Massachusetts Drive Clean Workplace Charging Guide

Plug In America

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Linda Benevides – Massachusetts Executive Office of Energy and Environmental Affairs

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Plug In America is a 501(c)(3) nonprofit organization formed in 2005 to accelerate the shift to plug-in vehicles powered by clean, affordable, domestic electricity to reduce our nation's dependence on petroleum and improve the global environment.

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TABLE OF CONTENTS

Representative Jonathan Hecht at Massachusetts State House Ride and Drive. Sponsored by Drive Clean Massachusetts and Plug In America, *Photo by Gina Coplon-Newfield*

Executive Summary

This resource guide intends to assist companies of all sizes and circumstances in identifying critical issues unique to creating workplace-charging opportunities for plug-in electric vehicles and to help design a suitable workplace charging program. Since employees leave their plug-in electric vehicles (PEVs) unattended for long periods, workplaces offer drivers the second most valuable daily opportunity to charge.

Key Themes Emerging in the Mass Drive Clean Workplace Charging Guide

1. Massachusetts is committed to meeting its goal of 300,000 plug-in electric vehicles (PEVs) by 2025 through the use of a wide array of state incentives and programs. The Bay State's companies will see accelerated growth in their employee use of PEVs and should anticipate how best to respond to a growing need for charging infrastructure.

2. The benefits of providing workplace charging are far ranging, impacting employees, companies, and local communities through economic stimulus, improvements in environmental and public health, amplification of corporate sustainability messaging, as well as promoting growth of renewable energy resources.

3. A road map for workplace charging should generally include:

A) Perform company self-assessment

B) Identify goals and objectives of the program

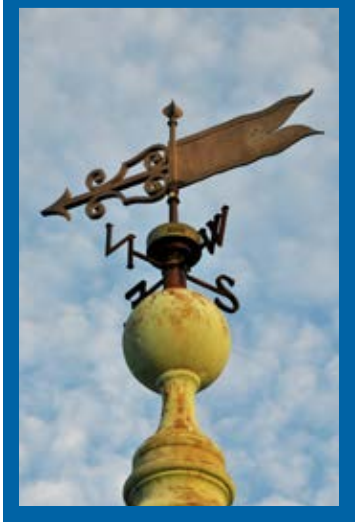
C) Prepare implementation and operating budgets to include:
   i. Hardware Costs
   ii. Installation Costs
   iii. Operational Costs
   iv. Maintenance Costs
   v. Incentives

D) Implement the program

E) Evaluate actual operations against goals/objectives/budgets

4. The corporate/employee fleet of PEVs will likely include a mix of vehicle types, some using a combination of gas/battery and some exclusively electric. Each vehicle's charging needs are different and charging clusters and policies should reflect these differences.

5. Companies should emphasize basic charging using low cost equipment, such as Level 1 charging, as a viable and effective alternative in situations where a PEV is likely to be at a specific location for continuous periods of four or more hours. Most companies will find installing a mix of Level 1 and Level 2 charging stations to be the most strategic use of their financial, electrical and facility resources.



6. Charging technology hardware runs the gamut in price and features, from basic to smart chargers. Host sites should determine what features, if any, are critical to investing in and managing their charging clusters while also recognizing that the pace of change and innovation in electric vehicles and charging technology is very high.

7. While providing free electricity might make sense for low concentrations of vehicles, ultimately, companies should charge a fee for electricity that is a little over prevailing market price in order to:

   A) Discourage PEV drivers who don't actually need to recharge their battery from using the charging space to the detriment of PEV drivers who must charge out of necessity.

   B) Avoid the appearance of creating an employee benefit available only to those who currently can afford the acquisition price of a PEV.

   We refer to this as the Goldilocks "just right" approach to charging station fees.

8. Providing dedicated, expandable locations for charging spaces is critical. Locating charging stations close to existing electrical panels reduces installation costs, as does overbuilding during installation for anticipated expansion, such as oversizing the electrical service panel and electrical conduit. Level 2 chargers should be sited to serve two or more charging spaces so drivers need only move cords, not cars.

9. Every company should have a workplace charging policy that spells out expected charging etiquette.

10. Every company should regularly monitor charging use and employee behavior to assess its program's effectiveness in meeting corporate goals and objectives, and use this information to address current and future needs.

11. As their workplace-charging program grows, companies should publicize their success to accelerate further adoption of this critical technology and reap the benefits of the positive image this creates.

Left to right: Gina Coplon-Newfield, Sierra Club's Director of Future Fleet and Electric Vehicle Initiative and Martin Suuberg, Commissioner of Massachusetts Department of Environmental Protection during National Drive Electric Week. *Photo courtesy of the Massachusetts Department of Environmental Protection.*

Introduction

Companies new to the world of Plug-In Electric Vehicles (PEVs) often struggle over what a workplace charging program might look like. Not only do they learn the language of electric transportation is complex but also the range of options for workplace charging is vast and rapidly changing. Acquiring practical knowledge about workplace charging, however, is increasingly pressing. With 400,000 registered electric vehicles currently driving on US roads and ten thousand or more added each month, the impact of PEV technology on workplace facilities will only grow.[1] Given that 77% of Americans drive less than 20 miles per day to work[2] and a majority of households still own two vehicles, current PEV model offerings, many of which go 80 miles between charges, are more than sufficient to meet most commuter needs. In addition, competition to increase vehicle range and efficiency is stiff, with three major manufacturers promising to produce 200-mile range all-battery versions at the current new car median price point of $30,000 by 2017.[3, 4]

Plug In America estimates that currently 60% of PEV drivers will need charging at work, either because of longer commute distances or lack of convenient charging where they live. Employees will expect workplace charging solutions, and companies must anticipate how to exploit the benefits of vehicle electrification. As the preeminent independent nonprofit dedicated to accelerating the shift to plug-in vehicles, Plug In America has many years of consumer experience with PEV technology and Electric Vehicle Supply Equipment (EVSE, aka: charging stations). By using this Guide, companies should feel confident they have the proper decision-making framework to construct a workplace charging program.

Massachusetts's Leadership with Electric Vehicles

Not surprisingly, Massachusetts is leading the revolt to end our country's reliance on fossil fuel and embrace a clean energy future. Over the last five years, Massachusetts has ranked first in the country on the American Council for Energy Efficient Economy's (ACEEE) state energy-efficiency scorecard.[5] Massachusetts now turns its attention to the transportation sector, which alone contributed 39% of all Greenhouse Gas emissions (GHG) in the Bay State – the single largest contributor.[6] GHG emissions are a key cause of climate change, as well as a wide range of negative public health outcomes.[7] Fossil fuel dependence also affects the economic health of the state, causing a petro-dollar outflow of over $9.7B annually, a huge redistribution of the common wealth, often to overseas, politically repressive regimes.[8] As a result of transportation's dramatic impact on the Bay State's environment, economy and communities, Massachusetts has launched a number of notable state agency efforts to curb its citizens' appetite for oil and accelerate the adoption of PEVs.

In 2008, Massachusetts signed the Global Warming Solutions Act,[9] creating a framework for reducing GHG by 25% below 1990 levels by 2020 and 80% below 1990 levels by 2050. On September 30, 2013, Massachusetts convened the MA EV Initiative Task Force[10] to develop an electric vehicle action plan; barely a month later the state voluntarily signed onto California's Zero Emission Vehicle (ZEV) Memorandum of Understanding[11] setting a goal, with eight other signatory states, to register 3.3 million PEVs and fuel cell vehicles nationally by 2025. Massachusetts's share of this goal is to register 300,000 zero emission vehicles by 2025. To succeed, Massachusetts recognizes it must spur dramatic market transformation as, at the end of the third quarter 2015, it had 5,500 registered PEVs.[12]

The State's Action Plan for achieving its share of ZEVs focuses on three main goals:

1. Continuing to build the needed charging infrastructure and planning for the future;
2. Spur market growth of ZEVs through incentives; and
3. Expand potential buyer awareness of ZEVs.

