# Alternative Fuel Tool Kit

# How To Implement: Electric Vehicles

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## Introduction to Plug-In Electric Vehicles (PEVs)[1]

There are a wide variety of electric vehicles available in North Carolina. A plug in electric vehicle (PEV) is any vehicle that plugs into the electric power grid to receive energy for propulsion. There are two types of PEVs on the market today:

A Plug-In Electric Vehicle (PEV) is any vehicle that plugs into the electric power grid to receive energy for propulsion.

- A Battery-Electric Vehicle (BEV) is a vehicle that only utilizes electricity for propulsion, which is stored in an on-board battery. This type of vehicle has no additional source of energy other than electricity from the power grid and stand alone renwable energy, such as solar arrays. Two examples of this type of vehicle on the market in North Carolina are the Ford Focus EV and the Nissan Leaf. Also included in the all-electric vehicle category are neighborhood electric vehicles (NEVs), which are four-wheeled all-electric vehicles that are limited to a top speed of 25 mph. NEVs are generally restricted to roads with a speed limit of 45 mph and under[2] and are commonly used for maintenance or security at universities and other large campus-style facilities.
- A Plug-in Hybrid Electric Vehicle (PHEV) is similar to a hybrid electric vehicle (having both a gas engine and an electric motor), but is able to recharge its battery by plugging into the electric power grid. Because PEVs can charge using the grid, they typically have larger capacity battery packs than hybrid electric vehicles (HEVs). The PHEV batteries can provide 10-60 miles of additional driving distance depending on the battery size. The Chevrolet Volt (a series hybrid) and Ford Fusion Energi (a parallel hybrid) are two examples of PHEVs that are available in North Carolina. With a combustion engine as part of the PHEV architecture, some of the barriers associated with battery-electric vehicles, such as range limitations, do not apply.

**Series vs. Parallel Hybrid Architecture:**

Hybrid electric vehicles, both the standard and plug-in varieties, combine a traditional internal combustion engine (ICE) and an electric motor to increase a vehicle's fuel efficiency. In a series hybrid, the wheels are driven by the electric motor only and the ICE acts as a generator to charge the batteries. In a parallel hybrid, the ICE and electric motor are attached to the transmission, and the wheels are driven by the electric motor, the ICE, or both simultaneously, depending upon driving conditions.

Hybrid electric vehicles (HEVs) use both an electric motor and and an internal combustion engine to propel the vehicle, but do do not require an additional electric source and are not to be confused with PHEVs. The most popular HEV in the United States is the Toyota Prius. HEVs were introduced in the U.S. market place in the late 1990's. PEVs were introduced into the US market in 2010, but were not available in most parts of North Carolina until late 2011.

Although PEVs have only been available for purchase for a few years, the sales in the US are strong and steadily increasing. As of December 2013, there were over 170,000 cumulative electric vehicle sales[3] in the U.S., which is outpacing hybrid electric vehicle sales over their initial three year deployment time period. By 2022 Navigant Research estimates that there will be nearly 2.6 million PEVs in the U.S.[4] NC DMV data for North Carolina from August 2013 showed over 1,600 PEVs registered in the state, an increase of over 130% from the previous year.

Plug-in Electric Vehicle Sales (2010-2013):

- U.S. - 170,000
- NC - 1,600

By 2022, estimates indicate there will be nearly 2.6 million PEVs in the U.S.

[1] Advanced Energy, "Community Planning Guide for Plug-in Electric Vehicles" (2011), 7, 9.
[2] Neighborhood Electric Vehicles, http://en.wikipedia.org/wiki/Neighborhood_Electric_Vehicle
[3] Electric Drive Sales, http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952
[4] http://www.navigantresearch.com/newsroom/nearly-2-6-million-plug-in-electric-vehicles-will-be-sold-in-the-united-states-between-2013-and-2022

## Benefits of Plug-in Electric Vehicles

There are many benefits to driving PEVs including lower cost, energy security, fewer emissions, and better performance.

- Lower Cost: PEVs have lower fuel and maintenance costs, which can be enough to offset higher vehicle purchase costs (purchase costs will be offset more quickly with higher annual miles). PEVs can run at a cost equivalent to $0.50 - $0.70 per gallon of gasoline.[5] Additionally, electricity rates are fairly stable compared to the price of gasoline, allowing for more accurate long-term fleet budgeting and planning. The existing power grid has ample capacity to handle vehicle charging, especially during off-peak times.
- Energy Security: The United States transportation system is currently heavily dependent on oil, with around 45% of its petroleum being imported in 2011.[6] PEVs utilize a domestically-produced fuel source, so replacing typical passenger vehicles with PEVs provides the U.S. with an opportunity to make a significant decrease in petroleum use, increasing energy security.
- Fewer Emissions: PEVs are a much cleaner vehicle choice. PEVs have significantly lower emissions than conventional vehicles[7], and BEVs actually have zero tailpipe emissions. Lower emissions mean improved air quality, which contributes to improving the environment and public health.

