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Massachusetts Plug-in Electric Vehicle and Charging Infrastructure Case Study

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EXECUTIVE SUMMARY

Currently in the United States, the majority of plug-in electric vehicle (PEV) sales have been in certain, highly conducive metropolitan areas, instead of being broadly distributed across the country. The U.S. Department of Energy's (DOE) EV Everywhere Grand Challenge is assessing the barriers and opportunities to enable more localities and states to more rapidly increase PEV use and enjoy the resulting economic and environmental advantages. To gain insight, DOE selected the Massachusetts Plug-in Electric Vehicle and Charging Infrastructure Program for development of a case study because Massachusetts compares favorably with other cold weather states as to the per capita market share of PHEVs and all-electric vehicles. Massachusetts has also seen a rapid increase in public PEV charging infrastructure installations (33 to 596) from 2011 until July 2016.

The objective of this case study is to use the lessons learned to increase adoption of PEVs and charging infrastructure in Massachusetts, as well as apply these lessons in other places. This includes better understanding the activities most effective at encouraging acquisition of PEVs and deployment of charging infrastructure in diverse urban, suburban, and rural settings, and determining priorities.

The Massachusetts Plug-in Electric Vehicle Program was launched in 2010 at the Electric Vehicle Summit and Workshop at the University of Massachusetts Lowell. The goal of the program is to increase the use of electrified transportation in Massachusetts through state leadership, education and outreach, and infrastructure development. The program can be broadly broken into five components: (1) strategic planning/leadership, (2) stakeholder/partnership development, (3) policy development, (4) education and outreach, and (5) incentives. The early phases of the program focused heavily on strategic planning, and stakeholder and partnership development. This was followed by a transition to education and outreach activities, charging infrastructure development, and, subsequently, grant and incentive programs that support charging infrastructure deployment and PEV purchases. Plans include a strong emphasis on further incentivizing the PEV market, education and outreach, and policy development.

In Massachusetts, the number of PEVs grew from under 100 in 2011 to 5,610 in January 2016, with a high percentage (39%) of battery electric vehicles (i.e., 2,193). The most popular PEVs are the Toyota Prius Plug-in, Chevy Volt, Tesla Model S, and Nissan Leaf, which make up a combined 70% of total PEV ownership in the Commonwealth. PEVs are predominantly clustered surrounding Boston and, to a lesser extent, around Worcester and the Springfield – Chicopee areas of southwest Massachusetts. There is a somewhat higher PEV registration per capita in smaller communities, with the majority of PEVs in communities between 5,000 to 50,000 people. There is also a correlation between where PEVs are registered and where they publicly charge.

The number of public PEV charging stations in Massachusetts grew from 33 in 2011 to 596 (Level 2 electric vehicle supply equipment and direct current fast chargers) by July 2016 at a variety of charging venues, including retail, parking (short term and long term), workplaces, dealerships, hotels, schools, recreational facilities, and medical. The vast majority of the charging venues contain Level 2 electric vehicle supply equipment (EVSE) solely or combined with Level 1

EVSE or direct current fast chargers. Well over half of the charging locations in Massachusetts offer free charging. For those that require payment, different pricing models are employed: hourly; by energy transferred based on kWh drawn from the EVSE; adjustable hourly and monthly; and a flat fee. There is no correlation between pricing models and community size and region; the strongest correlation is by network provider. Charging events across Massachusetts generally correlate with the density of PEVs and charging infrastructure (see Figure ES-1. Charging events occur most predominantly around Boston and, to a lesser extent, around the Worcester and Springfield – Chicopee areas of the Commonwealth).

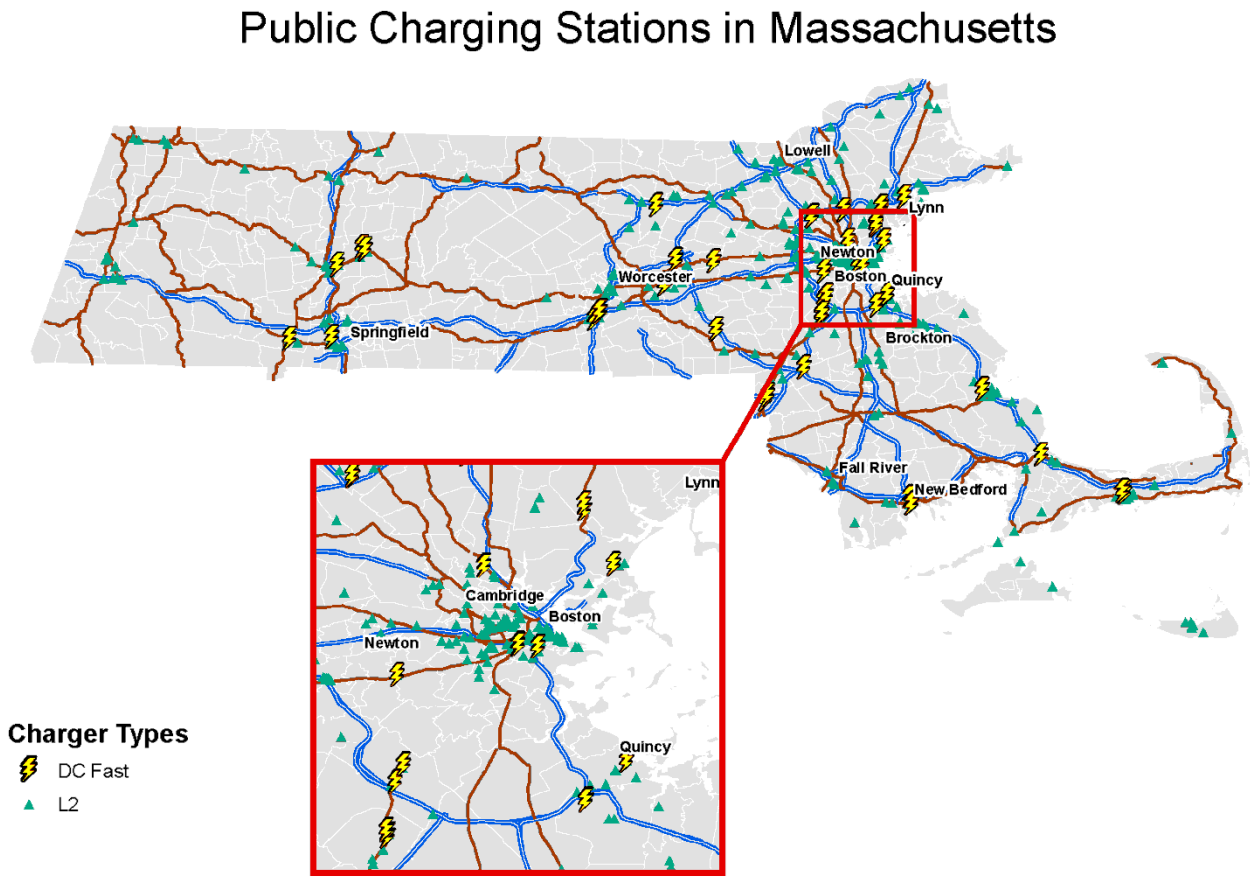

Figure ES-1. Charging infrastructure locations in Massachusetts.

A number of critical factors are important to the success of the Massachusetts PEV and Recharging Infrastructure Program, including the following:

- **Legislation and Policy:** In Massachusetts, high-level political support provides a sturdy foundation, raises visibility, and gains stakeholder buy-in.
- **Incentives:** Commonwealth incentives are in place and have been instrumental to the success of the program. It is recommended that the incentive base be deeper, more diversified, and institutionalized. For example, funds from the Regional Greenhouse Gas Initiative (RGGI) are not guaranteed in the future and other potential funding sources exist such as foundations.

- **Auto Dealerships:** Strong engagement is essential, especially with early adopter dealerships. An increased overall awareness of PEVs is needed as well as incentives and other motivational tools for dealerships and salespeople.
- **Utilities:** Significant opportunities exist for utilities to play a role in accelerating recharging infrastructure in accordance with stipulations of the Department of Public Utilities.
- **Outreach and Education:** Consistent, centralized PEV/EVSE messaging is important with one-stop, on-line technical support and increased public promotion.
- **Workplace Charging:** Workplace charging is the most attractive venue for placement of EVSE having a consistent and predictable demand. Larger, green-minded organizations are typically more conducive to the placement of EVSE and frequently utilize incentives to defray costs. These organizations usually have parking policies for PEV charging and plan EVSE deployment with an eye to the future.
- **Communities:** Massachusetts communities that deploy EVSE are heavily dependent on incentives. In order to open doors for EVSE deployment, it is important to make a business case to community leaders.
- **Non-Governmental Organizations:** NGOs maintain a broad participant base and diverse outreach mechanisms. Their capabilities include technical and policy expertise, as well as deep coalition building, advocacy, and lobbying skills.
- **Clean Cities:** The Massachusetts Clean Cities Coalition is a force multiplier for technical assistance, education and outreach, and incentives. Clean Cities has been very successful in innovatively obtaining and leveraging funding in support of PEVs and recharging infrastructure.
- **Cultural and Climatic Factors:** Massachusetts has a receptive PEV culture including an awareness of energy and environmental issues, high levels of income and education, and an innovative mentality. This contrasts with the challenges of a cold weather climate.

The Massachusetts PEV/EVSE Program has proven successful in expanding the acceptance and use of PEVs in a mixed urban, suburban, and rural cold weather environment. PEVs are becoming more mainstream, with fewer barriers to PEV adoption. The timeline for developing a PEV program (similar to Massachusetts) in other states could be expected to proceed at a faster pace due to greater current knowledge, ability to leverage a broader range of existing resources, and much broader PEV availability and consumer awareness than 3 to 4 years ago. This may be especially true given the expected availability of new, longer-range battery electric vehicles during 2017.

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ACRONYMS

BEV	battery electric vehicle
CMAQ	Congestion Mitigation and Air Quality
DCFC	direct current fast charger
DOE	U.S. Department of Energy
DOER	Department of Energy Resources
DPU	Department of Public Utilities
EVSE	electric vehicle supply equipment
LRTP	Long-Range Transportation Plan
MAPC	Metropolitan Area Planning Council
MassEVIP	Massachusetts Electric Vehicle Incentive Program
MEPA	Massachusetts Environmental Policy Act
MOR-EV	Massachusetts Offers Rebates for Electric Vehicles
OEM	original equipment manufacturer
PEV	plug-in electric vehicle
PHEV	plug-in hybrid electric vehicle
RGGI	Regional Greenhouse Gas Initiative
ZEV	zero emission vehicle

Massachusetts Plug-in Electric Vehicle and Charging Infrastructure Case Study

1. OVERVIEW

Since introduction of the Nissan Leaf and Chevy Volt in 2011, there has been a steady increase in the adoption of plug-in electric vehicles (PEVs), especially on the west coast of the United States and select urbanized areas of the eastern United States. In these areas, PEVs are transitioning from the early adopter to the early mass market phase. As of 2016, most major automobile original equipment manufacturers (OEMs) were providing PEVs to the market, with at least 27 models available in limited regional or national distribution, often in response to ZEV emission standards requirements. In regards to PEV charging infrastructure, in September 2016, there were 14,457 public electric vehicle charging stations in the United States; this includes 36,284 charging outlets.[a]

Despite promising growth in PEV sales and expansion of charging infrastructure, several factors currently dampen this momentum. During the latter part of 2016, low oil prices have continued to reduce the economic incentive of purchasing PEVs and consumer preferences have leaned toward larger sport utility vehicles and crossover models that presently have few PEV options. Consumer awareness and education regarding PEVs, incentive availability, and charging infrastructure are also affecting market growth, with 2016 year-to-date (January – September) PEV sales 39% higher than 2015 sales. Currently, the majority of PEV sales have been in certain, highly conducive metropolitan areas that benefit from moderate temperatures, State and other incentives, and as well at times mandates This case study provides an example of a broad PEV-supportive initiative across urban, suburban, and rural areas as an illustration for other states and communities that are advancing PEVs in their regions.

2. U.S. DEPARTMENT OF ENERGY EV EVERYWHERE GRAND CHALLENGE

The U.S. Department of Energy's (DOE's) EV Everywhere Grand Challenge is looking carefully at the barriers and opportunities for states to more actively support the PEV market and benefit from the economic and environmental advantages of PEVs. The goal of this case study is to answer a series of comprehensive questions that subsequently may be used to support recommendations for increasing the market penetration of PEVs in the Commonwealth of Massachusetts and inform activities in other states. The study identifies what activities are most effective at encouraging the acquisition of PEVs, deployment of charging infrastructure, and help better understand prioritizing and sequencing their implementation. As such, this case study performs a detailed review by organizations with the Commonwealth of Massachusetts to establish a statewide PEV program and look at the current status of Massachusetts' actions to prepare the state for further PEV penetration. It is critical that DOE understand the challenges/barriers to PEV penetration that must be overcome by a state and incorporate solutions in a PEV plan that will be necessary to attract additional states outside of California to follow Massachusetts' lead.

3. MASSACHUSETTS PLUG-IN ELECTRIC VEHICLE AND CHARGING INFRASTRUCTURE PROGRAM

3.1 Background and Progress

The genesis of the Massachusetts PEV and Charging Infrastructure Program goes back to the Electric Vehicle Summit and Workshop at the University of Massachusetts Lowell, during 2010. Also in 2010, $200K was announced for municipalities to purchase and install electric vehicle supply equipment

[a] U.S. Department of Energy Clean Cities Alternative Fuels Data Center, September 2016.

(EVSE) as part of a pilot program. Subsequently, a variety of stakeholder development, policy, and educational and outreach activities were undertaken for the next 2 to 3 years. In 2013, a roundtable stakeholder meeting led to development of the Massachusetts Electric Vehicle Initiative Task Force and that same year Massachusetts signed a memorandum of understanding committing the Commonwealth to support actions to place 300,000 ZEVs on Massachusetts' roads by 2025. Presently, the ZEV Commission (composed of multiple stakeholders and led by representatives of the Commonwealth of Massachusetts) serves as the focal point and steering committee for coordinating PEV and charging infrastructure activities with the state. The goal of the Massachusetts PEV and Charging Infrastructure Program is to increase the use of electrified transportation in Massachusetts through strategic leadership, education and outreach, and infrastructure development. Figure 1 illustrates the cumulative growth in PEV registrations in Massachusetts from 2011 through 2015. The smaller number above each bar indicates the annual sales that year, while the bars themselves indicate cumulative ownership statistics over time.

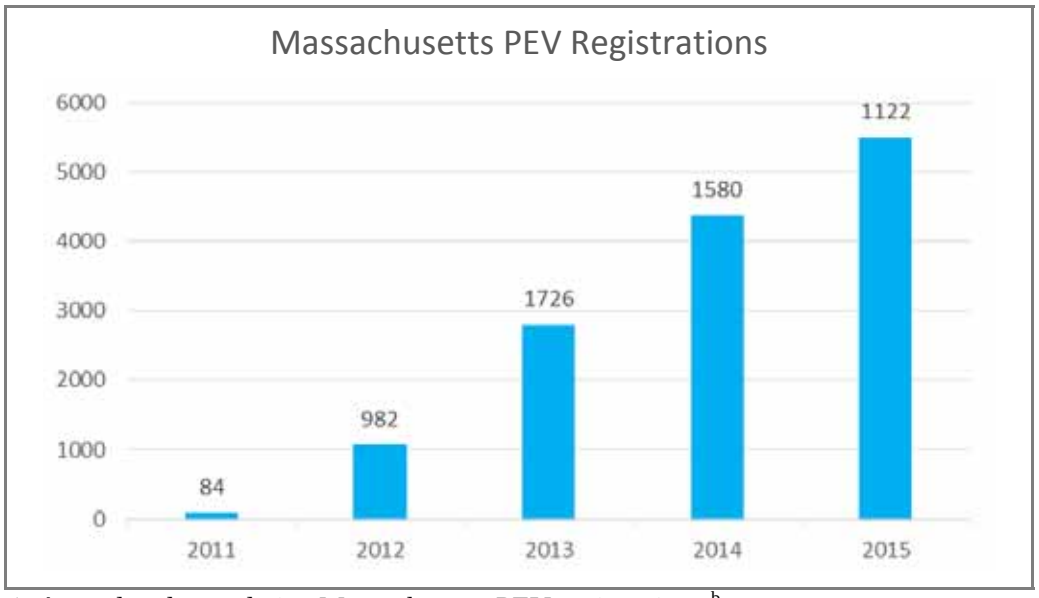


Figure 1. Annual and cumulative Massachusetts PEV registrations.[b]

Table 1 illustrates new 2014 registrations of PEVs and includes plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) as a percentage of total new 2014 light-duty vehicle registrations in Massachusetts. This is compared to Vermont and New Hampshire, and several high PEV penetration cities across the United States in temperate or warm climates. While not achieving the PEV penetration rates of highly conducive (i.e., moderate temperatures, strong state support, and environmentally conscious) west coast cities, Massachusetts fares well against other similar locales.

Massachusetts is also a leader when comparing new PEV registrations with other cold weather cities as a percentage of the total new 2014 registrations in Boston. In this regard, Boston is tied with Indianapolis, Indiana in fourth place with the highest percentage of PEV registrations (0.30%). Additionally, Boston has one of the highest percentages of BEV to PEV ratios (i.e., 45.3%) in cold weather cities.

