are located around Massachusetts Avenue and MIT.

Jamaica Plain

Jamaica Plain is an outlying neighborhood in Boston with a strong residential character. Much of the area contains lower-density residential housing and parkland in the form of the Arnold Arboretum and the Emerald Necklace.

The northern portion of the neighborhood has a concentration of healthcare facilities, including the American Cancer Society, VA Boston Healthcare System, New England Baptist Hospital, and Brigham and Women's Hospital.[15] Household incomes are lowest toward Jamaica Plain's Roxbury border in the Northeast, while the neighborhood's southern portion is single-family detached homes. Centre Street, the main

9 Cambridge Department of Pubic Works, Street Cleaning Schedule 2015 https://www.cambridgema.gov/theworks/ourservices/streetcleaning/schedulesandroutes

10 Calculations made based on CDD Cambridge GIS, Traffic, Basemap and Land Use Data, http://www.cambridgema.gov/GIS/gisdata

11 Sample site located between River St. and Magazine St., and Putnam Ave and Memorial Dr. Google Maps, 2015 https://www.google.com/maps/place/Cambridgeport,+-Cambridge,+MA/@42.3604378,-71.114338,18z/data=!4m2!3m1!1s0x89e379fd099ea5bd:0x1a8d84d84b68093e

12 Google Maps, 2015, https://www.google.com/maps/@42.3575222,-71.1133427,18z

13 CDD Cambridge GIS, Land Use Data, http://www.cambridgema.gov/GIS/gisdatadictionary/CDD/CDD_LandUse

14 Whole Foods Market, 2011, http://media.wholefoodsmarket.com/news/whole-foods-market-opens-its-doors-in-jamaica-plain

15 Google Maps, 2015, https://www.google.com/maps/place/Jamaica+Plain,+-Boston,+MA/@42.3138475,-71.1188239,14z/data=!3m1!4b1!4m2!3m1!1s0x89e379722be419d1:0x33126c67b2261812

