2. PEV BASICS

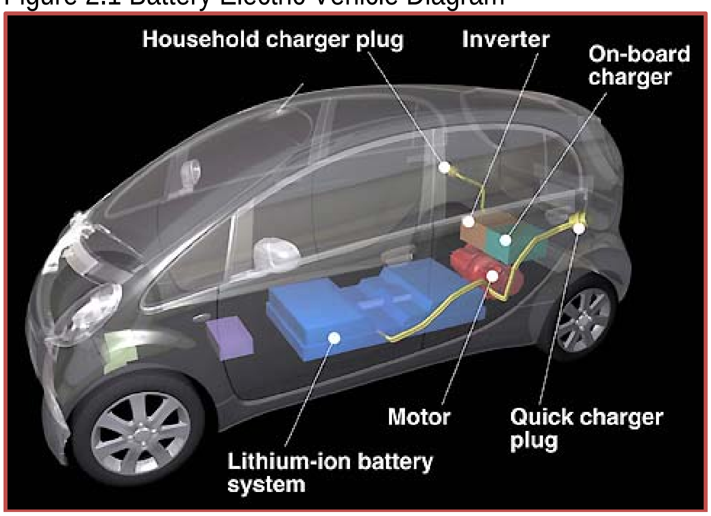
2.1 Vehicles

Plug-in Electric Vehicles (PEVs or EVs) are powered by batteries that can be charged by plugging the vehicle into an electrical outlet. The two types of PEVs include plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs).

Types of Plug-in Electric Vehicles

Battery Electric Vehicles (BEVs)
Battery electric vehicles, also known all-electric vehicles, have no Internal Combustion Engine (ICE) and are dependent on plugging into the electric power grid for fueling. BEVs can also be charged in part by regenerative braking. Since BEVs have no ICE, they produce no tailpipe emissions. Mainstream BEVs have batteries that provide a driving range of 80 to 300 miles. Most automakers are targeting a driving range of 100 miles for their BEV model, which is sufficient for more than 90% of all household vehicle trips in the United States according to the US Federal Highway Administration.10 For longer trips, BEVs must be charged en route. Depleted batteries in BEVs can be charged up to 80% in less than 30 minutes using DC fast charge stations that deliver 480 Volts. Most cars will be recharged at home, overnight using Level 2 (240 Volts) charging stations, which return 10 to 20 miles of driving range for every hour the vehicle charges. Examples of BEVs include the Nissan Leaf, Tesla Model S, Coda Sedan, Ford Focus EV, Honda Fit EV, and Mitsubishi i-MiEV.

Figure 2.1 Battery Electric Vehicle Diagram



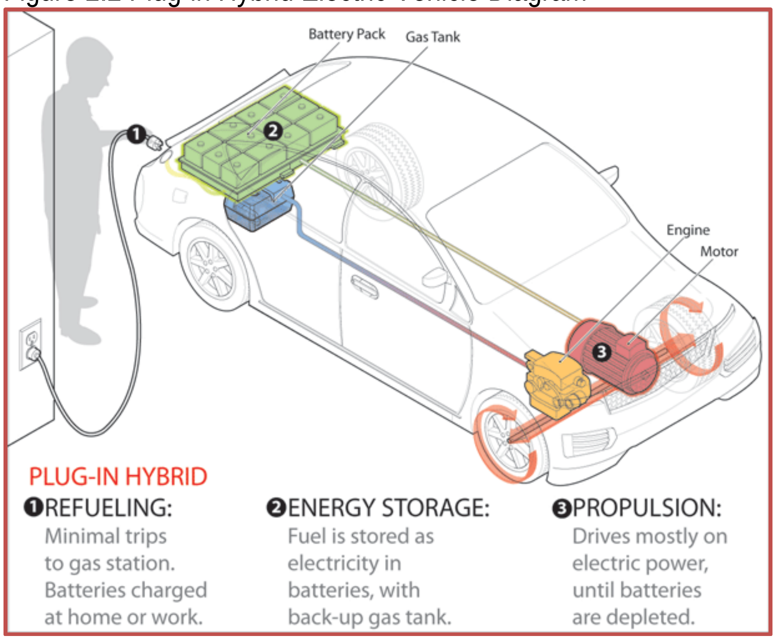
Source: http://goelectricdrive.com/index.php/plug-in-electric-vehicles

Plug-in Hybrid Electric Vehicles (PHEVs)
Plug-in Hybrid Electric Vehicles, sometimes called Extended Range Electric Vehicles, can be powered by a battery that is charged by plugging the vehicle into an electric power source, but also

[10] http://www.fhwa.dot.gov/publications/publicroads/13novdec/01.cfm

by a small internal combustion engine (ICE) that can be fueled either by conventional or alternative fuels. PHEVs have smaller batteries than BEVs, giving them a shorter electric driving range of 10 to 40 miles, but also shorter recharging periods. However, the auxiliary ICE in a PHEV provides an extended driving range of 300+ miles, eliminating the range concerns associated with BEVs. With an empty battery, PHEVs perform like Hybrid Electric Vehicles (HEVs), consuming less fuel, producing fewer emissions than similar ICE vehicles, and charging the battery through regenerative braking. Powering the vehicle some of the time with electricity from the grid cuts petroleum consumption and tailpipe emissions compared with conventional vehicles. PHEV fuel consumption depends on the distance driven between battery charges. For example, if the vehicle is never plugged in to charge, fuel economy will be about the same as for a similarly sized HEV. If the vehicle is driven less than its all-electric range and plugged in to charge, it is possible to use only electric power.

Figure 2.2 Plug-in Hybrid Electric Vehicle Diagram



Source: http://goelectricdrive.com/index.php/plug-in-electric-vehicles

PHEVs can be subdivided into series hybrids and parallel hybrids (Figure 2.3). Series hybrids can use an ICE to turn a generator that powers an electric motor, but only the electric motor powers the wheels. The Chevy Volt is an example of a series hybrid. Parallel hybrids can simultaneously transmit power to the drive wheels from an ICE and an electric motor. The Toyota Prius Plug-in is an example of a parallel hybrid.