In regard to charging infrastructure, Massachusetts has seen rapid growth in placement of EVSE (see Figure 2). EVSE installations have increased from 33 up through 2011 to 596 (Level 2 and direct current fast charger [DCFC]) by July 2016, with especially large growth in the years of 2012 and 2015.

[b] Center for Sustainable Energy, VIN decoded information from the Massachusetts Registry of Motor Vehicles database

Table 1. 2014 PEV registrations in Massachusetts and other U.S. cities.[c]

	PHEV	BEV	Total PEV	% BEV of PEV	% of All 2014 Registered Vehicles		
					PHEV	BEV	PEV
Massachusetts	666	627	1,293	48	0.21	0.20	0.41
Vermont	176	55	231	24	0.45	0.14	0.59
New Hampshire	115	61	176	65	0.14	0.08	0.22
Atlanta Metro	621	6,711	7,332	92	0.19	2.03	2.22
Los Angeles Metro	16,559	9,489	26,048	36	1.52	0.87	2.38
Portland Metro	544	979	1,523	64	0.48	0.87	1.35
San Diego Metro	1,840	2,185	4,025	54	1.05	1.25	2.30
Austin Metro	272	409	681	60	0.22	0.33	0.54

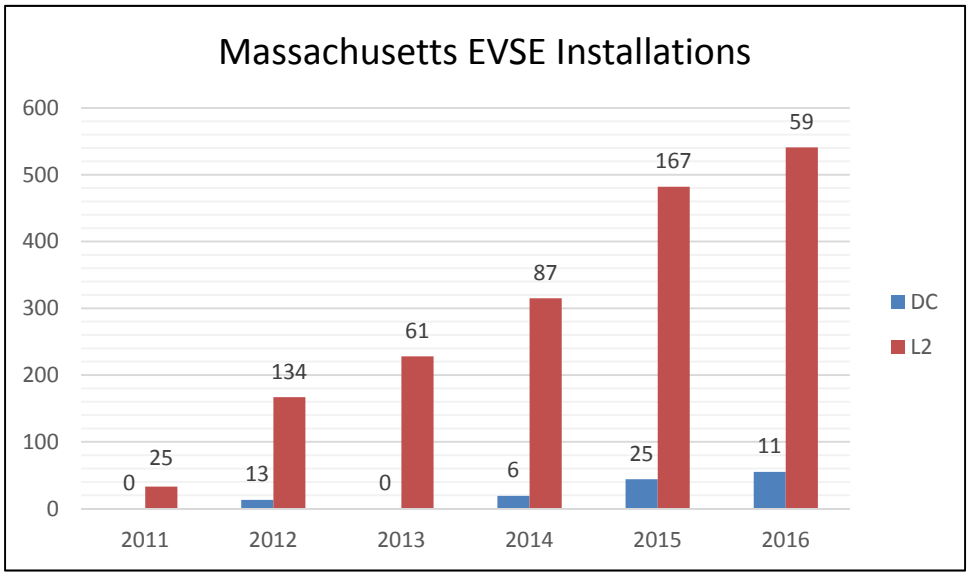


Figure 2. EVSE installations in Massachusetts by year through mid-July 2016.[d]

3.2 Activity Areas and Timeline

The Massachusetts PEV and Charging Infrastructure Program can be broadly broken into five activity areas: (1) strategic planning/leadership, (2) stakeholder/partnership development, (3) policy development, (4) education and outreach, and (5) incentives. Table 2 illustrates the highlights of the Massachusetts Program's timeline in regard to these five activity areas. The early phases of the program focused heavily on strategic planning and stakeholder and partnership development. As the foundation of the program increasingly became established, a transition was made to education and outreach activities and policy development. Presently, this emphasis has continued with the addition of grant and incentive programs supporting implementation of charging infrastructure and purchasing of PEVs, as well as promotion of additional policy initiatives, including electric vehicle-friendly building code language. The following listing of activities under the program timeline also provides an idea of the funding investments incurred to pursue the activities of the Massachusetts PEV and Charging Infrastructure Program.

[c] Argonne National Laboratory.

[d] Data courtesy of National Renewable Energy Laboratory and ICF International.

Table 2. Massachusetts Program activities and timeline.

	Jan 2010	Jan 2011	Jan 2012	Jan 2013	Jan 2014	Jan 2015	Jan 2016	Jan 2017
Strategic Planning/Leadership	1,2	3		18	23	25,28	31	
Stakeholder/Partnership Development		4		13	22,24			
Policy Development		5	10,11,12	14	21	26,30	35,37,38	
Education/Outreach		7,8	9			27,29	32,34,36	
Incentives		6		15,16,17	19,20		33	

2010

1. Electric Vehicle Summit and Workshop at University of Massachusetts Lowell on October 6, 2010, drew nearly 200 participants, including automakers, charging station manufacturers, electrical unions, municipal officials, and environmental organizations for a day of panels and talks on topics related to promoting ZEVs in Massachusetts. The summit featured workshops on topics such as vehicles and batteries, infrastructure installation, safety and permitting, and sustainability. Participants also had opportunities to ride and drive in a variety of BEVs and PHEVs onsite.
2. Funding ($200,000) was announced for municipalities to select locations and purchase and install EVSE as a pilot program.

2011

3. Partnered with other northeast and Mid-Atlantic States to create a Transportation and Climate Initiative with environmental, energy, and transportation agency participation. A key focus area of the Transportation and Climate Initiative is promoting PEVs in the region. Funding for this activity was one of 15 awards selected by the U.S. Department of Energy Clean Cities solicitation for PEV Community Readiness projects.
4. Partnered with Chrysler to obtain six pre-production, PHEV Dodge Ram trucks for Massachusetts Bay Transportation Authority use in a 3-year pilot.
5. Through the Department of Energy Resources (DOER), EVSEs were evaluated and put on state contract, allowing agencies and municipalities to simplify purchasing (ongoing).
6. The DOER Program used American Recovery and Investment Act stimulus funds ($800,000) and environmental settlement funds matched with EVSE vendor funds to install approximately 140 publicly available electric vehicle charging stations in 25 communities across the Commonwealth.
7. Designed and made available new electric vehicle license plates for hybrids and electric vehicles to ensure that first responders could identify and react appropriately in an emergency.
8. Worked with the National Fire Protection Association to provide a first-in-the-nation training class for emergency responders when responding to battery electric vehicles (BEVs) in the event of a crash.

2012

9. Held several Massachusetts Clean Cities meetings with fleet owners to emphasize the success stories of electric vehicles and provide information for helping in their purchasing or leasing decisions.
10. Placed ZEV vehicles on statewide contract, allowing municipalities, colleges, and agencies to purchase at the best value price (ongoing).
11. Included electric vehicles and charging station installation in parking areas as a greenhouse gas reduction strategy for proponents of development projects requiring Massachusetts Environmental Policy Act (MEPA) review.
12. Requested addition of a relevant section of the National Electric Code to the re-certification training for

electricians regarding installation of EVSE.

2013

13. The Massachusetts Electric Vehicle Roundtable Stakeholder Meeting on Thursday, March 7, 2013, led to formation of the Massachusetts Electric Vehicle Initiative task force. The group met quarterly and was managed by top officials from state energy and environment, consisting of key stakeholders to provide advice.
14. The Massachusetts Executive Office of Energy and Environmental Affairs published a Global Warming Solutions Act progress report 5 years after the promulgation of the Global Warming Solutions Act, as required in that statute. The Transportation and Land Use Subcommittee proposed that clean transportation is a key policy, which was adopted as a recommendation by the Global Warming Solutions Act Implementation Advisory Committee on January 31st to support greenhouse gas emissions reductions.
15. The Massachusetts Department of Environmental Protection's fleet grant funding was announced on Earth Day; with three phases, funding has been provided to municipalities, state universities, colleges, and state agencies with $1,435,580 for 144 ZEVs and $454,830 for 48 EVSE (ongoing). Total grant funding available is $2.5M.
16. In December 2013, the DOER announced the Clean Vehicle Project with $6M of Congestion Mitigation and Air Quality (CMAQ) Improvement funding dedicated to ZEVs and infrastructure.
17. Worcester Regional Transit Authority added PEV and BEV buses with the help of funds from the Massachusetts Department of Transportation and federal grants.
18. Eight governors signed a memorandum of understanding committing Massachusetts to coordinate ZEV actions on October 4, 2013.

2014

19. The Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) consumer rebate program for BEVs and PHEVs began (ongoing), with $6M allocated and $4,677,750 reserved or issued as of May 23: https://mor-ev.org/program-statistics.
20. The Massachusetts Department of Environmental Protection's Workplace Charging Program grant funding started in June 2014. The funding provided $1,074,890 to 150 separate employers for installation of 391 electric vehicle charging stations (ongoing). Total grant funding available is $1.5M.
21. The Department of Public Utilities (DPU) issued an order in August 2014 that electric vehicle charging stations provide a service and are not regulated as a utility. The order also permitted distribution companies to recover the cost of electric vehicle charging station ownership and operation for their own vehicle fleet and employee vehicle charging.
22. The DPU kept the docket open and held two technical sessions in late 2014 to gather information on distribution system impacts, grid interactive pilots, electric vehicle rates, and other stakeholder issues (ongoing).
23. A Multi-State ZEV Action Plan was released May 2014, with Massachusetts following with a draft action plan.
24. The Electric Vehicle Workplace Charging Program held an Electric Vehicle Charging Station Workshop in June to encourage employer investment in workplace charging stations. The Massachusetts Department of Environmental Protection announced a workplace charging grant program for employers with more than 15 employees.

2015

25. Published an update to the Massachusetts Clean Energy and Climate Plan for 2020. While some improvements in vehicle efficiency were realized since 1990, increases in the amount of driving offset these gains, such that transportation is the only fuel combustion sector to realize increases in emissions since 1990. Meeting the 2050 emission limit requires powering the transportation sector largely with electricity. This transition requires new infrastructure, incentives, and sustained policy over the 15 to 30 years it takes for the vehicle fleet to turn over.

26. The 2015 budget section established the ZEV commission to study the economic and environmental benefits and costs of increased use of ZEVs, prepare a report to the legislature, and provide guidance to the Commonwealth (ongoing).
27. First-in-the-nation, state-sponsored ZEV test drive program (Massachusetts Drive Clean); eight test drive events (ongoing).
28. Governor Charles Baker joined with other states and regions around the world in endorsing the Subnational Global Climate Leadership memorandum of understanding and the International ZEV Alliance specifically aimed at global ZEV deployment.
29. On August 31, 2015, published the MOR-EV Year One Final Report that analyzes survey results from rebate recipients.
30. MOR-EV VIN-decoding of Registry of Motor Vehicles data (95% of BEVs correctly classified and 17% of PHEVs correctly classified) (ongoing).

2016

31. Governor Baker signed the Governors' Accord for a New Energy Future that includes clean vehicles and fuels.
32. Hosted MOR-EV and ZEV information booth at the 2016 New England International Auto Show.
33. The DOER awarded grants to four school districts for a pilot project to evaluate the economic viability and vehicle-to-grid of electric school buses.
34. Auto dealer training and promotion program being designed.
35. Low-income electric vehicle ownership program pilot being designed.
36. Massachusetts Drive Clean Workplace Charging Guide prepared (by Plug in America) and webinar held to inform.
37. Drafted electric vehicle-ready commercial and residential building code language with public comment period and hearing to modernize building envelope and promote cost savings for builders, owners and residents.
38. Working with EV Everywhere Program on a Massachusetts Case Study and EVSE Assessment Study to help guide future efforts.

4. PLUG-IN ELECTRIC VEHICLE MARKET PENETRATION

As of January 2016, there was a total of 2,193 registered BEVs and 3,417 registered PHEVs in Massachusetts, according to information from the Massachusetts Executive Office of Energy and Environmental Affairs. Table 3 offers a breakdown of the Massachusetts PEV market by make and model. The Toyota Prius Plug-in, Chevy Volt, Tesla Model S, and Nissan Leaf cover a large bulk of the market (70%), with a second tier (i.e., Ford C-Max Energi, Ford Fusion Energi, Smart ForTwo, and BMW i3) covering an additional 21%. The remaining vehicles have extremely low sales (i.e., BMW i8, Porsche Panamera and Cayenne, and Cadillac ELR) or have been discontinued (i.e., Fisker Karma, Honda Fit EV, and Toyota RAV4EV). The neighborhood electric vehicles category includes vehicles that generally have a top speed of 25 miles per hour, falling under the U.S. Department of Transportation's "low-speed vehicle" classification. Most neighborhood electric vehicles were sold between 2002 and 2013 and the vast majority are either Ford TH!NK or GEM 825 models.

4.1 Plug-In Electric Vehicle Registrations

As shown in Figure 3, there is a clear clustering of PEVs surrounding Boston on all sides, with the highest density of PEVS to the west, northwest, and southwest in the suburbs and exurbs of the city. There is also a more modest presence of PEVs to the north and south of the city. Additionally, there is also a clustering of PEVs around Worcester and in the southwestern area of the state around Springfield

and Chicopee, as well as some isolated spots of high density such as Plymouth and along the far western border of New York State.

Table 3. Massachusetts PEV registrations by model. [e]

PHEVs	
Toyota Prius Plug-in	1,337
Chevy Volt	1,040
Ford Cmax Energi	482
Ford Fusion Energi	376
BMW i3 REX	56
BMW i8	30
Cadillac ELR	36
Honda Accord Plug-In	21
Porsche Panamera	18
Porsche Cayenne	12
Other Passenger PHEVs	9
BEVs	
Tesla Model S	909
Nissan Leaf	645
Smart ForTwo	171
BMW i3	164
Volkswagen e-Golf	62
Ford Focus Electric	61
Honda Fit EV	52
Mercedes B-Class	42
Mitsubishi iMiEV	30
Other Passenger BEVs	57
Other	
Neighborhood Electric Vehicles	365
Motorcycles	36
Buses	6
Other (e.g., conversions)	163
Total PEVs	6,180

[e] Massachusetts Executive Office of Energy and Environmental Affairs, January 2016.

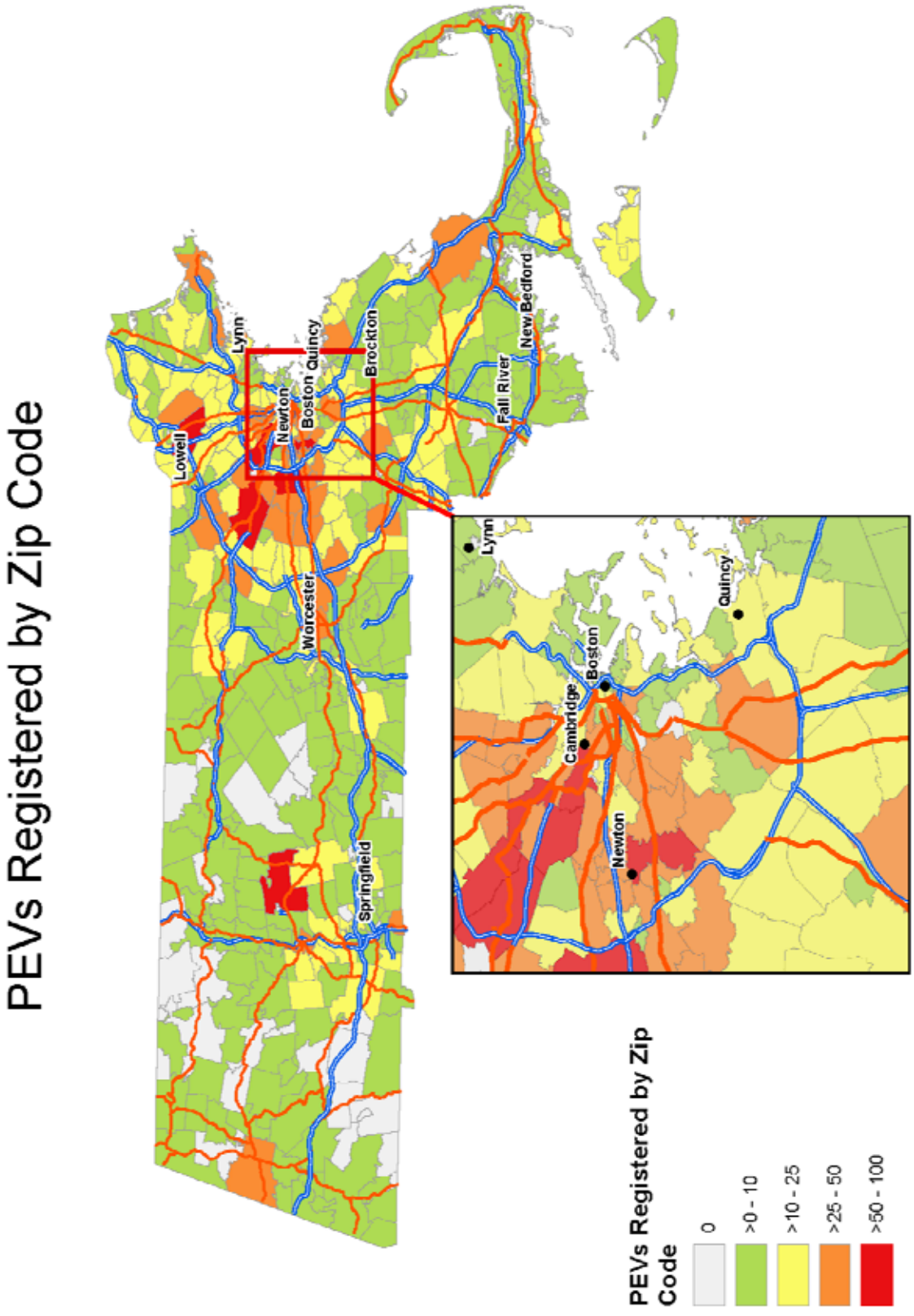


Figure 3. PEVs registered in Massachusetts by zip code (Idaho National Laboratory).