Massachusetts's implementation of this action plan is broad-based. The Massachusetts Department of Environmental Protection has created the Mass Electric Vehicle Incentive Program (Mass EVIP), allocated over $2.4M to fleet vehicle rebates, and added $1.4M in grants for workplace charging installations.[13] In conjunction with the Center for Sustainable Energy and the Massachusetts Clean Cities Coalition, the Massachusetts Department of Energy Resources program (MOR-EV) offers rebates of up to $2,500 to customers purchasing or leasing a PEV or zero-emission motorcycle. At the same time, the Mass Department of Public Utilities passed regulations necessary for streamlining EV deployment within utility service territories. The final language[14] exempted public charging stations from retail sale electricity regulations, enhanced time-of-use rate options to promote off-peak charging, and framed expectations for utility involvement in charging infrastructure. Additional efforts include the state's Mass Drive Clean Campaign, in partnership with Plug In America/ REACH Strategies, MassDEP, and the John Merck Fund, which by the end of 2015 had funded eight ride-and-drive events at public and private company campuses.

Because expanded workplace charging is critical to help the state reach its adoption goals, company-based efforts will be increasingly emphasized.

Why Charge at Work? Assessing the Benefits

Workplace charging enhances the economic, environmental and cultural goals of companies. A majority of companies (80%) offering charging as a benefit provide it free, to attract and retain their workforce.[15] Since most commuters drive less than 20 miles to work, this amounts to about eighty cents worth of electricity being used per day per PEV.[16] US Department of Energy data also shows employees who were offered charging at work were 20 times more likely to drive a PEV.[17]

EMPLOYEE

When companies provide charging, employees directly benefit, with huge savings in fuel and enhanced range of their PEV.

It is common for PEV drivers to save an average of 30-50% in fuel costs.[18] Over a year's time, even at today's deceptively low gas prices, the average Massachusetts driver would receive the equivalent of a $300 cash bonus from gas savings.[19] With the sixth highest average commute times in the country - 27.3 minutes - Massachusetts drivers idle in traffic more than most.[20] PEVs use virtually no electricity when stopped, saving fuel and cutting GHG emissions.

Multi-unit Dwellings (MuDs) comprise nearly a third of urban residential markets in the Northeast[21] so many drivers are without access to a garage or charging where they live. At the same time, when compared to other regions of the country, Massachusetts lacks widely deployed public charging infrastructure. As a result, many employees simply could not use PEVs without the option of workplace charging.

COMPANY

While employees enjoy extended range and low emission commutes, companies also reap benefits. Many companies are increasingly concerned about sustainability performance on their bottom line, with shareholders assessing the impact of nonsustainable practices on different industry sectors. Proactive companies are even baking sustainability reporting into their corporate structures, becoming certified B-Corps or forming under Benefit Corporation statutes.[22] Electric vehicles can become part of this powerful new story. Companies adopting PEV technology can report carbon-reduction progress to their shareholders and help their region meet greenhouse gas and criteria pollutant emissions reduction goals. These companies demonstrate leadership to employees,

shareholders, competitors and community alike with visible, dedicated PEV charging spaces. Workplace charging promotes a message that attracts and retains talented employees, branding the company as forward thinking and community minded.

Participating companies can join the USDOE Workplace Charging Challenge for national recognition and access to a variety of resources and benefits.[23] Web-based mapping applications, such as PlugShare.com and USDOE's alternative fueling station locator,[24] (accessible from smart phones and WiFi connected devices) further enhance the visibility of corporate investment in workplace charging.

COMMUNITY

Economic and environmental benefits accrue for the local community as well.

Vehicle emissions represent the second largest source of air pollution after electric utility generation nationally[25] and are the cause of 40% of GHG in Massachusetts. Thankfully, Massachusetts's grid is significantly cleaner than other states. In 2014, Massachusetts generated 59% of its electricity from natural gas, which emits half the carbon of oil and coal, and 9.5% from renewable energy.[26] Because electric drive is four times more efficient than its combustion engine counterpart, even if it charges with coal-generated electricity, the vehicle's total emission profile is far less than a typical new gasoline engine. As more renewable energy comes on line, electric vehicles operating in Massachusetts "burn" cleaner as they age.

Public health impacts of tailpipe emissions are not trivial. Passenger vehicles remain a major source of carbon monoxide, nitrogen oxides and volatile organic compounds. As many as 159 million Americans live in areas where the air is unhealthy to breathe, and emerging research indicates that those who live and work near major roadways suffer disproportionate health effects. Removing fossil fuel from our communities makes them healthier, saving huge amounts in related healthcare costs.[27]

PEVs are even good for the local economy. Money spent on electricity benefits domestic energy suppliers, reducing the amount of exported petro dollars (currently worth over $9.7B annually). Money not spent on fuel translates into consumer savings – which results in additional consumer spending. One study suggests such spending has a remarkable 16:1 multiplier effect on local job creation.[28] Electric vehicles can actually strengthen Massachusetts's economy while cleaning its air and improving its public health.

Dirty Electricity and the Long Tailpipe Myth

PEVs get unjustly criticized for merely transferring tailpipe emissions to smokestack emissions. It boils down to where the electricity comes from. A study released by the Union of Concerned Scientists in 2012, "State of Charge: Electric Vehicles Global Warming Emissions and Fuel-cost Savings across the United States," concluded EVs are vastly superior in their emission profiles over most regions of the US. If you live in Wyoming, where coal is used for baseload electricity generation, your PEV does contribute to GHG emissions on a par with a high mileage nonplug-in hybrid. Conversely, if you live in Massachusetts, with an increasingly healthy mix of renewable energy generation sources, including wind, hydro, solar, and biomass, and the cleanest grid in New England, your electric vehicle emits much less GHG than your neighbor's gas-powered car. The good news is that as Massachusetts's grid gets cleaner, so does your PEV.

Planning For Success; A Road Map for Workplace Charging

Is your company a good candidate for workplace charging? What follows is a recommended "road map" of steps needed to design, implement, and maintain your organization's PEV Charging Program:

1. Perform Company Self-Assessment: survey employees and identify who will be acting as the organization's program sponsor
2. Identify goals/objectives of the program
3. Understand the technology choices and related costs
4. Prepare implementation and operating budgets
5. Implement the program
6. Evaluate actual operations against the goals/objectives/budgets

COMPANY SELF-ASSESSMENT

As a first step, identify interested stakeholders, look for motivated employees and key decision makers, and bring them to the table to begin the conversation. Companies with a sustainability team can leverage that interest. Building facilities managers are also likely participants. A company self-assessment can help the group anticipate the path forward.

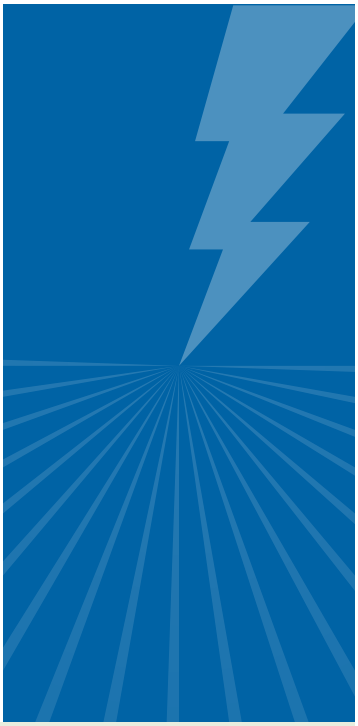
For starters, the group should consider the following questions:

1. Do one or more employees already drive a plug-in electric vehicle?
2. Do you already have employees expressing an interest in electric vehicle commuting?
3. Has a survey found employee interest in providing workplace charging? For a sample survey see *Appendix B Sample Employee Survey*.
4. Does your company or organization have an existing sustainability mission or green team?
5. Is your company concerned about the environment and/or public health; does it actively brand itself as sustainable or a registered benefit corporation?
6. Is it looking for a way to distinguish itself from competitors?
7. Is your company a member of a Mass DOT Transportation Management Association (TMA)[29] or involved in a low emission Clean Air program? To find out more about these programs see *Appendix E Massachusetts Workplace Charging Resources- Links*.

If you responded "Yes" to any of these, we advise the group to move to the next step: drafting a road map for instituting workplace charging with recommendations to bring to management.

