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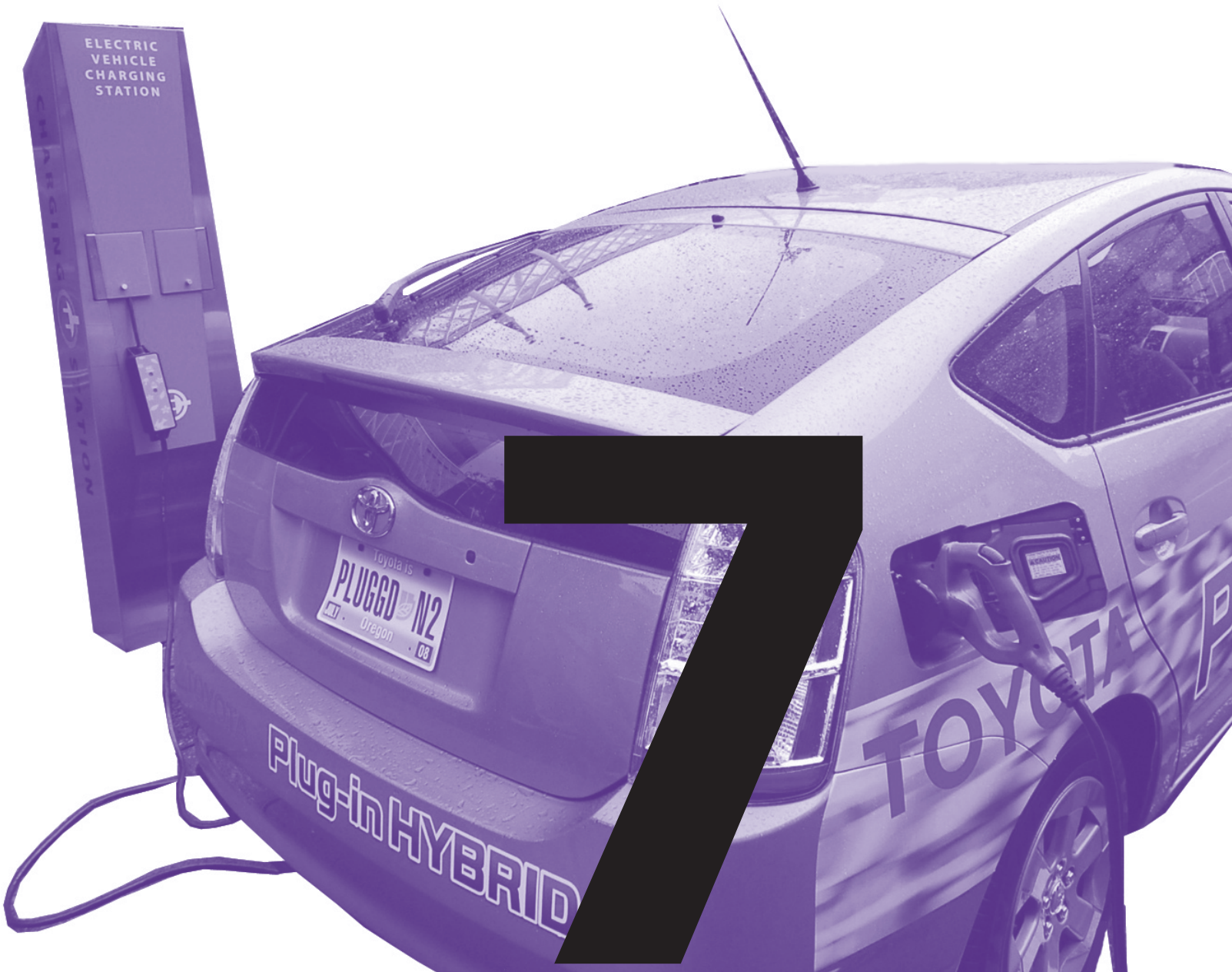
# PRACTICE ELECTRIC VEHICLE INFRASTRUCTURE

