2011

Massachusetts 2011 Clean Cities Coalition
Plug-in Vehicles Strategic Planning/Feasibility Plan/Program

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Commonwealth of Massachusetts

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Massachusetts 2011 Clean Cities Coalition Support Contract
Plug-in Vehicles Strategic Planning/Feasibility Plan/Program

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Attachments: In folders attached to this email

"The State of Massachusetts EV policy," MIT Graduate Class project
EVSE Stakeholder lists
EV Graphics: License plate sample, Map of EVSEs,& Parking sign
Program Opportunity Notice for cities and towns to install EVSEs
RFP for EVSE manufacturers and other documents from these Programs

Massachusetts 2011 Clean Cities Coalition Support Contract
Plug-in Vehicles Strategic Planning/Feasibility Plan/Program

Massachusetts Clean Cities Coalition (MCCC) has been working on the deployment of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) over the past two years. Its aggressive approach goes hand-in-hand with the state's green house gas emission targets for 2020 as outlined in the Clean Energy and Climate Plan.

In addition to the seven parts in this report, this document is accompanied by several attachments. The attachments are: MIT Graduate student report: "The State of Massachusetts EV policy," "Installation Guide for Electric Vehicle Supply Equipment," EVSE Stakeholder list, sign sample, EV License plate sample, Program opportunity notices for cities and towns to install EVSEs, and an RFP for EVSE manufacturers to provide equipment to be purchased from the state purchasing system. You will find when reading this report that Massachusetts is well beyond the Planning/feasibility phase of plug-in vehicles and has moved into the implementation phase.

1. *Assessment Summary and Purpose*

In the past two years MCCC director has accomplished the following:

- Arranged stakeholder meetings: In June 2010 an initial stakeholder meeting with the Undersecretary of Energy set the tone for Massachusetts' support for EVs. In October 2010 a gathering of 200 stakeholders took place at the University of Lowell. In addition the state organized an ongoing working policy review stakeholder group. The working group has met monthly and has reviewed all policies related to the EV program. This smaller group has enabled Massachusetts to move forward much more rapidly than calling a vast group of stakeholders together to get feedback. Once vehicles begin to show up for sale in Massachusetts, MCCC will hold a large EV stakeholder meeting again to alert the public of supply station locations and methods for developing the clean transportation. This coalition is well into the EV planning and now is beginning to and has implemented several programs and policies which are covered in this document.
- Coordinated the signing of MOUs: The Secretary of Energy and Environment Ian Bowles signed a ground-breaking MOU with Nissan at the Boston Museum of Science in February 2010. This well-attended day-long event featured three speeches by representatives of the executive office of energy and the registry of motor vehicles. The

first Nissan Leaf was available for public viewing. In early 2011 Massachusetts also signed an MOU with BMW (MOUs attached).

- Enlisted the help of four MIT graduate students to assess the opportunities and polices of EVs for Massachusetts. (Report attached)
- Wrote an EVSE installation manual. (Manual attached)
- Initiated dialogue with utilities and met regularly with REVI "Regional Electric Vehicle Initiative."
- Initiated dialogue with non-union and IBEW electricians. Massachusetts, with the involvement of Marty Akins at IBEW, has contributed to the development of the EVITP program which is a nationwide EV training program for electricians.
- Funded the conversion of 10 State Toyota Prius's to plug-ins. These vehicles are currently being used by the state fleet in various departments.
- Initiated dialogue and presented to the state electricians' licensing board.
- Initiated dialogue and presented to the electrical inspectors organization.
- Opened discussions with Registry of Motor Vehicle staff to inform them of the electric vehicle movement. DOER is funding the initial round of EV license plates. (License plate sample attached)
- Developed sign for EV parking. (Sample attached)
- Opened discussion with NFPA regarding first responder training for EVs
- Attended first *Train the Trainers* class held for first responders by NFPA.
- Acquired $384,000.00 in funds to install 142 EVSE, charging stations, throughout the State of Massachusetts. (Sorry no check attached)
- Lobbied for and acquired 105 Coulomb charging stations through the ChargePoint DOE funded program.
- Bid for EVSE equipment to be listed in the state purchasing system.(PON attached)
- Will have battery electric vehicles for sale in first quarter 2012 (PPT attached)
- Presented at several environmental events to discuss EVs exclusively.
- Represented Massachusetts at the Regional Greenhouse Gas Initiative which is a 10 State Coalition of States working to develop low carbon fuel standards.
- Became a founding member of the Transportation Climate Initiative which explores Electric vehicle initiatives for the 10 state regions and became funded through a DOE grant to research and develop EV policies for the region. Massachusetts coordinated and recruited 14 Clean Cities Coalitions to be part of this region-wide initiative.
- Provided EV input during utility merger discussions so that new merged company will support EV infrastructure and develop policy to support Smart Grid technology.
- Massachusetts is a demonstration site for Chrysler Motors. We are demonstrating 10 plug in Hybrid Dodge Ram 4 x4 pickups for 3 years. We will be collecting data on the charging and use of the trucks.

A. Charging Station Infrastructure:

The Commonwealth of Massachusetts has awarded grants to 25 communities. These communities have determined the best locations for the electric charging stations to be installed. The assessment for installing the electric chargers in the state has been a two-phase project. The first phase will provide an insight to the opportunities and barriers to the EV deployment in the state. The second phase analyzes the opportunities to strengthen the incentives of EV users to arouse and encourage an interest in EVs.

This assessment is required due to the prevailing economic instability due to high gasoline price, reduction in fossil fuel supply and significant decrease in environmental pollutants. One of the primary interests of Massachusetts in promoting EV deployment within the state is its potential benefits for reducing greenhouse gas (GHG) emissions. The transportation sector accounts for at least one-third of GHG emissions, hence electrification of the transportation sector could produce substantial emissions reduction results. Moreover, this new development can promote a variety of job opportunities.

2. *Past and Current Plug-in Vehicle Implementation*

Massachusetts does have experience with plug-in vehicles. In 1992 to 1998 the State developed a pilot program with the Citizens of the Commonwealth and Solectria. 18 vehicles were offered to citizens to use as commuter vehicles. Solectria worked with an auto manufacturer and provided the battery electric drives to these vehicles. In those days it was a painstaking process of pulling the Gasoline engine and installing an electric drive with a massive, heavy battery pack in the trunks of these vehicles. The project had its ups and downs. Lucky for the commonwealth the electrical engineering department at the University of Lowell was on call to fix the myriad of problems that came about during this project. Batteries not charging, Cars dying for no reason and short battery life were all problems that U Lowell was able to solve to keep the commuters in their cars. Ask the commuters and they loved the cars for the commute. Ask them to go beyond the commute and they all said that range was a huge issue. The batteries were lead acid and had a memory. Recharging batteries that were not fully discharged became a problem. Heat needed for the cab in the winter also robbed the distance out of the batteries.

A. Current Plug- in Vehicle implementation

The demographic analysis and survey of interest from a variety of stakeholders throughout the state suggest that there are opportunities for deployment of both personal EVs and fleets of EVs throughout the state, not just Boston area. The state is positively engaging a variety of stakeholders in deploying EVs which will be effective in developing a unified rollout across the state. The current plan for EV deployment includes several time horizons: present day, within a year and 3-5 years. The plan for installing charging station is tracking demand from the users to decide the locations for installation of these stations. Boston is focusing more on requirements and permitting for in-home and parking garage charging. Some localities are doing their analysis to figure out what location will serve the best purpose. Northampton is one of them. Deployment of EVs in commercial and municipal fleets is also a state perspective which could be significant as these fleets tend to be more visible. This will provide an enhanced exposure to EVs for customers.

