Encouraging Electric Vehicle Adoption in Newton

By

Collin Fedor
James Newhouse
Kelly Rethmeyer
Salvatore D’Amico

Presented to:

Professor Tara Pisani-Gareau
Alderwoman Emily Norton
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1. Abstract

Electric Vehicles (EVs) are an emerging technology with the potential to replace conventional vehicles while reducing the amount of carbon emissions in the atmosphere. The City of Newton, Massachusetts is a city of nearly 88,000 people that is interested in becoming more eco-friendly. This report outlines ways in which the City can achieve this goal through the promotion of EVs. Using survey data, spatial analysis, and best practices research, we identify opportunities for Newton to improve electric vehicle infrastructure and promote adoption of EVs amongst its residents. The study determined that lack of knowledge and awareness of EVs is the major reason why EV adoption is low in Newton. It found that public charging stations are desirable by EV owners and non-owners alike, and can contribute significantly in educating the populace. The City must balance policies that promote rapid adoption in the short term with policies that plan for future widespread adoption in the future. This report makes clear that providing infrastructure for EVs should be a priority for the City moving into the future.
2. Introduction

In 2008 Massachusetts stormed into the national spotlight when the passing of the Global Warming Solutions Act (2008) establishing the most aggressive set of measures to address climate change of any state in the country (Commonwealth of Massachusetts 2008). The Commonwealth showed it was committed to addressing the multiple threats of climate change and that everyone had the collective responsibility to make the environment better for future generations. It set ambitious emissions reductions targets: 25% reduction of Greenhouse Gas (GHG) emissions by 2020 and an 80% reduction by 2050. It encouraged policies and regulations that spurred economic development and innovation within the Commonwealth. Since its passage, emissions have already decreased 15% below 1990 levels (Department of Energy and Environmental Affairs, 2014). Massachusetts was set to be living proof that reducing carbon emissions and dependence on fossil fuels can be accomplished when all sectors works toward a common goal.

Despite this significant progress, all indications show Massachusetts is not on track to meet its goals (Commonwealth of Massachusetts, 2013). In order to be on track to meet the 2050 target, the state would have to reduce emissions by 25 percent of 1990 levels by 2020. Massachusetts needs an additional 52 million metric tons in GHG emissions reductions above and beyond the 24 million metric tons of reductions needed to meet the 2020 emissions limits (Commonwealth of Massachusetts, 2013). This translates to a very aggressive GHG reduction rate of 1.7% per year from 2020 to 2050, much faster than the 0.9% per year pace of emissions reductions needed from 2011 through 2020. Transportation accounts for 39% of greenhouse gas emissions in the state. Within transportation, light duty vehicles encompass over 60% of emissions. Therefore, converting from fossil fuel intensive vehicles to zero emissions vehicles is an incredibly important step in achieving emissions reductions goals.

As a designated member of the Green Communities Division in the Commonwealth of Massachusetts, the City of Newton, Massachusetts (“Newton”) has an obligation to help Massachusetts to reduce greenhouse gas emissions. The City has taken significant strides in becoming environmentally friendly and living up to its nickname “The Garden City.” Newton can significantly contribute to the Commonwealth’s reduction objectives by encouraging its residents to purchase and use electric vehicles. Electric vehicles emit no tailpipe emissions, so widespread adoption would significantly reduce total GHG emissions produced by transportation.

Newton has some EV infrastructure in place, but it is lackluster at best. Despite a population of 87,971, there are a total of eight charging stations in Newton: two free charging stations at City Hall and off of Route 9 on Elliot Street, one membership chargeshare station at
the Mall at Chestnut Hill, and five private chargers for guests at the Indigo Hotel, owners of Nissan Leafs at Clay Nissan, and employees of a private office complex. As EV infrastructure and use increases nationwide, many expect a drop in EV price and increase in the EV adoption rate. Newton can either wait for that time to come (and be unprepared to meet citizen demand for charging stations), or lead the charge as one of the most EV-friendly cities in the Commonwealth of Massachusetts.

Accomplishing this task will not be easy. Therefore, it is the purpose of this study to take a comprehensive and systematic look at the way in which Newton can increase EV adoption. This study has four objectives that, when combined, will help Newton to navigate the complicated web of EV infrastructure and policymaking:

1. To identify case studies where municipalities have successfully set up EV infrastructure and policies
2. To determine if, and where, Newton should install public EV chargers by using spatial analysis, residents’ input from surveys, and successful case studies
3. Use survey results to identify how to make EV charging easier for the unique challenges of Newton residents who own EVs and to understand what obstacles prevent the widespread adoption of EVs by Newton residents
4. To understand what policy mechanisms Newton can use to improve EV usage and decrease carbon emissions

These findings will be used to create a comprehensive recommendation of ways Newton can increase EV infrastructure to encourage EV adoption.

It should be noted that, while the study initially hoped to incorporate Boston College (“BC”) as a potential venue for a public charging station, it was decided to exclude BC from the study for a number of reasons. While parts of BC are in Newton, the vast majority of the school’s parking lots are located in the Boston side of the campus. Moreover, this study was conducted with the intention of being presented to the City of Newton to highlight city-level actions. To include BC in our analysis of how to improve Newton’s infrastructure capability, then, would not be relevant to the goals of the project. However, it is recommended that Newton engage with BC, specifically the Office of Sustainability and the Environmental Studies Department, in the future as it considers a broader sustainable transportation network.

3. Background and Rationale

3.1 Electric Vehicles: A Run Down

The electric vehicle (EV) has started to appear on the market as nearly all major vehicle manufacturers offer or plan to offer an EV model. Electric vehicles have fewer moving parts than conventional cars, require less maintenance, produce very little noise, and can be recharged overnight at home (Babaee et al. 2014, Zhang et al. 2013, US DOE 2012). Despite their high
initial price, advocates have argued that economies of scale as well as lower operating costs will soon make EVs cost competitive with conventional vehicles (Sierzchula 2014).

Plug-in electric vehicles (PEV) are powered only by one or more electric motors. They receive electricity by plugging into the grid, and they store it in batteries. They consume no petroleum-based fuel while driving and produce no tailpipe emission. HEVs (hybrid electric vehicles) combine an internal combustion engine (ICE) or other propulsion source with batteries, regenerative braking, and an electric motor to provide high fuel economy. They rely on a petroleum-based or alternative fuel for use and are not plugged in to charge. HEV batteries are charged by the ICE or other propulsion source and during regenerative braking. PHEVs (plug-in hybrid electric vehicles) use batteries to power an electric motor, plug in to the electric grid to charge, and use petroleum-based or alternative fuel to power an ICE or other propulsion source. There are two categories of PHEV systems, parallel and series. With a parallel system, PHEVs connect the engine and the electric motor to the wheels through mechanical coupling. Both the electric motor and the engine can drive the wheels directly. A series system uses only the electric motor to drive the wheels. The ICE is used to generate electricity for the motor. The Chevy Volt uses a slightly modified version of this design: the electric motor drives the wheels almost all of the time, but the vehicle can switch to work like a parallel PHEV at highway speeds and/or when the battery is depleted.

Today’s EVs typically have a shorter range than the range of conventional vehicles. Most light, medium, and heavy-duty EVs are market a range of about 100 miles on a fully charged battery. The range depends in part on the driving conditions and the habits of the driver. Extreme outside temperatures tend to reduce range because more energy must be used to heat or cool the cabin and cold batteries do not provide as much power as warm batteries do. High driving speeds also reduce range because more energy is required to overcome increased air resistance. The time required to fully charge depleted batteries can range from less than 30 minute to almost a full day, depending upon the size of battery and type of charging equipment that is used (US Department of Energy 2012).

The type of PEV purchased determines the way people charge their vehicle. Homeowners may plug their vehicles into a conventional 120-volt household outlet or install a 240-volt circuit for faster-charging. PEVS come with a 120-volt charging cord that enables owners to charge their vehicle with a conventional outlet (Level 1 charging). Level 1 charging provides 3-4 miles per hour of charge. This is a very practical solution for owners of plug-in hybrid vehicles such as the Toyota Prius or the Chevy Volt. However, a person who purchases a battery electric vehicle such as the Nissan Leaf may choose to use a Level 2 charging station. Level 2 chargers use 240 volts and cut the charging time by about one-half compared with 120 volt charging, meaning one hour of charge garners 8-20 miles of range. Level 2 charging requires the installation of a dedicated circuit and a charging station, and cost around $600-$700. If a homeowner decides to install a Level 2 charging station they must obtain a permit from their local jurisdiction (US Department of Energy 2012).

Vehicle emissions can be divided into two general categories: air pollutants, which contribute to smog, haze, and health problems; and greenhouse gases (GHGs), such as carbon dioxide and methane, which contribute to climate change. Local emissions are emitted through
the tailpipe, as well as through evaporation from the vehicle’s fuel system during the fueling process. Unlike gasoline cars, EVs produce zero local emissions (Table 1). Nor do they have emissions control technologies that can malfunction or be disabled. PHEVs produce zero tailpipe emissions when they are in all-electric mode but they do produce evaporative emissions. When using ICE, PHEVs do produce tailpipe emissions. However, their direct emissions are typically lower than those of conventional vehicles (Elgowainy et al. 2009).