Table 4 provides a breakdown of PEV ownership in the state by community size (as of May 2016), where only communities with PEV drivers are counted in the totals. Most of the PEVs sold in Massachusetts are found in towns of between 5,000 and 50,000 people, likely due to the fact that most of the state's population lives in communities of that size. Figure 4 shows how many PEVs have been sold per capita in each community population group. Surprisingly, there seems to be a trend where smaller communities have higher PEV penetration rates per capita than larger communities.

Table 4. Breakdown of PEV ownership by community size.[f]

	Number of Communities	Cumulative Number of PEVs	PEVs per Community	Percent of Total PEVs in Massachusetts
Less than 5,000	76	362	4.76	5.86%
5,000 to 25,000	172	2,325	13.52	37.62%
25,000 to 50,000	50	1,680	33.60	27.18%
50,000 to 100,000	20	983	49.15	15.91%
Greater than 100,000	5	830	166.00	13.43%

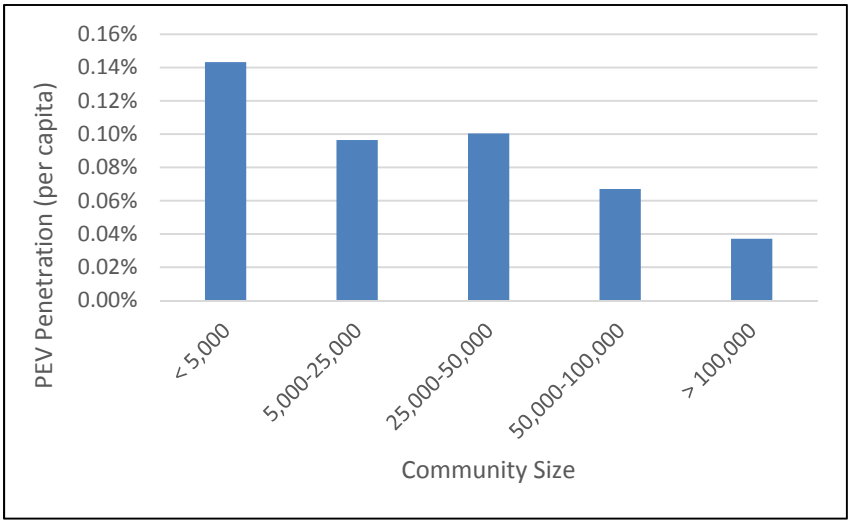


Figure 4. PEV sales penetration per capita, by community size.[g]

5. MASSACHUSETTS CHARGING INFRASTRUCTURE

The following subsections discuss the status of charging infrastructure in the state of Massachusetts; specifically, the number, composition, locations and venues, and pricing structure of EVSE are detailed.

5.1 Electric Vehicle Supply Equipment Statistics, Venues, and Pricing Structures

As shown in Table 5, most of the public access EVSE (i.e., greater than 80%) are Level 2 chargers, with a nearly equal number of Level 1 and DCFCs filling out the total. Most of the Level 1 locations are actually co-located with Level 2 chargers, while the overlap between Level 2 and DCFCs is not as prominent. A majority (i.e., 64%) of the stations are on the ChargePoint network, with EVgo, Tesla,

[f] U.S. Census Bureau and Massachusetts Executive Office of Energy and Environmental Affairs.

[g] U.S. Census Bureau and Massachusetts Executive Office of Energy and Environmental Affairs.

SemaConnect, and other providers splitting up the remaining share. There also is a relatively large percentage of installations that are not associated with a specific network. A majority of the public access EVSE are located in communities with populations between 5,000 and 50,000, but there is not a general trend in EVSE installations by community size.

Table 5. Massachusetts public access EVSE statistics.[h]

	Level 1	Level 2	DCFC	Total
Total Stations	52	586	55	693
Total Plugs	56	1,036	83	1,175
Average Plugs/Station	1.08	1.77	1.51	1.45
EVSE Locations by Community Size				
Less than 5,000	1	13	1	15
5,000 to 25,000	11	149	19	179
25,000 to 50,000	13	134	24	171
50,000 to 100,000	10	102	7	119
Greater than 100,000	17	188	4	209
Stations by Network				
ChargePoint	45	389	11	445
EVgo	0	9	23	32
Tesla	0	28	4	32
SemaConnect	0	21	0	21
Other/No Network	7	139	17	163

EVSE have been installed in a variety of venues in Massachusetts. Figure 5 shows all installations in different venue segments, including retail, parking (short and long term), workplace, dealership, hotel, education, leisure, multi-family, and hospital, and provides charging level information for each of these venue categories as of July 2016. Most EVSE are in short-term parking and retail locations. Retail locations are those that are specified as being available to patrons of a certain company or business; whereas short-term parking locations are more general (e.g., parking garages and parking lots). Long-term parking includes airports, metro stations, and other areas where the vehicle will likely be parked for more than 8 hours. A number of dealerships (i.e., BMW, Nissan, VW, Ford, and Mitsubishi) also have charging available, although drivers are expected to call beforehand. EVSE under "Education" are those installed at schools, with the Massachusetts Institute of Technology and University of Massachusetts hosting over half of these EVSE. Tesla has targeted the hotel segment, operating 55% of the EVSE at lodging businesses across the state. Breaking the data down by charging level, one can see that DCFC are focused in both retail and dealership settings, Level 1 is primarily in shorter-term parking, and Level 2 dominates all areas. This is interesting, especially for long-term parking, where Level 2 should not be necessary for most travelers because vehicles that charged at Level 1 stations would receive at least 30 miles of charging for an 8-hour stay (and more for longer stays).

[h] U.S. Census Bureau and Massachusetts Executive Office of Energy and Environmental Affairs, U.S. Department of Energy Clean Cities Alternative Fuels Data Center, and PlugShare.com. Massachusetts statistics as of July 2016.

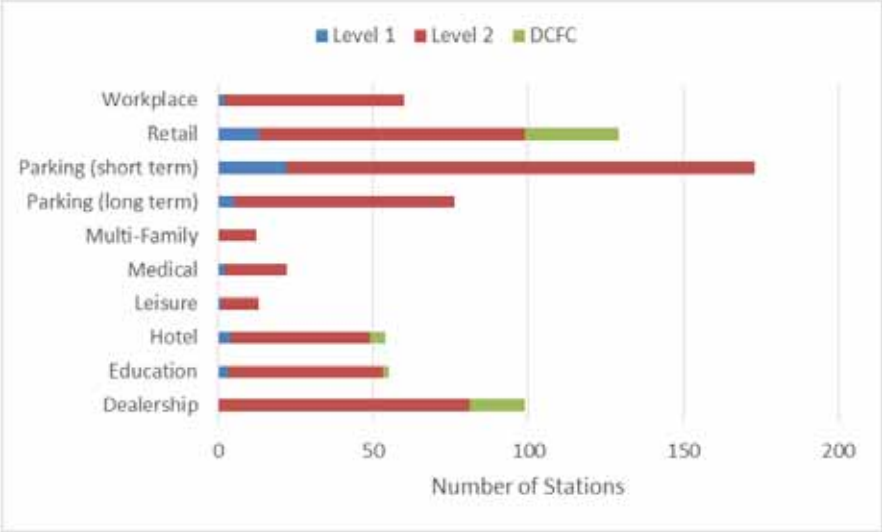


Figure 5. EVSE venues and charging levels.[i]

As shown in Table 6, free charging is strongly dependent on the charging network provider. All Tesla, most ChargePoint, and half of SemaConnect's stations offer free charging as of July 2016.[j] One provider, EVgo, does not offer any free charging. Users are required to have an EVgo membership, which assesses a monthly fee. Regarding community population and the availability of free charging, there is no clear correlation. There is a correlation though between free charging and charging level with a larger percentage of Level 2 stations being free compared to Level 1 or DCFC.

Table 6. Public EVSE free charging.[k]

	Level 1	Level 2	DCFC	Total
Free Charging by Community Size (% free stations)				
All	75%	84%	44%	80%
Less than 5,000	100%	77%	100%	80%
5,000 to 25,000	73%	85%	53%	81%
25,000 to 50,000	77%	87%	38%	79%
50,000 to 100,000	60%	92%	29%	86%
Greater than 100,000	82%	77%	50%	77%
Free Charging by Network (% free stations)				
ChargePoint	65%	72%	57%	72%
EVgo	NA	0%	0%	0%
Tesla	NA	100%	100%	100%
SemaConnect	NA	52%	NA	52%
Other/No Network	100%	88%	39%	80%

[i] U.S. Department of Energy Clean Cities Alternative Fuels Data Center, ChargePoint, and PlugShare.com. Accessed: July 2016. EVSE venue categories assigned based on information available from the hosts' websites.

[j] Note: This includes a few stations that offer free charging for a set period of time (a couple of hours), after which they charge an hourly fee.

[k] Primary data sources are the U.S. Census Bureau and U.S. Department of Energy Clean Cities Alternative Fuels Data Center, and free charging data supplemented through exploration of the PlugShare.com website (Accessed July 2016) and directly from ChargePoint (November 2016).

Figure 6 breaks down pay-to-charge EVSE in Massachusetts by pricing structure. The most popular method is *Hourly* with rates between $0.50 and $6.00/hour; *Energy* with rates between $0.10 and $0.50/kWh; and *Adjustable Hourly*. The *Adjustable Hourly* rates vary, but generally either allow free charging for a specified amount of time, after which an hourly rate is tacked on, or charge more per hour as the vehicle is plugged in for longer. This method prompts drivers to only get the fuel they need so others can plug in. *Monthly* fee structures are only used by EVgo in Massachusetts. Flat fee structures charge a set amount for a given session no matter how much time is spent charging or energy that is transferred.

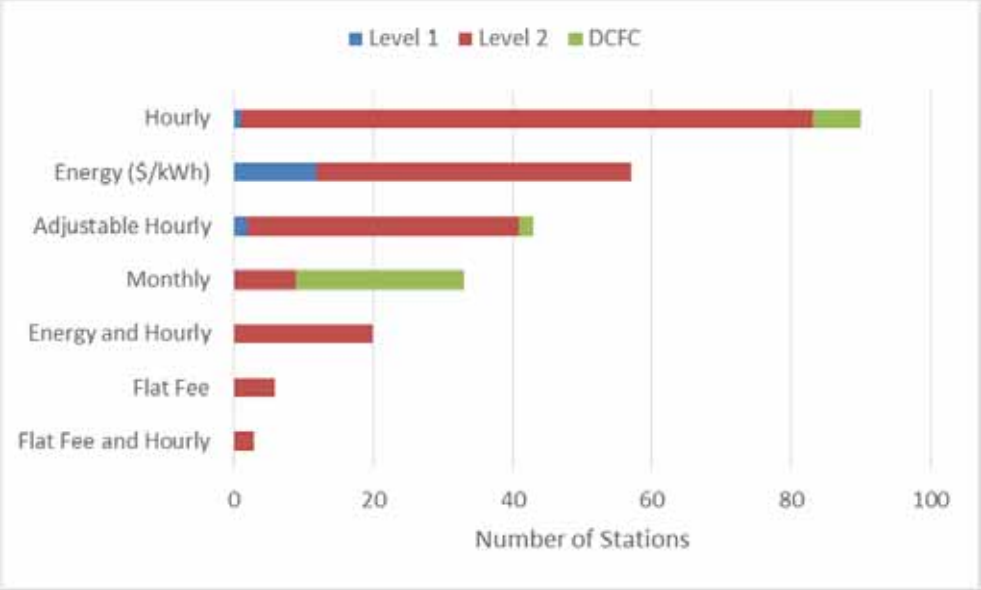


Figure 6. EVSE plugs (number of stations) by pricing structure.[1]

5.2 Infrastructure Mapping Analysis

Looking at the pattern of Level 2 and DCFC events by zip code in the Commonwealth of Massachusetts is informative. The maps in Figures 7 and 8 are based solely on charge station usage data provided by ChargePoint and EVgo. As shown in Figure 7, the preponderance of Level 2 EVSE (data were provided for 583 ChargePoint and 10 EVgo chargers) are located in and around cities (especially Boston) on associated interstates and major roads. There is a noticeable dearth of charge stations directly south (mostly) and north of Boston until hitting the inner beltway of I-95. There are a couple of zip codes with very high charge station utilization in Boston, but most are in the 1 to 75 charges per month range. In other words, from very little to a respectable 2+ times per day on average. The bottom map in Figure 7 shows charging sessions *per station* per month by zip code opposed to total charging sessions per month within that zip code. In other words, the bottom map examines the average utilization rate per charging station and is indicative of charge station utilization rates in particular zip codes. With this in mind, there are a number of green areas throughout the state where charger stations are only being used 1 to 25 times per month. Because of these data, it may be questionable to consider putting more charger station in these areas; instead the focus should be on improving utilization rates at existing EVSE through better awareness, signage, availability, pricing structures, or other means. It would probably be beneficial to determine why some Level 2 EVSE have high local utilization rates and maybe consider placing more

[1] Primary data source is the U.S. Department of Energy Clean Cities Alternative Fuels Data Center, augmented data through exploration of the ChargePoint, and PlugShare.com websites. Accessed: July 2016.

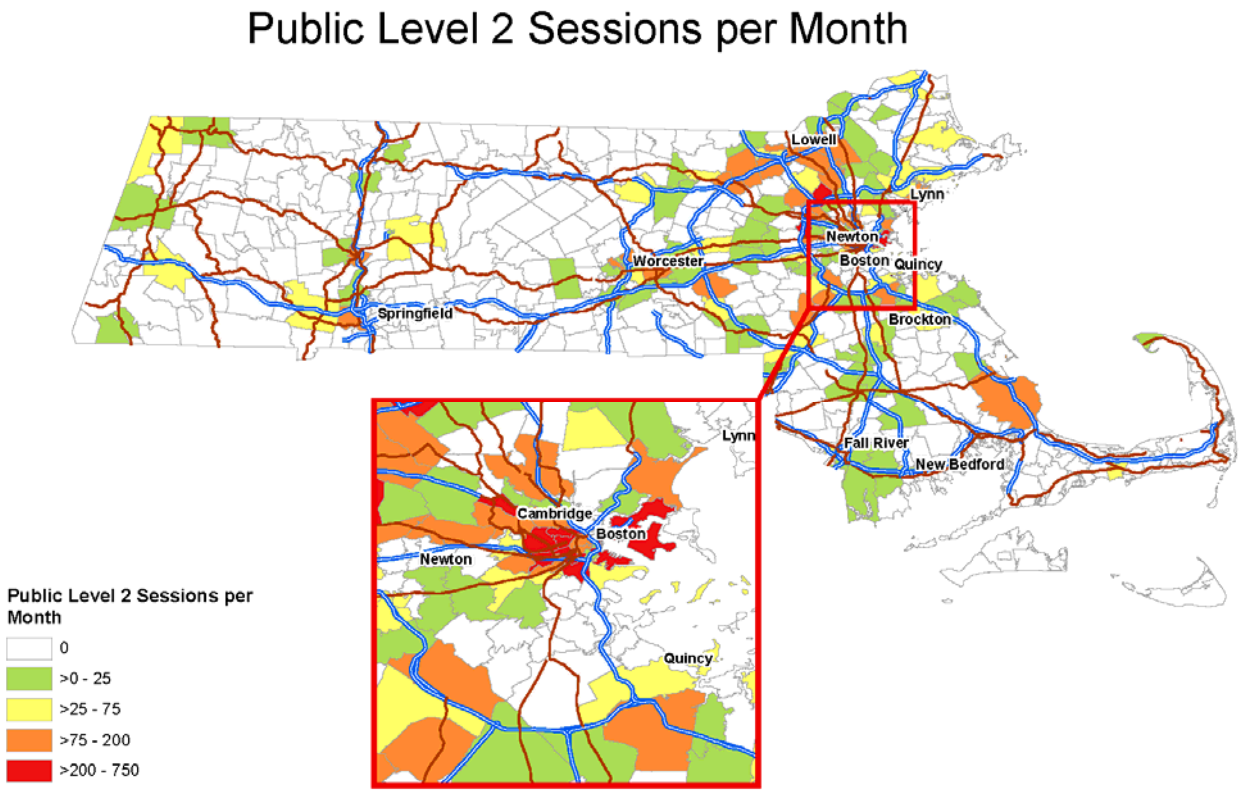
EVSE in these areas and transferring lessons learned to improve utilization rates of weaker performing EVSE. The utilization rates in other parts of the state are about the same as the Boston area.

As shown in Figure 8, there is a relatively limited number, but well-oriented distribution, of DCFC in Massachusetts. Use of DCFC is modest, with only a few being used more than once per day and most being used 6 to 25 times per month; others only see a charge per week. This may suggest the need for a closer examination of why this wide utilization distribution exists for DCFC: is it location, signage, pricing structure, available hours to charge, proximity to electric drive fleet, or other factors that influence utilization? From the highest macro, geographical perspective, there does not appear to be any clear reason why some are used more than others. A closer look locally may be in order to ascertain more clearly the reasons for the discrepancies in utilization. As shown in the lower map of DCFC sessions (Figure 8), the use *per charger* per month closely follows the total use per month by zip code, which is logical because there is not likely to be more than one to two DCFC in any particular Massachusetts state zip code at this time.