There are many organizations which are/can is involved. Smith Electric is one such company which plans of providing 6 all EV to the commercial fleet of Staples. Toyota, Ford, Chevrolet, Azure Dynamics, Peterbilt and Nissan are some other organizations which have planned to offer to the state for EV or HEV development in the commercial fleet or personal fleet.

Massachusetts Department of Energy Resources Clean Cities is heading the planning with Energy and Environmental Affairs. The role of MA Clean Cities Coalition is to help by providing monetary and non-monetary assistance and propelling the fleets to become an important first mover in EV development. Providing long-term information and support as a substantial incentive to invest in EVs is also an effort of MA Clean Cities Coalition. The federal $7,500 tax credit is also planned to be a part of rebate to make EVs immediately affordable to consumers. New R&D investments are being made, and grants to 30 communities is planned to be awarded on a competitive basis to fund EV infrastructure.

Several local utilities are stakeholders of the Massachusetts Clean Cities Coalition. There are some 30 local utilities in the state and NGrid, NSTAR, WMECO are some of the utilities among the stakeholder list of Clean Cities. The Regional Electric Vehicle Initiative which was begun by Northeast utilities and has involved several western Mass utilities and is play an important role in making sure the utilities understand what the role out of electric vehicles means to the grid. Evaluating EVSE's and looking at vehicle technologies are all goals of REVI.

Current degree of infrastructure includes 12 electric charging stations in the state available for public and private use. 25 communities have also come forward with an interest towards developing electric charging infrastructure. The main support which communities are looking for from the state is: cost and reliability. This means an additional 142 Supply stations will appear on the landscape soon. Cambridge, a community in Massachusetts noted that a clear understanding of fuel usage and GHG comparisons to conventional vehicles will be made available to the public and EV users. These will in-turn increase their ability to get funds allocated for purchasing a more expensive EV. More Electric Vehicle Information Training Practices (EVITP) will held in the state and assistance is being provided on EV rollout toolkit to simplify charging infrastructure installation. See "Installation Guide for Electric Vehicle Supply Equipment"

3. *Assessment of Plug-in Vehicle Implementation Potential:*

Chevrolet, Ford, Mercedes, Nissan, BMW, Think and Chrysler Plug in EVs and Toyota PHEVs are some of the OEMs which are deploying their plug-ins in few numbers to judge the public approach. Though the number is small, but it makes high visibility and reflects significant interest in an emerging technology. There are no current local/state incentives available for plug-ins; the state depends upon the existing federal incentives of $7,500 tax credit. Hence, lack of funding incentives is one such unattractive feature of Massachusetts which has a potential negative effect on the growth of alternative vehicles in the state. The car manufactures such as Nissan or Chevrolet will be releasing their EVs in early 2012 with The All EV Ford focus to be among the lineup of cars for Massachusetts

The best locations for the future public stations are considered to be the most frequently visited places by public. Some of them shortlisted are: hotel parking, parks, schools and university parking lots, city center, supermarkets and shopping centers. Places near to utilities are also considered to be the best places for the installation of charging stations due to uninterrupted electricity supply. 25 communities in the state have shortlisted various locations in their territory for the charging station installation and these communities will be used to gather data from these locations. (See attached map)

4. Permitting Process Analysis:

A. Electricians and permitting

Early on in the process of meeting with stakeholders we learned that the permitting, installation and ultimately approving the installation of EVSEs was going to need attention. Clean Cities had several meetings with electricians and building inspectors to make sure they are aware of the code for installing the systems and can more easily put and permit the systems in homes and in fleet or public locations. Early in the process the Department sent a letter requesting time to meet with the State licensing examiners board to discuss the coming of EVSEs and make them aware of NEC code 625. This meeting was a success in educating this board that EV’s are coming and they will play an important role in supporting the infrastructure needed to support these vehicles.

B. NEC code 625 Education.

After the licensing board meeting a letter was sent to the licensing board. In that letter it requested that during the license renewal education program, time be devoted to reviewing the NEC 625 code as well as make the electricians aware of the vehicles coming to the State. This request was received and acknowledged and put into place. For the next two years electricians in the State will be learning about NEC 625. Another group to be aware of in the EVSE installation program is the Town and City inspectors that issue permits for and then approve installation of the EVSE units. Clean Cities has done several presentations to those groups across the State. We have found that there is a great deal of interest in this technology. See installation manual for more detail on the NEC 625 code.

C. *5 day issue and 5 day approval of permits*:

In the state of Massachusetts the State requires by law that once a completed application is received in the municipal office the permit must be issued within 5 days and then when the work is complete and a final inspection is required it must be done within 5 days.

The pilot program the State has embarked on will really determine if any adjustments to this Policy is needed.

5. *Analysis of Public Information and Education Needs*

A. First responder training

Massachusetts has the National headquarters for NFPA located in Braintree Mass. This organization was the recipient of ARRA funds to develop first responder safety training. Over the last 2 years NFPA has developed a program related to handling crashes involving battery electric vehicles also including hybrid vehicles.

To prepare the first responders, Massachusetts was the site of the first NFPA "Train the Trainers" program to handle electric vehicles that are involved in crashes.

B. Electric vehicle identification (a safety concern for first responders)

Listening to these safety officials, we met with the RMV in Massachusetts and worked with license plate department. This has resulted in Massachusetts being one of only a few States that will have license plates that will identify the Hybrid, Electric and Battery Electric vehicle. In today's Automotive market the automotive manufacturers, while they are committed to the battery electric and the electric hybrid market there is no clear standard location or marker that identifies either a BEV, HEV, or EREV. This will certainly go a long way to keep everyone at the crash scene as safe as possible.

C. Clean Cities stakeholder meetings

Over the past two years Massachusetts has had several stakeholder meetings on EVSE's and most recently dedicated an entire breakout session of EV's at this year's AltWheels day in Norwood Mass.

In Addition Mass Clean Cities holds Stakeholder meeting every other month throughout the year updates on EV progress are given at each of these meetings. In addition the Coalition provides information and attends environmental events that have showcased Electric vehicle technology, Earth day event on the Esplanade along the Charles, Environmental events in Medford, Newton and Boston all have contributed and necessary for the education of the public of the new technology coming in the transportation sector. As outlined in the opening of this document the State has a small group of State policy makers involved in an EV stakeholder group that reviews and approves policy development for the EVSE program. This is a reflection of the State's strong commitment to the environment and clean transportation.

6. *Analysis of other barriers*

See the MIT report "The State of Massachusetts EV policy, assessing the opportunities"**.**

7. *Role of Coalition to facilitate plug-in vehicle implementation*

As evident in this report the Massachusetts Clean cities coalition is very involved in the deployment of Plug –in vehicle development and will continue as it has over the last two years to identify barriers and then eliminate these barriers so that Plug in vehicles can be a significant factor in Massachusetts to not only reduce petroleum use in the transportation sector but also clean up the air.

Over the next year Massachusetts will be meeting with the public utilities commission to assist the DPU in developing positive regulations that support the long time use of Plug- in vehicles. It will also seek additional funding to continue the development of infrastructure in the commonwealth.

A. **Region-wide Plug-in development**.

Massachusetts Clean Cities will continue to work with all the coalitions in the region to share the lessons learned in this Electric vehicle plug-in development that has taken place over the last two years. Massachusetts Clean Cities believes that as the Electric vehicle planning and infrastructure movement goes forward it is imperative that it is done as a region. This commitment has been proven through work on the recent DOE grant award. This grant request involved the 10 state regions from Washington DC to Maine. Massachusetts took the lead to encourage and bringing in 14 Clean Cities coalitions for this grant.