IDENTIFY GOALS AND OBJECTIVES OF THE WORKPLACE CHARGING PROGRAM

The goals and objectives of your program can be customized to reflect a variety of institutional needs. Workplace charging can be installed to respond to existing workplace demand, to generate further employee interest in the technology, or to spur conversion of the corporate fleet. Whatever the goal, consider what you intend to evaluate about your program and select the most important data points to monitor from the beginning. Finally, who will be responsible for monitoring, collecting, and analyzing the data collected on your charging program?



PREPARE IMPLEMENTATION AND OPERATING BUDGETS

After formulating your goals and objectives, we recommend you carefully consider your budget priorities. Budgeting for charging stations has several key cost components – hardware, installation, operational and maintenance costs.

Comparison of Common Charging Levels

CHARGING LEVEL	DESCRIPTION	SUPPLY VOLTAGE	AMPS	CHARGING RATE	RANGE PER HOUR OF CHARGING
Level 1	Slow Charging	120	up to 16A	1.9+ kW	5-8 miles
Level 2	Medium Charging	208/240	up to 80A	3.3+ kW	10-24 miles
DC Fast Charger	Fast Charging *(also "rapid" or "quick")*	208/480	100-200A	25+ kW	40-80 miles*

**Range reflects 20-30 minutes of charge time*

UNDERSTAND CHARGING STATION HARDWARE CHOICES: THE BASICS

Charging station hardware encompasses every level of functionality imaginable, from units that just plug and play to units with smart meter connectivity, allowing your local utility to manage your vehicle's charge rate based on peak load needs.

Charging a PEV's battery takes more time than pumping gas into a fuel tank. However, charging takes advantage of a feature common to all passenger vehicles – they sit unused an average of 23 hours out of every day.[30] With Massachusetts average daily commute distance of 21 miles, drivers have ample time to meet their daily driving needs.[31] While most PEV owners will charge where they live, workplaces offer plenty of vehicle down time for batteries to charge, even using lower amperage (and less costly) charging equipment.

Electric vehicle supply equipment (EVSE), also known as charging stations, fall within three categories of charging speeds: Alternating Current Level 1, Alternating Current Level 2, or Direct Current (DC) Fast Charger. *Appendix A is a good reference guide to a variety of common terms.*

Each may have a role in a workplace charging cluster, with some important distinctions. First, **always keep in mind, no matter how fast the charging station, the PEV's software dictates the charge rate**. A charging station's primary role is to act as a safety device between the vehicle's battery and the electric grid, ascertaining state of charge and adjusting the electric current feeding the battery based on the vehicle's specifications. Merely connecting a 2014 Nissan LEAF, whose maximum onboard charge rate is 6.6 kW, to a 100A Level 2 charger capable of providing 20 kW, won't "speed up the charging."[32] The LEAF will only draw 6.6 kW.

When researching charging technology, consider the type of PEVs likely to use your charging cluster. By necessity, employees using battery electric vehicles often must charge at work to ensure adequate range to get home. Plug-in *hybrid* electric vehicle drivers have some form of gasoline backup, making charging more a matter of convenience done to extend the electric range, perhaps making an all-electric round trip possible. It is always preferable to have the appropriate level of charging available for both vehicle types to maximize their battery use. Besides employee usage, does your business expect to convert any of its light-duty/passenger fleet vehicles to electricity? Will they be used frequently during the day, requiring dedicated charging spaces as well as the fastest available charging? Next to the average commute distance of your employees, the vehicle fleet composition should help guide your decisions on the appropriate charging levels to install.

LEVEL 1 CHARGING

Level 1 - wall outlet

Level 1 charging (can but doesn't have to) uses a 120-volt AC outlet protected by either a 15- or 20-amp circuit breaker with a ground-fault interrupter. The cost of a Level 1 charging station can be less than $400; installation can be even less, depending on power availability and siting. Level 1 charging stations can provide up to 1.9 kW (5-8 miles of PEV range per hour). Since Level 1 and 2 charging stations all use the universal standard connector, the SAE J-1772, all PEVs have charging ports that work with either charger level.

The many virtues of Level 1 charging arise precisely because vehicles tend to sit unused for long periods. While it can take 48 hours to charge a Tesla's large battery using Level 1, the average daily amount of energy needed by a typical PEV is approximately 8 kWh, which equates to approximately four hours of charge time on a Level 1 service. An entire class of PEVs called Plug In Electric Hybrids, such as the Chevy Volt, have smaller batteries that need only Level 1 charging during the day. It also bears saying that all PEVs come equipped with a portable Level 1 charging station using a

standard three-prong plug. Some drivers use this portable Level 1 charging station exclusively, either where they live or at their workplace, making the availability of a simple 120V electrical outlet a key consideration. Providing an outlet is a thrifty solution for some users, although a permanent, hardwired Level 1 charging station with a J-1772 plug adds convenience and eliminates wear and tear on a driver's portable charging unit.

For companies concerned about the cost of providing electricity to employees, Level 1 charging stations offer the most cost-effective form of charging (averaging 15 cents per kilowatt hour of electricity consumption). Employees plugged in to Level 1 chargers also need not worry about moving their vehicles during the workday as they often need all day to charge their batteries. Level 1 draws the least current during daytime peak usage, thereby subjecting companies to less risk of incurring special utility fees associated with excessive demand or higher time varying electricity rates penalizing users during peak demand.

Level 1 operates at lower amperages such that many more chargers can be deployed given an available electrical panel space than higher amperage Level 2 units, obviating the need for a costly upgrade of the service panel. That means more access to PEV charging for everyone. Often energy efficiency measures reduce a facility's load sufficiently to create ample panel space for Level 1 for no additional cost. The Seattle-Tacoma International Airport, for example, installed 48 additional Level 1 charging spaces in their parking garage by using the excess electric service panel capacity gained after replacing existing light fixtures with LED fixtures.

Level 1 charging is a cost-effective, functional way to charge a PEV for many drivers.

LEVEL 2 CHARGING

Level 2 charging units come in much greater variety of capacity sizes than Level 1, providing anywhere from 15 amps to 80 amps of continuous current. Stated alternatively, Level 2 can provide a vehicle from 3 kW (10-12 miles of PEV range per hour) to 20 kW (60-70 miles of PEV range per hour), depending on the vehicle. Currently, most PEVs charge between 3.3-7.6 kW. Tesla products boast the industry's fastest Level 2 onboard charge rates – nearly 20 kW. Given the current and future state of vehicle charge rates and battery sizes, a 32A Level 2 charger is probably the most practical for workplace charging, providing up to 7.7 kW.

The cost of Level 2 charging stations has also dropped significantly since their introduction. Some can be had for less than $400. Adding "smart" and networked features for enhanced access control, Internet connectivity, and data management functionality bumps the base price up significantly.

ClipperCreek Dual Port Pedestal HCS-40 Level 2 charging station

SAE J-1772 Standard connector

For comparison, a basic dual port pedestal 32A Level 2 charging station can cost less than $1,600 while a networked “smart” dual port version can exceed $6,000, plus include additional monthly connectivity fees. While installation of Level 2 charging need not cost much more than Level 1, with its larger wiring and higher power draw, it more frequently impacts the available capacity on a facility’s electrical panel.

Level 2 charging most directly benefits vehicles that rely solely on their battery, not plug-in hybrid electric vehicles. This is true because the battery electric vehicle comes with a larger battery and has faster onboard charge rates. An empty 2015 Nissan LEAF can recover all its charge in a little over 3.5 hours when using a 32A Level 2 charging station. Of course, faster charging means the hourly cost of electricity is commensurately higher, averaging almost 80 cents per hour. Because of its fully onboard charging speed and the average commute mileage, a battery electric vehicle can recharge from a typical work commute within 1-2 hours.