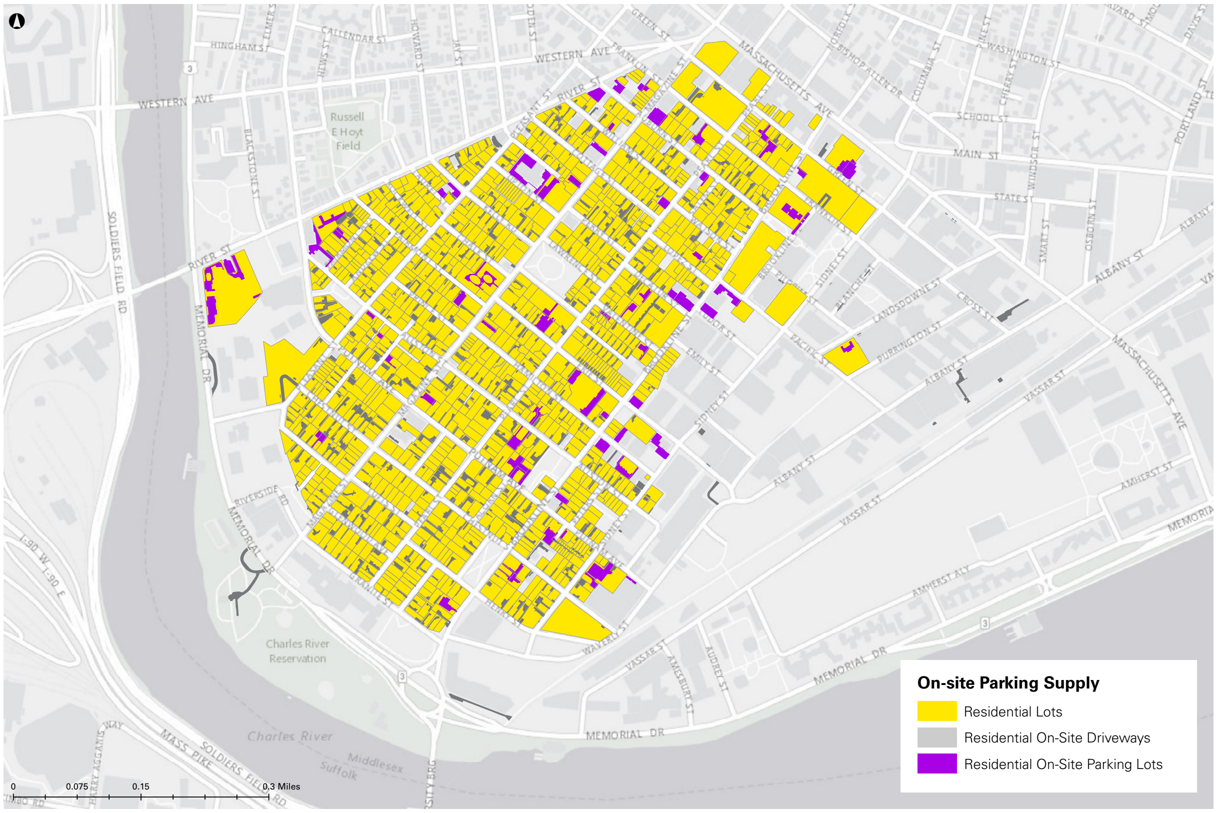

Figure 29: Cambridgeport on-site parking supply

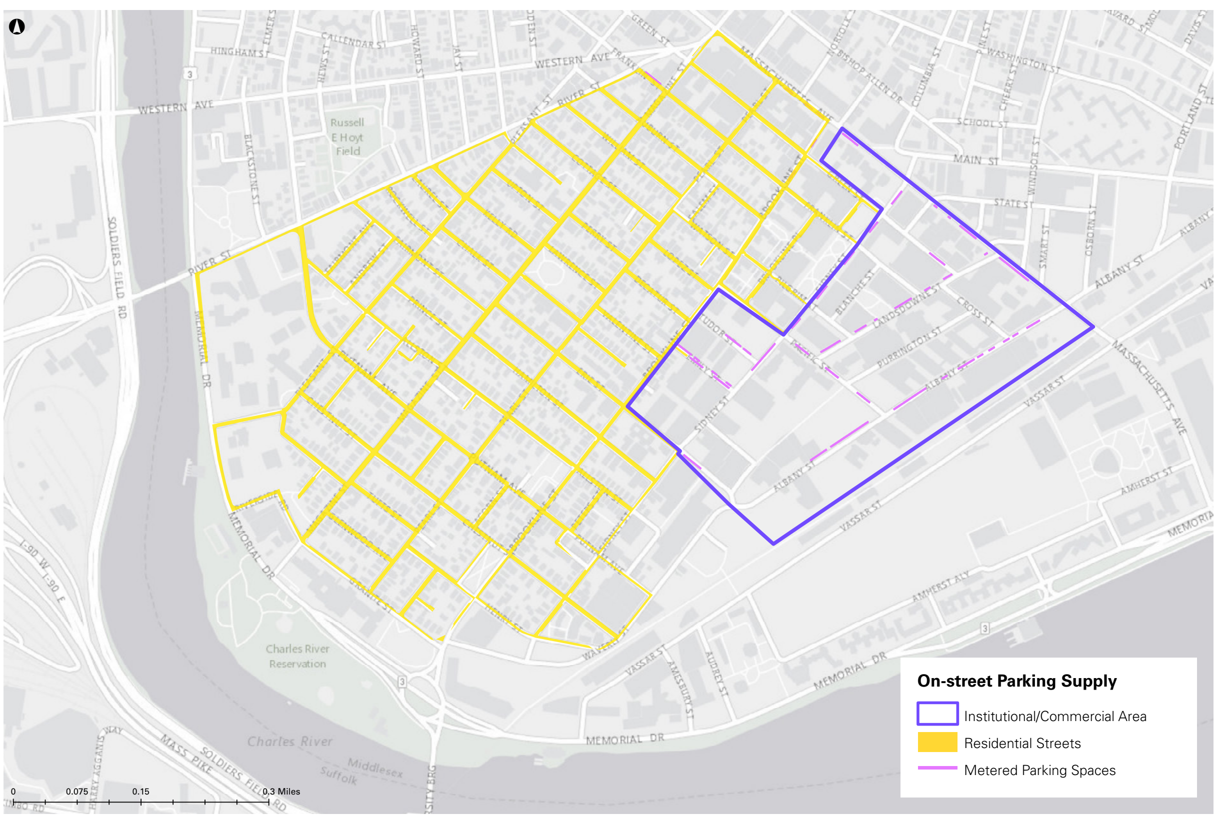

Figure 30: Cambridgeport on-street parking supply

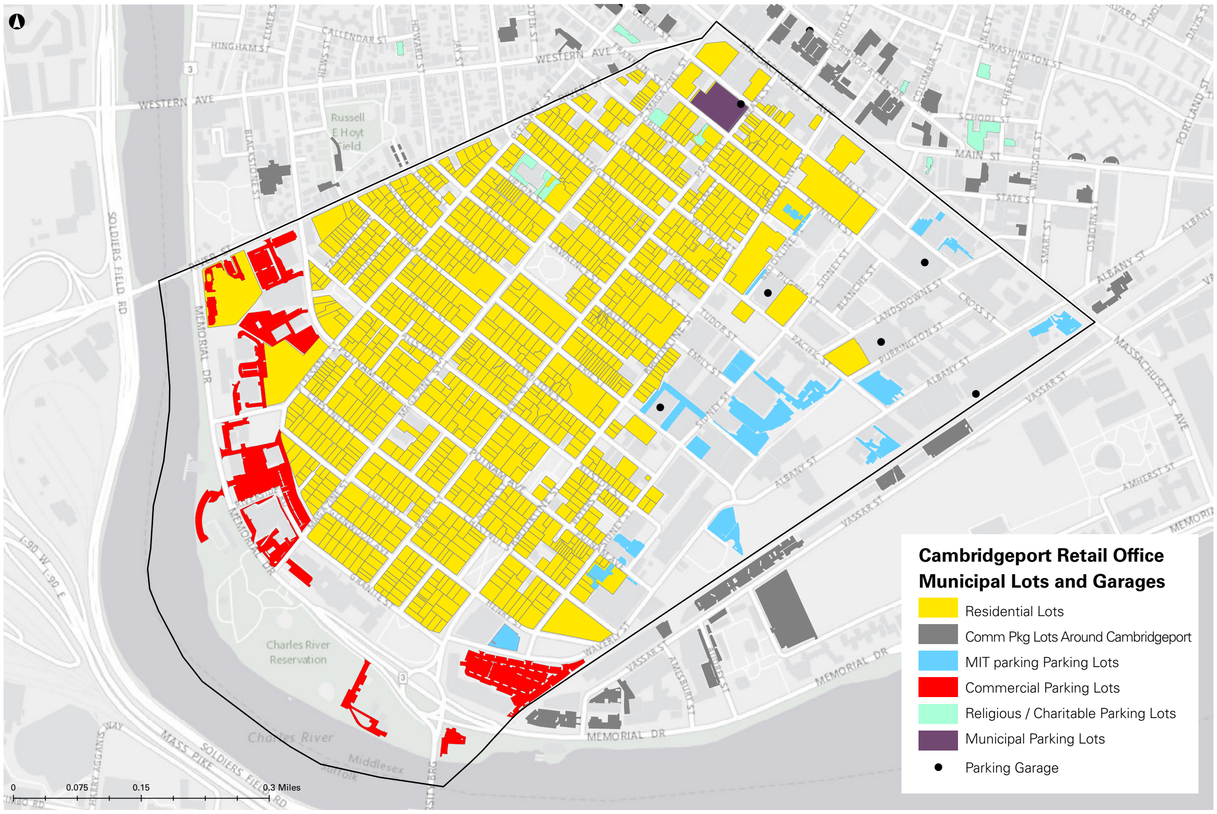

Figure 31: Cambridgeport off-site parking supply

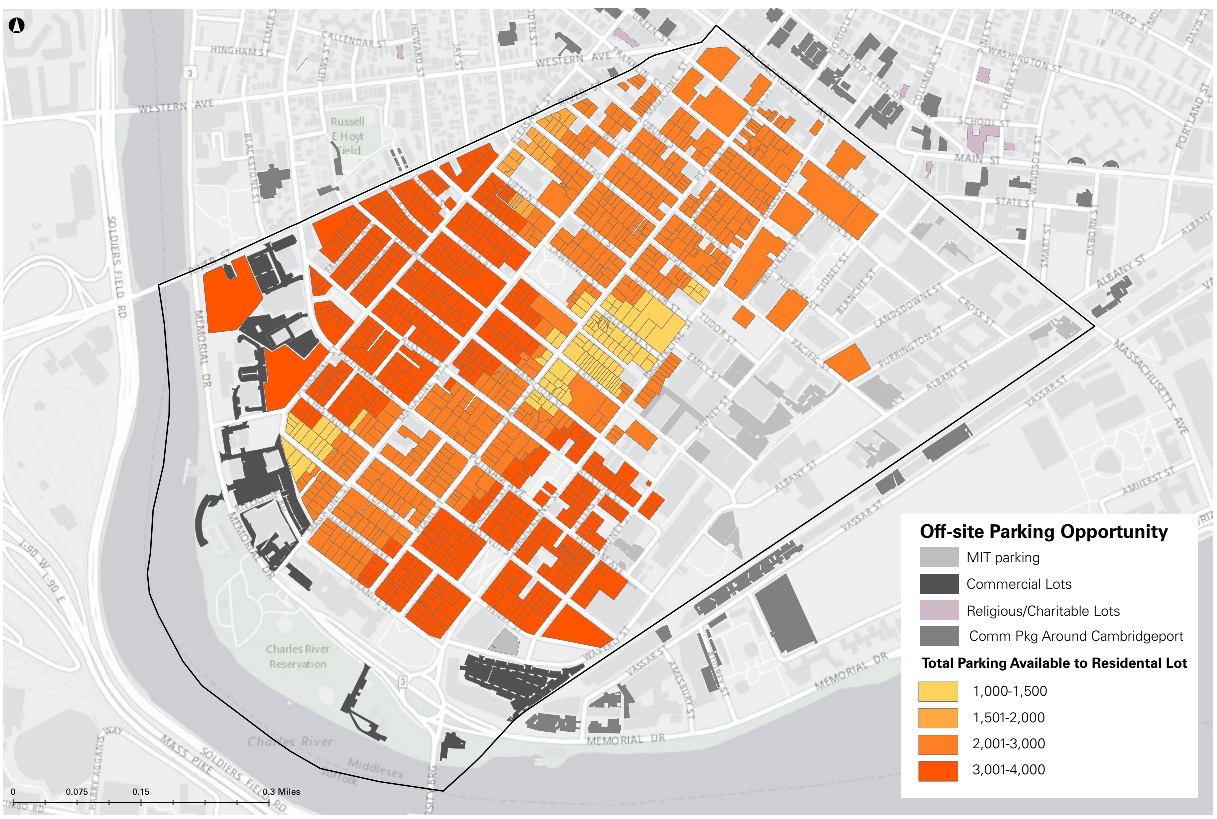

Figure 32: Cambridgeport off-site parking opportunities

Jamaica Plain, Snapshot

Population
37,468
8,515 people/square mile[1]

Parking
27,795 street parking spaces[2]

Housing
21% single-family homes
27% 2-6 unit buildings
52% apartment building units
16,797 housing units[3]

Vehicles
14,223 parking permits
75.8% of residents have 1+ vehicle
Approximately 16,000 vehicles[4]

Land Use
48% residential
30% retail, office, industrial

Transportation/Commute
46% commute by car
39% public transit
9.5% bike or walk

1 American Community Survey, 2006-2011 5-year estimates, U.S. Census Bureau
2 Calculation based on U.S. Census Tigerline Geography 2010, U.S. Census Bureau
3 MassGIS Physical Resources, Land Use Data, http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/layerlist.html
4 Boston Redevelopment Authority, Boston In Context, Neighborhoods, 2007-20111 ACS, 2010 Census.

commercial corridor, cuts through the neighborhood, with retail and office activity along its length.[16] The neighborhood encompasses a range of land uses, from a heavy institutional presence in the north, to low-density residences in the south, to a concentration of lower-income residences in the east. Jamaica Plain can be considered a transitional neighborhood, where Boston's low-density wealthy suburbs converge with its higher-density, and lower-income inner city.

Demand

Jamaica Plain has a population of 37,468 with a population density of 8,515 people per square mile. It has a lower population density than Boston's average; 21% of its dwellings are single-family and 27% are 2 to 6 unit multi-family buildings. Whereas in the southern portion of the neighborhood over 90% of households own cars, in the northern portion of the neighborhood, just 44% do.[17]

Because of its population density, proportion of single-family homes and limited mixed uses, Jamaica Plain is categorized as a Type 3 neighborhood. While the blocks closest to Centre Street contain a greater density and mix of uses, much of the neighborhood is defined by its residential nature.[18] Over 75% of the neighborhood households have at least one vehicle, and the high demand for parking is met by both on-site and on-street solutions.