Table 1. Comparing Greenhouse Gas Emissions

<table>
<thead>
<tr>
<th>Vehicle (Compact Sedans)</th>
<th>Greenhouse Gas Emissions (pounds of CO₂ Equivalent)</th>
<th>Total Fuel Cost (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>99 lb CO₂</td>
<td>$9.96</td>
</tr>
<tr>
<td>Hybrid Electric</td>
<td>51 lb CO₂</td>
<td>$5.12</td>
</tr>
<tr>
<td>Plug-In Hybrid Electric</td>
<td>61 lb CO₂</td>
<td>$5.90</td>
</tr>
<tr>
<td>All-Electric</td>
<td>51 lb CO₂</td>
<td>$3.56</td>
</tr>
</tbody>
</table>

Life cycle emissions include all emissions related to fuel and vehicle production, processing, distribution, use, recycling and disposal. Gasoline produces emissions during extraction, processing, and distribution of fuel. For all types of vehicles, emissions are also produced when extracting raw materials for vehicle production. The life cycle emissions associated with an PEV depends on the source of electricity used to power it. In areas that use relatively low-polluting energy sources for electricity generation, PEVs typically have a life cycle emissions advantage over vehicles that run on gasoline. However, in areas that rely on conventional fossil fuels for electricity generation, PEVs may not provide a lifecycle emissions benefit (Elgowainy et al. 2009).

3.2 Obstacles to Adoption

According to Carlsson and Johansson-Stenman (2010), electric vehicles are still very rare and various ways of supporting them financially are still being debated. Studies have indicated that in order for battery powered electric vehicles to be cost effective and competitive, battery performance must improve and costs must be reduced substantially (Lipman et al. 2000, Deluchi 2001). A fairly common view maintains that although EVs are privately profitable, they are, or will be, socially profitable when the external costs are taken into account. However, Carlsson (2010) finds that while EVs may be profitable for some segments, governments should not subsidize most passenger cars on a large scale. Therefore, the cost of an EV must go down for more consumers to be able to afford them, because it is unsustainable for the government to continue to subsidize the purchase of EVs in perpetuity.

Another obstacle to widespread adoption is described as the attitude-action gap, where people indicate an attitude favorable towards electric vehicles, but do not act on these views. Most of our knowledge of factors that contribute to EV adoption are based on consumer surveys. However, there is a concern that information from these surveys that focus on attitudes may have little relation to action or decision to the purchase of low-emission vehicles. For this reason, research that analyzes actual consumer actions is heavily valued by the scientific community and needs to be pursued in order to lead to an increase in adoption. Relative to an ICE, an EV’s high
purchase price, limited driving range, and long charge time all negatively impact adoption rate (Sierzchula et al 2014).

Another barrier to adoption has to do with investment. Arrow (1962) determined that in a capitalist system, one of the barriers to innovation is underinvestment. This is primarily due to uncertainty but also because often, the benefit to the public outweighs the private interest of the company. In addition, emerging technologies face hurdles because they usually pale in comparison to existing designs in price and performance. For this reason, early adopters must pay a premium and potentially make sacrifices in performance in order to stay abreast of the latest technology. Investments in eco-innovation are disincentivized because benefits from lower pollution are not included in the product’s price. Even though eco-innovations provide societal benefits, businesses cannot include the health benefits in the overall price, leading to low levels of adoption. This is indeed where governments have stepped in. Many, including Massachusetts, subsidize EV and eco-friendly purchases (particularly in the solar industry). Other governments, such as British Columbia in Canada, have introduced a carbon tax to address this shortfall. These combined actions lower the cost and barriers to entry for businesses to invest in sustainable technology, meaning that ultimately costs will be lower to the consumer.

Providing EV technology to potential customers who live in multi-dwellings has also proven to be difficult. It is difficult to ensure reliable access to charging and this is often met by resistance from managers and owners to install EVSE that may go unutilized or replace a conventional vehicle’s parking spot. There is also a degree of uncertainty in whether managers or tenants should bear the costs of installation and maintenance of the EVSE. Beyond this, physical limitations are more common in larger and older buildings. These limitations include inadequate electrical capacity and substantial distance between electrical panel and designated parking (Balmin et al., 2012).

However, EV purchase prices, which are heavily dependent on battery costs, have been identified as the most significant obstacle to widespread EV diffusion (Sierzchula et al, 2014). The IEA found that the purchase price of an EV with a 30 kWh battery would be $10,000 more than a comparable ICE. Battery costs also have an impact on the driving range of an EV. An increase in the size of an EV’s battery increases both its driving range and purchase cost. This indicates that although the consumer may be sensitive to the limited range of the electric vehicle, it must be balanced with the battery costs.

Finally, vehicle charging time influences consumption behavior (Sierzchula et al, 2014). While most conventional vehicles can refuel in roughly 4 minutes, EVs require around 30 min at a fast charging station and up to several hours from a 110 or 220 V outlet. Consumer characteristics also factor highly in determining uptake. For example, levels of education, income, and environmentalism may all be positively correlated to likelihood to purchase an EV or HEV (Hidrue et al., 2011). However, these characteristics often have less importance to consumers than vehicle cost and performance. Contextual factors such as fuel and electricity prices also affect adoption rates in the sense that when fuel prices are higher than electricity prices, the consumer is more likely to consider going electric (Sierzchula et al, 2014).
3.3 Literature Review

This report looked to scholarly articles and studies covering EV use and policy with hopes of garnering a perspective to compliment the study. Zhang, Brown, and Samuelson (2013) provided a thorough analysis of infrastructure costs associated with EV installation. They found that non-home charging stations (public charging stations) are useful in reducing EV operating costs, but are not as socially efficient as home charging stations. They recommend a city’s optimal charging strategy be comprised of 80 percent of charging occur at home, 9 percent at work, and 11 percent at other places.

A number of real world academic studies also provided extensive insight, particularly with regards to the relationship between pricing incentives and EV recharging frequency. Most notably, Bruce et. al (2012) demonstrated EV users’ willingness to capitalize on market incentives: those offered reimbursements were likely to recharge after 23 hours. Scheetal (2013) also demonstrated that financial incentives effectively influenced when users elected to utilize charging stations.

Druitt and Früh (2012) demonstrated that users could be financially incentivized to use stations at off-peak hours, ensuring that energy demand was allocated intelligently across the grid. Saxton (2012) similarly concluded that pricing mechanisms directly impact consumers decisions to utilize resources. Recharging posts where drivers paid standard rates for electricity received only 28% as much use as the average post that was available for free. Given Newton’s goal of effectively stimulating ramp up demand for EV use, these insights on pricing reinforce a fundamental and simple truth: people will use the resource much more if they don’t have to pay for it.

Among the most comprehensive of studies into the effectiveness of pro-EV policy comes from Gass, Schmidt and Schmid’s (2012) analysis of EU-based countries’ efforts to encourage EV adoption. While their analysis of fuel taxes, price supports, and other measures provides excellent insight into the European EV regulatory climate, it falls short of being applicable to US municipal policy. Given the scope of this project, that the City of Newton wishes to understand and eventually aide EV users in better accessing recharging resources, Schmidt and Schmid’s (2012) study only serves to illustrate broad points about the EV market instead of providing specific relatable policy options.

Finally, Robinson et al. (2013) built consumer profiles for EV users in London. These profiles provided substantial insight as to the consumer behavior of British EV users. Unless incentivized otherwise, private users demand peaked at home in the evening on weekdays. By contrast, organizational EVs demand peaked in the morning, when users arrived at work. These users recharged both at work and throughout the day.

3.4 EV Infrastructure in the United States

EVs are in an early stage of adoption in the United States. According to the most recent data from the US Department of Energy and Federal Reserve Bank of St. Louis Economic Research Center (2014), EV sales accounted for 96,702 (or 0.05%) of 186,267,000 total auto &
light truck sales in. Estimates expect this number to increase significantly over the next twenty years (US department of Energy, 2014). The United States government has taken several steps to incentivize the purchase of electric vehicles. Currently, it provides a federal income tax credit of up to $7,500 to those who purchase EVs. The U.S. Department of Energy announced a Notice of Intent in November 2014 to support new, competitively-awarded projects of up to $2 million, to enable aggregated purchases of EVs for commercial fleets and other advanced technology vehicles (The White House, 2014).

States and municipalities have taken additional action to spur investment in EVs. Newton can look to successes across the country to implement a comprehensive EV infrastructure plan. California offers an additional EV rebate through the California Air Resources Board of $2,500 (2012). The state also allows single-occupant EVs to drive in high occupancy lanes in order to make zero emission vehicles more palatable. These initiatives have proven successful: a 2012 study by the California Center for Sustainable Energy and the Air Resources Board found that about 1,000 new plug-in vehicles are sold in the state every month. At that time, Californians owned more than 12,000 plug-in electric vehicles -- roughly 35 percent of the nation's total.

The rate is particularly high in Palo Alto, the home of Tesla Motors and long-time electric vehicle hotspot (Sheyner 2014). The city is attempting to promote the adoption of electric vehicles by changing infrastructure by revising city ordinance to require every new single-family home come pre-wired for electric charging. This means that every home must have the circuitry required to support a level 2 charging station. The rationale for this ordinance is that it is far easier to build a home wired for charging than it is to retrofit a house for electric vehicle charging (Oremus, 2013).