**Emission Comparison***

| Emission Category | Conventional Gasoline Vehicle | | | Battery-Electric Vehicle (Total) |
|---|---|---|---|---|
| | Upstream/Refinery | Vehicle (T2B5) | Total | |
| CO2 (gram/mile) | 65.3 | 343 | 408 | 153 |
| SO2 (gram/mile) | 0.075 | 0.004 | 0.08 | 0.18* (~0) |
| NOx (gram/mile) | 0.111 | 0.072 | 0.18 | 0.10 |

*SO2 emission increase in the electricity sector is theoretical, but hard caps in NC prevent any net increase in utility emissions. Upstream and vehicle emissions for conventional gas vehicles interpolated from NREL report, http://www.nrel.gov/docs/fy07osti/41410.pdf p.21-23; Electricity emissions for NC grid from www.eia.gov; Analysis by Mike Waters, Duke Energy and Chris Werner, NCCETC.

**CO2 Content of Gasoline:**
The CO2 emissions in gram/mile expressed above can also be expressed in pounds. A gallon of gasoline, when burned, releases about 20 pounds of CO2 into the atmosphere, not including upstream and refinery emissions from producing the gasoline. This translates to a conventional gasoline vehicle emitting a total of about 0.9 pounds of CO2 per mile travelled, nearly three times that of a BEV that is recharged using NC's electrical grid.

- Fuel Economy: PEVs can offer a dramatic improvement in fuel economy compared to conventional vehicles. Miles per gallon (MPG) figures are provided by the U.S. EPA for all vehicles, regardless of the fuel the vehicles use. BEVs and PHEVs are rated in terms of MPGe, or "miles per gallon equivalent", which reflects the number of miles the vehicle can travel on the energy equivalent to that contained in a gallon of gasoline.

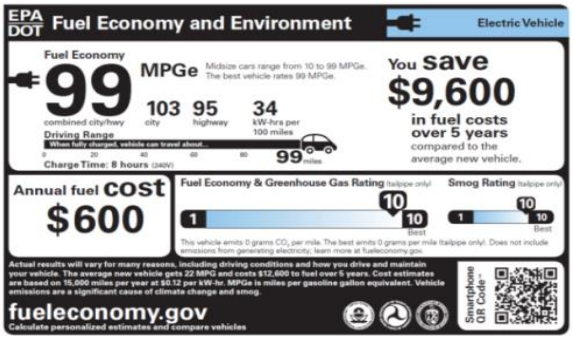


Figure 1. EPA fuel economy window sticker for a BEV

[5] http://www.fueleconomy.gov
[6] http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf, Page 83
[7] Union of Concerned Scientists, State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States, page 11.

- Better Performance: PEVs are designed to operate at a high level of performance, and will meet or exceed the expectations of U.S. drivers through improved acceleration and favorable handling characteristics, as well as quiet operation. This has been demonstrated through various recognitions and awards, such as the Chevy Volt topping the Consumer Reports' Annual Owner Satisfaction Survey in 2011 and 2012.

## Electricity Providers and Sources in North Carolina

Electric vehicles use electricity as a fuel source and receive it in a similar way as residential, commercial and industrial properties. North Carolina generates its electricity primarily from coal and nuclear, with smaller amounts of hydroelectric, natural gas and other renewable sources such as solar, wind and biomass. The U.S. Energy Information Administration indicates that North Carolina has decreased its use of coal as an energy source from 62% in 2001 to 44% in 2012 (North Carolina Net Electricity Generation by Source information)[8]. Several more coal plants are expected to be retired in the coming years, to be replaced by natural gas combined cycle plants, shifting the fuel mix even further toward cleaner sources.

