# Installing Public Electric Vehicle Charging Stations:
# A Site Suitability Analysis in Los Angeles County, California

by

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A Thesis Presented to the
Faculty of the USC Graduate School
University of Southern California
In Partial Fulfillment of the
Requirements for the Degree
Master of Science
(Geographic Information Science and Technology)

May 2016

To a special person, my mother.

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# Acknowledgements

I am grateful to all faculty from the USC GIST program, who assisted me in completing the master's program.

# List of Abbreviations

| | |
|---|---|
| AB | Assembly Bill |
| BEV | Battery-only Electric Vehicles |
| DC | Direct Current |
| EV | Electric Vehicle |
| EVCS | Electric Vehicle Charging Station |
| EVSE | Electric Vehicle Supply Equipment |
| GIS | Geographic information system |
| GISci | Geographic information science |
| HOV | High Occupancy Vehicle |
| LAC | Los Angeles County |
| MUD | Multi Unit Dwellings |
| PEV | Plug-In Electric Vehicles |
| SB | Senate Bill |
| SSI | Spatial Sciences Institute |
| USC | University of Southern California |

# Abstract

Plug-in electric vehicles (EVs) have shown benefits in reducing gasoline consumption. One of the key domains affecting EV penetration in the U.S. market is the EV charging station infrastructure. Charging equipment varies by charging time, how much a battery holds, types of batteries, and the types of Electric Vehicle Supply Equipment (EVSE). The charging time can range from 15 minutes to 20 hours depending on the above variables (Alternative Fuels Data Center 2015). The most affordable EVs on the U.S. auto market, excluding the Tesla, are able to cover approximately 70–80 miles on a full charge (Schaal 2015). The average range of electric vehicles per charge is much less than that of conventional gasoline vehicles. Currently, the problem is that there are not enough public charging stations to supply the increasing number of electric vehicles on the road. The goal of this thesis is to determine where to install EV charging stations at public facilities of Los Angeles County. The data used in this study are based on existing public facilities of Los Angeles, such as government offices and public libraries and parks. This analysis section is divided into three sub-sections: DC Fast Charging Infrastructure, Public Access Charging, and Workplace Charging. The three approaches are explained in the Methodology section and the results are discussed in the Results section. This study demonstrates how site suitability analysis based on geographic information system (GIS) data can provide information useful for installing public EV charging stations in Los Angeles County. The findings of this study show that, by applying the site suitability method, Los Angeles County would be able to install more EV charging stations at optimal locations and to serve the needs of their intended users.

# Chapter 1 Introduction

Plug-in electric vehicles (EV) have shown benefits to reduce gasoline consumption, and one of the key domains affecting EV penetration in the US market is EV charging station infrastructure. EVs have many benefits like low emissions to the environment and higher energy efficiency, and both Federal and State agencies advocate for EVs on this basis (U.S. Department of Energy 2012). The challenge of driving EVs is the short mileage range compared with gasoline vehicles and long hours of charging activities. In Los Angeles County, California, new EV charging station infrastructure can be installed at many public facilities like beaches, libraries, parks, and schools. In this thesis, a site suitability analysis is used to locate areas needed to install EV charging stations in Los Angeles County. The locations of existing public EV charging stations and the needs of EV drivers are examined to guide decision makers in placing new charging stations.

## 1.1 Motivation

The U.S. federal government has released relevant policies and several incentive programs to encourage the use of EVs to ease dependence on gasoline consumption. The EV incentives include purchasing tax credits and installing EV charging stations. These incentives have been adopted by state and local governments. The American Recovery and Reinvestment Act of 2009 provided a tax credit of $2,500 per plug-in hybrid electric vehicle sold. The U.S. Department of Energy also granted $37 million for installing 4,600 charge points around the nation and allocated $99.8 million to fund the EVProject, which is installing 14,000 level 2 charges (Peterson and Michalek 2013, 430). After 2010, federal tax credits of up to $7,500 were made available for purchasing EVs. The credit amount varies based on the capacity of the battery used to the fuel the vehicle. Small neighborhood EVs do not qualify for this credit, but they may qualify for another credit from the Internal Revenue Service (Fuel Economy 2015).

The State of California is also a leading state in promoting sustainable transportation. The State's ongoing campaign is to get 1.5 million EVs on the road by 2025. California has long led the nation in promoting the development and adoption of EVs through the Zero Emissions Vehicle Program, which aims to have new cars emit 34 percent fewer global warming gases, 75 percent fewer smog emissions, save consumers over $6,000 over the life of the car, and bring more efficient vehicles (Lavring 2013). Also in California, the State Legislature has passed a series of bills and laws to support EV use. Assembly Bill 1092 required state agencies to set standards for installing charging outlets in apartment commercial buildings (California Legislative Information 2013). Bills AB 266 and SB 286 extended the High Occupancy Vehicle (HOV) lane sticker program through 2019, giving drivers access to carpool lanes no matter how many people are in the car (California Legislative Information 2013). SB359 funded four programs that encourage green vehicle purchases, including $20 million for the Clean Vehicle Rebate Project (California Legislative Information 2013).

According to a press release from ChargePoint, Los Angeles ranks second among the top 10 EV-friendly metropolitan areas, with nearly 57,000 registered EVs. The number of EV owners has nearly tripled from 17,000 in 2013 (ChargePoint 2015). Los Angeles County is one of the most populous areas in the United States, and the daily commute is heavily dependent on vehicle transportation. Therefore, the County should offer more charging stations to better serve the increasing number of EV drivers. Installing EV charging stations will not only increase the driving range but also attract more foot traffic to these public facilities. In addition, it will increase usage of recreational areas in Los Angeles County, such as public parks and libraries.

In a recent Canadian consumers-based study, 18% of Canadian respondents' report being aware of at least one public charger. For comparison, a 2011 U.S. survey found that 12% of respondents had seen public charging locations in their communities (Bailey et al. 2015, 8). This study shows that there is no significant relationship between consumer awareness of public charging stations and interest in purchasing a plug-in EV. Thus, awareness of public charging stations is a strong indicator of purchasing electric vehicles (Bailey et al. 2015, 1). Therefore, the intent of increasing public charging stations is to extend driving ranges and increase the number of charging opportunities on the road.

In California, where the state has been pushing to be greener, EV owners are also experiencing unpleasant interactions at public charging stations. Most people charge at home but also want to use public chargers, in part because the cars have a limited range—typically, 80 miles. On top of this "range anxiety," as it is called, drivers like the idea of getting a free or low-cost charge at a public station (Richtel 2015). Unlike gas stations, charging stations are not yet in great supply, and that has led to sharp-elbowed competition. EV owners are unplugging one another's cars, trading insults, and creating black markets and side deals to trade spots in corporate parking lots (Richtel 2015). The number of public EV charging stations is not meeting the need of these charging stations. About half of the 330,000 electric vehicles in the U.S. are registered in California, and Governor Jerry Brown plans to increase the number of electric vehicles to 1.5 million (Richtel 2015). Only more public charging station are the obvious long-term solution.

In terms of spatial distribution, the existing gasoline station networks in many urban areas are more than sufficient (Melaina and Bremson 2008, 3233). The average range of electric vehicles per charge is much less than that of conventional gasoline vehicles. Range anxiety is the term used to describe worry on the part of a person driving an electric car that the battery will run out of power before the destination or a suitable charging point is reached (Oxford Dictionaries 2015). An EV can take up several hours to charge, depending on charging levels and car models. Most EV drivers have reliable primary charging sources at home or at their workplaces. However, EV driving range can be greatly increased on the road if additional charging stations are available. Despite fast charging stations that can charge 80% of the battery in less than 30 minutes, it still takes longer than fueling a gasoline vehicle, and it requires more EV charging infrastructure. In order to have EVs act as primary vehicles for an increasing number of drivers, more opportunities for EV charging must be created to extend the driving range.

## 1.2 Research Gap

An article, “Ready, Set, Charge California!” was a collaborative project by the Association of Bay Area Governments, Bay Area Climate Collaborative, Clean Fuel Connection, EV Communities Alliance, and LightMoves Consulting. In this article, EV-readiness issues include encouraging PE deployment at the regional level and investigations regarding EV infrastructure planning and investment (PEV Collaborative 2011). It discusses some guiding principles for installing charging stations like electrical requirement and design in residential and multi-unit dwellings. However, it lacks information on building an EV charging network in California.

In 2011, Sonoma County released a general set of guidelines for EV charging stations. The vision of the County of Sonoma’s Electric Vehicle Charging Station (EVCS) Program is to provide a comprehensive network of distributed chargers throughout the County which services both public agencies and the private sector and inspires other communities to initiate their own

EVCS programs (County of Sonoma 2011, 1). The planned distributive system of chargers in Sonoma included both County-owned or leased properties. The County's guidelines for installing charging stations were intended for both public and private application.

In Los Angeles County, an EV deployment plan was researched by the UCLA Luskin School of Public Affairs. The UCLA study was divided into three main charging areas: workplace charging, multi-unit dwelling (MUD) charging, and retail charging. For workplace charging, the researchers considered Electric Vehicle Charging Station (EVSC) installation sites by answering the following questions: what are the largest employers and where are they located? Which employers are located in neighborhoods where current PEV owners drive on weekday mornings? Which employers have the highest numbers of white-collar and high-tech workers? (UCLA Luskin School of Public Affairs 2013, 14).

From the UCLA study, the authors also suggested considering social characteristics of these employers. Defense contractors are important sources of technology research and development; workplace PEV charging may thus align with the mission, interest, and image of the companies and their employees, some of whom may be Plug-in Electric Vehicle (PEV) drivers. However, security protocol makes it difficult for planners to conduct employee outreach or establish on-site demonstration projects. Oil companies' business models would appear to discourage them from offering workplace charging, but they may wish to demonstrate an interest in sustainability. Other employers, particularly in the health, technology, and public sector, may wish to accommodate or attract employees and clients that drive PEVs (UCLA Luskin School of Public Affairs 2013, 17). These suggested variables could be considered as social indexes in spatial analysis, but they omit applying it in identifying potential EVCS locations.

In fact, at the local government level, Los Angeles County has been installing charging stations at several departmental faculties. In September of 2014, Supervisor Mark Ridley-Thomas announced that Los Angeles County residents could take advantage of charging stations at various County faculties—for instance, at the Los Angeles County Sheriff's station in Lynwood or the Department of Health Services in Downey. EV drivers can charge their vehicles for up to four hours, free of charge, during the initial year of the program. At the onset of the EV program, there were over 20 EVCS sites across the County (Supervisor Mark Ridley-Thomas 2014). These charging stations are located at Los Angeles County Sheriff's stations, county medical centers, the Department of Human Resources, the Office of the Registrar-Recorder, Walt Disney Concert Hall, Arboretum, and other locations (see Figure 1 and Appendix A). The charging availability is subject to office business hours, parking garage hours and basis of first come first service. Altogether, over 200 publicly accessible charging stations are distributed throughout Los Angeles County and operated by a variety of other service providers (Los Angeles County Economic Development Corporation 2015). At the County level, more EV charging stations should be installed where people can have more charging opportunities.

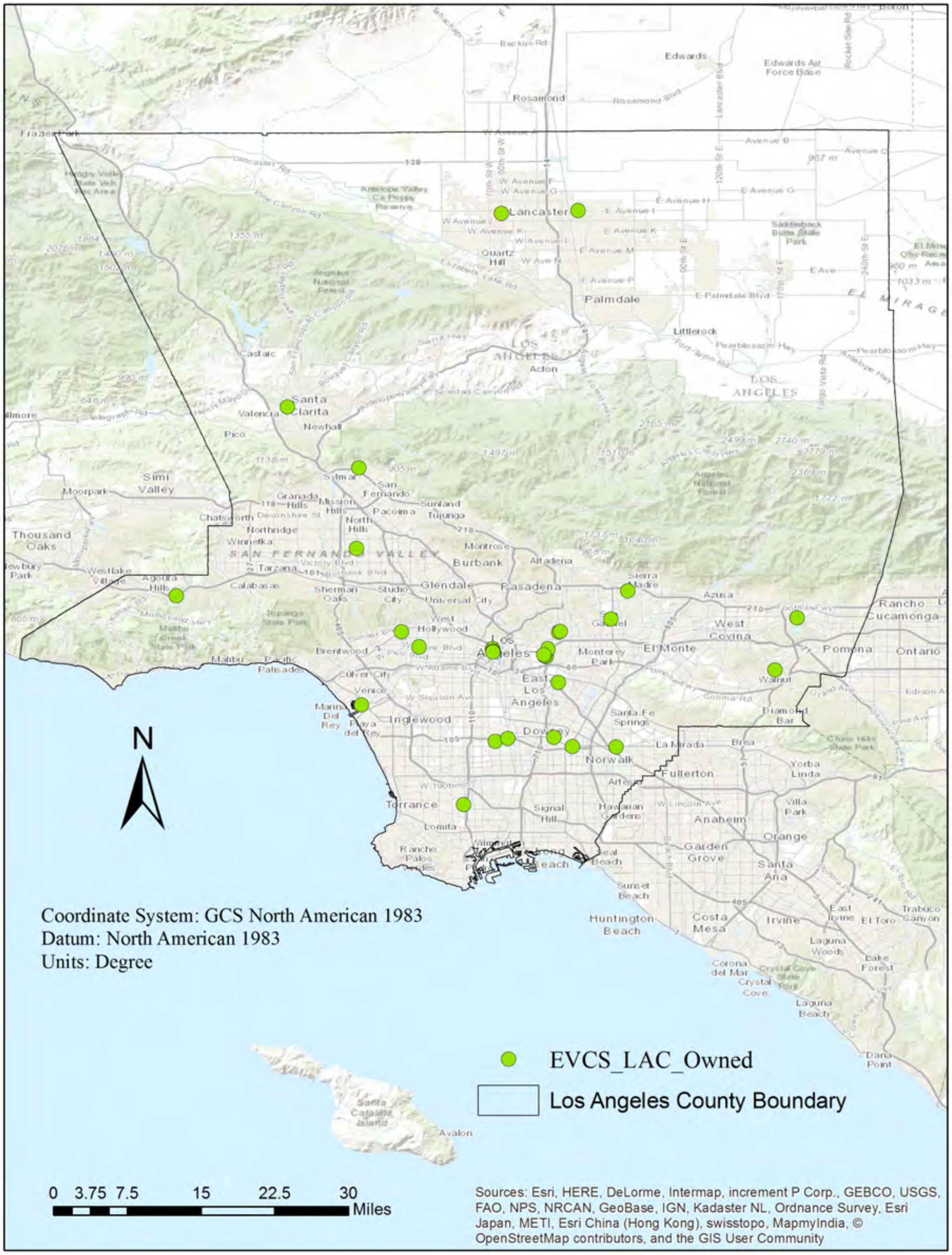


Figure 1 Los Angeles County Owned Public Charging Stations

One of the most recent studies, conducted by San Joaquin Valley in 2014, considered installing two commonly used types of public charging equipment: DC fast charging stations and Level 2 charging stations. The analysis is based on regional transportation origin and destination data, industry expertise, and other demographic information (San Joaquin Valley Air Pollution Control District 2014, 3). Researchers of the San Joaquin Valley study were seeking to develop a network of EV charging stations, so that people cannot only easily travel within an urban area, but also provide the charging station available for rural residents to make a long drive into a city (San Joaquin Valley Air Pollution Control District 2014, 3)

DC fast charging stations offer a shorter waiting time while charging than do Level 2 EV chargers. In a charging plan based in San Joaquin Valley, California, the authors considered installing DC fast charging stations to connect the long commute between rural and urban areas or cities. To better accommodate the rural residents, additional analysis on commute patterns and travel flows in the rural areas of the region are necessary to address adequately the charging needs of those communities (San Joaquin Valley 2015, 3). A DC fast charging station can provide an 80 percent full charge on a light-duty electric vehicle in as few as 30 minutes. This type of charging equipment serves the needs of interregional and intraregional travel by having multiple DC fast charging points on the road. Consequently, a “safety net” of charging stations is offered to all EV drivers throughout the Valley (San Joaquin Valley 2015, 5). In order for a site to be considered as an optimal location for hosting fast chargers, a charging station must be within half a mile of a highway exit, easily accessible, and well-lit, and it must offer facilities and shelter for drivers while charging and a “destination” point (San Joaquin Valley 2015, 5). In their proposal, the authors choose shopping malls, restaurants, and airports for their electric power capacity and existing parking availability.