Figure 2.3 Vehicle Categories and Examples

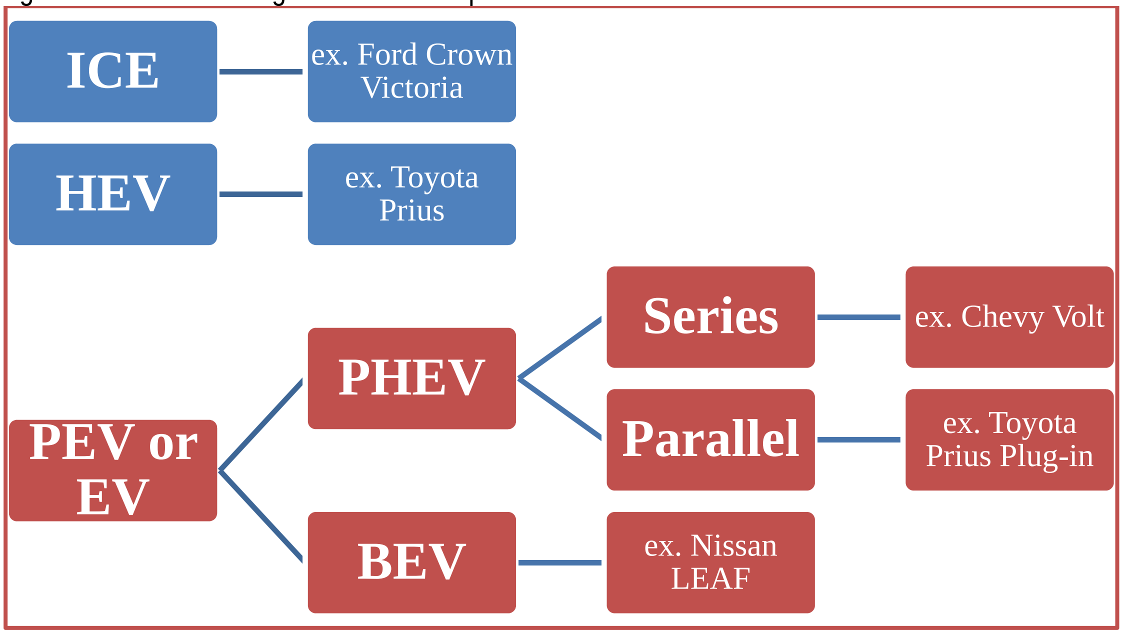


Figure 2.4 PHEVs and BEVs

PEV Type	Plug-In Hybrid Electric Vehicle	Battery Electric Vehicle
Example		
	Chevy Volt	**Nissan LEAF**
Range	**35 miles (Electric) + 350 mile (Hybrid)**	**100 miles (Electric)**
Price	**$34,000 (after $7,500 tax credit)**	**$28,000 (after $7,500 tax credit)**
Fuel Savings	**$0.02 to $0.04 per mile (Electric) $0.05 to $0.07 per mile (Hybrid)**	**$0.02 to $0.04 per mile (Electric)**
	conventional gasoline vehicles cost $0.10 to $0.15 per mile	

Vehicle Availability

In 2012 there were 13 light duty plug-in electric vehicles on the US market. For model years 2013 and 2014, manufacturers are expected to debut at least 18 new plug-in hybrid and battery electric vehicles.

It is common for manufacturers to introduce new vehicle technology slowly and methodically. Given early production limitations and the need to train and equip dealers and service technicians, manufacturers are rolling out these vehicles in select markets before offering them in smaller markets like the Asheville region.

In fall 2011 the Nissan LEAF and the Chevy Volt became the first highway-ready plug-in electric vehicles for sale in the Asheville region. In May 2012 the Mitsubishi i became the third electric vehicle available in the region. In the coming year, many more PEV makes and models are expected to become available, such as the Ford Focus Electric and the Toyota Plug-in Prius, which are already on sale in select markets.

Figure 2.5 PEV Availability in North Carolina Markets, 2012

When	Type	PEV	Driving Range	Battery (kwh)	MSRP
Today	PHEV	Chevy Volt	35 miles + gas	16	$39,100
		Fisker Karma *	32 miles + gas	16	$96,000
	BEV	Nissan LEAF	73 miles	24	$35,200
		Mitsubishi i-MiEV	62 miles	16	$29,900
		Tesla Model S *	300 miles	85	$88,000
		Coda Electric Sedan *	88 miles	34	$39,900
2013 Target	PHEV	Toyota Prius Plug-in	11 miles + gas	4.4	$32,000
		Ford C-Max Energi	21 miles + gas	9	$33,800
	BEV	Ford Focus Electric	76 miles	23	$40,000
		Honda Fit EV	82 miles	20	
		Chevrolet Spark		20	
TBA	PHEV	Volvo V70 Plug-in	30 miles +gas		
		VIA Motors VTrux	40 miles + gas		
	BEV	BMW Active E	94 miles		
		Toyota RAV 4 EV	100 miles		
		VW E-Golf	95 miles		

Source: www.plugincars.com/cars ; www.pluginamerica.org
*Limited production

Vehicle Purchase Price

As with most new technologies, the initial purchase price of PEVs is still relatively high when compared with similar conventional gas powered vehicles. As of 2012, the initial price premium paid for PEV ranges from $8,000-15,000 above the comparable gasoline model. Much of the premium paid for PEVs is related to the cost of lithium ion batteries used to store energy on board the vehicle. As battery technology improves and production of PEVs is ramped up, the initial cost of PEVs is expected to decrease.[11] Before 2009, a 100-mile range electric battery cost $33,000. Today the same battery costs about $17,000, and it is projected to drop to $10,000 by the end of 2015, thus making PEVs much more cost competitive.[12]

Fuel Economy and Total Cost of Ownership

For many driving applications and behaviors the total cost of ownership (TCO) for a PEV is lower than that of a comparable gas vehicle after five to ten years. According to a study by Edmunds, it takes the average consumer 6.5 years to recoup the $10,000 price premium on a BEV.[13] Charging an electric car costs three to five cents per mile. In contrast, fueling a gasoline car that has a fuel economy of 27.5 mpg costs about 14 cents per mile. If you drive 15,000 miles per year, you could save $1,300 to $1,600 per year in fuel costs annually by driving a PEV in all-electric mode instead of driving a conventional gasoline car.[14] If your utility offers lower electric rates for charging during off-peak times, such as at night, you may be able to reduce your PEV fuel costs even further by charging during these times. In addition, maintenance costs for BEVs are expected to be relatively low, due largely to the fact that there are fewer moving parts in electric powered vehicles. A recent study by Pike Research of alternative fuel vehicles found that, for a majority of fleet applications, BEVs offered a total cost of ownership that was lower than the TCO for most other vehicle fuel types, including gasoline.[15]

Incentives

Governments, utilities and private businesses have developed a variety of financial and non-financial incentives to promote PEV adoption. Some of the most popular types of incentives are summarized in the Figure 2.6.

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[11] Battery cost can contribute approximately 30% to the total cost of the vehicle and according to a 2012 study by McKinsey & Company, the cost of a PEV lithium-ion battery pack could fall to about $200 per kWh by 2020 and to about $160 per kWh by 2025, down from about $500-600 today. This could equate to a $10,000 savings on the overall PEV price in 2025.; http://www.mckinseyquarterly.com/Battery_technology_charges_ahead_2997

[12] http://energy.gov/articles/top-10-things-you-didn-t-know-about-electric-vehicles

[13] http://www.edmunds.com/car-news/price-of-electric-vehicles-shows-disconnect-study-says.html

[14] Fuel cost savings depend on electricity and gasoline prices, as well as vehicle types and driving patterns. This example compares a gasoline car with a fuel economy of 27.5 mpg (combined city and highway) assuming a gasoline cost of $3.75/gallon versus PEVs operated in electric mode at 3 to 5 cents per mile (which assumes an electricity cost of 11 cents/kWh).