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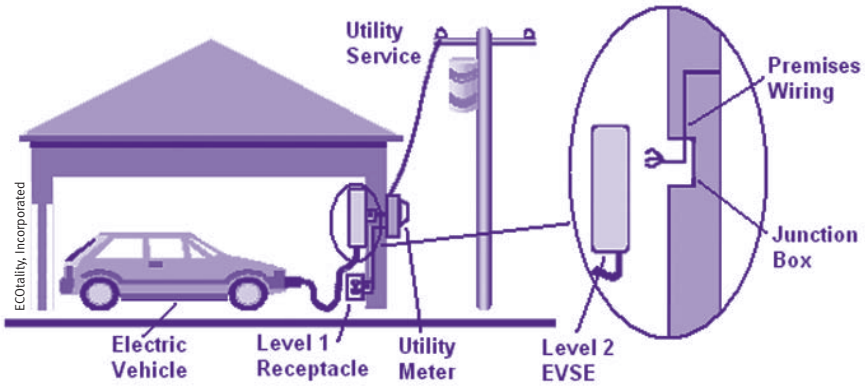
# Electric Vehicles: Is Your Community Connected?

*By Timothy M. Bourcier,* AICP

Electric vehicles are coming soon to a community near you.




This diagram shows typical Level 1 and Level 2 charging station installations in a residential garage.

In early 2010, California-based Tesla Motors became the first company to boast mass production of an electric vehicle in the U.S., and it has recently partnered with Toyota to produce and market these vehicles. Before this, two major companies had low-speed, plug-in vehicles on the market (also known as neighborhood electric vehicles). The BMW Mini E, Chevrolet Volt, Toyota Prius PHEV (electric-gas hybrid), and the Nissan Leaf (plug-in rechargeable—all electric power) will be sold in select U.S. markets by the end of 2010, with a full rollout of the vehicles nationwide in 2011.

While customers are lining up to purchase plug-in electric vehicles (EVs), organizations, utility companies, and governments are concurrently forming partnerships and working to craft policies to promote the sale and use of EVs. More than 6,500 charging stations across southern California and Tennessee will be installed as part of the initial rollout.

However, it is likely that many localities have not considered how to regulate and permit individual charging stations at homes and commercial centers. The location of charging stations probably has not been thoroughly considered, either. This article explores a number of issues communities should consider when regulating charging stations. It also examines current community initiatives and the development of charging stations. Finally, this article will look at how potential technologies could further change how EVs will be integrated so communities can plan for them.

## BRIEF HISTORY OF THE ELECTRIC VEHICLE

Electric vehicles have been around since the early 1800s. The gas-powered internal combustion engine became more popular over time because higher performance and top speeds were achievable. Moreover, rechargeable, high-performance batteries and other technologies were not as viable as they are today.

With advances in new technologies and policies pushing for alternative energy sources, automakers began reintroducing the EV. These new EVs use banks of rechargeable batteries to power their electric motors. The batteries will be recharged by plugging the vehicle into an electrical outlet, similar to recharging household batteries in a battery charger.

While Tesla and Nissan have developed cars that run completely on battery power, Chevrolet and others are introducing vehicles that will continue to run on gas and also incorporate plug-in rechargeable technologies. These cars are more advanced than existing hybrid vehicles and will rely less on gasoline.

## LOCAL ELECTRICAL CODE

This article does not examine local electrical and building codes. This is an important consideration, however, as charging stations will likely have to be permitted and inspected by the local permitting authority. Professional installers will likely already be familiar with local codes or will have to become familiar with the code. Planning and development divisions should examine the electrical code and determine how this new technology is regulated.

## INITIAL CONSIDERATIONS

EVs operate either partially or entirely on battery power. The batteries need to be recharged periodically in order to receive the benefits of electrical power, or in the case of Tesla models and the Nissan Leaf, the battery must be charged to operate at all. If these vehicles become as popular as hybrid vehicles, there will be a demand for places to charge them.

In touting the ease of their products, some manufacturers seem to imply that EVs can be charged by simply plugging them in to a conventional outlet. However, recharging is not exactly that easy. These new electric vehicles will require a special outlet, specifically the J1772 five-pronged outlet, which has been developed for uniform use with plug-in vehicles. The vehicles charge at different rates based on the voltage of the outlet. A Level I station charges at 110 volts. A conventional 220 volt household outlet, or Level II charging station, will require eight hours connection time to fully charge an all-electric-powered

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vehicle (hybrid vehicles require a shorter charging time, which is based on the battery's capacity). A Level III 440 volt station has also been developed, but is not being widely used at this time. Most plug-in vehicles that are in production or planned for production can be charged at a Level III station to near capacity within 20 to 30 minutes.