Municipalities have taken commonsense actions to increase EV usage. New York City provides significant incentives for the purchase of medium- and heavy-duty electric vehicles (US Department of Energy, 2012). The City of Raleigh, North Carolina removed and reduced barriers to PEV adoption by addressing building codes, electrical codes, and city ordinances related to uniform standards, signage, parking, and fees for charging. The city also streamlined the permitting and inspections process for EVSE installation (City of Raleigh, 2015). In Houston, the nation’s oil capital, more than half of the vehicles in the city’s light-duty fleet are hybrids, according to the report. This includes 27 Nissan Leaf battery electric vehicles and 15 Toyota Prius plug-in electric hybrids (Rocky Mountain Institute 2012). San Francisco plans to institute a program to rebate permit fees for the first 500 San Francisco residents who install EV chargers (Toraya 2010).

Additionally, it should be noted that municipalities across the country have tackled EVs with more creative solutions. Chicago has recently transitioned their garbage truck fleet to EV (Motiv, 2014). Portland and Atlanta have capitalized on their warmer climate to install solar-paneled electric charging vehicles (Ashton, 2010). Thus, Newton would join an elite group of trailblazing cities if it were to invest heavily in EV-based transportation.

Closer to home, Massachusetts encourages municipal establishment of public charging stations. The Massachusetts Electric Vehicle Incentive Program (MassEVIP) provides grants for 50% of the total costs, or up to $25,000 so businesses can install level 2 EVSE at the workplace. Massachusetts also incentivizes local investment through the form of Alternative Fuel Vehicle
and Infrastructure Grants. These Grants provide extensive funding for public and private fleets to purchase alternative fuel vehicles and infrastructure, as well as idle reduction technology. Finally, the Massachusetts Department of Energy Resources adds to the federal income tax credit by offering rebates of up to $2,500 to customers purchasing or leasing a PEV or zero-emission motorcycle through the Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) Program.

Cities and towns in the Boston area have jumped on the EV bandwagon. The City of Boston has been granted 22 free dual electric vehicle charging stations by the Green Communities Division of the State’s Department of Energy Resources (DOER) (City of Boston Press Office, 2011). The City of Cambridge also received a grant from the DOER and have installed 10 publically accessible Level 2 stations at various locations throughout the city (City of Cambridge, 2011). All city-owned charging stations cost $1.25 per hour for the use of the station. This price has been set in order to cover the charge of electricity, cover the administrative fees associated with offering EV charging station services, and keeping the cost per mile for electricity lower than the cost per mile for gas (Cooke). Further, the Town of Brookline has partnered with the ChargePoint network to install two public chargers at Brookline Town Hall and near Coolidge Corner (US Department of Energy, 2012).

Since EVs are still relatively new, there is a great amount of work ahead in order for EVs to become feasible. Newton can be on the cutting edge and be regarded as a regional leader if it adapts effective policies and installs comprehensive infrastructure to encourage and support electric vehicles. This study will analyze the above literature by putting it in conversation with survey results and attitudes of Newton residents in order to assert recommendations and a comprehensive plan the City of Newton can use to promote EV adoption.

4. Methods

Three main methods were used in order to study the state of Electric Vehicle infrastructure in Newton, understand resident attitudes toward EVs, and provide recommendations for the City to adopt in order to promote EV adoption. An online survey was distributed to Newton residents to measure attitudes. Spatial data of land use designations in Newton was analyzed to identify high concentrations of multi-unit dwellings. Best practices were collected and analyzed to see how city policies could address user concerns.

4.1 Surveys

An online survey was created on Google Forms in order to better understand the needs of Newton residents who own EVs, what barriers exist that prevent Newton residents from purchasing EVs, and what might incentivize them to purchase an EV.

With the help of Newton Ward 2 Alderman Emily Norton, the survey was distributed to various environmental and civic groups within the Newton community. The researchers reached out to members of state government who represented Newton communities asking to publicize the survey, but did not receive replies.
A single survey link was distributed, in which the respondent had to answer, “Do you or anyone in your household own or lease an Electric Vehicle?” Those who answered “Yes” were redirected to a survey that aimed at understanding the needs of EV owners in Newton. Those who answered “No” were redirected to a survey asking questions to understand why they do not own an EV, what they think of EVs, and feelings toward different incentives that promote EVs. For a comprehensive list of the survey instruments, refer to the Appendix A. The survey accepted responses for three weeks.

Qualitative responses from non-EV owners were coded to identify what prevents them from purchasing EVs. Responses were sorted under the following themes:
- Need more range
- Need more chargers
- They don’t make that big of a difference
- Unsure/need more information
- Prefer hybrid
- Too expensive

Qualitative responses from EV owners were coded to identify how Newton could make owning an EV easier for residents. Responses were sorted under the following themes:
- Create dedicate parking spots for EVs
- Subsidize the cost of charging
- Increase the number of public chargers
- Make chargers more efficient
- N/A, no need

Further, quantitative data was summarized in Excel from the survey to measure the influence various incentives would have on non-owners to purchase an EV, awareness among non-owners of EV rebates, and whether EV owners would use public chargers. These sentiments were ranked on a scale of 1 to 5, with 1 being “No influence” and 5 being “Very influential.” These scores were averaged for each category to calculate average influence.

4.2 Spatial Data Analysis

Spatial data analysis was conducted to create a GIS “heat map” of Newton, which revealed the areas with the highest density of multi-unit residences. The Newton Department of Planning provided parcel data for the City. The shapefile listed parcel area, location, and land use. Land use codes are consistent across the state and used by the City for planning the purpose of each land parcel (such as residential, commercial, industrial, etc.). For the purpose of this research, the following land use codes were relevant:
- 101: Single Family
- 102: Condominium
- 111: Apartment (4-8 Units)
- 112: Apartment (9-99 Units)
- 113: Apartment (100+ Units)
Parcels with land use codes 102, 111, 112, & 113 were selected for analysis.

Next, census block groups were downloaded from the US Census Bureau Website. A Census Block Group is a geographical unit used by the United States Census Bureau, which is between the Census Tract and the Census Block. It is the smallest geographical unit for which the bureau publishes sample data. A density calculation was conducted that divided the number of multi-unit parcels (land use codes = 102, 111, 112, & 113) inside each census block group by the area of the census block group.

The resulting densities were ranked amongst each other to create a scale. Parcels were colored the same as the census block group in which they were located in order to identify their relationship to each other. Three distinct areas/villages were identified as having a high concentration of multi-unit dwellings.

Locations of Electric Vehicle charging stations throughout the United States are tracked by the US Department of Energy’s Alternative Fuels Data Center. The most up to date data were downloaded from the website in February 2015 (AFDC, 2015). These data were added to the spatial analysis to indicate chargers already exist in Newton.

4.3 Best Practices Research

Alderman Emily Norton was consulted to gain a baseline understanding of EVs in Newton and to aid in navigating Newton’s unique governmental intricacies. As an environmental consultant by trade, she provided an anecdotal history of EVs and public chargers in Newton, and communicated with other departments of the City’s government to collect data for the project, such as relevant zoning ordinances, budget data, and land use data.

Sustainability directors and planners in the cities of Cambridge, MA and Palo Alto, CA and the Town of Brookline were contacted but did not respond to requests for an interview. Planners in the City of Boston were contacted but did not respond in time to schedule an interview. Clay Nissan of Newton was contacted but did not schedule an interview.

Outside secondary sources were consulted in order to learn what other cities and towns have done to promote EV adoption. Municipal and state press releases were used in addition to local news media. City policies, initiatives, and ordinances were collected and compared to qualitative survey responses. Research findings that solved the concerns and problems voiced in the survey were included in the final recommendations.

5. Results

5.1 Survey Results

The survey was a very crucial component of the study since it provided insight into the habits and beliefs Newton residents have about electric vehicles. 95 responses were collected from 11 of the 13 villages. 77 of 95 respondents (80%) did not own EVs. Overall, respondents
tended to be between the ages of 35 and 64, while no EV owner was younger than 35 (Figures 1 and 2). The surveys collected quantitative and qualitative data that creates a better understanding of EV infrastructure in Newton.

![Age of Respondents (All)](image1.png) ![Age of EV Owner Respondents](image2.png)

**Figure 1. Age distribution of all 96 survey respondents**  
**Figure 2. Age distribution of 19 EV owner respondents**

**EV Owners**

Among owners, 16% currently use public chargers. Of that number, 66% have only level 2 charging at home. However, 89% of those EV owners said they would use a public charger. 68% of EV owners charge their vehicles while they sleep, a number which correlates with the percent of users who have level 2 EVSE at home. 21% of EV owners charged their EV at work, indicating that either EV owners do not drive their EV to work or charging stations are not available at their workplace. All but two respondents use their EV every day. Table 2 shows a distribution of the types/models of EV survey participants used:

<table>
<thead>
<tr>
<th>Types of Cars</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volt</td>
<td>2</td>
</tr>
<tr>
<td>Leaf</td>
<td>6</td>
</tr>
<tr>
<td>Prius Plug In</td>
<td>4</td>
</tr>
<tr>
<td>Tesla</td>
<td>3</td>
</tr>
<tr>
<td>SmartCar</td>
<td>2</td>
</tr>
<tr>
<td>BMW i3</td>
<td>1</td>
</tr>
<tr>
<td>Zero ZF9 motorcycle</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>19</td>
</tr>
</tbody>
</table>

Almost all EV owners have a conventional vehicle; the one who doesn’t owns a PHEV. When asked about how they split their time, they indicated that EVs are driven 66% of the time. This means that either range anxiety persists as a problem, or that a charging network is absent to make 100% EV usage possible.
Coding refers to the practice in sociology and the social sciences to categorize qualitative data by theme in order to extrapolate quantitative conclusions from it. Coding was used to analyze qualitative responses from the survey. Among EV owners, certain themes emerged throughout open-ended responses to the question, “How could Newton make charging easier?” These themes were:

Table 3. Qualitative data coding results for EV owners (N=19).