[15] The compact BEV and hybrid electric vehicle (HEV) models have lower TCOs than the small gasoline model, while the plug-in hybrid, mid-size HEV, diesel and CNG all have lower TCO than the mid-sized gasoline sedan. http://www.pikeresearch.com/newsroom/alternative-fuel-vehicles-offer-fleet-operators-lower-total-cost-of-ownership-hedge-against-future-fuel-price-shocks

Figure 2.6 Common Types of PEV Incentives

Financial Incentives	
Incentive	**Responsible Party**
Rebates or tax credits on vehicles	Federal and state governments
Exemptions from vehicle registration taxes or license fees	State governments
Discounted tolls and parking fares	City, county, and state governments and property managers
Tax rebates for charging equipment and installation	Federal and state governments
Discounted electricity rates for EV users from utilities	Utilities
Non-financial Incentives	
Incentive	**Responsible Party**
Dedicated parking spaces	Property managers, employers, local governments
Access to restricted highway lanes	State governments
Free charging at public and workplace charging stations	Property managers, employers, local governments

Incentives currently available to PEV buyers in North Carolina are detailed below.

Federal

- The **Qualified Plug-In Electric Drive Motor Vehicle Tax Credit with a value of up to $7,500** is available for the purchase of new plug-in electric vehicles with at least four kilowatt hours of capacity. 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. [16] Car buyers that purchase PEVs with batteries that are 16 kWh or larger are able to take the full $7,500 tax credit. Virtually all BEVs have batteries large enough for the full $7,500 credit to be taken. PHEVs with longer electric ranges like the Chevy Volt also have the 16 kWh capacity, but PHEVs like the Toyota Plug-in Prius have smaller batteries that will only allow buyers to claim a certain portion of the credit.

State Government Incentives

- North Carolina has **no state tax credit** for the purchase of an electric vehicle or installation of electric vehicle service equipment. States such as California, Tennessee, South Carolina and Georgia offer PEV tax incentives that range in value from $2,000 to $5,000.
- As per 2011 legislation, qualified plug-in electric vehicles may use North Carolina **HOV lanes**, regardless of the number of occupants.[17] As of 2012 the only HOV lanes in the state were located in the Charlotte region. There are no current plans for HOV lanes in the Asheville metro area.

[16] It is important to note that the tax credit does not actually reduce the purchase price of an electric car. Buyers can claim the rebate on their next tax return, but only receive a rebate that matches their tax liability. (e.g. If and individual owes $3000 in taxes, they will only receive $3000 back)
[17] Reference House Bill 222, 2011, Senate Bill 194, 2011, and North Carolina General Statutes 20-4.01 and 20-146.2.

- Qualified plug-in electric vehicles are **exempt from annual state emissions inspection** requirements. This fee in North Carolina is $30.[18]

Utility Incentives

- Progress Energy Carolinas currently offers a **whole house time-of-use rate** which may be utilized by customers with PEVs.
- Home charging station subsidies are available on occasion from Duke Energy and Progress Energy Carolinas

Local Incentives

- Charging is currently free at all public charging stations in the Asheville area.

Vehicle Emissions

PEV adoption can also dramatically reduce vehicle emissions of air pollutants and greenhouse gases (GHGs). When PEVs are driven in all-electric mode, they produce zero direct emissions, thereby reducing air-pollutants that contribute to local smog, haze and health problems.

In most areas of the country PEVs also have a significant *well-to-wheel emissions* advantage over similar conventional vehicles running on gasoline or diesel. Well-to-wheel emissions include all emissions related to fuel production, processing, distribution, and use. In the case of gasoline, emissions are produced while extracting petroleum from the earth, refining it, distributing the fuel to stations, and burning it in vehicles. In the case of electricity, most electric power plants produce emissions, and there are additional emissions associated with the extraction, processing, and distribution of the primary energy sources they use for electricity production.

Based on DOE estimates, well-to-wheel emissions from a PEV that is powered solely by electricity in North Carolina can be 50% lower than the well-to-wheel emissions from a conventional gas vehicle with an Internal Combustion Engine (ICE), and roughly 25% lower than the emissions from a hybrid electric vehicle (HEV) like the Toyota Prius. These emissions estimates are based on the mix of fuels that power the electrical grid in North Carolina. The grid is primarily powered by a mix of coal, natural gas, nuclear and hydroelectric power. A 2012 report from the Union of Concerned Scientists also found that charging a PEV on the North Carolina electrical grid produces significantly lower emissions than the most efficient gasoline powered hybrid electric vehicles (HEVs).[19]

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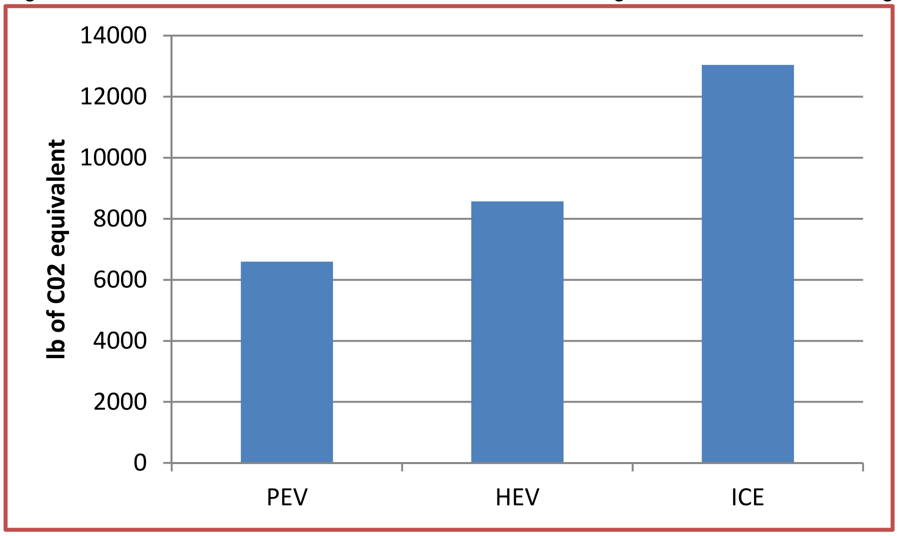
[18] Visit http://www.ncdot.gov/dmv/vehicle/registration/inspection/ for more information. See also: http://daq.state.nc.us/motor/inspect/emission_faq.shtml#G14

