# CITY *of* BOSTON

# ZERO-EMISSION VEHICLE ROADMAP

## 2020

*Mayor Martin J. Walsh*

CREATED WITH SUPPORT FROM THE
BLOOMBERG PHILANTHROPIES AMERICAN CITIES CLIMATE CHALLENGE

American Cities Climate Challenge

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# EXECUTIVE SUMMARY

# OUR MOBILITY VISION

**Decrease the need for and prevalence of single-occupancy vehicle trips**

**Expand access to transportation choices to all neighborhoods and communities**

**Have everyone – irrespective of their age, income, and access to technology – experience our transportation system with the same amount of access and convenience**

The primary goal of this Zero-Emission Vehicle Roadmap is to complement and support Go Boston 2030 and the City's ongoing efforts to increase mode shift away from single-occupancy vehicles into more sustainable modes of transportation like walking, biking, and public transit. Boston's vision to transform how we travel around our city – from driving alone to transit, walking, biking, and other shared and active modes of travel – is detailed in Go Boston 2030, the City of Boston's comprehensive transportation plan, and in the 2019 Climate Action Plan Update. Climate change presents a unique threat to the health and safety of Boston's residents.

Our mobility vision also includes reducing greenhouse gas emissions from transportation and improving our air quality. Mayor Martin J. Walsh has pledged to make Boston a carbon-neutral city by 2050. This means that in 30 years, our community can only release as much carbon pollution as our environment can safely absorb.

In order to reduce our emissions from transportation, which account for nearly a third of the total community-wide emissions, we must support electrification across all travel modes. *While prioritizing policies and programs that support public transit, active transportation, and shared trips, all residents who must drive personally owned vehicles will be encouraged to choose ZEVs over internal combustion engine (ICE) vehicles.* The City will continue to install supportive infrastructure and will continue to support widespread adoption of ZEVs, including electric vehicles (EVs) and electric bikes (e-bikes), the most commonly available forms of ZEV, for shared, personal, or fleet vehicles in Boston. The City will ensure not only that there is equitable access to the benefits of electrification but also that those most impacted by climate change are directly involved in the planning process. This means designing and implementing policies for our most vulnerable populations.

This Roadmap was informed by a comprehensive analysis of the current market for EV adoption in Boston. Key takeaways include:

- In 2018 (the last year for which there is full data), EV adoption in Boston and neighboring municipalities represented 2.8% of new vehicle registrations, compared with 2.5% statewide. However, Boston's neighboring municipalities have seen stronger growth in EV adoption, with 2.4% EVs of new vehicle registrations just within Boston proper in 2018.
- As of mid-2019, it's estimated that there were nearly 2,000 EVs registered in the City of Boston, and over 4,800 registered in the City of Boston plus its neighboring municipalities.
- Consumer EV adoption in Boston is projected to reach a range of 54% (Low Scenario) to 71% (High Scenario) of new vehicles purchased by 2050, based on differing rates of technology advancement, policy impacts, and charging infrastructure build-out.

Even in the High Adoption Scenario, which includes stronger investments in EV charging infrastructure and policy interventions, Boston is not projected to be on a trajectory that reaches carbon neutrality, which would entail only ZEVs on the road by 2050. Boston will need to continue to adopt all known policies to encourage EV adoption and will need to look towards policy innovations in future iterations of this Roadmap that can enable more widespread adoption of EVs. Additional policy levers, expanded charging infrastructure, incentives, and programs will be necessary to reach the City's carbon neutrality goal. Based on stakeholder input and the City's other climate and transportation goals, this Roadmap is guided by the following three goals to achieve Boston's Electric Mobility Vision:

**GOAL 1**
**Support widespread adoption of electrification**

**The City of Boston's priority is to shift people from personal, single-occupancy vehicles into more sustainable modes such as shared trips, walking, biking, and transit. Widespread electrification, not just for personal vehicles but also for shared light-duty vehicles and shared micromobility modes, is imperative to our mode shift and carbon neutrality goals.**

**GOAL 2**
**Ensure affordable, convenient access to charging**

**Even with a massive mode shift, there will continue to be vehicles on the road. To reach carbon neutrality, those vehicles must be ZEVs. Adoption of personal EVs in Boston has been slow due to lack of access to affordable charging infrastructure, especially in neighborhoods outside of Downtown. Expanding access to EV charging will help overcome a major adoption hurdle.**

**GOAL 3**
**Electrify the municipal fleet**

**The City of Boston is leading by example to electrify our municipal fleet, which accounts for 25% of emissions from local government operations. The City is now focused on electrifying the light-duty Central Fleet by 2035 and will focus on medium- and heavy-duty segments as more models become available and cost effective.**

Boston and Massachusetts have led the nation in electric vehicle adoption. In 2019, the State of Massachusetts ranked eighth out of the 50 states for EV sales,[1] and the Boston metro area ranked 10th among the nation's most populous metros.[2] As of December 2019, Boston had 709 publicly accessible charging stations throughout the City – more than 1 per 1,000 people. In the past several years, Boston has implemented an Electric Vehicle Readiness Policy for New Developments, created how-to guides to support residents and workplaces in navigating the nuances of electric vehicles, conducted electric mobility outreach through our Recharge Boston website, and released a Request for Proposals for publicly accessible, City-owned charging stations in six of our municipal lots.

To reach carbon neutrality, Boston must also transition all remaining vehicles on the roads to EVs or other ZEVs over the next 30 years. This Roadmap analyzes the barriers and benefits to EVs and market trends, and takes a critical eye to our own municipal fleet to better understand the pathways to carbon neutrality. The result is an action plan that provides the framework for the next three years of our efforts towards electrification, to be revisited annually to measure success, and shift course if needed.

Table 1 summarizes aspirational targets and actions that support each Roadmap goal. The following sections go into greater detail on each of these targets and actions.

1 Auto Alliance Advanced Technology Vehicle Sales Dashboard. Includes BEV & PHEV, 2019.
2 *The surge of electric vehicles in United States cities*

TABLE 1: Goals, aspirational targets, and actions

| GOAL | ASPIRATIONAL TARGETS | ACTIONS |
|---|---|---|
| **1** Support widespread adoption of electrification | • 23% of all new car purchases in Boston are EVs by 2025<br>• Every household will be within a 10-minute walk of an EV car share facility or a publicly accessible charging station by 2040 (also supports Goal 2) | EXISTING CITY PROGRAMS THAT WILL CONTINUE<br>• Recharge Boston outreach materials and programs<br>• Small Vehicle Sharing Business Advisory Committee<br>• Mayor Walsh's 2019 legislative agenda includes an Act Relative to Transportaion Network Company Rider Assessments<br>FUTURE ACTIONS<br>1. Develop TNC electrification policy/program<br>2. Support the growth of personal and shared e-bike use<br>3. Support shared micromobility charging infrastructure<br>4. Release an RFP for an EV car share by FY2022<br>5. Explore opportunities to develop auto dealership and customer engagement programs |
| **2** Ensure affordable, convenient access to charging infrastructure for all residents | • Total EV charging plugs needed by 2025: 1,055 Level 2 and 320 DC Fast chargers that are City- or privately owned<br>• Free-to-access public charging infrastructure available in every neighborhood by 2023 | EXISTING CITY PROGRAMS THAT WILL CONTINUE<br>• Install EV charging stations in municipal lots<br>• EV Readiness Policy for New Large Developments<br>• Rights to Charge policy for condominiums<br>FUTURE ACTIONS<br>6. In addition to the 658 Level 2 charging plugs currently installed, the City of Boston will aspire to add 50% of the remaining needed Level 2 Charging plugs by 2025, totalling in 198 charging plugs<br>7. Develop a curbside charging policy and launch pilot by 2022<br>8. Explore expanding Right to Charge to include rental properties |
| **3** Electrify the municipal fleet | • All vehicles purchased for Central Fleet are electric or ZEVs, or best in class if an appropriate ZEV is not available<br>• 100% of light-duty vehicles are emissions free by 2035<br>• 100% of medium-duty vehicles are emissions free by 2050<br>• 100% of heavy-duty vehicles are emissions free or low emissions by 2060 | FUTURE ACTIONS<br>9. Operationalize green fleet purchasing policy to govern recurring purchases<br>10. Develop strategic, cost-efficient, and future-proofed fleet charging station plan<br>11. Test vehicle-to-grid technology<br>12. Continue to align fleet procurement policy citywide best practice<br>13. Rightsize the fleet and shed and repurpose underutilized assets |

# INTRODUCTION

PHOTO 1: Chargers at South Bay Shopping Plaza in Dorchester. Samantha Devine

Our climate in Boston has changed considerably. In the past 10 years, we've seen the hottest month on record, the largest single-day record of rainfall, and coastal storm flooding resulting in the highest water levels in the Boston Harbor. These effects are all projected to become more extreme and will disproportionately affect communities of color, women, youth, elderly, and people with limited English proficiency.[3]

Cities contribute 70 percent of global emissions. Boston has long been a global leader in reducing carbon emissions and preparing the City for the effects of climate change. Mayor Martin J. Walsh has committed to a goal of making Boston carbon neutral by 2050. In 2019, the City of Boston updated its Climate Action Plan (CAP) to get on track and meet that goal. Becoming carbon neutral means that our community can only release as much carbon pollution as our environment can safely absorb. In 2017, the transportation sector in Boston accounted for 29% of our total emissions.

**Existing Action: The Go Boston 2030 Vision and Action Plan establishes goals and actions related to the transportation networks and assets in the City that include:**

- **Expanding access of all modes of travel in Boston's neighborhoods;**
- **Improving safety related to transportation; and**
- **Ensuring reliability of Boston's transit and roadway networks.**

The action plan highlights the importance of increasing the use of public transit in order to reduce greenhouse gas emissions and incorporates measures to ensure the resilience of our transportation networks in light of projected climate change impacts. It details 58 projects and policies including transit and active transportation projects that would contribute to reductions in emissions. Go Boston 2030 will help decrease our transportation carbon emissions, but it is recognized that there will still be vehicles on the road. Those vehicles must transition to zero-emission vehicles (ZEVs) by 2050 to meet our carbon neutrality goal.