<table>
<thead>
<tr>
<th>Theme</th>
<th>Percent of EV owners mentioning theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create dedicated parking and charging spots for EVs</td>
<td>21%</td>
</tr>
<tr>
<td>Subsidize costs</td>
<td>11%</td>
</tr>
<tr>
<td>Increase the number of public chargers</td>
<td>53%</td>
</tr>
<tr>
<td>Make chargers more efficient</td>
<td>11%</td>
</tr>
<tr>
<td>N/A, no need</td>
<td>16%</td>
</tr>
</tbody>
</table>

Over half of EV owners responded mentioned increasing the number of public chargers would make charger their EVs easier (Table 3).

Non-EV-Owners

There were 76 respondents who owned conventional cars. Among these non-EV owners, 92% indicated that public charging stations would be an asset to the community. 34% of respondents indicated that they were likely to purchase an EV in the near future.

Non-EV owners were asked if various incentives would influence their decision to buy an EV (Figure 3). Only 34% of non-owners responded saying tax incentives had some influence or a high influence on their decision to purchase an EV. This was significantly lower than the next lowest incentive, potential savings (at the p=.01 significance level). Availability of public chargers ranked as the most influential incentive. 58% of non-EV owners were aware of tax rebates for purchasing EVs. Of those aware of the tax rebates, 58% indicated that such rebates has some or a high influence on their decision to purchase an EV. This is higher than the percent of non-EV owners group as a whole, but more broadly illustrates that people are unaware of financial incentives.

Figure 3. Percent of non-EV owners who responded saying the incentive had “Some influence” or “High influence” on their decision to purchase an EV.
Coding indicated several themes around why non-EV owners had not yet purchased an EV (Table 4). Responses to the question, “What are your feelings about electric vehicles compared to a regular car?” produced the following themes:

Table 4. Qualitative data coding results for EV owners.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Percent of non-EV owners mentioning theme (out of 49)</th>
<th>Percent of non-EV owners mentioning theme (out of 76)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need more range</td>
<td>24%</td>
<td>15%</td>
</tr>
<tr>
<td>Need more chargers</td>
<td>22%</td>
<td>14%</td>
</tr>
<tr>
<td>They don’t make that big of a difference</td>
<td>14%</td>
<td>9%</td>
</tr>
<tr>
<td>Need further development</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Unsure/need more information</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td>Prefer hybrid</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td>Too expensive</td>
<td>12%</td>
<td>8%</td>
</tr>
</tbody>
</table>

It remains a popular idea to install public chargers.

5.2 Spatial Analysis Results

Multiunit dwellings was an obstacle to adoption we found in our literature review (Balmin et al. 2012). Spatial analysis conducted in ArcGIS produced Figure 5. Brown areas indicate higher concentrations of multi-unit dwellings and are recommended locations to install public EVSE. Blue boxes indicate the location of existing EVSE. These locations are recommended because barriers to EV adoption exist to residents in multiunit dwellings, as described in Section 3.2.
This analysis determined high densities in Upper Falls (Figure 5), West Newton, (Figure 6) and Newtonville and Newton Corner (Figure 7).

Figure 5. Density of multi-unit dwellings in Upper Falls.

Figure 6. Density of multi-unit dwellings in West Newton.

Figure 7. Density of multi-unit dwellings in Newtonville and Newton Corner.
6. Discussion and Recommendations

Newton has a history of being at the forefront of environmental progress in the Commonwealth. It was the one of the first communities to join the Green Communities Program, which “strives to help all find clean energy solutions that reduce long-term energy costs and strengthen local economies” (Newton, 2015). The City installed 8,406 energy efficient LED streetlight fixtures throughout the city to reduce municipal energy consumption and costs (Wicked Local Newton, 2014). Newton has dedicated itself to significant energy reductions with Energy Smart Newton, “a new, innovative initiative aimed at reducing energy usage city-wide by 20% by the year 2020” (Newton, 2015).

The next logical step is for Newton to lead the Commonwealth’s adoption of Electric Vehicle technology. EVSE, EV-specific policies, and publicity efforts must take place prior to widespread adoption of electric vehicles. While the survey focused on the role of implementing public chargers in raising awareness, secondary research revealed Newton could adopt municipal policy options that proved successful in other communities. Specifically, through subsidizing public chargers, streamlining the permitting process for Level 2 EVSE, creating smart charge infrastructure to anticipate future grid demand, and switching the Newton municipal fleet to EV, the City of Newton can effectively encourage EV adoption and provide ample infrastructure to support future EV usage. While raising public awareness of EV feasibility would most effectively achieve this goal, every aforementioned policy avenue would, to an extent, encourage adoption and is discussed in further detail below.

6.1 Newton Residents: A Profile

Newton is amongst the wealthiest and most environmentally conscious cities in the Commonwealth of Massachusetts. Its population is 87,971. A 2012 estimate placed the median Newton income at $119,148, up from the $66,866 state average (The United States Census, 2013). In fact, research from the Boston Business Journal found that Waban, Newton Center, and Chestnut Hill ranked the 10th, 16th, and 23rd wealthiest zip codes in the state in 2012 (2012). Residents from these zip codes comprised 24% of the survey participants. 76.2 percent of people 25 years and older in Newton have at least a bachelor’s degree (The United States Census, 2013). These factors align to suggest that Newton residents fit the profile for early adopters, since they are highly educated and relatively wealthy (Sierzchula 2014).

Survey respondents represented a further niche group within the Newton community. The Newton Democratic City Committee, Sierra Club, Green Decade, Waban Area Council, and Newton Aldermen advertised the survey to their members and constituents. These groups were chosen to distribute the survey because they were civically minded organizations capable of mobilizing members to participate. Due to the nature of groups that agreed to advertise, the
survey was more likely to reach environmentally conscious and/or civically active Newton residents.

As such, this survey is in no way a comprehensive or representational depiction of the average Newton resident’s opinion. Nonetheless, it provides insight into the perspective of two crucial Newton constituencies. First, the nineteen EV owners to respond highlight the charging behavior and preferences of current EV users. Second, the non-users effectively represent a portion of the Newton community likely to purchase an EV in the coming years. Given Newton’s interest in encouraging EV use and incentivizing EV purchase, both of these demographics provide helpful insight, even though their perspective may not be representational of the greater population.

6.2 Public Chargers

Installing public EVSE would help Newton encourage EV use primarily because it would increase visibility for EVs more generally, not because it would lead to widespread public charging use, as initially hypothesized. 92% of non-EV users indicated that public chargers were an asset to the community. 89% of EV users indicated they would use a free public charger and 57% believed that public chargers would make charging easier. Surprisingly, only 16% of EV users currently use public chargers, but this number may be low due to lack of availability in the community. Charger use would likely increase if public chargers were made readily available, but the most important impact of increased chargers would be to publicize the utility of EVs.

Increasing public EVSE is often regarded as the obvious method to increase EV adoption because it eases the perception of range anxiety. Range anxiety refer to fears of would-be EV users that their EV would run out of charge without existing infrastructure nearby. Fortunately, concerns about range capacity could easily be quelled if Newton made itself an EV-friendly city like Palo Alto, Brookline, or Cambridge. Current EV owners indicated that they use their EVs to cover 66% of their driving needs. This would indicate that range concerns currently limit EV users from using their EVs in an extent.

Quantitative data from Non-EV survey respondents substantiates the belief that public chargers would signal the feasibility of EV ownership: 76 percent of Non-EV users ranked the availability of a public charger and as the top incentive that would convince them to buy an electric vehicle. A non-user summarized range concerns effectively, admitting, “it is key to have fast charging stations… I don’t like the idea of running out of electricity with no hope of getting more in some remote place… if electric vehicles were more reliable by having more charging places, I might consider one.” Coding revealed that 66% of non-users pointed to range concerns (without prompting) as a primary concern behind EV adoption and that 6 respondents specifically called out increased public charging stations as a solution to this concern. Thus, increasing public charging stations would quell this concern.

Coding of survey results confirms existing research about EV usage and charging: charging primarily takes place at home (Neenan 2010, Zhang et al. 2013, Morrow et al. 2008). 68 percent of survey respondents who owned EVs charge overnight in their homes. However, strategic placement of EVs at crucial points throughout Newton would highlight the feasibility of
EV ownership, which many non-users would take as an indication that they should purchase an EV. This is supported by the findings in Sierzchula et al. (2014), who found “a positive and significant relationship between charging stations (adjusted for population) and EV adoption rates” (Sierzchula et al. 2014: 189). Thankfully, the cost for Level 2 charging stations is comparably much lower than many other financial options, like offering tax rebates and subsidizing EV ownership. Appendix B communicates the affordability of public charging stations.