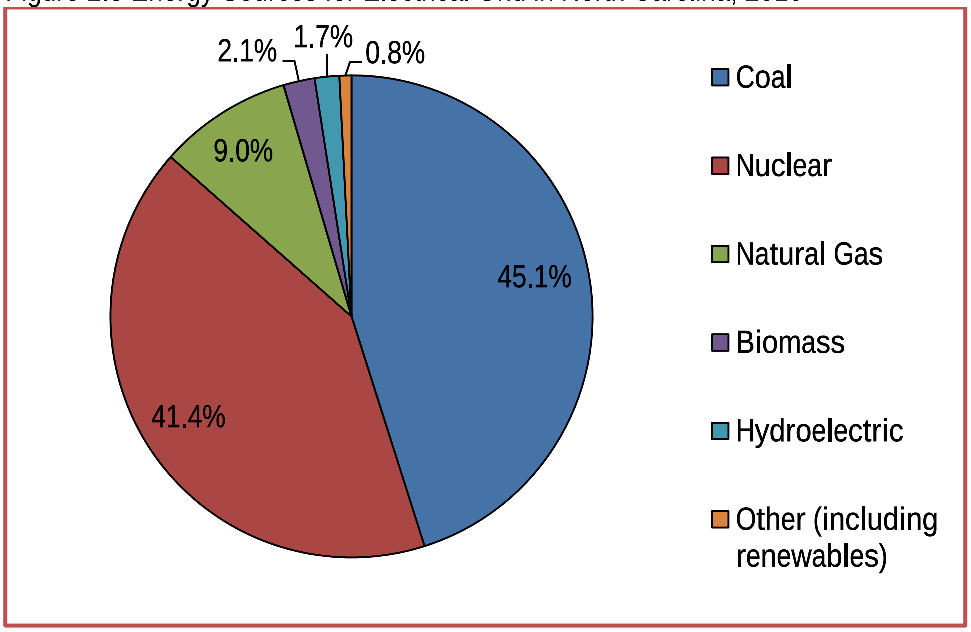
[19] "State of Charge" Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States, Union of Concerned Scientist, June 2012, http://www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf

Figure 2.7 Estimated Annual Emissions of PEV Charged in the Asheville Region



Source: http://www.afdc.energy.gov/vehicles/electric_emissions.php

Figure 2.8 Energy Sources for Electrical Grid in North Carolina, 2010



Source: http://www.afdc.energy.gov/vehicles/electric_emissions.php

As North Carolina utilities shift to cleaner sources of energy the well-to-wheel emissions advantage of PEVs will improve. Carbon emissions from PEVs are already decreasing significantly as utilities replace coal power with cleaner burning natural gas, which has become very cheap since the boom in US shale gas production.[20] [21] North Carolina also benefits from both policy and market driven

[20] http://www.forbes.com/sites/energysource/2012/12/07/surprise-side-effect-of-shale-gas-boom-a-plunge-in-u-s-greenhouse-gas-emissions/

[21] http://energync.org/blog/ncsea-news/2012/10/17/progress-energys-new-natural-gas-plant-slowly-rising/

initiatives that aim to increase the use of renewable sources of energy. In 2007, North Carolina became the first state in the Southeast to adopt a Renewable Energy and Energy Efficiency Portfolio Standard (REPS), which requires that electric utilities obtain a portion of their energy through renewable energy resources or energy efficiency measures.[22] In a market driven initiative, electric utility customers have the ability to help mitigate greenhouse gas emissions by purchasing renewable energy via NC GreenPower, an independent nonprofit organization established by the NC Utilities Commission. NC GreenPower supports electrical generation from renewable energy sources such as solar, wind, and organic matter.[23] In addition, Many PEVs owners in the Asheville region and around the country are installing solar PV at their home to offset emissions from charging or using public solar EV charging stations to offset some portion of their charging needs. A recent survey of PEV owners found that a third of the group already own or plan to install a solar PV system at their home.[24]

Battery Longevity

PEVs on the market today use lithium-ion batteries rather than the nickel-metal hydride batteries used in most hybrid electric vehicles. Although some consumers have concerns over the lifespan of the lithium-ion batteries used in today's PEV s, auto manufacturers and industry groups have subjected PEV batteries to extensive testing to prove their endurance, and almost all car companies offer extended warranties on the vehicle's battery for 8 years or 100,000 miles. Market analysts are also expecting a secondary-use market for lithium ion batteries that may significantly offset the cost of replacing the battery, if needed. Demand for used electric vehicle batteries is expected in applications such as ships, trucking, aircraft, military, EV retrofit, electrical grid backup power, and renewable energy.[25]

PEV Impact on the Electrical Grid

National studies have predicted that widespread PEV adoption will not have a significant effect on the U.S. electric system. A study by Edison Electric Institute anticipates that if 80 percent of 2010 U.S. sales of cars, SUVs, and light trucks were replaced by PEVs with 40 miles of electric range, the resulting load from those 10 million cars would add less than 1 percent to the total U.S. electricity consumption.[26] Even if the majority of Americans started driving PEVs today, the existing electrical grid's off-peak capacity for power generation is sufficient without building a single new power plant.[27] Studies have confirmed that electric vehicle owners are largely charging their vehicles at night when there is plenty of capacity on the grid. Under the expected penetration rates of PEVs and with modest charge rates, North Carolina utilities also expect the grid impact to be negligible in the years to come. Utilities are also working on future enhancements to the grid which will enable additional customer features and options to help manage their loads and mitigate peak demand from vehicles and other sources of demand.[28]

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[22] http://www.ncuc.commerce.state.nc.us/reps/reps.ht
[23] NC GreenPower Website, http://www.ncgreenpower.org/about/
[24] Haynes, Cary. "PV Meets EV". 2012 ASES Conference. Denver, Colorado. 5/12/12
[25] Ghosh, Dr. Samit. "Secondary Use: What to do with used electric vehicle batteries." CHARGED: Electric Vehicles Magazine, Jun/Jul 2012: 24-29.
[26] Edison Electric Institute. (2011). The Utility Guide to Plug-in Electric Vehicle Readiness. Washington, D.C. p. 5
[27] Electric Power Research Institute and Natural Resources Defense Council. "Environmental Assessment of Plug-in Hybrid Electric Vehicles." 2007. Cited February 16, 2011.
[28] Waters, Mike. "Community PEV Readiness Plan Corrections". Email to Brian Taylor . 12/28/2012

2.2 Charging Stations

Charging stations, also known as Electric Vehicle Supply Equipment (EVSE), provide for the safe transfer of energy between electric utility power and the electric vehicle. The EVSE consists of the connector, the cord, and the interface to utility power. The EV charger itself is typically on board the PEV.

Charging Levels

There are three basic levels to charge any PEV, and since the adoption of the SAE J1772 connector, every new PEV can be charged using any charging equipment with this standard connector (Figure 2.11). How long it takes to charge at each level depends on how far the vehicle has been driven and the size of the battery. Charging speed is also governed by the size of the on-board charger and the power level of the charging equipment.

<u>Level 1: 120-volt</u>

Every new PEV comes with portable charging equipment that allows them to plug in to any 120-volt outlet for Level 1 charging. Level 1 charging provides about 3 to 5 miles of range per hour of charge (Figure 2.9). Level 1 charging is ideal in places where a vehicle will be parked for 6 or more hours, and for PEVs that have smaller batteries, including many of the PHEVs on the market today.

<u>Level 2: 240-volt</u>

Level 2 charging uses 240 volts AC power and requires EVSE to be installed. Level 2 charging provides about 10 to 20 miles of range per hour of charge. From empty, a full size battery electric car takes about 4 to 7 hours to recharge. Hardware and installation costs can vary greatly. The cost of a Level 2 public charging station generally ranges from $2,000 to $5,000 and the average cost of installation ranges from $1,500 to $3,000.