Go Boston 2030 is the City's long-term plan to transform Boston's transportation system. The action plan details 58 projects and policies including transit and active transportation projects that would contribute to reductions in emissions. In accordance with the 2014 CAP, Go Boston 2030 adopted climate responsiveness as a guiding principle and set goals to make Boston a city where all residents have better and more equitable travel choices, where efficient transportation networks foster economic opportunity, and where steps have been taken to prepare for climate change. By emphasizing accessibility, safety, and reliability, Go Boston 2030 will make it easier and more attractive for Bostonians to go car-free. Actions to shift travelers from driving alone to choosing shared and active transportation modes will make travel more efficient, reduce total vehicle miles traveled in Boston, and help decrease our transportation carbon emissions.[4] While it is expected that there will be a reduction in the utilization of automobiles, the reduction will occur gradually over time and demand will still exist for light-duty vehicles (LDV). As determined by the 2019 CAP Update, to reach carbon neutrality, Boston must transition all remaining vehicles on the road to electric or other ZEVs over the next 30 years, in addition to maximizing mode shift from single occupancy vehicles to shared and active modes.

3 Climate Action Plan Update 2019
4 Go Boston 2030

# BOSTON'S CURRENT EV LANDSCAPE

## Benefits and Barriers to EV Adoption

### BENEFITS

In addition to supporting the City's efforts to reach carbon neutrality, EVs also have the potential to provide a number of other important benefits to City residents, the environment, and the economy.

*Economic Development Benefits*

The consumer savings from switching to EVs, such as drivers benefiting from reduced fuel and maintenance costs, will also result in consumers spending less on imported energy. Shifting dollars away from the fossil fuel industry will allow funds to be spent more locally. On average, a dollar not spent on fossil fuels and instead spent on other goods and services is estimated to create 16 times more jobs than a dollar spent on fossil fuels.[5] The ZEV industry and electric utility sector have an opportunity for widespread economic and employment growth, such as installation, operation, maintenance, and subsequent local utility expansion.

The economic benefits of EV adoption include:

- "56% ($3.6 billion) will accrue directly to EV owners in the form of reduced annual vehicle operating costs;
- 21% ($1.4 billion) will accrue to electric utility customers in the form of reduced electric bills; and
- 23% ($1.5 billion) will accrue to society at large, as the value of reduced greenhouse gas (GHG) emissions."[6]

*Benefits to the Electricity Grid*

The Commonwealth has seen a recent decrease in overall energy demand as a partial result of new energy efficiency and demand response programs, such as its partnership with neighboring states through the Regional Greenhouse Gas Initiative (RGGI).[7] Overall, EVs are expected to provide an increase in energy demand to the electrical grid, with EV-specific energy demand projected to grow by 300% across the entire state of Massachusetts by 2030.[8] The Clean Energy Standard (CES) Regulation set a minimum percentage standard of electricity sales that utilities and competitive retail suppliers must procure from clean energy sources. When EVs plug-in over the next few decades, they will be consuming increasingly cleaner energy from the grid.[9] Electric vehicles have the potential to reduce overall utility ratepayer costs by improving the load factor (i.e. the utilization rate) of the electricity grid. Particularly when new electric load from EV charging can be added to the grid at strategic times (e.g., when the grid has excess capacity or at times of high output of renewable energy), this new load can increase utility revenues without adding substantial cost, thereby reducing the need for electricity rate increases and driving down the cost to all ratepayers over time.[10]

*Greenhouse Gas Reduction and Air Pollution Reduction*

Nationally, vehicles that meet current emission standards cause $14.5 billion in public health and societal costs annually. Cars and SUVs are responsible for 65% of transportation emissions in Boston. Life-cycle greenhouse gas emissions are calculated from the global-warming potential of a vehicle through the entire life cycle, from manufacturing to retirement. Tailpipe emissions are the direct result of combustion engines burning fuel on an onboard source and are released through a tailpipe on a vehicle. Switching to EVs will decrease street-level emissions and eliminate tailpipe emissions. In addition to eliminating tailpipe emissions, the life-cycle emissions of driving

5 Roland-Holst, D. 2012. *Plug-in Electric Vehicle Deployment in California: An Economic Jobs Assessment*
6 *Electric Vehicle Cost-Benefit Analysis: Massachusetts*
7 ISO New England, *New England Power Grid State Profiles 2018-2019 (January 2019).*
8 New England ISO. *Final Draft 2020 Transportation Electrification Forecast*
9 Alternative Energy Portfolio. *"Clean Energy Standard (CES)"*
10 *Electric Vehicles Are Driving Electric Rates Down*


PHOTO 2: Dedicated EV Charging Parking in Fenway. Samantha Devine

a compact EV are about three times lower than for an ICE vehicle, before accounting for the grid's transition to cleaner electricity during a car's lifetime. Massachusetts is powering its electricity grid with cleaner sources, with a goal of 35% renewable or clean energy by 2030, meaning each mile converted to electric vehicles will yield even larger reduction of greenhouse gas and air pollution emissions. With planned municipal aggregation programs, Boston residents may be able to opt-up to 100% clean energy even sooner. ZEV adoption will reduce annual carbon emissions by up to 400,000 tons. The Commonwealth has a goal of deploying 300,000 EVs by 2025. If achieved, it will be on track to reduce annual transportation emissions by over 35% by 2030.

## BARRIERS

ZEVs can provide significant benefits for the environment, economy, and Boston residents, yet ZEV adoption continues to fall behind market forecasts due to a range of barriers.

*Awareness*

Many Americans have never ridden in or driven an EV. Specific challenges include lack of understanding of the difference between a battery electric vehicle (BEV) and a plug-in hybrid electric vehicle (PHEV), how to charge a vehicle, different charging stations, and the different makes and models of EVs.

*High Up-front Costs*

Most ZEVs have higher up-front costs compared with their gasoline-powered counterparts. Many consumers purchase cars based on the sticker price, not lifetime costs or total cost of ownership. Yet ZEV owners can save over $450 per year on maintenance and fuel costs in Massachusetts when compared with operating a new ICE vehicle.[11] With effective outreach and education consumers will increasingly consider the lifetime vehicle cost when making purchases. Additionally, most car buyers do not purchase new vehicles, and because ZEVs are a relatively new market, there is not a significant supply of affordable used ZEVs on the market. To address the cost barrier, the federal government and a number of state governments, including Massachusetts, offer tax credits and other incentives to ZEV buyers that lower the up-front cost. Finally, battery costs are dropping, which suggests that the cost premium for new EVs will decline over time and savings will grow.[12]

*Range Anxiety*

According to a recent survey of prospective car buyers in the Northeast, two of the top concerns about EVs are the availability of charging locations and the time to recharge.[13] Range anxiety is the fear that an electric vehicle battery will run out of power before the destination or a suitable charging point is reached. Range anxiety may be exaggerated, as the majority of batteries have ranges that are in excess of the average number of miles traveled per day. Americans drive an average of 40 miles per day, according to the U.S. Department of Transportation, and the average mileage by a vehicle registered in Boston is 24 miles per day, which makes current EV models on the market very practical.[14] While the majority of daily trips are well within the range of a current battery capacity, many nearby desirable destinations are not. Given that both residents and visitors in New England commonly travel for both work and pleasure, collaboration with regional stakeholders to increase the number of charging stations is necessary to address this barrier. There are many regional charging strategies in New England that support Boston's efforts to expand infrastructure, including, but not limited to, Electrify America's nationwide publicly accessible DCFC network with installations in Massachusetts.[15]

*Garage Orphans*

In the United States, 80% of charging is currently done at home; but most Boston car owners do not have a garage and rely on street parking.[16] Urban areas, including Boston, often have weaker EV adoption rates compared with neighboring suburban communities due to challenges of accommodating public charging stations and accommodating garage orphans. "Garage orphans," or vehicle owners not in full possession of a parking spot, must rely on condo associations, property or lot managers, or municipalities to dependably provide access to charging. One of the primary challenges to widespread EV adoption is the lack of garage or driveway ownership.[17]

11 *Alternative Fuels Energy Calculator.* Compares Operating 2020 Chevy Bolt with 2020 Chevy Malibu in Massachusetts
12 NCSL. 2020. *State Renewable Portfolio Standards and Goals*
13 Edelman Intelligence, *Electric Vehicle Audience and Benchmark Survey, January 2017*
14 *MAPC Open Data*
15 *Electrify America Station Map*
16 For Electric Car Owners, 'Range Anxiety' Gives Way to 'Charging Time Trauma'
17 WXY. June 2015. *Accommodating Garage Orphans.*

# ELECTRIC VEHICLE ADOPTION IN BOSTON

## Recent trends and future projections

*Electric Vehicle Model Choices*

The EV market is advancing at a rapid rate. In 2010, there were two EV make-and-model options available. As of September 2019, the available PHEV and BEV models have surged to just over 50. EVs are representing a larger percentage of cars on the road each year. EV sales have grown rapidly in Massachusetts, nearly doubling between 2017 and 2018 alone.

*Electric Vehicle Battery Capacity*

Battery technology is improving rapidly, with eight 2019 BEV models operating with range estimates in excess of 200 miles. The projections for future models support the trend of progressively improved battery life, with some models expecting range estimates of over 600 miles, or nearly the distance from Boston City Hall to Richmond, Virginia, compared with a typical range of about 400 miles for conventional gasoline vehicles.[18] The amount of time required to reach a full charge in most batteries is becoming shorter thanks to higher voltage chargers and batteries that can charge more rapidly. The question of mass adoption for EVs is no longer if, but when.

*Historical and Current EV Adoption*

The Boston region has been a leading market for EVs in the state, and among other metro regions in the nation. In 2018 (the last year for which there is full data), EV adoption in Boston and neighboring municipalities represented 2.8% of new vehicle registrations, compared with 2.5% statewide.[19] In 2019, the Boston region ranked 10th out of the top 50 most populous U.S. metro areas in EV market share.[20] While the Boston region has exhibited relatively strong EV uptake in recent years, this growth has been led by neighboring municipalities while adoption in Boston proper has lagged slightly (2.4% of new vehicle sales).