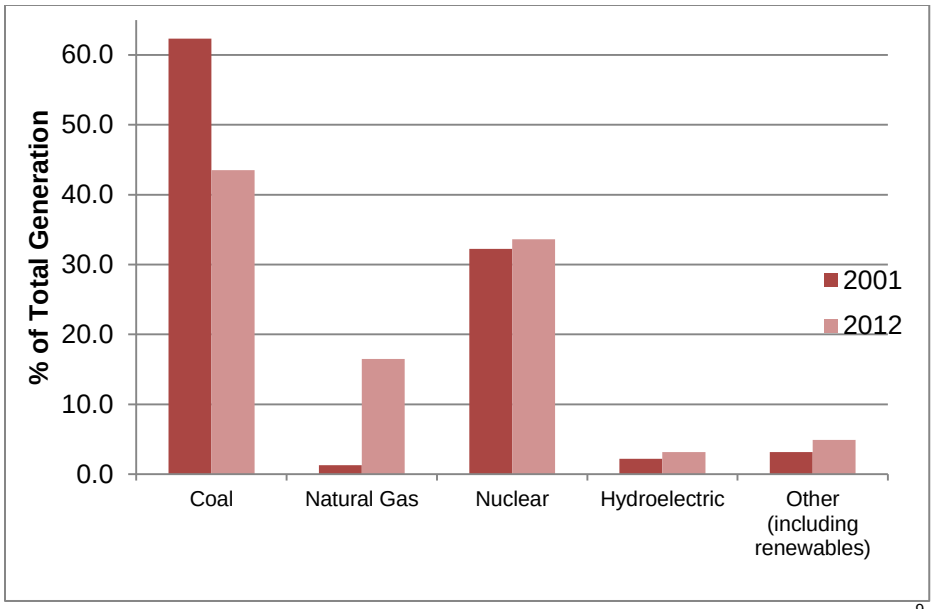



Figure 2. North Carolina Net Electricity Generation by Source, comparison 2001, 2012[9]

North Carolina benefits from both policy- and market-driven initiatives that aim to continue the shift to cleaner electricity generation that increases the use of renewable sources of energy. In 2002, the NC Clean Smokestacks Act was enacted with the support of North Carolina's electric utilities and has contributed to a significant reduction of emissions related to coal generation. 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.[10] 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.[11]

[8] Electricity Data, http://www.eia.gov/electricity/data.cfm
[9] Electricity Data, http://www.eia.gov/electricity/data/browser/#/topic/0?agg=2
[10] http://www.ncuc.commerce.state.nc.us/reps/reps.htm
[11] NC GreenPower Website, http://www.ncgreenpower.org/about

## Applications, Available Vehicles, Vendors in the NC Market

### Light Duty Vehicles

There are numerous hybrid electric vehicles (HEVs) commercially available.[12] At the end 2013, there are 14 models of battery electric (BEV) and plug-in hybrid electric vehicles (PHEV) available nationally, the Chevrolet Volt and the Nissan LEAF being the two most popular. North Carolina has eight of the overall 14 PEVs vehicles available for direct sale in the state and their costs are shown in the Table 1 below.


| Electric Vehicle Costs in North Carolina | |
|---|---|
| Make and Model | Lowest Starting Manufacturer's Suggested Retail Price (MSRP)* |
| **Battery Electric Vehicles** | |
| 2014 Chevrolet Spark EV | $26,685 |
| 2014 Ford Focus EV | $35,170 |
| 2014 Mitsubishi i-MieV | $22,995 |
| 2014 Nissan Leaf | $28,800 |
| 2013 Tesla Model S | $69,900 |
| **Plug-in Hybrid Electric Vehicles** | |
| 2014 Chevrolet Volt | $34,185 |
| 2014 Ford C-Max Energi | $32,950 |
| 2014 Ford Fusion Energi | $34,700 |

Table 1. Electric Vehicle Cost. *These vehicles are available for a federal tax credit up to $7,500 based on battery size.[13] *Many of these vehicles offer leasing options for fleets (including government fleets).*

For vehicle comparisons on all available HEVs, BEVs, and PHEVs, visit the US Department of Energy Alternative Fuels Data Center at http://www.afdc.energy.gov/calc/.

### Medium-Heavy Duty Vehicles

The medium-heavy duty vehicle options for hybrid and plug-in electric include school, shuttle, and transit buses, as well as refuse and vocational trucks, vans, and tractor trailers. For additional information regarding different manufactures, vehicle types, models, applications, and fuel types, visit: http://www.afdc.energy.gov/vehicles/electric_availability.html; http://www.afdc.energy.gov/uploads/publication/medium_heavy_duty_guide.pdf.

### State of North Carolina Motor Fleet Contract

The NC Department of Administration Division of Purchase and Contract has a term contract (http://www.pandc.nc.gov/070a.pdf) for passenger vehicles from which all state agencies purchase their fleets. Additionally, some municipalities and local governments can procure vehicles through the State Contract. Among 2014 vehicles available for purchase are two hybrid-electric vehicles, the Ford Fusion Hybrid SE for $23,148 and the Toyota Prius C for $19,571. There is an additional contract provided for the use of neighborhood electric vehicles (NEV) by state agencies. The contract includes 14 different battery operated NEVs that are available for purchase.