8. ***Next steps for the Massachusetts Clean Cities coalition:***

A. *Continue to monitor installation process for EVSEs and make sure any issues that arise are quickly dealt with.*

B. *Meet with DPU and review electric vehicle issues related to the charging for electivity in the non utility environment.*

C. *Continue and expand Stakeholder meetings*

D. *Collect and share data from EVSE pilot*

E. *Encourage and support the sale of plug-ins in the State.*

F. *Work with Airports to develop EVSE policies and practices for this unique location for charging Plug-Ins.*

G. *Work with utilities to make sure they are aware of all EVSEs installed.*

H. *Work with other coalitions in the region to make sure that program continues to move forward.*

Photos on next page:

Top center – MOU signing with Nissin Motor Ccompany February 2010.

Middle Left – First "tall boy" Coulomb charger that has been installed at Caliper Life services Hopkinton MA first of 105 Charging station being provided by the ChargePoint America program. 10/2011

Middle right– Nissan Leaf plugged into an AV level 2 supply station.

Bottom Left - Plug-in Ford Transit Connect van. Note: EV Drive train designed and built here in Massachusetts.


NISSAN
NISSAN LEAF
zero Emission


TRANSIT
connect
electric
AZD

INSTALLATION GUIDE FOR ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

An Introduction to EVSE

Prepared by:
The Massachusetts Department of Energy Resources
March, 2011

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This Guide is not intended to be an installation manual or a replacement for approved codes and standards, but rather is intended to create a common knowledge base of EV requirements for stakeholders involved in the development of EV charging infrastructure. EVs have unique requirements that differ from internal combustion engine (ICE) vehicles, and many stakeholders currently are not familiar with these requirements.

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Charging station (free Juice bar) at the Charles Hotel in Cambridge, MA.

1. Introduction

In the early years of the automobile industry -- around the turn of the century -- battery-powered electric vehicles (EVs) were quite popular. More than 360 electric recharging stations dotted the landscape in and around Boston alone! Despite the advantages of reduced air pollutants, convenience, and virtually silent driving, electric vehicles fell from favor because of their slow acceleration, low speeds, and limited range between battery recharges.

This is no longer the case with EVs. A new generation of electric vehicles has come to market with the technical sophistication and performance able to serve the needs of many of today's drivers. Most drivers (78%) commute less than 40 miles per day and the most recent national statistics (1995) show that the U.S. average person-miles per day is 39.[1] Industry has received over two billion dollars from the federal government and is investing in EVs that meet commuter and driving needs as well as provide jobs for battery and car production in the U.S. These vehicles will deliver to the public lower fuel and maintenance costs, reduced pollution and reduce reliance on foreign oil.

Massachusetts is committed to a clean environment and EVs will play an important part in our implementation of the 2008 Global Warming Solutions Act and the Green Communities Act. In addition the State has adopted zero emissions vehicle regulations which requires auto manufacturers to sell at least 11 percent of their total vehicle sales "zero emission vehicles" (ZEV), such as electric vehicles with increasing percentages through model year 2018.

As the EV industry reemerges in the beginning of the 21st century, the development of an infrastructure for recharging at home, at work, and at public locations has developed as an imperative need. Generally, EV charging infrastructure consists of three components:
(1) electrical service from the local utility,
(2) on-site wiring, and
(3) charging stations.

Because electrical service is available almost everywhere, the widespread development of EV charging stations is technically feasible. The New England bulk electricity supply system can generally meet the demand for power, and the utilities are involved with us in ensuring that local distribution issues are minimized. For installation of EVSE to occur, EV users will need to learn about the EV Equipment and the requirements for proper installation - subjects covered in this guide. Users of EV charging equipment can be assured that EVSE is designed with multiple safety features, preventing the possibility of electric shock, even if the person charging the vehicle is exposed to rain, snow, or inadvertently touches the EVSE connector.

In most cases, EV owners seek the economy and convenience of on-premises charging facilities and will have to assume responsibility for installing the EVSE. While the process of installing the EVSE at a home or business is not complicated, important procedures must be followed.

We hope this guide will increase understanding of the Battery electric cars and how they work with an EVSE to make installation easier.

2. Electric Vehicle Technology/configurations

This section describes the basic EV car and light and medium duty truck technologies that are either available in the marketplace or coming to market in the near future. The focus of this section is on street-legal vehicles that incorporate a battery energy storage device that can connect to the electrical grid for the supply of some or all of its fuel energy requirements.

[1] US Department of Tranpsortaion, Bureau of Transoprtation Statistics, 2003 and Transportation Statistics Annual Report, 199.

There are two main vehicle configurations and the relative size of their battery packs are discussed in relationship to recommended charging infrastructure.

A. *Battery Electric Vehicle (BEV)*

Battery Electric Vehicles (BEVs) are powered 100% by the battery energy storage system available on-board the vehicle. The Nissan LEAF is an example of a BEV. A BEV is refueled by connecting it to the electrical grid through a connector system that is designed specifically for this purpose. Most advanced BEVs have the ability to recapture some of the energy storage utilized through regenerative braking (in simple terms, the propulsion motor acts as a generator during braking). When regenerative braking is applied, BEVs can typically recover 5 to 15 percent of the energy used to propel the vehicle to the vehicle speed prior to braking. Sometimes manufacturers install solar photovoltaic (PV) panels on vehicle roofs. This typically provides a very small amount of energy relative to the requirements of propelling the vehicle, but integrating PV in the roof typically can provide enough power to operate some small accessory loads, such as a radio.

A typical BEV is shown in the block diagram in Figure 2-1. Since the BEV has no other significant energy source, a battery must be selected that meets the BEV range and power requirements. BEV batteries are typically an order of magnitude larger than the batteries in hybrid electric vehicles and are generally found in the vehicle's trunk

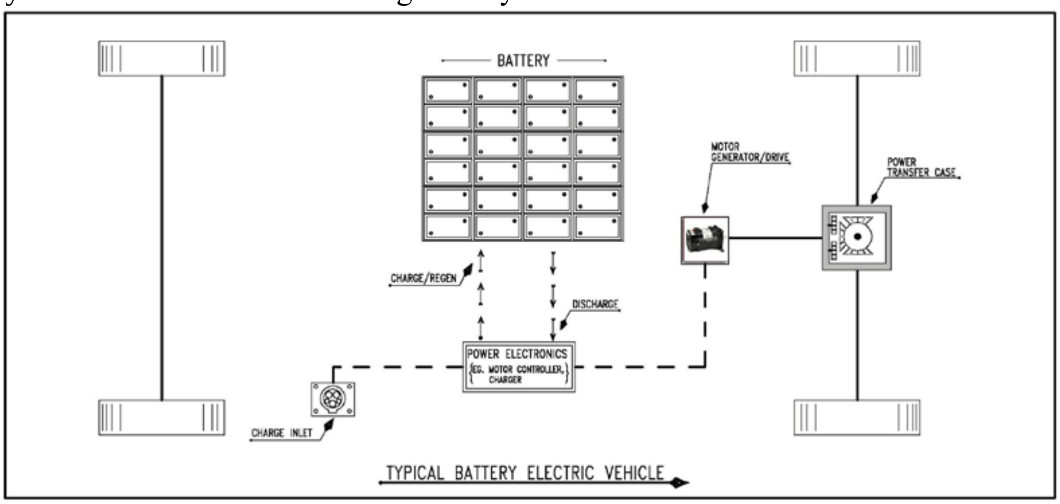


Figure 2-1 Battery Electric Vehicle

Plug-in Hybrid Electric Vehicle (PHEV)

B. *Plug –in Electric vehicles(PHEV)*

PHEVs are powered by two energy sources. The typical PHEV configuration utilizes a battery and an internal combustion engine (ICE) powered by either gasoline or diesel. Within the PHEV family, there are two main design configurations, a *Series Hybrid*, as depicted in Figure 2-2, and a *Parallel Hybrid*, as depicted in Figure 2-3.