**Recommended Locations**

Given their importance not only in providing a charging resource but also in raising awareness for and encouraging further EV adoption, public chargers should be installed in locations that would maximize their exposure. Be it a city center, mall, or any high-traffic location, a public chargers’ utility is maximized only when the highest number of people know about it and can access it. Newton is a relatively spread out community of 18.2 square miles, so it is difficult for one or two chargers to be accessible to all residents. City Hall already has a public charger, but its location on Commonwealth and Chestnut does not maximize exposure, nor is its charger currently publicized with street signage.

There is currently no set limit Newton is willing to spend on installing EVSE. Therefore, the following recommended locations are a shortlist of the top locations to install a public charger as a result of qualitative and spatial analysis. Ranked from highest utility to lowest, Newton should prioritize charging in the following locations: Newton Centre, the Riverside T stop, the Chestnut Hill Mall, and somewhere in the Newtonville, West Newton, and Newton Corner. For convenience, these locations have been called out on our original GIS map with red stars, show below. Additionally, Newton should raise awareness of existing EV infrastructure by installing signs calling out existing but hidden public chargers at City Hall and off Route 9 on Elliot St.

![Figure 8. Recommended locations for public charging stations based on density of multi-unit dwellings and high public exposure.](image-url)
Newton Centre

Newton Centre is the largest downtown area among all the villages of Newton. Numerous businesses preside in Newton Centre, with a convenient shared parking lot located in the center of Newton Centre, on the corner of Beacon Street and Centre Street. The surrounding Newton Centre neighborhood contains among the highest density of multi-family residences, per our GIS map. Additionally, multiple survey respondents called out Newton Centre as a promising location, with one noting that “For Newton, installing a station or two in major city-owned lots near village centers (e.g. the main lot at Newton Center)” would be preferable. Newton Centre serves as a “shopping destination for the western suburbs of Boston” (City of Newton, 2013). A public charging station in the Newton Centre parking lot would encourage visitors and residents alike to shop in the area because they know they have a guaranteed charge. Newton Centre should be the first location in which Newton installs a public charger because of its centrality, high traffic, and feedback from survey respondents. A Newton Centre public charging station would effectively signal to EV users and non-users alike that the Newton has the requisite infrastructure to make EV ownership feasible.

Riverside MBTA Station

The Riverside MBTA Station parking lot provides another great opportunity to encourage EV use, provide charging infrastructure, and help create a comprehensive sustainable transportation network. The Riverside lot holds 925 spaces that the MBTA estimate to be filled 93% at any given time during the week (The MBTA, 2015). Installing EV-only spots with chargers would provide public charging infrastructure to many individuals whose workplace does not have charging infrastructure. Commuters could park their car in the morning, and it would be fully charged when they return from work. More importantly, a Riverside Station EVSE would maximize exposure and increase awareness in ways that other locations could not. On a typical weekday, 2,241 customers enter Riverside Station (The MBTA, 2015). With clear signage, these customers would be able to witness the dedication and advantages of owning an EV in Newton. Because of its importance to Newton commuters and its frequent use, the Riverside lot presents Newton with an ideal location in which to place a public charger.

Because of the nature of a commuter-dominant train station, there is low turnover in parking throughout the day. Therefore, it is recommended that multiple charging station parking spots be installed at Riverside Station. In order to attract EV users to park and ride, they need to be able to rely on having a spot to park their EV. One spot would benefit only one person, and would prevent many others from driving their EV to Riverside to take the T. Newton should anticipate this problem and install multiple spaces. Due to the cost of this endeavor, it is recommended that the City investigate potential partnerships with the MBTA, MassDOT, and interested private entities to bear the burden of multiple parking spots with EVSE. Although an additional cost, there could be a valet service to rotate EVs amongst the chargers to ensure all are fully charged by the end of the day.
The Mall at Chestnut Hill

Located in the wealthy Chestnut Hill village of Newton, the Mall at Chestnut Hill is a commerce center with ample parking spaces located in a high-density zone off route 9 near prototypical early adopters. For these reasons, Chestnut Hill would make for an excellent charging location, after Newton Centre and Riverside. There is currently only one charging station at the mall operated by NRG eVgo, one of several chargeshare companies (NRG eVgo, 2015). The mall’s only drawback is that many of its users come from surrounding areas, unlike Newton Centre, which draws from a local crowd. Dedicating parking spaces in the mall would raise public awareness for EVs. They would also likely be used frequently, although the obvious drawback exists in that Newton EV owners would have to share the space with other mall users. Nonetheless, one Newton resident echoed their support for a charging station, asking for a charging station “near large grocery store/shopping centers (e.g. the Shaws and Wegmans on Route 9).” As a third option, then, the Mall at Chestnut Hill could effectively encourage EV use.

Multi-Unit Dwellings: Newtonville, West Newton, and Newton Corner

Crucial to an understanding of the potential benefit of public chargers is an understanding of their importance in bringing EV technology to residents of multi-unit dwellings, such as apartment complexes and condominiums. At-home charging is easy for a majority of Newton households, since 69.6 percent of housing in the city is owner-occupied (The United States Census, 2013). However, finding a 120V outlet is not as easy for those living and renting in multi-unit dwellings. They may rely on street parking, or not have the authority to install EVSE in their parking garage. A smaller percent of Newton’s population lives in multiunit dwellings compared to single-family homes, but considering them is no less important in planning a comprehensive EV implementation plan. This barrier to EV access is less about cost, and more about ensuring reliable access to an EV charging station. But even if cost is an issue, as prices come down, this group could eventually be in the market for an EV. Thus to mainstream EV use in Newton, it is important to think ahead and plan for this group.

Spatial analysis found that Newtonville, West Newton, and Newton Corner contain the highest density of multi-unit homes (Figure 8). Locating a public charging station in these neighborhoods would go a long way to making EV ownership feasible for these residents. EV ownership in multi-unit homes is not feasible without close public charging available. As such, these users would depend on public charging stations for their public charging needs. Newton should consult community members and Aldermen from these villages in order to determine where EV-only street parking would be most efficient and practical. Additionally, the City should engage apartment managers and owners to determine if cost sharing is possible to help with the cost and installation of EVSE. In order to even make EV ownership possible for residents of Newtonville, West Newton, and Newton Corner, making EV charging stations is essential. Newton must plan for the future because although many do not now, many residents will surely own EVs in the near and far future.

Guidelines to Installing Public Chargers

It is important for any public charging stations the City installs be clearly marked. To date, Newton has failed to publicize their existing EV infrastructure to its residents. For example, a sign for the City Hall public charger has been paid for and made available by the Commonwealth, but Newton has yet to pick it up and install it. It would also be cost-effective to create and install signs publicizing the location of the Public Works EVSE station off Route 9 on
Elliot St. This station has a free public charger located in an incredibly convenient location off Route 9, but few residents are aware of its existence because the station is hidden from view and not located somewhere people typically go. Installing signs in key locations would be very effective in increasing awareness for EVs and promoting the steps Newton has taken to help EV infrastructure.

6.3 Zoning and Policies

Newton can also alter current zoning laws and create new policies in order to incentivize EV adoption. Studying best practices from other cities revealed that streamlining the permit process for EVs is an effective way to increase EV ownership (Toraya, 2010). Currently, users must obtain a permit prior to installing a Level 2 EVSE. This requires hiring an electrician, waiting for a permit to be processed, and possibly having to pay to upgrade the home’s electrical capacity. These many steps often seem insurmountable to a first time buyer, and may be enough to prevent the purchase of an EV. A host of different cities such as Los Angeles and Raleigh reduced the red tape involved in purchasing an EV to combat this problem. Newton can do the same to reduce the waiting period between purchasing and EV and recharging it.

Green Building Code

Many of Newton’s old and historic buildings may not be properly wired or capable of handling the extra load of an EV. Incorporating a green building code, such as that in Los Angeles, ensures that new construction be capable of providing the electricity necessary for Level 2 EVSE. In Los Angeles, all new construction is required “to install a listed raceway to accommodate a dedicated 208/240 volt branch circuit” (Rocky Mountain Institute, 2012). This is the minimum infrastructure required for a Level 2 EVSE.