16 Google Maps, 2015, https://www.google.com/maps/place/Jamaica+Plain,+Boston,+MA/@42.3147995,-71.1112493,15z/data=!4m2!3m1!1s0x89e379722be419d1:0x33126c67b2261812
17 American Community Survey, 2006-2011 5-year estimates, U.S. Census Bureau
18 MassGIS Physical Resources, Land Use Data, http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/layerlist.html

Supply

Jamaica Plain has different EV parking opportunities than Cambridgeport. 21% of Jamaica Plain's residential dwellings are single-family homes, compared to Cambridgeport's 4.4%. This has an impact on the quantity of on-site residential parking lots available to vehicle owners and indicates higher levels of residents parking in driveways or garages. Because parking data for Jamaica Plain is limited, a full understanding of supply solutions is not possible. Open Street Map and U.S. Census Geography data provide some indication of on-street and off-site supply solutions, which contribute to suggested EVSE interventions.

On-Site Multi-Family Residential Parking

Although data on Jamaica Plain's on-site parking is unavailable, rough estimates can be made based on parking calculations for Cambridgeport. Applying the finding that 26% of Cambridgeport's parking demand for its resident-owned vehicles is fulfilled by on-site driveway spaces and 25% by on-site residential parking lots, it follows that around 26% of Jamaica Plains' parking demands can be met by on-site residential driveways and 25% by residential parking lots. This suggests that Jamaica Plain's on-site parking supply may provide parking spaces for about 50%, or 8,000, of its resident-owned vehicles. This estimate does not take into account the differences in the

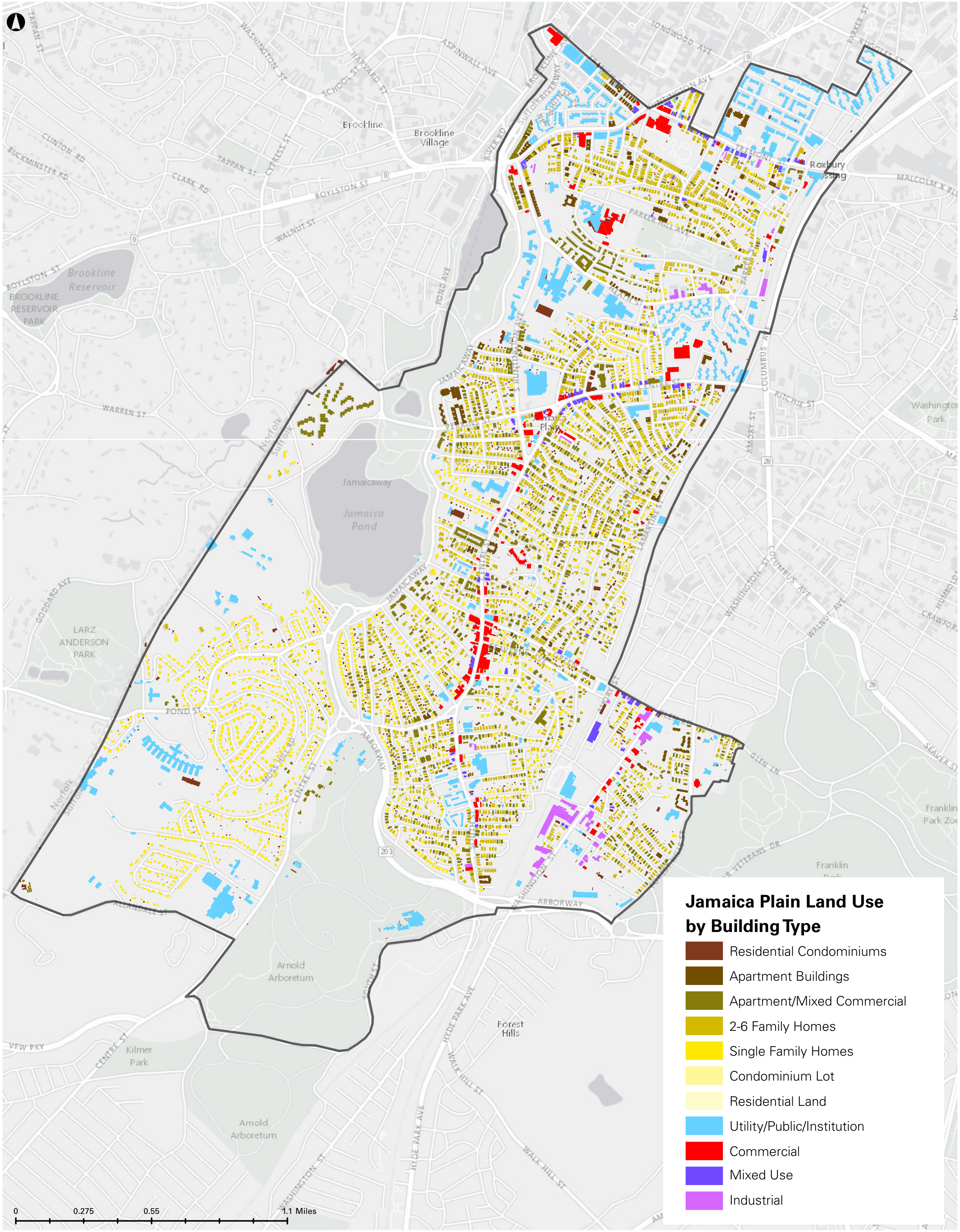

Figure 33: Jamaica Plain land use

two neighborhoods' residential patterns, and may vary based on Jamaica Plain's higher proportion of single-family homes. These on-site parking opportunities suggest supply solutions for convenient EV overnight and home charging.[19]