## 1.3 Study Area: Los Angeles County

Los Angeles County is the most populous county in the United States, according to the 2010 U.S. Census. In 2010, the population of Los Angeles County was 9,818,605. Like other major urban cities in the U.S., people depend on automobile transportation which public transits and driving a personal vehicle. According to a 2013 American Community Survey, about 86 % of all workers commuted to work by private vehicle, either driving alone or carpooling (McKenzi 2015). People depend on private vehicle in daily life and electric vehicles offer an alternative to gasoline vehicles. According to another study, Los Angeles (LA) has been shown to be a perfect place to have an electric vehicle in the near future; LA has a car centric culture, because of the spread-out nature of the city and lack of public transportation options (Schaal 2015).

Existing public EV charging stations have shown EV popularity in the region. In Figure 2, the map shows the location of Los Angeles County within the state of California. Los Angeles County locates in the southern region and the county boundary is in green shade. Right now, 2804 EV charging stations locate mainly in the northern and southern regions of the State (Alternative Fuel Data Center, 2015). The existing charging station data is used in this site suitability analysis. Installing more charging stations in Los Angeles County also offers more charging access in Southern California (see Figure 2).


Figure 2 Los Angeles County Location within the State of California

In applying the concept from related studies, this thesis aims to perform a site suitability analysis to locate optimal charging stations within Los Angeles County. The precedent components are by understanding different types of charging stations, identifying where these charging services are needed and the intended users. The remainder of this research includes four chapters. Chapter 2 discusses important background related to the basic features of electric vehicles, their environment impact, various charging equipment and other relevant studies in this field. Chapter 3 describes the data and methods used in this study. In Chapter 4, the results of the study are shown in maps and in tables. Lastly, Chapter 5 reviews the results and discusses the importance of this research.

# Chapter 2 Literature Review

Recent published studies on the topic of EVs and their charging equipment focus mainly on where to install a single charging station. However, researchers have begun considering solutions that can solve issues of environmental pollution wrought from gasoline vehicles. Currently, inadequate research exists to examine the potential benefits of installing multiple EV charging stations at local government facilities. This section introduces the various types of electric vehicles; the section also outlines state and federal environmental rules and regulations pertaining to electric vehicles and the installation of electric vehicle charging stations (EVCS); and the section presents related EV charging studies in the field of Geographic Information System (GIS).

## 2.1 Electric Vehicles

Energy-saving vehicles are categorized as hybrids, plug-in hybrids, and all-electric vehicles. Hybrids do not require charging electricity, whereas plug-in hybrids and battery electric vehicles (BEVs) must be charged partially or fully. Hybrids, also known as hybrid-electric vehicles (HEVs) combine the benefits of gasoline engines and electric motors (International Energy Agency 2015). HEVs have several advantages, including improved fuel economy, increased power, and additional auxiliary power for electronic devices and power features. The electric motor applies resistance to the drivetrain causing the wheels to slow down; it also provides additional power with which to assist in engine acceleration, as ell as passing or hill climbing. Also, the HEV automatically shuts off the engine when the vehicle comes to a stop, and restarts when the accelerator is pressed: this prevents wasted energy form idling (Plug-in Electric Vehicle Resource Center. 2015).

Plug-in hybrid, or Plug-in Hybrid-Electric Vehicles (PHEVs) are hybrids with high-capacity batteries, which can be charged by plugging them into an electrical outlet or charging station. These vehicles can store enough electricity from the power grid to significantly reduce their gasoline consumption under typical driving conditions. When compared with conventional gasoline vehicles, PHEVs offer benefits of less petroleum use, less greenhouse gas emissions, and lower gasoline costs (Plug-in Electric Vehicle Resource Center. 2015).

All-electric vehicles or Battery-Electric Vehicles (BEVs) run on electricity alone. They are propelled by one or more electric motors, powered by rechargeable battery packs. BEVs have several advantages over vehicles with internal combustion engines: they are energy efficient, environmentally friendly, possess performance benefits, and reduce energy dependence of gasoline (Plug-in Electric Vehicle Resource Center. 2015). Electric vehicles convert approximately 59-62 % of the electrical energy at the wheels, whereas conventional vehicles only convert about 17-21% of gasoline energy. EVs emit no tailpipe pollutants (Plug-in Electric Vehicle Resource Center. 2015). Electricity from nuclear-, hydro-, solar-, or wind-powered plants causes no air pollutants. Electric motors provide quiet, smooth operation, stronger acceleration, and require less maintenance from internal combustion engines. Comparing with gasoline, electricity is a domestic energy source.

Installing electric vehicle charging stations and deploying of a charging station network has been researched in urban areas. These urban areas often represent concentrated EV usage, such as in major cities in Asia, Europe, and North America. Although EV studies have mostly concentrated on technical requirements, offering recommendations at single site installation, researchers are now advancing plans for charging networks in urban areas. Successful studies from other cities have demonstrated different planning approaches to such EV charging.

## 2.2 Environment Impact

Electric vehicles offer the potential of reducing greenhouse gas emissions, as well as exposure to tailpipe emissions from personal transportation. According to a recent study, EVs offer a 10% to 24 % potential decrease in global warming impact compared to conventional diesel or gasoline vehicles (Troy et al. 2012, 1). In the 1960s and 1970s, soaring oil prices and gasoline shortages peaked with the 1973 Arab Oil Embargo, which created a growing interest in lowering the U.S.' dependence on foreign oil, and finding homegrown fuel sources. The 1975 Energy Policy Conservation Act created the Corporate Average Fuel Economy (CAFE) standards, which mandated efficiency increases in the vehicle fleet by setting standards for passenger cars starting in 1978 (Peterson and Michalek 2013, 429).

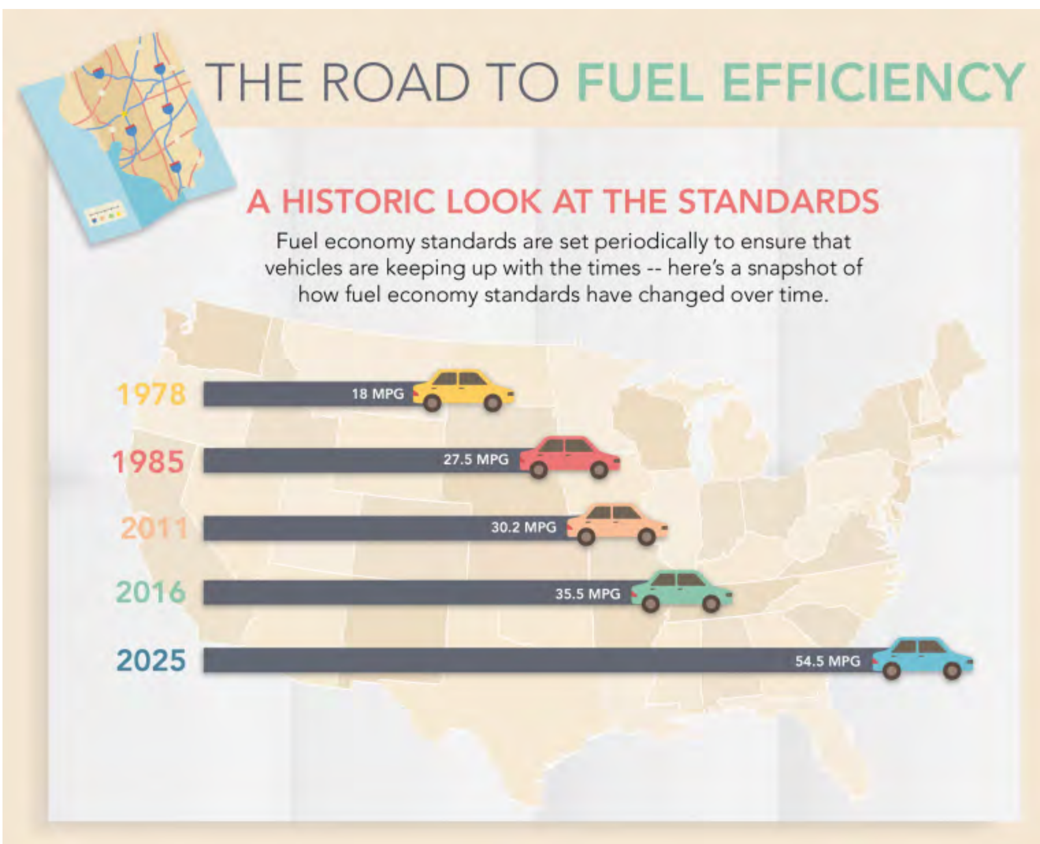


Figure 3 Fuel Efficiency Standards. *Source*: U.S. Department of Energy 2012

In August of 2012, the Obama Administration's first phase of fuel economy proposed to raise the average fuel economy of passenger vehicles to 35.5 miles per gallon by 2016. Under the new rules, cars and light duty trucks built for model years 2017-2025 are expected to achieve industry-average fuel efficiency equivalents of 54.5 miles per gallon by 2025 (U.S. Department of Energy 2012). As automobile makers are under pressure to increase miles per gallon (MPG), there is added incentive to increase production of electric vehicles and balance this with improved MPGs of conventional gasoline vehicles. Thus, more EVs from different automobile makers will be on the road, and more EV infrastructure will be required to fulfill these needs.

## 2.3 EV Charging Equipment

Charging plug-in electric vehicles requires plugging into electric vehicle supply equipment (EVSE). Hybrids (HEVs) are charged using regenerative braking and the internal combustion engine, and are not plugged into charging equipment. Only PHEVs and BEVs require electric charging and charging equipment. Charging equipment varies by charging time, battery capacity, types of batteries, and the types of EVSE's. Charging time can range from 15 minutes to 20 hours, depending by above variables (Alternative Fuels Data Center 2015).

AC level 1 EVSE provides charging through a 120-volt AC plug, and most PHEV and BEVs come with AC level 1 cord set. Based on the battery type and vehicle, AC level 1 charging adds about 2 to 5 miles of range to an EV per hour of charging time. AC level 1 is typically used for charging when the only outlet available is 120 V. AC level 2 equipment offers charging through 208-volt or 240-volt electrical service. AC level 2 EVSE requires installation of home charging or public charging equipment, and a dedicated circuit of 20 to 100 amps, depending on the EVSE requirements. At residential charging, this charging option can operate at 80 amps and 19.2 kW, which means other household electrical equipment should consume less power than normal usage, and requires a protective high circuit breaker. If 240-volt services are available at home, most EVs can be fully charged overnight. Level 2 and level 1 charging equipment uses the same connector as the EVs (Alternative Fuel Data Center 2015), and are both used in residential buildings.

Table 1 Driving Range per Charging Hour

| **Charging Level** | **Miles Per Charging Hour** |
| --- | --- |
| AC Level 1 | 2-5 |
| AC Level 2 | 10-20 |
| DC Fast Charging | 50-70 |

*Source*: Alternative Fuel Data Center 2015

The standard J1772 receptacle (right) can receive a charge from AC Level 1 or AC Level 2 equipment. Direct-current (DC) fast charging equipment at 480-volt enables rapid charging at public stations, and DC fast charging are commercial only, and for safety reasons cannot be installed at residential buildings. Most EVs may not be equipped for fast charging, and fast charging varies depending vehicle make. Inductive charging is alternative charging method, which does not require an electric cord, and offers an equivalent of a Level 2 charging capacity (Alternative Fuel Data Center, 2015) (see Figure 5). For this study, DC fast charging stations and Level 2 charging stations are considered for site suitability analysis. Both DC fast charging stations and Level 2 charging stations are commercial grade which can be installed at public places. In short, DC fast charging is considered fast charge and Level 2 is regular slow charge.

Among DC fast charging stations, there are three main primary type of quick charges CHAdeMO, SAE Combo, and Tesla Supercharges (Birdman 2014). CHAdeMOis an abbreviation for “CHArge de Move” or “charge for moving.” CHAdeMO cords are compatible with electric vehicles made by Toyota, Nissan and Mitsubishi. As of July 2014, there are more than 600 CHAdeMO charging stations in the United States, more than 1,000 in Europe, and nearly 2,000 in Japan (Birdman 2014). SAE Combined Charging System, or "Combo Cord" were invented by American and German automotive engineers, and the electric vehicles made by General Motor and BMWs are compatible SAE combo cord. All three types of DC fast charging stations deliver a voltage of 480 volts, and the only difference in the design of the plug. In Figure 4, the lower left plug is CHAdeMO and the upper right one is SAE combo cord plug (Birdman 2014).

Figure 4 Two Common DC Fast Charging Plug. *Source*: Birdman 2014

In Figure 4, the receptacle on the left is for the DC fast charging and the receptacle on the right is for Level 2 charging. This vehicle uses the CHAdeMO standard for DC fast charging. In Figure 5, it is a Level 2 charging station from a commercial network, ChargePoint. The DC fast charging station is typically one unit, and one charging equipment usually does not contain both DC fast charging and Level 2 charging capabilities.

Figure 5 Electric Vehicle Charging Receptacles. *Source*: Alternative Fuel Data Center 2015


Figure 6 Level 2 Charging Station. *Source*: ChargePoint Network 2015

## 2.4 Related Studies in GIS

In Lisbon, Portugal, an EV charging plan examined daytime and nighttime demands. The study area was in the center of the Avenidas Novas. The researchers collected demographic information in this area, such as population older than 17 years of age, the percent of people who completed high school ($p\_H$), residents working in the tertiary sector ($p\_r$), proportion of residents younger than 20 years of age ($p\_20$), and the proportion of residents older than 64 years of age (p_64). The regression equation was obtained after stepwise elimination of the variables, and the intercept was forced to be 0; the final equation for nighttime was $v\_h = 3.90 \times p\_H - 1.18 \times p\_r + 3.41 \times p\_20 + 3.28 \times p\_64$ (Frade et al. 2011, 93). This regression equation captures the relationship between the number of cars per household and household characteristics. Through two math equations, the number of EVS needed to refuel during nighttime in census block was estimated. With centroids of census blocks, possible EV charging station locations were determined. This study provides accurate estimations of EV charging stations requirements; however, its limitation is that the number and characteristics of existing EV drivers do not change over time.

In the Greater Chicago Area, consisting of four surrounding counties, an agent-based decision support system for electric vehicle charging infrastructure deployment was investigated in 2011 (Sweda & Klabjan 2011, 1). This paper identifies patterns in residential EV ownership and driving activities, enabling strategic deployment of new charging infrastructure (Sweda & Klabjan 2011, 1). Agent-based modeling is a technique for studying interactions among many autonomous and heterogeneous decision-makers. The agents all exist within an environment that consists of houses (where the agents live), workplaces (where the agents work), points of interest, or other destinations where the agents may visit, charging stations (where agents that own EVs can recharge their vehicles), and a road network, along which agents travel. Agents are assigned values for several different attributes, including income, preferred vehicle class, and level of range anxiety. The results show that increasing numbers of nearby charging stations correlated to increasing probability for an agent to visit. One of the study's limitations was its ability to collect accurate agents' information. Each agent in this study has different variables; thus, the study is suitable for determining optimal locations around existing EV drivers.