[12] Hybrid electric vehicle information resources: www.HybridCars.com, http://www.afdc.energy.gov/data/10301 ; http://nccleantech.ncsu.edu/wp-content/uploads/Clean-Transportation-Technology-Industry-Directory.pdf

[13] Plug in electric drive vehicle credit, http://www.irs.gov/Businesses/Plug-In-Electric-Vehicle-Credit-(IRC-30-and-IRC-30D)

Numerous state agencies and universities are utilizing neighborhood vehicles on-site. As of 2012, UNC-Charlotte had 126, UNC-Greensboro had 35, UNC-Chapel Hill had 26 and Fayetteville State University has 17. The North Carolina Department of Environment and Natural Resources had the most of all the state agencies with 10, and has plans to add more. For specific information regarding these vehicles please visit: http://www.doa.state.nc.us/PandC/070n.pdf. Currently there are no plug-in electric vehicles (PEVs) available on the state contract, but the Nissan Leaf and Chevy Volt have both been on the contract in the past. If state agencies are interested in purchasing plug in electric vehicles they should request that Department of Administration Purchasing and Contracing Division include specific language in state passenger vehicle bids. Refer to the current list of alternative fuel vehicle options on the State Purchasing Contract for the most up to date information (http://nccleantech.ncsu.edu/clean-transportation/get-involved/alternative-fuel-implementation-toolkit/, click on State Contract Bid Calendar).

## Infrastructure Options

**Electric Vehicle Charging options and availability[14]**

With the increasing market adoption of PEVs, there is a need for electric vehicle supply equipment (EVSE), most commonly referred to as charging stations. Charging stations are the refueling locations for electric vehicles, ranging in style and charging levels and subject to specific standards and codes. The main purpose of a charging station is to establish communication with the vehicle and to transfer power in the form of electricity to the PEV while providing proper grounding, shock protection, overload protection and general safety.

There are four levels of charging, offering a range in charge time and infrastructure simplicity, however only three are widely used in the United States and North Carolina.

- Level 1
  - 120 Volts Alternating Current (VAC), 15 or 20 Amp (A) circuit based on the standard U.S. home outlet
  - Will take the longest time – 8 to 10 hour typical re-charge[15]
  - Provides approximately 4.5 miles range per hour of charging
  - Least expensive to install. Uses amount of power similar to a hair dryer or microwave
  - Suited for low-speed NEVs and some PEVs with short electric-only range; may also be well suited for locations where a PEV will be parked for extended periods (overnight/days/weeks) and locations to which PEVs commute from a short distance
  - A good fit for residential charging (where vehicles are often parked overnight), and for some workplace charging scenarios depending on employee commutes and driving behaviors.
- Level 2
  - 208/240 VAC, 80 A maximum current (100 A circuit)
  - Uses amount of power similar to large appliances, such as air conditioners or clothes dryers
  - Requires 2 to 3 hour typical re-charge[16]
  - Provides approximately 26 miles range per hour of charging
  - A good fit for workplace charging scenarios where most employees have longer commutes and/or use their vehicles periodically throughout the work day.
- DC Fast Charge
  - 480 Volts Direct Current (VDC), 100 A (and up) fast charge

[14] Advanced Energy, "Charging Installation Handbook for Electrical Contractors and Inspectors" (2011) 7.
[15] Estimated charge time based on a vehicle utilizing 40 miles of electric-only driving between charges.
[16] Estimated charge time based on a vehicle utilizing 40 miles of electric-only driving between charges.

- 80% charge in approximately 30 minutes
- Provides up to 40 miles range per 10 minutes of charging

There are multiple options for locating electric vehicle charging stations in North Carolina, and the Alternative Fuels Data Center has an infrastructure map showing each charging station including type (AFDC NC EVSE map). As of February 2014, there are currently 197 public electric vehicle charging stations in North Carolina and that number increases to 266 when private stations are included. In addition, the National Renewable Energy Laboratory released a smartphone application with the same information that you can download by clicking here.

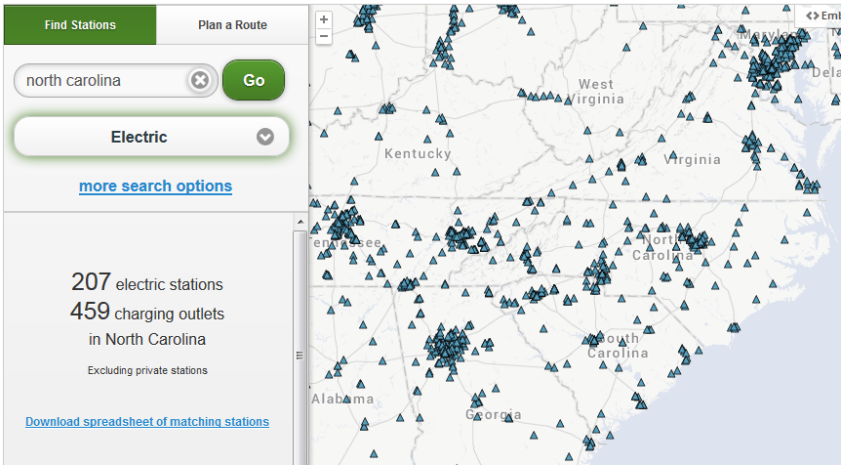


Figure 3. Screen shot of the AFDC electric vehicle charging station map output for North Carolina, taken May 2014.