As users approach the end of the battery range of an all-electric-powered vehicle, they will have to make arrangements for recharging. In neighborhoods comprised exclusively of detached single-family homes with off-street parking, users can charge vehicles on their property. Areas without off-street parking make recharging more complicated. When users get to the end of the battery range of an all-electric-powered vehicle, they will need to plan in advance where and how to recharge. As EV sales increase, so will the demand for convenient places to fuel the vehicles. Since recharging takes considerably longer than filling up a gas tank, it's necessary to accommodate the required 30-minute and longer refueling stops.

Beyond the need for recharging infrastructure, the proliferation of EVs may have additional community impacts. Part of the allure of EVs is the reduction or elimination of greenhouse gas emissions. In areas where electricity is generated by coal plants, recharging the vehicle will create emissions at the plant, which may defeat the purpose of using the vehicle to lower emissions. Other issues arise in areas where energy infrastructure is stretched thin and vehicle recharging may further strain the system (although some preliminary studies suggest infrastructure is in place nationally to handle widespread use of EVs). King County, Washington, is discovering that the overall electrical capacity exists, but the microgrid (transformers, conduits, etc.) needs to be upgraded. In response, some communities are requiring or incentivizing users to plug in during off-peak hours (this is discussed in greater depth later). How the electricity will be paid for is also an issue. If a shopping mall provides charging stations, will the user have to pay to fill up (as we currently do at a gas station) or will they provide "free" charging stations, where costs likely will be passed on to all consumers? Do local governments have an opportunity and the capability (politically and legally) to control higher prices for everyone by making EV users pay their own way?

> Each community will have to decide whether or not it will require designated parking areas for EV charging and how those requirements will be reflected in the local zoning code.

The shopping mall example above also raises the issue of parking. Each community will have to decide whether or not it will require designated parking areas for EV charging and, if so, how those requirements will be reflected in the local zoning code. Beyond zoning, local governments will have to determine what role to take in creating public charging stations or setting aside publicly owned and maintained parking places for EVs. This will require much planning to account for installation, operation, and maintenance costs. Also, if a community sets aside parking spaces for EVs to conveniently recharge, it will need to enforce their provision in order for the initiative to be successful.

Finally, new development and the built environment are macro considerations. How will charging stations affect historic communities? Should EV charging stations be required in new development? How will local design standards be affected? All of these items will be discussed later as current local initiatives are explored. In the next section, this article takes a closer look at the development, planning, and land-use considerations for requiring and allowing charging stations.

### ZONING AND LAND-USE CONSIDERATIONS

Parking is the primary land-use consideration associated with EVs. Having designated areas specifically for vehicle recharging purposes seems incompatible with a current trend away from residential garages and on-site surface parking lots across the U.S.

When designating future land uses, charging stations should be an additional consideration for transportation planners with Metropolitan Planning Organizations (MPOs) and state and federal transportation entities. Stations will need to be strategically located along major transportation routes. Incorporation of charging stations at interstate rest areas that already exist should be further considered in the planning process.

For the most part, recharging stations and devices are accessory to functions and facilities already in existence. One challenge for local governments will be incorporating these stations into zoning definition lists and use tables. Communities will have to determine where charging stations are appropriate (in which zones) and under what

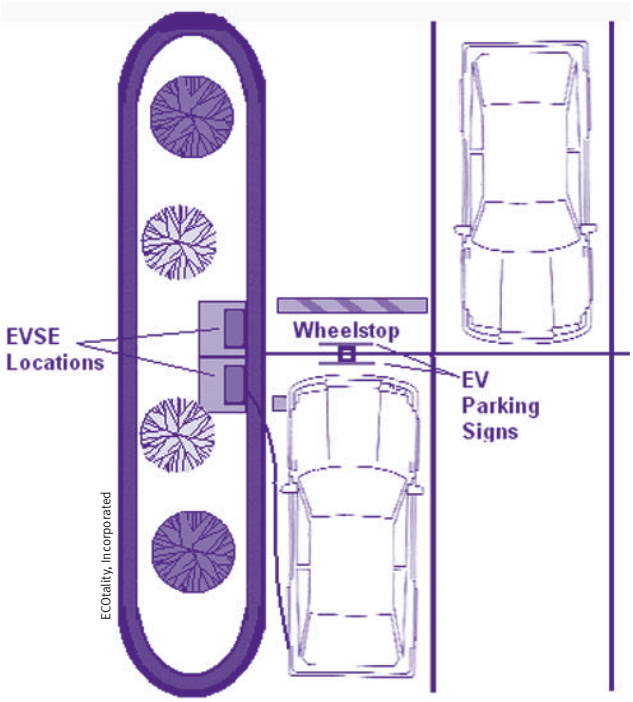
conditions. Initially, this should be done through a study or a local comprehensive plan update process.