On-Street Parking
Jamaica Plain has approximately 28,000 on-street parking spaces both metered and unmetered, and around 16,000 resident-owned vehicles. On-street parking provides the most supply opportunities for Jamaica Plain residents and visitors. Jamaica Plain's bi-monthly street cleaning schedule allows cars to park on-street, uninterrupted for up to two weeks at a time.[20] Metered and time-restricted parking also line commercial and institutional corridors like Centre Street.[21]

Retail, Office, and Municipal Lots and Garages
There are at least 500 parking spaces in commercial, municipal, retail and office lots based on Open Street Map designated parking lots.[22] Commercial lots serve as potential sites for workplace and overnight residential charging for neighborhood residents. 13% of housing units (or 2,274) in the neighborhood are within five minutes of these parking lots.[23] This data presents only a fraction of off-site parking lots in the neighborhood; more comprehensive data could demonstrate the full extent of the supply solution for EV charging and garage orphans.

Conclusions
Both Jamaica Plain and Cambridgeport provide examples of the possibilities for neighborhood-based EV charging supply solutions. This analysis details the prospects available in Cambridge and Boston neighborhoods for on-site, on-street parking and retail, office and municipal parking. Cambridgeport demonstrates the opportunities available to Type 1 neighborhoods. Its mixed-uses and density distinguish its retail, office and municipal opportunities from Type 3 neighborhoods like Jamaica Plain. Jamaica Plain's on-site and on-street supplies define its residents' parking behaviors, and provide opportunities to reach its low-density population. Supply solutions can be tested based on this comprehensive analysis of Jamaica Plain and Cambridgeport as representative of their corresponding neighborhood typologies.

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19 Calculations made based on CDD Cambridge GIS, Basemap Data, http://www.cambridgema.gov/GIS/gisdatadictionary/Basemap and CDD City of Cambridge Neighborhood Statistical Profile, 2013.
20 City of Boston Street Cleaning Schedule, http://www.cityofboston.gov/publicworks/sweeping/?streetname=&Neighborhood=2
21 Google Maps, 2015, https://www.google.com/maps/place/Jamaica+Plain,+-Boston,+MA/@42.314565,-71.114123,73m/data=!3m1!1e3!4m2!3m1!1s0x-89e379722be419d1:0x33126c-67b2261812!6m1!1e1
22 Open Street Map, tag parking lot, https://www.openstreetmap.org/search?query=parking#map=14/42.3128/-71.1187&layers=N
23 MassGIS Land Use Data, http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/layerlist.html