The Series Hybrid vehicle is propelled solely by the electric drive system, whereas the Parallel Hybrid vehicle is propelled by both the ICE and the electric drive system. As with a BEV, a Series Hybrid will typically require a larger and more powerful battery than a Parallel Hybrid vehicle in order to meet the performance requirements of the vehicle solely based on battery power.

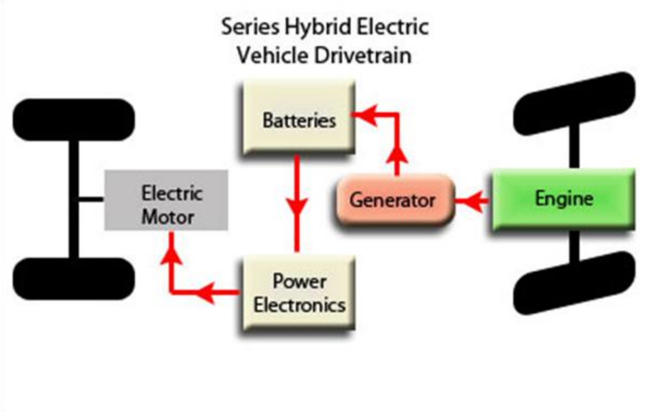


Figure 2-2 Series Plug-In Hybrid Vehicle Block Diagram

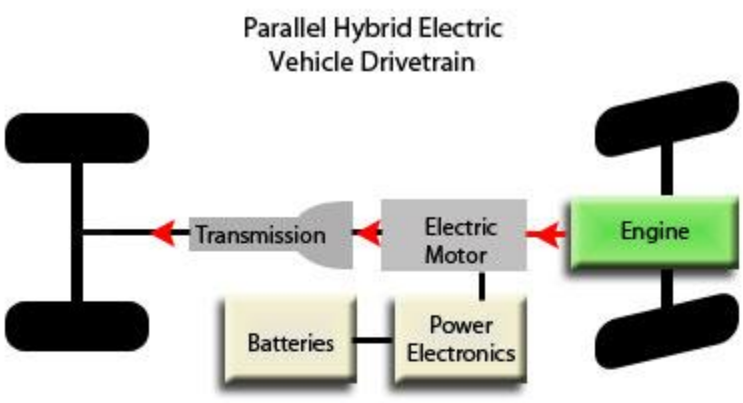


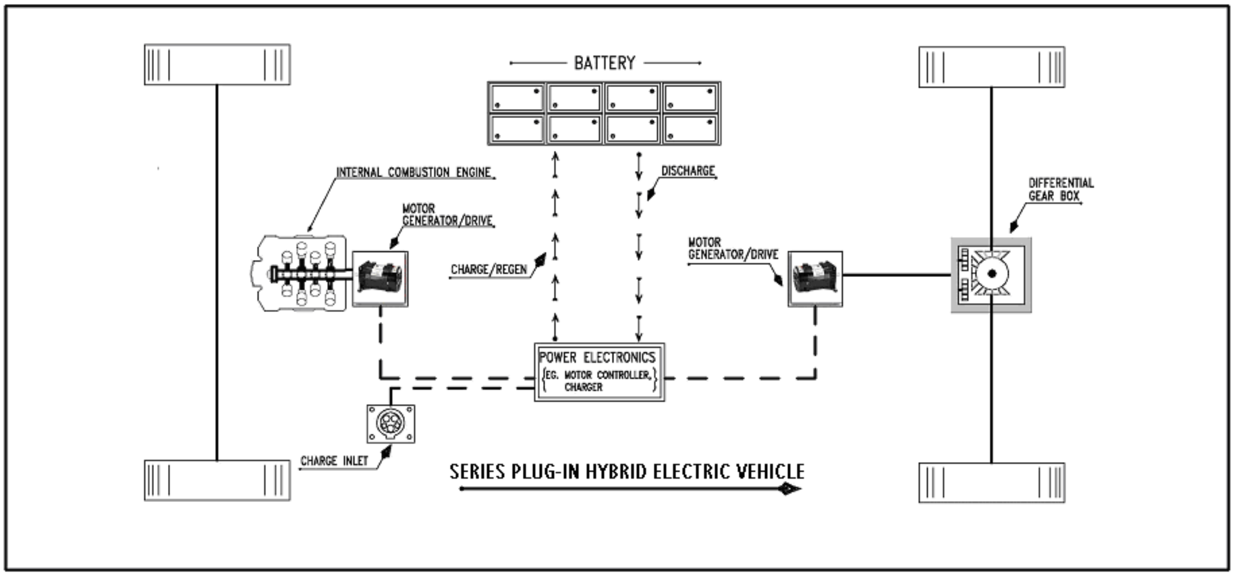
Figure 2-3Parallel Plug-In Hybrid Vehicle Block Diagram

Manufacturers of PHEVs use different strategies in combining the battery and ICE. For example, the Chevy Volt utilizes the battery only for the first 40 miles, with the ICE generating electricity for the duration of the vehicle range. Other PHEVs may use the battery power for sustaining motion and the ICE for acceleration or higher-energy demands at highway speeds. Frequently, the vehicles employing the first strategy gain a designation such as “PHEV-20” to indicate that the first 20 miles are battery only. Other terms related to PHEVs may include *Range Extended Electric Vehicle* (REEV) or *Extended Range Electric Vehicle* (EREV).

C. Batteries

1. **Battery Technology:** Recent advancements in battery technologies will allow EVs to compete with ICE vehicles in performance, convenience, and cost. Although lead-acid technology serves many EV applications like forklifts and airport ground support equipment very cost-effectively, the limitations on energy density and repeated cycles of charging and discharging make its application to on-road highway speed EVs less practical. Today, most major car companies utilize nickel-metal-hydride or various lithium-based technologies for their EVs. Lithium provides four times the energy of lead-acid and two times that of nickel-metal-hydride. The materials for lithium-based batteries are generally considered abundant, non-hazardous, and lower cost than nickel-based technologies. The current challenge with lithium-based technologies is increasing battery capacity while maintaining quality and cycle life and lowering production costs. From an infrastructure standpoint, it is important to consider that as battery costs are driven down over

time; auto manufacturers will increase the size of the lithium-based battery packs, and thus extend the range of electric vehicles.



2. **Relative Battery Capacity:** Battery size, or *capacity*, is measured in kilowatt hours (kWh). Battery capacity for electric vehicles will range from as little as 3 kWh to as large as 40 kWh or more. Typically, PHEVs will have smaller battery packs because they have more than one fuel source. BEVs rely completely on the storage from their battery pack for both range and acceleration and therefore require a much larger battery pack than a PHEV for the same size vehicle.

3. **Battery charging Times:** The amount of time to fully charge an EV battery is a function of the battery size and the amount of electric power or kilowatts (kW) that an electrical circuit can deliver to the battery. Larger circuits, as measured by voltage and amperage, will deliver larger amounts of kW. The common 120 volts AC (VAC), 15 amp circuit will deliver at minimum 1.2 kW to a battery. A 240 VAC, 40 amp circuit (similar to the circuit used for household appliances like dryers and ovens) will deliver at minimum 6.5 kW to a battery. Table 2-1 provides information on several different on-road highway speed electric vehicles, their battery pack size, and charge times at different power levels to replenish a depleted battery. EV owners should check with their manufacturers for more specific charging time requirements for their vehicle.