The zoning districts in which stations are permitted should be based on several factors. First, wires will come from a station and connect into a vehicle; wires can be hazardous for pedestrians and can create an unattractive nuisance. The vehicle will have to occupy a space for at least 30 minutes with a high-voltage outlet to charge, and much longer times are required for the lower voltage chargers that are more widely available at this time.

Though allowing charging stations as a use within specific zoning districts will open the door for their development, the act of placing charging stations into the built environment is much more of a challenge. There are many issues to consider.

Assuming there is agreement to place charging stations in these private areas, location of the charging stations must be considered. First, it will need to be determined whether a few stations should be placed strategically around a site, or whether a central location should be set aside for charging all vehicles within a complex. This decision will be partly based on several other issues discussed below.

The size and layout of the complex or neighborhood should be the first consideration. For larger neighborhoods, one or several centralized charging stations would be most efficient, keeping in mind the general rule that people will not walk further than five minutes or one-quarter mile from their place of residence. A centralized parking location would also provide the opportunity for extra security to prevent mischief or accidents in areas with high foot traffic.




This diagram shows how public charging stations could be integrated into existing surface parking lots.

Higher density residential areas with no off-street parking, such as apartments, dormitories, and similar dwelling types, create the biggest challenges for siting charging stations. In areas like San Francisco and Washington, D.C., where single-family attached town houses or row houses are prevalent, charging stations affixed to the buildings themselves may not be viable. Cords stretching across sidewalks would create a hazard and might be a detriment to the pedestrian and bicycling environment. In these areas, the vehicle user will need the owner of the property or the jurisdiction to install the station.

For smaller neighborhoods, sporadic placement of stations would be more efficient. In areas where parking is assigned to leasing residents, placing a station for their use in a specific parking space would not be viable since apartments change hands fairly regularly. This means apartment complexes, dormitories, and other types of multifamily development that place stations in designated spaces will have to restrict use of those spaces to EV owners.

This creates two obstacles: enforcement of designated parking and an overall loss of parking spaces. Similar to parking spaces for the handicapped, use of these spaces must be limited to recharging vehicles. For private parking facilities, owners or managers will have to come up with a system of enforcement, including punishment for misuse (fines or towing), permitting (stickers or other labels), and outreach to the community to provide information on the stations and their restrictions.

Sporadic placement of stations again brings up safety and vandalism problems. If everyone has access to a charging area, it is likely cords will be cut. Children running between cars and the curb could trip or otherwise be injured, and an endless number of other scenarios could lead to lawsuits. More importantly for this article, it reduces the likeliness of installing charging stations. Stations may need to be installed near existing security stations or monitored by camera to help decrease the chance of vandalism. The stations should also be located away from sidewalks and bicycle areas, near walls, and preferably alongside parallel parking areas. Since most parking lots are designed for perpendicular and angle parking, the wall is important to limit traffic between the areas in the front or rear of the car where the cord will be stretched to the outlet.

If communities install chargers on public streets, the local jurisdiction will have to work through the same issues discussed for private developers. However, resolving these issues can be more complicated in the public realm. The location and type of charging station (speed of charge and pay versus free) are the most vital issues. Staff studies, committee reviews, policy adoption, and allocation of funds can take a long time. On-street charging areas will need to be specifically designated for EVs only, and communitywide training and outreach will be required for code enforcement officers, police, residents, and visitors. This will include creating signage for EVs and deciding on how to monitor the security of the stations. These types of campaigns may require extensive partnerships and planning.

Cost is also an issue that needs to be considered in advance. Users will likely either "pay at the pump" by using a card or a pass with a barcode or other identifying device, or simply plug in without paying. While the pass allows a driver to use the charging station, it also gives the owner of the station the ability to charge the user immediately like gas stations now do. Without a way to identify the user, plugging in to public charging stations will likely require passing on the cost to everyone, including non-users.

In a private residential setting, requiring permits for users or placing stations in existing carports where the person leases the space can help avoid more sophisticated stations where a pass is required. While electricity is the main cost, maintenance and replacement of stations is another factor.