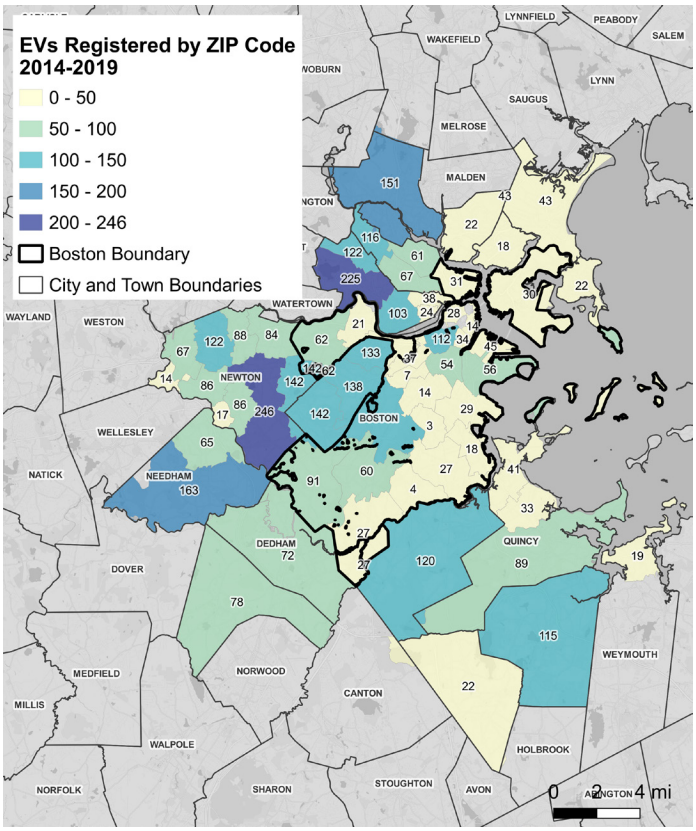



**FIGURE 1: Map of EVs registered by zip code 2014-2019**

Figure 1 shows the number of EVs purchased between 2016-2019 in Boston and neighboring municipalities. Overall, there have been higher rates of EV adoption in neighboring municipalities than in Boston, with the least amount of uptake in Downtown and areas of Dorchester. The highest rates of uptake have occurred around Newton, Cambridge, and Needham, which reflects wealthier, early adopter demographics similar to other markets. In addition, higher uptake in these communities highlights the garage orphan effect potentially at play in Boston, whereby urban residents often do not have access to their own parking space where they can charge an EV. As of mid-2019, it's estimated that there were nearly 2,000 EVs registered

18 *All-Electric Vehicle Ranges Can Exceed Those of Some Gasoline Vehicles*
19 IHS Markit vehicle registration data, *Advanced Technology Vehicle Sales Dashboard.*
20 ICCT. 2019. *The surge of electric vehicles in United States cities*

in the City of Boston, and over 4,800 registered in the City of Boston plus its neighboring municipalities.[21] Income and age for new EV owners from 2014 to 2019 align with national findings, as EV owners orient towards younger age and higher average income demographics when compared with non-EV owners. The charts below show the income of new EV owners. Overall, Boston EV owners are slightly younger (66% are age 54 and younger, compared with 62% of non-EV owners). Additionally, Boston EV owners generally have higher incomes; 75% earn $100,000 a year or more, compared with 65% of non-EV owners. It should be noted that these figures only capture new vehicle registrations. New vehicle buyers in general are disproportionately wealthier.

**FIGURE 2: Income distribution of EV owners and non-EV owners in the City of Boston (2014-2019)**

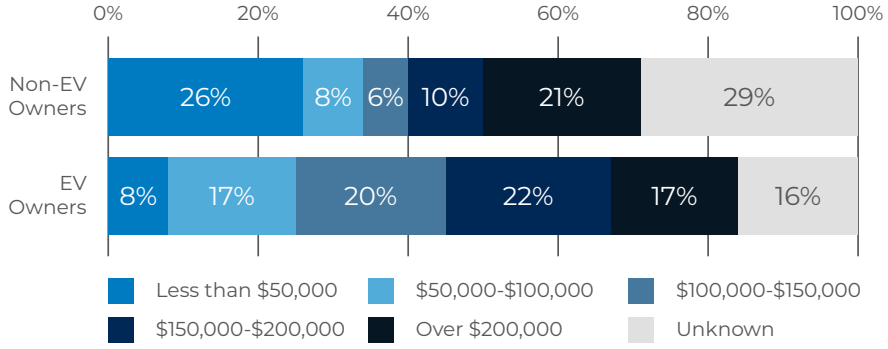



Table 2 displays the most popular EVs purchased in the Boston area between 2016-2019. Of these vehicles, Tesla, Chevrolet, and Toyota were found to be most popular for manufacturer choice, with Tesla making up about half of the market.

**TABLE 2: Top 10 EVs purchased in Boston Area (2016-2019)**

| VEHICLE | PERCENTAGE |
|---|---|
| TESLA MODEL 3 | 27% |
| TESLA MODEL S | 13% |
| CHEVROLET VOLT | 13% |
| TOYOTA PRIUS PRIME | 12% |
| CHEVROLET BOLT | 10% |
| TESLA MODEL X | 8% |
| HONDA CLARITY | 5% |
| NISSAN LEAF | 5% |
| SMARTCAR FORTWO | 2% |
| VOLKSWAGEN GOLF | 2% |

**TABLE 3:**
**Top 10 zip codes in Boston region for EV Purchases (2016-2019)**

| ZIP CODES | NEIGHBORHOOD | TOTAL |
|---|---|---|
| 02459 | Needham/Newton | 246 |
| 02138 | Cambridge | 225 |
| 02492 | Needham | 163 |
| 02155 | Medford | 151 |
| 02467 | Brookline/Newton/ Brighton/Boston | 142 |
| 02445 | Boston/Brookline | 138 |
| 02446 | Brookline | 133 |
| 02130 | Jamaica Plain | 132 |
| 02465 | Newton/Auburndale | 122 |
| 02140 | Cambridge | 122 |

21 Estimate is based on 2016 Boston metro region data for registered EVs (6,600) apportioned to each municipality based on registered vehicles, and IHS Market new registration data from 2017-2019. Estimates do not account for vehicles that may have been scrapped or otherwise left the area. They also do not account for registrations that may be allocated to ZIP codes of auto dealerships where owners lease or purchase vehicles.

*Future Projections for Consumer EV Adoption in Boston*

In order to anticipate how consumer EV adoption citywide will grow and scale, the Automotive Deployment Options Projection Tool (ADOPT), developed by the National Renewable Energy Laboratory (NREL), was utilized to project EV growth from 2020 to 2050.[22] By utilizing this tool, LDV adoption can be forecast over a span of time, based on consumer choice, available vehicle options, EV charging availability, and policy inputs.[23] The differences between the high, medium, and low scenarios include variations in technology improvements, level of EV charging infrastructure investment (including coverage and charging speed), and policy interventions such as incentives.

Consumer EV adoption in Boston is projected to reach a range of 54% (Low Scenario) to 71% (High Scenario) of new vehicles purchased by 2050. While the scenarios are tightly aligned between 2020 and 2025, an acceleration in EV adoption is anticipated for the latter half of this decade and beyond, which reflects lower battery costs and new vehicles expected to come to market. Based on vehicle fleet turnover rates embedded in the ADOPT model, it's estimated that these scenarios will result in a range of 45% of registered vehicles being electric vehicles by 2050 (Low Scenario) to 62% (High Scenario). Even in the High Scenario, the model is not on a trajectory that reaches carbon neutrality, which would entail only ZEVs on the road by 2050. The annual estimated life-cycle EV emissions for passenger vehicles in the City of Boston would reduce 25% from baseline by 2030 in the High Scenario, and 51% by 2050. This suggests Boston will need to continue to adopt all known policies to encourage EV adoption and will need to look towards policy innovations that can enable more widespread adoption of EVs. Additional policy levers, expanded charging infrastructure, incentives, and programs will be necessary to reach the City's carbon neutrality goal.

## EV CHARGING INFRASTRUCTURE IN BOSTON

Boston's EV charging infrastructure is expanding. As of 2019, there are 658 Level 2 and 51 DCFC publicly accessible chargers within Boston. That is equivalent to about one charger for every 1,000 residents. In the 50 largest metropolitan areas in the United States, there is a correlation between publicly accessible charging and EV uptake, with 275 charge points per million residents as a benchmark for leading U.S. markets.[24] The Boston metropolitan area exceeds the suggested benchmark by 446 additional charge points.[25] Boston still faces challenges to uptake due to the concentrated location of chargers and the cost to access charging stations. In Boston at the end of 2019, 99% of publicly accessible chargers were on private property, behind a "paywall" (e.g., located in commercial parking garages) and concentrated in Downtown and the Seaport District. Many of the EV charging stations in Boston are currently located at condominiums, hotels, public garages, multiuse high-rises, and shopping centers. While the chargers are technically publicly accessible, they are not free-to-access, meaning you have to pay a parking garage or entrance fee, which presents an additional barrier to purchasing an EV. This section utilizes the following definitions to refer to different types of EV charger access:

- Publicly Accessible Charger: A charging station that is publicly owned and publicly available (e.g., Park & Ride lot, public library parking lot, on-street parking) or privately owned and publicly available (e.g., shopping center parking lot, commercial office parking garage).
- City-Owned Charger: A charger that is a publicly accessible. It may be owned or leased by the City of Boston.
- Restricted Charger: A charging station that is publicly owned and has restricted access (e.g., fleet parking for designated vehicles) or privately owned and is not open to the public for access (e.g., fleet parking for designated vehicles) or privately owned and has restricted access (e.g., single-family residence, designated employee parking). Restricted chargers are prevelent in Boston but rarely captured in public datasets used in this analysis and are not the focus of this Roadmap.