Streamlining Permits

In addition to preparing new homes for EVSE, it is important to retrofit older homes and buildings. In Massachusetts, EVSE level 2 models must be installed by a Massachusetts licensed electrician and in compliance with NFPA 70, National Electric code article 625 and applicable Massachusetts electrical code adopted (Commonwealth of Massachusetts, 2011). This is a lengthy and complicated process that may prevent someone from purchasing an EV. Newton can streamline this process by engaging with all necessary parties (utilities, car dealers electrical contractors, and the customer) to outline and clarify the required steps to install necessary infrastructure. There are other actions Newton can take to streamline the permitting process:

- Prioritize permits and inspections for EVSE. This can be done in conjunction with local auto dealers that sell EVs
- Allow online filings for permits
- Properly train and educate staff to be able to handle EVSE inspections and installation
- Address issues related to uniform standards, signage, parking, and fees for charging.
- Subsidize electrical inspections
Zoning Ordinances

There are currently no mention of Electric Vehicles in Newton’s zoning code, whereas conventional motor vehicles are mentioned 80 times (City of Newton Ordinances, 2015). It is important that Newton pass zoning code language to clarify the classification of EVs. Specifically, Newton can outline a vision for public charging infrastructure for amending the zoning code. Example ordinances may be:

- Ordinance to include electric vehicle charging stations (i.e., parking equipped with level-1 and level-2 EVSE) as a permitted accessory use and structure in all districts
- Ordinance to require EVSE and EV-only parking spots in parking lots of a certain size
  - Further, for new non-residential and multi-family residential buildings that install more than 100 new parking spaces, require the installation of Level 2 EVSE to 1% of the parking spaces
- Ordinance to allow a charging station parking space to be included in the calculation for minimum parking spaces that are required pursuant to other City and State regulations
- Design criteria requiring the posting of EV-related signs for public chargers
- Limiting the time one may charge in certain lots, similar to time limits in major lots like Newton Center
- Prohibit the use of a charging station space by a non-electric vehicle

These ordinances would help clarify Newton’s vision and ensure that the utility of EV infrastructure is maximized. They also would eliminate confusion and ensure developments are capable of handling widespread EV adoption in the future. These actions are important to initiate the installation of EVSE Level 2 at home, which makes EVs more attractive and more feasible for users who drive far and frequently.

6.4 Financial Incentives

When non-EV owners ranked which incentives would cause them to buy EVs, only 34 percent said tax rebates would influence their decision to purchase an EV. This claim at first appears counterintuitive; research indicates that cost is the most substantial barrier preventing EV adoption. Newton residents, and the survey participants, however, represent a wealthy demographic that evidently is not as influenced by financial considerations as it is by public charger availability and range anxiety. Therefore, it is recommended that Newton save money and not offer financial incentives for owners to buy EVs, as is done in some municipalities like Glendale, CA.

Eventually, EV prices are projected to become competitive with conventional cars even without the subsidy. At this point, at-home level 2 EVSE purchase and installation will become the expensive component of buying an EV, and the up-front cost of EVSE might deter someone from buying an EV (it can cost as much as $5,000). When this point comes, it is recommended that Newton study whether subsidies for Level 2 EVSE at home is beneficial. Such analysis is not possible at this time since both the future efficiency of Level 1 and the future price of EVSE Level 2 is unknown.

Newton should also encourage residents to save money by participating in smart meter pilot programs if given the opportunity. Eversource, Newton’s main energy provider, currently
provides only Automated Meter Reading (AMR) devices, which use transmitters that broadcast meter readings at regular intervals, as opposed to smart meters, which are capable of two-way communication that records energy usage in much more detail (Eversource, 2015). Smart meters are a financial incentive since they can allow customers to remotely turn off chargers if peak electricity rates are too high. Although financial incentives may not be important in initial adoption of EVs in Newton, the City should take cost-minimizing efforts in anticipation of the future costs and electricity demands.

6.5 Awareness

Overall, the most effective way for Newton to promote EV usage is to increase awareness of the benefits of the technology. As a whole, people are uneducated on available rebates, requirements for at-home charging, the reduction of total GHGs, and the potential long-term savings resulting from owning an EV. Therefore, Newton needs to find ways to effectively communicate the benefits of owning an EV to its constituents.

One of the easiest ways has been mentioned: install visible EVSE with clear signage and marking. When people see and recognize the available EV infrastructure, it is more likely to be on their mind. Consequently, they are more likely to be thinking about EVs the next time they consider purchasing a new car. It also shows visitors that Newton is a city that is a dedicated leader to green infrastructure.

Another important step toward awareness is for the Mayor to form a stakeholder group comprised of regulatory, commercial, and community interests. The city of Atlanta found that this was an effective way for cities to show leadership and create a vision that champions the interests of all three groups (Toraya, 2010). They should work together to identify EV objectives and develop a plan to identify these goals. This will indicate to the public that the City is serious about electric vehicle adoption, will guide city spending on initiatives actually desired by the community, and will ensure all interests in the City benefit from Electric Vehicle infrastructure.

Survey results showed that some people were skeptical about the environmental impact of EVs, questioning the carbon emissions via electricity generation. These responses are available in the code map in Appendix C. These concerns were initially shared by the researchers, too; are EVs really worth it if they are charged by dirty energy? The fact is that Massachusetts’ energy supply is very clean. According to the most recent 2013 data from the EIA, only 6 percent of Massachusetts total electric power from coal or petroleum, a number that continues to decrease. Natural gas is the dominant fuel for Massachusetts’ electricity, accounting for 68 percent of the state’s generating capacity. EVs release half as many carbon emissions compared to the tailpipe emissions of a vehicle. Also, EVs release zero local emissions. It is clear that the public does not know exactly how environmentally friendly EVs are to the environment. Increasing public awareness of this fact is crucial to encourage EV adoption in Newton.

City officials can do this through traditional PSA campaigns and word of mouth, but it can also be done through visibility. Newton can be ahead of the game by installing solar powered
public charging stations as Atlanta, Georgia and Portland, Oregon have already done (two of these researchers happened to stumble upon Atlanta’s while at a track meet!). (Florian, 2010). These are grand displays hammer home the point that Newton has taken strides to be energy efficient and environmentally friendly, and also reassure people that the energy charging EVs is sustainable. Knowledge is power. EVs are at an early stage of adoption, so arming the public with facts will speed adoption rates of EVs and help Newton to become a national model for EVs.

6.6 Newton EV Fleet Investments

Through investing in EVs for the Newton municipal fleet, Newton can lower its operating costs while demonstrating a commitment to the environment and leading by example. In 2012, the Newton Department of Public Works spent a total of $2,033,130 on vehicle maintenance. EVs may be 40 to 70 percent cheaper to operate, depending on gas prices (PlaNYC, 2010: 4). This means EVs would save the city large amounts of money in the long run by reducing maintenance and fuel costs.

In considering EV municipal vehicles, it is important to be sure that municipal workers will actually use EVs if purchased. EVs may be useful for Inspectional Services workers making site visits, but may not have enough range for the meetings away from the city that Engineering employees must attend, according to former Newton Sustainability Director, Robert Garrity. This is an important but as of yet unanswered question in implementing this particular proposal. Exact feasibility studies for EV Fleet procurement for the City of Newton were beyond the scope of this study. However, it is recommended that Newton investigate purchasing EVs for the municipal fleet when it comes time to procure new city vehicles.

7. Conclusion: Future Research and Next Steps

This report draws on and compliments existing research covering EV adoption ramp up. There is a need for continued research, especially with regards to the attitude-action gap discussed by Sierzchula, et al (2012). The attitude-action gap was particularly relevant with regards to the non-EV users in our survey, as 92% of non-users believed public charging stations were a public asset and many articulated favorable views towards EVs in their qualitative responses. Despite their favorable views of EVs, none had committed their preference for EVs into action. For example, one non-user from Chestnut Hill lauded EVs for being “excellent clean energy, emissions far preferable to combustion engines.” This participant was far from alone in his pro-EV sentiment. Our research failed to provide a substantial, quantitative analysis to highlight the cause for this gap in stated consumer attitude and behavior. Survey participants justified their non-ownerships with a number of reasons, but Sierzchula, et al (2012) correctly identified the need to better understand this gap between behavior and action.

Additionally, potential for future research exists with regards to Boston College’s potential role in encouraging EV infrastructure. Originally, we intended to address BC’s potential to encourage EV adoption by gaging employee attitudes towards EVs and researching potential locations on campus to place an EV charger. Unfortunately, most of BC’s parking infrastructure falls in the city of Boston, not in Newton. Given that this project aimed to research
and provide recommendations for the city of Newton, we did not include Boston College in our report. Nonetheless, future studies could tackle the possible role of BC and universities in providing private partnerships to municipal EV initiatives.

Despite this gap in existing research, a number of clear steps exist for Newton if it chooses to become a municipal leader in EV infrastructure. We recommend that the Newton City Council use this report, the survey results, and the policy recommendations outlined in this section to springboard into a dialogue about improving EV infrastructure. Some potential solutions are logical next steps; posting signs outside existing charging stations is simultaneously low-cost, uncontroversial, and reasonably effective. Others, like determining where and how many public charging stations to install, will likely involve a longer conversation and require larger amounts of city resources. Nonetheless, Newton’s potential to install EV infrastructure, encourage EV use, and thereby anticipate future demand for EVs has been made clear in this report. Ninety-six Newton residents have spoken; public charging stations are not only a public good, they should be a priority for the city moving forward.

7.1 Contact Information

Over the past four months, we have grown very passionate and educated about EV usage and municipal policy. As such, we hope to continue to participate as Newton paves the way forward for electric vehicle adoption in Massachusetts. We would love to have the opportunity to speak with officials from the City of Newton as well as any City’ representatives about this issue. For questions and further discussion, do not hesitate to contact the researchers.

- Collin Fedor: (630) 666-8511 / collinfedor@gmail.com
- James Newhouse: (626) 890-8554 / newhousj@bc.edu
8. References


MBTA. n.d. “Riverside Station.” Massachusetts Bay Transportation Authority.