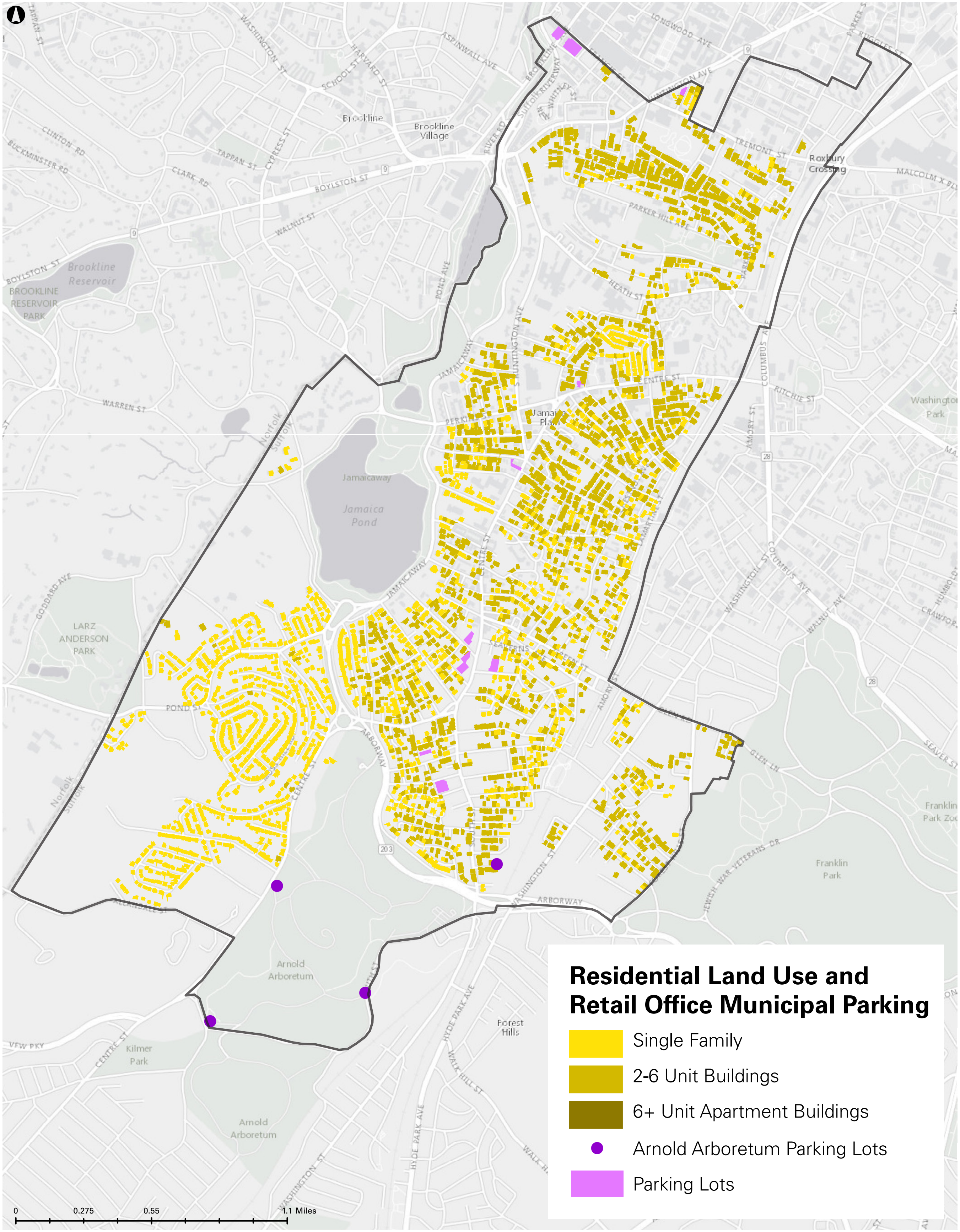


Figure 35: Jamaica Plain residential land use and off-site parking supply

4. RECOMMENDATIONS

This section reviews the parking demand and supply solutions for garage orphans within the neighborhood context. It examines specific solutions through the framework of Policy & Politics, Technology & Infrastructure, and Market Feasibility & Viability at a neighborhood level. The strategies matrix, introduced in the analytical framework, addresses the attractiveness of each solution within a given neighborhood typology and the results serve as a guide for policymakers to develop appropriate strategies to encourage EV use among vehicle owners in different urban contexts.

4.1 Overview of Strategies

The results of the analysis indicate significant variations in strategies for different neighborhood typologies. Five strategies stood out as among the top three for any neighborhood typology. Only one strategy, expanding access to EVSE at multi-family garages and lots, placed in the top three of each typology. This is likely due to the strong user demand, more-established technical solutions, and broad political support for charging EVs at home.

1. *Install EVSE at on-site residential parking garages and lots.* At-home charging accounts for at least 80% of EV charging in the U.S. Removing barriers to installing EVSE in multi-family buildings can enable the next-best alternative, specifically this can be accomplished by outlining the roles and responsibilities of each stakeholder and by prohibiting unreasonable demands of condo associations and property managers.

2. *If so desired by the municipality, create a legal framework for ad-hoc or 'shared parking' that includes the regulation of access to electricity.* Non-traditional parking is a real component of the parking market in the study area. Recognizing its role in addressing the parking needs of residents is an opportunity to outline the terms of contract, including the right or privilege of an EV owner to access to an electrical outlet, and potentially a standalone EVSE.

3. *Promote overnight charging at retail, office, and municipal lots and garages.* Currently, office parking is reserved for employees unless the spaces are designated "commercial". Municipal parking lots and garages are primarily used by retail patrons during the day and restaurant-goers at night. Similarly, retail parking is used by patrons during business hours. All three contexts provide an opportunity for overnight charging

for those regularly commuting. By allowing these facilities to open up their spaces to local garage orphans during specific hours, they may be incentivized by the potential revenue stream to install EVSE, which could also serve patrons or employees during the day. Facility access could be granted through extension of parking permits as described in recommendation number 4.

4. *Create special EV curbside parking permits in neighborhoods and planning districts.* Parking permits systems already exists within the stakeholder municipalities. Establishing on-street charging in residential neighborhoods can be facilitated through siting on-street spaces for charging and instituting a tiered permit system or application form, whereby EV owners will apply for a special permit that allows parking in EV only on-street spaces, clustered and targeted in residential areas. However, mechanisms to nudge EVs from staying in these spots for extended periods are a necessary component.

5. *Install high-visibility EVSE at metered on-street parking.* Metered on-street parking is primarily located along commercial corridors. Installing EVSE there would allow retail patrons to charge their vehicles during the day and for nearby residents to utilize the EVSE overnight at a lower rate.

6. *Create a robust workplace charging outreach strategy.* The MassEVIP program already exists to encourage businesses to install EVSE, through directed subsidies. Furthering that program through awareness campaigns to educate firms about the costs and benefits of participating will result in more garage orphans being able to charge their vehicles while at work and even serve as advertising to non-EV owners who will know they could have the ability to charge their vehicles each day while at the office. Care should be taken to limit EVSE usage where alternative transportation options exist. This may require having non-free charging, or providing free or discounted transit fare.

7. *Create a robust destination charging outreach strategy.* Concentrate on installing high-power EVSE at destination locations such as State parks, stadiums, concert venues, and big-box retailers in order to encourage EV use by non-car commuters. This simultaneously supports longer-distance EV usage for everyone.

8. *Support a DC Fast-Charging network.* Installing DC Fast-Chargers as a means of addressing garage orphan needs would require significantly fewer EVSE and allow EV owners to most closely simulate refueling their vehicle at a gas station. This solution requires a substantial process for siting, balancing car owner access, available infrastructure, site ownership, and local environment.