<u>Direct Current (DC) Fast Charging: up to 480-volt</u>

DC fast chargers typically use a three-phase service at 208V AC or higher, with output levels between 25-50kW. DC fast charging provides 50kW on average, which can recharge the battery on a PEV to 80% in less than 30 minutes on average. DC fast charging is expected to be used by BEVs only, and primarily for en route charging for longer trips at or beyond 70 miles. For this reason DCFC infrastructure deployed to date has been located near major highways. A dense network of DCFC has the potential to expand the appeal of BEVs by doubling the convenient electric driving range and allowing for inter-regional travel. Few DCFC stations have been deployed to date due to the high cost of installation and the small number of BEVs currently on the road.

Figure 2.9 PEV Charging Levels

Charging Level	 Level 1	 Level 2	 DCFC
Miles Recovered Per Hour of Charge	~ 4 mi	~ 10-20 mi	~ 140 mi.
Voltage	120V	240V	480V
EV Connector	J1772 AC	J1772 AC	SAE AC/DC Combo or CHAdeMO
Hardware Cost	Comes with EV	Res: $500-$1,500 Comm: $2,000-$5,000	$15,000 - $50,000
Installation Cost		Res: $750-$1,500 Comm: $1,500-$3,000	$50,000-$80,000

Source: NC PEV Taskforce

Charging Connectors

Almost all PEV sold in the U.S. today are equipped to use the SAE J1772 AC connector based on the standard developed by the Society of Automotive Engineers (Figure 2.10). Any vehicle with this plug receptacle should be able to use any J1772-compliant Level 1 or Level 2 EVSE (Figure 2.11). All major vehicle and charging system manufacturers support this standard in the U.S., which should eliminate drivers' concerns about whether their vehicle is compatible with the infrastructure.

Figure 2.10 SAE J1772 AC Connector

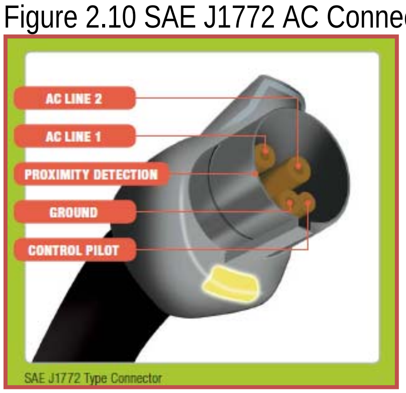


Figure 2.11 Receptacles for SAE J 1772 AC (right) and CHAdeMO (left) on Nissan LEAF

Source: http://www.afdc.energy.gov/fuels/electricity_infrastructure.html

CHAdeMO DC Fast Charging is the trade name of a fast charging solution currently adopted by several Japanese automakers to deliver up to 62.5 kW of DC power via a specialized connector (Figure 2.12). Several early battery electric vehicles in the marketplace currently offer this solution as the SAE North American standard was not in place when the vehicles were developed. Although the European and North American automakers have announced their plan to incorporate the new SAE combo connected standard, it is possible that some Japanese automakers will continue with this solution. Note that all vehicles will still be capable of utilizing the SAE AC level 1 and level 2 connector and charging levels regardless of the DC charging solution, although the CHAdeMO option will require a separate DC charging inlet in addition to the AC inlet.

Figure 2.12 CHAdeMO DC fast charge connector in Vacaville, CA

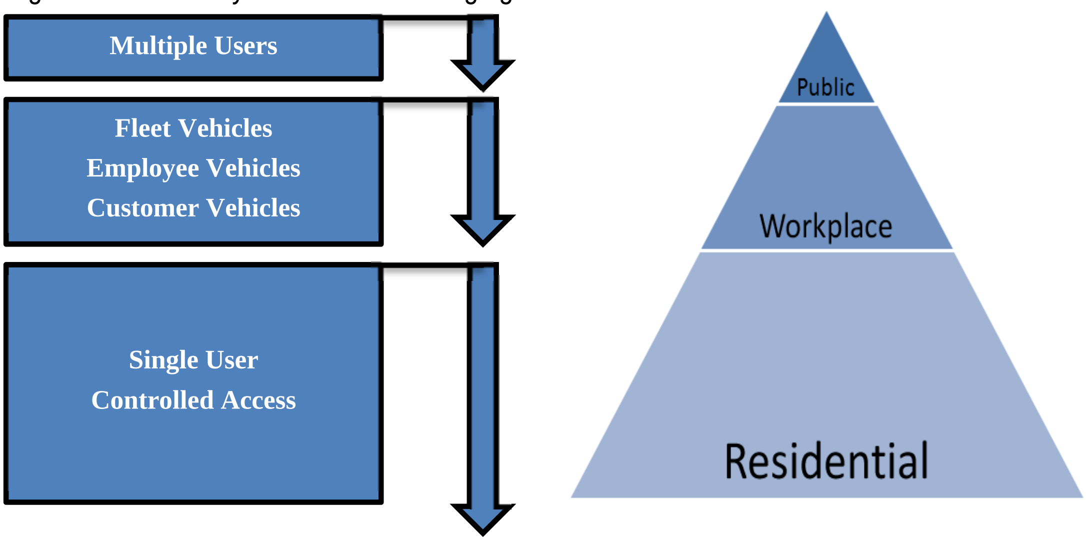
SAE J1772™ AC/DC Combo Connector is a new standard that expands the standardized SAE connector listed above to also include the ability to charge with low and high power Direct Current (DC) electricity (Figure 2.13). This is enabled by the addition of two DC pins below the existing AC pin design as depicted in the figure below. Despite the new functionality, the vehicle ports and connectors will maintain backward compatibility with the AC Level 1 and 2 charging levels. The largest seven automakers in the U.S. and Europe have all agreed upon this new SAE standard to incorporate DC fast charging capability in future models, some expected in 2013. Note that some Japanese auto manufacturers are currently using a Japanese DC fast charging connector and system called CHAdeMO and at the time of this report publishing have not agreed to adopt the new SAE combo connector solution for DC fast charging.

Figure 2.13 SAE Combo Connector courtesy SAE International

Charging Locations

PEVs will be charged at one of three locations: at home, at the workplace, and in public. The EPRI Pyramid, popularized by the Electric Power Research Institute (EPRI), demonstrates the expected distribution of charging station locations across various vehicle user types (Figure 2.14). [29] It is projected that 80% of vehicle charging will be done at home by individuals.

Figure 2.14 EPRI Pyramid of PEV Charging Locations



Public Charging

While it is expected that the majority of vehicle charging will take place at home, appropriately placed public charging capability will be necessary, to enhance consumer adoption of electric vehicles and to respond to the issues of range anxiety that EV owners will experience. Publicly available charging infrastructure may be installed on public property owned by public entities such as municipalities or utilities. Commercial establishments, such as retail outlets, may also decide to install charging stations open to the public. It is most likely that public charging infrastructure will consist of Level 2 and DC Fast Charging Stations. Due to the long charge times necessary for Level I charging, the installations of Level 1 chargers would be impractical except for special locations with long dwelling times such as airports and park & ride lots.