**Charging Station Manufacturers and Pricing**

The number of companies offering electric vehicle charging hardware and service is continually expanding. There are several resources for potential consumers to identify and research charging infrastructure availability and vendors:

- http://www.goelectricdrive.com/index.php/charging/charging-equipment-virtual-showroom-new-ged: The Charging Equipment Showroom is representative of Electric Drive Transportation Association member companies in charging segment. All products listed on this site are presented as listed with a nationally recognized testing laboratory. GoElectricDrive does not endorse or recommend a specific product.
- http://www.advancedenergy.org/portal/evse/: Advanced Energy reviews, analyzes, and evaluates technical information submitted by commercial vendors and service providers and provides that information here. The EVSEs can be categorized by company, charging level, and mounting type.
- http://www.pluginamerica.org/accessories: This tracker focuses on latest revision SAE J-1772 and CHAdeMO compliant units that are designed for North American commercial and residential end-users. Prices shown are base (no options) equipment

**Charger Plugs (SAE J1772, CHAdeMO, Combo)**

The SAEJ1772 plug and inlet is the universal standard for AC Level 1 and 2 charging. All passenger EV and Level 1 and 2 charging station manufacturers use the J1772 as the standard plug/inlet.

For DC fast charging, there are still competing standards wherein different vehicles may require different plugs and inlets. The Nissan Leaf and Mitsubishi i MiEV use the CHAdeMO/TEPCO standard, Tesla uses their own proprietary fast charging plug/inlet, and some automakers have adopted other competing standards for DC fast charging. Ford is waiting to offer a DC fast charging option until there is a universally accepted plug/inlet standard for this service. The SAE J1772 Combo connector is based on the SAE J1772 Level 1 and Level 2 plug/inlet, would allow drivers to charge with either AC or DC, and is used by the Chevy Spark and BMW i3. With slight modification, the Nissan Leaf and Chevy Volt could also use this plug, and in 2012 seven car makers agreed to use the Combo plug.

only (some vendors require that installation be done by their own contractors) and are before any applicable credits or rebates.

- Clean Transportation Technology Industry Directory: http://nccleantech.ncsu.edu/wp-content/uploads/Clean-Transportation-Technology-Industry-Directory.pdf, this document provides the contact information of EVSE companies from around the United States that serve the North Carolina market.
- State Contract Bid Calendar: https://docs.google.com/spreadsheet/ccc?key=0AugCe0upK-zodElNTFEwMHc0azd3YUVlVWl6Um9tNVE&usp=sharing#gid=1, this document provides information about the EVSEs available for purchase from the state contract.

The cost of level 1 or 2 EVSE for commercial use can range from $1,000 to $5,000.[17] The cost of installing a commercial AC Level 2 charging unit for use by fleet vehicles is typically between $1,500 and $5,000. Data collected for the *NC PEV Roadmap*[18] indicates the average cost in North Carolina to install a charging station is approximately $2,000 for a wall mount, ~$3,000 for a single pedestal unit, and ~$4,000 for a dual cord pedestal unit.[19] Note that there may be a range in these costs and they are very specific to the power supply and location of a given site.

**Fleet Charging**[20]

For fleet charging it is important to determine the number and power level of charging stations required by estimating the size and electrical requirements of your PEV fleet over the next few years. The NC PEV Roadmap assesses fleet charging for PEVs. Below is information identified through the Roadmap on the findings. PEV fleets can reduce operating costs and assist compliance with government transportation emissions requirements. Common charging station installation challenges for fleet charging include:

*Parking Location*

To identify the best-fit installation location:

- Assess the available vehicle charging station options
- Consider the planned parking scenario and time-of-use

When considering eventual expansion of a PEV fleet, add extra electrical capacity to support future charging station locations. It is usually less expensive to install extra electrical capacity during initial construction than to modify the site later.

*Utility Access*

In most fleet applications, AC Level 2 charging is recommended for fleet charging as it can minimize charging time, maximize vehicle utilization, and efficiently make use of charging infrastructure. Typically this would require a 208/240 volt, 40 amp circuit for each charging station. A single DC Fast Charge station might also suffice in the right vehicle applications where vehicles are simply rotated through the unit to keep fully charged. On the other end, Level 1 charging or low power AC Level 2 charging may work in certain fleet situations where the vehicles can achieve their limited fixed routes within a full charge on a daily basis and then have sufficient time to recharge overnight. In all cases, sites should be evaluated for existing power capacity and proximity to the nearest electrical supply panel.