Supply Solution	Policy	Infrastructure	Market
On-Site Multi-Family Residential Parking Garages and Lots	(1) Condo associations and other garage owners should not be able to unreasonably prevent EV owners from installing an EVSE in a dedicated space. (2) Allow EVSE rebates to be combinable and transferable from EV to parking space owner.	Level 1 or 2 EVSE is sufficient for overnight charging. Low-power Level 2 EVSE are recommended for multiple installs. (2) Either rely on metering capabilities of (sub)meters or EVSE.	(1) Multi-Family properties should install multiple EVSE when undergoing installation process to reduce average cost per station. (2) Bank of chargers should be metered separately, if not individually.
Shared Driveway at Multi-Family Properties	Establish legal framework for informal market that includes access to electricity in shared driveways from associated residential building.	In informal cases, an extension cord serves the basic needs of an EV owner; however the installation of a low-power Level 2 EVSE is preferred.	Charging should be incorporated in the price of renting the parking space.
Retail, Office, Municipal Garages and Lots	Because of overlapping clean air goals, provide parking variance to allow residential EV parking on non-commercial lot during non-business hours.	Low power Level 2 EVSEs are adequate for office lots and the most efficient means of installing multiple EVSE on a single electrical panel. Retail and municipal lots should consider regular or high-powered Level 2 EVSE.	A two-tier pricing system for off-peak and peak hours is recommended. Off-peak, overnight charging should be a set nightly/weekly/monthly fee. Alternatively, can be folded into municipal parking permit.
Residential On-Street Parking	Implement a tiered parking permit system that provides parking access to EV-only on-street spaces with charging access.	When installing on-street EVSE, a string of spaces should be outfitted with charging capability in order to reduce the installation cost per space. Low-power Level 2 dual-charging EVSE should be installed.	(1) A parking permit that provides access to EV only spaces should be priced higher than a regular parking permit. (2) A third-party install may not be viable unless mechanism to induce turnover is provided.
Metered On-Street Parking	(1) Establish a citywide lease contract with a third party operator at 5 to 10 year terms. (2) If they are near residential areas, they have potential to be used for nighttime charging as well. (3) Cannot operate with nightly street cleaning.	(1) Level 2 EVSEs with metering capability should be installed. (2) For 8pm - 8am, low-power Level 2 is adequate.	Overnight charging can be accessible by EV-parking permit holders and/or through tiered pricing structure.
Workplace Charging	MassEVIP rebates should be issued in concert with other PTDM measures.	Low power Level 2 EVSEs are adequate for full-day charging.	(1) Day time (peak) periods should bill per hour of usage at a rate between home electrical rates and gasoline prices. (2) Installations should be in large batches to lower average cost.
Destination Charging	Coordinate with Regional and State entities to encourage expansion of destination charging network.	Number of EVSE installs depends on average dwell time, size of venue and existing infrastructure. Level 2 EVSE is appropriate for 1 to 4 hour duration.	User pays an hourly rate or can be provided free to attract EV owners.
DC Fast-Charging Network	(1) Explore infrastructure provision model of zero-cost long-term lease with EVSE operator. (2) Municipality should decide geographic and land use priorities. (3) Government agency and/or utility will likely need to provide substantial subsidy.	Requires guidelines from utility on electrical grid capabilities.	User pays per kWh. with penalty for idling after EV is charged.

Table 5: Supply solutions framework

No.	Strategy	Market Demand	Market Supply	Technical Feasibility	Infra-structure Feasibility	Political Viability	Policy Feasibility	Total	Rank
1	Install EVSE at on-site Residential Parking Garages and Lots	Adequate	Low	High	High	Very High	Adequate	21	3
2	Create 'shared parking' legal framework that includes regulation on electricity access	Very High	Adequate	High	High	Low	Low	20	4
3	Promote Overnight Charging at Commercial, Office, and Municipal Lots	High	High	Very High	High	High	Low	23	1
4	Create Special EV Curbside Parking Permits in Neighborhoods	Very High	Adequate	Adequate	Adequate	Low	Adequate	19	5
5	Install High-Profile EVSE at Metered On-Street Parking	Very High	Low	High	Low	Low	High	19	5
6	Create Robust Workplace Charging Outreach Strategy	High	High	High	High	High	Low	22	2
7	Create Robust Destination Charging Outreach Strategy	Low	Adequate	High	Adequate	Adequate	Adequate	18	7
8	Support DC-Fast Charging Network	High	Low	Adequate	Low	Low	Low	15	8

Table 6: Applicability of Strategies in Neighborhood Typology 1

No.	Strategy	Market Demand	Market Supply	Technical Feasibility	Infra-structure Feasibility	Political Viability	Policy Feasibility	Total	Rank
1	Install EVSE at on-site Residential Parking Garages and Lots	Very High	Adequate	High	Adequate	High	High	23	1
2	Create 'shared parking' legal framework that includes regulation on electricity access	Very High	High	High	Adequate	Adequate	Low	21	2
3	Promote Overnight Charging at Commercial, Office, and Municipal Lots	Low	Low	High	High	Low	Adequate	17	5
4	Create Special EV Curbside Parking Permits in Neighborhoods	Very High	Adequate	Adequate	Adequate	High	Adequate	21	2
5	Install High-Profile EVSE at Metered On-Street Parking	Adequate	Low	Adequate	Very Low	Adequate	Low	14	8
6	Create Robust Workplace Charging Outreach Strategy	High	Very Low	High	Adequate	High	High	20	4
7	Create Robust Destination Charging Outreach Strategy	High	Low	Low	Low	Adequate	High	17	5
8	Support DC-Fast Charging Network	High	Very Low	High	Very Low	Adequate	Low	15	7

Table 7: Applicability of Strategies in Neighborhood Typology 2

No.	Strategy	Market Demand	Market Supply	Technical Feasibility	Infra-structure Feasibility	Political Viability	Policy Feasibility	Total	Rank
1	Install EVSE at on-site Residential Parking Garages and Lots	High	Very High	High	Adequate	Very High	High	25	1
2	Create 'shared parking' legal framework that includes regulation on electricity access	High	High	High	Adequate	Low	Low	19	4
3	Promote Overnight Charging at Commercial, Office, and Municipal Lots	Very Low	Very Low	High	High	High	Adequate	17	7
4	Create Special EV Curbside Parking Permits in Neighborhoods and Planning Districts	High	Very High	High	Adequate	Adequate	Low	21	2
5	Install High-Profile EVSE at Metered On-Street Parking	Very Low	Very Low	Adequate	Low	Low	Adequate	12	8
6	Create Robust Workplace Charging Outreach Strategy	High	Very Low	High	High	High	High	21	2
7	Create Robust Destination Charging Outreach Strategy	High	Low	Adequate	Adequate	Adequate	Adequate	18	5
8	Support DC-Fast Charging Network	High	Low	High	Low	High	Low	18	5