[29] Guidebook for Multi-Family Installations, Advanced Energy

Workplace Charging

Workplace charging is defined in this PEV plan as private charging stations installed by an organization for fleets, employees, customers and or guests. Workplace charging is the second most frequent venue that PEV drivers are likely to use to recharge. Property managers are expected to install either Level 1 and/or Level 2 charging opportunities at the workplace.

- Fleets: The workplace will be the primary charging location for fleet vehicles purchased by organizations and become more common as private and public organizations find fleet applications for electric vehicles that lower overall business operating costs and assist in compliance with government transportation emissions policies. As the primary charging location for fleet vehicles, most charging installed for these vehicles is expected to be at Level 2.
- Employees and Guests: While the majority of vehicle charging for individuals is expected to occur at the owner's residence, some employers will provide workplace vehicle charging opportunities as a perk or an incentive for employees to adopt more sustainable transportation. These same charging stations could also be reserved for guests. Given the relatively long dwelling time of cars parked at work, Level 1 charging may be sufficient for employees. Level 2 charging would provide added convenience and may be more appropriate for guests that visit for only part of the work day.
- Customers: Many service sector businesses may decide that it makes sense to install charging stations for their customers as a way to increase business from EV owners and renters. Charging availability at commercial and retail locations allows users to charge where they shop, dine, or lodge. Availability of vehicle charging opportunities at commercial locations may increase customer visits and lengthen their time of stay. Hotels will make up a specific sub-set of these businesses, where charging could serve as a necessity for some customers renting PEVs.

Residential Charging

As charging at home provides drivers with a safe, reliable and readily-accessible charging opportunity, it is expected the majority of PEV drivers will charge their vehicles at home – overnight – using Level 1 or Level 2 charging.

Charging Station Features

Communications

Networked charging stations can:

- communicate station location and status information to online maps or mobile devices,
- collect charging usage data for EVSE owners, and
- allow owners to restrict access and accept payment for charging.

Some EVSE manufacturers, such as Chargepoint and Blink, have equipped all of their charging stations with network capabilities and provide all of these features as part of a package service to all of their EVSE customers. This business strategy provides a simple network solution for EVSE owners that can pay a premium for networked charging stations and ongoing service plan fees. Most EVSE makers offer some type of private networking features and software to remotely monitor and manage charging stations. Cellular, wireless and Ethernet interfaces can be used to provide EVSE with network capabilities.

Access and Payment Options for Public and Workplace Charging

EVSE makers offer a range of different features that allow charging station owners to collect payment for charging from EV drivers, such as

- smart card readers,
- RFID readers and fobs,
- credit card swipes, and
- numeric keypads.

Chargepoint, for example, allows the station owner to restrict access with a smart card reader and set up monthly or per-use fees for charging. All of these access and payment features require stations to be networked, which increases the cost of EVSE hardware and installation, and can often involve ongoing service fees.

Figure 2.15 Communication, Access, and Payment Features for Charging Stations

Optional Feature	Description
Radio Frequency Identification (RFID) Reader	Allows station owners/operators to restrict usage to authorized drivers by requiring a RFID card to initiate charging
Energy Meter	Provides accurate energy and power measurement through the station with integrated power metering circuitry
Cellular Network Interface	Allows seamless integration network application services from nearly any location, direct from the station
Wireless Network Interface	Allows seamless integration network application services from a station to a local router and through the internet
Ethernet Network Interface	Allows seamless integration network application services from a station to a local router and through the internet
Software Application Services	Set pricing and collect fees, provide 24/7 driver assistance, control access, display advertisements, track usage, and diagnose the station remotely ;Most often used in conjunction with RFID controlled access
Credit Card Reader	Set pricing and collect fees without the need of a RFID card or membership system
Numeric keypad module	Set pricing, collect fees, and control access through local synchronous codes

At this early stage of EVSE deployment, collecting payment for charging is still the exception rather than the rule. Given the initial low demand for charging, free charging is seen as an inexpensive way to promote PEV adoption in the near term. As a result, information on rates for charging is limited. Some retail businesses and downtown development associations are considering offering free PEV charging as a perk, similar to free wireless, to attract more customers and encourage them to spend more time (and money) at a location.

In North Carolina, assessing fees for charging is complicated by state utility laws. North Carolina does not allow the third party sale of electricity, except through regulated entities, which include the utilities in the state. Currently, charging station operators can assess a fee for access to a parking space, but not for the actual amount of electricity used at a charging station.

Station Installation

For a comprehensive guide to charging station siting and installation please refer to the following guidance documents:

- Advanced Energy *Charging Station Installation Handbook*, www.advancedenergy.org/transportation/evse/charging_station_installation_handbook.php
- DOE Clean Cities *Plug-in EV Handbook for Electrical Contractors,* www.afdc.energy.gov/afdc/pdfs/51228.pdf
- DOE Clean Cities *Plug-in EV Handbook for Public Charging Station Hosts,* www.afdc.energy.gov/afdc/pdfs/51227.pdf

Provided below are some general considerations for the installation of public and workplace charging stations.

General Considerations for Public and Workplace EVSE installation

- Compliance: EVSE should meet the appropriate codes and standards and must be certified and so marked by a nationally recognized testing laboratory (e.g., UL). EVSE should be installed to standards outlined in the National Electric Code (NEC) Section 625. Government inspectors may differ in what NEC publication they inspect to (2005, 2008 or 2011).
- Protection: EVSE should be positioned in a way that allows a physical barrier for its protection. Wheel stops or bollards may be used to prevent a vehicle from contacting the EVSE, depending on how the property owner wants to mitigate risk.
- Convenience: Locate EVSE and associated PEV parking as close as possible to the electric service while accommodating other activities within your facility. Keep in mind that PEVs can be parked for hours at a time for charging.
- Avoiding Hazards: Cords and wires associated with EVSE should not interfere with pedestrian traffic or present tripping hazards. PEV charging spaces should not be located near potentially hazardous areas.
- Preventing Impact: Curbs, wheel stops, and setbacks should be used to prevent PEVs from colliding with EVSE. However, accessibility issues must also be considered when using these strategies.
- Vandalism: Assess the risk of vandalism and minimize risk through use of preventive strategies, such as motion detectors, security lighting, tamper alarms, and locked enclosures.

- **Signage:** Use signs that can be seen over parked vehicles to designate PEV-only parking spaces. Any publically accessible EVSE installed that is not visible from the street would benefit from street-side signs directing drivers to the charging station.
- **Accessibility:** Evaluate and address requirements for complying with the Americans with Disabilities Act, as well as state, local, and organizational accessibility policies. Compliance measures may include adjusting connector and receptacle heights, cutting curbs, and providing handicap-accessible parking spaces.