In some cases, an upgrade to the existing electrical service may be required for the additional load of vehicle charging. Work with the organization's facilities manager to determine the building's electrical capacity. If an electrical service upgrade is needed, installation costs may be significant.

[17] Accessory Tracker, http://www.pluginamerica.org/accessories
[18] http://www.advancedenergy.org/portal/ncpev/readiness_plans.php; The NC PEV Roadmap is a planning project allowing for the creation of a state-wide plug-in electric vehicle readiness plan.
[19] "Plug-in Electric Vehicle (PEV) Roadmap for North Carolina" (February 2013), 55, 63
[20] "Plug-in Electric Vehicle (PEV) Roadmap for North Carolina" (February 2013), 61

*Electric Rates*

Check with the local utility provider to see if a commercial time of use rate or load control incentive is available. In late 2013, Duke Energy started a Home Time-of-Use Rate pilot program for their customers. Under this program, you pay a higher rate during times of the day when demand for electricity is higher, and a lower rate during times when demand for electricity is lower. By charging a vehicle at home during off peak times, you could save money on your electric bill. Restricting vehicle charging to off-peak times may help keep utility costs low.

*Resources for Charging Station Installation Recommendations and Best Practices*

Resources for Installation Recommendations and Best Practices

- Advanced Energy's Charging Station Installation Handbook for Electrical Contractors: http://www.advancedenergy.org/brilliance/post/transportation-initiatives-guides
- Clean Cities Plug-in Electric Vehicle Handbook for Electrical Contractors and Clean Cities Plug-in Electric Vehicle Handbook for Fleet Managers: www.afdc.energy.gov/publications
- Electric Drive Transportation Association/Go Electric Drive – Fleet Charging: www.goelectricdrive.com/index.php/fleet-charging
- Electrification Coalition – Fleet Electrification Roadmap: www.electrificationcoalition.org/policy[21]

## Barrier Busters

There are both real and perceived barriers to fleet adoption of electric vehicles in North Carolina. The barriers exist across many fronts including customers, manufacturers, dealers, technology, charging infrastructure, and the electric grid. In 2012 a survey of fleet managers conducted for the *NC PEV Roadmap*, the top three perceived barriers as identified by the respondents were initial purchase price, new technology and vehicle choice. Below, some answers on how to address these barriers are provided.

*Initial Purchase Price*

In many cases, PEVs may have a higher purchase price than comparable conventional gasoline powered vehicles. However, because of the lower operating cost (reduced maintenance, lower fueling costs), PEVs may have an equivalent or reduced total cost of ownership. Fleet managers are encouraged to consider the total cost of ownership when deciding whether a PEV is a good fit for their operations.

Fleet adoption of PEVs is expected to grow faster in applications where the business case can be made to them. A new report from Pike Research that compared the total cost of ownership (TCO) of alternative and conventional fuel vehicles, showed that BEVs offer the lowest TCO for a majority of fleet applications in the United States, assuming that the operator is able to claim the $7,500 federal tax credit.[22] In addition, the plugin hybrid was projected to offer a lower TCO than the mid-sized gasoline sedan in most scenarios, especially for vehicles with a lifespan at or above 120,000 miles. According

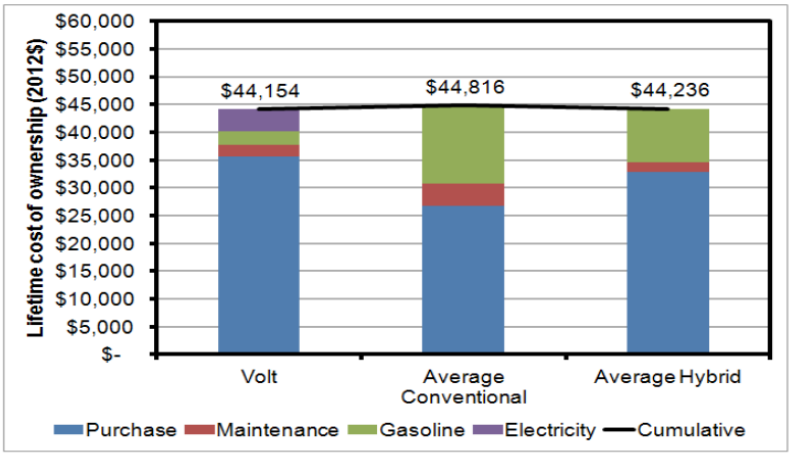



Figure 4. Total cost of ownership comparison between the Chevrolet Volt (PHEV), Chevy Cruz, and Toyota Prius. Chart created by Electric Power Research Institute (EPRI), Source: NC PEV Roadmap.