DC QUICK CHARGING TECHNOLOGY

DC Quick Charging (DCQC) technology is very different from Level 1 or 2 charging. Designed to operate on much higher power, up to 480 VAC three-phase electrical superstructure, DCQC can charge battery electric vehicles with up to 50 kW, which recover up to 80% of their battery capacity within the first 30 minutes. Bypassing the vehicle’s onboard charger, DCQC units transfer DC current directly into the vehicle’s battery, rather than rely on the vehicle’s charger to convert AC current to DC. Only some battery electric vehicles with specialized charging ports can connect to DCQC. Unlike the J-1772 universal connector common to Level 1 and Level 2 charging, no standard yet governs the DCQC connector. A rivalry between Asian and European/North American manufacturers has produced two competing DCQC connector approaches – the CHAdeMo connector and the SAE CCS connector. CHAdeMO is a defacto standard in Japan and Korea, but not accepted nor ratified by the American SAE. DCQC units can cost over $20,000, require expensive three-phase power hookup to install, and, with the lack of a uniform standard, have seen limited deployment as part of workplace charging infrastructure. Nonetheless, several hardware manufacturers are now offering units with both connectors, enabling any vehicle with either DCQC charge port style to charge, and prices are coming down.

Veefil 50kW DC Fast Charger charging station

CHARGING LEVEL ANALYSIS AND RECOMMENDATIONS

Notwithstanding some similar up-front costs between Level 1 and Level 2 charging, **we strongly recommend that businesses emphasize Level 1 charging for employees.** Vehicle manufacturers are in a race to create cars with faster and faster charging capabilities – with EVSE manufacturers following their lead. Vehicles with large batteries certainly benefit from faster charging when the battery is heavily depleted and the owner needs to drive the car immediately. However, in the most common scenario, an employee drives 20 miles to work and leaves the car unattended for 8 hours, allowing ample time for any PEV's battery to recover charge lost during their commute with a slower charge rate. Level 2 charging either pressures workers to take time out of their day to go back out to the parking lot and unplug to allow someone else to access the unit – creating a "car shuffling" program rather than a "car charging" one – or creates frustration between drivers when someone needs to charge and a station is not available.

Level 2 charging does have its place. Many commuters travel long distances in battery electric vehicles or need to use their vehicles during the day for work-related functions. Many companies are converting their own fleets to electricity and demand faster charging to maximize road time during the day.

Accordingly we recommend providing a mix of both Level 1 and Level 2 charging stations to address the different battery sizes, range requirements, and onboard charge speeds of vehicles and drivers. Ideally, those driving plug-in hybrid electric vehicles with back-up gas engines do not use Level 2 charging stations but leave them for the all-battery electric vehicles. While we believe longer-range battery electric vehicles will become reality, commute distances will remain the same, making the practicality of Level 1 charging still attractive to a large number of companies.

Given the current cost and specialized nature of DCQC, it is unlikely companies will invest widely in this technology in the near term. Some large companies, particularly those with active corporate fleets, may find using the rapid charge rate helpful. Most, however, will find that DCQC offers little competitive advantage, especially with extremely high up-front costs and risks of incurring utility demand charges. For the foreseeable future, DCQC technology will likely remain part of much larger projects creating public supercharging networks and electrifying major travel corridors.

A Note on Tesla

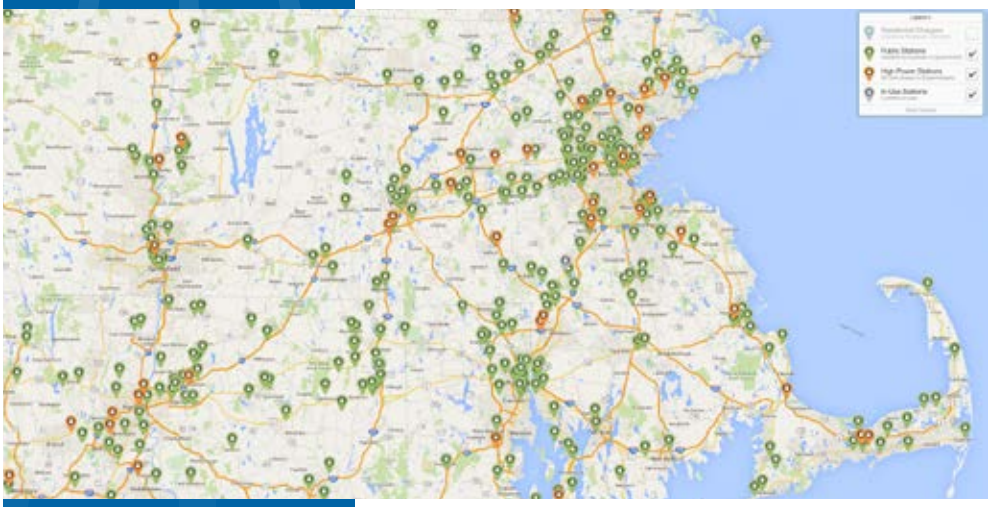
No discussion of EVSE would be complete without some discussion of Tesla, an industry leader in innovative design and function. The first to create long-range all-battery electric vehicles (200+ miles) with high-performance and luxury features, Tesla's success portends the impending dominance of the electric vehicle. Notwithstanding Tesla's critical acclaim, companies need to understand that if you install a Tesla charger at your workplace, only Tesla's can use it. On the other hand, Tesla's vehicles come equipped with an adapter to access the universal J-1772 standard connector. Some larger amperage Level 2 chargers (e.g., 80A versions) are fully capable of matching the Tesla S's maximum onboard charge rate of 20 kW. Stick with the industry standard J-1772 connector to be compatible with all vehicles.

BASIC, SMART AND NETWORKED CHARGING

ChargePoint Level 2 - Smart charger

After determining the appropriate mix of charging levels, companies must next consider the value of additional features.

Basic charging stations stress no-frills reliability and low cost. They perform out of the box and are compatible with all vehicle types but offer the host no direct means of measuring electricity consumption, monitoring, controlling access, or billing for electricity. Often hosts using basic chargers develop alternative solutions to address these issues, if they are deemed critical, such as constructing behavior policies or adding accessories that meet access or reporting goals. One simple solution to collecting fees for electricity use is to provide window stickers or a monthly charging pass to employees to show they are entitled to use charging spaces. Companies can implement and manage such a system much like handicapped spaces are managed. Another solution is to have employees pay to receive a key used to activate the charger with a simple key-lock switch – the "bathroom key" design.



Massachusetts current infrastructure deployment courtesy of www.plugshare.com

Smart chargers can collect granular data on the number of charging sessions per day, the amount of electricity consumed per charging station, and charger availability for the purpose of energy management. For example, energy consumption by a few dozen vehicles pales by comparison to chillers and other plant equipment usage. In some situations, not every penny needs to be accounted for, so that the cost of extravagant reporting mechanisms can be avoided. Smart chargers also can provide sophisticated access control features that can facilitate billing by credit card, pay by cell phone, or use of employee RFID cards to prevent public access and allow the host to set pricing. Smart chargers also can be part of a larger networked service, which allows a paid subscriber to activate any of that network's charging stations, usually with a unique identifying fob, and offers some form of electricity discount. Smart chargers are typically connected to a cloud-based dashboard via cellular or Wi-Fi communication platforms; of course, these communication platforms also mean additional monthly or annual connectivity charges. Nonetheless, this

range of services might offer particular advantages to companies who must manage and monitor PEV fleets, yet not all companies need these. Networked and smart charging solutions can offer a wide range of services rolled into one unit or network service.

Whether choosing a networked or non-networked "smart"[33] charger, enhanced functionality means costs rise accordingly. Basic charging stations can also provide à la carte solutions to create desired functionality while leveraging their cost-effectiveness. Many of these features can be strategically added to existing basic charging clusters as the company's charging policy evolves and usage increases.

Each company will need to consider what features they are likely to need and how best to address these issues within their available budget. Simple solutions already exist for most companies to be able to provide economical charging to their employees. Given how inexpensive electricity is, however, carefully consider the cost of hardware versus the return on investment. We believe companies using state incentives promoting investment in workplace charging should tailor their technology choices carefully to match their actual needs. These incentives are intended to maximize the amount of charging infrastructure available to employees.

A Note on Disruptive Technology

EVSE and auto manufacturers are rapidly evolving access and energy management accessories, many of which use smart phone technology as well as the vehicle's telematics and onboard capacity to manage charging data. The market is still at a very early stage. While the future is bright, the long-term role of workplace charging remains largely unforeseeable; we simply do not know what a world will look like when everyone drives a PEV that gets 300 miles of range, how mass consumer behavior will influence charging technology, and how charging technology itself will evolve. Deployment of charging infrastructure should be done through judicious investment to accentuate this growth, yet with the reasonable expectation that both the vehicle and EVSE industries will continue to undergo rapid change.