Mapping of Public Charging Stations

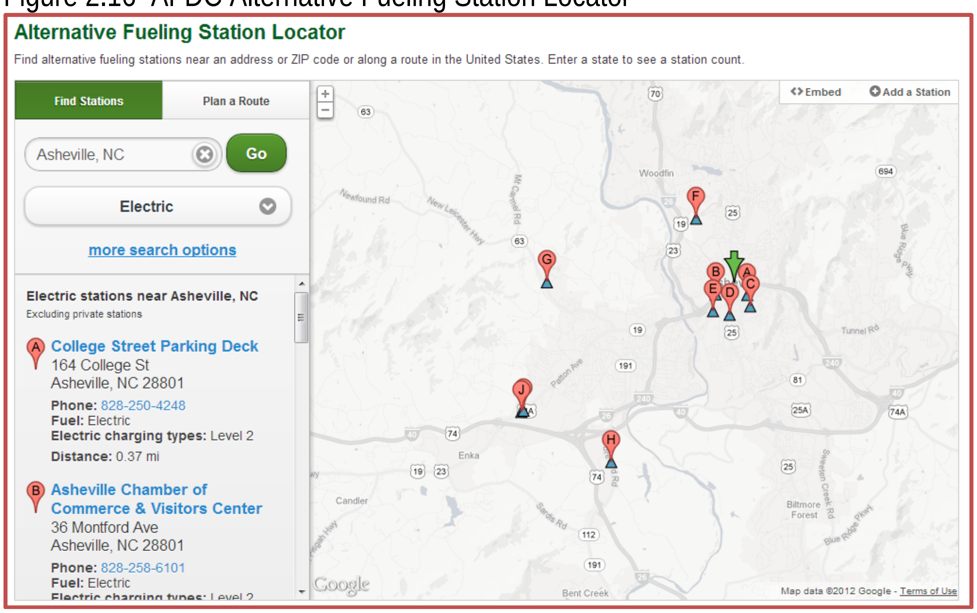
Deploying public charging infrastructure will do little to promote PEV adoption if drivers are unaware of the charging locations or unable to navigate to them. Over the past year numerous online EVSE mapping tools have emerged to help PEV drivers find charging stations with the help of online maps and smart phone applications.

US Department of Energy's Alternative Fueling Station Locator

The Alternative Fuels Data Center of the US DoE has an interactive map that allows you to look for many types of alternative fueling stations including electric. The site allows you to search by charging speed (Level 1, Level 2, or DC Fast Charge) and you can search for public or private stations. This map is recognized by EVSE firms and automakers as the central clearing house for information on charging station locations.

- AFDC Alternative Fueling Station Locator (www.afdc.energy.gov/locator/stations/)
  - No smart phone app
  - New station locations can be submitted online to US DOE
  - Stations on networks such as Blink and Chargepoint show up automatically

Figure 2.16 AFDC Alternative Fueling Station Locator



Crowd-sourced Smart Phone Applications

Numerous other mapping services have popped up over the past two years that offer online maps and smart phone applications to track down charging stations. These maps pull charging station location data from other online maps such as AFDC Alternative Fueling Station Locator, but also from individuals that add new stations to their map. As a result these maps often have locations that do not yet show up on other maps. Users can also provide comments about the station functionality, access, and location. As with any crowd-sourced tool, the quality and amount of information can vary greatly from entry to entry.

- Plugshare (www.plugshare.com)
- Recargo (www.recargo.com)
- Car Stations (carstations.com)

Figure 2.17 PlugShare Smart Phone App

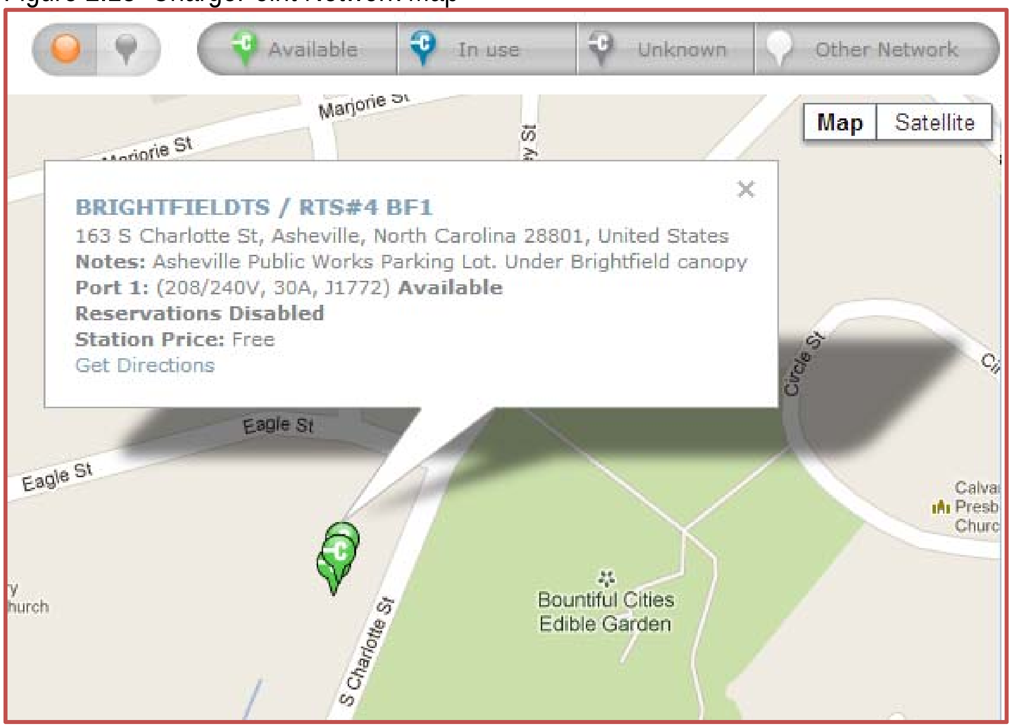
Charging Station Manufacturer Maps and Smart Phone Applications

Charging station manufacturers such as Blink and Chargepoint have installed networking capabilities on all of their charging stations so that they can provide real time information on charging station status to EV drivers through online maps and smart phone apps. Access to charging at these charging stations requires the use of a card that can be swiped in front of the station.

- Chargepoint Network (www.chargepoint.com)
    - Now includes stations not on Chargepoint network, including non-networked stations
    - To access a Chargepoint station you will need a ChargePoint card, which can be ordered on their website.

- o Non-ChargePoint charging stations, including the Eaton Pow-R-Station, can now be uploaded to the ChargePoint network
  - o As of October 2012 a total of 8 ChargePoint stations have been deployed at 3 sites in the Asheville region
- Blink Network (www.blinknetwork.com)
  - o Only maps Blink charging stations installed by Ecotality.
  - o To access a Blink station you will need a Blink Network card, these are available for free on their website.
  - o As of October 2012 there were no Blink charging stations deployed in North Carolina

Figure 2.18 ChargePoint Network Map



<u>Regional Map</u>

The CVC maintains a *Public Charging Stations in Western NC* Google map on the EV Committee website. This map was created as a regional clearing house for the most up-to-date and accurate information on EV charging locations in western North Carolina.