In the deployment of public charging stations for EVs, scholars have attempted to develop an equilibrium-modeling framework, which captures interactions among the availability of public charging opportunities, prices of electricity, and destination and route choices of PHEVs at regional transportation and power transmission networks (He et al. 2011, 87). In their study, the authors derived a mathematical program to describe the equilibrium state of prices of electricity, traffic, and power flow distributions. The numerical example indicates that charging load from PHEVs has substantial impact on the operations of the power network and the price of electricity. Consequently, it is important to consider this impact when allocating public charging stations (He et al. 2011, 100). Two critical assumptions of the availability of public charging stations and prices of electricity need to be verified for future empirical studies. For this thesis, these two assumptions are omitted from deployment of public charging stations.

In recent spatial studies, GIS has been used to analyze grid impact of EVs in the U.K. This was the first time origin-destination analysis was used to model spatial and temporal characteristics of EV charging loads (Mu et al. 2014, 456). The average nodal voltages (summation of the nodal voltage from the Monte Carlo simulations, divided by the simulation times) with "dumb" and "smart" charging for one day with hourly time step are presented (Mu et al. 2014, 464). The voltage magnitude with "smart" or "dumb" charging is also shown during a different time of a day. This model enables power planning and evaluation by identifying the most critical network components, providing more accurate results with spatial-temporal characteristics. The authors also suggest that this model is more suitable for the EV impact analysis of urban electricity networks.

For planners in urban cities, the location selection process can be complicated when implementing a power network. In 2011, a similar proposal was conducted on determining EV charging stations in the city of Tianjin, China. The authors proposed a method of locating and sizing the charging stations for electric vehicles based on grid partition. This method aimed at minimizing users' loss on the way to the charging station, zoning the planning area with a grid partition method, and then selecting the best locations for each partition with a genetic algorithm based on considerations of traffic density and charging station capacity constraints (Ge et al. 2011, 2726). The authors evenly divided an area into rectangular nodes, and assigned a partition number within several nodes; thus, each partition was weighted by the traffic and charging resources required in the surrounding area. By calculating the energy needed and supplied within a partition, a charging station installation locations could be determined within a single node. This practical method could be assessed repeatedly as inputs changed. The selection process used in this study is based on grid. To repeat this successful model, it is designed with known traffic information and the number of electric vehicles. It is also more viable within an area with high density of electric vehicles because the chances of using charging stations are higher.

In a comparative study on services by Level 2 and fast charging methods, researchers set parameters for battery size, charging capacity, and level of services, using vehicle information from several current EV models. One of the findings was that level 2 charging does not adequately serve traditional long-distance trips (Nie & Ghamami, 2013, 188). The authors also demonstrated that in order to achieve a reasonable level of service, the fast charging method is needed to minimize the social cost (Nie & Ghamami, 2013, 189). For this thesis study, the specific types of charging stations will be considered.

As other researchers have pointed, the benefits of mapping public-owned parcels is modest, as there are relatively fewer of them as they represent a diverse set of destination types like recreational areas, workplaces, etc.(DeShazo 2012, 98). These destination types must consider the potential EV users and how to maximize the usage as pubic benefits. In the study of San Joaquin Valley Air Pollution Control District (2014), the data obtained from National Household Travel Survey was set as a basis with which to understand where drivers tend park for longer periods. These locations may attract drivers to travel “medium-to-long” distances from their home, as they tend park at these locations for at least one hour, generally providing enough time to sufficiently charge their vehicles with a Level 2 Charger (San Joaquin Valley Air Pollution Control District 2014, 13-14). In Table 2, these are considered to be optimal locations for public charging according to the National Household Travel Survey.

Table 2 Best Locations for Public Access Charging

| | | | |
|---|---|---|---|
| Airport | Amusement park | Aquarium | Art gallery |
| Camp ground | Casino | Dentist’s office | Department store |
| Doctor’s office | Grocery store | Supermarket | Hospital |
| Library | Local government office | Lodging | Movie theater |
| Museum | Park | Restaurant | Shopping mall |
| Stadium | Train Station | University | Zoo |

*Source*: San Joaquin Valley Air Pollution Control District 2014

The types of locations listed in Table 2 can be used to meet the goal of this thesis, which is to identify where to install EV charging stations at public facilities in Los Angeles County. In this thesis, public facilities employ only County-owned facilities as the study object. These County-owned facilities are currently owned, rented, or operated without inquiring permission to access. Table 2 indicates locations of local government offices, libraries, and parks that are considered the best locations for public access EV charging, and Los Angeles County has direct access to these areas.

The demographics of existing EV drivers are used to predict the high likelihood of owning EVs in a community or neighborhood, therefore the increasing the chances of using these charging stations. Previously, a published GIS study explored early adoptions of electric vehicles using multi-dimensional analysis. The study area focused on London, and the surrounding region. The paper incorporated geospatial modeling approach, exploring the potential for deploying publicly accessible charging opportunities for consumers based on two traits: trip characteristics (journey purpose and destinations), and PEV adoption intensity (Namdeo, Tiwary, & Dziurla 2013, 188). Applicability was demonstrated through a case study, which combined census statistics including lifestyle trends, family size, age group, affordability, along with travel patterns, for an administrative region in North-East England (Namdeo et al 2013, 188). As such, for this thesis, the demographic data of Los Angeles County are used in seeking optimal public charging locations.

# Chapter 3 Methodology

The objective of this study is to determine suitable installation locations in Los Angeles County for electric vehicle charging stations. In reference to EV charging location suggested by the San Joaquin Valley Air Pollution Control District (2014), optimal EV locations selected for the purpose of this thesis include public libraries, public parks and government offices. In the methodology section, a site suitability analysis is divided into three sub-sections: DC Fast Charging Infrastructure, Public Access Charging and Workplace Charging. The data sources of public libraries, parks, and government offices are first reviewed; then, this chapter provides an overview of the specific data needed, the variables for the analysis, the charging type that will be installed, and information about how locations were selected through ArcGIS.

In order to determine potential EV charging stations using GIS, this study applies four general steps. The main methodology is as follows:

1) Obtain public facilities and their shapefiles

2) Define the key variables for each sub-section and choose the data needed

3) Perform ArcGIS analysis to seek locations that fulfill criteria from each sub-section

4) List the results in maps and tables

Each data shapefile can be tracked from a current, accurate, and reliable source, and contains addresses of each location, including the name, general service or category, as well as a site description. In short, DC fast charging equipment can be viewed as providing a “fast” charge. Level 2 charging equipment installed at public access and workplace sections can be viewed as providing a “slow” charge.

### 3.1 Methodology Workflow

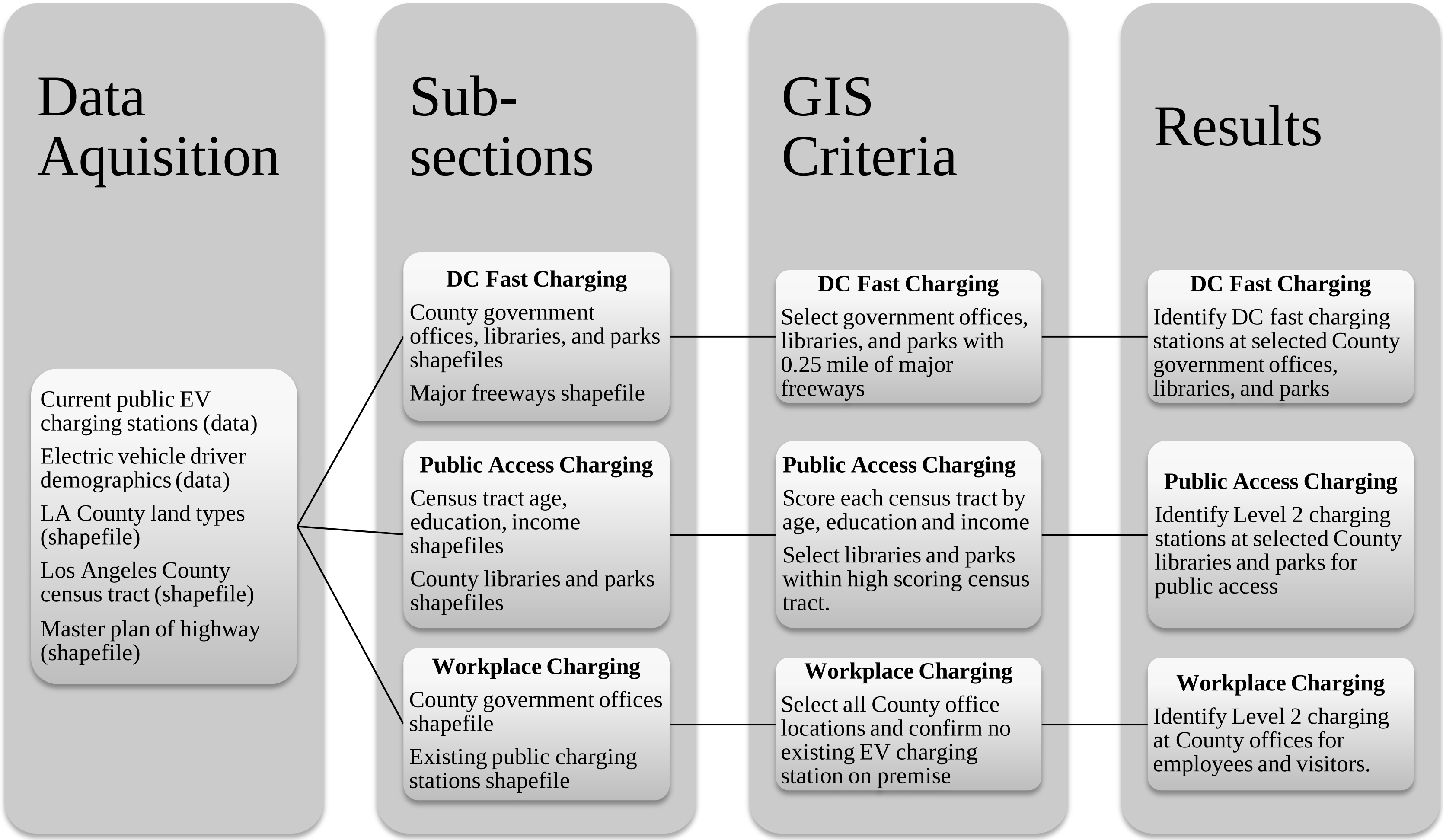


Figure 7 Methodology Framework

The following portion explains the variables used in the sections of DC fast charging, public access charging areas and county government offices. The information includes where the data was downloaded (see Table 3), how it was prepared for geoprocessing, and how the variables were determined and selected for ArcGIS spatial analysis. All of the data has been projected and transformed to NAD 1983 State Plane California V FIPS 0405 (US Feet), and the geographic coordinate system used in the analysis is GCS_North_American_1983.

Table 3 List of Data Sources

| **Data Source** | **Organization** | **Published Date** | **Feature Class** | **Website** |
|---|---|---|---|---|
| Electric Charging Stations | US Department of Energy, Alternative Fuels Data Center | Updated August 2015 | CSV | http://www.afdc.energy.gov/locator/stations/ |
| LA County Land Types | Los Angeles County GIS Data Portal | January 2015 | Polygon | http://egis3.lacounty.gov/dataportal/2015/01/08/la-county-land-types/ |
| Locations/ Points of Interest (LMS Data) | Los Angeles County GIS Data Portal | July 2014 | Point | http://egis3.lacounty.gov/dataportal/2014/07/07/locationspoints-of-interest-lms-data/ |
| Los Angeles County Demographic Information | USC Geospatial Geoportal, original creator: U.S. Census Bureau | Unknown | Polygon | http://geospatial.usc.edu/geoportal/catalog/download/download.page |
| Master Plan of Highway | Los Angeles County GIS Data Portal | June 2015 | Polyline | http://egis3.lacounty.gov/dataportal/2015/06/25/master-plan-of-highways/ |

## 3.2 DC Fast Charging

For DC fast charging and public access charging, public facilities must be easily accessible, support adequate electrical power and have existing parking availability (San Joaquin Valley Air Pollution Control District 2014, 6). In Los Angeles County, county-owned libraries and parks are located throughout the county. Parks are managed and maintained by the Los Angeles County Department of Parks and Recreation because the County of Los Angeles has direct access, and the right to add public equipment to these parks.

### *3.2.1. Freeways*

The original name of the highway shapefile downloaded from the Los Angeles County GIS portal website is “Master Plan of Highways.” The shapefile consists of polyline feature data, and contains all existing and proposed road information of expressways, limited secondary highways, parkways, major highways, secondary highways, and freeways. For this study, existing freeways were created as a new feature data. By selecting “select by attributes” in ArcGIS, a SQL query of “‘HCODE_NAME’ = ‘FREEWAY – EXISTING’” was performed. In the County of Sonoma, the parameters for searching DC fast charging stations were ½ mile to the highway exit (County of Sonoma 2014, 5).

### *3.2.2. County Government Offices*

County offices are extracted from the point shapefile of Locations/Points, and the original file was downloaded from the Los Angele County GIS Data Portal official website. The original zip file name is LMS_Data_20140707; and the file was last updated in July 2014, and the original file contains 63,650 points of various locations. County government offices are selected by choosing cat 1 of “Government” and cat 2 of “County Offices, the selected attributes with duplicate locations are processed with data the management tool: “Delete Identical in the column of “post_id”. The result contains 42 locations of County offices.

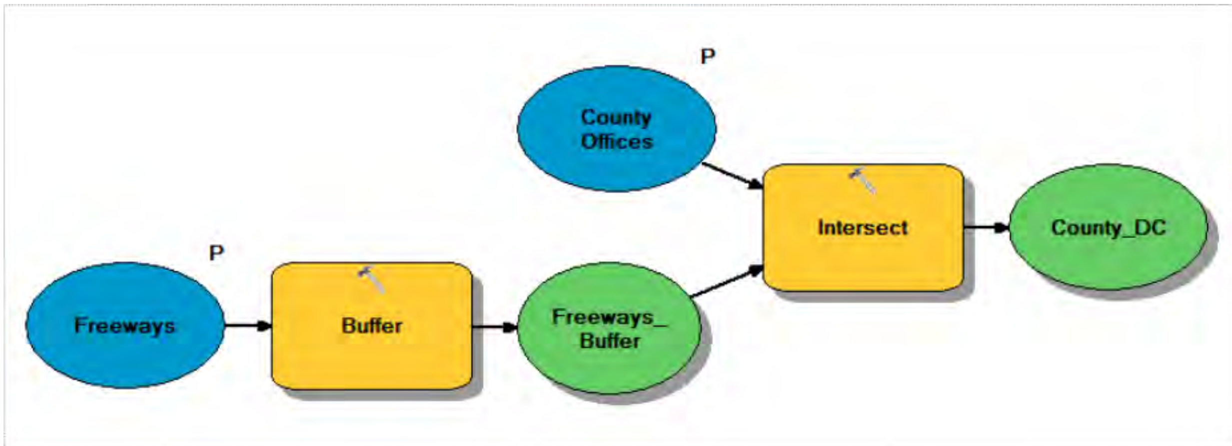


Figure 8: Select County Government Offices to Install DC Fast Charging Stations in Modelbuilder

*3.2.3. Public Libraries in Los Angeles County*

In Los Angeles County, over 1,000 libraries are accessible to the general public, and are operated by local city governments, schools, universities, and the county. This study used public libraries maintained by Los Angeles County. The County Public Library serves 51 of 88 cities and unincorporated areas through 84 community-based library outlets, including four bookmobiles (County of Los Angeles 2015).