Table 2-1 EV Charge Times

Circuit Size and Power in kW Delivered to Battery					
EV Configuration	**Battery Size (kWh)**	**120 VAC, 15 amp 1.2 kW**	**120 VAC, 20 amp 1.6 kW**	**240 VAC, 40 amp 6.5 kW**	**480 VAC, 85 amp 60 kW**
PHEV-10	4	3 h 20 m	2 h 30 m	35 m	n/a
PHEV-20	8	6 h 40 m	5 h	1 h 15 m	n/a
PHEV-40	16	13 h 20 m	10 h	2 h 28 m	16 m
BEV	24	20 h	15 h	3 h 41 m	24 m
BEV	35	29 h 10 m	21 h 50 m	5 h 23 m	35 m
PHEV Bus	50	n/a	n/a	7 h 41 m	50 m

Charging times for the Nissan Leaf according to the manufacturer :

It takes about ~30 minutes to 80% at a 480 volt quick-charge station. Starting from a depleted battery, ~7 hours at 220/240V (depending on amperage), about 20 hours at 110/120V.

D. Auto Manufacturer Plans for EV production

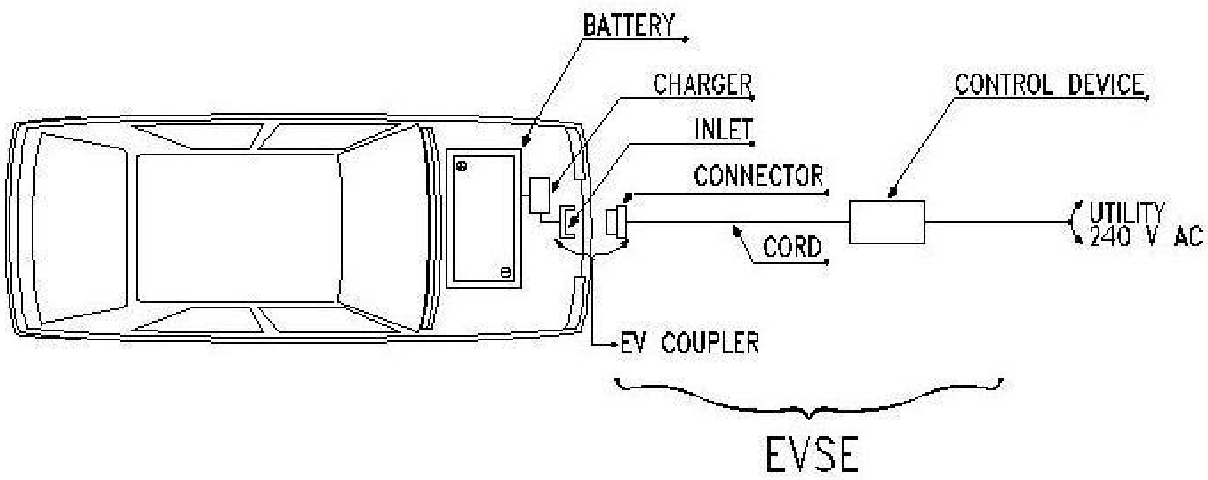
President Obama hopes that the US will have 1 million EV/PEVs on the road by 2015. Many automakers have announced plans for the introduction of on-road highway speed EVs in the near future. Nissan, Ford, GM, BMW, Think, Mitsubishi, Chrysler, Mercedes, and Tesla all have plans for the manufacture of EV vehicles The market is changing very rapidly. Each manufacturer has a web site and by accessing this information, one can look at EV availability for both personal and fleet use.

3. Electric Vehicle Charging Stations

This section covers the terminology and general requirements of Electric Vehicle Supply Equipment (EVSE). EVSE provides for the safe transfer of energy between electric utility power and an electric vehicle.

Level 2 home charger by AV

A. Vehicle Charging Components



Power is delivered to the EV's onboard battery through the *EV inlet* to the charger. The *charger* converts Alternating Current (AC) from the home or site to the Direct Current (DC) required to charge the battery in the vehicle. The charger and EV inlet are considered part of the EV. A *connector* is a device that, by insertion into an EV inlet, establishes an electrical connection to the electric vehicle for the purpose of charging and information exchange. The EV inlet and connector together are referred to as the *coupler*. The EVSE consists of the connector, cord, and interface to utility power. The interface between the EVSE and utility power will be directly "hardwired" to a control device, as illustrated in Figure 3-1, or a plug and receptacle, as illustrated in Figure 3-3. During the 1990's, there was no consensus on EV inlet and connector design. Both conductive and inductive types of couplers were designed and in both cases, different designs of each type were provided by automakers. At the present time, however, the Society of Automotive Engineers (SAE) has agreed that all vehicles produced by automakers in the United States will conform to a single design, known as the *J1772 Standard*.

Cold temperatures can cause cords to freeze to the parking surface, so cord support should be considered.

ADA Compliance: Connector and receptacle heights, special curb cutouts, and disabled parking access are some of the measures that may be necessary to make a charging station fully accessible for the disabled. Each operator must assess their compliance with the federal Americans with Disabilities Act, as well as state and company policies regarding disabled access.

J1772 Connector

J1772 Inlet

Figure 3-2 J1772 Connector and Inlet

B. J1772 Coupler:

The J1772 Standard EV coupler is designed for 10,000 connections and disconnections with exposure to dust, salt, and water; is able to withstand a vehicle driving over it; and is corrosion resistant.
The J1772 Standard and National Electrical Code (NEC) requirements create multiple safety layers for EV components, including:

The EV coupler -
- is engineered to prevent inadvertent disconnection.
- has a grounded pole that is the first to make contact and the last to break contact.
- has an interlock device that prevents vehicle startup while connected.
- is unique to EV charging and cannot be used for other purposes.

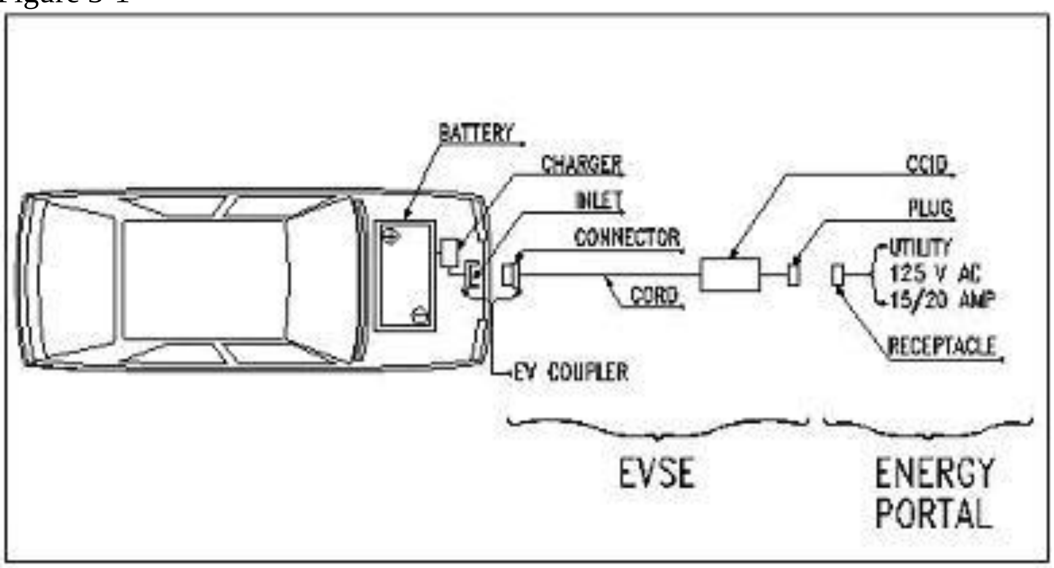
• The EV inlet -
o is de-energized until it is attached to the EVSE.