5.3 Installation Lessons Learned

Massachusetts maintains a state contract with approximately seven EVSE installation vendors who, when operating under this contract, can bypass the standard bidding process, sell equipment, and install turnkey systems. Voltrek is one such vendor who was initially drawn into the EVSE business as a result of the Massachusetts' state contract. Voltrek is the largest EVSE installer in the state and has sold and installed a significant portion of Massachusetts' EVSE infrastructure, with more than 400 ports, including 369 ChargePoint ports and GE, Eaton, and Aerovironment ports. These installations have been roughly equally split between government and private company installations, including a significant number of workplaces and universities. These are overwhelmingly Level 2 EVSE with a few DCFC. Initially, the first phase of EVSE units installed were Level 1 tied to Level 2 ChargePoint combo units. Voltrek no longer installs Level 1 because new Level 2 units allow power dialing up or down to correlate with the available capacity on the circuit. For example, if one car is charging at full power and a second car plugs in, the charger dials down. This approach is more cost effective for installation and is less taxing on the electrical system. Most business is from reorders and word of mouth; Voltrek is just starting to do proactive marketing through fleet and alternative fuel vehicle shows.

Voltrek has established best practice guidelines for installation of EVSE, including distance to the curb (i.e., reachability for EVSE is 10 to 15 in.) and height, close proximity to power, reliability, mounting preferences (typically on wall), and, soon, Americans with Disabilities Act (ADA) specifications. The State of California is now issuing ADA regulations. Typically, customers know where they want to install EVSE, but it is important to balance proximity and visibility with economic viability. Initially, Voltrek will walk the site with the customer, examine potential upgrades, determine cellular signal strength, and lay out options. After a comprehensive site assessment, a bid is established. A major obstacle to installation of EVSE can be limited electrical capacity where many garages only maintain 30 kVA and small panels. This necessitates upsizing the transformer and panels and running conduit that is expensive when retrofitted. During initial construction is it more cost effective to establish sufficient electrical capacity for EVSE access. Another important lesson learned is that when establishing PEV charger spaces, they should be restricted to charging PEVs only, supported by good signage.



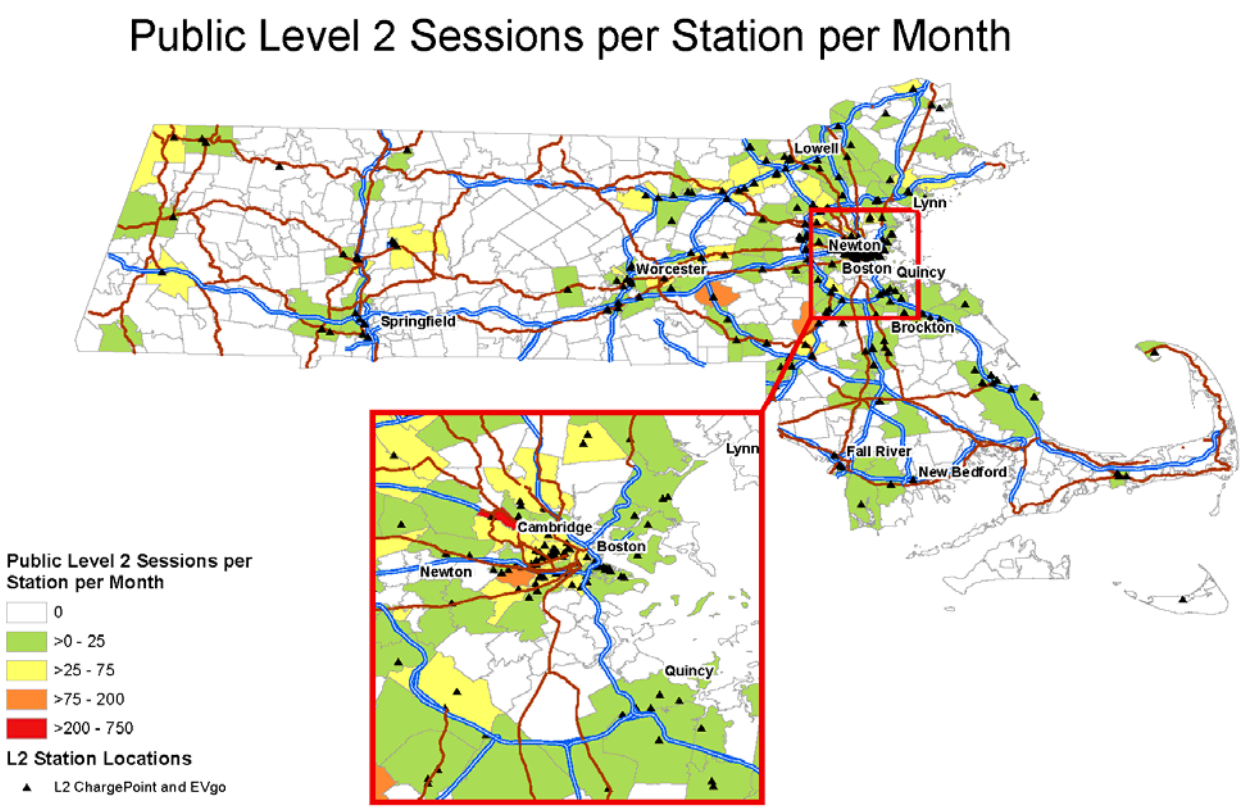


Figure 7. Public Level 2 charging sessions by zip code based on ChargePoint and EVgo data (Idaho National Laboratory).

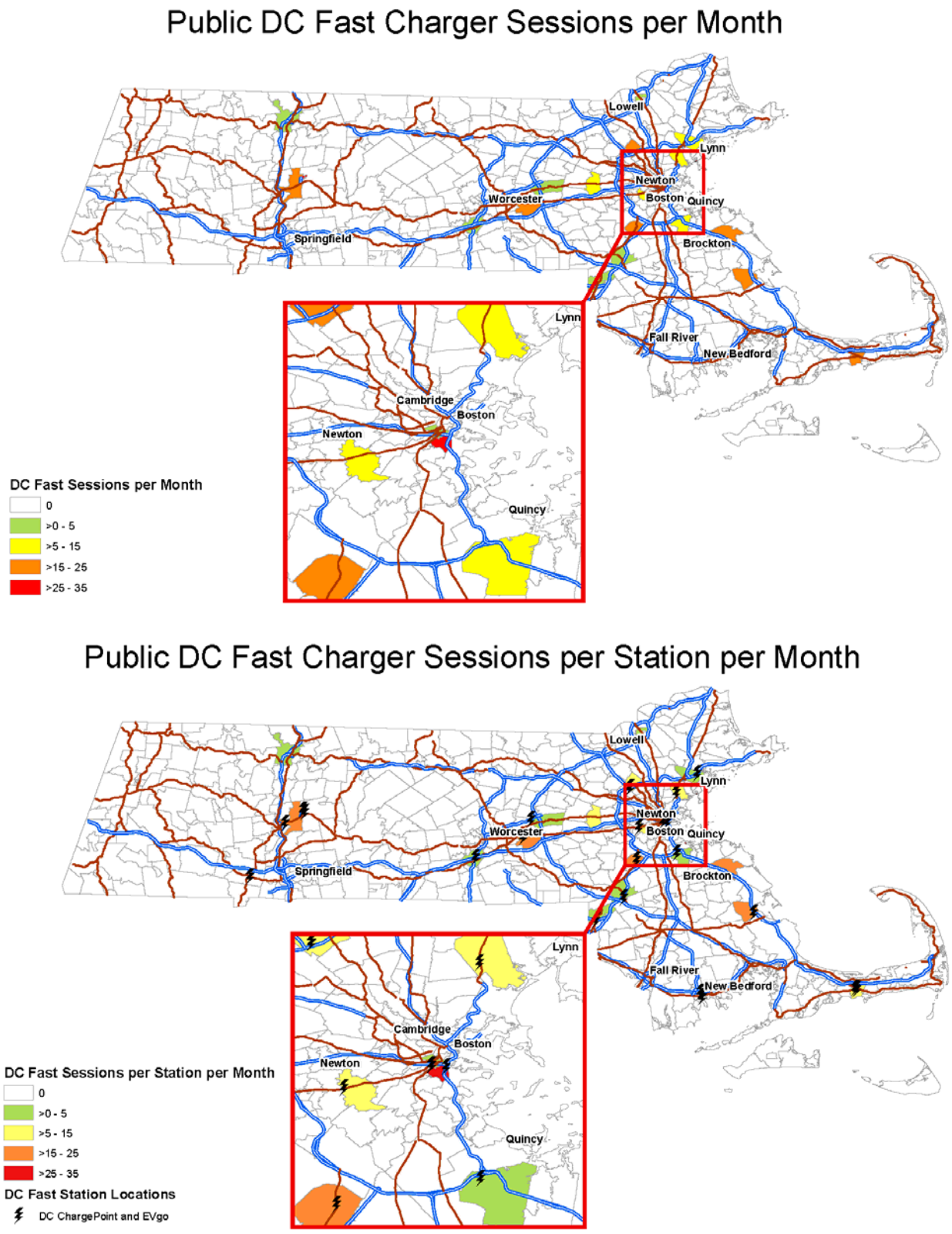


Figure 8. Public DCFC sessions by zip code based on ChargePoint and EVgo data (Idaho National Laboratory).

6. CRITICAL FACTORS EVALUATION

A number of critical factors are important and contribute to the success of the Massachusetts PEV and Charging Infrastructure Program. These are legislation and policy (including the critical role of incentives), communities, OEMs and automobile dealerships, utilities, workplace charging, non-governmental organizations, Massachusetts Clean Cities Coalition, and cultural and climatic factors. Each of these factors is discussed in detail in the following subsections.

6.1 Legislation and Policy

The Commonwealth of Massachusetts has done an excellent job of establishing high-level governmental support for PEV and recharging infrastructure. As far back as 2008, the foundation was being set in support of the establishment of a PEV-friendly state environment. Progressively since then, a number of legislative and policy initiatives have been unveiled, with each further strengthening this foundation. The following subsections discuss key legislative and policy initiatives in detail that have directly or indirectly promoted a hospitable environment for PEVs and charging infrastructure in the Commonwealth.

6.1.1 Legislation

In 2008, the Global Warming Solutions Act was signed into law by Governor Patrick Deval. This act mandates Massachusetts to reduce greenhouse gas emissions from all sectors by 25% and 80% below 1990 levels by 2020 and 2050, respectively. Transportation accounts for 40% of greenhouse gas emissions in Massachusetts. Additionally, in 2008, the Green Communities Act was signed in Massachusetts. This act focused on the following objectives:

- Reducing growth in the Commonwealth's electricity demand through economical investments in energy-saving equipment devices
- Expanding the ability of municipalities, residential customers, and businesses to own and benefit from new technologies to produce electricity on their own premises
- Facilitating commercialization of a growth in large-scale energy sources that produce little or no greenhouse emissions
- Expanding activity and employment within the state in the advanced energy technology sector
- Reducing Massachusetts' dependence on and payment for fossil fuel energy resources outside the state.

In October 2013, Massachusetts joined seven other states in the signing of a ZEV memorandum of understanding to put 3.3 million ZEVs on the roads in their states by 2025, along with the refueling infrastructure required to support those vehicles. Massachusetts' contribution to this requirement is 300,000 ZEVs on the road and new vehicle market penetration of about 15% by 2025. Under the memorandum of understanding, the signatory states agreed to create and to participate in a multi-state ZEV Program Implementation Task Force to serve as a forum for coordination and collaboration on the full range of program support and implementation issues to promote effective and efficient implementation of ZEV regulations. Governors agreed to pursue the following efforts:

- Harmonize building codes to make it easier to construct new electric car charging stations
- Seek to establish ZEV purchase targets for government and quasi-governmental agency fleets and report annually on ZEV acquisitions
- Evaluate the need for and effectiveness of monetary incentives to reduce the upfront purchase price of ZEVs and non-monetary incentives (e.g., high-occupancy vehicle lane access, reduced tolls, and preferential parking) and to pursue such incentives as appropriate
- Consider establishing favorable electricity rates for home charging systems

- Subject to respective legislative requirements, work to develop uniform standards to promote ZEV consumer acceptance and awareness, industry compliance, and economies of scale. These standards may include, but are not limited to, adopting universal signage, common methods of payment and interoperability of electric vehicle charging networks, and reciprocity among states for ZEV incentives, such as preferential parking and high-occupancy vehicle lane access.

The states also agreed to share research and a coordinated education and outreach campaign to highlight the benefits of ZEVs and advance their use.

The Massachusetts ZEV commission (which has a broad mix of stakeholders) is a major driver behind the PEV/EVSE push in Massachusetts, where there is strong bipartisan support for PEVs.

6.1.2 Policy

Established on Earth Day 2013, Massachusetts announced the Massachusetts Electric Vehicle Incentive Program (MassEVIP) that provides incentives for eligible public and private entities to acquire electric vehicles and acquire/install charging stations at reduced cost. This Massachusetts Department of Environmental Protection open grant program provides incentives to Massachusetts cities, towns, state agencies, and public colleges and universities to acquire electric vehicles and charging stations to help offset the higher costs of these advanced technologies. A related open grant program also provides incentives to workplace employers for acquisition of Level 1 and Level 2 electric vehicle charging stations. MassEVIP seeks to incentivize installation of chargers depending on the level and numbers of PEVs ($5,000 rebate for PHEVs and $7,500 for BEVs) and Level 2 chargers purchased. If 1 to 2 BEVs are purchased, applicants are eligible for up to a $7,500 rebate for equipment and installation of a Level 2 dual head EVSE; if 3 to 4 BEVs are acquired, rebates are up to $10,500; and if 5 or greater BEVs are acquired, rebates up to $13,500 are available. See Figure 9 for the status of MassEVIP as of April 2016.

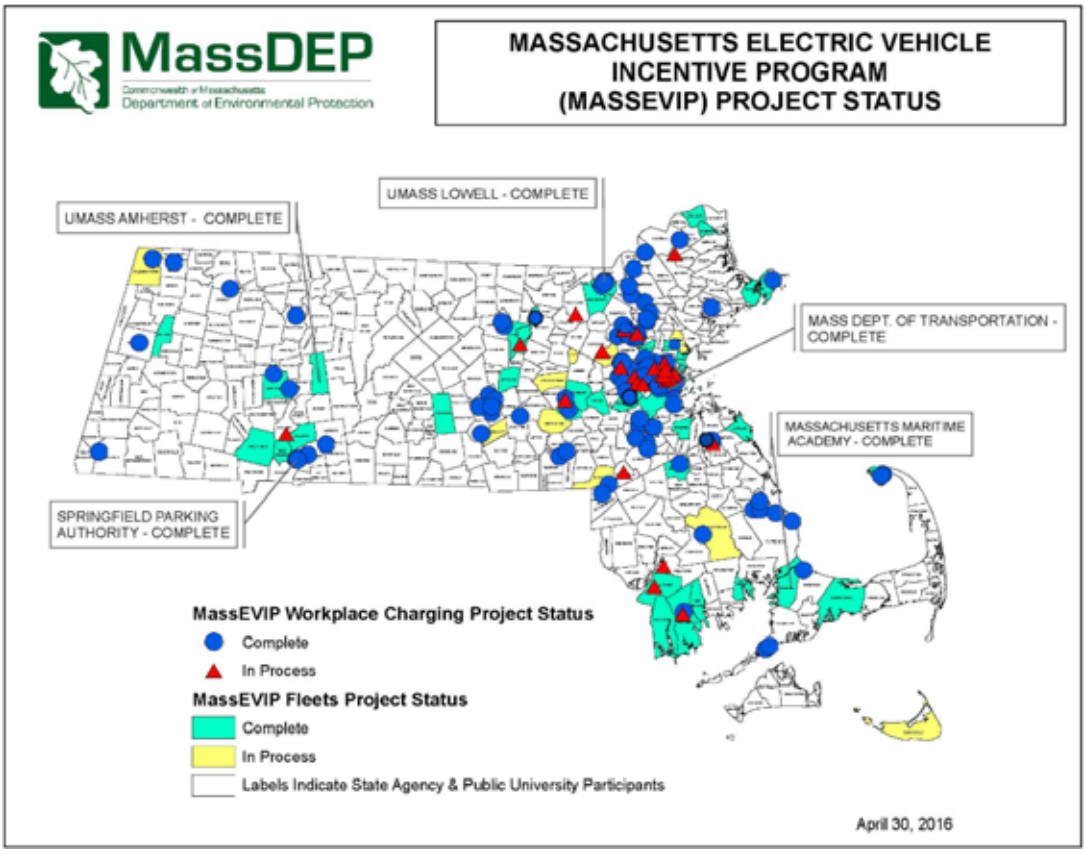
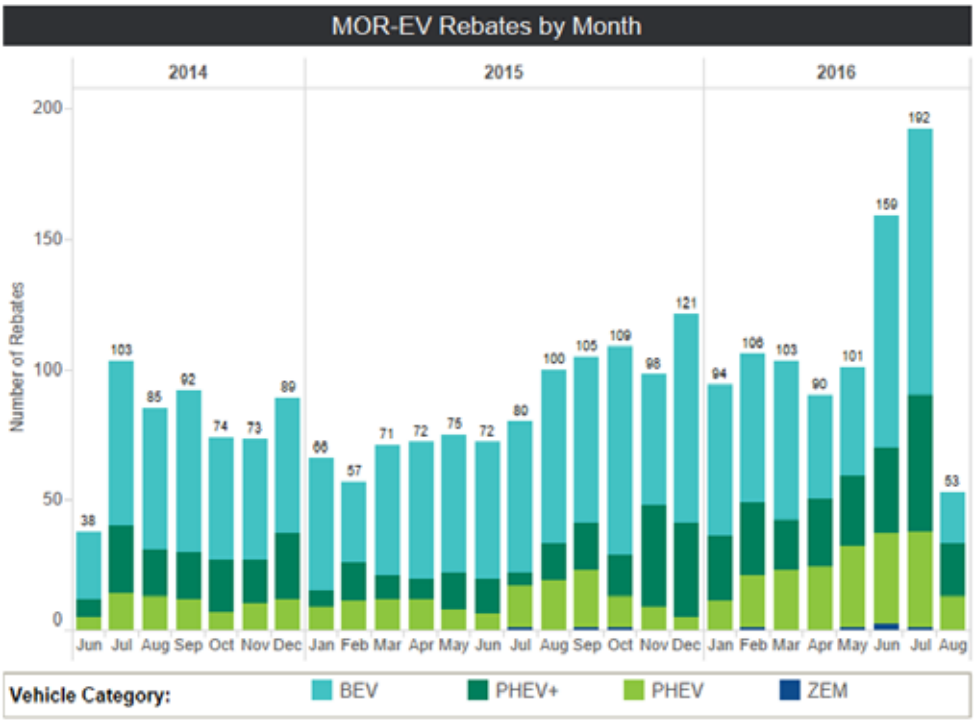


Figure 9. MassEVIP project status.