Table 8: Applicability of Strategies in Neighborhood Typology 3

1 Very Low
2 Low
3 Adequate
4 High
5 Very High

Strategy Scoring Guide

4.2 Conclusion

Making EV ownership easier in urban areas aligns strongly with clean air goals, and should be a primary method for lowering emissions in non-attainment areas, which include Suffolk and Middlesex Counties.[1]

Furthering EV ownership within urban areas requires serious consideration and action from municipalities and residents. Policy & Politics recommendations identify specific policies that can be revised or implemented to ease the installation or access to EVSE. Technology & Infrastructure recommendations highlight the most effective and appropriate equipment to be used and strategies to overcome or avoid infrastructure barriers. Market Feasibility & Viability recommendations focus on ways to leverage or entice the market to participate in the provision of charging.

Policy & Politics

1. Rebate programs should be expanded, and made available for the installation of any non-single-family home EVSE. Further, these rebates should be flexible or transferable to other contexts where garage orphans are able to charge their EV.

2. Tailor charging strategies at the local or neighborhood level to account for variations in supply solutions, parking demand, and existing charging infrastructure.

3. Establish legal provisions clarifying that condo associations and other garage owners or operators should not be able to unreasonably prevent EV owners from installing EVSE in a

1 http://www.epa.gov/airquality/greenbook/ancl.html

designated parking space. If not possible in the existing context, EV owners should be allowed to request a new spot where EVSE install is reasonable. Alternatively, EVSE should be installed in common areas, with approval of the condo association or owner.

4. Incorporating 'shared driveways' and other spaces on the ad-hoc parking market into a legal framework so that electricity access can be included in the provision of terms, and potentially, sublease fees can be collected.

5. Augmenting existing residential parking permit programs with a special EV charging permit is the simplest policy and least likely to encounter resistance, though may not be compatible with a third-party EVSE market strategy.

6. A parking variance or special permit may be possible to allow non-"commercial" garages and lots to accept nearby residents' use of EVSE during non-business hours where existing pollution and congestion policy says otherwise. Though there is obvious environmental overlap with EV policy, this requires further investigation.

Technology & Infrastructure
1. Installing multiple EVSE at once, or at a minimum install pre-wiring, in garages, lots, and curbside to realize installation savings of up to 30% per station.

2. Low-power, Level 2 EVSE can serve one or two users, such as in multi-family and workplace garages and lots. This allows up to six times more chargers to be installed on a single panel, while realistically matching electrical demand needs.

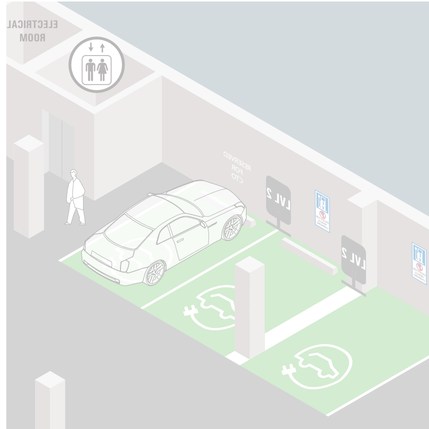
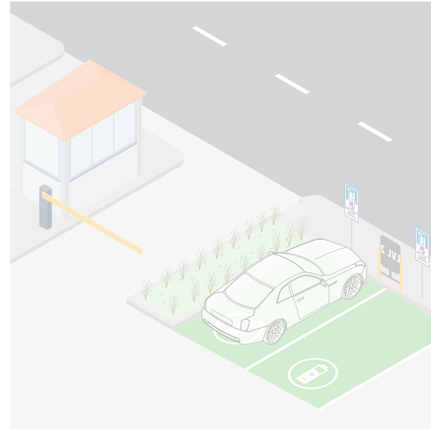
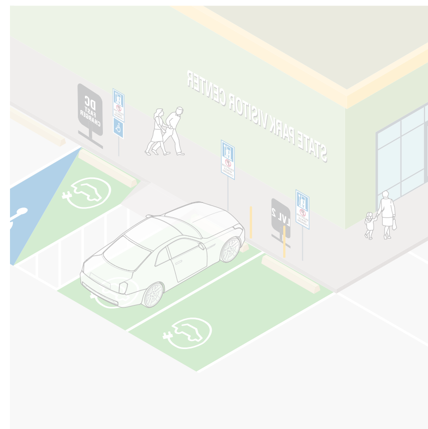
3. Using EVSE or outlets that require EV owners to bring their own cord can eliminate some of the concerns around on-street provision of EVSE, in particular equipment maintainance, cord damage and theft, and tripping hazards, while reducing installer costs. Unlike in Europe, no plug standard exists for this purpose, though plug standards such as NEMA 14-30 or 14-50 could be appropriated.

4. DC Fast-Chargers may be most easily sited in portions of Boston and Cambridge served by the network electrical system.

Market Feasibility & Viability
1. An on-street charging network may be achieved through the large-scale solicitation of a third-party to lease public parking spaces for several-year terms for Level 2 EVSE and longer for DC Fast-Charging stations. To achieve market viability, siting and parking regulations for these on-street EVSE should be coordinated to facilitate use by many EVs. One standard of viability is 360kWh of charge, or approximately 20,000 miles of EV range per month.

2. Public and workplace charging should bill users at a rate between the cost of charging at home and of gasoline. Providing free access to public and workplace charging shifts electrical load to peak demand times and otherwise may shift commute mode to driving.

3. Residential charging at multi-family properties should be metered or submetered directly to EV owner where possible. If not possible, the low monthly cost can be absorbed by the property owner or association.

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