[21] "Plug-in Electric Vehicle (PEV) Roadmap for North Carolina" (Feb

[22] http://www.pikeresearch.com/newsroom/alternative-fuel-vehicles-offer-fleet-operators-lower-total-cost-of-ownershiphedge-against-future-fuel-price-shocks

to a total cost of ownership study by EPRI, PEVs can have a 2 to 6 year payback period, which can save fleets a significant portion of their operations and maintenance costs over a 10 year duty cycle.[23] Findings from a NC PEV Taskforce survey of fleet managers across North Carolina found that 65% of respondents utilized vehicles in the range of 7 to 10 years and 34% keep vehicles for 10 or more years, which allows for PEV total cost of ownership savings to accrue. If appropriate PEV applications can be identified, these findings suggest that a business case for PEV ownership can already be made to a significant portion of fleets in North Carolina.[24]

*New Technology*

There are a small percentage of people and businesses that have experience with electric vehicles. Even with those that do, their experience with new technology is limited. Current and future fleet managers will need information on performance, operation and maintenance, and charging infrastructure to assist in their understanding of the new technology associated with electric vehicles. The North Carolina Clean Energy Technology Center has a database of alternative fuel vehicle fleet users (http://nccleantech.ncsu.edu/clean-transportation/alternative-fuels-user-database/) that highlights a few current fleets in NC that are utilizing PEVs and/or hybrids in their operations that may serve as a resource for those fleets looking for 'real world' experience in alternative fuel vehicle usage.

For organizations that are unable to take advantage of the up to $7,500 tax credit for purchasing AFVs, such as local and state governments, vehicle and charging station manufacturers are offering competitive leasing options so that a fleet owner does not have to purchase the new technology. Additionally, a majority of manufacturers are offering vehicle warranties to help alleviate concerns that surround the introduction of new technology that does not have a long track record. For example, Nissan has a 60-month/60,000-mile electric vehicle system and 96-month/100,000-mile Lithium-Ion Battery warranty that are standard with the purchase of a new LEAF.

*Vehicle Choice*

In North Carolina today, there are eight light-duty plug-in electric vehicles available for purchase. There are approximately 40 medium and heavy duty plug-in electric vehicles available in the United States, many of which can be shipped to North Carolina fleets. Currently on the market, there are few all electric or BEV options compared to the entire vehicle market, however the variety of vehicles does provide different levels of range and style. In order to continue to overcome the limits to vehicle choice continued investment and support in research and development of electric vehicle technology is needed to improve their performance and reduce costs. To make the best choice among available vehicles, fleet managers are encouraged to review their usage and needs before selecting a PEV.

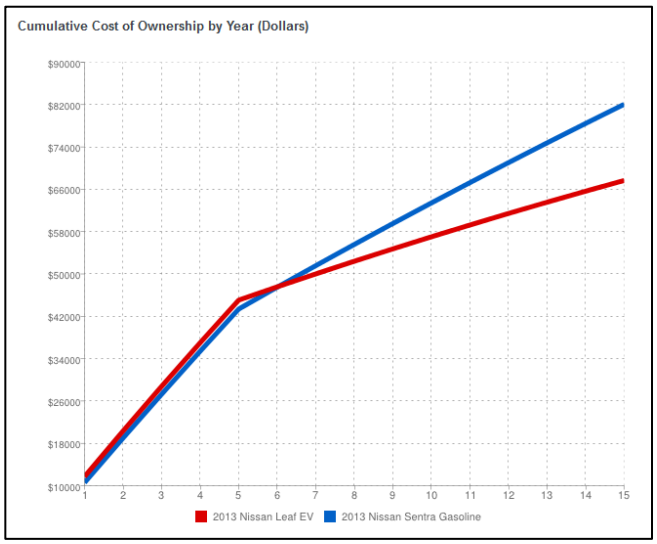
## Crunch the numbers: Vehicle cost calculators

The Alternative Fuels Data Center has a Vehicle Cost Calculator (http://www.afdc.energy.gov/calc/) that will compare the costs of operating any vehicles from 1998 through 2014, allowing the user to see the direct cost benefits of owning and operating an electric car. It allows the user to see results based on annual fuel use, annual electricity use, annual fuel/electricity cost, annual operating cost, cost per mile, and annual emissions (lbs $CO_2$). The calculator also includes a graph showing the cumulative cost of ownership by year for each vehicle evaluated. The cumulative cost of ownership includes fuel, tires, maintenance, registration, license, insurance, and loan payment. The tool assumes a five-year loan with a 10% down payment. Year one on the graph represents the 10 percent down payment plus the first year's total operating costs. For more information on this graph and other calculations, visit the assumptions page (http://www.afdc.energy.gov/calc/cost_calculator_methodology.html).