22 Brooker, A., Gonder, J., Lopp, S., and Ward, J., "ADOPT: A Historically Validated Light Duty Vehicle Consumer Choice Model," SAE Technical Paper 2015-01-0974, 2015, doi:10.4271/2015-01-0974.
23 National Renewable Energy Laboratory. "ADOPT Model" *https://www.nrel.gov/transportation/adopt.html*
24 ICCT. 2017. *Emerging best practices for electric vehicle charging infrastructure*
25 DOE. Alternative Fueling Station Locator

# CURRENT POLICIES, PROGRAMS, AND INITIATIVES

**The chart below details the ways in which the Commonwealth, City of Boston, and electric utility Eversource are currently participating in and supporting EV adoption.**

| OUTREACH | STATE | CITY | UTILITY | NOT OCCURRING |
|---|---|---|---|---|
| OUTREACH EVENTS | • | | • | |
| PUBLIC CHARGER PROMOTION | • | • | • | |
| INFORMATIONAL MATERIALS & HOW-TO GUIDES | • | • | • | |
| DEALERSHIP ENGAGEMENT PROGRAM | | | | •* |
| **EXPANDING ACCESS TO CHARGING INFRASTRUCTURE** | | | | |
| EV READY BUILDING CODE | • | • | | |
| RIGHT TO CHARGE - CONDO | • | • | | |
| RIGHT TO CHARGE - APARTMENT | | | | • |
| PUBLIC CHARGING INFRASTRUCTURE | • | • | • | |
| CURBSIDE CHARGING STRATEGY | | | | • |
| EXPEDITED PERMITTING PROCESS | | | | • |
| **MONETARY** | | | | |
| EV PURCHASE INCENTIVE* | • | | | |
| COMMUTER TAX BENEFIT | | | | • |
| PARKING BENEFIT | | | | • |
| FLEET PURCHASING BENEFIT | • | | | |
| FEE REDUCTION, TESTING EXEMPTION, + NO ANNUAL EV FEE | • | | | |
| CHARGER PURCHASING INCENTIVE | • | | • | |
| HOV LANE ACCESS/TOLL DISCOUNT PROGRAM | | | | • |
| INCREASED EVSE INCENTIVE FOR LOW-INCOME COMMUNITIES | | | • | |
| MANUFACTURING INCENTIVES | | | | • |
| PREFERENTIAL EV CHARGING RATES | | | | • |
| CASH FOR CLUNKERS EV PROGRAM | | | | • |
| IDLE REDUCTION WEIGHT EXEMPTION | | | | • |
| **OTHER EFFORTS** | | | | |
| ZEV PROGRAM AND STRATEGY | • | • | • | |
| ELECTRIC CAR SHARING PROGRAM | | | | • |
| ELECTRIC TNC PROGRAM | | | | • |
| LOW CARBON FUEL POLICY | | | | • |
| OEM SALES REQUIREMENTS | • | | | |

*EV purchase incentives are also occurring at the federal level, which is not captured in this table.

Boston, Eversource, and the Commonwealth already have implemented a wide range of supportive EV policies and programs. These actions have been complementary, with each entity filling gaps and enabling opportunities within their respective domain.

**The electric vehicle readiness policy for new large developments (made official 3/2019) is one of the most progressive EV installation policies in the U.S. New large developments shall have EV chargers installed in at least 25% of parking spaces; and the remaining 75% will have the appropriate infrastructure for future installations.**

**The purpose of this policy is to support not only personal EV ownership but vehicle electrification and transportation mode shift. Because of this focus, compliance options also include EV car share and electric bike parking.**

*Inclusive Electrification*

This ZEV Roadmap defines equity in the context of electrification. There are many barriers to owning an EV that make EV access inequitable. The purpose of this Roadmap is to focus on building access and affordability, with an intention to direct benefits towards low-income communities and communities of color first.

*Equitable Stakeholder Engagement Plan*

The City is working towards making Boston a healthy, thriving, and resilient city for all residents. We want to ensure all of us have access and support to thrive from childhood to retirement. The City's role is to listen and acknowledge the needs of the community, and to plan and adjust in order to understand and improve inequalities. A key principle of the ZEV Roadmap is to ensure everyone can share equitably in the benefits and opportunities associated with the electrification of the transportation sector. Everyone deserves clean air.

The ZEV Roadmap adapted the Urban Sustainability Directors Network Equitable Clean Energy Guidebook to develop an outreach plan that builds on the Recharge Boston program.[26] Outreach will be conducted in meetings, interviews, and presentations to strengthen close, two-way relationships with key community group stakeholders including community groups, Main Street organizations, and community development corporations to get engagement on specific programs. These partnerships will build on a dialogue that began during the 2019 Climate Action Plan update around electrification and understanding the specific needs of different stakeholders.

Current Equitable Procurement Initiatives that Boston's Economic Development Office is already undertaking efforts to build relationships with a more diverse pool of potential vendors. Additional actions that the City will pursue can be found in Action 12.

Existing efforts include:

- The creation of a Supplier Diversity Advisory Council, created by Mayor Marty J. Walsh's Executive Order in October 2019.[27]
- Modernization of a public-facing directory of small and local businesses including minority-owned businesses (MBEs), woman-owned businesses (WBEs), and veteran-owned small businesses.
- The creation of a training program for City employees and departments who manage procurement as part of their roles.
- A requirement that each department create a procurement plan that prioritizes equitable business practices.
- A requirement that City employees verify they have utilized the City's procurement directory when soliciting bids.
- A disparity study to examine the participation of MWBEs in City contracting, measure the availability of MWBEs for City contracts and procurements, and assess marketplace conditions for MWBEs.

26 USDN Equitable Clean Energy Guidebook
27 City of Boston. July 2020. Executive Order to Support Equitable Procurement Process


# POLICY AND PROGRAM RECOMMENDATIONS

**This analysis has identified a number of policies and incentives that have yet to be implemented which could further accelerate the city's transition to EVs while meeting the other goals of this roadmap. The consumer EV adoption projections developed for this roadmap underscore the need for additional policies and programs to support EV uptake in line with the city's carbon neutrality goal. Even in the high uptake scenario, there are still 29% ICE vehicles on the road in 2050, suggesting complementary policy levers will be necessary to ensure the 2050 carbon neutrality goal is achieved.**

PHOTO 3: Chargers in Fenway. Samantha Devine

# GOAL 1


PHOTO 4: City chargers in municipal lot in Jamaica Plain. Samantha Devine

# GOAL 1: SUPPORT WIDESPREAD ADOPTION OF ELECTRIFICATION

TABLE 4: Actions and targets for Goal 1

| GOAL | ASPIRATIONAL TARGETS | ACTIONS |
|---|---|---|
| 1 Support widespread adoption of electrification | • 23% of all new car purchases in Boston are EVs by 2025<br>• Every household will be within a 10-minute walk of an EV car share facility or a publicly accessible charging station by 2040 (also supports Goal 2) | EXISTING CITY PROGRAMS THAT WILL CONTINUE<br>• Recharge Boston outreach materials and programs<br>• Small Vehicle Sharing Business Advisory Committee<br>• Mayor Walsh's 2019 legislative agenda includes an Act Relative to Transportaion Network Company Rider Assessments<br>FUTURE ACTIONS<br>1. Develop TNC electrification policy/program<br>2. Support the growth of personal and shared e-bike use<br>3. Support shared micromobility charging infrastructure<br>4. Release an RFP for an EV car share by FY2022<br>5. Explore opportunities to develop auto dealership and customer engagement programs |

# OVERVIEW OF ACCELERATING ELECTRIFICATION


PHOTO 5: City chargers in municipal lot in Jamaica Plain. Samantha Devine

This section focuses on how the City of Boston will pursue accelerating widespread adoption of electrification of both electrified multimodal options and personal vehicles. The City of Boston has a variety of both public and private multimodal options that are currently available, but as of 2020 few are electric. One public sector options is the large capacity transportation systems with fixed routes that are developed and managed through the Massachusetts Bay Transportation Authority (MBTA). The MBTA provides a variety of subway, bus, train, trolley, shuttle, and ferry options to carry travelers across the city. The MBTA already operates several electrified services such as the subway lines, the Silver Line BRT, and trolleybus lines, and is currently working to electrify more of its buses and commuter rail lines, with plans to invest billions of dollars in electrification. The plans include but are not limited to renovating or building four garages to accommodate electric bus charging (with the first slated to open in 2025) and electrifying three commuter rail lines. The efforts that the MBTA is making towards a cleaner energy use for public transportation support the carbon neutrality goals of the City of Boston.

The City of Boston also has public transportation by bike, Bluebikes. Bluebikes consists of 3,500 bikes and 330 stations and is jointly owned and managed by Boston, Brookline, Cambridge, Everett, and Somerville. Our bike share system is essential to Boston's transportation system. Bluebikes is a reliable, low-cost and zero-emission option – and fun, too!

Boston's private sector multimodal systems help to ensure greater access to non-single occupancy vehicle transportation options and help to lower costs and lower emissions from transportation. The City's private sector multimodal options are primarily made up of small-capacity transportation systems such as transportation network companies (TNCs) and car share. There have also been electric scooter pilots in some neighboring municipalities. There have been recent steps taken by local municipalities across the nation, and within the Greater Boston area, in conjunction with private industries, to accelerate electrification in the shared vehicle sector.

# TARGETS TO SUPPORT WIDESPREAD ELECTRIFICATION

**ASPIRATIONAL TARGET 1:**
**Every household will be within a 10-minute walk of an EV Car Share facility or a publicly accessible charging station**

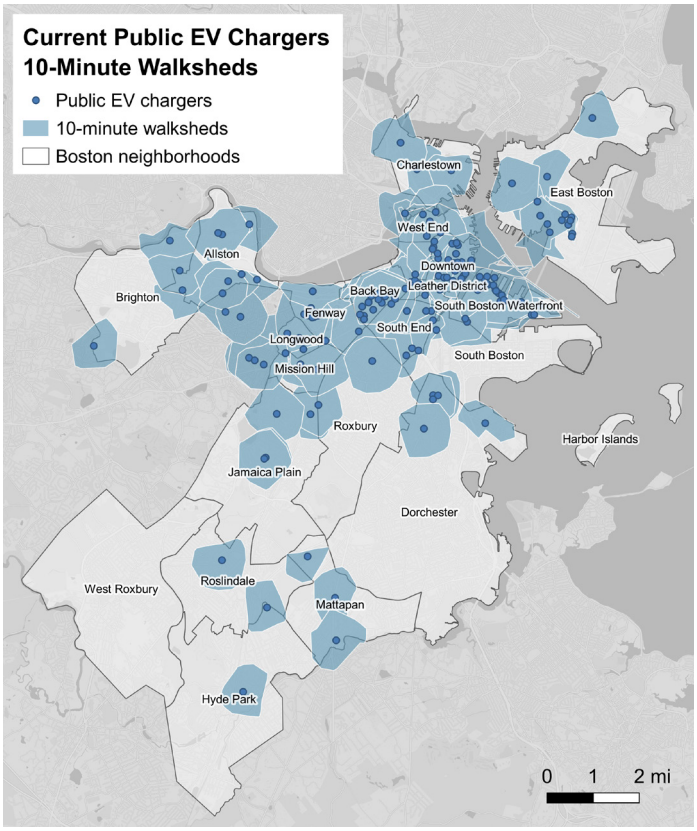
Consistent with goals set by Go Boston 2030 to have every household within a 10-minute walk of a car share, bike share, and rapid transit route, the CAP Update identified an aspirational target to have every household within a 10-minute walk of an EV car share facility or EV charger. This analysis focuses on filling in EV charging "gaps"; that is, distance between EV chargers. These chargers are not necessarily free-to-access or City-owned. Currently, it's estimated that 57% of City residents have access to a publicly accessible EV charger within a 10-minute walk.