In June 2014, the MOR-EV Program was initiated; this program issues rebates up to $2,500 for the purchase or lease of ZEVs and PHEV light-duty vehicles. The MOR-EV Program has continued to be funded through proceeds from the Regional Greenhouse Gas Initiative, which is a regional allowance for carbon dioxide emissions with proceeds going to green initiatives. This essentially is a first come, first serve program that will soon cap the rebate on high-price PEVs. Those with manufacturer-suggested retail prices of over $60,000 will only be eligible for rebates of $1,000. As shown in Figure 10, as of August 2016, discretionary funds from Regional Greenhouse Gas Initiative (RGGI) have been used by the MOR-EV Program toward the purchase of about 2,500 PEVs (including BEVs) with more than $5.5M reserved and issued. Governor Baker has continued to strongly back this program, with active support from the Massachusetts Secretary of Energy (Matthew Beaton) and Environmental Affairs. The MOR-EV Program is managed by the Massachusetts Department of Energy Resources. A challenge facing the MOR-EV Program is that it is not currently permanent and RGGI funds supporting it are discretionary. Presently, there is a bill in the Massachusetts House of Representatives (H2884) to make the MOR EV Program statutory. In August 2015, the year one report for the MOR-EV Program was issued (https://mor-ev.org).



Rebates Reserved & Issued	
BEV	1,507
PHEV+	555
PHEV	408
ZEM	8
Grand Total	2,478

Rebate Dollars Reserved & Issued	
BEV	$3,535,000
PHEV+	$1,386,000
PHEV	$598,000
ZEM	$6,000
Grand Total	$5,525,000

Figure 10. Massachusetts MOR-EV Program. Note a “PHEV+” is a PHEV with battery capacity greater than 10 kWh and “ZEM” is a zero emission motorcycle.

The MOR-EV year one final report provides extensive statistical information about the program's results, including eligibility requirements, program participation, outreach and education, survey results, and analyses. Two items of particular note are that, according to a survey of consumers of PEVs that utilized the MOR-EV rebate, 75% say the rebate was an "extremely" or "very" important factor in the decision-making process. Furthermore, half of respondents would not have purchased nor leased their PEV without the MOR-EV rebate. This sentiment crossed most income levels (being most prominent in the middle income ranges) until reaching the very highest income brackets. Additionally, the MOR-EV Program website identifies the top PEV retailers by rebates within the Commonwealth of Massachusetts.

Massachusetts is currently proposing to update state building codes, including elements that apply to EVSE. The Massachusetts legislature is working on a proposed bill entitled, "An Act Promoting Electric Vehicle Adoption," which directs the Department of Energy Resources to develop a common electric vehicle charging standard as part of the state building code. This bill would require prewiring, including space at the panel and conduit in both new commercial construction and homes. Massachusetts is also focusing on the interoperability of recharging stations and encouraging development of an industry standard. Massachusetts wants to utilize an industry-developed interoperability standard; however, if the industry does not set a national standard in a timely fashion, Massachusetts will proceed on their own to set state requirements and a target date for implementation. This interoperability standard for Massachusetts is also likely to be included in the bills (H3065 and S2266). Because of a number of other priorities, these bills may not have been considered in the legislative session that ended July 31, 2016.

A number of other policy and legislative options are being considered by the Commonwealth of Massachusetts to accelerate adoption of PEVs and recharging. This includes access to high-occupancy vehicle lanes, preferential parking, and requirements for EVSE data sharing and common payment options, additional incentives, and a feasibility study to convert the state fleet to PEVs. The state has developed a state fleet fuel-efficiency standard that will require a combination of ZEVs, hybrids, and alternative fuel vehicles. In Massachusetts, there is strong bipartisan support for PEVs and recharging infrastructure; however, at times, it is a challenge to convince the legislature that PEVs are key to the ZEV mandate and achieving the requirements of the Global Warming Solutions Act of 2008. In response, there have been briefings and vehicle ride and drives for the legislature to try and bring PEVs and recharging infrastructure to the forefront.

6.1.3 Massachusetts Grid/Renewable Portfolio

The Massachusetts Renewable Energy Portfolio Standard requires that electricity suppliers (both regulated distribution utilities and competitive suppliers) obtain a percentage of electricity from renewable sources (e.g., solar, wind, hydro, and others) for their retail customers. The Renewable Energy Portfolio Standard began with an obligation of 1% in 2003 and then increased by 1/2% annually until it reached 4% in 2009. The current requirement is 11% by the end of 2016 and will continue to increase by 1% each year with no expiration date. There are additional facets of the regulation that include older renewable equipment and specific solar power carve-outs.[m]

Massachusetts has installed 1,058 MW of solar power, 107 MW of wind power, and 483 MW of combined heat and power capacity.[n] The state has implemented the Energy Storage Initiative to promote advancement of energy storage technology and availability for grid applications[o] and has been working to increase the proliferation and feasibility of growth in distributed generation resources.[p] The state's efforts in grid modernization and efficiency have contributed to their winning the American Council for an

[m] http://programs.dsireusa.org/system/program/detail/479.

[n] http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/doer/renewable-energy-snapshot.html.

[o] http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/energy-storage-initiative/.

[p] https://sites.google.com/site/massdgic/.

Energy-Efficient Economy's "Most Energy Efficient State" for 6 consecutive years.[q] Increased grid efficiency improvements and integration of renewable electricity sources will directly reduce PEV source emissions and a base will continue to grow as PEV sales increase.

6.2 Massachusetts Communities

The following sections discuss four diverse Massachusetts communities and their efforts to expand the presence of PEVs and charging infrastructure. Each maintains their own unique circumstances and approaches to expanding their PEV and infrastructure footprint.

6.2.1 Boston

Over the last 3 to 4 years, a number of factors have driven the City of Boston to pursue electric drive vehicles and installation of charging infrastructure. These factors are broadly separated into three areas: (1) legislation and policy, (2) City of Boston PEV acquisition and EVSE installation, and (3) the Metropolitan Area Planning Council (MAPC).

6.2.1.1 Legislation and Policy. The following list identifies the key multi-faceted legislation and policy initiatives impacting acceptance and implementation of PEVs and charging infrastructure in the Boston metropolitan area:

- **Air Pollution Reduction:** The Boston Air Pollution Control Commission protects air quality in the city. Its regulations for the control of atmospheric pollution prohibit the emission of air contaminants that cause nuisance, tend to be injurious, or unreasonably interfere with the comfortable enjoyment of life. These regulations cover transportation, building, and industrial sectors and address a number of provisions, including, but not limited to, programs that administer parking freezes and prevent vehicles from idling. These air pollution reduction programs are also part of the Federal Clean Air Act requirements and state implementation plans.
- **Climate Action Plan:** A City of Boston 2007 executive order on climate action calls for the city to have a climate plan that is updated every 3 years. The Climate Action Plan serves as Boston's blueprint for reaching its goals for greenhouse gas emission reductions of 25% by year 2020 and 80% by year 2050 and making sure the city is prepared for the impacts of climate change. It also focuses upon community engagement, social equity, and green jobs.
- **Boston Long-Range Transportation Plan:** The Long-Range Transportation Plan (LRTP) of the Boston Region Metropolitan Planning Organization is the long-range comprehensive planning document for the Boston region. The region encompasses 101 cities and towns in metropolitan Boston. Covering 1,405 square miles, the region makes up about 18% of the state's land area and has 48% of the state's population (more than three million residents). The LRTP outlines transportation visions for the future of the region, establishes goals and policies that will lead to achievement of the visions, and allocates projected revenue to transportation programs and projects that implement those goals and policies. In accordance with applicable federal planning regulations, the LRTP addresses surface transportation issues only.
- **Go Boston 2030:** This is a long-range planning initiative for envisioning a bold transportation future for the city for the next 5, 10, and 15 years. Based on input from 600+ participants, a vision framework has been drafted and an action plan was developed during summer 2016. A parking policy is anticipated to be rolled out next year as a recommendation by the mayor as part of GoBoston 2030.
- **Imagine Boston:** "Imagine Boston" ties into GoBoston 2030 and is a resident-driven visioning action plan to preserve and enhance what residents love about Boston, while embracing growth as a means of addressing the city's challenges and making Boston stronger and more inclusive.

[q] http://www.mass.gov/eea/pr-2015/massachusetts-named-most-energy-efficient-state.html.

- **Boston "Complete Streets":** "Complete Streets" is an advanced vision of roadways based on European city design and envisions more urban aesthetics such as shorter crosswalks, increased tree plantings, and includes alternative fuel vehicles and electric vehicles.
- **Parking Freeze Program:** First established in 1976 as a result of the Commonwealth of Massachusetts implementation plan and requirements of the Federal Clean Air Act, Boston has implemented three parking freezes in downtown, east, and south Boston. The freeze limits parking in these three areas to a maximum of 35,556 spaces. This program issues permits and requires that 5% of any new parking be electric vehicle ready and that 15% of the spaces be pre-wired for electric vehicles charging. For commercial applications, the only way to get more parking would be to have electric vehicle charging and installation of electric vehicle signage.
- **Transportation Access Plan Agreement:** An executed Transportation Access Plan Agreement between the Boston Transportation Department and a developer is required for any project subject to or electing to comply with Article 80, "Large Project Review." A large project review is broadly defined as development projects with a gross floor area of 50,000 square feet or more. Key components of a Transportation Access Plan Agreement include transportation demand measures, guidelines for ensuring the proposed development is consistent with the character of the surrounding neighborhood, and efficient use of the land.
- **Green Fleet Policy:** By executive order of the mayor, any new city vehicle should be electric/hybrid, alternative fuel, or highly efficient with a focus on replacing old vehicles with newer, more energy efficient and cleaner options. Boston is currently obtaining 25 new propane bi-fuel retrofit pickups.
- **DriveBoston:** Mayor Martin Walsh announced in August 2015 that the City of Boston has partnered with ZipCar and Enterprise Carshare to bring 80 new car-share vehicles to Boston. The program will distribute the vehicles in dedicated spaces around the city, including many locations that are currently underserved by car-share options.

6.2.1.2 City of Boston Plug-In Electric Vehicle Acquisition and Electric Vehicle Supply Equipment Installation.

There are several drivers moving Boston toward PEVs, including state and city legislation/policy, potential fuel and maintenance cost savings, and the availability of state incentives. Presently, Boston has 12 PEVs and four BEVs in the city's fleet, with a total of 10 PEVs in the central fleet hub that are available to any city employee (see Figures 11 and 12). Here, an interested city employee can easily go online to reserve these vehicles. The remaining six PEVs are spread out among the City of Boston's departments.

Boston acquires vehicles through a competitive bidding process and a purchasing agent. Specifications are identified for vehicles, the bid is open to everyone, and the vendor who meets the specifications at the lowest cost is awarded. Additionally, Boston also purchases vehicles through a statewide Massachusetts contract. For the last 3 years, Boston has only utilized incentives ($7,500 for PEVs) from MassEVIP to purchase vehicles. Boston has found the grant process to be very simple and convenient, with only the city, state, and dealerships being involved. Depending on the application of the vehicle, there are significant environmental benefits and cost savings from PEVs. This, combined with available grant funding and more extensive infrastructure, has resulted in PEVs being introduced to the city's light-duty vehicle fleet.

Figure 11. Boston central fleet hub.

Figure 12. PEVs charging at Boston's central fleet hub.

The City of Boston uses MassEVIP funds and federal tax incentives to support installation of EVSE. Most city of Boston EVSE have been sited near city-operated electric vehicles. Presently, Boston has a total of 11 electric vehicle charging stations (six Level 2 charging stations at their Frontage Road site, one at City Hall, two at the Parks Department, and two more at other central city vehicle locations). These are a combination of networked and non-networked stations and are required to be available to the public but do have a 4-hour charging limit. If charging stations are city installed, charging is free and on street charging is usually limited to 2 hours. Boston believes additional charging stations are needed and it would be useful to partner with utilities to expand the presence of charging stations. Overall, Boston is very conducive to PEVs and plans to place additional stations in the future, but specific sites have not yet been identified.

6.2.1.3 Metropolitan Area Planning Council. The MAPC is a metropolitan planning organization responsible for transportation and urban planning in the metropolitan Boston area, which emphasizes smart growth, collaboration, protection of natural resources, clean energy, and overall improved public health. MAPC has a seat on the metropolitan planning organization board and has a role in determining the transportation improvement program) projects that are slated to receive federal funds. All metropolitan planning organizations are required to develop transportation improvement programs (a

list of upcoming transportation projects) covering a period of at least 4 years. The transportation improvement program must be developed in cooperation with state and public transit providers.

MEPA applies to projects that exceed MEPA review thresholds and require state agency action. While not a permitting process, MEPA does require public study, disclosure, and development of feasible mitigation for a proposed project. MAPC will elect to submit comment letters on projects undergoing MEPA review. If a proposed project is projected to have significant transportation impacts, MAPC will recommend parking mitigation such as the installation of EV charging stations.

The following are two additional MAPC transportation activities of particular note.

- **Bid Announcement for Advanced Vehicle Technologies:** Over the last several months, MAPC has collaborated with the state's Operating Services Division and DOER to develop a bid to solicit vendor responses for a range of advanced vehicle technologies. This groundbreaking bid was advertised at the end of June 2016 and comprised the following three categories: (1) EVSE, (2) anti-idling technologies, and (3) aftermarket conversion technologies. Municipalities will have the opportunity to purchase equipment that will reduce the negative impacts on air quality or make currently owned fleet vehicles more efficient by reducing their fuel use and emissions through retrofits. It is anticipated that multiple vendors will be awarded in each category by fall 2016. MAPC and the Operational Services Division plan to hold informational workshops for municipalities to provide more detailed information about the availability of the products offered as part of the Advanced Vehicle Technologies Program.
- **Regional Procurement Program for Fuel-Efficient Vehicles:** MAPC is among a handful of organizations nationwide to pilot a regional procurement program for fuel-efficient vehicles as part of a special new partnership with the National Association of Regional Councils (see press release http://www.mapc.org/mapc-receives-grant-advance-fuel-efficient-vehicle-technologies).

DOE funded a second multistate aggregated purchasing project with NESCAUM called EV SmartFleets. Both of these projects are DOE funded out of the same grant opportunity.

6.2.2 Plymouth

The Town of Plymouth is a tourist destination, with a small budget that strives to improve energy efficiency and provide cost savings to the municipality and small businesses. The City's Visitor Service Board has been looking to become more of a tourist destination and is working on plans to enhance the city's appeal. It views electric vehicles and charging infrastructure as a way of attracting an increasingly diverse demographic to Plymouth. Toward this end, the first step was meeting with the Plymouth Office of Community Development and exploring acquisition of funds through the Department of Housing and Urban Development's Economic Development through Tourism Pilot Program.

Plymouth acquired the first EVSE unit for free as part of an American Recovery and Reinvestment Act grant, where the Plymouth Office of Community Development paid for the unit's installation and monitoring cost. The remaining six private property units used a Commonwealth of Massachusetts grant that covered 50% of the unit cost. ChargePoint provided an additional 15% reduction of the remaining units' cost, with the Plymouth Office of Community Development funding the balance of unit cost and installation. The first unit was installed 2 to 3 years ago, and had approximately 500 charging sessions in the first year. The other six units were installed in May through June 2015. There have been over 2,200 charging sessions over the last 2 years for all units.

The first EVSE was placed downtown on public parking property, with the remaining six on private property. Plymouth looked at where to best place EVSE, specifically areas with a lot of destination-type traffic. An EVSE "sales" package was assembled, providing a 5-year lease to potential private site owners in return for dedicating two parking spaces. The site owner does not incur any costs for purchasing or installing the EVSE and, at the end of the 5-year lease, can acquire the unit for free. At this point, the site

owner would be responsible for future maintenance and monitoring costs. The public has 24/7 free charging access, but at one public site has to pay for parking. One of the private property units is located at Plimoth Plantation (see Figure 13), a historic attraction, and the remaining five at a commercial retail center (with four retail outlets and a car dealership). Signage is decided on by the private property owner ("EV use ONLY"); on the one public site, there is towing and ticketing for violators. All seven EVSE are Level 2 dual port ChargePoint 2000 Series and 4000 series with video screens. Several of the units are used every day, with a couple seeing less activity.