Commercial uses, especially larger shopping centers, will also face many of the same issues. Commercial entities are already requesting installation of stations at existing developments, well ahead of the development of regulations at the local level. Surface parking lots at medium and large shopping centers will likely pose the greatest challenges due to the layout of parking lots, pedestrian traffic between parking lanes, shopping carts, and other physical obstacles.

While private landowners will ultimately have to deal with their own liabilities, local governments have a duty to keep people safe and reduce potential hazards. Communities will have to work with stakeholders to determine the best locations for charging stations, taking into consideration convenience, safety, and other factors prior to amending the local zoning ordinance.

Setting aside parking spaces for EV users at existing commercial centers with surface parking lots can also create parking congestion. Transforming existing parking spaces into charging stations will reduce the number of spaces allowed for general use. Local governments will need to review requests on a development-by-development basis to determine how congested existing parking is and what the effect will be of taking spaces away from all users.

As communities continue to grow, they can avoid many of the challenges presented by retrofitting by requiring the installation and set-aside of recharging spaces in a safe and efficient manner for new developments. The next section looks at how some communities are addressing the issues discussed earlier for new development, including initiatives and incentives by states and groups like the U.S. Green Building Council.

## EXISTING INITIATIVES

Major financial incentives are in place to get people to consider purchasing EVs. The IRS is offering a $7,500 tax credit for the purchase of an EV, and states have additional incentives, with California and Georgia each providing $4,000 in additional tax credits. Many state governments also provide grants to help consumers pay for the cost of charging stations at their homes. Meanwhile, millions of dollars have been doled out to companies for continued research and development to improve related technologies.

Since there is a strong effort to get EVs on the streets, there needs to be a similar effort to get charging stations on the streets. The strongest initiative for providing charging stations is occurring in California's Bay Area. The mayors of San Francisco, Oakland, and San Jose have developed a partnership to get charging stations placed in communities throughout the region. These cities are also looking to enhance their municipal fleets by purchasing more EVs. Currently, seven communities in the Bay Area and Northern California have installed charging stations.

Communities will have to work with stakeholders to determine the best locations for charging stations, taking into consideration convenience, safety, and other factors prior to amending the local zoning ordinance.

King County, Washington, through the American Recovery and Reinvestment Act (stimulus package) and financial assistance from King County municipalities, approved of the installation of 200 charging stations on county-owned lands. Users will be able to access the stations by making an online reservation.

The county is still in the process of determining where to place most of the stations. So far, it has placed Level I (110 volt) units at park-and-ride carpooling lots throughout the county as part of an initiative to promote plug-in car use prior to the unveiling of the Chevrolet Volt and the Nissan Leaf. There are no Level II stations currently installed, but the county's transportation department is working with the Puget Sound Regional Council (Seattle's regional MPO) to determine the best locations. However, only 25 percent of the funding for installation of Level II stations is designated for public chargers; most funds are being allocated for installations at private residences. While Level III station installation is not part of this rollout, the county recognizes the eventual need for strategically located fast-charging stations.

Part of King County's effort in determining the location of public charging stations is trying to predict which neighborhoods contain residents likely to purchase plug-in electric vehicles. While this is important since demand will be higher in these neighborhoods, it is likely difficult to determine who will buy plug-in vehicles until a profile can be made after vehicles are widely available. Furthermore, since one of the major efforts is to install charging stations at owners' homes, public stations should be focused on places of more frequent activity when users are away from home.

The county has partnered regionally with Oregon and British Columbia representatives to understand where stations should be located for travel between southern Oregon and Vancouver on the I-5 corridor. This study is in its infancy, but is important to make sure EV owners are not stymied from travel due to a lack of stations. Along with the EV project, King County is also working to make sure users can find EV stations by GPS. Nissan will offer this feature with the purchase of a Leaf.

Finally, another important King County regional initiative is the creation of a model ordinance to help municipalities understand how the stations can be installed, in which land-use areas they can be located, and what local permits are required. The main goal of this is to make sure all municipalities across King County properly install and locate charging stations. Another important use for the model ordinance is to help potential purchasers have transparency with dealerships by making sure the locations where the vehicles will be used will allow the installation of charging stations. The ordinance was not complete as of the date of publication.

Many public charging stations will also be used for charging municipal fleet vehicles. Although the installation effort is admirable, current policies concerning the number and type of units installed should be scrutinized by other communities looking to install charging stations.