**ASPIRATIONAL TARGET 2:**
**23% of all new car purchases in Boston are EVs by 2025**

The cars registered in Boston make up 16.8% of the total vehicles in Massachusetts. In order to proportionally support the statewide ZEV goal to have 300,000 EVs registered by 2025, the number of EVs registered in Boston must be 16.8% of the total statewide goal. To accept the statewide target proportionally, Boston has set a target of 8% of vehicles registered in Boston and 23% of all new car purchases in Boston to be EVs by 2025.

The High Scenario of the ADOPT model is on track to achieve this aspirational target, with 32% of new car sales projected to be EVs by 2025 – with the understanding and assumption that the City continues to adopt policies, install supportive infrastructure and that the market continues to evolve and mature. It's to be noted that the Medium and Low Scenarios achieve 21% of new car sales being EVs by 2025 – and are just 2% shy of achieving the target.

**FIGURE 3: Current 10-minute walksheds for publicly accessible EV chargers in Boston**




While several future actions in other sections of this Roadmap directly support this target, there are many existing actions that also support this goal, including but not limited to:

- *Massachusetts Offers Rebates for Electric Vehicles* (MOR-EV): The MOR-EV program is a Commonwealth program that aims to support the statewide emissions reduction goals for the Commonwealth by increasing the use of EVs through rebates of up to $1,500 for the purchase or lease of a PHEV, EV, or fuel-cell EV and up to $450 for zero-emission motorcycles.

# ACTIONS TO SUPPORT WIDESPREAD ELECTRIFICATION

**ACTION 1:**
**Develop TNC electrification policy/program**

**The City of Boston will explore opportunities to enact policies and programs designed to accelerate the electrification of TNC vehicles.**

Ride-hailing fleets result in a net increase in vehicle miles traveled, typically in the most dense and congested areas of the cities.[28] Specific initiatives within this package could include:

- Providing riders in-application options for selecting an EV
- Requiring companies to give EV TNC drivers a weekly stipend
- Offering reduced per-mile fees or exemptions
- Existing Action: Mayor Walsh's 2019 legislative agenda included an Act Relative to Transportation Network Company Rider Assessments. The bill would provide a financial incentive for ZEVs, such as EVs, with a reduced per-mile fee or an exemption in some cases.

Case Study: Lyft has introduced "Greenmode," which enables users to request hybrid and electric vehicles. While this has not been introduced in the Boston area, it has been introduced in other cities in the U.S.

**ACTION 2:**
**Support shared micromobility**

**A charging solution that is accessible across different modes and platforms will be deployed by 2021.**

As trips increasingly become electric and shared, and as more micromobility options become mainstream, charging infrastructure that can provide electricity to all types of EVs, and support new forms of shared micromobility such as e-bikes and e-scooters, will be needed. Electrification across the multimodal landscape requires collaboration among local, state, and private entities to ensure steady progress towards a cleaner, more cost-efficient, and safer transportation system.

**ACTION 3:**
**Release an RFP for an EV car share by FY2022**

**Expanding Car Share Boston to specifically offer EV options would create opportunities for residents to benefit from electrification without owning a personal EV**

Car share programs decrease individual car ownership, reduce the number of vehicle miles traveled, make more curb space available for a range of uses, and reduce the City's rate of carbon emissions. Car Share Boston is the City of Boston's program to improve access to car share vehicles by leasing public parking spaces in municipal lots and on City streets to car share operators. Car Share Boston currently offers 250 spaces for shared vehicles. While the program is open to EVs, most, if not all, vehicles participating in the program are ICE vehicles.

Case Study: The BlueLA Electric Car Sharing Program is a program with 100 electric cars and 200 EV charging stations available to the public for rent by the minute. BlueLA offers varying rates depending on an individual's income. It is being funded by a $1.7 million grant through California Climate Investments, a statewide program aimed at reducing GHG emissions and improving public health in disadvantaged communities. The goal of the car service, stated by Blue Solutions, "is to give low-income residents options other than public transportation and to provide them with autonomy and independence."[29]

28 ICCT. 2019. *Emerging Policy Approaches to Electrify Ride-Hailing in the United States.*
29 Los Angeles Times. 2017. *New L.A. car-sharing service aims to serve low-income neighborhoods.*

# ACTIONS TO SUPPORT WIDESPREAD ELECTRIFICATION

Designing for Equity: Independently, or folded into the RFP, the City will pilot an EV car share in partnership with community organizations. The City will prioritize locations near GoHubs! and in environmental justice communities. The City is currently exploring sustainable business models for community-owned or -managed EV car share in partnership with nonprofits and community development corporations.

**ACTION 4:**
**Support the growth of e-bike use**

**E-bikes could complement the existing Bluebikes system and offer more residents of Boston a reliable zero-emission transportation option to replace personal car use.**

Bicycles are a zero-emission way to get around the city. Ridership rates and popularity have grown dramatically in Boston in the last 10 years with the installation of bike infrastructure, including protected bike lanes, expanded community programs, and the launch and expansion of shared Bluebikes.

While ridership rates have grown, there is a percentage of the population who may be willing to ride a bike but are limited by ability, distance, and unwillingness to exert too much energy getting to their destination. E-bikes offer a potential solution to make biking more accessible.

E-bikes use rechargeable batteries that provide added propulsion to pedal bicycles. The added battery support means that e-bikes can go much faster than most people can pedal over a sustained period of time, and there is less energy exertion needed to travel for long distances. For most, a bike trip of 0-5 miles is fairly easy, and there is a willingness to travel by bike if the trip takes 20 minutes or less. E-bikes can extend the miles a trip is easy to make and reduce the time to travel. E-bikes could complement the existing Bluebikes system and offer more residents of Boston a reliable zero-emission transportation option to replace personal car use.

One reason e-bikes have limited uptake is their high up-front cost. The average e-bike costs $2,600 to purchase based on a national survey. In Boston, entry-level e-bikes are available for $1,200-1,500. Overcoming the cost barrier can increase uptake and reduce SOV and car ownership. Assessments of e-bike incentives in France found that nearly half of users used e-bikes to replace car trips, that one in five users decided to forgo a vehicle purchase, and that 7% of users gave up a vehicle after participating in an e-bike purchase incentive program.

E-bikes can make biking more accessible. Studies reveal that e-bike users on average are older with 65%-75% of users being over the age of 65, and that a majority of riders are female. E-bikes require less energy exertion and make it easier to tackle hilly terrain, allowing older adults to travel greater distances. Existing Actions:

- The *Electric Vehicle Readiness Policy for New Developments* allows developers to install e-bike parking accommodations as one compliance option to meet the policy requirements.
- The City of Boston released a *Request for Information* in July 2020 to understand how e-cargo bikes could fit into Boston's delivery landscape, current obstacles to adoption by private businesses, and other opportunities to green last-mile solutions.

Opportunities to advance e-bikes could include:

- Offering subsidies for personal e-bike ownership.
- Support small businesses and delivery services to incorporate e-bikes in their fleet.
- Support education and outreach around e-bikes.

# ACTIONS TO SUPPORT WIDESPREAD ELECTRIFICATION

**ACTION 5:**
**Explore opportunities to develop auto dealership and customer engagement programs**

**A dealership engagement program can include education for dealers and sales representatives, marketing techniques, and ride & drive event support.**

Modern EVs have been sold for nearly two decades – but dealerships have appeared to be a bottleneck in EV uptake. Car sales representatives fail to sell as many EVs as ICE vehicles, possibly due to a longer sales pitch and explanation required, charging infrastructure hurdles, and sales representatives' general unfamiliarity.

Case Study: Smart Columbus is a nonprofit organization in Columbus, Ohio, that created a dealership engagement program as one part of its efforts to support EV uptake. While all dealerships are eligible, certain requirements must be met including but not limited to having a charger on site, committing to keeping up with EVs in their inventory, and having two sales representatives trained in the program. The program offers educational resources, marketing materials, and promotional support.

The City of Boston will explore opportunities and partnerships to develop auto dealership and customer engagement programs to increase EV adoption.

PHOTO 6: Charger in parking garage. Samantha Devine

# GOAL 2

PHOTO 7: Car charging in Dorchester. Samantha Devine

# GOAL 2: ENSURE AFFORDABLE, CONVENIENT ACCESS TO CHARGING INFRASTRUCTURE FOR ALL RESIDENTS

TABLE 5: Actions and targets for Goal 2

| GOAL | ASPIRATIONAL TARGETS | ACTIONS |
|---|---|---|
| **2** Ensure affordable, convenient access to charging infrastructure for all residents | • Total EV charging plugs needed by 2025: 1,055 Level 2 and 320 DC Fast chargers that are City- or privately owned<br>• Free-to-access public charging infrastructure available in every neighborhood by 2023 | EXISTING CITY PROGRAMS THAT WILL CONTINUE<br>• Install EV charging stations in municipal lots<br>• EV Readiness Policy for New Large Developments<br>• Rights to Charge policy for condominiums<br>FUTURE ACTIONS<br>6. In addition to the 658 Level 2 charging plugs currently installed, the City of Boston will aspire to add 50% of the remaining needed Level 2 Charging plugs by 2025, totalling in 198 charging plugs<br>7. Develop a curbside charging policy and launch pilot by 2022<br>8. Explore expanding Right to Charge to include rental properties |

# OVERVIEW OF SUPPORTING ACCESS TO CHARGING INFRASTRUCTURE

This section focuses on the efforts that the City of Boston will undertake to support conveniently accessible and affordable charging infrastructure for all residents. Within the City of Boston, as of 2019, there are 658 Level 2 and 51 DCFC publicly accessible chargers. Currently, two of the publicly accessible chargers in Boston are City-owned, and 99% of the current chargers are behind a paywall, meaning they require a payment to access. This payment, for example, could be to a private garage. A survey conducted as part of the 2019 Climate Action Plan Update revealed that 45% of Bostonians would purchase an EV if they had access to a charger, suggesting the currently-available charging infrastructure is not sufficient to further the transition to EVs. To provide options for those who can't charge an EV at home, the City is working to increase access to public chargers. The actions below provide the details for the scale of this effort. To ensure that there is access throughout the City's neighborhoods as well as sufficient capacity to serve areas with more demand for publicly accessible EV charging, the City has set targets for both access and demand.