INSTALLATION COSTS

Besides hardware costs, a significant part of your budget will go to installation. Locating charging spaces close to the electric panel makes the installation easier and cheaper. Avoid running conduit under hardscape (e.g., asphalt road or concrete sidewalk) as this will dramatically increase costs. If you must trench to reach charging spaces, strive to go through softscape (e.g., grass). Always plan for expansion over time and place oversized conduit to allow future rewiring. Conduit is a cheap component to oversize compared to recutting and patching pavement.

Available Power

You will need to review your available power and electrical panel, as well as the ease with which it might be upgraded for expansion. Any investment made in electrical upgrades during installation, just as with oversizing conduit, will save time and money when electrical demand increases. Always consider the added electrical draw of an expanding charging cluster. Review case studies in Appendix C to see the experiences other businesses have had with expansion. Start small, but anticipate growth.

Utility

We recommend you speak with your local electric utility account representative as part of your installation planning. Your utility has a vested business interest in promoting electricity and growing load related to transportation within its service territory. They should be willing to assist in reducing installation costs on their side of the meter. In some instances, they might be willing to bring power even closer to your proposed charging space site.

They can also provide information about:

- Your prevailing electricity rate and likely impact of charging on your current utility bill;
- Green power options for subscribing to renewable sources of electricity to further the zero emission benefits of electric vehicles;
- The availability of time-of-use (TOU) rates to promote more efficient use of power during peak usage periods;
- Any risk of incurring additional demand charges as electric power consumption rises at your facility and possibly exceeds the monthly consumption cap for your existing rates;
- Any incentives they might provide for EVSE or PEVs;
- Assisting in identifying the location of available transformers and any power distribution upgrades needed for expansion.

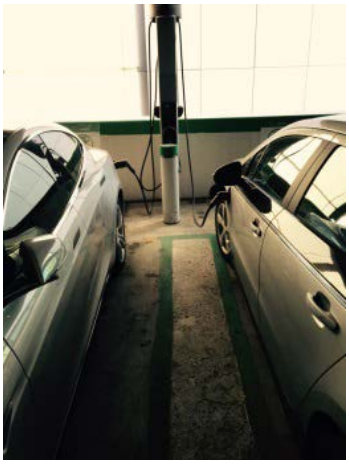
Electricians/State Permitting[34]

EVSE installations do not require specialized electrical knowledge and any licensed electrician should be capable of understanding how to prepare the charging site and supply the proper wiring configurations. Section 625 of the National Electric Code (NEC) as well as most EVSE manufacturer materials provide electricians with the necessary installation information. All Massachusetts's electricians who are members of the International Brotherhood of Electrical Workers (IBEW) have exposure to emerging technologies, like EVSE, through their apprenticeship and continuing education curriculum. Permitting of installations is generally administered through the code enforcement authority of your local town or municipality.

Dedicated Charging Spaces/Site Location

Any investment in charging stations requires some form of dedicated charging space.

Does your company own its parking facility or lease it? If the former, making decisions taking parking spaces out of general rotation will be easier. If you are leasing space, you will need to bring the parking lot owner or landlord into the discussion and work together on a plan. Irrespective, the core issues are the same.



Logan airport garage electric vehicle charging stations

There is no standard ratio of chargers to total available spaces. Some states, such as Hawaii, have passed statutes that require one charger per 100 spaces in public parking lots.[35] Google targets 10% of its spaces to have charging stations – admittedly, a very aggressive ratio. We recommend clustering spaces together and that they not be located in areas considered "privileged." Most EV drivers are happy to have electricity available and don't need further preferential treatment. Nonetheless, to keep the installation economical, placement must be made in close proximity to the electrical supply, which often is near the side or front of buildings. Sound planning means having spaces located in areas where expansion is possible.

Parking Configuration

We recommend using head-in parking configurations. Consider placing one charging opportunity per dedicated space when using Level 1 charging stations so a vehicle plugs in and "owns" the location for the duration of the working day. When placing Level 2 chargers, because of their faster charge rate, the emphasis should be on moving cords not cars. Positioning Level 2 chargers to access two to three spaces makes the most efficient use of their speed advantage. Select Level 2 units with longer cord sets (>20 feet) to allow these chargers to service multiple spaces. Positioning chargers on "islands" that allow spaces on either side to access the cord set also increases availability.

ADA

The Americans with Disabilities Act (ADA)[36] has guidelines that likely impact charging spaces in Massachusetts. The 2010 standards set minimum requirements – both scoping and technical – for newly designed and constructed or altered State and local government facilities, public accommodations, and commercial facilities to be readily accessible to and usable by individuals with disabilities. These might impact the height and location of the charger's connector and activation panel as well as the amount of parking space available for ingress and egress from the vehicle. For information about the ADA, including the revised 2010 ADA regulations, please visit the department's website www.ADA.gov, or for answers to specific questions, call the toll-free ADA Information Line at 800-514-0301.

Snow Removal/Cold-Weather Impacts

Besides choosing hardware with sufficient reliability ratings for outdoor applications, prepare the site adequately to address harsh winter conditions. Locating chargers close to the curb facilitates use and minimizes tripping risks from the cord, but places the unit at risk during snow removal activities. Steps should be taken to adequately educate snow removal contractors about the charger locations and how to safely clear around chargers. Site chargers away from snow storage areas. Provide bollards where necessary to minimize risk of plowing damage to units. Ensure that cord sets are properly stored off the ground before snow events. Connectors should always be placed in holsters to avoid rain, snow and ice accumulation. While most pedestals hold chargers sufficiently far off the ground to protect them from car bumpers, significant snowfall and drifting could bury cords and even the charging stations themselves. Self-retracting cord sets are available for many EVSE models to minimize the risk of having the connector left on the ground. Consider placing charging stations in areas that are protected from the elements – closer to buildings or sheltered by roof overhangs.

OPERATIONAL COSTS

Connectivity-Related Costs

Smart chargers will add to your company's ongoing operational costs. These systems require some form of communication connectivity. Some networked smart charging station systems contractually assume the *initial* cost of this connectivity or subsidize it when you agree to use their products. Others require the host site assume the cost. In addition, the host might bear merchant fees associated with credit card transactions. Having a networked solution might, however, reallocate maintenance costs to the network service provider. When opting for a smart charging solution, we recommend you compare providers carefully as to ongoing monthly fees, available service plans, and associated operational costs.

Electricity Costs and the Goldilocks "Just Right" Fee

As your company considers its charging station program it will need to decide whether to impose a fee for such use. Concern over recovering payment for electricity is often based on the misguided comparison with refueling a gas tank. Powering a vehicle by electricity costs dramatically less than gasoline – on average half as much.[37] The most a PEV can draw from a 120-volt outlet over 8 hours is about $1.80 a day.[38]

Many companies currently provide free charging. Offering workplace charging at no cost is perhaps the greatest incentive to move an individual to consider purchasing a PEV, but in the long run it complicates matters and creates a race to the bottom when it comes to fostering appropriate charging behavior. Free charging invites abuse. Drivers who don't need a charge to get home – or who just want free electricity – can monopolize the chargers, preventing access by those who must charge by necessity.[39] Opportunistic use also increases overall electricity consumption during peak rate periods of the day – adding costs to the company.

Conversely, companies who opt to charge exorbitant rates per kilowatt hour have a chilling effect on all charging behaviors. Drivers know well how much they spend per kilowatt hour at home and feel abused if the cost is excessive. Expensive electricity deters charging.

As a general rule we believe that the "Goldilocks Approach"[40] works best for workplace charging. We recommend companies charge a little over prevailing market price for electricity. This extends the economic advantages of driving electric to those who cannot charge at home and eliminates the incentive to shift charging from home to work for those who do have it. Billing can be achieved by having an employee pay a fixed monthly amount for a charging "pass" or using a smart charger with credit or RFID card access. The fee for electricity should be calibrated depending upon whether Level 1 or Level 2 charging (3.3 kW or higher) is used, the latter at a more expensive rate.