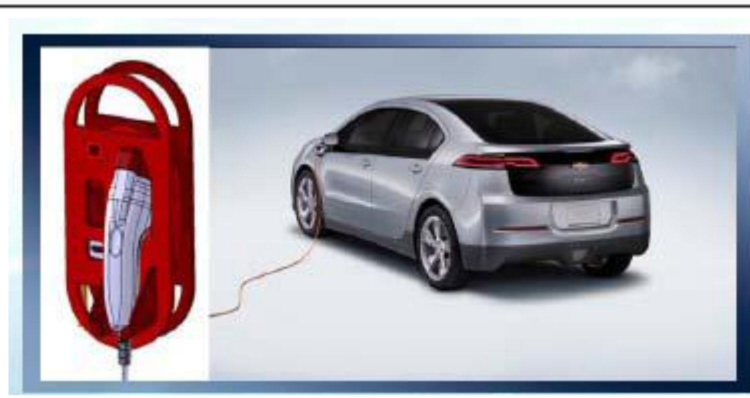
o will de-energize prior to removal of the connector.

The J1772 coupler and EV inlet will be used for both Level 1 and Level 2 charging, which are described below.

C. Charging Station Levels
In 1991, the Infrastructure Working Council (IWC) was formed by the Electric Power Research Institute (EPRI) to establish consensus on several aspects of EV charging. Charging levels were defined by the IWC, along with the corresponding functionality requirements and safety systems. EPRI published a document in 1994 that describes the consensus items of the IWC4.
Note: For Levels 1 and 2, the conversion of the utility AC power to the DC power required for battery charging occurs in the vehicle's on-board charger. In DC Fast Charging, the conversion from AC to DC power typically occurs off-board, so that DC power is delivered directly to the vehicle.5
Level 1 – 120 volt AC
The Level 1 method uses a standard 120 volts AC (VAC) branch circuit, which is the lowest common voltage level found in both residential and commercial buildings. Typical voltage ratings can be from 110 – 120 volts AC. Typical amp ratings for these receptacles are 15 or 20 amps. A 15 amp charge takes twice as long as a 20 amp outlet. –

Figure 3-1





EV suppliers will provide a Level 1 Cord Set (120 VAC, 15 or 20 amps) with the vehicle. The Cord Set will use a standard 3-prong plug (NEMA 5-15P/20P) with a charge current interrupting device (CCID) located in the power supply cable within 12 inches of the plug. The vehicle connector at the other end of the cord will be the design identified in the J1772 Standard. This connector will mate properly with the vehicle inlet, also approved by J1772.

Because charge times can be very long at Level 1 (see Table 2-1), many EV owners will be more interested in Level 2 charging at home and in publicly available locations. Some EV manufacturers suggest their Level 1 Cord Set should be used only during unusual circumstances when Level 2 EVSE is not available, such as when parked overnight at a non-owner's home.

Several companies provide kits to convert ICE and hybrid vehicles to plug-in vehicles. Many of these conversions use a standard 3-prong electrical plug and outlet to provide Level 1 charging to their vehicles. With the standardization of EVs on the J1772 Standard and the higher level of safety afforded by a J1772-compliant charging station, existing vehicles will need to be retrofitted to accommodate a J1772 inlet in order to take advantage of the deployment of EVSE infrastructure.

Level 2 – 240 volt AC

Level 2 is typically described as the "primary" and "standard" method for the EVSE for both private and publicly available facilities. This method specifies a single-phase branch circuit with typical voltage ratings from 220 – 240 volts AC. The J1772-approved connector allows current as high as 80 amps AC (100 amp rated circuit). However, current levels that high are rare, and a more typical rating would be 40 amps AC, which allows a maximum current of 32 amps. This provides approximately 7.7 kW with a 240 VAC circuit.

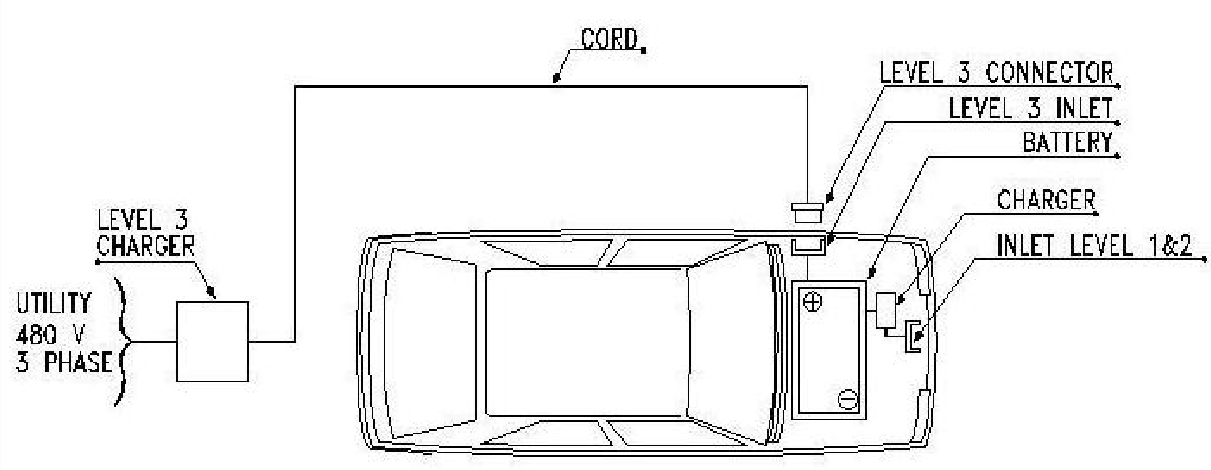
The higher voltage of Level 2 allows a much faster battery charge. Because of the higher voltage, Level 2 has a higher level of safety requirements than Level 1 under the NEC, including the requirement that the connector and cord be hardwired to the control device and premises wiring, as illustrated in Figures 3-1 and 3-5.

Level 2 Charging a Nissan Leaf

DC Fast Charging and Level 3 (no Standard as of this printing)

DC Fast Charging was developed for commercial and public applications, and is intended to perform in a manner similar to a commercial gasoline service station in that recharge is rapid. Typically, DC Fast Charging would provide a 50% recharge in 10 to 15 minutes. DC Fast Charging typically uses an off-board charger to provide the AC to DC conversion. The vehicle's on-board battery management system controls the off-board charger to deliver DC directly to the battery. The off-board charger is serviced by a three-phase circuit at 208, 480, or 600VAC.

The SAE standards committee is working on a higher-powered J1772 Level 3 method, but placed the highest priority on approving the J1772 Level 1 and 2 connector first. The Level 3 standard is expected to be approved in 2011 – 2012. **Figure 3-5**



Note: Although it is uncommon, a vehicle manufacturer may choose not to incorporate an on-board charger for Levels 1 and 2, and instead utilize an off-board DC charger for all power levels. In this case, the EV would only have a DC charge port. Another potential configuration that may be found, particularly with commercial vehicles, is providing 3-phase power directly to the vehicle. This configuration requires dedicated charging equipment that will not be compatible with typical publicly available infrastructure.

D. Charging level considerations Level 1 versus Level 2

For a BEV owner (and some PHEV owners who choose the utility time of use rates), the preferred method of residential charging will be Level 2 (240VAC/single phase power) in order to provide a reasonable charge time and to also allow the local utility the ability to shift load as necessary while not impacting the customer's desire to obtain a full charge by morning. For other PHEV owners, a dedicated Level 1 circuit may adequately meet the owner's charging needs.

Level 1 will suffice for some BEV owners who have the opportunity for Level 2 charging at work or in public areas, as they may find the vehicle battery remains at a higher charge and thus home charging time is not a concern. See Table 2-1 for relative battery sizes and estimated recharge times. Depending on the amperage of your home electrical service you will be able to use appliances at the same time when you are charging your vehicle.