PHOTO 8: City EV charger interface. Samantha Devine

# TARGETS TO SUPPORT ACCESS TO CHARGING INFRASTRUCTURE

**ASPIRATIONAL TARGET 1:**
**Free-to-access publicly accessible charging infrastructure available in every neighborhood by 2023**

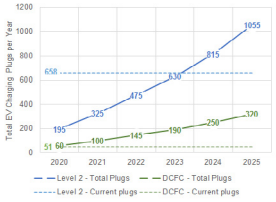
A goal identified by the Climate Action Plan is to have free-to-access publicly accessible chargers in every neighborhood by 2023. Seven of the 22 neighborhoods in Boston have free-to-access publicly accessible chargers or have near-term plans for installation. Existing Actions:

- *How to Install an Electric Vehicle Charging Station*: Many stakeholders are unfamiliar with the requirements and process for installing off-street Electric Vehicle (EV) Charging Stations. The City of Boston has created a document to provide guidance on how to navigate the range of decisions necessary to choose and install charging stations in a residential or commercial development.
- *MassEVIP*: The Massachusetts Electric Vehicle Incentive Program (MassEVIP) supports eligible public entities to purchase EVs and charging stations. MassEVIP is one of several Department of Environmental Protection open grant programs aimed to support more widely available charging stations and electric vehicles across Massachusetts. The program is funded by the Volkswagen Settlement, a $1.45 billion civil penalty that Volkswagen paid for violating the Clean Air Act after the company installed defeat devices in its vehicles that cheated emissions tests. There are five different programs within the MassEVIP program including fleets, multi-unit dwelling charging, public access charging, workplace charging, and open solicitation. Eligible entities for the program include cities and towns, state agencies, and state colleges and universities.
- *Eversource Make Ready Program*: Eversource, Boston's local utility, offers a Make Ready Program that facilitates the adoption of EVs by covering the cost of installing the electric infrastructure to allow for the installation of up to 10 EV charging connectors per site. The program's budget for the first funding round is $45 million. Eligible sites include public, workforce, and multifamily homes. Eversource will also cover the full cost of the charger in Environmental Justice Communities in addition to the network expansion.

**ASPIRATIONAL TARGET 2:**
**1,055 Level 2 and 320 Direct Current Fast Chargers (DCFC) City-owned and privately-owned total EV charging plugs needed by 2025**

Providing sufficient capacity for EV owners to charge their vehicles will be essential as adoption grows. Publicly accessible EV charging infrastructure has been widely deployed in Boston, with an estimated 658 Level 2 charging plugs and 51 DCFC plugs as of December 2019. To support continued growth of EV adoption in Boston in line with the High Scenario in the projection of consumer adoption, it's estimated that the total number of publicly accessible EV chargers in Boston will need to grow by an additional 395 Level 2 charging plugs and 290 DC fast charging plugs by 2025, in addition to the current charging infrastructure. Given the rapidly changing technology and consumer behavior of the EV market and transportation sector as a whole, these estimates should be revisited with each Roadmap update and recalibrated with charger utilization data.

**FIGURE 4: Total EV charging plugs needed to support high scenario EV adoption (2020-2025)**



# ACTIONS TO SUPPORT ACCESS TO CHARGING INFRASTRUCTURE

**ACTION 6:**
**The City of Boston will aspire to install 50% of the needed Level 2 chargers by 2040, deployed with consideration for 10-minute walksheds, and with each neighborhood having a free-to-access charger.**

**The City will evaluate the installation of up to an additional 198 Level 2 charging plugs in the next four years.**

In partnership with the utility Eversource through its Make Ready Program, the City is installing publicly accessible EV charging stations in municipally owned parking lots. This includes installing infrastructure necessary to support the deployment of both Level 2 and DCFC stations.

The City of Boston will not install or host all of the chargers needed to meet demand, but will pursue a variety of actions to encourage continued investment by the private sector in addition to utilizing City property to host chargers. The City will evaluate the installation of up to an additional 198 Level 2 charging plugs in the next four years, which accounts for about 50% of the additional Level 2 chargers needed by 2025. A graph of the total EV charging plugs needed can be found in Figure 4. This number will be evaluated on an annual basis to monitor how many charging stations have been installed by private entities. This commitment is subject to change as private EV charging stations are installed.

To meet the Climate Action Plan Update goal and reach the goal of having 100% of residents be within a 10-minute walk of an EV car share facility or publicly accessible EV charger by 2030, it's estimated that at least 60 additional charger locations would need to be deployed strategically throughout the City. It's estimated that about 60 additional locations could provide coverage for the whole City within a 10-minute walk, but only if optimally placed, which is unlikely. It's likely more chargers will be needed once realistic locations are identified. This goal relates to all publicly accessible chargers, including those behind a paywall, such as in a commercial parking garage. To meet the CAP goal of having publicly accessible chargers in every neighborhood by 2023, 15 additional neighborhoods need free-to-access chargers. This goal relates to publicly accessible chargers, City-owned or private, that you do not need to pay to access, such as paying to enter a garage.

**TABLE 6: Number of Level 2 charging plugs to be evaluated for installation by the City of Boston**

| YEAR | NEW PLUGS |
|---|---|
| **2020** | 42 |
| **2021** | 56 |
| **2022** | 25 |
| **2023** | 25 |
| **2024** | 25 |
| **2025** | 25 |
| **TOTAL** | 198 |

Across these sites, a number of common factors arose to vet ideal charger placement, including but not limited to:

- Nationwide, 80% of charing is done at home. But home charging is not an option for garage orphans and is especially challenging for residents who rent rather than own their home or apartment. Locating EV chargers in residential areas, especially those with limited off-street parking and areas with a high density of multifamily housing, can greatly increase access to charging and mitigate barriers and concerns for charging at home.

# ACTIONS TO SUPPORT ACCESS TO CHARGING INFRASTRUCTURE

- Access to power – Some sites are not feasible for charger installation because of the current electrical capacity and infrastructure.
- Proximity to other points of interest – Charger utilization is found to greatly increase when chargers are located near destinations and attractions, such as museums, movie theaters, restaurants, or other activities. EV owners are able to "top up" their vehicles while running errands or otherwise contributing to the local economy.
- Proximity to chargers outside of Boston proper – While analysis conducted for this Roadmap was focused on Boston, EV chargers deployed in neighboring municipalities support EV users in Boston. A charger deployed in Brookline, for instance, might support EV users in Jamaica Plain or Allston.

**ACTION 7:**
**Develop a curbside charging policy and launch pilot by 2022**

**Curbside charging is an opportunity to provide additional charging options to meet the needs of EV drivers.**

Curbside charging is an opportunity to provide additional charging options to meet the needs of EV drivers, including people who drive EVs for ride-hail companies, people without access to a private garage, and people who may not have access to reliable home or workplace charging options. There are a few privately operated curbside chargers spread throughout the City, and the City of Boston currently operates two dual plug curbside chargers on Cambridge Street in Downtown Boston. By 2022, Boston will create a curbside charging policy and guidelines document. The City will launch a subsequent curbside charging pilot in the following year, adhering to these guidelines.

Existing Action: Curb Use Guidelines prioritize curb uses based on land use and establish a decision-making process for curb management strategies. As part of the Shared Mile Playbook, the Curb Use Guidelines will define curb functions and set standards for when curb management strategies should increase access for people, goods, services, or parked vehicles.

Case Study: As the EV market matures, other cities such as New Orleans, Sacramento, and Seattle have created a strategic and organized approach to allow residents to apply to fund unreserved curbside charging near their home. Seattle's pilot identified and deployed the solution of allowing residents to lay a Level 1 charging cord over the sidewalk from their home to the curb to charge their personal vehicles. The cord must have a compliant charging cord cover.

Case Study: Los Angeles has a goal of 10,000 electric vehicle supply equiptment (EVSE) units within four years, and 4,000 on City property. To reach this goal, LA has launched a few different curbside charger efforts including mounting Level 2 chargers on streetlight poles. In addition to existing streetlight poles, there are 12,000 locations throughout the City where light and power poles are not present, but underground vaults with vents exist, which will be used to place DCFC and Level 2 chargers.

**ACTION 8:**
**Explore expanding Right to Charge to include rental properties**

**The current Right to Charge legislation supports only condominum owners.**

In January 2019, the Right to Charge petition was signed into law by the governor of Massachusetts, declaring an association may not prohibit or unreasonably restrict

# ACTIONS TO SUPPORT ACCESS TO CHARGING INFRASTRUCTURE


PHOTO 9: City charger in municipal lot in Jamaica Plain. Samantha Devine

an owner of a condominium from installing an electric vehicle charging station. This is a great measure to ensure access to EVSE for condo owners, but it does not support residents in Boston who do not own their dwelling or commercial space. The City of Boston will explore expanding Right to Charge to include rental properties.

Case Study: The State of California has a Right to Charge law for both residential tenancies and commercial tenancies, providing the framework for how a tenant can request an EVSE for their dwelling. This law also includes the ability for a utility to install a Time-of-Use meter to monitor when the charging station is being used. Time-of-Use meters are designed to help utility companies in determining what price per kilowatt-hour should be charged for the use of an EV charging station at specific times of the day.[30]

30 *Right to Charge: California.*

# GOAL 3


PHOTO 10: City of Boston Fleet Hub EV - Chevy Bolt charging. Katherine Eshel

# GOAL 3: ELECTRIFY THE MUNICIPAL FLEET

TABLE 7: Actions and targets for Goal 3

| GOAL | ASPIRATIONAL TARGETS | ACTIONS |
|---|---|---|
| **3** Electrify the municipal fleet | • All vehicles purchased for Central Fleet are electric or ZEVs, or best in class if an appropriate ZEV is not available<br>• 100% of light-duty vehicles are emissions free by 2035<br>• 100% of medium-duty vehicles are emissions free by 2050<br>• 100% of heavy-duty vehicles are emissions free or low emissions by 2060 | FUTURE ACTIONS<br>9. Operationalize green fleet purchasing policy to govern recurring purchases<br>10. Develop strategic, cost-efficient, and future-proofed fleet charging station plan<br>11. Test vehicle-to-grid technology<br>12. Continue to align fleet procurement policy citywide best practice<br>13. Rightsize the fleet and shed and repurpose underutilized assets |

# OVERVIEW AND TARGETS OF ELECTRIFY THE MUNICIPAL FLEET

The 2007 Executive Order on Climate Action ordered that City departments purchase alternative fuel, flexible fuel or hybrid vehicles, or the most fuel-efficient vehicles within their class. In 2017, fuel used to power the City of Boston's vehicle fleet accounted for 0.5% of Boston's total emissions, and 25% of emissions from local government operations.