IRS Reporting Requirements

For companies that provide employees free charging, there has been some concern over possible tax implications and creating a reportable employee benefit. While you should consult your own tax advisor, some believe this qualifies as "de minimis" employee fringe benefit, such as providing free coffee or qualified parking spaces. While workplace charging is not specifically identified in any IRS publication as an example of a "de minimis" fringe benefit, sufficient analogy exists to make a good faith argument under s.132(a)(4)IRC.

MAINTENANCE COSTS

The more features your EVSE has, the more likely you will incur maintenance costs over the life span of the charging station. Basic charging stations have been deployed from a variety of manufacturers for several years, however little industry data exists to show overall reliability and servicing requirements. Many manufacturers offer three-year warranties. Most Level 1 and Level 2 charging stations are reliable and exceed these warranties, however, daily usage at workplaces heightens the pressure on connectors and cord sets. A useful service life in excess of 10 years is not uncommon! We recommend you look for chargers that have been UL or ETL listed and that have a high NEMA (National Electrical Manufacturers Association) rating for indoor/outdoor applications. Temperature, ice, and water intrusion – common variants of New England weather – should not be an issue for unit enclosures rated NEMA 4X. In cold-weather climates, such as in Massachusetts, seek out data on reliability for each manufacturer you are considering.

INCENTIVES FOR EVSE/EVS

As you budget for your charging cluster, be aware financial incentives might be available to you.

FEDERAL

Qualified Plug-In Electric Drive Motor Vehicle Tax Credit

A tax credit is available for the purchase of a new qualified plug-in electric drive motor vehicle that draws propulsion using a traction battery that has at least five kilowatt hours (kWh) of capacity, uses an external source of energy to recharge the battery, has a gross vehicle weight rating of up to 14,000 pounds, and meets specified emission standards. The minimum credit amount is $2,500, and the credit may be up to $7,500, based on each vehicle's traction battery capacity and the gross vehicle weight rating. The credit will begin to be phased out for each manufacturer in the second quarter following the calendar quarter in which a minimum of 200,000 qualified plug-in electric drive vehicles have been sold by that manufacturer for use in the United States. This tax credit applies to vehicles acquired after December 31, 2009. For more information, including qualifying vehicles, see the Internal Revenue Service (IRS) Plug-In Electric Vehicle Credit website. Also refer to IRS Form 8936, which is available via the IRS Forms and Publications website.

Alternative Fuel Infrastructure Tax Credit (Extended through December 31, 2016, applied retroactively)

The Federal Government recently renewed a 30% tax credit for residential and business owners installing EVSE, good for both hardware and installation costs – retroactively. This means individuals or businesses with appropriate tax appetite can recover a significant portion of their investment in charging stations. Retain all receipts associated with your charging installation and check with your tax advisor to see if this credit applies. Its language reads, in relevant part:

For property of a character subject to an allowance for depreciation (business/investment use property), the credit for all property placed in service at each location is generally the smaller of 30% of the property's cost or $30,000. For property of a character not subject to an allowance for depreciation placed in service at your main home (personal use property), the credit for all property placed in service at your main home is generally the smaller of 30% of the property's cost or $1,000.

Please refer to IRS Form 8911, available via the IRS Forms and Publications website.

MASSACHUSETTS

Workplace Electric Vehicle Supply Equipment Grants

The Massachusetts Electric Vehicle Incentive Program (MassEVIP) provides grants for 50% of the cost of Level 1 or Level 2 workplace EVSE, up to $25,000. Eligible applicants include companies with 15 or more employees in a non-residential place of business. Funding is available on a first-come, first-served basis. For more information, including application and eligibility requirements, visit the MassEVIP website.

Plug-In Electric Vehicle (PEV) and Electric Vehicle Supply Equipment (EVSE) Grants

The Massachusetts Electric Vehicle Incentive Program (MassEVIP) provides grants for the purchase or lease of qualified PEVs, zero emission electric motorcycles (ZEMs), and Level 2 EVSE. Grants are available for up to $7,500 for the purchase or lease of a PEV, up to $13,500 for the purchase or lease of Level 2 EVSE, and up to $750 for the purchase or lease of a ZEM. Eligible applicants include local governments, universities and colleges, public and private driving schools, and state agencies. Funding is available on a first-come, first-served basis. For more information, including application and eligibility requirements, visit the MassEVIP website.

Point of contact for both of the above programs:
Ms. Sejal P. Shah, Environmental Analyst, Massachusetts Department of Environmental Protection; Phone: 617-556-1015; sejal.shah@state.ma.us

Alternative Fuel Vehicle and Infrastructure Grants

The Massachusetts Department of Energy Resources' Clean Vehicle Project offers grant funding for public and private fleets to purchase alternative fuel vehicles and infrastructure, as well as idle reduction technology. Eligible vehicles include those fueled by natural gas, propane, and electricity, including hybrid electric, solar electric, and hydraulic hybrid vehicles. Eligible infrastructure includes natural gas fueling stations and electric vehicle supply equipment. For information about how to apply for funding, visit the Massachusetts Clean Cities website.

Electric Vehicle Emissions Inspection Exemption

Vehicles powered exclusively by electricity are exempt from state motor vehicle emissions inspections. For more information, see the Massachusetts Vehicle Check website. (Reference Massachusetts Department of Environmental Protection Regulations and Standards 310 CMR 60.02.)

Massachusetts Plug-In Electric Vehicle Rebates

Massachusetts Department of Energy Resources Offers Rebates for Electric Vehicles (MOR-EV) Program offers rebates of up to $2,500 to customers purchasing or leasing a PEV or zero-emission motorcycle. Rebates are only available to Massachusetts residents for vehicles registered in the commonwealth for a minimum of 36 months. For more information, including application and eligibility requirements, visit the MOR-EV website.

MOR-EV
Massachusetts Offers Rebates for Electric Vehicles

COMPANY INCENTIVES

Beyond these incentives, many companies feel strongly enough about the benefits of this technology they devise their own methods of promoting employee adoption. Some programs include providing employees cash toward the purchase of a PEV or a charging station, preferred or dedicated charging space at the workplace, free electricity, and special recognition within the organization for promoting its goals.

IMPLEMENT THE PROGRAM

COMPANY POLICY

Providing online resources on the company website to discuss PEV policies is a great way to educate your workforce as well as to advertise to customers your corporate commitment to sustainable transportation.

See Appendix D for Sample Workplace Charging Policy Booklet

SIGNAGE AND CHARGING ETIQUETTE

Signage is particularly important for assisting drivers in locating charging and dictating proper charging etiquette. While no uniform signage symbols have yet been formally approved by the Federal Highway Administration, there are several designs that use word legends.[41] Only vehicles that are plugged in should be allowed to park in dedicated charging spaces – they should be either actively charging or recently completed charging. Further, each vehicle driver should receive a sign to display on their dashboard with their contact information and charging preferences. As an example, Plug In America offers a laminated placard that displays helpful driver charging information.[42] Some companies provide an EV charging space next to a nonmarked space that is nonetheless accessible to charging. This allows other vehicle types to occupy those spaces and relieves some of the tension surrounding unoccupied "EV only" spaces during critical parking periods or where space is at a premium. Some companies are now moving to identify such spaces are "EV-preferred" to make people more respectful of taking up charging spaces with traditional vehicles.

pluginamerica.org/evcard

Typically Level 2 charging stations should be reserved only for battery electric vehicles, not plug-in hybrid electric vehicles with smaller batteries. Both battery electric vehicles and plug-in hybrid electric vehicles should be allowed access to Level 1 charging stations, with battery electric vehicles always having priority given their dependence on electricity. Most drivers behave equitably and do not block other drivers from using the appropriate charging resources; nonetheless, there needs to be a policing mechanism to check on charging behavior and provide a courtesy warning for improper use. Often PEV drivers register with their company and communications regarding charging policy can be widely and accurately distributed to the relevant membership. Anyone parking inappropriately should receive a courtesy warning.