9. Appendix

Appendix A: Research instrument
The following is a copy of the online survey. There are eight pages total. Page 1 is a prompt that led to either page 2 (if selected “Yes”) or page 7 (if selected “No”)

Page 1:

Newton Electric Vehicle Survey

Do you or anyone in your household own or lease an Electric Vehicle? *

- Yes — (Leads to next page titled “EV Owners Survey”)
- No — (Leads to page titled “Non-EV Owners Survey”)

Continue »
Newton Electric Vehicle Survey

EV Owners Survey

How many electric vehicles does your household own/lease?
☐ 0
☐ 1
☐ 2
☐ 3+

What model, make, and year is/are your EV(s)?

How many non-electric vehicles does your household own or lease?
☐ 0
☐ 1
☐ 2
☐ 3+

How often do you drive your EV?
☐ 0 days per week
☐ 1-2 days per week
☐ 3-4 days per week
☐ 5-7 days per week

Not taking into account the days you do not drive, how many miles on average do you drive in a day?
☐ < 5 miles
Page 3:

- 5-9 miles
- 10-14 miles
- 15-19 miles
- 20-24 miles
- 25-30 miles
- > 30 miles

How frequently do you drive your EV compared to non-EV(s) (e.g. 70% Only EV and 30% Non-EV)?

1 2 3 4 5 6 7 8 9 10

Only EV  Only Non-EV

« Back   Continue »  40% completed

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Newton Electric Vehicle Survey

What type of charger do you have at home?
- I don't charge my EV at home
- Level 1 (regular wall outlet)
- Level 2
- Tesla Supercharger

About how many times per week do you charge at home?
- 0
- 1
- 2
- 3
- 4
- 5
- 6+

About how many times per week do you charge your car at work?
- 0
- 1
- 2
- 3
- 4
- 5
- 6+

About how many times per week do you charge your car at a public charging station?
- 0
Page 5:

Do you find current public charging stations easily accessible? Explain.

What do you usually do while your vehicle is charging?
- Sleep
- Work
- Drink coffee
- Read
- Run errands
- Go shopping
- Other: [ textbox ]

« Back  Continue »

60% completed
Newton Electric Vehicle Survey

Non-EV Owners Survey

Do you currently own a vehicle?
☐ Yes
☐ No

Are you aware that there are tax rebates available for residents who drive electric vehicles?
☐ Yes
☐ No

How much would potential tax rebates influence you to drive an electric vehicle?

1 2 3 4 5

No Influence ☐ ☐ ☐ ☐ Very Influential

How much would reducing your environmental footprint influence you to drive an electric vehicle?

1 2 3 4 5

No Influence ☐ ☐ ☐ ☐ Very Influential

How much would potential savings influence you to drive an electric vehicle?

1 2 3 4 5

No Influence ☐ ☐ ☐ ☐ Very Influential
How much would fuel efficiency influence you to drive an electric vehicle?

1 2 3 4 5

No Influence ☐ ☐ ☐ ☐ ☐ Very Influential

How much would the availability of a public charger influence you to drive an electric vehicle?

1 2 3 4 5

No Influence ☐ ☐ ☐ ☐ ☐ Very Influential

How likely are you to buy an electric vehicle in the near future?

1 2 3 4 5

Not Likely ☐ ☐ ☐ ☐ ☐ Very likely

Do you believe a public charging station would be an asset to the community?

☐ Yes
☐ No

What are your feelings about electric vehicles compared to a regular car?

Never submit passwords through Google Forms.
Appendix B: Cost of installing public EVSE

8. Cost Estimating

This section provides a cost estimate worksheet and sample costs for residential, commercial fleet and public scenarios. The material and labor costs provided here are for general information purposes only and should not be used for actual planning purposes.

A. Residential Cost Worksheet

Referring to Figure 4-1 for a Residential EVSE installation, Table 8-1 provides a generic Cost Table Worksheet that can be used as a guideline residential installations. As noted in Section 4, some homes may require a service panel upgrade but the following table assumes they do not.

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Cost, Ea</th>
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Source: Electric Transportation Engineering Corporation
Appendix C: Qualitative responses coded

Non-EV owner code map

Coding refers to the practice in sociology and the social sciences to categorize qualitative data by theme in order to extrapolate quantitative conclusions from it. Below, we’ve coded our collective survey responses from EV owners and non-owners to provide color on certain themes that consistently emerged in our respondents’ feedback.

Question Asked: What are your feelings about electric vehicles compared to a regular car?

Theme: environmentally responsible

Always open to the latest research, but it seems environmentally responsible and offers the potential to save money and not pay it to the oil companies.

Beneficial to the environment - decrease in particulate matter air pollution and noise pollution

They are better for the environment.

Excellent clean energy emissions far preferable to combustion engines

I think they have great potential to affect our environmental impact, but I am nervous about changing something I rely upon so fundamentally. Also, the capital cost is significant: I'm the type of person who wants to drive a car for 10+ years.

They are better for the environment. They should be less expensive to operate with fewer repairs. Getting better mileage on a charge would make a huge difference. The costs of purchasing the electric vehicles are too high for cars with less than 100 miles per charge.

Theme: Reduce Dependence on Oil

We intend to buy an electric vehicle as soon as possible - i.e.when the used EV price is comparable to a used gas powered vehicle. We only purchase used vehicles - 2 to 3 years old. It never makes sense to buy new from a dealer when depreciation of the value of a new vehicle is 20% right off the lot. I like the idea of being free of the petro-chemical industry and not supporting the international oil conglomerates.

Great, not the least of which reason being a step towards reducing our dependence on foreign oil.

We need to take steps to be less reliant on non-renewable resources. I would like to drive an EV but commute a little distance, and the presence of chargers will really help sway me into buying one
Theme: Need more range

Electric cars are a great idea, but we need to be able to travel distances in order to be in a position to buy one.

The only factors holding us back from purchasing one are distance per charge (which is improving) and availability of public charging stations. Once both improve, we are pretty likely to buy an EV.

I think they are good, but I worry about running out of power, and the time it takes to recharge. These concerns would keep me from using an electric vehicle for anything but short-range trips. That is the main thing that keeps me from buying an electric car. The other issue is that there are certain makes of cars like Subaru and some other that have a reputation for being good cars for dealing with snow and ice in our harsh New England winters. If Subaru made an electric car, I would be very interested in buying it.

I think they're great .... for others. For my family, I don't think the technology is advanced enough e.g. can't travel very far, charging stations are not available everywhere etc. I would support Newton having a charging station to promote this technology, though. We have a hybrid (Prius) that we're very happy with.

I am concerned about travel distance, but as charging stations become more available, I become more excited about owning an electric car.

Great for short trips where I'm guaranteed not to run out of charge.

EV's would be great for running errands and short trips since conventional cars use so much gasoline in those conditions. On an un-obstructed highway the advantage is less. To use an EV on a commute anywhere close to its mileage limit would require charging facilities at one's workplace to cover side trips, traffic jams, cold weather etc.

I would love to make the switch, but I'd be worried about resources (i.e. not having a place to charge it if I went on a long car trip, running out of power and getting stranded), so I probably won't look into getting one until they become more common and popular.

I'm not so concerned with local charging stations as I would be with those that would be available when I'm farther away from home - it seems that local stations wouldn't be used by locals but by people from farther away?

They are on balance a good idea. But the electricity to run them is not free of environmental harm. If we burn carbon to generate the electricity, the climate benefit is reduced. I'm concerned about limited driving range.

I think they are good, but I worry about running out of power, and the time it takes to recharge. These concerns would keep me from using an electric vehicle for anything but short-range trips.
That is the main thing that keeps me from buying an electric car. The other issue is that there are certain makes of cars like Subaru and some other that have a reputation for being good cars for dealing with snow and ice in our harsh New England winters. If Subaru made an electric car, I would be very interested in buying it.

Less convenient, not too reliable

**Theme: Need more chargers**

It is key to have the fast charging stations. Although there are benefits in no emissions from vehicles themselves - it's important that we have clean electricity production./

I don't like the idea of running out of electricity with no hope of getting more in some remote place. I have a Prius and like that it runs on both gas and electricity. But if electric vehicles were more reliable by having more charging places, I might consider one.

I think they are a great idea but in reality, I am afraid that I would forget to charge the vehicle or that I would go on a trip it was farther than the vehicle could handle and it would interrupt the trip to stop and charge.

The only factors holding us back from purchasing one are distance per charge (which is improving) and availability of public charging stations. Once both improve, we are pretty likely to buy an EV.

I think they're great .... for others. For my family, I don't think the technology is advanced enough e.g. can't travel very far, charging stations are not available everywhere etc. I would support Newton having a charging station to promote this technology, though.

We have a hybrid (Prius) that we're very happy with.

I would love to own an electric vehicle, if I could find reliable charging stations when I travel.

We need to take steps to be less reliant on non renewable resources. I would like to drive an EV but commute a little distance, and the presence of chargers will really help sway me into buying one

I think it's a great idea, but the whole charging station issue is a problem. I like the idea of a public charging station, but who would pay for this?