**ASPIRATIONAL TARGET 1:**
**All vehicles purchased for Central Fleet are electric or ZEVs, or best in class if an appropriate ZEV is not available**

- **100% of passenger (light-duty) vehicles are emissions free by 2035**
- **100% of medium-duty vehicles are emissions free by 2050**
- **100% of heavy-duty vehicles are emissions free or low emissions by 2060**

In 2019, Boston set the following fleet transition goals in the Climate Action Plan Update: The Central Fleet Management division of the Public Works Department for the City of Boston maintains just under 1,000 vehicles for about 20 city departments, just over half of which are light-duty vehicles. Boston's Central Fleet of LDVs is currently made up of a mix of sedans (127), vans (126), SUVs (92), and light-duty pickup trucks (205). Currently, 30% of light-duty municipal vehicles in the Central Fleet are BEVs or PHEVs.

The analysis and recommendations below pertain to LDVs and the pathways to achieving a 100% emissions-free light-duty Central Fleet by 2035. At present, there are limited commercially available, cost-competitive medium- and heavy-duty ZEVs. The City will monitor technology developments in these vehicle classes and add actions to address these vehicles in future updates to this Roadmap.

*Telematics Assessment*

Telematics systems, which can monitor vehicles' fuel use, mileage, speed, and location data, were installed and analyzed on 19 representative Boston City fleet vehicles to understand the typical patterns of these fleet vehicles and their suitability for conversion to an electric vehicle. Out of the 19 vehicles analyzed, 18 vehicles were considered feasible for an immediate transition to an EV because an electric vehicle would have suitable range for their typical use and would be expected to provide operational cost savings and emissions benefits over the life of the vehicle. None of these 18 vehicles would require midday EV charging, and the vehicles were parked for 16 hour periods, meaning Level 1 charging infrastructure would be sufficient. Overall, the findings from the telematics assessment suggest the following principles for transitioning Boston's light-duty fleet to all-electric by 2035:

- Prioritize high-mileage vehicles – Given the lower cost to fuel and maintain an electric vehicle, higher mileage vehicles save more money compared with a gasoline vehicle, as long as the battery capacity does not limit the duties of that vehicle.
- Prioritize soon-to-be-retired vehicles – Focusing on vehicles that need to be replaced immediately can enable Boston to meet its 2035 goal without retiring vehicles early.
- Prioritize vehicles with dedicated centralized parking and share chargers – The telematics results indicate that many vehicles only need to charge every third night. The City does not need to have a ratio of one charger to one vehicle. Vehicles can share Level 2 chargers, or each vehicle can have a dedicated Level 1 charger.

*Fleet Transition Scenario Analysis*

Multiple purchasing scenarios were modeled to understand different potential pathways to achieve a 100% electrified LDV fleet by 2035 for the 550 light-duty vehicles in the Central Fleet. One scenario was identified to have an EV acquisition schedule that fit into the City's typical annual purchasing schedules, while also considering EV model type availability, as shown in the target trajectory displayed in Figure 5. Due to the current limited availability of electric SUVs, vans, and trucks, the target trajectory prioritizes purchasing EV sedans in the early 2020s, and phasing in the other vehicle models over time as more options become available and prices decrease.

*Emissions and Economic Impact of LDV Fleet Electrification*

While EVs are expected to cost more up front, they are also anticipated to yield savings from lower fuel and maintenance costs, providing yearly operating savings. While some fleets are able to see total cost of ownership savings from switching to EVs, Boston's high electricity costs and low mileage for these fleet vehicles inhibit total cost of ownership savings. The City could save on upfront costs for fleet electrification if it is able to continue to monetize the MassEVIP program. EV purchase costs are expected to continue to decline alongside battery costs, and analysts anticipate cost parity for up-front costs for sedans and SUVs with ICE vehicles between 2024 and 2028.

Between 2020 and 2035, electric vehicles purchased on the schedule illustrated below are anticipated to cost the City $5.5 million more than comparable ICE vehicles and will save nearly $1 million in operating costs.[31]

As the City procures more EVs and the electric grid continues to become cleaner, greenhouse gas emissions savings are anticipated to grow. The difference between the estimated emissions from new EVs and the estimated emissions from new ICE vehicles that would have otherwise been procured between 2020 and 2035 in CFM totals in an estimated 4,600 metric tons of greenhouse gas emissions saved during this time period.

31 ICCT. 2019. Update on electric vehicle costs in the United States through 2030

**FIGURE 5: Light-duty EV Fleet purchase scenarios**

# SPOTLIGHT: MEET KNOX

Mayor Martin J. Walsh, the Environment Department, Office of Women's Advancement, Public Works Department, Property Management Department, and the Mayor's Office of New Urban Mechanics collaborated to add the City's first electric-assist cargo tricycle to the municipal fleet. Early anecdotal evidence indicates that employees plan to use the trike for delivering physical materials for annual compliance processes, carting construction cones for street-based interventions, moving bike racks from a warehouse to their installation locations, and bringing children's books to early education centers.

**"This new tricycle is an innovative new program as Boston continues its work towards achieving carbon neutrality in our city," said Mayor Walsh. "I'm proud this tricycle is named after Ms. Knox, an early leader who championed equity in the bicycle community. In Boston, we have also proclaimed August 20, 2020, as Kittie Knox Day."**

The tricycle is named after Katherine "Kittie" Knox, a Black West End resident in the 1880s who confronted racial and gender stereotypes in Boston's bicycling community. The new tricycle supports Boston's work to reduce emissions from municipal sources, a critical goal of the 2019 Climate Action Plan Update.

Some of the civic research questions that we hope to learn about through this prototype include:

- Are we able to logistically implement and maintain a single cargo e-trike, and what does that tell us about a future world in which Central Fleet contains more e-bikes/e-trikes?
- To what degree do City employees feel aligned with city goals (such as those outlined in Go Boston 2030) when they are using the cargo e-trike?
- How do residents perceive the City's use of the cargo e-trike to enable employees to attend public meetings for which they are carrying many items?
- What would it take for the City to envision a cargo bike/cargo trike fleet for employees that residents could also access through a check-out system?


**PHOTO 11: City of Boston e-Cargo Bike, Knox. Jaclyn Youngblood**

# ACTIONS TO SUPPORT ELECTRIFY THE MUNICIPAL FLEET

**ACTION 9:**
**Operationalize Green Fleet Purchasing Policy and Create Long-Term Plans**

**When it comes to accelerating or streamlining the procurement of EVs, an operationalized fleet purchasing process is necessary to achieve a fully electric city fleet across all departments.**

By establishing a separately administered protocol to govern LDV purchases, a city can focus on achieving its high-order goals and expedite the decision-making process. This action will include the following steps to operationalize light-duty EV purchases:

- Each department, external to the Central Fleet, will create a 10-year vehicle replacement plan by the 2023 ZEV Roadmap update, identifying when vehicles will be replaced and what suitable EV or alternative fuel vehicles are available. Each fleet will create a long-term reduction of the number of vehicles and will shed excess underutilized vehicles.
- The City of Boston will continue to meet with the Municipal Fleet Working Group on a quarterly basis, as needed.
- A new budget process and purchasing form will be created and operationalized. A formal requirement for approval from department heads in the event of any vehicle besides an EV is being requested, and the duties required of the specific vehicle.
- The City of Boston will formalize training, outreach, and education on EVs to fleet users.

Case Study: City of Seattle's procurement process includes a decision hierarchy for vehicle purchases based on fuel type. The procurement process calls for the engineers and the fleet manager to jointly determine the best purchasing method for the new vehicle and specifically references collaborative purchasing as an option.

**ACTION 10:**
**Develop strategic, cost-efficient and future-proofed fleet charging station plan**

**To enable widespread transition, a more detailed plan that takes into account parking locations and driving distances will be needed to identify a cost-effective approach to providing fleet charging infrastructure.**

One of the biggest differences in managing an EV fleet is how to charge vehicles. To enable a widespread transition, a more detailed plan that takes into account where vehicles park and how far they drive will be needed to identify a cost-effective approach to providing fleet charging infrastructure. Through its fleet charging station plan, City of Boston will adopt and formalize the following strategies:

- Operationalize request form – Central Fleet Management will make an online request form for departments to request additional charging infrastructure.
- Site strategically to minimize cost and maximize impact – The City of Boston will further analyze the fleet and departments' vehicle replacement schedules to determine which locations can be outfitted as hubs for charging multiple vehicles, as well as where to make Level 1 charging infrastructure available on a more distributed basis.
- Plan for an electrified future – If an infrastructure upgrade is needed for an existing facility (or if a new facility is being constructed), make the investment to upgrade necessary conduits for more capacity than is currently needed. As battery technology evolves, increasing charger strength will be necessary. Boston will consider DCFC options for fleet vehicles, as needed.

# ACTIONS TO SUPPORT ELECTRIFY THE MUNICIPAL FLEET

- Engage with utility – Many utilities, including Eversource, continue to offer financial support or incentives to encourage vehicle electrification. Eversource will be integral to providing guidance on how to take advantage of opportunities and how to plan for the future.
- Mobile chargers – The City will consider purchasing mobile chargers that can be shared between departments, do not require utility upgrades in order to allow for flexible solutions, and reduce peak demand charges.

**ACTION 11:**
**Secure funding and subsequently release request for proposals (RFP) to test vehicle-to-grid (V2G) and/or vehicle to building (V2B) technology by 2023**

**Vehicle-to-grid can support demand response, frequency regulation, and emergency backup power.**

Vehicle-to-grid technology refers to EV charging that occurs bidirectionally – where the vehicle can be charged the same way that it is typically charged, and the grid can also pull energy from the car battery, to be used as a source of power. This can work to scale. According to one study, 10 Nissan Leafs can power 1,000 homes for an hour.[32]

Case Study: Octopus Energy operates a vehicle-to-grid program called Powerloop in parts of the United Kingdom. For a monthly fee, Powerloop offers consumers a new Nissan Leaf, a free charger, a smart meter, and cash back each month if they plug into the grid for 12 nights. When vehicles are plugged in each night, they release energy to the grid, creating a more flexible and stable grid, in turn offering lower rates to consumers. Powerloop also allows increased use of renewable energy in the grid. Because wind and solar energy fluctuates, the utility can store and release renewable energy when needed.