For example, in Martinez, California, three 110 Volt units were installed for public use and for charging four municipal vehicles. These Level I units will take at least five hours to fully charge an electric/gas hybrid vehicle

## CHARGING STATIONS AND TOURISM


During the summer, many people make vacation trips and weekend getaways from Washington, D.C., Baltimore, and Philadelphia to Ocean City, Maryland. The nearly 150-mile trip from Washington, D.C., would require at least one stop along the way for an all-electric vehicle with a 100-mile range. More stops would be necessary for hybrid vehicles trying to maximize battery powered travel.

As you can see from the map, U.S. 50 and U.S. 13 are the main routes to Ocean City. These thoroughfares are littered with gas stations, outlet stores, fast food restaurants, and other businesses you would expect to see in highway commercial areas. While the map includes several communities along these routes, not shown are the 50 or more other municipalities with their own unique features and historic main streets.

Taking a comprehensive look at where to locate stations and the type of stations to install could provide additional benefits to a community. For instance, it is likely a community or consumer will not want to wait longer than 10 minutes to charge their car at a fast food restaurant or at a gas station. In this situation, the locality should require the highest voltage technology available for charging stations (Level III) to prevent congestion and loitering where parking is limited.

However, strategically placing Level I or Level II stations in a main street community could draw people in to find something to do while their car is powering up. These leisurely stops often occur anyway, but an EV driver may stop in a specific community if they can both charge their vehicle and take in the small-town charm.

More importantly for the planner, once ideal locations and charging station types are determined, the zoning districts in which they lie can be found by overlaying the proposed location on the zoning map. This can help determine the sections of the local zoning and development codes that need to be revised to incorporate the local EV strategy.

or neighborhood electric vehicle. With a few sales to the general public and increased use by city workers, the four units could become quickly exhausted. The city may have to consider adding additional charging stations, which could have adverse impacts on parking as discussed earlier. Another option would be to replace existing units with Level II stations, or Level III stations when available.

Adding stations, juggling parking issues, and upgrading existing units may all be costly options. This is why it is important for communities to study the expected impact of EV sales locally and to learn about existing technologies for charging stations and their effects on parking facilities in order to develop a comprehensive strategy in advance of purchasing and installing units.

Concerning local initiatives for installation by developers, Vancouver is the first (and only known municipality) in the world to require the installation of charging stations at new developments. In Vancouver, all new condo developments must dedicate 20 percent of parking spaces to EV charging (http://vancouver.ca/sustainability/electric_vehicles.htm). All new one- and two-family dwellings are also required to install charging stations for each unit as part of the city's Green Homes Program (http://vancouver.ca/commsvcs/CBOFFICIAL/greenbuildings/greenhomes/electricvehicle.htm). Although there was some pushback from the development community, Vancouver studies indicate that there is only a 0.5 percent increased cost to the developer to install a charging station.

The added cost for developers brings up the dilemma seen in many planning issues: Should charging stations be mandated or should incentives be provided to promote installation? While the question of whether developers can be mandated to install charging stations in new developments has not yet been tested in U.S. courts, there is enough precedent with similar mandates to say that governments are likely able to legally require installation.

Whether a community will exercise its power to mandate charging stations is a different issue. The community will have to consider how the added cost (though arguably minimal) will affect the consumer it will be likely passed on to.

Option two is to provide incentives to a developer to install charging stations for public use. We found no instances of local initiatives to promote installation of charging stations by developments while researching this article. However, a variety of incentives has been used to promote voluntary set-aside of affordable housing units in new developments. Tax abatement, reductions in parking, density bonuses, and other creative incentives are all possibilities for communities unwilling to mandate installation of charging stations.

Nationally, there are two major incentives available to promote adding charging stations in new developments. UDR, Inc., has installed charging stations at two Texas multifamily developments and is requesting that the U.S. Green Building Council recognize these features as part of the LEED certification scoring. If recognized, adding charging stations can help developers easily add points to achieve LEED certification.

An additional incentive for developers is cost savings over time. This can be achieved in areas with Smart Grid electrical technology. Using solar technology, with or without Smart Grid infrastructure, can also help developers recoup the costs of adding enhanced charging stations.

While a complete discussion of a Smart Grid is beyond the scope of this article, there are two important aspects of this technology that could provide incentives for developers to install charging stations. First, a Smart Grid would allow consumers to choose what time of day they wanted to take power from the grid. Second, it would permit consumers to sell excess electricity generated on-site by solar panels back to the utility provider.