The public facilities in Los Angeles County consist of a point shapefile that was downloaded from the official website of the Los Angeles County GIS Data Portal. The original zip file name was LMS_Data_20140707, and the file was last updated in July 2014. The original file contains 63,650 points of various locations. County libraries were selected by choosing cat 1 of “municipal,” cat 2 of “libraries,” and the description of “The County of Los Angeles” The selected attributes with duplicate locations were processed with the data management tool:

“Delete Identical in the column of “post_id.” Eighty-nine county libraries are within 0.25 miles of existing freeways, as described in Figure 9.

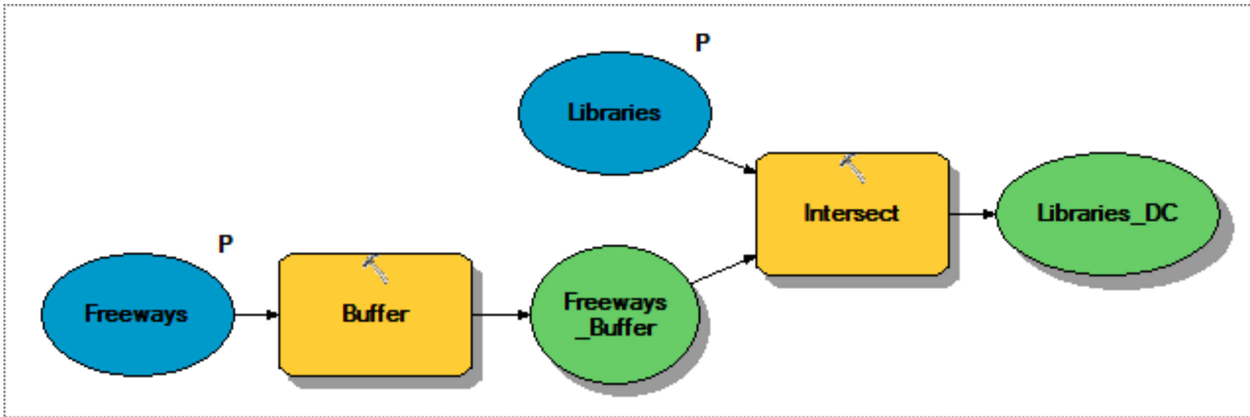


Figure 9 Select County Libraries to Install DC Fast Charging Stations in Modelbuilder

*3.2.4. Public Parks in Los Angeles County*

The Los Angeles County parks and recreation system includes 63,000 acres of parks, lakes, trails, natural areas, and gardens. The County of Los Angeles’ Department of Parks and Recreation maintains 169 sites for residents. These areas include parks, playgrounds, swimming pools, gardens, golf courses, sanctuaries, staging areas etc. The swimming pools are amenities of these parks. The County’s gardens are Descanso Gardens, Los Angeles County Arboretum and Botanic Garden, South Coast Botanic Garden, and Virginia Robinson Gardens (County of Los Angeles 2015).

There are 1,277 points in the shapefile of parks and recreation areas. The full list of 169 park and recreation locations is found in Appendix C. For this study, only public parks maintained by the Los Angeles County Department of Parks and Recreation were selected and used for analysis from the following data. The land types file in Los Angeles County is a polygon shapefile, and was downloaded from the official Los Angeles County GIS Data Portal website.

The original zip file name is LA County Land Types, and the file was last updated in August 2015. The original file contains 6,735 locations. County parks are selected by choosing cat 1 of “Arts & Recreation,” with the source “LA County Parks and Recreation.” The selected attributes with duplicate locations were processed with the data management tool: “Delete Identical in the column of “OBJECTID.” One hundred and fifty-two locations were selected as park layers, outlined in Figure 10, consisting of amusement parks, golf courses, historical parks, museums and aquariums, natural areas and wildlife sanctuaries, regional parks and gardens, and sports complexes. This Modelbuilder completed the site suitability of DC fast charging stations at the County parks.

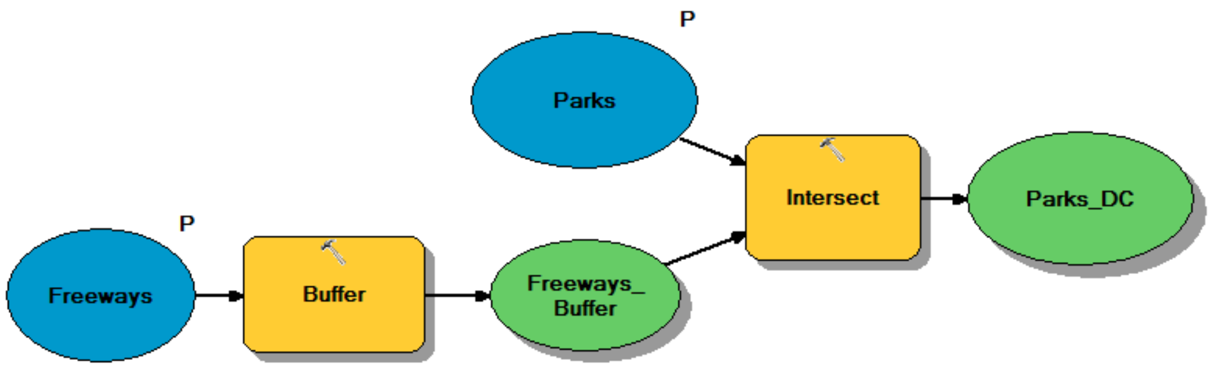


Figure 10 Select County Parks to Install DC Fast Charging Stations in Modelbuilder

## 3.3 Public Access Charging

The Clean Vehicle Rebate Project (CRVP) is administered by the Center for Sustainable Energy (CSE) for the California Air Resources Board. The Electric Vehicle Consumer Survey gathers data from recipients of California’s CRVP, providing monthly updates on a variety of demographic and behavioral topics. The survey data include responses from a subset of CVRP applicants who purchased or leased their vehicle between September 1st, 2012 and May 31st,

2015. Surveys were collected between October 25th, 2013 and June 23rd, 2015. Los Angeles County and the surrounding counties are included in the South Coast region.

In the South Coast region, 29% of the survey respondents are in the age range of 45 to 54, 25% of respondents are 35-44 years old, and 22% are 55-64 years old. After adding the top three age groups, 76% of survey respondents are between 35 and 64 years old, and are middle-aged (Center for Sustainable Energy 2015). In terms of gender, 75% of respondents are male. Thirty-seven percent of survey respondents have attained bachelor's degrees as their highest level of education, while 44% report their highest level of education as graduate degrees. A small portion of survey respondents report having completed some college work or a high school diploma, and the majority (81%) of survey respondents possess either a bachelor's degree or other advanced degrees (Center for Sustainable Energy 2015). EV driver respondents with annual household incomes of $100,000 or more represent 74% of the sample, and 26% of EV drivers report incomes of $99,999 or less. Seventy-nine percent of respondents reside in detached houses (Center for Sustainable Energy 2015).

The corresponding demographic information of EV drivers generally represent middle-aged people with bachelor's degrees or higher, and with high household incomes. Los Angeles County census tract data were downloaded from USC Geoportal, and three variables – age, education, and household income – are used in the analysis, and the original census data of 2010 was created by U.S. Census Bureau.

In Figure 11, three census tract shapefiles of age, education, and income are first converted to raster files by "Polygon to Raster" in ArcGIS. Then, raster files are reclassified, as outlined in Figures 8, 9, and 10. These reclassified files are combined through the "Weighted Overlay" tool, and then converted back to a weighted polygon file. This file has the highest weighted score of 5 to each census tract in Los Angeles County, and 5 is the highest possible score.

The ranking categories are determined by the Jenks natural break. In the attribute table of the “LAC_CT_Age” layer, adding people in the age range of 35-64 from other columns creates a new column of “Middle-age.” The data in this column represents number counts of people in the age range of 35-64 in each census tract. The higher number of middle-aged people in a census tract receives a higher-ranking score. In the attribute table of the “LAC_CT_Education” layer, adding total populations of bachelor and graduate degrees creates a new column of “AdvEdu.” The data in this column represents number counts of people with advanced education levels in each census tract. In the attribute table of the “LAC_CT_Income” layer, the median household income of each census tract is used for analysis. This data is also ranked: the higher the household income, the higher the score each census tract receives.

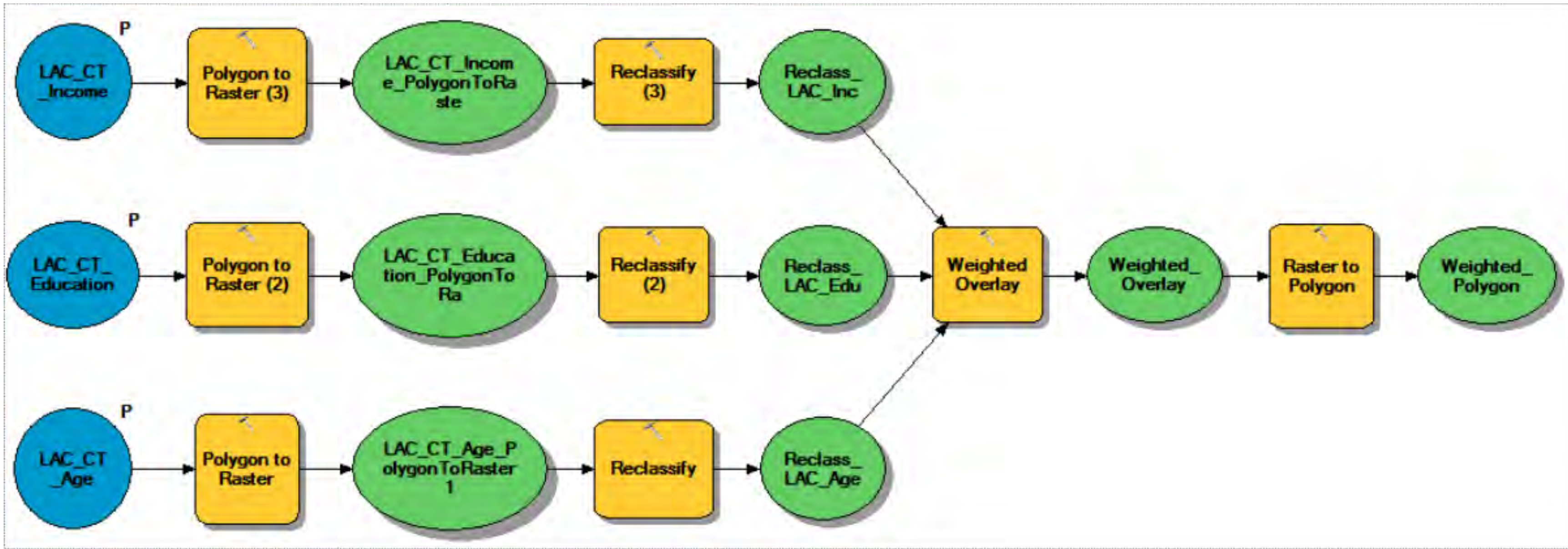


Figure 11 Score Demographic Feature and Add Weighted Score to Census Tract in Modelbuilder

The ranking categories are determined by the Jenks natural break. In the attribute table of "LAC_CT_Age" layer, adding people in the age of 35-64 from other columns creates a new column of "Middle-age". The data in this column represents the number counts of people in the age of 35-64 in each census tract. The higher number of middle-aged people in a census tract receives a higher-ranking score. In the attribute table of "LAC_CT_Education" layer, a new column of "AdvEdu" is created by adding total populations of bachelor and graduate degrees. The data in this column represents number counts of people with advanced education in each census tract. In the attribute table of "LAC_CT_Income" layer, the median household income of each census tract is used for analysis. This data is also ranked by the higher of household income, the higher of the score each census tract receives.

Table 4 Census Tract Demographic Characteristic Ranking System

| **Demographic Data** | **Scoring** | **% Influence** |
|---|---|---|
| **Age** | 5 = 3063-5455<br>4 = 2244-3063<br>3 = 1627-2244<br>2 = 881-1627<br>1 = 0-881<br>(Unit: number of people in the age 35-64 per census tract) | 33.33% |
| **Education** | 5 = (56-142)x10<br>4 = (44-69)x10<br>3 = (24-44)x10<br>2 = (3-24)x10<br>1 = (0-8)x10<br>(Unit: number of people having bachelor and/or graduate degree)<br>Note: original data number were shown in 10^-1 per census tract. | 33.33% |
| **Income** | 5 = 115099 - 225885<br>4 = 79297 - 115099<br>3 = 55368 - 79297<br>2 = 22865-55368<br>1 = 0-22865<br>(Unit: Average household income per census tract) | 33.34% |

In Figure 12, weighted polygon file of census tract is added to parks or libraries files separately. This gives every park and library a weighted score. The higher the score a library or a park receives, the more suitable it is to install a DC fast charging on site.

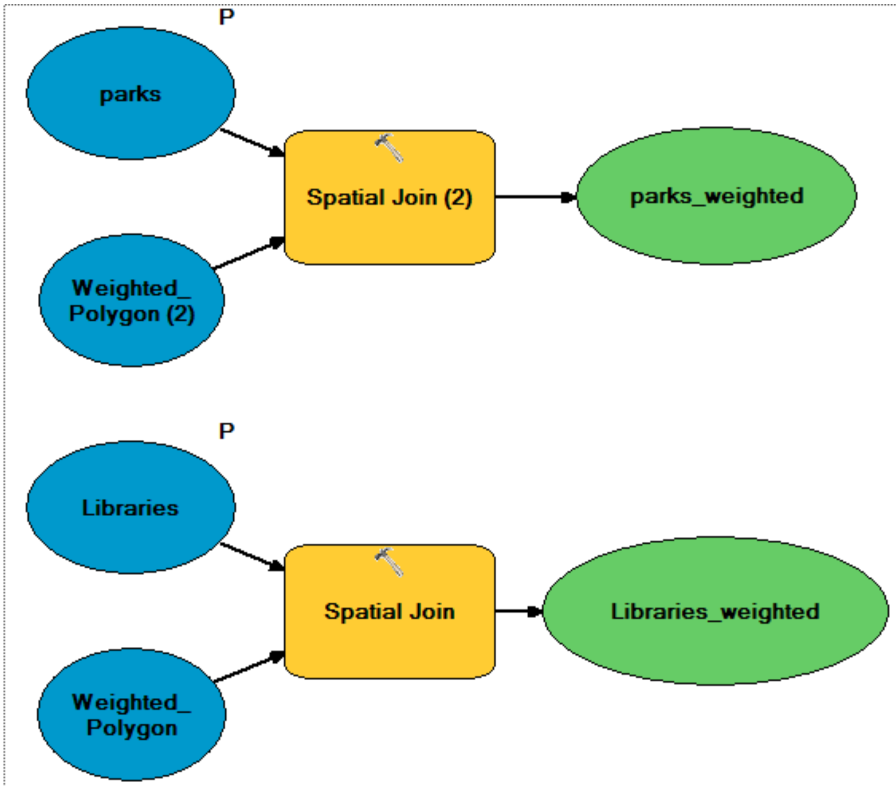


Figure 12 Add Weighted Scores to County Libraries and Parks within Census Tract in Modelbuilder

## 3.4 Workplace Charging

The U.S. Energy Department shows that for 78% of Americans, daily round-trips to and from work are less than 40 miles. Furthermore, if charging is available at the workplace, then the number shifts to 65% of people who charge at home, and 32% at work (Spross 2014). Earlier, local government offices were rated to be best location for pubic access charging. In this section, County government office data from DC fast charging section will be used for workplace analysis. At local government offices, EV charging stations carry out as public access charging points for the general public so as workplace charging points for the employees. Therefore, in this sub-section, all County offices are considered suitable unless there are existing EV charging stations. To locate County offices without a charging station, the two data layers of County offices and existing public EV charging stations were examined by “Intersect” tool by location in ArcGIS. No Modelbuilder was required to in this sub-section. The overlapping mechanism between these two data were further examined by checking the name and addresses of a location.