This is why it is strongly recommended that one has a licensed electrician evaluate one's house's readiness to install an EVSE. This electrician can also advise you on the best and lowest cost location for the EVSE.

E. Installation of EVSE code and UL information.

EVSE level 2 models selected must be:

- UL certified.
- Installed by a Massachusetts licensed electrician.

- Installed in compliance with NFPA 70, National Electric code article 625 and applicable Massachusetts electrical code adopted and enforced within the jurisdiction of installation.

It is suggested that the utility supplying power to the installation site be contacted to ensure adequate power supply to the site. This may become standard procedure as more EVSEs are installed in a neighborhood or in district with heavy power demands.

Installation is generally straightforward and under state permitting laws each City or Town is required to issue a permit to install a device within 5 days from request and then upon completion of the work the Town or City must inspect the completed job within 5 days.

F. NEC 625 code information. This is the 2008 code soon to be adopted in the 2011 code.

NEC ITEM Chapter or Article	**Below are the NEC Items required for the installation of on EVSE to meet code**

Chapter 2 and 3	**Branch Circuit** **A new electrical box added on a branch circuit shall comply with NFPA 70 National Electrical Code® Chapter 2 Wiring and Protection and Chapter 3** **Wiring Methods and Materials and all administrative requirements of the NEC or the electrical code in effect in the jurisdiction.**
625.4	**VOLTAGES** Unless other Voltages are specified, the nominal ac system voltages of 120, 120/240, 208Y/120, 240, 480Y/277, 480, 600Y/347, and 600 Volts shall be used to supply equipment
625.5	**LISTED OR LABELED** All electrical materials, devices, fittings, and associated equipment shall be listed or labeled.
625.9	The electric vehicle coupler shall comply with 625.9(A) through (F). (A) Polarization. The electric vehicle coupler shall be polarized unless part of a system identified and listed as suitable for the purpose. (B) No interchangeability. The electric vehicle coupler shall have a configuration that is no interchangeable with wiring devices in other electrical systems. No grounding-type electric vehicle couplers shall not be interchangeable with grounding-type electric vehicle couplers. (C) Construction and Installation. The electric vehicle coupler shall be constructed and installed so as to guard against inadvertent contact by persons with parts Made live from the electric vehicle supply equipment or the electric vehicle battery. (D) Unintentional Disconnection. The electric vehicle coupler shall be provided with a positive means to prevent unintentional disconnection. (E) Grounding Pole. The electric vehicle coupler shall be provided with a grounding pole, unless part of a system identified and listed as suitable for the purpose in Accordance with Article 250. (F) Grounding Pole Requirements. If a grounding pole is provided, the electric vehicle coupler shall be so designed that the grounding pole connection is the first to Make and the last to break contact.
625.13	**ELECTRIC VEHICLE SUPPLY EQUIPMENT** Electric vehicle supply equipment rated at 125 volts, single phase, 15 or 20 amperes or part of a system identified and listed as suitable for the purpose and Meeting the requirements of 625.18, 625.19, and 625.29 shall be permitted to be cord-and-plug-connected. All other electric vehicle supply equipment shall be Permanently connected and fastened in place. This equipment shall have no exposed live parts
625.14	**Rating** Electric vehicle supply equipment shall have sufficient rating to supply the load served. For the purposes of this article, electric vehicle charging loads shall be Considered to be continuous loads.
625.15	**Markings** The electric vehicle supply equipment shall comply with 625.15(A) through (C). (A) General. All electric vehicle supply equipment shall be marked by the manufacturer as follows: FOR USE WITH ELECTRIC VEHICLES (B) Ventilation Not Required. Where marking is required by 625.29(C), the electric vehicle supply equipment shall be clearly marked by the manufacturer as follows: VENTILATION NOT REQUIRED

	The marking shall be located so as to be clearly visible after installation. (C) Ventilation Required. Where marking is required by 625.29(D), the electric vehicle supply equipment shall be clearly marked by the manufacturer, "Ventilation Required." The marking shall be located so as to be clearly visible after installation.
625.16	**Means of Coupling** The means of coupling to the electric vehicle shall be either conductive or inductive. Attachment plugs, electric vehicle connectors, and electric vehicle inlets shall Be listed or labeled for the purpose.
625.17	**Cable** The electric vehicle supply equipment cable shall be Type EV, EVJ, EVE, EVJE, EVT, or EVJT flexible cable as specified in Article 400 and Table 400.4. Ampacities shall be as specified in Table 400.5(A) for 10 AWG and smaller, and in Table 400.5(B) for 8 AWG and larger. The overall length of the cable shall not Exceed 7.5 m (25 ft) unless equipped with a cable management system that is listed as suitable for the purpose. Other cable types and assemblies listed as being Suitable for the purpose, including optional hybrid communications, signal, and optical fiber cables, shall be permitted.
625.18	**Interlock** Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connector and its cable whenever the electrical connector Is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for Connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes.
625.19	**Automatic De-Energization of Cable** The electric vehicle supply equipment or the cable-connector combination of the equipment shall be provided with an automatic means to de-energize the cable conductors and electric vehicle connector upon exposure to strain that could result in either cable rupture or separation of the cable from the electric connector and Exposure of live parts. Automatic means to de-energize the cable conductors and electric vehicle connector shall not be required for portable cord-and-plug connected Electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes.
625.21	**Over current Protection** Over current protection for feeders and branch circuits supplying electric vehicle supply equipment shall be sized for continuous duty and shall have a rating of not Less than 125 percent of the maximum load of the electric vehicle supply equipment. Where noncontiguous loads are supplied from the same feeder or branch Circuit, the over current device shall have a rating of not less than the sum of the noncontiguous loads plus 125 percent of the continuous loads.
625.22	**Personnel Protection System** The electric vehicle supply equipment shall have a listed system of protection against electric shock of personnel. The personnel protection system shall be Composed of listed personnel protection devices and constructional features. Where cord-and-plug-connected electric vehicle supply equipment is used, the interrupting device of a listed personnel protection system shall be provided and shall be an integral part of the attachment plug or shall be located in the power Supply cable not more than 300 mm (12 in.) from the attachment plugs.
625.23	**Disconnecting Means** For electric vehicle supply equipment rated more than 60 amperes or more than 150 volts to ground, the disconnecting means shall be provided and installed in a Readily accessible location. The disconnecting means shall be capable of being locked in the open position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock Installed. Portable means for adding a lock to the switch or circuit breaker shall not be permitted.
625.25	**Loss of Primary Source** Means shall be provided such that, upon loss of voltage from the utility or other electrical system(s), energy cannot be back fed through the electric vehicle and the Supply equipment to the premises wiring system unless permitted by 625.26.
625.26	**Interactive Systems** Electric vehicle supply equipment and other parts of a system, either on-board or off-board the vehicle, that are identified for and intended to be interconnected to a vehicle and also serve as an optional standby system or an electric power production source or provide for bi-directional power feed shall be listed as suitable for That purpose. When used as an optional standby system, the requirements of Article 702 shall apply, and when used as an electric power production source, the