EVALUATE ACTUAL OPERATIONS AGAINST GOALS AND OBJECTIVES

Once the charging cluster is in place, planning ends and monitoring begins. Hopefully, you will have set out clear expectations for the goals and objectives of your charging program and started collecting relevant data. Starting an email distribution list of users allows you to monitor issues as they emerge, whether passing along alerts as to equipment malfunctions or helping educate new EV users on the company's charging policies. If you opted not to use smart charging technology, creating a user list also allows you a means of monitoring frequency of use and provides some measure of the program's success. Direct user feedback will help your program change and grow. As you acquire expertise in administering your program, consider sharing your experiences with other companies in your network, including sponsoring workplace charging workshops and ride and drive events.

Educating Employees and Building Momentum

Now that you have a successful program in place, consider how to use your company to better promote the technology in the communities of which you are a part. A simple but highly effective program can be centered on creating ride and drive opportunities to generate interest and increased sales. Educating your workforce is the single most powerful tool you have to increasing PEV adoption rates in the state. Massachusetts is already devoting significant resources to workplace related programs through its Mass Drive Clean Campaign events, in partnership with Plug In America and Reach Strategies. Through Fall 2015, eight events will have been held at universities, towns and company campuses with a goal of recruiting 1,000 new ZEV drivers. For more information on the Mass Drive Clean Campaign contact: info@massdriveclean.org.

MASS DRIVE CLEAN
ON THE ROAD TO CLEAN AIR

Appendices

APPENDIX A *Key Terminology*

Basic Charging: EVSE that are plug and play and without additional sophisticated functionality; any driver can access basic charging.

BEV: Battery Electric Vehicle; wholly reliant on battery-based electricity.

CHAdeMO Connector: Asian standard connector used for DC Quick Charger.

DC Fast Charger: Category of chargers that use three-phase AC power that is converted to DC power, delivering much higher voltages (250-410V) and much higher amperages (125A) directly to the battery. DC Fast Chargers only benefit battery electric vehicles with special charge ports and are much more expensive to purchase and install. They charge at commensurately faster rates, capable of bringing battery electric vehicles up to 80% state of charge within 20-30 minutes.

EREV: Extended-Range Electric Vehicle.

EVSE: Electric Vehicle Supply Equipment.

ICE: Internal Combustion Engine.

Level 1: Category of AC-based charging stations or charging outlets using low voltage (120V)/low amperage (15 or 20A) capable of charging all vehicles but requiring longer periods of time. Current draw is generally limited to 80% of the breaker rating, or 12/16A. That yields a 1.4 or 1.9 kilowatts (kW) rate of charge.

Level 2: Category of AC-based charging stations using higher voltage (240V)/higher amperage (16-100A) capable of rapidly charging all vehicles, usually within three to four hours. A typical 32A Level 2 charging station can deliver a 7.5 kW rate of charge.

Networked Charging: EVSE that are smart and are part of a larger, often subscriber-based, network such that EV drivers who are part of the network can access any charging station located within the network.

PEV: Plug In Electric Vehicle; includes battery electric vehicles, plug-in hybrid electric vehicles and EREVs.

PHEV: Plug-In Hybrid Electric Vehicle.

SAE CCS Connector: American standard connector used for DC Quick Charger.

SAE J-1772: Universal connector used for Level 1 and Level 2 chargers and compatible with products from virtually all vehicle manufacturers.

Smart Charging: EVSE equipped with energy data collection and management functionality, as well as access-control features such as credit card or RFID card activation. Such chargers must be equipped with a communications platform, such as cellular or Wi-Fi connectivity.

ZEV: Zero Emission Vehicle; encompasses many forms of alternative fuel sources such as battery electric and hydrogen fuel cell.

APPENDIX B *Sample Employee Survey*[43]

Start with this Employee Survey to determine if you have a commuting population able and willing to benefit from PEV use. The survey's primary purpose, however, will be to identify an employee or group to champion your company's workplace charging program.

1 If you drive to work, how far is your trip one way?

a) Less than 10 miles
b) 10-25 miles
c) 26-50 miles
d) More than 50 miles

2 How often do you use your car during the workday?

a) Daily
b) 1-2x per week
c) Rarely (less than 1x per month)
b) Never

3 Do you drive a PEV or are you considering acquiring one in the future?

a) I already drive a PEV
b) I'm considering acquiring a PEV within 6 months
c) I'm considering acquiring a PEV within 12-24 months
d) I'm not considering a PEV for personal use

4 If you already drive a PEV, what type do you drive?

Make_____ Model_____
Battery Size_____kWh

5 Do you have the ability to install PEV charging equipment at your residence? (Y/N)

6 Do you think your company should install charging stations for employees? (Y/N)

7 If EVSE were available at work would you use them? (Y/N)

8 Would you be willing to pay a fee, if necessary, to use a charging station at work? (Y/N)

9 Would the availability of workplace charging increase your likelihood of acquiring a plug-in electric vehicle? (Y/N)

10 Are you interested in participating in an employee taskforce on workplace charging? (Y/N)

APPENDIX C

Massachusetts Company Workplace Charging Case Studies

Summary: EMD Serono is a biopharmaceutical division of Merck KGaA and has over 1,200 US employees, with 1,000 in Massachusetts, evenly divided between their Billerica and Rockland offices. As a healthcare company, providing workplace charging neatly fits their corporate mission. Typical employee one-way commute distance is 22 miles.

In 2012, they started providing charging stations because an employee purchased a Chevy Volt and asked for workplace charging. Currently their Billerica campus has seven dedicated charging only spaces with two dual Level 2 smart chargers and their Rockland office has three dedicated spaces, with one dual Level 2 charger. All spaces are located in preferred parking areas. Currently six employees drive some type of PEV, including one battery electric vehicle (Tesla). They used the MassEVIP program to help subsidize the cost of their most recent hardware and installations, which ran to $18K for one installation. Despite the cost, they prefer smart charging because of the need for energy/vehicle metrics and to better manage charging accessibility. The charging stations are used all the time in Billerica; Rockland's charging station is currently underutilized. Total electricity cost is $15 per day for providing charging to employees; charging is provided free to employees and is not publicly available. They do not have a PEV in their corporate fleet, although they are exploring vehicle options.

Lessons learned: Overbuild any charging installation to anticipate growth (e.g., use larger conduit and have additional space on the electrical panel). They would consider more creative use of Level 1 charging given costs and accessibility benefits. Place charging stations relative to charging spaces in a manner that allows employees to move charging cords, not their cars; units on islands allow cars on either side access to the charging station.

Contact: Jeff Hyman, Senior Manager Environment, Health & Safety US, EMD Serono, Inc.

Email: jeff.hyman@emdserono.com

Raytheon

Summary: A leader in the Aerospace and Defense industries, Raytheon has over 60,000 employees with 10,000 in Massachusetts, spread over six campuses in Waltham, Andover, Tewksbury, Woburn, Marlboro and Sudbury. Most employees drive cars and have a commute of between 20-25 miles each way. An estimated 6-10 employees currently drive a type of PEV. Currently two campuses, Tewksbury and Woburn, offer charging at their covered garages, with more on the way at other campuses. Since 2012, Raytheon has provided a dual Level 2 smart charger at both locations, with two dedicated, preferred charging spaces at Woburn and four at Tewksbury. As a defense contractor, Raytheon is precluded from giving away free charging and charges $1.00 for the first hour and 40 cents per hour thereafter; they are considering recalibrating these charges to reflect actual per kW consumption by the individual vehicles given their different charge rates. No public access is allowed. Each dual Level 2 station cost approximately $20,000 to install, in addition to the hardware costs of between $4000-$6,000 per unit, which makes overall cost of charging an issue. They did not use MassEVIP incentives because their program predated the state program. They like the ability to use the online portal provided by their smart charger provider to monitor use and energy data, which helps with their corporate social responsibility reporting.

Lessons learned: Placing charging stations at the nexus of four spots allows drivers to move cords not cars. Cord management is a concern for snow and safety; having cord retraction is a good feature. Workplace charging is a soft ROI. Placement in a garage is cheaper because it only involves running conduit.

Contact: Frank Marino, Senior Corporate Environmental Health and Services Manager, Raytheon Company.