*3.4.1. Existing Public EV Charging Stations Data*

The addresses of current or existing EV charging stations can be geocoded into an ArcGIS shapefile for use in this analysis. Existing public EV charging stations data were downloaded from the Alternative Fuels Data Center official website. The Alternative Fuels Data Center (AFDC) is a resource of the U.S. Department of Energy’s Clean Cities program. The AFDC can provide current and existing public charging stations, including a subcategory for electric vehicles. Current public EV charging stations can be charging networks, government, or privately owned.

The original file format from ADFC was CSV, with 11,059 EV charging locations, and can be opened with Microsoft Excel. It contained records for all electric vehicle-charging stations in the U.S. Before importing the file to ArcGIS, it was sorted and narrowed down to charging stations in California. The file includes: general name, addresses with zip code, phone numbers, hours of operation, number of charging outlets, associated network, longitude/latitude, and types of charging (level 2 or fast charging). Addresses were geocoded on ArcGIS by longitude and latitude. By intercepting with the Los Angeles County boundary polygon, the charging stations within county boundaries were transferred to a new dataset. The final number of charging stations used in this study was 393.

# Chapter 4 Results

This chapter describes the results of the site suitability analysis conducted in the previous chapter, and how the final results were filtered by the initial goals and parameters in the County of Los Angeles. In addition to existing publicly accessible charging stations at Los Angeles County facilities, more EV charging stations should be installed for the public and County employees. In particular, this chapter delineates the type and location of charging stations that should be installed at public facilities in Los Angeles County. The first goal of this thesis project is to place DC fast charging stations at County government offices, public libraries, and public parks near major freeways. The second goal is to place Level 2 charging stations at public libraries and parks according to EV drivers' demographic features. The third goal is to place Level 2 charging stations at all County government offices where there are no existing EV charging stations.

## 4.1 DC Fast Charging Results

DC Fast Charging allows an 80% charge in as little as 30 minutes, and it serves the needs of interregional and intraregional travel while also supplying "safety net" charging opportunities for all types of drivers throughout a large geographic region (San Joaquin Valley Air Pollution Control District. 2014, 5). The type of electric vehicle. As explained in Chapter 2, DC fast charging stations direct current (DC) at 480-volt enables rapid charging at public stations, and the driving range for per hour charging is 50-70 miles, as outlined in Table 4. In this analysis, the locations for installing DC fast charging stations are based on the Los Angeles County government offices, public libraries, and public parks. Optimal locations of DC fast charging stations must be within one half mile of a highway. Also, the freeways crossing Los Angeles

County are used for analysis. There are total of 27 existing and major freeways used in this study.

In identifying optimal locations for installing DC fast charging stations, ArcGIS Modelbuilder was used and created two sequences for government offices, public libraries, and public parks. These two Modelbuilders run separately and each generate its own result. Modelbuilder is an application to create, edit, and manage models. Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as inputs. Executing a series of buffer and intersecting tools automatically generates the output or resulted features. The geoprocessing tools used were common in ArcGIS applications and they were executed and used to build a Modelbuilder.

In this sub-section, the freeway layer was first used to create a freeway buffer layer by applying ½ mile "buffer" tool. Then, the input layers of libraries and parks were geoprocessed by "intersecting" with the freeway buffer layer, and the resulted layers were County government office, libraries and parks which were within ½ mile buffer of the freeways. Even seeking optimal charging locations for County government offices, libraries and parks were executed in two separate Modelbuilders, the results of these optimal DC fast charging locations were shown in the same map (see in Figure 13). Red lines represent major freeways, and the names of County public parks and libraries selected as locations for DC fast charging stations; in the legend three different symbols were used to represent County government offices, public libraries and parks. The blue house symbols are the County government offices, the orange symbols are the County public libraries, and the green trees are the County public parks.

For County government offices, there are 18 offices identified as optimal locations to install DC fast charging stations, and the name of the government offices are listed in Table 5.

For County libraries, there are 10 libraries identified as optimal locations to install DC fast charging stations, and the results are described in Table 6, excluding one bookmobile location. For County parks, the initial results from ArcGIS included parks, golf courses, and other facilities that are maintained by Los Angeles County Department of Parks and Recreation. For this thesis research, only County parks are considered as locations to install DC fast charging stations, and in Table 7, the final results are selected by location name with “park.”

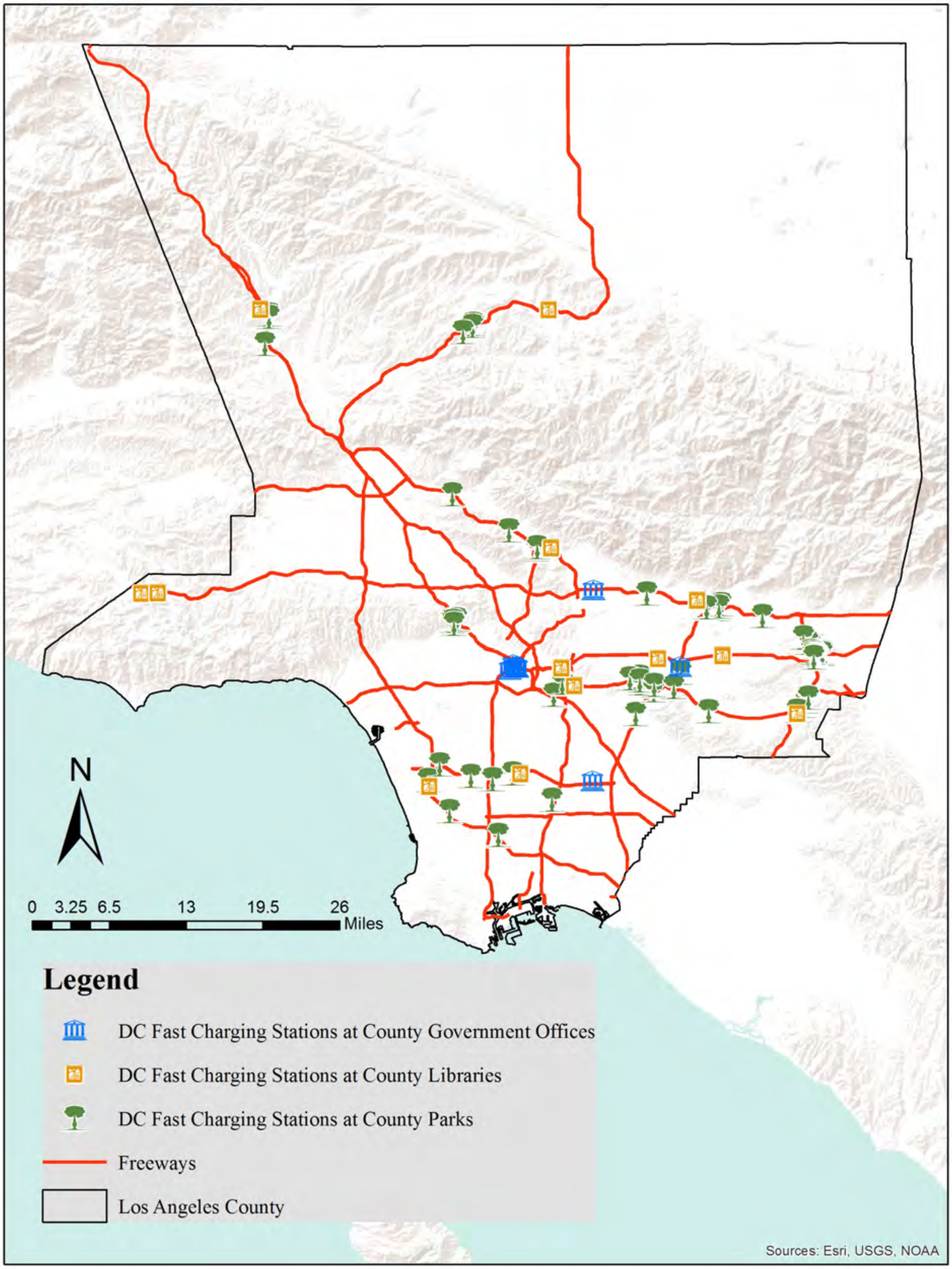


Figure 13 DC Fast Charging at Los Angeles County Libraries and Parks

Table 5 Selected Government Offices to Install DC Fast Charging Stations

| **Name** | **Address** | **City** | **State** | **Zip Code** |
|---|---|---|---|---|
| ISD - Service Planning Areas 3 And 4 | 241 N. Figueroa St. | Los Angeles | CA | 90012 |
| Los Angeles County Department Of Parks And Recreation - Regional Parks | 265 Cloverleaf Dr. | Baldwin Park | CA | 90706 |
| Los Angeles County Employees Retirement Services | 300 N. Lake Ave. | Pasadena | CA | 91101 |
| Los Angeles County Alternate Public Defender Office | 320 W. Temple St. | Los Angeles | CA | 90012 |
| Hall Of Records | 320 W. Temple St. | Los Angeles | CA | 90012 |
| Los Angeles County Chief Information Office | 350 S. Figueroa St. | Los Angeles | CA | 90071 |
| Civil Service Commission Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Claims: Damage, To Person Or Property, Against The County | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Commission For Children & Family Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Commission On Disability Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| County Administration | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Department of Human Resource | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Domestic Violence Council Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| EEC Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Los Angeles County Auditor-Controller Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Los Angeles County Treasurer-Tax Collector Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Uncashed Checks Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Los Angeles County Probation Department-Administration | 9150 E. Imperial Hwy | Downey | CA | 90242 |

Table 6 Selected Libraries to Install DC Fast Charging Stations

| Name | Address | City | State | Zip Code |
|---|---|---|---|---|
| Wiseburn Library | 5335 135th St. | Hawthorne | CA | 90250 |
| Willowbrook Library | 11838 Wilmington Ave. | Los Angeles | CA | 90059 |
| Diamond Bar Library | 21800 Copley Dr. | Diamond Bar | CA | 91765 |
| City Terrace Library | 4025 City Terrance Dr. | Los Angeles | CA | 90063 |
| El Monte Library | 3224 Tyler Ave. | El Monte | CA | 91731 |
| Duarte Library | 1301 Buena Vista St. | Duarte | CA | 91010 |
| Westlake Village Library | 31220 Oak Crest Dr. | Westlake Village | CA | 91361 |
| La Canada Flintridge Library | 4545 Oakwood Ave. | La Canada Flintridge | CA | 91011 |
| Acton Agua Dulce Library | 33792 Crown Valley Rd. | Acton | CA | 93510 |
| Castaic Library | 27971 Sloan Canyon Rd. | Castaic | CA | 91384 |

Table 7 Selected Parks to Install DC Fat Charging Stations

| Name | Address | City | State | Zip Code |
|---|---|---|---|---|
| Athens Park | 12603 S. Broadway Ave. | Los Angeles | CA | 90061 |
| Del Air Park | 12601 S. Isis Ave. | Hawthorne | CA | 90251 |
| East Rancho Dominguez Park | 15116 S. Atlantic Ave. | Compton | CA | 90221 |
| George Washington Carver Park | 1400 E. 118th St. | Los Angeles | CA | 90059 |
| Hasley Canyon Park | 28700 West Quincy St. | Castaic | CA | 91384 |
| Lenonx Park | 10828 S. Condon Ave. | Lennox | CA | 90304 |
| Ruben F. Salazar Park | 3864 Whittier Blvd. | Los Angeles | CA | 90023 |
| San Angelo Park | 245 S. San Angelo Ave. | La Puente | CA | 91746 |
| William Steinmetz Park | 1545 S. Stimson Ave. | Hacienda Heights | CA | 91745 |
| Crescenta Valley Park | 3901 Dunsmore Ave. | La Crescenta | CA | 91214 |
| Eugene A. Obregon Park | 4021 E. First St. | Los Angeles | CA | 90063 |
| Frank G. Bonelli Regional Park | 120 Via Verde Park Rd. | San Dimas | CA | 91773 |
| Amigo County Park | 5700 S. Juarez Ave. | Whittier | CA | 90606 |
| Dalton Park | 18857 E. Armstead St. | Azusa | CA | 91702 |
| Highland Camrose Park | 2101 N. Highland Ave. | Los Angeles | CA | 90068 |
| Walnut Creek Community Regional Park | 1100 Valley Center Ave. | San Dimas | CA | 91773 |

## 4.2 Public Access Charging, Level 2

This section details how county libraries and parks were selected to install Level 2 charging stations. Charging time at Level 2 charging stations can be as long as 3-4 hours, where people typically park longer than the wait time for a DC fast charging station. Again, the data from National Household Travel Survey suggested the best location for public access charging including libraries and parks (San Joaquin Valley Air Pollution Control District. 2014, 13). For this thesis, only county libraries and parks data were studied because Los Angeles County has direct access to install EV charging stations at these locations where the County of Los Angeles have direct jurisdiction to modify and to install electric vehicle charging equipment. These public access charging locations are designed to offer immediate service to the neighboring communities.

In considering this, the demographic features of electric vehicle drivers were used to perform a site suitability analysis. Given the survey results from the Clean Vehicle Rebate Project (CRVP), the majority of the EV drivers are middle-aged, have a bachelor's degree or higher, and have relative high household incomes. These features are used as variables with which to analyze 2010 U.S. Census tract in Los Angeles County. They represent the current EV owners, and can also be used to predict future EV drivers in an area.

In this section, Modelbuilder tools are created to perform site suitability analysis in determining optimal locations for Level 2 charging stations at public libraries and parks. To ensure the successful running of the Modelbuilder, the Modelbuilders used in this study are created as the first and second part. The resulting layer of the first part is used in the second part of the Modelbuilder. The first part can also be considered as data preparation for selecting the demographic features needed in each Los Angeles County census tract. In the second part, weighted census tract data was geoprocessed with public libraries and parks in order to determine the libraries and parks with high weighted scores. Two Modelbuilder files were created separately for layers of libraries and parks.

In the first Modelbuilder, the “age” layer was people count who are in the age of 35-64 within a census tract; the “education” layer was also people county who held with bachelor or graduate degrees within a census tract; and the “income” layer was the average household income per census tract. In the analysis process, demographic variables of age, education, and income were scored from 1-5 in the 2010 U.S. Census tract data. Then, the scored variables equally representing 33.33% influencing factor contributed to a weighted scoring of 1-5. The low score was 1, and the high score was 5. Each census tract was then labeled with a weighted score of 1-5. In Figure 13, the weighted polygon from light purple to dark purple represents a census tract with a weighted score from 1 to 5. Accordingly, the County libraries and parks are scored depending on where they are located by the census tract, and then selected by the high weighted score. In Figure 13, one library with a weighted score of 5 is selected, four libraries have weighted scores of 4, and thirty-three libraries have weighted scores of 3. By excluding bookmobile services, thirty libraries are selected as locations to install Level 2 Charging stations for public access charging. The final result is specified in Table 7.