Plymouth has found that placing EVSE units on private property is the preferred pathway, because it is quicker with less red tape. However, it is sometimes a challenge to convince potential site hosts to reserve two parking spots for electric vehicle charging only as part of the agreement. Moving forward, if the budget is available, Plymouth would like to place more Level 2 EVSE, including at places such as the regional airport, Chamber of Commerce facility, and the new town hall building. Additionally, Plymouth is researching the viability of a DCFC, especially at one of the highway exits for intercity travel. Tesla currently has an eight Supercharger complex south of Plymouth. Combining tourism with workplace charging is important and continuing the MassEVIP grant program is needed to fund the purchase and placement of additional EVSE.

Figure 13. ChargePoint EVSE at Plimoth Plantation.

6.2.3 Melrose

Melrose is a residential community 7 miles north of Boston at the end of a commuter rail with approximately 27,000 people. The Municipality of Melrose has been a Green Community since 2010, with energy reduction plans that include city fleet vehicles. Melrose wanted to gain experience with electric vehicles and set a good example when the opportunity arose through MassEVIP to buy new electric vehicles and install charging infrastructure. Melrose purchased two Ford Focuses in March 2015 (Figure 14), one of which is used by an engineer and the other by the fire captain to do safety checks. Melrose received $7,500 from the EVIP grant for each vehicle, which the fleet manager coupled with a good deal from a local Ford dealership. In order to purchase the vehicles, it required appropriation of funds for the balance of the vehicle cost, with each vehicle costing about $20K. First, the state government grant was obtained and then efforts commenced with the fleet manager and public works director to get the balance of funds through the city appropriations committee. This included briefing the city appropriations committee, who ultimately agreed with the proposal to purchase new electric vehicles.

In Melrose, there is one city-owned ChargePoint (dual head) charging station in city hall parking (Figure 14) that was installed at the end of 2014 and is accessible to the public during the day (9:00 a.m. to 3:00 p.m.). This charger is available to the public for 3 hours at a time and is free to charge, while city-owned vehicles use the charging station at night. The cost of the EVSE equipment and installation was covered by the EVIP grant, with the charger being located close to the existing meter to reduce

installation costs. There is no wayfinding signage for the charger, but there is signage in place onsite (behind center city). The public locates the charger through the ChargePoint app, which shows locations for all ChargePoint chargers. The city charging station is used fairly often; most days there is a car plugged in, in addition to the city vehicles at night.

Melrose is working on being a pilot community for increasing consumer awareness and education of PEVs. As part of this effort, private entities are talking with utilities to help fund outreach efforts, such as increasing awareness of the MOR-EV Program. Melrose will again consider an electric vehicle when the time comes to purchase another vehicle. Melrose is also considering installing a new charger in an expanded parking lot. Expanded outreach/education and incentives are necessary to increase PEV adoption and are very useful for changing behavior. For municipalities, incentive programs are very important and often a necessity.

Figure 14. Melrose public works electric vehicle and charging station.

6.2.4 New Bedford

The city of New Bedford has adopted a comprehensive building and transportation energy strategy. The basis of the strategy was established through the 2010 Energy Reduction Plan that called for a 20% reduction in building energy use in 5 years and conversion of 5% of the city fleet to alternative fuel vehicles by 2015. Today, 25 to 26% of the city fleet has been converted to alternative fuel vehicles.

New Bedford currently possesses 25 Level 2 EVSE along with two DCFC and 19 BEVs (see Figure 15). Of the 19 BEVs now within the city's fleet, ten are being used by the health department and nine are being used by the school department. Fifteen of the Level 2 EVSEs are used by the city fleet and school departments. The remaining ten Level 2 EVSEs are publicly accessible and located throughout the city. All of these EVSE have no fee to charge and are posted with a 4-hour time limit with a dedicated, painted green EV parking space. The public use locations are three EVSE in the Zeiterion Garage, one EVSE in the Elm Street garage, one EVSE installed near the high school, and two dual pedestal EVSE in the International Marketplace. Because the initial four public chargers were installed in the garages in 2014, the public stations have now been used over 1,266 times and have shown a steady yearly increase with 780 sessions alone last year.

There are three different types of Level 2 EVSE units installed throughout the city: Aerovironment, ClipperCreek, and ChargePoint. The city of New Bedford owns all 25 Level 2 stations. For the DCFC, the city also owns these two units, which were donated by Nissan. The DCFC are located at the State Pier (Pier 3) and the International Market Place. Both locations were agreed upon by the city and Nissan.

Overall, the city of New Bedford has received four grants for the BEVs and EVSE infrastructure. The first grant was only for EVSEs and was funded through the Massachusetts DOER. The remaining three grants were from the Massachusetts Department of Environmental Protection's MassEVIP Program and covered EVSE and BEVs. This program awarded a grant of $7,500 for each BEV and a sum for the chargers and infrastructure development needs. Depending on the quantity and type of vehicle(s), $7,500, $10,500, or $13,500 was awarded to cover the cost of the EVSEs and to offset any needed infrastructure work for the EVSE. Because of the city's success with MassEVIP, the city has submitted a fifth grant application consisting of an additional four BEVs and six EVSE for use by the Department of Public Infrastructure.

Figure 15. New Bedford electric vehicles and charging infrastructure.

6.3 Original Equipment Manufacturers and Automobile Dealerships

The following subsections discuss the results of phone interviews with three OEMs (i.e., General Motors, Toyota, and Nissan); two dealerships (Boch Toyota and Dube Hyundai); the Massachusetts State Auto Dealers Association (MSADA); and 12 dealer visits by Richard Valentinetti of NESCAUM during the winter of 2015. This section is organized into two major elements in order to provide a perspective from both the OEM and dealership standpoints.

6.3.1 Original Equipment Manufacturers

6.3.1.1 Holistic Approach to Supporting Dealerships and Greater Plug-In Electric Vehicle and Infrastructure Adoption.

All three OEMs take a holistic approach to supporting dealerships in the lease/sale of PEVs. The next generation of PEVs is expected to be released within a year, including the Bolt, Leaf, and Prius Plus with extended electric range and nationwide marketing efforts to support the release of these vehicles as with the previous generation of PEVs. The OEMs realize it is harder (often takes three times the effort) to sell PEVs than comparable conventional vehicles. As a result, OEMs provide dedicated and continual training to dealerships and salespeople; tools; charging stations; inform dealerships when new federal, state, or utility incentives become available; and conduct corporate ride and drives. OEMs are also promoting PEVs through ride/car sharing fleets. Additionally, OEMs have pioneered multi-unit dwelling, residential, and public infrastructure, including no charge-to-charge programs.

6.3.1.2 Auto Dealerships are Independent Franchises.

Every state has a separate franchise law, which protects dealers and defines the relationship between the OEM and dealerships. It is important to fully understand how the OEM and dealer relationship works, because the OEMs do not tell the dealerships how to conduct their business. The OEMs provide vehicle availability and work with regional purchasing officers to respond to what dealers say they want. There is diversity in dealership networks and all have different ways of operating and unique strategies and business models. For example, dealers are going to choose the inventory appropriate for their geographical area and some sell on commission, while most do not. Additionally, in a relatively small area, each dealership of the same make of vehicles will often try to be the highest seller for a particular model (for example, be the leading Volt or Corvette

seller depending upon the market). As a result, often 70 to 80% of a particular model is sold at 20% of the dealerships. This is equally true for PEVs and it is these 20% or so of dealerships that should be focused on. Outside the highest selling dealerships, those selling 2 to 5 PEVs per month are also worth pursuing.

6.3.1.3 Alternative Fuel Vehicles Require Dealer Investment. For a dealership to become a seller of PEVs requires investment, including training, purchasing of tools, placement of onsite chargers, marketing, and so forth. OEMs typically require dealerships to be certified PEV dealers and their technicians and salespeople must attend training. This training often requires several specific rounds at different levels of participation, with the dealership usually deciding who attends. This training is often a two-way street, where principals are asked to bring their ideas to the table on how to better promote and sell these products. Dealerships are required to purchase tools for servicing PEVs and training technicians, the cost of which can be considerable (i.e., often in the $30 to $50K range). If it is a small dealership, cost can become a real barrier. Placement of at least one PEV charger is typically required, with it often being more than one or even a DCFC if it is a large dealer. Frequently, OEMs challenge dealerships to promote PEVs.

6.3.1.4 Incentives for Plug-In Electric Vehicles and Charging Infrastructure. Clearly, financial incentives for PEVs and chargers are helping in Massachusetts and, in general, OEMs gravitate to where the market is most receptive. There is a general consensus among the OEMs that the current Massachusetts consumer incentive of approximately $2,500 for PEVs (as well as the federal incentive) is on target for getting the consumers' attention without overinflating the market. OEMs believe consumer incentives should be provided for both purchased and leased vehicles and, as shown in Figure 16, leasing has continued to grow as a percentage of total PEV sales in Massachusetts, while outright ownership still holds a majority. The numbers above the bars indicate annual data, while the bars indicate the cumulative ownership statistics over time.

Figure 16. PEV ownership versus leasing annually and cumulatively in Massachusetts.[r]

In general, the OEMs prefer to see incentives for dealerships as opposed to individual salespeople, although there is not complete consensus that financial incentives for dealerships from the state are a good idea. For dealerships that sell many PEVs, the financial incentive should be for the customer. If incentives are to be provided to dealerships, they need to be in sync with the dealership business model. Also, it is

[r] Massachusetts Executive Office of Energy and Environmental Affairs.

thought that it would be good to encourage dealerships through incentives to build holistic systems that look at the bigger picture to include dealership participation in ride and drives, marketing activities, agreement to work with other entities to install charging infrastructure, and so forth. It is important to consider all ingredients for making the system work, including trying new pilot programs. Training for dealerships that are doing well to keep their basic knowledge level up and incentivizing PEVs through ride and drives is also beneficial. It would also be helpful for the state of Massachusetts to designate dealerships that are PEV friendly and demonstrate significant sales and possibly provide a green dealer tax break.

6.3.1.5 Original Equipment Manufacturer Recommendations for the Commonwealth of Massachusetts.

In short, OEMs recommend more state involvement in the areas of utility participation, placement of additional infrastructure, consumer education, and coordination at the dealership level. OEMs have spent a considerable amount of time educating utilities on PEVs and being synergistic on infrastructure, but a lot of untapped potential still exists. It is very important for state policymakers to work closely with utilities. A lot more charging infrastructure is also needed, and the OEMs recommended sustainability and reliability planning with the target ratio of at least 1 to 5 or 1 to 10 public EVSE per PEV. The more public education the better and with gasoline prices so low, it is important to emphasize how fun PEVs are to drive. Increasing coordination with dealerships in regard to incentives, training, and consumer outreach is key and getting them involved early in the process through the Massachusetts State Automobile Dealership Association is ideal. Additionally, more pressure could be applied to businesses to be good corporate citizens and adopt PEVs and/or install workplace charging. Finally, while Massachusetts does not have a great network of carpooling lanes (only 11 miles), some potential high-occupancy vehicle lane access could be provided for PEVs. This approach provided a real boost to hybrid and PEVs sales in states such as California and Virginia.

The Massachusetts Department of Transportation is completing a technical capacity analysis and air quality impact analysis of high-occupancy vehicle lanes. If these reports show the capacity for access by ZEVs carrying only the driver, the Massachusetts Department of Environmental Protection would need to draft regulations and consult with the U.S. Environmental Policy Act on the Clean Air Act's State Implementation Plan.

6.3.2 Automobile Dealerships

6.3.2.1 Incentivizing Auto Dealerships and Sales Personnel.

In general, many dealers are not aware nor particularly interested in PEVs and not completely knowledgeable of the MOR-EV and MassEVIP programs. It is important to overcome this deficiency and mindset through certain actions such as dealer incentives, salesperson incentives, and information. Therefore, it may be helpful to develop a module for self-education of dealership managers and salespeople. On the contrary, employees at high-volume PEV dealerships are very knowledgeable about the MOR-EV Program and the PEVs. They engage the customer, assess the consumer's particular needs, and assist with the financial incentive application form.

It is important to generate interest at the dealership level and focus on those dealerships that are truly responsive. Unlike OEMs, auto dealerships generally believe it is beneficial to incentivize the salespeople, with approximately $250 per PEV sold being the right incentive. It requires more effort by the sales staff to sell or lease PEVs than conventional vehicles and most dealerships pay $100 to $150 per vehicle for a minimum sales commission.

6.3.2.2 Consumer Plug-In Electric Vehicle Incentives and Favorable Customer Financing.

Automobile dealerships and MSADA agree that the MOR-EV Program provides a financial incentive for consumers to purchase/lease PEVs and, when combined with OEM incentives, is especially effective. In general, roughly 8 out of 10 people who get vehicles will finance them and it is important to have innovative financing to make monthly payments more affordable for PEVs. Sometimes, OEMs offer lower interest rates on 2-year leases that would not be eligible under the MOR-EV Program for rebate,

which should be in sync with OEM incentive programs that sometimes have shorter lease periods. Auto dealerships feel incentives should be provided for purchased or leased vehicles, but are not in consensus as to whether incentives should be provided for used vehicles. However, potentially a low-income rebate program for used PEVs may be beneficial (the Commonwealth of Massachusetts currently has this under development as a pilot). As shown in Figure 17, the number of PEV sales has fluctuated over the past several years, while the number of used PEV sales in Massachusetts has slowly increased. This is most likely due to the larger proportion of used PEVs available on the market as 2011 and 2012 models reached the end of their standard 3-year lease periods. Used PEVs have a tendency to sell at relatively low prices and, typically, the batteries maintain extended 10-year warranties. However, consumers do not get a tax credit on the purchase of a used PEV. Nonetheless, the number of used PEV sales will continue to grow as the market develops further.

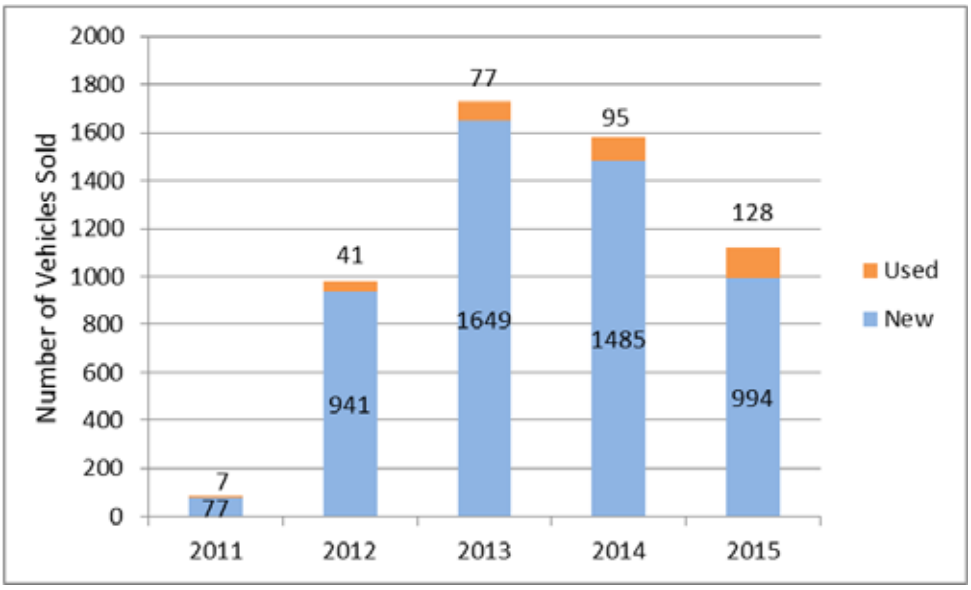


Figure 17. New versus used PEV sales in Massachusetts.[s]

6.3.2.3 Outreach and Advertising. There needs to be more pull for PEVs from OEMs, states, and most particularly from customers in the marketplace. A potentially effective approach for increasing outreach and advertising for PEVs is to utilize Tier 2 regional associations, which, in conjunction with dealers and manufacturers, put together advertisements. Going directly to the customer is the best approach through television advertising. Education (e.g., some form of state certification) is also possibly needed to combat the public perception that dealers are not interested in selling electric vehicles. MSADA and dealerships feel that a state logo or PEV certification would be beneficial for increasing dealership interest in selling PEVs and helping consumers find certified PEV dealers.

6.4 Utilities

In Massachusetts, DPU is responsible for oversight of investor-owned electric power, natural gas, and water utilities; developing alternatives to traditional regulation; monitoring service quality; regulating safety in the transportation and gas pipeline areas; and for certain aspects associated with the siting of energy facilities. The DPU mission is to ensure utility consumers are provided pilots, PEV rates, and other PEV-related stakeholder issues, with the most reliable service at the lowest possible cost; to protect public safety from transportation and gas pipeline-related accidents; and to ensure residential rate payer rights are protected.

[s] Massachusetts Executive Office of Energy and Environmental Affairs.