[23] Plug-in Electric Vehicle Roadmap for North Carolina, page 36. http://www.advancedenergy.org/portal/ncpev/readiness_plans.php
[24] Asheville Area Plug-in Electric Vehicle Plan, http://cleanvehiclescoalition.org/pdfs/Chapter3-VehicleDeployment.pdf, page 55.

Using this calculator, the payback period for the additional cost of the LEAF was approximately 6 years with 10-year total cost of ownership of approximately $57,000 for the 2013 LEAF (purchase price $28,800) and $63,000 for the 2013 Sentra (purchase price $19,820).[25] It should be noted that this analysis did not assume the applicability of any tax credits, which can further reduce the payback period to less than a year in the case of a $7,500 federal credit. The table and Figure below shows sample calculator outputs:

| | Sentra | LEAF |
|---|---|---|
| Purchase Price | $19,280 | $28,800 |
| Annual Fuel/Electricity Cost | $1852 | $446 |
| Annual Operating Cost | $4452 | $2812 |
| Cost per Mile | $0.24 | $0.15 |
| Annual Emissions (lb. $CO_2$) | 13292 | 7017 |




The North Carolina Clean Energy Technology Center (NCCETC) also offers a Vehicle Cost Calculator that can be used to compare a baseline fleet to a potential alternative fuel replacement fleet. Inputs include average vehicle miles per gallon, fuel costs, vehicle costs, charging infrastructure costs, and training costs. It also offers the option to include vehicle and/or charging infrastructure financing. This calculator returns fuel cost per mile, net present value (based on cost of capital rate), cumulative savings, return on investment, and payback period.

There are a number of fleet management solutions that can help optimize a fleet's performance on safety, utilization, customer service and cost, by monitoring and tracking many vehicle parameters and statistics. Some of these solutions, such as Fleet Carma, offer electric vehicle metrics features that can help fleet managers make appropriate selection of electric vehicles and charging infrastructure.[26]

## North Carolina PEV Case Study

While individual consumers have adopted PEVs a higher rate than when conventional hybrids were first rolled out, use of PEVs in fleet applications is still relatively new. In North Carolina, there are a handful of public fleets that have incorporated a small number of PEVs into their fleets. Details regarding PEV adoption by the City/County of Durham NC, including motivation, factors tied to the decision, lessons learned and the overall experience, can be found at "Electric Vehicle Case Study". For additional case studies of fleets outside of North Carolina using electric vehicles, visit the Alternative Fuels Data Center website. Additionally, the Alternative Fuels User Database includes an online, searchable map that allows website visitors to learn more about some fleets in North Carolina that are already using alternative fuels, including plug-in electric vehicles. A few North Carolina fleets in the Database that have PEVs are:

- City of Asheville
- Buncombe County

[25] Assumptions include 18,300 miles per year (60-miles per weekday, plus 3,600 additional miles for special after-hours or weekend trips), gasoline price of $3.45 per gallon, and NC rates for electricity. Comparing these vehicles using 15,000 miles per year, the payback period is 7.5 years, still within the average fleet vehicle lifecycle.

[26] Electric Vehicle Metrics, http://www.fleetcarma.com/vehicle-analytics/electric-vehicle-metrics

- Town of Cary
- Durham (City and County)
- City of Raleigh
- Town of Waynesville

In addition to these public fleets, several utilities in the Southeastern US (including Duke Energy) are in the midst of a pilot program to test two kinds of plug-in electric hybrid trucks. Results of this pilot are due out in late 2014 or early 2015, and will likely drive increased use of these kinds of trucks in other private fleets.

## Trends: Looking Ahead

As vehicle fuel economy and emission standards continue to tighten in the United States the number of automakers building electric vehicles and their availability for purchase will continue to expand over the coming years. Fleet managers across the state should position themselves to be able to take advantage of the benefits that electric vehicles offer. Along with fleet assessments and individual vehicle tracking via telematics that help organizations better understand usage patterns, widespread adoption of total cost of ownership models will drive increased adoption of PEVs in applications where air quality is a concern and/or where the business case for them is either neutral or favorable. Moreover, as the NC electric grid gets cleaner with increases in natural gas and renewable energy use, the overall all air quality benefits from PEV adoption will continue to increase. With expanding availability of public and workplace charging stations, range anxiety will continue to decline and additional organization types will feel comfortable considering PEVs as a real option for their fleets. Fleet managers should consider alternative fuel vehicles such as PEVs to take advantage of the wide range of benefits, most notably cost savings and emissions reductions.