Email: Frank_Marino@raytheon.com

TUFTS Health Plan

Summary: Tufts Health Plan is a regional health plan with presence in New Hampshire, Rhode Island and Massachusetts. Three thousand employees reside in Massachusetts, including campuses in Watertown and Worcester. Eighty-five percent of employees drive to work, with a typical commute of 25 miles each way. Awareness grew after a Toyota Plug in Prius driver asked about using a 120V outlet in their 1,400 space garage. Now Tufts Health Plan has three dual Level 2 charging stations for six dedicated charging spaces. The average installation cost per unit was $9,000 after using the MassEVIP grant. All six spaces are used daily. Tufts Health Plan allows drivers a maximum of four hours to charge before rotating out, a rule enforced by parking security, which means that six cars can charge in the morning slot and six in the afternoon. Electricity is free to employees with no public access allowed. Expansion plans are in the works if the units become fully used. Tufts Health Plan has a workplace charging policy in effect.

Lessons learned: Employees will come to you because they are thinking of buying a PEV so be ready. The benefits to the company include mitigating the environmental impact of the workplace and being a good community partner, especially when you are a large company involved in health care.

Contact: Mark Foster, Manager of Security and Safety at Tufts Health Plan

Email: Mark_Foster@tufts-health.com

Summary: UM-Lowell is the second largest public educational institution in Massachusetts, with 17,000 students and 3,000 faculty and staff. Divided over three areas in Lowell, 50% of its student population commutes to campus and 90% of its staff drives to work. The school initially placed charging stations in 2014 as a result of its climate action plan and sees its vehicle-centric population as a critical source of GHG pollution. Smart Dual Level 2 chargers are located in three of its large parking facilities and an additional dual Level 2 is in a neighboring public parking lot. Students who register a PEV are allowed access to any garage (usually, they are assigned a lot); there is otherwise no written policy. They used a grant from MassEVIP for one charger to date. Students pay for access to the Level 2 charging stations; and the public lot charges a flat rate of $1.00 per hour with a maximum stay of two hours. In addition, a number of Level 1 outlets are available in their parking garages, which are typically used by faculty and staff for free. They like the ability to monitor usage provided by the existing smart charging technology, where GHG reduction can be monitored by an online dashboard. Monthly usage currently amounts to one hundred and twenty hours of charging. They anticipate continuously adding charging stations given the size of their driving population. They found huge variation in the bids for installation they received – a $16,000 spread for three stations – so getting a number of bids is critical. Ultimately, it cost them approximately $3,000 to install each station and the hardware cost was $7,000 per station.

Lessons learned: If they build, they add conduit and create room in their electrical panel. When installing, always try to avoid trenching and boring. It is critical to reach out to existing companies providing charging to get real-life experience and learn the scale of commitment involved when providing charging.

Contact: Ruairi O'Mahony, Associate Director of Sustainability,
University of Massachusetts- Lowell

Email: Ruairi_OMahony@uml.edu

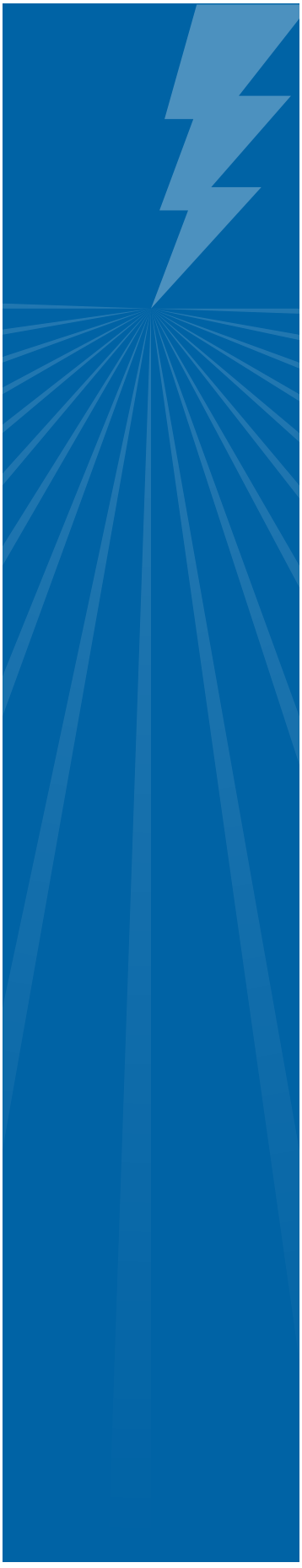
APPENDIX D *Sample Workplace Charging Policy Booklet*

CHARGING STATION/EV PARKING ETIQUETTE

Please note that charging station infrastructure is a limited resource that requires consideration by all users to ensure it is properly used and available to everyone who needs it for commuting purposes.

The following charging rules are to be observed by everyone:

1. Electric vehicle-only charging spaces shall be properly designated with appropriate signage. These spaces are STRICTLY for use by plug-in vehicles that are actively charging or awaiting charging. They are not to be used by other types of vehicles or by EV drivers solely for convenience of parking location.
2. You should NOT unplug another driver's vehicle unless you are absolutely certain it is done charging or the vehicle's driver has indicated that it is okay to unplug the vehicle after a certain time. This can be done by leaving a sign on the dashboard indicating when adequate charging is expected to be completed. NOTE: If you unplug another vehicle without confirming it is charged adequately you may be significantly delaying their return home that night.
3. Every plug-in vehicle driver shall register their vehicle with human resources with information including, but not limited to, the vehicle make, model, license plate, personal cell phone, and email address.
4. [Space reserved for description of company policy toward electricity costs, e.g., provided as a free amenity to employees or requiring monthly payment in exchange for a sticker.]
5. When an electric vehicle has completed charging, the vehicle's owner should if practicable move the vehicle to make the charging station accessible to others.
6. Plug In Electric Hybrids or any battery-electric vehicle with gas as a backup energy source MUST use Level 1 charging stations unless exigent circumstances exist. All Battery Electric Vehicles shall have first priority use of Level 2 chargers. If you don't absolutely need a charge to return home you should also consider waiting to plug in later in the day to ensure other workplace charge dependent electric vehicle drivers have been able to fully charge.
7. We encourage you to find other EV drivers to assist you in partnering and sharing charging stations.
8. Failure to observe these rules shall result in a written courtesy warning for the first offense and, for subsequent offenses, may result in the loss of charging privileges.



APPENDIX E *Massachusetts Workplace Charging Resources- Links*

RESOURCE LINKS

State Incentives Available
www.afdc.energy.gov/laws/state_summary?state=MA

Massachusetts Electric Vehicle Rebate Program
mor-ev.org

Massachusetts Electric Vehicle Incentive Program (MassEVIP)
www.mass.gov/eea/agencies/massdep/air/grants/massevip.html

Installation Guide for Electric Vehicle Supply Equipment, Massachusetts Department of Energy Resources, June 2014.
www.mass.gov/eea/docs/doer/clean-cities/ev-charging-infrastructure-manual.pdf

Directory of Massachusetts Transportation Management Associations
www.masscommute.com/tma_directory/

U.S. Department of Energy- Workplace Charging Challenge
energy.gov/eere/vehicles/ev-everywhere-workplace-charging-challenge

California Plug In Collaborative- Workplace Charging
www.pevcollaborative.org/workplace-charging

Plug In America
www.pluginamerica.org

STATE/COUNTY AGENCIES

Stephen Russell
Clean Cities Co-Coordinator
Massachusetts Clean Cities Coalition
Phone: (617) 626-7325
Fax: (617) 727-0030

Mike Manning
Clean Cities Co-Coordinator
Massachusetts Clean Cities Coalition and AVSG LP
Phone: (617) 242-8755
Fax: (617) 242-0814

Erin Russell-Story
Project Manager
U.S. Department of Energy, National Energy Technology Laboratory
Phone: (412) 386-7334

Ms. Sejal P. Shah
Environmental Analyst
Massachusetts Department of Environmental Protection
Phone: (617) 556-1015

Mr. Ariel Garcia
Environmental Engineer, Region 1
U.S. Environmental Protection Agency
Phone: (617) 918-1660
Fax: (617) 918-0660

Massachusetts Cleans Cities Coordinator
www.afdc.energy.gov/cleancities/coalition/massachusetts

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