DPU Order 13-182, August 2014, permits distribution companies to recover the cost of EVSE ownership and operation for their own vehicle fleet charging and employee vehicle charging. Further, DPU allows and encourages investment in and cost recovery for research, development, and demonstration related to electric vehicles, EVSE, and electric vehicle charging as part of a distribution company's research, development, and demonstration proposal in its grid modernization plan or as a separate approved pilot (see Modernization of the Electric Grid, D.P.U. 12-76-B at 27-30, June 12, 2014). The DPU may also grant cost recovery for distribution company EVSE ownership and operation in response to a company proposal. For DPU approval and allowance of cost recovery, any proposal must be in the public interest, meet a need regarding the advancement of electric vehicles in the Commonwealth that is not likely to be met by the competitive electric vehicle charging market, and not hinder development of the competitive electric vehicle charging market. Additionally, DPU issued an order that PEV charging stations provide a service and are not regulated as a utility. DPU has kept the docket open and is continuing to examine distribution system impacts, grid interactive pilots, PEV rates, and other PEV-related stakeholder issues.

Massachusetts is a decoupled state, meaning that utility profits are separate from sales where utilities do not earn more money the more electricity they sell. In Massachusetts, consumers do pay a surcharge for public energy efficiency programs such as MASS SAVE, which has a mission to make energy more affordable and sustainable with energy efficiency being a major theme. MASS SAVE is technically a state program, but it is administered by gas and utility companies. In November 2015, a group of 15 stakeholders requested that Massachusetts encourage utilities to accelerate the electric vehicle charging market consistent with a set of specific criteria, including stimulating innovation, competition, and customer choice in equipment and services, leveraging private capital investment, and creating high-quality jobs.

Details provided in the following subsections detail the activities of the three utility organizations in Massachusetts most involved with PEVs and charging infrastructure to-date.

6.4.1 National Grid

National Grid's commitment to PEVs and charging infrastructure development is driven by a number of factors, including customer interest, establishing new energy solutions that facilitate movement toward a less carbon-intensive world, and synergy with National Grid's "Connect 21 Strategy," which is a guiding corporate philosophy. PEVs offer many potential benefits to consumers such as lower cost of ownership, reduced greenhouse gas emissions, and freedom from gasoline refueling stations. National Grid is a member of the ZEV Commission Task Force in Massachusetts and supports the task force's efforts to promote PEVs and encourage installations of EVSE.

National Grid installed 40+ Level 2 publicly accessible EVSE in Massachusetts between 2011 and 2013, as well as additional EVSE in Rhode Island and New York. These stations provide National Grid with information such as when drivers charge their vehicles, charging durations, and energy used. At this time, drivers are not charged to access these stations. National Grid owns and maintains all Level 2 chargers that are sited in a variety of locations, including retail, colleges / universities, public, and municipal. A couple of years ago, site owners often times did not see the value of installing EVSE given the low adoption rates, although many did recognize how it differentiated their business from others. In addition, the site owners had to agree to construction at their location (e.g. running conduit to the designated charging spots in the parking lot).

In the last 2 years, National Grid, as a DOE Workplace Challenge Ambassador, has installed Level 2 EVSE at National Grid facilities so employees can charge their electric vehicles. In addition, National Grid conducts ride and drives at their facilities, prompting some employees to purchase electric vehicles.

National Grid is currently working with the Massachusetts DOER to install three DCFC along north – south travel corridors, which will complement east – west rest stop placement of EVSE by the

Commonwealth of Massachusetts. These DCFC are targeted for easy on/off highway access points such as supermarkets and hotel parking lots.

As a member of the Edison Electric Institute, National Grid signed onto the "5% Commitment" pledge that 5% of utility vehicles will be electrified. Last year, National Grid electrified 75 vehicles, including passenger vehicles and bucket trucks. In 2015, National Grid worked with Massachusetts on ride and drive events, including one at the National Grid Energy Summit. National Grid's largest customers came to the New England Patriots football stadium and participated in a ride and drive event, as well as a panel session with presentations on PEVs and charging infrastructure. National Grid has also conducted PEV outreach as part of its utility bill newsletter, which talks about the benefits of PEVs and availability of federal and state incentives. Also, being investigated are opportunities to support PEV adoption by focusing on "underserved markets" to fill a void for charging stations. This potential market acceleration pilot is similar to California utility efforts, with a good target opportunity for underserved markets being apartment owners. National Grid does not have an electric vehicle charging rate in Massachusetts. Figure 18 provides a montage of National Grid's activities in support of PEVs and charging infrastructure.

The Massachusetts' goal to have 300,000 PEVs on the road by 2025 is highly challenging and it is critical for all stakeholders to participate to reach the ZEV goal. It is important to educate the public and convince consumers that PEVs provide value, as well as convincing potential site owners of the value proposition of EVSE.

Figure 18. National Grid support of PEVs and recharging infrastructure.

6.4.2 Eversource

Eversource became interested in PEV charging infrastructure as a result of customer pull, environmental benefits, and the fact that utilities are an integral component of the PEV supply infrastructure. Additionally, PEVs are a small-scale, flexible load that provides a diversity of opportunities to integrate into the grid and, unlike some other alternative fuels, the electrical supply infrastructure is already in place. In 2011, Eversource purchased a number of PEVs, including plug-in hybrid electric bucket trucks and other PEVs (see Figure 19), which are often worked up to 18 hours per day. Eversource is currently looking to source more PEVs.

Starting approximately 4 years ago, Eversource began installing ClipperCreek Level 2 EVSE on their utility properties (see Figure 20). These EVSE are owned by Eversource and are used solely by utility employees who are charged through payroll. ClipperCreek Level 2 EVSE were purchased largely for economic reasons, costing about $500 per unit. Initially, just one or two EVSE would be placed on a site; more recently, five or six are now placed per site. Based on the number of EVSE, the installation processes may differ. Sometimes it is best not to bring power through a building, just to bring it in from outside. It is always possible to install three to four EVSE at a site, but for higher numbers it may be more difficult to fit into an existing panel. The tipping point is often when installation of new electrical service is required.

Figure 19. Eversource plug-in hybrid electric bucket truck and PEV.

Figure 20. Eversource ClipperCreek EVSE.

In 2012, Eversource conducted a mini pilot where charging stations were given away to interested site owners who had to pay for installation. A total of approximately 30 charging stations were distributed with less than 10 in Massachusetts. In the last year, Eversource has been conducting a residential pilot for EVSE to inform how to integrate PEVs into the grid. Participants received a reduced fee for the ClipperCreek EVSE and customers with demand management functions enabled received a $10 monthly credit. The focus of this effort is to meter and study residential charging patterns with the project broken into three groups. The first is a control group where participants charge at will with no restrictions to help establish a baseline. For the second group, the vehicle charging scheme is managed (time and speed) by Eversource. Vehicle charging for the third group is managed for time and speed as well, but offers the

option for users to override. To a large extent, most customers really do not notice when Eversource manages the charging scheme.

For Eversource, utility rates are designed based on public policy, design structure, and demand on the circuit, which influences cost. For utilities, DCFC has a unique demand profile, frequently sitting idle and then spiking often at inauspicious times (such as late in the afternoon). Driven by public policy, over the last 2 years, Eversource has been conducting a pilot rate in Connecticut for charging PEVs. Essentially, Eversource has built a commodity rate (i.e., demand charge) to match the DCFC profile. This pilot adds approximately $.05/kWh to the utility rate and is similar to a built-in demand charge that is not metered. Eversource also has special time of use rates for PEV charging in multiple states. A major challenge for PEV charging (especially DCFC) is conflicting policy perspectives. Utilities of the future will have flatter, lower demand profiles and public policy says demand charges make sense to facilitate this flatter rate profile. However, this conflicts with PEVs, which tend to create electricity spiking, especially for DCFC.

In Massachusetts, the DOER has utilized penalty dollars to build out workplace and fleet EVSE in the state through MassEVIP for municipal programs and businesses. Massachusetts is putting in DCFC at service plazas and Eversource has helped look at infrastructure issues and how to select sites for DCFC (e.g., need three-phase power, which is not available everywhere on the grid). Eversource has also worked to a limited extent with Massachusetts on PEV ride and drives. Additionally, Eversource maintains a "plug-my-ride" website for educational materials on PEVs and EVSE, has a dedicated representative to answer questions on PEVs and EVSE, and periodically provides PEV/EVSE information in their monthly bill circulation.

Eversource recognizes the growing importance of PEVs with customers and public policy goals in Massachusetts. There are opportunities for Eversource to contribute more on the educational, outreach, and infrastructure side. Massachusetts has a public policy for energy efficiency, but presently there is a lack of clarity from the PUC on PEVs and EVSE with the PUC's primary focus to bring reliable, low-cost power. When guidance from the public policy side is clarified, utilities will aggressively implement it.

6.4.3 Massachusetts Municipal Wholesale Electric Company

The Massachusetts Municipal Wholesale Electric Company (MMWEC) contains member territories and the effort to build-out charging infrastructure in support of PEVs just starting to develop. Factors driving the increased interest in EVSE include customer pull and efforts to meet various towns' climate action plan recommendations. One MMWEC member territory has four standard charging stations at three different business locations with plans to install five more standard slow charging stations at another business location. Another MMWEC member has purchased a PEV as a demonstration vehicle to determine how it would work in a real-world environment. One MMWEC member considered purchasing PEVs in the past, but the costs for these vehicles has been a little too high to justify. An additional MMWEC member is currently evaluating their rate structure to determine the best way to incentivize PEVs, while another MMWEC member does not have any rates tied to PEV's and has not had any requests from customers to offer this option.

6.5 Workplace Charging

As of May 2016, there were 93 MassEVIP workplace charging participants that have completed their projects and installed charging stations, while others are currently in progress. These participants include a variety of entities, including medical institutions, universities and schools, office parks, restaurants, resorts, property ownership companies, municipal entities, and technical corporations. The lack of data availability precluded ascertaining the percentage of mid- to large-size organizations (greater than 150 employees) that have installed workplace charging in Massachusetts.

The following paragraphs discuss results from phone interviews with three workplaces that have installed PEV charging infrastructure at their facilities in Massachusetts. There are notable common

threads in these workplace applications, including they are all large facilities, are environmentally inclined companies, and have receptive management. Each company has felt a pull from employees for workplace charging, has utilized Massachusetts state incentives for purchase of the EVSE, has maintained a parking policy, and has subscribed to the philosophy of planning for the future.

6.5.1 EMD Serono

EMD Serono is a biomedical pharmaceutical Division of Merck KGAA with $2B in annual U.S. sales. EMD Serono has two locations in Massachusetts: (1) a research laboratory in Billerica, north of Boston, and (2) a business division in Rockland, 12 miles south of Boston. In 2011, an employee purchased a Chevy Volt, asked for workplace charging, and the request was granted. This provided an opportunity to be part of an emerging technology and when selling to management, it is important to emphasize the benefits of PEV charging, such as attracting top talent (i.e., scientists). EMD Serono participates on the Massachusetts ZEV Commission, conducted ride and drive events in 2014, and has brought in Nissan to discuss electric vehicles.

An EVSE recharging station was placed in Billerica in 2012 (i.e., a Level 2 dual port SemaConnect), which was handled by the facility manager. Another SemaConnect Level 2 dual port was placed in Rockland. Facilities maintain their own budget and the company-managed installation of the stations using known electricians. They also poured the concrete. In 2015, EMD Serono installed a turnkey ChargePoint Level 2 dual port in Billerica with user and owner tracking capability and access to other ChargePoint stations. Figure 21 shows utilization data for this EVSE in late summer 2016. As indicated, most standard workdays (i.e., non-weekends) showed utilization of this EVSE from one to five times per day, with the average being two charging sessions per day. This station utilized a ChargePoint incentive of 50% (approximately $2,500) toward the purchase of the unit. For this unit, ChargePoint handled all aspects of installation up to final connection. The sites are in preferred parking, near entranceways, and all charging is currently free to employees.

EMD Serono believes a designated *parking policy* is very important, which indicates who can park in each area, including those who carpool (two or more people), high-efficiency vehicles, and PEVs. For PEV charging, it is first come, first serve for employees and PEVs do not require a tag. The parking spaces are clearly marked as charging spaces, not a parking spot, and when charging is completed, the owner is expected to move the vehicle. It is still pretty much a grass roots process to maintain simplicity and there have not been any problems with non-PEVs using the spaces. Currently, there are about 10 PEVs using charging at EMD Serono, which is working fine; however, if the number increases to 20 or so, it could become problematic. In April 2016, six cars typically recharged every day, consuming about 250 kWh of energy.

To optimize the use of charging stations, it is recommended they be sited so cars can face one another similar to an island. It is beneficial to find a location where you can easily shift cables from one vehicle to the next without having to always move the vehicles. At EMD Serono, there are four spaces that can use each individual dual head unit for recharging. There are some challenges to the island approach, including snow removal in the winter. For the future, EVSE placement will always be site specific. EMD Serono is currently expanding its site and may have to rethink its PEV recharging strategy, including possibly moving its parking structure. It is important to always plan for the future and prewire whenever possible.

Figure 21. EMD Serono EVSE charger session data

Figure 22. Dual port ChargePoint EVSE at Dunkin Brands headquarters.

6.5.2 Dunkin Brands

There are 650 employees at the Dunkin Brands headquarters site comprising 191,000 square feet of building space in Canton, Massachusetts. This is the world headquarters, and research and design facility for Dunkin Brands and Baskin Robbins. PEV charging has been an easy sell for Dunkin Brands because the Chief Executive Officer and leadership are onboard and a Go Green Department was already in existence. In addition, Dunkin follows the green building Leadership in Energy and Environmental Design guidelines of which installation of PEV charging infrastructure is a component.

Dunkin Brands purchased two ChargePoint dual port charging stations (with full data analytics, communications capabilities, and that electronically informs the PEV owner when the vehicle is fully charged) and installed them at their headquarters site in 2014 and 2015 (see Figure 22). The charging stations are only for use by Dunkin employees and visitors. Incentives from the MassEVIP covered half the cost of the equipment with Dunkin Brands paying for the remaining equipment cost and installation. Installation was undertaken by known electricians familiar with ChargePoint equipment and it went very smoothly. The site is about 100 feet from the power source and runs through the grass. It did not require

any cutting of concrete. Dunkin has a large parking lot and the EVSE were placed right next to each other in advantageous locations adjacent to handicapped and hybrid parking. These preferred parking spaces help incentivize employees.

The principal drivers for installing PEV charging infrastructure was employee demand and that 50% of the equipment cost was covered by Massachusetts state incentives. If the employee need continually gets stronger and the state incentive becomes somewhat less, Dunkin would probably still install more EVSE. An advantage at Dunkin is that EVSE projects go through the finance department and the cost of the stations can be amortized over 5 years. Presently, there are no plans to install more EVSE, but if 10 to 15 more PEVs start to utilize the charger, Dunkin may install two more stations. To date, Dunkin has been very satisfied with the charging stations and their usage. The recharging sites are used every day by the same individuals, including four employees plus franchise owners. Dunkin Brands maintains a charging policy stating that once a vehicle is charged it should be moved out of the parking spot, and as more PEVs participate, the policy will be more closely enforced. Charging is currently free for employees, but this may change in the future if demand greatly increases. Dunkin does not currently own any company PEVs.

6.5.3 Tufts Health

Tufts Health is an insurer (not associated with the medical center or university) with its headquarters in Watertown, a suburb of Boston near Cambridge, Massachusetts. There are 2,800 employees scattered throughout several buildings at the headquarters site, as well as remote facilities in Worcester, Massachusetts; Concord, New Hampshire; and Providence, Rhode Island. Tufts is active in MassRides, sponsored by the Commonwealth of Massachusetts and has been involved in van pooling, carpooling, and bike riding. Being involved in conservation and sustainability, Tufts became interested in PEVS and charging infrastructure through MassRides and inquiries by several employees already plugging into 120-volt outlets at headquarters. The availability of the Commonwealth of Massachusetts EVSE rebate was especially attractive.

Tufts installed three ChargePoint Level 2 dual port EVSE at headquarters during fall 2014. BMW recently contributed another ChargePoint Level 2 dual port EVSE to install in the summer of 2016. The 220-volt EVSE were installed in the Tufts-owned parking lot (which simplified the process by not having to work with other property owners) by Tufts personnel. The EVSE were installed near power outside the garage, with all three grouped together and lined up linearly against the building and adjacent to the handicapped parking spaces (see Figure 23). Incentives from the Commonwealth of Massachusetts covered 50% of the cost of the equipment ($3,352 out of $6,700) while Tufts electrical staff managed the installation process.

There are company policies and procedures for using the EVSE, with clear signage indicating a 4-hour time limit before being required to move. Presently, only Tufts employees can use the EVSE and it is free for them, but the electricity is shut off at night. Tufts envisions charging to be self-regulated and managed in the future. The use of recharging is gradually increasing, starting initially with one Tesla and two Prius. Now there are two Teslas, two Prius, one Chevy Volt, one Leaf, and a Ford CMAX Energi, most of which use the workplace charging every day. It is expected that more employees will purchase vehicles and Tufts is presently working with BMW, which provides an opportunity for employees to get further rebates on PEVs. Tufts just joined the DOE Workplace Charging Challenge, but does not have immediate plans to place more EVSE; however, they will promote it on the company website. Tufts does sponsor an energy fair every year, where it invites PEV dealers to conduct ride and drive events. At this time, there are no specific company-owned PEVs.

Figure 23. Bank of EVSE chargers at Tufts Health.