	Requirements of Article 705 shall apply.
625.28	**Hazardous (Classified) Locations** Where electric vehicle supply equipment or wiring is installed in a hazardous (classified) location, the requirements of Articles 500 through 516 shall apply.
625.29	**Indoor Sites** Indoor sites shall include, but not be limited to, integral, attached, and detached residential garages; enclosed and underground parking structures; repair and nonrepair commercial garages; and agricultural buildings. (A) Location. The electric vehicle supply equipment shall be located to permit direct connection to the electric vehicle. (B) Height. Unless specifically listed for the purpose and location, the coupling means of the electric vehicle supply equipment shall be stored or located at a height of not less than 450 mm (18 in.) and not more than 1.2 m (4 ft) above the floor level. (C) Ventilation Not Required. Where electric vehicle nonvented storage batteries are used or where the electric vehicle supply equipment is listed or labeled as Suitable for charging electric vehicles indoors without ventilation and marked in accordance with 625.15(B), mechanical ventilation shall not be required. (D) Ventilation Required. Where the electric vehicle supply equipment is listed or labeled as suitable for charging electric vehicles that require ventilation for indoor Charging, and is marked in accordance with 625.15(C), mechanical ventilation, such as a fan, shall be provided. The ventilation shall include both supply and Exhaust equipment and shall be permanently installed and located to intake from, and vent directly to, the outdoors. Positive pressure ventilation systems shall be Permitted only in buildings or areas that have been specifically designed and approved for that application. Mechanical ventilation requirements shall be determined By one of the methods specified in 625.29(D) (1) through (D) (4). (1) Table Values. For supply voltages and currents specified in Table 625.29(D)(1) or Table 625.29(D)(2), the minimum ventilation requirements shall be as Specified in Table 625.29(D) (1) or Table 625.29(D) (2) for each of the total number of electric vehicles that can be charged at one time. (2) Other Values. For supply voltages and currents other than specified in Table 625.29(D)(1) or Table 625.29(D)(2), the minimum ventilation requirements shall be **Indoor sites(con't)** Calculated by means of general formulas stated in article 625.39(D) (2). (3) Engineered Systems. For an electric vehicle supply equipment ventilation system designed by a person qualified to perform such calculations as an integral part Of a building's total ventilation system, the minimum ventilation requirements shall be permitted to be determined per calculations specified in the engineering study. (4) Supply Circuits. The supply circuit to the mechanical ventilation equipment shall be electrically interlocked with the electric vehicle supply equipment and shall Remain energized during the entire electric vehicle charging cycle. Electric vehicle supply equipment shall be marked in accordance with 625.15. Electric vehicle supply equipment receptacles rated at 125 volts, single phase, 15 and 20 amperes shall be marked in accordance with 625.15(C) and shall be switched, and the Mechanical ventilation system shall be electrically interlocked through the switch supply power to the receptacle.
625.30	**Outdoor Sites** Outdoor sites shall include but not be limited to residential carports and driveways, curbside, open parking structures, parking lots, and commercial charging Facilities. (A) Location. The electric vehicle supply equipment shall be located to permit direct connection to the electric vehicle. (B) Height. Unless specifically listed for the purpose and location, the coupling means of electric vehicle supply equipment shall be stored or located at a height of not less than 600 mm (24 in.) and not more than 1.2 m (4 ft) above the parking surface.

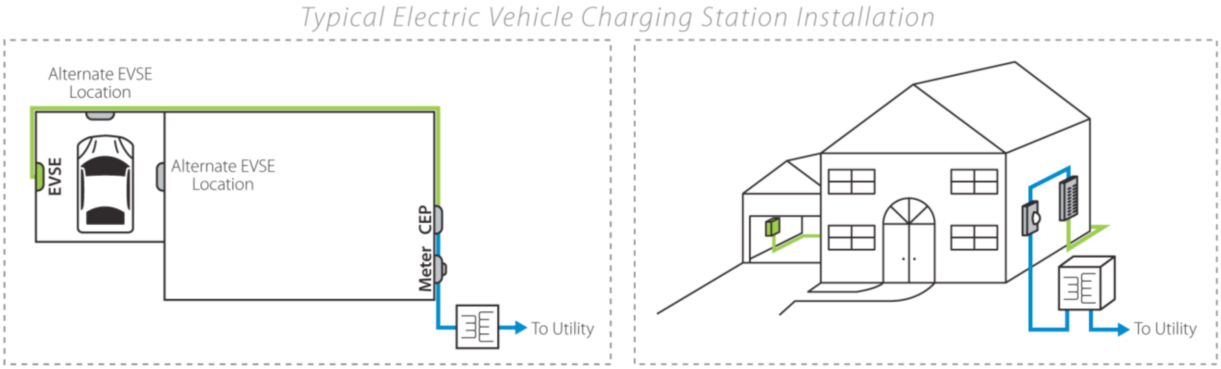
G. Programming the EVSE

• Some Level 2 EVSE suppliers will provide controls in the EVSE to allow charging at programmable times to take advantage of off-peak power pricing. If not, homeowners may wish to install a timer device in this circuit to control charging times. Check with your utility about off-peak power pricing.

H. Installation Diagram:

Figure 3-6. TYPICAL ELECTRIC VEHICLE SERVICE EQUIPMENT

INSTALLATION·

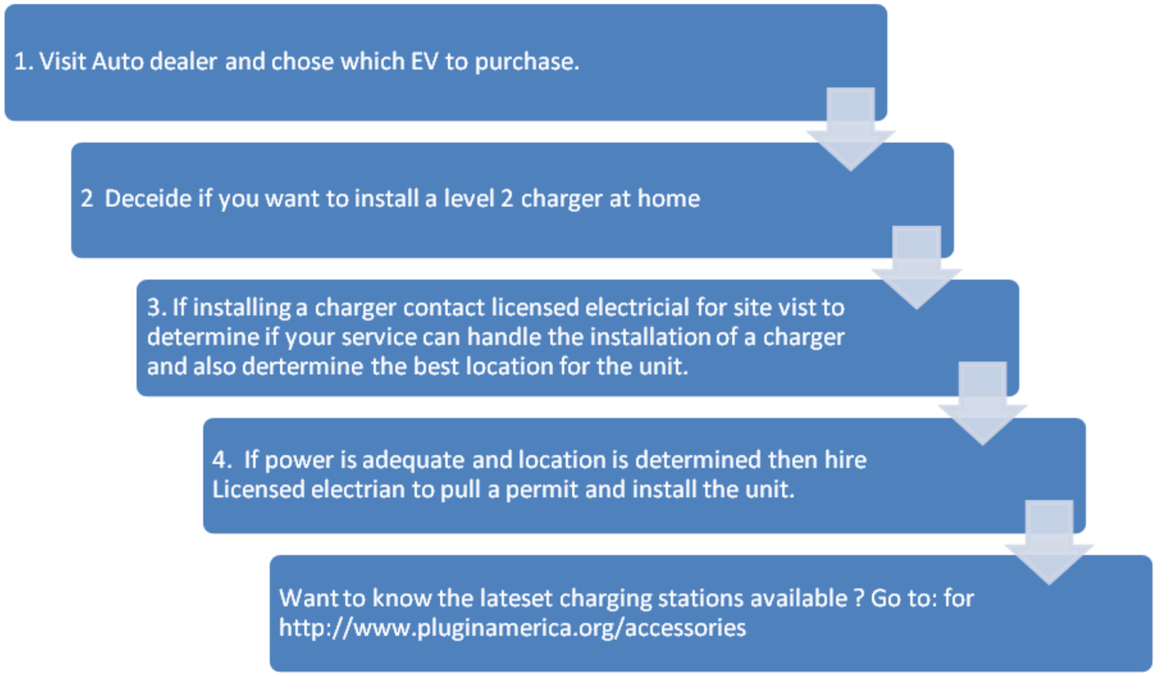


· Meter and Circuit Breaker Panel on Exterior of home and on opposite side of Parking Location
· Charging Station to be located inside of garage
· Exterior cable run from Charging Station to CBP.

I. Installation flowchart:

The specific steps involved in this process are shown in the flowchart below. In general, they include:

Figure 5: Residential EVSE Installation Flowchart



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www.mass.gov/energy/cleancities