I would love to trade my gas vehicle for an electric vehicle (EV). My chief impediments are the unavailability of an affordable, small wagon model and availability of more charging facilities. I encourage City of Newton to participate more than it has in the Massachusetts EVIP and to create at least four additional public charging stations around the City for residents and commuters. I encourage the City pursue market pricing incentives at all meters and include incentives/exemptions for EVs. I encourage the City to consider a prorated reduction of excise taxes for EVs and Plug-In EVs respectively. I encourage the City to combine and advance tax/rebate incentives for EVs and residential solar installations. Thanks BC students for preparing this survey.
A public charging station in Newton would only benefit drivers who could leave their car for a while ie shoppers, people who work in Newton, restaurant goers and others. And we'd need a lot. A couple in the parking lots in Newton Center and Highlands to start. Maybe at the Schools and City Hall.

I would love to make the switch, but I'd be worried about resources (i.e. not having a place to charge it if I went on a long car trip, running out of power and getting stranded), so I probably won't look into getting one until they become more common and popular.

It is key to have the fast charging stations. Although there are benefits in no emissions from vehicles themselves - it's important that we have clean electricity production.

**Theme: Don’t make that big of a difference**

I am concerned that they require the burning of fossil fuels also (coal-electricity) so how much of a difference do they make?

I am concerned about the environmental impacts of manufacturing the electricity as compared with the use of fossil fuel in the gas tank.

The trade offs are such that it is not worth buying an EV.

They are on balance a good idea. But the electricity to run them is not free of environmental harm. If we burn carbon to generate the electricity, the climate benefit is reduced. I'm concerned about limited driving range.

If the electricity used to charge the vehicle is not produced by fossil fuels, but comes from solar or sun; and if the range of electric cars were increased significantly; and if there were convenient charging stations, I would get an electric car for my next purchase. I cannot afford a Tesla, and I'm waiting for the next generation of those cars to come to market. The range of the Leaf is too small. An increase in local charging stations would help me to purchase a car with a smaller range. I don't want to get stuck in the middle of the night or the middle of no where, without a way to charge the vehicle. We need lots of charging stations at places where we shop - Whole Foods, other markets, gyms, all the malls, restaurants, office complexes, library parking lot, city hall, hospital lots, museums, at the curb, everywhere. We have gas stations everywhere so why not charging stations everywhere.

Right now, a small car is more environmentally sound than driving a large electric vehicle. You need to compare apples and oranges. You may want to redesign survey to ask people first what they are driving today and if they plan to scale up--or down--when they get a new car.

**Theme: Need more development**

They're getting there....
I think they are good, but I worry about running out of power, and the time it takes to recharge. These concerns would keep me from using an electric vehicle for anything but short-range trips. That is the main thing that keeps me from buying an electric car. The other issue is that there are certain makes of cars like Subaru and some other that have a reputation for being good cars for dealing with snow and ice in our harsh New England winters. If Subaru made an electric car, I would be very interested in buying it

**Theme: Overall Positive**

they used to have negative stigma compared to gas vehicles but I believe that Tesla has changed that.

Our household currently has 2 hybrid vehicles. We hope that our next car purchase will be an electric vehicle!

I believe it is a game changer for all the arguments about the pollutive effects of commuters.

Great alternative to regular cars. The way to go. Hopefully the electricity generating capacity will be increasing at the same rate at the same time as the number of the electric car increases.

Very positive

Great alternative to regular cars. The way to go. Hopefully the electricity generating capacity will be increasing at the same rate at the same time as the number of the electric car increases.

Its only a matter of time when EVs replace Gas powered cars, and the sooner the better. Anything we can do to speed up the transition is good.

**Theme: Unsure/need more information**

Don't know much about them. Would consider a vehicle that could fit 5 passengers.

I would enjoy the benefits of an electric car but I have to increase my knowledge of them in terms of the distance they can drive without charging and how much they cost to own and maintain compared to a regular car.

I would love to know more and wish I could afford to do something like this, but I'll likely drive my two gas-guzzlers into the ground to be frugal.

i have heard that the batteries for electric cars are not good for the environment either. but i don't know if they are worse than the oil.

**Theme: Prefer Hybrid**

I prefer hybrid vs all electric.
I wish I could buy one but just bought a hybrid

We would love to own an EV, though it may take a few years, since our 2010 Prius is alright in the meantime.

We are thinking our next vehicle will be electric but hopefully that is still at least a few years away! Now we have one Prius and one conventional vehicle.

**Theme: Too Expensive**

Price is a deterrent- convenience and access to charging will likely not be an issue when I M considering such an investment

I would love to know more and wish I could afford to do something like this, but I'll likely drive my two gas-guzzlers into the ground to be frugal.

I would love to trade my gas vehicle for an electric vehicle (EV). My chief impediments are the unavailability of an affordable, small wagon model and availability of more charging facilities. I encourage City of Newton to participate more than it has in the Massachusetts EVIP and to create at least four additional public charging stations around the City for residents and commuters. I encourage the City pursue market pricing incentives at all meters and include incentives/exemptions for EVs. I encourage the City to consider a prorated reduction of excise taxes for EVs and Plug-In EVs respectively. I encourage the City to combine and advance tax/rebate incentives for EVs and residential solar installations. Thanks BC students for preparing this survey

They are way too expensive for me to buy.

We intend to buy an electric vehicle as soon as possible - i.e.when the used EV price is comparable to a used gas powered vehicle. We only purchase used vehicles - 2 to 3 years old. It never makes sense to buy new from a dealer when depreciation of the value of a new vehicle is 20% right off the lot. I like the idea of being free of the petro-chemical industry and not supporting the international oil conglomerates.

Great but expensive. Will likely get one with our next car purchase but that may not be for a few years

**EV owner code map**

**Question: How could Newton make charging easier?**

**Theme: Dedicated Parking**

It would be nice to have dedicated parking with charging stations in the major parking lots.
Designated charging stations at public lots.

Dedicated parking spots for EVs with chargers that activate when the meter is paid (preferably by credit card) and are free when meters are not required.

Look to Brookline as a model -- they've done a great job installing charging stations in city-owned lots. For Newton, installing a station or two in major city-owned lots near village centers (e.g. the main lot at Newton Center) and near large grocery store / shopping centers (e.g. the Shaws and Wegmans on Route 9) would be a great start. Make sure that any parking spot adjacent to the charging station is marked for EV use only (at least during regular business hours), and enforce this rule.

I'm actually surprised that the new Wegmans shopping center doesn't have a single EV charger, even though the parking lot and garage can hold several hundred vehicles. If a progressive-minded city like Newton is serious about embracing EVs, perhaps the city could pass a carrot-and-stick ordinance whereby new commercial developments are required to provide [x] charging stations per [y] available parking spaces, while at the same time offering incentives to meet or exceed those requirements (on top of the generous incentives that the State of Massachusetts already provides).

**Theme: Subsidize Cost**

Provide more public charging stations either free or lower rate and 240V for faster charging

Subsidize cost of home charging

**Theme: Increase Public Charging**

More charging stations.

Add charging locations in the city squares

More charging stations, especially near large facilities like schools, government offices, shopping centers, village centers.

More chargers and dedicated spaces in municipal lots (Newton Center), grocery stores, Chestnut Hill mall/The Street, Newton Free Library at corporate centers/office parks like Riverside Center, movie theaters, doctors offices.

Install more charging stations. There should be several in the library lot, some stations should be on School lots for week-end only charging

This is a great service - and i like the fact that they're on plugshare and charge point. but i worry that as the rest of the city comes to their senses and get electric vehicles the available chargers
will fill up - we could use a few more chargers, eg in the village centers, library parking lot, etc., would be great. Also think about putting the chargers in the less favored spots, eg the far side of the library lot, so you don't get electric cars just parking there for convenience and not to charge.

install charging stations in public lots, require shopping malls to do the same, require stores over a certain square footage to do the same in their lots”

I own my home, so I installed my own charger. I believe that renters rarely have access to chargers. Could multi-unit apartment owners install some chargers for renter use? Could chargers be installed in public parking lots -- like the lot across from Star Market in Newtonville? the public library? Maybe one in the lot at Newton Center?

Look to Brookline as a model -- they've done a great job installing charging stations in city-owned lots. For Newton, installing a station or two in major city-owned lots near village centers (e.g. the main lot at Newton Center) and near large grocery store / shopping centers (e.g. the Shaws and Wegmans on Route 9) would be a great start. Make sure that any parking spot adjacent to the charging station is marked for EV use only (at least during regular business hours), and enforce this rule.

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Provide more public charging stations either free or lower rate and 240V for faster charging

**Theme: More Efficient Charging**

Provide more public charging stations either free or lower rate and 240V for faster charging

Why not have solar arrays and meters located throughout public areas? My Leaf is getting 5 mi Wh so it's not a lot of charging required for the milage I have.

**Theme: No Need**

don't know as it doesn't currently apply to me

I do not personally drive enough miles locally to make a charger needed in Newton outside my home. For emergencies I can use the Tesla service facility just across the river in Watertown. I also believe there is a charging station at city hall which could be used if really needed.

A charging station at the library would be useful, since I spend more time there than at a market, like Whole Foods. If the charging station was walking distance to my house, at the Waban T
station for instance, I might charge it there instead of at home. That said, our need for a public charging station is very limited; because it takes so long to charge, charging at home or at work is most convenient. I suppose a charging station at a movie theatre or restaurant could be useful -- Newton Centre parking lot.