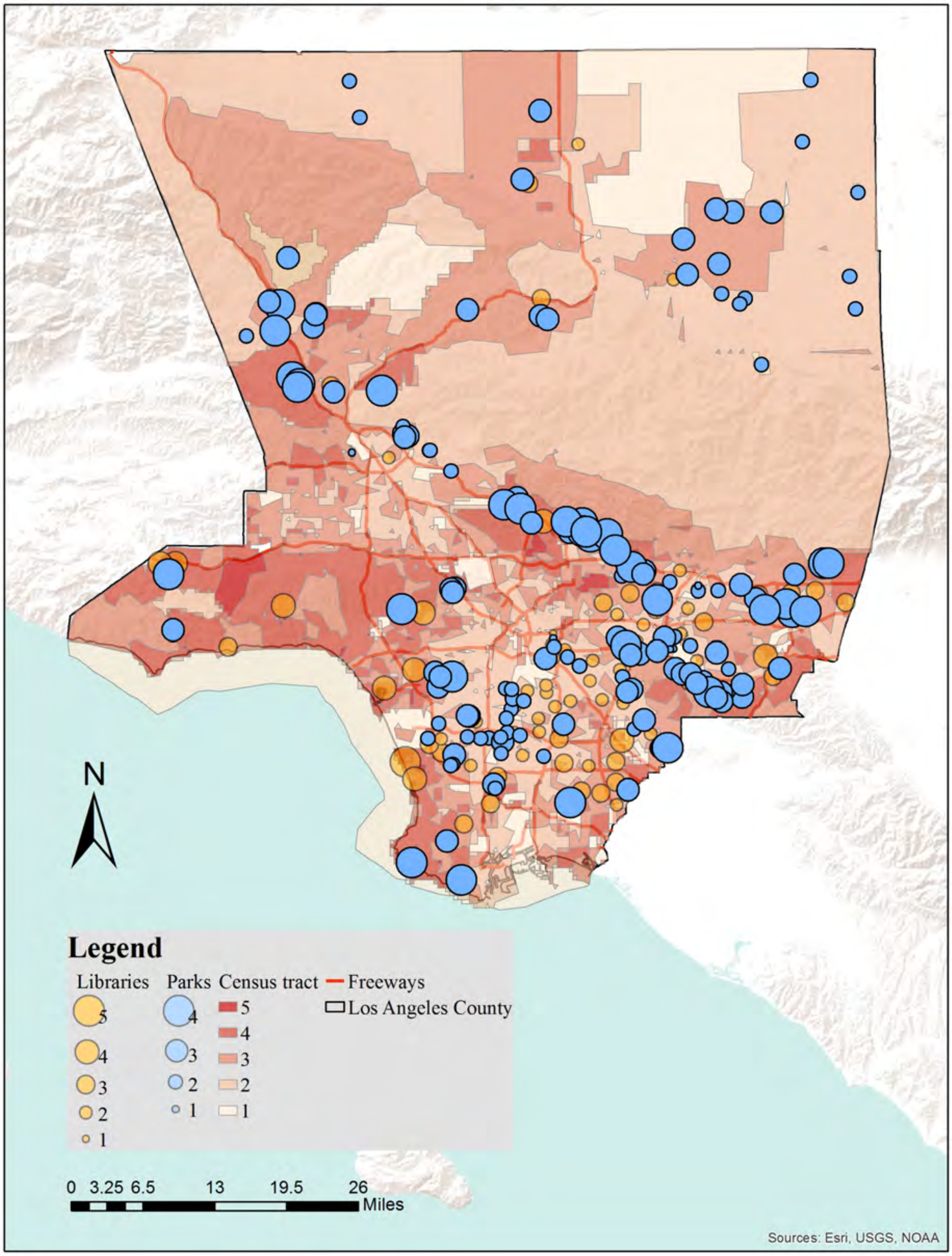


Figure 14 Identified Los Angeles County Libraries and Parks to Install Level 2 Charging Stations for Public Access in GIS Application

Table 8 Selected Libraries to Install Level 2 Charging Stations for Public Access

| **Weighted Score** | **Library Name** |
|---|---|
| 5 | Manhattan Beach Library |
| 4 | Agoura Hills Library |
| | Culver City Julian Dixon Library |
| | Hermosa Beach Library |
| | La Canada Flintridge Library |
| | Lloyd Taber-Marina Del Rey Library |
| | Norwalk Regional Library |
| | Walnut Library |
| | West Hollywood Library |
| | Westlake Village Library |
| | Steven Son Ranch Express Library |
| | Topanga Library |
| 3 | Acton Agua Dulce Library |
| | Alondra Library |
| | Angelo M. Lacoboni Library |
| | Caron Regional Library |
| | Castaic Library |
| | Charter Oak Library |
| | Claremont Library |
| | Claremont Library |
| | Diamond Bar Library |
| | Dr. Martin Luther King, Jr. Library |
| | George Nye, Jr. Library |
| | Hacienda Heights Library |
| | Hollydale Library |
| | La Crescenta Library |
| | La Mirada Library |
| | La Verne Library |
| | Lawndale Library |
| | Live Oak Library |
| | Lomita Library |
| | Malibu Library |
| | Norwood Library |
| | Paramount Library |
| | Quartz Hill Library |
| | San Dimas Library |
| | Sorensen Library |
| | Temple City Library |
| | View Park Library |
| | West Covina Library |
| | Wiseburn Library |
| | Artesia Library |

Also, in Figure 12, County parks are selected according to the weighted score of their locations within a census tract. The GIS application results in 32 parks with weighted scores of 4, 66 parks with weighted scores of 3, 49 parks with weighted scores of 2, and 5 parks with weighted scores of 1. A similar approach for searching among County public libraries was applied to public parks in this section. In Table 9, the final result of 17 selected parks with weighted scores of 4 is listed, excluding sports complexes, golf courses sanctuaries, and other natural areas managed by the Department of Regional Parks and Recreations. No parks with weighted scores of 5 are identified.

Table 9 Selected Parks to Install Level 2 Charging Stations for Public Access

| **Weighted Score** | **Park Name** |
| --- | --- |
| 4 | Crescenta Valley Park |
| | Deane Dana Friendship Park |
| | Dr. Richard H Rioux Memorial Park |
| | Farnsworth Park |
| | Frank G Bonelli Regional Park |
| | Ganesha Park |
| | Hasley Canyon Park |
| | Jake Kuredjian Park |
| | Loma Alta Park |
| | Marshall Canyon Park |
| | Monteith Park |
| | Monument Park |
| | Peck Road Water Conservation Park |
| | Peter F Schabarum Regional County Park |
| | Pickens Canyon Park |
| | Pico Canyon County Park |
| | Walnut Creek County Park |

## 4.3 Workplace Charging, Level 2

In this section, the goal is to locate Los Angeles County government offices or locations to install Level 2 charging stations, without existing EV charging stations on site. According to the Electric Power Research Institute, the workplace is the second-most frequented location for charging, following the home. Workplace charging also serves as an alternative for EV drivers who may not have available residential charging. (San Joaquin Valley Air Pollution Control District 2014, 39). All County government offices or locations are considered as potential locations to install Level 2 charging stations. Charging stations at these government offices can serve both office employees and the visitors upon individual availability. By checking with existing public charging stations data from U.S. Department of Energy, only one location – LA County Probation Department, located at 9150 E. Imperial Hwy. Downey, CA 90242 – has already installed EV charging equipment. Figure 13 indicates the 393 public EV charging stations, shown in dots as EVLAC.

Table 10 lists the final result of installing Level 2 charging stations at Los Angeles County government facilities. For the addresses bolded in dark rectangles, they are County Departmental offices in the same building, sharing different floors or units. These can be grouped as one location. For this section, the major limitation is the availability of accurate and current data.

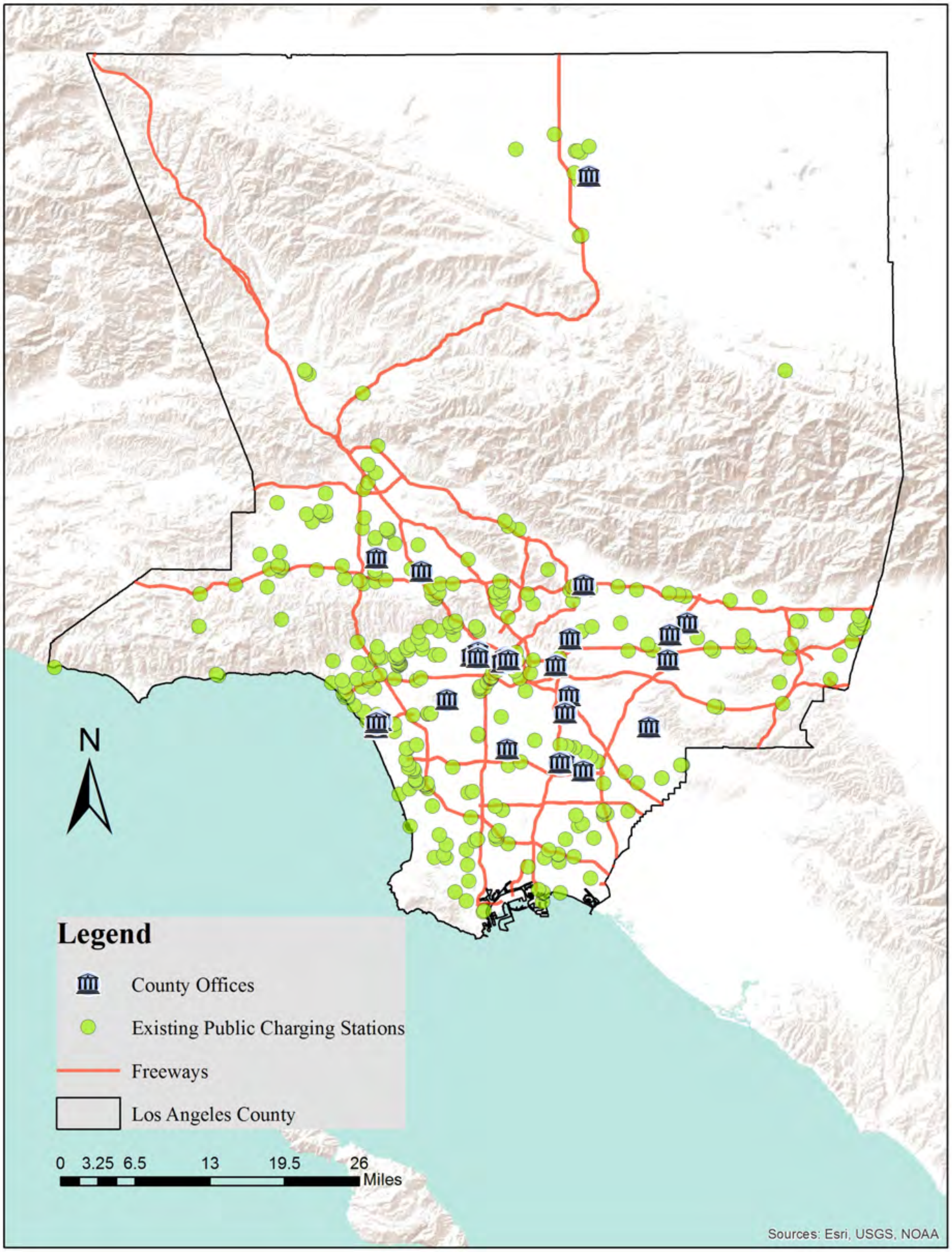


Figure 15 Los Angeles County Offices to Install Level 2 Charging Station

Table 10 Los Angeles County Offices
Table continued to the next page

| **Name** | **Address** | **City** | **State** | **Zip Code** |
|---|---|---|---|---|
| Fraud Hotline | 1000 S. Fremont Ave. | Alhambra | CA | 91803 |
| County Procurement & Contracts | 1100 N. Eastern Ave. | Los Angeles | CA | 90063 |
| Small Business Assistance Main Office | 1100 N. Eastern Ave. | Los Angeles | CA | 90063 |
| Department of Agricultural Commissioner/Weights and Measures South Gate Office | 11012 Garfield Ave | South Gate | CA | 90280 |
| Department of Agricultural Commissioner/Weights and Measures Headquarters | 12300 Lower Azusa Rd | Arcadia | CA | 91006 |
| Anchorage 47 (Santa Monica Windjammers Yacht Club) | 13575 Mindanao Way | Marina del Rey | CA | 90292 |
| Burton Chace Park | 13650 Mindanao Way | Marina del Rey | CA | 90292 |
| Los Angeles County Department Of Beaches And Harbors | 13837 Fiji Way | Marina del Rey | CA | 90292 |
| Service Planning Areas 5 And 6 | 1522 E. 102nd St. | Los Angeles | CA | 90002 |
| Service Planning Areas 3 And 4 | 241 N. Figueroa St. | Los Angeles | CA | 90012 |
| LA County DPW Waterworks - North Maintenance Office | 260 E. Avenue K-8 | Lancaster | CA | 93535 |
| Los Angeles County Department Of Parks And Recreation - Regional Parks | 265 Cloverleaf Dr. | Baldwin Park | CA | 90706 |
| County Employees Retirement Services | 300 N. Lake Ave. | Pasadena | CA | 91101 |
| Human Relations Commission Main Office | 3175 W. Sixth St. | Los Angeles | CA | 90020 |
| Alternate Public Defender (APD) Main Office | 320 W. Temple St. | Los Angeles | CA | 90012 |
| Hall Of Records | 320 W. Temple St. | Los Angeles | CA | 90012 |
| Department of Agricultural Commissioner/Weights and Measures Antelope Valley Office | 337 E Ave K10 | Lancaster | CA | 93535 |
| LA County Chief Information Office (CIO) | 350 S. Figueroa St. | Los Angeles | CA | 90071 |
| Immunizations | 3530 Wilshire Blvd. | Los Angeles | CA | 90010 |
| SA 6 Advisory Committee (SAAC) West Central Mental Health | 3751 Stocker St. | Los Angeles | CA | 90008 |

| | | | | |
|---|---|---|---|---|
| LA County Parks And Recreation Department - Headquarters | 433 S. Vermont Ave. | Los Angeles | CA | 90020 |
| Marina Del Rey Visitors Information Center | 4701 Admiralty Way | Marina del Rey | CA | 90292 |
| Civil Service Commission Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Claims: Damage, To Person Or Property, Against The County | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Commission For Children & Family Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Commission On Disability Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| County Administration | 500 W. Temple St. | Los Angeles | CA | 90012 |
| DHR Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Domestic Violence Council Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| EEC Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| LA County Auditor-Controller Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Treasurer-Tax Collector Main Office | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Uncashed Checks | 500 W. Temple St. | Los Angeles | CA | 90012 |
| Housing Inspection Program Headquarters | 5050 Commerce Dr. | Baldwin Park | CA | 91706 |
| Service Planning Areas 1 And 2 | 5300 Tujunga Ave. | North Hollywood | CA | 91601 |
| Emergency Medical Services Agency | 5555 Ferguson Dr. | Commerce | CA | 90022 |
| Missing Persons | 5747 Rickenbacker Rd. | Commerce | CA | 90040 |
| Van Nuys Civic Center | 6262 Van Nuys Blvd | Los Angeles | CA | 91401 |
| African/African-American Subcommittee | 695 S. Vermont Ave | Los Angeles | CA | 90005 |
| Hearing Officer Program | 7500 E. Imperial Hwy. | Downey | CA | 90242 |
| Service Planning Areas 7 And 8 | 7643 Painter Ave. | Whittier | CA | 90602 |

# Chapter 5 Discussion and Conclusion

The main goal of this thesis research was to identify optimal locations throughout Los Angeles County to install EV charging stations. This study analyzed the demographic features of existing electric vehicles drivers, and used these data to predict where current and future EV drivers will publicly charge their vehicles. While the initial goal was broad, this research clarified where and what types of EV charging stations should be installed, and also discussed the intended uses of this equipment, as well as who would benefit from installing charging devices. The remainder of this chapter discusses key observations of this thesis and the valuable outputs to the decision-makers in Los Angeles County government; this chapter also presents similarities and contrasts to recent EV charging infrastructure researches; and the chapter explores possibilities and suggestions to future research in this field.