The ability to control when charging would take place could lead to stations only being used during off-peak hours when electrical costs are much cheaper. Depend-

ing on the amount of energy created by solar panels and the amount of energy used by recharging vehicles, a developer could easily recoup installation costs, reduce overall electrical costs paid by the developer in common areas, and ultimately reduce costs to consumers. The City of Orlando has installed a solar powered charging station and is currently testing this model.

While much of the previous discussion shows how other communities are working to promote EVs, each community is different. Though not explicitly discussed, communities should come up with a plan that comprehensively looks at how potential mandates, incentives, technologies, and locations will best serve the government, utility providers, and users. The following section provides a brief discussion on developing a local EV strategy.

## ESTABLISHING A LOCAL EV STRATEGY

Problems stemming from adding charging stations into a community can be boiled down to the following major issues: 1) the location of stations; 2) how fast they will charge vehicles; and 3) the type of station. Breaking down each of these items is obviously more complex, especially location. In order to keep costs low, communities should consider forming a technical committee to deal with creating the overall EV strategy.

Creating a committee is recommended because of the variety of items to consider within each greater problem area. With location, for instance, technicians will need to be consulted about the actual installation of the device. Code enforcement officials could help point out some of the safety hazards that may arise. An economic development official could help point out strategic locations to draw in those who have to wait for recharging vehicles. Each community will need to examine the best makeup of the committee based on their own unique needs.

The goal of the committee should be to "measure twice and cut once." A good strategy can help lower a community's costs by limiting the upgrade stations. It is inevitable that upgrades will be necessary as new technologies will better fit the needs of the community. The following section examines some additional short- and long-term technology advances that should be considered as part of any future strategy.

## FUTURE TECHNOLOGIES

Much like cell phones and MP3 players, EVs and charging stations are going through a technological evolution to become better for consumers—smaller, smarter, longer lasting, and wireless. Research is currently being performed to create smaller batteries that charge faster, higher voltage charging stations, and wireless charging options. Though nanotechnology concepts are being used to try to reduce battery size while maintaining or improving performance, other technological advances are on the brink.

Two Massachusetts Institute of Technology researchers experimented with an iron phosphate solution to use in battery packs and were successful in charging batteries at a higher rate of speed. The solution is expected to be available in markets in 2011.

Evatran Corporation has developed Level I and Level II wireless charging stations and are currently marketing these to residences and to commercial establishments where consumer trips are likely to exceed 45 minutes. Plugless Power proximity charging systems allow a user to pull into a charging area and receive a charge based on inductive power transfer technology. Evatran is still working with carmakers at this time to install technology to make wireless charging possible.

The Better Space project and SwapPack are providing an alternative to the park-and-recharge concept. Each company is proposing stations where EV users can swap out their used battery packs for newly charged ones. Though heavy equipment is needed for the switch, the entire process is expected to take less than two minutes. Battery packs have not been standardized at this time, so logistically how this would work for different models is still to be determined. However, the concept is quick, convenient, and gets rid of many of the cord-related liability concerns.

## CONCLUSION

The regulation of new technologies can often overwhelming for communities. The goal of this article is to help governments prepare for plug-in vehicles before they become common. Though specific electrical specifications may be above and beyond the technical expertise of planning teams, the discussion herein is meant to include everyday concepts of zoning, land use, and economic development.

The initial consideration for every community is identifying the best public locations for charging vehicles. These places already exist: park and ride lots, commercial centers, main street communities, and the like. Local governments should determine maximum charge times before installing Level I, II, or III charging stations. The recommendations in this article will help planners determine where stations will actually be installed. Regional coordination of station locations is vital to this process, as MPOs and other organizations will likely have the best data and resources for helping determine how a local community fits in to the larger needs of travelers over long distances. Other information, such as renewable stations using solar technology or the future of wireless stations, are things to keep in mind.

Finally, the language and visual aids within local zoning and design codes need to be updated. This is much easier to do after determining the locations of the charging stations and the zoning districts in which they lie. For new developments, Vancouver's mandatory charging station requirements, King County's upcoming model ordinance, and other potential problem areas discussed in this article can help communities craft the appropriate language to avoid pitfalls. One interview subject mentioned that he was trying to learn from crises planners ran into when cell phone towers were being installed across the country. The process for regulating charging stations is very similar.

Photo courtesy of Portland General Electric. Design concept by Lisa Barton.

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# HOW WILL YOUR COMMUNITY ACCOMMODATE ELECTRIC VEHICLE CHARGING?

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