- Land-of-Sky Clean Vehicles Coalition (www.cleanvehiclescoalition.org/page.php?22)
  - o Google map of public EV charging stations in Western North Carolina
  - o Provides more accurate and up-to-date information than the AFDC map

On-board Mapping

PEVs such as the Nissan LEAF come with on-board LCD screens with navigation programs that map out charging station locations. New charging stations can be downloaded or entered manually by the driver.

- CarWings for Nissan LEAF (www.nissanusa.com/innovations/carwings.article.html)

2.3 Key Terms and Acronyms

Term	Acronym	Definition
Alternative Fuels Data Center	AFDC	The Alternative Fuels Data Center (AFDC) is a comprehensive clearinghouse of information about advanced transportation technologies created by USDOE to support Clean Cities coalitions like the CVC. Important tools include the Alternative Fueling Station Locator and the Vehicle Cost Calculator
Asheville region		Planning area for Asheville Area PEV Plan that includes Buncombe, Haywood, Henderson, Madison, and Transylvania Counties
Battery Electric Vehicle	BEV	Battery electric vehicles are all-electric, have no Internal Combustion Engine and are totally dependent on plugging into the electric power grid for fueling. BEVs have a driving range of 80 to 300 miles. Examples: Nissan Leaf, Tesla Sedan, Coda, Ford Focus Electric, Mitsubishi i-MiEV
CHAdeMO		Trade name of a DC fast charging method for battery electric vehicles via a special electrical connector. It is proposed as a global industry standard by an association of the same name.
Clean Cities Coalition		Clean Cities Coalitions help fleets and consumers reduce their petroleum use by building partnerships with local public and private organizations to help them adopt alternative and renewable fuels, idle reduction measures, fuel economy improvements, and new transportation technologies. There are 3 Clean Cities Coalition in North Carolina: Triangle Clean Cities, Centralina Clean Fuels Coalition, and the Land-of-Sky Clean Vehicles Coalition.
DC Fast Charger	DCFC	DC chargers, aka "DC Fast Chargers," are currently the fastest way to charge a battery. These chargers will only charge a battery up to 80% to protect the battery's life span and installation requires a qualified electrician. Application: Retail, Commercial, and On Street Technical: 480VOC, 100+ A Charging time: 80% charge in 30 minutes. Connector: CHAdeMO (SAE approval pending)
Electric Power Research Institute	EPRI	The Electric Power Research Institute conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. EPRI is well known for their Pyramid of Charging Locations and developed the EV and EVSE projections projection for the North Carolina.
Electric Vehicle Supply Equipment	EVSE	Refers to charging stations for plug in electric vehicles.
Extended Range Electric Vehicle	EREV	EREV is a term popularized by General Motors for a series PHEV like the Chevy Volt
Hybrid Electric Vehicle	HEV	HEVs are powered both by an internal combustion engine as well as an electric motor. The energy for the electric motor is store in a battery which is charged through regenerative braking and by the Internal Combustion Engine (ICE). HEVs do not plug in to an

		electricity source to charge. All HEVs are parallel hybrids. *Range*: (300+ with gas motor) vehicle selects mechanical or electric power *Examples*: Toyota Prius, Honda Civic Hybrid
Internal Combustion Engine	ICE	Engines in which the internal combustion of fuel powers the drive train. ICE vehicles are usually fueled by petroleum or diesel, but may also use alternative fuels such as biodiesel, compressed natural gas, or ethanol.
Land-of-Sky Clean Vehicles Coalition	CVC	The Land-of-Sky Clean Vehicles Coalition is a Clean Cities Coalition based at Land-of-Sky Regional Council that promotes alternative fuel vehicle adoption in Buncombe, Haywood, Henderson, Madison and Transylvania counties. The CVC is leading the planning process for the Asheville Area PEV Plan.
Level 1 Charging		Level 1 charging is provided by plugging in to a standard 120 volt (V) outlet. Level 1 charging adds about 2 to 5 miles of range per hour of charging time, making it most appropriate for residential and long term parking locations. PEVs will come with a Level 1 EVSE cord set with a standard, three-prong household plug (NEMA 5-15 connector) on one end and the SAE J1772 standard connector on the other end.
Level 2 Charging		Level 2 charging requires the installation of a charging station that provides 240 V at up to 80A. Most units operate at 30 amperes, delivering 7.2 kW of power, which requires a dedicated 40 amp circuit. Level 2 adds about 10 to 20 miles of range per hour of charging time. This is an appropriate application for public, workplace and residential sites where a vehicle is parked for over an hour. Most PEV drivers will install Level 2 EVSE at home to charge their vehicle battery overnight. Level 2 equipment also uses the same J1772 connector as Level 1 equipment. Level 2 EVSE must be installed by an electrical contractor.
Miles per Gallon Equivalent	MPGe	MPGe is used to compare the amount of energy consumed when driving a PEV with the amount of gasoline used when driving gasoline-powered vehicle. Since electricity cannot be measured in gallons, an equivalency of the amount of energy is used. The EPA uses MPGe in fuel economy labels for alternative fuel vehicles. One U.S. gallon of gasoline is equal to 33.7 kWh of electricity.
NC PEV Readiness Initiative: Plugging in from Mountains to Sea	M2S	The M2S project is a planning initiative funded by the U.S. DOE to prepare North Carolina for PEV adoption. The M2S project includes multiple initiatives consisting of the development of a state-wide PEV Roadmap and four community PEV readiness plans for Asheville, Charlotte, the Piedmont Triad and the Triangle.
NC PEV Taskforce	NCPEVTF	The North Carolina Plug-in Electric Vehicle Taskforce is a statewide group of Clean Cities Coalitions, non-profits, utilities, EV-industry, and state agencies that are working to develop the NC PEV Roadmap for the M2S project.
Parallel hybrid		Parallel hybrids are PHEVs that simultaneously transmit power to

		the drive wheels from two distinct sources: an ICE and a battery-powered electric drive. *Examples*: Toyota Prius
Plug-in Electric Vehicle	PEV or EV	Plug-in Electric Vehicles (PEVs or EVs) are powered by batteries that can be charged by plugging the vehicle into an electrical outlet. The two types of PEVs are Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs), also known as all-electric vehicles
Plug-in Hybrid Electric Vehicle	PHEV	PHEVs can be powered by an internal combustion engine or a battery that is charged by plugging the vehicle into an electric power source. PHEVs have an electric driving range of 20-40 miles and an additional 300+ miles of range from the gas engine. PHEVs can either be parallel or series Hybrids. Examples: Chevy Volt (series), Toyota Plug-In Prius (parallel)
Society of Automotive Engineers J1772	SAE J1772	US-based organization for engineering professionals in the aerospace, automotive, and commercial vehicle industries. The Society coordinates the development of technical standards based on best practices identified and described by SAE committees and task forces comprising engineering professionals in the relevant fields. They have developed the American standard for electrical connectors for electric vehicles known as the J1772 connector
Series hybrid		Series hybrids are PHEVs that use an ICE to turn a generator that fuels an electric motor. Only the electric motor powers the wheels. *Examples*: Chevy Volt, Fisker Karma
US Department of Energy	USDOE	Federal governmental department whose mission is to advance energy technology and promote related innovation in the United States.