The City will evaluate the feasibility of deploying a vehicle-to-building pilot at a municipal building. If the project proves feasible, the City will explore external funding sources to support the building pilot. Should the City secure funding, it will release an RFP to test this technology by 2023.

**ACTION 12:**
**Continue to align fleet procurement policy citywide best practice**

**The City of Boston will incorporate existing and additional measures into their procurementoperations in order to facilitate the participation of MWBEs.**

There are additional measures that the City of Boston will explore, in addition to the existing  incorporating into their procurement operations in order to facilitate the participation of MWBEs. This is a nascent market and as suppliers diversify, the City will ensure that vendors are inclusive.

Case Study: Memphis, Tennessee has implemented a policy where City-certified MWBE firms are paid within five business days. This is designed to increase working capital for small, diverse businesses that may lack cash flow in order to purchase equipment or meet payroll needs for a large job for the City. This program could decrease the net payment terms for a designated MWBE, ensuring a prompt disbursement of funds. The City of Boston will explore:

- Opportunities to break up contracts into smaller, more manageable contracts including different pieces of the contract or, into multiyear phases
- Alerting WMBEs of bid releases to provide additional communication of opportunities

32 Moxia. 2018. *How we're putting you in the EV driving seat.*

# ACTIONS TO SUPPORT ELECTRIFY THE MUNICIPAL FLEET

- Inclusion of EVSE installers and suppliers in the public-facing business directory
- Future updates to this EV Roadmap can include metrics on the inclusion of MWBEs in the EVSE processes.

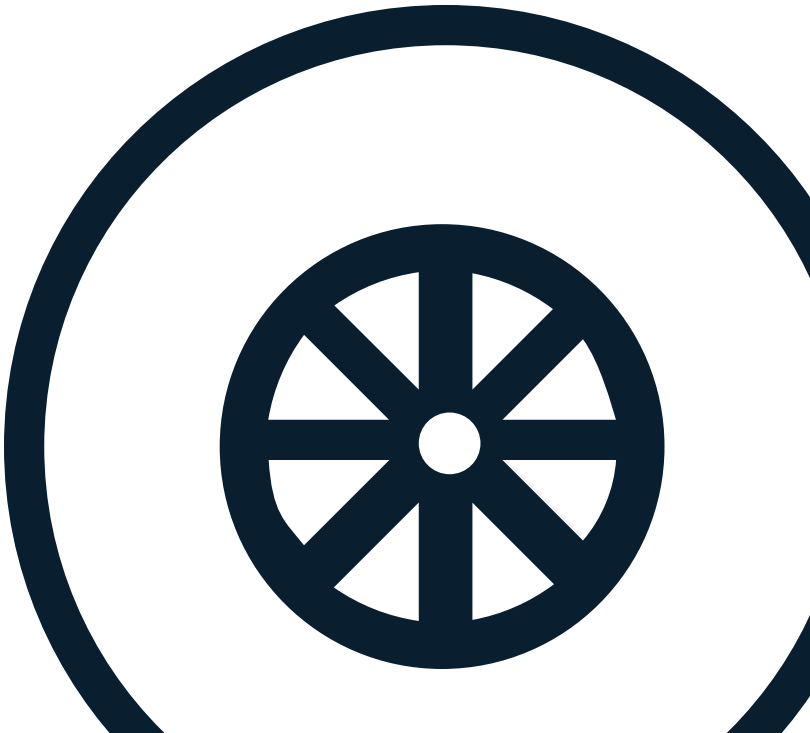
**ACTION 13:**
**Rightsize the fleet and shed and repurpose underutilized assets**

**An important element in effective management of our assets is the establishment of a vehicle and equipment utilization policy.**

The City of Boston recognizes that it has a substantial investment in vehicles and equipment assets that its departments need for the delivery of services to its constituents. Effective management of these assets is imperative in order to peak efficiency and readiness. An important element in achieving this objective is the establishment of a vehicle/equipment utilization policy.

The City of Boston will:

- Evaluate vehicles based on age, mileage, overall condition, maintenance cost, and operating cost.
- Form a Fleet Utilization Review Committee to be charged with making decisions on retaining, reassigning, eliminating, or changing vehicles to pool status.
- The Committee will meet quarterly to aid in the budget preparation and equipment requests.



# CONCLUSION

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Go Boston 2030 and the CAP both set ambitious targets to reduce single-occupancy vehicle use, but even with the city's mode shift goals, 25% of travel into Boston and 19.5% of travel within Boston is projected to remain as personal vehicular travel. To reach Boston's carbon neutrality goals, it is imperative that as many travelers as possible are shifted out of personal vehicles, while ensuring that any vehicles left on the road become ZEVs, such as EVs. This ZEV Roadmap identified opportunities to set goals and evaluate based on measurable outcomes – from mode shift, to electrifying the municipal fleet, to supporting adoption. The strategies identified through this inclusive process will have the greatest impact in creating an electric future that benefits all Bostonians.


PHOTO 12: Kat Eshel rides Knox in front of City Hall. Jaclyn Youngblood

# ACRONYMS AND KEY TERMS

## TYPES OF VEHICLES

(ZEV) *Zero-Emission Vehicles*: ZEVs are vehicles that produce no tailpipe emissions from the onboard source of power, such as some plug-in hybrid electric vehicles (PHEV), battery-electric vehicles (BEV), and hydrogen fuel cell vehicles.

(EV) *Electric Vehicles*: EVs are vehicles powered, at least in part, by electricity. Unless otherwise noted, EV refers to all plug-in vehicles in this report, including PHEVs and BEVs.

(BEV) *Battery-Electric Vehicles*: BEVs are vehicles powered entirely by electricity.

(PHEV) *Plug-in Hybrid Electric Vehicles*: PHEVs are vehicles with both an internal combustion engine and electric motor that can be powered either by gas or electricity through a rechargeable battery. PHEVs may be zero-emission vehicles if they're operated entirely as EVs but are not true ZEVs because the hybrid mode includes use of an internal combustion engine.

(ICE) *Internal Combustion Engine Vehicles*: ICE vehicles have an engine in which the combustion of a fuel occurs with an oxidizer in a combustion chamber. This term is used to describe vehicles powered by gasoline or diesel.

## ELECTRIC VEHICLE CHARGING TERMS

(EVSE) *Electric Vehicle Supply Equipment* refers to all of the equipment associated with transferring electric energy to a battery or other energy storage device in an electric vehicle. This includes hardware, including connectors, fixtures, devices, and other components. This is commonly called a charging station.

*Level 1*: AC Level 1 EV charging (often referred to simply as Level 1) provides charging through a 120-volt (120V) single-phase AC plug (a typical wall outlet) at 12-16 amps. Level 1 EV chargers provide about 3-5 miles of range per hour of charging.

*Level 2*: AC Level 2 EV charging offers charging through 240V (typical in residential applications) or 208V (typical in commercial applications) single-phase electrical service (like a dryer plug) at 12-80 amps (typically 32 amps). Level 2 EV chargers provide about 10-20 miles of range per hour of charging.

(DCFC) *Direct-current fast charging*: DCFC equipment (typically 208/480V AC three-phase input and less than 125 amps), enables rapid charging at a rate of at least 40 kW, with newer chargers rated up to 350 kW. Most commonly, DCFC can provide about 125 miles in 20-30 minutes.

## MOBILITY TERMS

*Bike Share*: Bike share is a service where bicycles are available for shared use to individuals on a short term basis.

*Car Share*: Car share is a service that gives members access to an automobile for short-term use □ usually by the minute, hour, or day.

*E-Bike*: E-bikes are bicycles with an electric motor that can be used for propulsion. There are a few different types of e-bikes:

*Class 1*: Pedal Assist: The electric drive on the e-bike is only activated by pedaling and ceases to provide assistance once the e-bike reaches 20 mph. Unless otherwise specified, the term e-bike refers to Class 1 pedal-assist e-bikes.

*Class 2*: Throttle on Demand: The electric drive on the e-bike can be activated through a throttle element and may also be activated through pedaling with top speeds limited to 20 mph.

# ACRONYMS AND KEY TERMS

*Class 3*: Speed Pedelec: The electric drive system on the e-bike is activated by pedaling and ceases to provide assistance once the e-bike reaches 28 mph.[33]

*Class 4*: Motorcycle/Moped: The electric drive system is activated by pedaling or throttle. These e-bikes can reach top speeds above 28 mph.

*Micromobility*: Use of a low-speed travel mode, or use by a single person.

*Multimodal*: Characterized by several different travel modes or options.

*Shared Mobility*: Shared use of a travel mode.

(TNCs) *Transportation Network Companies*: Programs, like ride-hailing apps, that provide prearranged and on-demand transportation services for compensation by connecting drivers of personal vehicles with passengers through mobile applications.

**CLIMATE-RELATED ACRONYMS:**

CAP: Climate Action Plan Update

GHG: Greenhouse Gas

**FLEET-RELATED ACRONYMS:**

HDV: Heavy-Duty Vehicles

LDV: Light-Duty Vehicles

MDV: Medium-Duty Vehicles

SUV: Sport Utility Vehicle

**MISCELLANEOUS ACRONYMS:**

RFP: Request for Proposals

MBE: Minority Business Enterprise

WBE: Women Business Enterprise

MWBE: Minority and Women Business Enterprise

33 What are E-Bike Classes and Why Do They Matter?

# ACKNOWLEDGMENTS

**THE CITY OF BOSTON'S ZERO-EMISSION VEHICLE ROADMAP IS A UNIQUE COLLABORATION BETWEEN CITY AGENCIES, THE BLOOMBERG PHILANTHROPIES AMERICAN CITIES CHALLENGE, AND SUBJECT MATTER EXPERTS FROM AROUND THE COUNTRY. IT WAS MADE POSSIBLE BY CONTRIBUTIONS FROM DEDICATED STAFF AND THE CONSULTANT TEAM.**

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# ACKNOWLEDGMENTS


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## CONSULTANT SUPPORT

Delivery Associates
Natural Resources Defense Council (NRDC)
Electrification Coalition (Fleet Modeling Scenarios)

## REPORT DESIGN

Vision Flourish
visionflourish.com