6.6 Non-Governmental Organizations

As part of the case study, three non-governmental organizations were interviewed, including the Sierra Club (both nationally and the Massachusetts Chapter), Acadia Center, and the Conservation Law Foundation. These organizations frequently work together and provide a unified front in regard to energy and environmental issues. In October 2015, they developed the report "Charging Up: The Role of States, Utilities, and Auto Industry in Dramatically Accelerating Electric Vehicle Adoption in Northeast and Mid-Atlantic States." The following subsections describe the roles, activities, and recommendations of these non-governmental organizations.

6.6.1 Sierra Club

The Sierra Club is the oldest and largest environmental advocacy organization in the Unites States, with over 2 million members nationwide (2.4 million members worldwide) and 60,000 in Massachusetts. It is a trusted voice and has many tools at its disposal, including legal, lobbying, grass roots outreach, and events, policy, and advocacy. The Sierra Club has the ability to turn out members and bring the public into the electric vehicle discussion. The following are key activities the Sierra Club has conducted nationally:

- Launched an electric vehicle campaign in 2011 as way of addressing petroleum displacement. This included public education and outreach, including establishment of National Drive Electric week with ride and drives, an online electric vehicle guide, media outreach, and social outreach. A focus was placed on priority states (i.e., Massachusetts, Connecticut, New York, California, and Florida), four of which are ZEV states and met high-level policy requirements. In 2011, National Drive Electric week hosted 16 events of which subsequently increased to 200 events in 2015.
- In 2014, the Sierra Club conducted analyses (with alternative actions) on the state of electric vehicle markets, where they need to move to meet climate goals, and which policies and programs should be priorities.

- Utility policy and advocacy: The Sierra Club is engaged in settlements in California and is working on issues in surrounding states, with rate basing and accelerating clean electricity and electric vehicles at the same time (i.e., Massachusetts, California, Missouri, and Kentucky).
- ZEV transit buses: Currently, strong advocacy is being provided for ZEV transit buses.

The Massachusetts Chapter of the Sierra Club conducts extensive education/outreach, policy lobbying, and, for over a year and a half, has partnered with Mass Energy, a non-profit organization with a mission to make energy more affordable and environmentally sustainable. The Massachusetts Chapter is continually looking for opportunities to partner with other stakeholders to advance PEVs and charging infrastructure in the state. For example,

- The chapter is working to get the state to allow utilities to promote and encourage electric vehicle/EVSE and is supporting utilities in the process. In California, there are significant incentives for utilities to promote green energy and the Sierra Club is promoting similar incentives in Massachusetts.
- Support is being provided to the Green Communities Program, which provides incentives for communities to be more energy efficient; in Massachusetts approximately 150 are currently involved.
- In regard to infrastructure, support is being provided to identify good locations to site EVSE.
- The Massachusetts Sierra Club works with MASS SAVE, an entity administered by utilities and gas companies, which offers free energy audits of which energy efficiency is a key component.

6.6.2 Acadia Center

The Acadia Center is a nonprofit research entity that encourages clean energy and brings research expertise and options analyses. Because the Acadia Center is not a grass roots organization, it has no membership. Its role on the Massachusetts ZEV commission is to bring technical expertise, with an objective perspective, and it is well versed in legislative activities and has strong relationships with numerous organizations in and out of state. The Acadia Center works on a variety of fronts to promote PEVs and infrastructure development. This includes coalition building, proposals for utilities to put in charging infrastructure, organizing stakeholders to attend legislative hearings, and incentive programs. Additionally, the Acadia Center is working on EVSE installation, a robust municipal program, gateway cities, using electric vehicles as an electric infrastructure resource to avoid transmission and capacity investments, and examining a number of initiatives the State of California has underway.

6.6.3 Conservation Law Foundation

The Conservation Law Foundation (CLF) works primarily at the state level and for a number of years has been targeting electric vehicles as a priority. Several years ago, CLF wrote to the Patrick Administration encouraging strong state coordination in regard to PEVs. CLF was a strong proponent of establishing the state electric vehicle task force, which formalized into the ZEV commission and was codified by legislation. More recently, CLF is pushing access for individuals in lower income communities to get greater rebates for PEVs, possibly for used PEVs. CLF watches issues from a New England-wide perspective and transfers lessons learned to other states while participating in smaller bodies like the ZEV commission in other states. In the future, CLF plans to work on protecting the state rebate program, help address automobile dealer issues, reach out to low income communities, and carry Massachusetts success stories to other New England states.

6.6.4 Non-Governmental Organization Recommendations

The following provides a synopsis of the thoughts and recommendations of the Sierra Club, Acadia Center, and CLF in regard to PEVs and recharging infrastructure in Massachusetts. Overall, the non-governmental organizations believe the basics are well established in Massachusetts, but the following additional challenges and opportunities still exist:

- *Prioritization and Coordination:* It is important to continue to prioritize amongst the various PEV and recharging infrastructure strategies available, as well as strategically coordinate amongst all stakeholders in the PEV space.
- *State Rebates*: The Massachusetts rebates are instrumental to the success of PEVs and recharging infrastructure in the state. It is essential this funding (i.e. RGGI) for these rebates be continued, more consistent, and becomes legislatively codified.
- *Auto Dealers:* It is important to work more closely with the auto dealer community to offer, promote, and incentivize the sale of PEVs. There are a number of different options, including increased marketing, outreach, better training, larger inventories, and incentives for dealerships and sales personnel. In January 2016, Massachusetts did announce a new training/certification program for dealers.
- *Utility Policy:* Utilities are crucial players in the PEV and charging infrastructure space and, while policy efforts are moving in the right direction, there are still considerably more opportunities available. Policy efforts for encouraging a greater role from the utilities should be more aggressive and urgent. There is also a need to expand programs for vehicles to incorporate buildings and storage. Massachusetts has passed a law that utilities pursue energy and efficiency for commercial and industrial applications.
- *Infrastructure Deployment*: Placement of infrastructure should be as strategic as possible with funds allocated accordingly. Workplace charging for businesses and municipalities is ideal, but additionally there is a need to go to the next level with a consumer-friendly network that is interoperable.
- *Assistance to Low-Income Communities:* It is important to create awareness and ensure low-income drivers have options in regard to PEVs. Massachusetts is considering a new pilot program to reduce the cost of PEVs for lower-income individuals, but it is relatively modest.
- *Outreach and Education:* Education and outreach needs to be greatly expanded and coordinated while tapping the distribution mechanisms of a broad spectrum of stakeholders such as utilities and non-governmental organizations.
- *Clean Bus Technologies:* There is a need to accelerate adoption of clean bus technologies, even as Worcester has added six electric vehicle transit buses and Boston has committed to five more.

6.7 Massachusetts Clean Cities Coalition

The Massachusetts Clean Cities Coalition is housed in the Massachusetts DOER and covers all of the state, with a focus on petroleum reduction. Originally, Massachusetts Clean Cities was very limited financially with only a small budget for hybrid electric vehicles. In 2010, a memorandum of understanding was signed between the Commonwealth of Massachusetts and Nissan to encourage sales of Nissan Leafs in the state. Later in 2010, Massachusetts Clean Cities developed an electric vehicle task

force and conducted a 1-day ride and drive event with a Nissan Leaf of which approximately 300 people attended. In 2011, Clean Cities received $300,000 and decided to promote EVSE as a marketing tool for encouraging the uptake of electric drive vehicles. Through extensive networking, Massachusetts Clean Cities also received 100 free ChargePoint EVSE, which increased the overall value to about $1 million. A program opportunity notice went out to the communities and 140 charging stations were installed in 25 communities across the state in 2011.

More recently, after 3 years of effort, the Massachusetts Clean Cities Clean Vehicles Program was able to acquire $11.7 million in CMAQ Program funding. This funding covers 80% of the incremental cost of alternative and advanced technologies, including light, medium, and heavy-duty vehicles. Over the last several years, electric drive vehicles have been the primary focus, with about half of CMAQ funding dedicated to electric drive vehicle technologies and infrastructure. Clean Cities is also using CMAQ funding for other infrastructure projects, including $400,000 for natural gas infrastructure. For electric drive vehicles, $50,000 per site is being provided for DCFCs across the state, with 20 specific sites identified with a focus on corridors and the Massachusetts Turnpike. Grantees have been identified for 12 DCFC and Clean Cities is currently working to identify an additional eight more. Presently, there is $5+ million remaining in unallocated CMAQ funding.

Massachusetts Clean Cities conducts a number of activities, including an AltWheels event to be held in autumn 2016, covering electric, propane, natural gas, and biofuel vehicles. There are stakeholder meetings every 2 months, where sustainability people from cities and towns, vendors, fleet managers, and representatives from the Massachusetts Department of Transportation, Department of Environmental Protection, and the Department of Energy Resources meet to discuss fuel and vehicle technologies. Meetings are held across the state. At the staff level, Clean Cities works to pull together and cross-pollinate amongst state agencies. Clean Cities believes the Massachusetts vehicle rebate program is highly utilized and the combination of this rebate and placement of infrastructure is very effective. Clean Cities has also examined softer avenues for expanding PEV presence in the state, such as high-occupancy vehicle lanes, and free and preferred parking, but do not feel they are very effective. However, assistance is needed for communities to keep conventional vehicles out of electric vehicle charging spots.

Presently, Massachusetts Clean Cities is working on an electric vehicle school bus pilot in four communities and a vehicle-to-grid pilot program. Each community is doing a request for proposal with two requests for proposals currently on the street and two more in the process of being developed. Clean Cities is looking to see if utilities are interested in being involved and want to make sure electric vehicles are not missed in the energy storage discussion. In Massachusetts, a renewable energy credit is driving installation of solar and when an individual receives a rebate, they are asked about PEVs. Finally, Clean Cities has established a “Rising Star” fleet designation for fleets that are at least 35% electric or alternative fueled.

6.8 Massachusetts Cultural and Climatic Factors

Massachusetts does have a receptive, though not necessarily unique, culture or demographic especially suitable to PEVs and EVSE. It is a very green-minded (i.e., energy and environmentally

consciousness) state being rated #1 by American Council for an Energy Efficient Economy for 5 years running and has a strong technology and innovative composition. The state population has high education and income levels (but is generally frugal) and has a broad university footing and large numbers of young people in Boston. Being a small, densely populated state, there are a number of communities that suffer from significant traffic congestion and emissions challenges; commuting distances generally are not excessive. Massachusetts does experience harsh winter conditions with low temperatures that reduce electric vehicle range.

Politically, in the past and currently, significant support exists at the highest state levels for green technologies such as PEVs. ZEV state regulations and greenhouse gas goals are key enablers and provide a foundation on which to build a PEV infrastructure. Achieve the goal of 300,000 ZEVs on Massachusetts roads by 2025 will require an order of magnitude increase with ZEVs accounting for approximately 15% of light-duty vehicle sales by 2025. This amounts to approximately 40,000 to 50,000 ZEVs sold per year in Massachusetts.

7. EXTRAPOLATION: TO OTHER STATES NATIONALLY

The Massachusetts PEV and Charging Infrastructure Program informally began in the 2010 timeframe and has proven successful in expanding the acceptance and utilization of PEVs in a mixed urban, suburban, and rural cold weather environment. Based on the activities and results of this Massachusetts program, the following are recommendations to consider for those who endeavor to expand the presence of PEVs and charging infrastructure in mixed population density states:

- **Legislation and Policy:** Broad, high-level political support is a first order requirement and provides a sturdy foundation, raises visibility, and gains stakeholder buy-in.
- **Incentives:** State incentives are very important to the success of a statewide program. It is recommended that incentive bases be deep, diversified, and institutionalized.
- **Auto Dealerships:** Strong engagement is essential, especially with early adopter dealerships; motivation/incentives and awareness are critical for dealerships/sales people.
- **Utilities:** Significant opportunities exist for utilities to play a role in accelerating recharging infrastructure in accordance with stipulations of the Department of Public Utilities.
- **Outreach and Education:** Consistent, unified, and centralized PEV/EVSE messaging is important, with one-stop, on-line technical support and wide public promotion being ideal.
- **Workplace Charging:** Workplaces are highly attractive venues to deploy EVSE with larger, green-minded organizations being especially conducive. Workplaces typically utilize financial incentives, maintain a PEV parking policy, and plan EVSE deployment with an eye to the future.
- **Communities:** Communities are heavily dependent on incentives to deploy EVSE. To encourage deployment, it is important to make a business case to community leaders.
- **Non-Governmental Organizations:** Provide a broad base and outreach, including policy, advocacy, technical expertise, coalition building, and lobbying.
- **Clean Cities:** Provides a strong force multiplier for technical assistance, education and outreach, and incentives.
- **Cultural and Climatic Factors:** A receptive PEV culture is beneficial, especially if confronted with a challenging climate.

There has been a rapid progression of PEV and charging technology and increased general PEV awareness over the last several years. PEVs are becoming more mainstream, there are fewer barriers, and there is no reason to start from scratch when implementing a PEV program. Currently, there are more and better PEV vehicles, including the advent of affordable 200-mile all electric range vehicles due to arrive

in late 2016 and 2017, with broad national availability anticipated soon thereafter. It is likely that DCFC (both CHAdeMO and the Society of Automotive Engineers combo) will increase in importance with the increased availability and affordability of these long-distance PEVs.

The information in Sections 3.*2* and 6.1.2 of this report provide a framework of funding requirements (and resulting outcomes) to pursue various activities from the scope undertaken in Massachusetts. These funding elements are heavily focused on state incentives for PEVs and recharging infrastructure. For any PEV and recharging infrastructure program, there will be other upfront financial investment requirements, but of a more modest scope. This includes baseline costs for items such as stakeholder commencement, website development and customization, installation guides, and building code updates. Additionally, there will be recurring costs for other areas, including technical assistance, information guides, workplace charging advocacy, dealer outreach, marketing, events, and media campaigns.

There are lower-cost opportunities for initiating and sustaining these activities, such as leveraging existing resources and successful approaches already developed and piloted in other states, as well as strongly networking and cost sharing with other public, private, and nonprofit organizations that share a similar mission. If resources are limited, a good approach is to start with EVSE in locations that have high visibility to show the OEMs that your state is serious about infrastructure. For regions within a state that have a preponderance of small communities, an especially advantageous tact would be to piggyback to the greatest extent possible on previously initiated fundamental program requirements at the statewide level (for example, tapping centralized statewide education/outreach websites, referencing existing PEV charger installation guides with any minor changes for local conditions, and leveraging existing statewide stakeholder forums, marketing, and media campaigns).

The timeline for implementing a PEV program in other states similar to Massachusetts could be expected to proceed at a faster pace, resulting from a greater current knowledge base, ability to leverage a broader range of existing resources, and, generally, much broader PEV availability and consumer awareness than 3 to 4 years ago. However, the lower price of gasoline and generally reduced availability of state funding to support PEV and EVSE implementation could act as a dampening effect on the current uptake of PEVs and EVSE in other state communities.

Appendix A

Case Study Methodology

The following six information data streams were used to frame and inform the case study analysis of the Massachusetts PEV and Charging Infrastructure Program:

1. **Commonwealth of Massachusetts:** The Commonwealth of Massachusetts, specifically the Executive Office of Energy and Environmental Affairs, Department of Energy Resources, and Department of Environmental Protection, supplied extensive information to development of this case study. Some notable aspects include programmatic details about the activities and timeline of the program, provision of extensive stakeholder contact lists and facilitation of communications therein, comprehensive PEV registration information (by zip code), detailed information on the MOR-EV and Mass EVIP incentive programs, coordination of the team trip to visit Massachusetts stakeholders, and review of draft reports.
2. **Massachusetts Stakeholder Trip:** The Idaho National Laboratory/Energetics team met with representatives of the Commonwealth of Massachusetts in Boston on April 13, 2016. Interactive discussions ensued and comprehensive notes and best practice feedback forms were distributed and subsequently compiled and analyzed.
3. **Massachusetts PEV Registrations and EVSE Installations:** The acquisition of PEV registration data through 2015 was obtained from the Massachusetts Executive Office of Energy and Environmental Affairs and utilized to assess sales progression and market penetration. Recharging infrastructure (i.e., EVSE) information was obtained through several sources, including the Clean Cities Alternative Fuels Data Center; U.S. Census Bureau; EVSE manufacturers and network providers; utilities; PlugShare; and ICF International. This information was used to assess various factors, including EVSE market penetration, which includes by year, level, community size, and network provider; venues; and pricing to recharge.
4. **Massachusetts Infrastructure Mapping Analysis:** EVSE manufacturers and network providers ChargePoint and EVgo provided extensive EVSE charging data at the aggregate zip code level, which was utilized by Idaho National Laboratory to assess Level 2 and DCFC use. These data helped stratify zip codes within Massachusetts based on the overall number of charges per zip code and average aggregate charging per station within corresponding zip codes. These data provide insight and inferences on possible areas to further explore and approaches to consider when considering a further build-out of PEV charging infrastructure within the state.
5. **Stakeholder Phone Interviews:** Phone interviews were conducted with 27 stakeholders representing Massachusetts Commonwealth planning and political entities; communities; OEMs, automobile dealers, and associations; EVSE manufacturers, network providers, and installers; utilities; workplace charging participants; non-governmental organizations; and the Massachusetts Clean Cities Coalition.
6. **Web Research:** Extensive web research was conducted to compliment the analysis of Massachusetts PEV registrations and EVSE installations, including assessment of PEV ownership by community size and per capita, as well as assessment of numbers, levels, venues, pricing structures, and installations by community size and EVSE provider. Research was also conducted on relevant legislation and policy at the state and Boston city level and on the Massachusetts grid and renewable portfolio.