## 5.1 Key Observations

At the onset of this research, the goal was simply to locate where to install more EV charging stations on Los Angeles County premises, that is, owned or rented properties where the County has direct jurisdiction to modify or install equipment. The trend of having electric vehicles is fairly new, and research on installing electric vehicles remains in its infancy. This research contributes to the literature by conducting a site suitability analysis to scientifically analyze existing data through ArcGIS tools. The ArcGIS tools used in this thesis were to identify places by location to major freeways, to add a weighted score by inferring demographic data, and to filter places with no exiting EV charging stations. Identifying public libraries and parks to install DC fast charging stations within ½ mile of the major freeways enables people to travel freely from one end to another end of Los Angeles County, and a network of DC fast charging stations along the freeways offers ease of commute in an interregional and an intraregional area.

Identifying Level 2 charging stations at public libraries and parks was to aim neighborhoods with designated demographic features, like middle-aged, advanced education, and median or above household income. Workplace charging was to offer charging opportunities to the employees and the visitors.

As expected, the results of this research provide recommended locations for public charging stations in the County of Los Angeles. Installing more charging stations by the County of Los Angeles would demonstrate how a local government entity follows Federal and State's advocacy for green energy and a clean environment. Having more EV charging stations will not only benefit existing EV drivers, but also will increase the benefits of driving electric vehicles for the densely-populated Los Angeles County. Currently, there are 31 public charging stations located in Los Angeles County premises, such as sheriff stations, concert halls, and departmental offices. These charging stations do not provide enough EV charging stations for the increasing number of EV drivers.

The ultimate goal of this research is to locate optimal new EV charging stations in order to maximize usage of these devices in Los Angeles County. This research study demonstrated how a large entity with multiple geographic locations could help increase the network of people accessing charging stations. A similar study was completed in another County in California and together with this study, it can provide valuable data for decision-makers. The selected public libraries, parks, and government offices offer a forward step in planning where to install charging stations. At the same time, each location still needs further assessment in order to determine the number of parking spaces that should be designated as an EV charging space.

## 5.2 Contrasts to Prior Studies

The analysis and results of this research offered several approaches of how to conduct site suitability analysis in searching optimal EV charging stations. In this thesis, a site suitability analysis was investigated in three subsections: to locate where to install DC fast charging and Level 2 charging stations at public place and to locate where to install Level 2 charging stations at workplaces. These subsections can be viewed and explored individually as well collaborating them into one expansive method. The various approaches researched in this thesis involved where and how Los Angeles County may better support installing EV charging stations at the municipal level where a large government has multiple departmental offices and branches. This study also offers Los Angeles County solutions where to install more EV charging stations and depicts actual locations via applicable GIS tools, whereas the current County charging stations are sparkly distributed at occasional Los Angeles County government offices. This also improves from previous analysis by Balmin et al (2012) and DeShazo et al (2012) that considers two types of commercial charging stations.

In contrasts to the two studies conducted by UCLA Luskin School Balmin et al (2012) and DeShazo et al (2012), this thesis first examined different types of DC fast charging stations and suggested where to install them in Los Angeles County. In DeShazo et al (2012), the authors reviewed the needs of EV charging infrastructure, travel patterns of EV drivers, challenges of creating charging opportunities at residences, workplaces, and retail centers, and the soft and hard costs of charging equipment installation. They suggested to install more charging stations at workplaces and publicly accessible sites for people lived in places without immediate home charging options. They also listed the number of employees and compared the percentage of people live in single family units and multi-unit dwellings. Even the DeShazo (2012) study pointed out the benefits of having EV charging stations at public-sector sites, their study didn't research or suggest where to install charging stations at either workplace or publicly accessible locations.

The Balmin et al (2012) study in Los Angeles area rather discussed barriers existed for building EV charging stations in multi-unit dwellings (MUD), but it did not perform a site suitability analysis on choosing a single EV charging site. In their study, the charging equipment considered for MUDs were either Level 1 and Level 2 charging, because DC fast charging require much larger power supply and installation cost and they are less likely to widespread in residential building (Balmin et al 2012, 10). The goal of Balmin et al (2012) study was to identify barriers, evaluate existing policies supporting home EV charging installations, and recommend policy options to address challenges to charging in MUDs in the city of Los Angeles (Balmin et al 2012, 1). The two EV studies by Balmin et al (2012) and DeShazo et al (2012) described out the foundation of learning about the new technology of electric vehicles and recognizing the barriers against how to widespread the charging possibilities at the time when they conducted the study. Their main concerns were how to install more charging stations at home, and this thesis focused on public facilities like libraries, parks and workplaces. As times progress and the need of public charging station increases, this thesis research offers a solution to a current public interest.

## 5.3 Future Research

This research successfully clarified two types of commercial EV charging equipment and identified optimal locations throughout the County of Los Angeles at public libraries, public parks and county government offices. While this study determined optimal site locations by considering demographic features of current EV drivers, such as age, education, and income, future research should incorporate other categories of public facilities owned by the County of Los Angeles. The goal of a site suitability analysis is to identify ideal locations publicly accessible equipment in order to increase its public use. The more variables a study can integrate, the more the results can be inclusive and can better represent the initial goals.

In the first and second sections explained earlier in the Methodology in Chapter 3, the public access charging stations selected only included Los Angeles County-owned public libraries and parks. These two locations were selected based on the findings from the National Household Travel Survey used in the San Joaquin Valley study. The San Joaquin Valley study listed a total of 20 optimal locations to install public accessing charging stations (San Joaquin Valley Air Pollution Control District 2014). They were chosen based on the average length of time a vehicle would park. Thus, future studies should perhaps also incorporate foot traffic at a given location, and the average time people leave their vehicles parked.

The goal of the third section of this research was to advocate for installing EV charging stations for Los Angeles County government employees, as well as visitors. For future study, the geographic context of workplace analysis can be enhanced by including other government facilities managed by the County of Los Angeles, like beaches and harbors, gardens and arboretum, museums and music center, and etc. At these locations, even the number of employees are scarce comparing with to the employees in regular Departmental buildings, the neighbors and visitors in the area can inevitably take advantage of the electric vehicle charging equipment.

Depending on locations and requirements of government facilities, parking lots are divided into two sections: one is gated for employees only, and other is for both employees and visitors. If such detailed information is available as GIS data, government locations could more specifically consider where to install charging stations in gated parking lots. As suggested, visitor traffic volume of a government office can also provide information as to whether a particular location is an optimal EV charging place. The limitations in this section were multiple agencies located within one building sharing same street address, and the parking lot might not be exclusive to one agency.

The building requirements of installing EV charging stations involves how to choose in one park space out of an entire parking lot, how to obtain building permits, and how to follow specific parking guidelines. These building requirements are excluded from this study. However, if specific data of a location like square feet or electric network is available, these data can be incorporated into ArcGIS processing on future researches. According to building codes of plug-in electric vehicle charging, new commercial, industrial and other uses buildings shall provide 2% of parking lot with EV charging equipment. New commercial development shall provide for electric vehicle charging stations. For instances, office buildings or office parks that employ more than 1,000 persons or contain more than 250,000 square feet of gross floor area; and new hopping centers or trade centers that employ 1,000 or more persons or contain 500,000 square feet of gross floor area (Governor’s Office of Planning and Research 2015). Future studies of conducting site suitability analysis on charging stations can be enhanced with additional detailed datasets.

# REFERENCES


Alternative Fuels Data Center. 2015. “Developing Infrastructure to Charge Plug-In Electric Vehicles.” Accessed June 21, 2015. http://www.afdc.energy.gov/fuels/electricity_infrastructure.html

Bailey, Joseph, Amy Miele, and John Axsen. 2015. "Is awareness of public charging associated with consumer interest in plug-in electric vehicles?" *Transportation Research Part D: Transport and Environment* 36 (2015): 1-9.

Balmin, Judith, Greg Bonett and Mega Kirkeby. 2015. “Increasing Electric Vehicle Charging Access in Multi-Unit Dwellings in Los Angeles.” Accessed September 21, 2015. http://luskin.ucla.edu/sites/default/files/EV%20Charging%20in%20LA%20MUDs.pdf

Berman, Brad. 2014. 2015. “Quick Charging of Electric Cars.” Plug-in Cars. September 03. Accessed on December 4, 2015. http://www.plugincars.com/electric-car-quick-charging-guide.html

Beverly Hills Community Development. 2015. “Electric Vehicle Charging Station.” Accessed September 20, 2015. http://www.beverlyhills.org/business/constructionlanduse/commercialbuildings/electricvehiclecharging/

California Green Building Standards Code. 2014. “Chapter 3 – Green Buildings” Accessed on September 1, 2015. http://www.ecodes.biz/ecodes_support/free_resources/2013California/13Green/PDFs/Chapter%203%20-%20Green%20Building.pdf

California Green Building Standards Code. 2014. “Chapter 5 – Nonresidential Mandatory Measures” Accessed on September 1, 2015. http://www.ecodes.biz/ecodes_support/free_resources/2013California/13Green/PDFs/Chapter%205%20-%20Nonresidential%20Mandatory%20Measures.pdf

California Legislative Information. 2013. “AB-1092 Building Standards: Electric Vehicle Charging Infrastructure” Accessed on September 20, 2015. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1092

California Legislative Information. 2013. “AB-266 Vehicles: High-occupancy Vehicle Lanes.” Accessed on September 20, 2015. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB266

California Legislative Information. 2013. “SB-286 Vehicle: High-Occupancy Vehicles Lanes.” Accessed on September 20, 2015. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB286

California Legislative Information. 2013. “SB-359 Vehicles: Retirement and Replacement.” Accessed on September 20, 2015. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB359

California Plug-in Electric Vehicle Collaborative. 2012. “Accessibility and Signage for Plug-in Electric Vehicle Charging Infrastructure.” Accessed on September 21, 2015. http://www.pevcollaborative.org/sites/all/themes/pev/files/PEV_Accessibility_120827.pdf

Carver, Stephen J. 1991. “Integrating multi-criteria evaluation with geographical information systems” *International Journal of Geographical Information Systems*, 5:3, 321-339, DOI: 10.1080/02693799108927858

Center for Sustainable Energy, 2015. “EV Consumer Survey Dashboard.” Accessed June 26, 2015. http://energycenter.org/clean-vehicle-rebate-project/survey-dashboard

ChargePoint. 2013. “ChargePoint Releases List of Top 10 Cities for Electric Vehicles.” Accessed June 20, 2015. http://www.chargepoint.com/press-releases/2013/1024

ChargePoint. 2015. “ChargePoint Announces the Nation’s Top 10 Cities for Electric Vehicles.” Accessed June 20, 2015. http://www.chargepoint.com/press-releases/2015/0302

County of Los Angeles. 2015. “Garden.” Accessed June 20, 2015. https://www.lacounty.gov/things-to-do/parks-and-recreation/gardens

County of Los Angeles. 2015. “Parks and Recreation.” Accessed June 20, 2015. https://www.lacounty.gov/things-to-do/parks-and-recreation

County of Los Angeles. 2015. “Libraries & Museums.” Accessed June 20, 2015. https://www.lacounty.gov/things-to-do/libraries-museums

County of Sonoma. 2011. “Electric Vehicle Charging Station Program and Installation Guidelines.” Accessed September 21, 2015. http://www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf

Dawod, Gomaa M. 2013. "Suitability analysis for tourist infrastructures utilizing multi-criteria GIS: A case study in Al-Hada city, Saudi Arabia." *International Journal of Geomatics and Geosciences* 4, no. 2 (2013): 313-324.

DeShazo, J.R., Ayala Ben-Yehuda, Norman Wong, Susan Woodward, Will Sherwood, Vicky Hsu, Patricia Kwon, Benjamin Nguyen, Jon Overman, Tamar Saksian, Michael Sin, Alex Turek, Brett Williams, and Christian Zarate. 2012. “Southern California Plug-in Electric Vehicle Readiness Plan.” Southern California Association of Governments. UCLA Luskin School of Public Affairs. https://www.scag.ca.gov/Documents/SCAGSouthern%20CA%20PEV%20Readiness%20Plan.pdf

Efthymiou, Dimitrios, Constantinos Antoniou, Yannis Tyrinopoylos, and Evangelos Mitsakis. 2012. "Spatial Exploration of Effective electric vehicle infrastructure location." *Procedia-Social and Behavioral Sciences* 48 (2012): 765-774.

Esri. 2011. "Hot-Spot Analysis Identifies Potential WIC Recipients." Accessed July 30, 2015. http://www.esri.com/news/releases/11-3qtr/hotspot-analysis-identifies-potential-wic-recipients.html

Frade, Inês, Anabela Ribeiro, Gonçalo Gonçalves, and António Pais Antunes. 2011 "Optimal Location of Charging Stations for Electric Vehicles in a Neighborhood in Lisbon, Portugal." *Transportation Research Record: Journal of the Transportation Research Board, No. 2252*, Transportation Research Board of the National Academies, Washington, D.C., 2011, pp. 91–98. DOI: 10.3141/2252-12

Fuel Economy. 2015. "All-Electric Vehicles." Accessed June 21, 2015. http://www.fueleconomy.gov/feg/evtech.shtml

Fuel Economy. 2015. "Federal Tax Credits for Electric Vehicles Purchased in or after 2010." Accessed June 21, 2015. http://www.fueleconomy.gov/feg/taxevb.shtml

Fuel Economy. 2015. "How Hybrids Work." Accessed June 21, 2015. http://www.fueleconomy.gov/feg/hybridtech.shtml

Ge, Shaoyun, Liang Feng, and Hong Liu. 2011. "The planning of electric vehicle charging station based on grid partition method." In *Electrical and Control Engineering (ICECE), 2011 International Conference on*, pp. 2726-2730. IEEE, 2011. DOI: 10.1109/ICECENG.2011.6057636

Governor's Office of Planning and Research. 2015. "Example Building Codes for Plug-In Electric Vehicle Charging." State of California. Accessed on Dec 17. http://webcache.googleusercontent.com/search?q=cache:jGTjTVdUpRkJ:https://www.opr.ca.gov/docs/Example_Building_Codes.docx+&cd=1&hl=en&ct=clnk&gl=us&client=safari

Hawkins, Troy R., Bhawna Singh, Guillaume Majeau-Bettez, and Anders Hammer Strømman. 2013. "Comparative environmental life cycle assessment of conventional and electric vehicles." *Journal of Industrial Ecology* 17 (1): 53-64.

He, Fang, Di Wu, Yafeng Yin, and Yongpei Guan. 2013. "Optimal deployment of public charging stations for plug-in hybrid electric vehicles." *Transportation Research Part B: Methodological* 47 (2013): 87-101.

International Energy Agency. 2015. "Hybrid Electric Vehicles." Accessed on Dec 12. http://www.ieahev.org/about-the-technologies/hybrid-electric-vehicles/

Lavring, Damon. 2013. "California's Sustainable Transport Incentives Leave Other States in the Stone Age." *Wired.* October 10. Accessed September 20, 2015. http://www.wired.com/2013/10/california-bills-ev-ready/

Los Angeles County Economic Development Corporation. 2015. “Getting EV Ready in Los Angeles County.” Accessed July 10, 2015. http://laedc.org/2013/03/08/getting-ev-ready-in-los-angeles-county/

LA County Electric Vehicle Charging Stations. 2015. “LA County Electric Vehicle Charging Stations Made with Google My Maps.” Accessed July 10, 2015. https://www.google.com/maps/d/u/1/viewer?authuser=1&mid=zy7nG5Nxlu1U.keADwzmJ6zsY

McKenzie, Brian. 2015. “Who Drives to Work? Commuting by Automobile in the United States: 2013.” *American Community Survey Reports*, August 2015. https://www.census.gov/hhes/commuting/files/2014/acs-32.pdf

Melaina, Marc, and Joel Bremson. "Refueling availability for alternative fuel vehicle markets: sufficient urban station coverage." *Energy Policy* 36, no. 8 (2008): 3233-3241.

Mu, Yunfei, Jianzhong Wu, Nick Jenkins, Hongjie Jia, and Chengshan Wang. "A Spatial–Temporal model for grid impact analysis of plug-in electric vehicles." *Applied Energy* 114 (2014): 456-465.

Namdeo, A., A. Tiwary, and R. Dziurla. "Spatial planning of public charging points using multi-dimensional analysis of early adopters of electric vehicles for a city region." *Technological Forecasting and Social Change* 89 (2014): 188-200.

National Renewable Energy Laboratory. 2014. “California Statewide Plug-in Electric Vehicle Infrastructure Assessment.” Assessed on September 21, 2015 http://www.energy.ca.gov/2014publications/CEC-600-2014-003/CEC-600-2014-003.pdf

Nie, Yu Marco, and Mehrnaz Ghamami. "A corridor-centric approach to planning electric vehicle charging infrastructure." *Transportation Research Part B: Methodological* 57 (2013): 172-190.

Oxford Dictionaries. 2015. “Range Anxiety.” Accessed July 10, 2015. http://www.oxforddictionaries.com/us/definition/american_english/range-anxiety

Peterson, Scott B., and Jeremy J. Michalek. 2013. “Cost-effectiveness of plug-in hybrid electric vehicle battery capacity and charging infrastructure investment for reducing US gasoline consumption.” *Energy Policy* 52: 429-38.

PEV Collaborative. 2011. “Ready Set Charge California.” Accessed July 10, 2015. http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/ReadySetCharge_EVGuidelines.pdf

Plug-in Electric Vehicle Resource Center. 2015. “Battery Electric Vehicles.” Accessed on Dec 12. http://driveclean.ca.gov/pev/Plug-in_Electric_Vehicles/BEVs.php

Plug-in Electric Vehicle Resource Center. 2015. “PEV Types.” Accessed on Dec 12. http://driveclean.ca.gov/pev/Plug-in_Electric_Vehicles/PEV_Types.php

Richtel, Matt. 2015. "In California, Electric Cars Outpace Plugs, Sparks Fly." *New York Times*, October 10. Accessed October 30, 2015. http://www.nytimes.com/2015/10/11/science/in-california-electric-cars-outpace-plugs-and-sparks-fly.html?_r=0

San Diego. 2012. "San Diego Regional Plug-in Electric Vehicle (PEV) Readiness Plan." Accessed September 21, 2015 https://energycenter.org/sites/default/files/docs/nav/programs/pev-planning/san-diego/Agenda%20Item%207A-DRAFT%20-%20SD%20PEV%20Readiness%20Plan%20Appendices_small.pdf

San Joaquin Valley Air Pollution Control District. 2014. "Charging Roadmap: Siting optimal Locations for Public Charging Stations in the San Joaquin Valley." Modified May. https://energycenter.org/sites/default/files/docs/nav/programs/pev-planning/san-joaquin/san_joaquin_valley_siting_analysis-web.pdf

Supervisor Mark Ridley-Thomas. 2014. "EV Charging Stations Available to Residents." Accessed June 20, 2015. http://ridley-thomas.lacounty.gov/index.php/ev-stations/

Schaal, Eric. 2015. "Why Los Angeles is the Perfect Place for Electric Vehicles." Autos Cheat Sheet. August 27. Accessed on December 7, 2015. http://www.cheatsheet.com/automobiles/why-los-angeles-is-the-perfect-place-for-electric-vehicles.html/?a=viewall

Schaal, Eric. 2015. "10 Electric Vehicles with the Best Range in 2015." Autos Cheat Sheet. September 27. Accessed on October 30, 2015. http://www.cheatsheet.com/automobiles/top-10-electric-vehicles-with-the-longest-driving-range.html/?a=viewall

Spross Jeff. 2014. "How Some Simple Changes to Building Codes Could Revolutionize the Electric Car Market." *Climate Progress*. May 7. Accessed September 20.2015. http://thinkprogress.org/climate/2014/05/07/3435439/ev-outlets-building-codes/

Sweda, Timothy, and Diego Klabjan. "An agent-based decision support system for electric vehicle charging infrastructure deployment." In *Vehicle Power and Propulsion Conference (VPPC), 2011 IEEE*, pp. 1-5. IEEE, 2011.

UCLA Luskin School of Public Affairs. 2013. "South Bay Cities Plug-in Electric Vehicle Deployment Plan." Accessed September 21, 2015. http://www.scag.ca.gov/Documents/SCAG_UCLA_Luskin-SBCOG%20PEV%20Deployment%20Plan%20Final.pdf

U.S. Census Bureau. 2015. "Los Angeles County, California Quick Links." Last Revised Oct 14. Accessed on October 30, 2015. http://quickfacts.census.gov/qfd/states/06/06037.html

U.S. Department of Energy. 2012 "54.5 MPG and Beyond: Fueling Energy-Efficient Vehicles." Accessed June 19, 2015. http://www.energy.gov/articles/545-mpg-and-beyond-fueling-energy-efficient-vehicles

U.S. Department of Energy. 2012 "The History of the Electric Car." Accessed June 19, 2015. http://www.energy.gov/articles/history-electric-car

U.S. Department of Energy. 2012 "Top 10 Things You Didn't Know About Electric Vehicles." Accessed June 19, 2015. http://www.energy.gov/articles/top-10-things-you-didn-t-know-about-electric-vehicles

Xu, Kun, Ping Yi, and Yudhveer Kandukuri. 2013. "Location Selection of Charging Stations for Battery Electric Vehicles in an Urban Area." *International Journal of Engineering Research and Science & Technology* 2 (3): 15-23.

# Appendix A: Los Angeles County Electric Vehicle Charging Stations

| Station Name | Address | City | State | ZIP | Access Days & Time | Level 2 EVSE Number | EV Connector Types |
|---|---|---|---|---|---|---|---|
| Los Angeles County - Department of Health Services Administration | 313 N Figueroa | Los Angeles | CA | 90012 | Business hours; pay lot | 4 | J1772 |
| Los Angeles County - Harbor UCLA Medical Center | 1000 W Carson St | Torrance | CA | 90502 | 24 hours daily | 4 | J1772 |
| Los Angeles County - Health Services | 5555 Ferguson Dr. | Commerce | CA | 90022 | 24 hours daily | 4 | J1772 |
| Los Angeles County - High Desert Regional Health Center | 335 E Ave I | Lancaster | CA | 93535 | Business hours | 4 | J1772 |
| Los Angeles County - Internal Services Department Headquarters | 1102 N Eastern Ave | Los Angeles | CA | 90063 | 6am-6pm M-Thur. | 4 | J1772 |
| Los Angeles County - Internal Services Department Telecomm | 1110 N Eastern Ave | Los Angeles | CA | 90063 | 6am-6pm M-Fri. | 4 | J1772 |
| Los Angeles County - Marina Lot 77 | 13560 Mindinao Way | Marina Del Rey | CA | 90292 | 24 hours daily; | 2 | J1772 |
| Los Angeles County - Martin Luther King Hospital | 1670 E 120th St | Los Angeles | CA | 90059 | 24 hours daily | 2 | J1772 |
| Los Angeles County - Mid-Valley Comprehensive Health Center | 7515 Van Nuys Blvd | Van Nuys | CA | 91405 | 6am-6pm M-F | 5 | J1772 |
| Los Angeles County - Music Center Parking | 135 N Grand Ave | Los Angeles | CA | 90012 | Business hours; pay lot | 3 | J1772 |
| Los Angeles County - Olive View UCLA Medical Center | 14445 Olive View Dr. | Sylmar | CA | 91342 | 24 hours daily | 14 | J1772 |
| Los Angeles County - Probation Department | 9150 E Imperial Hwy | Downey | CA | 90242 | Business hours | 2 | J1772 |
| Los Angeles County - Public Works Annex | 901 S Fremont Ave | Alhambra | CA | 91803 | 6am-6pm M-F | 3 | J1772 |
| Los Angeles County - Public Works Headquarters | 900 S Fremont Ave | Alhambra | CA | 91803 | 6am-6pm M-F | 8 | J1772 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Los Angeles County - Rancho Los Amigos Hospital | 7601 E Imperial Hwy | Downey | CA | 90242 | 24 hours daily | 5 | J1772 |
| Los Angeles County - Walt Disney Concert Hall | 115 S Grand Ave | Los Angeles | CA | 90012 | Business hours; pay lot | 6 | J1772 |
| Los Angeles County Arboretum | 301 N Baldwin Ave | Arcadia | CA | 91007 | 24 hours daily | 3 | J1772 |
| Los Angeles County Museum of Art | 5905 Wilshire Blvd | Los Angeles | CA | 90036 | Business hours; pay lot | 3 | J1772 |
| Los Angeles County Registrar-Recorder - County Clerk | 12400 E Imperial Hwy | Norwalk | CA | 90650 | Primarily for employee use | 3 | J1772 |
| Los Angeles County Sheriff - Century Station | 11705 S Alameda | Lynwood | CA | 90059 | Business hours; pay lot | 2 | J1772 |
| Los Angeles County Sheriff - Fleet Shop | 1104 N Eastern Ave | Los Angeles | CA | 90063 | 8am-5pm M-F | 2 | J1772 |
| Los Angeles County Sheriff - Headquarters | 4700 Ramona Blvd | Monterey Park | CA | 91754 | 8am-5pm M-F | 2 | J1772 |
| Los Angeles County Sheriff - Lost Hills | 27050 Agoura Rd | Agoura | CA | 91301 | 24 hours daily | 2 | J1772 |
| Los Angeles County Sheriff - Mira Loma Garage | 45000 N 60th St W | Lancaster | CA | 93536 | 7am-4pm M-F | 3 | J1772 |
| Los Angeles County Sheriff - San Dimas Station | 270 S Walnut Ave | San Dimas | CA | 91773 | 24 hours daily | 2 | J1772 |
| Los Angeles County Sheriff - Santa Clarita Station | 23740 Magic Mountain Pkwy | Santa Clarita | CA | 91355 | 24 hours daily | 2 | J1772 |
| Los Angeles County Sheriff - Temple City Station | 8838 Las Tunas Dr. | Temple City | CA | 91780 | 24 hours daily | 2 | J1772 |
| Los Angeles County Sheriff - Walnut Station | 21695 Valley Blvd | Walnut | CA | 91789 | 24 hours daily | 2 | J1772 |
| Los Angeles County Sheriff - West Hollywood Station | 780 San Vicente Blvd | West Hollywood | CA | 90069 | 24 hours daily | 2 | J1772 |

# Appendix B: Los Angeles County Public Libraries

| | |
|---|---|
| 1 | A C Bilbrew Library |
| 2 | Acton Agua Dulce Library |
| 3 | Agoura Hills Library |
| 4 | Alondra Library |
| 5 | American Indian Resource Center |
| 6 | Angelo M. Iacoboni Library |
| 7 | Antelope Valley Bookmobile |
| 8 | Anthony Quinn Library |
| 9 | Artesia Library |
| 10 | Asian Pacific Resource Center |
| 11 | Avalon Library |
| 12 | Baldwin Park Library |
| 13 | Bell Gardens Library |
| 14 | Bell Library |
| 15 | Black Resource Center |
| 16 | Carson Library |
| 17 | Castaic Library |
| 18 | Charter Oak Library |
| 19 | Chet Holifield Library |
| 20 | Chicano Resource Center |
| 21 | City Terrace Library |
| 22 | Claremont Library |
| 23 | Clifton M. Brakensiek Library |
| 24 | Compton Library |
| 25 | Cudahy Library |
| 26 | Culver City Julian Dixon Library |
| 27 | Diamond Bar Library |
| 28 | Dr. Martin Luther King, Jr. Library |
| 29 | Duarte Library |
| 30 | East Los Angeles Library |
| 31 | East Rancho Dominguez Library |
| 32 | El Camino Real Library |
| 33 | El Monte Library |
| 34 | Florence Library |
| 35 | Gardena Mayme Dear Library |
| 36 | George Nye Jr. Library |
| 37 | Graham Library |
| 38 | Hacienda Heights Library |
| 39 | Hawaiian Gardens Library |
| 40 | Hawthorne Library |
| 41 | Hermosa Beach Library |
| 42 | Hollydale Library |
| 43 | Huntington Park Library |
| 44 | La Cañada Flintridge Library |
| 45 | La Crescenta Library |
| 46 | La Mirada Library |

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|---|---|
| 47 | La Puente Library |
| 48 | La Verne Library |
| 49 | Lake Los Angeles Library |
| 50 | Lancaster Library |
| 51 | Lawndale Library |
| 52 | Leland R. Weaver Library |
| 53 | Lennox Library |
| 54 | Littlerock Library |
| 55 | Live Oak Library |
| 56 | Lloyd Taber-Marina del Rey Library |
| 57 | Lomita Library |
| 58 | Los Nietos Library |
| 59 | Lynwood Library |
| 60 | Malibu Library |
| 61 | Manhattan Beach Library |
| 62 | Masao W. Satow Library |
| 63 | Maywood César Chávez Library |
| 64 | Montebello Library |
| 65 | Norwalk Library |
| 66 | Norwood Library |
| 67 | Paramount Library |
| 68 | Pico Rivera Library |
| 69 | Quartz Hill Library |
| 70 | Rivera Library |
| 71 | Rosemead Library |
| 72 | Rowland Heights Library |
| 73 | San Dimas Library |
| 74 | San Fernando Library |
| 75 | San Gabriel Library |
| 76 | Santa Clarita Valley Bookmobile |
| 77 | Sorensen Library |
| 78 | South El Monte Library |
| 79 | South Whittier Library |
| 80 | Stevenson Ranch Library |
| 81 | Sunkist Library |
| 82 | Temple City Library |
| 83 | Topanga Library |
| 84 | Urban Outreach Bookmobile |
| 85 | View Park Library |
| 86 | Walnut Library |
| 87 | West Covina Library |
| 88 | West Hollywood Library |
| 89 | Westlake Village Library |
| 90 | Willowbrook Library |
| 91 | Wiseburn Library |
| 92 | Woodcrest Library |

# Appendix C: Los Angeles County Department of Regional Parks and Recreations

| | |
|---|---|
| 1 | 72nd Street Staging Area |
| 2 | 7th Avenue Staging Area |
| 3 | Acton Park |
| 4 | Acton Wash Sanctuary |
| 5 | Adventure Park |
| 6 | Alondra Community Regional Park |
| 7 | Alpine Butte Wildlife Sanctuary |
| 8 | Altadena Golf Course |
| 9 | Amigo Park |
| 10 | Apollo Community Regional Park |
| 11 | Arboretum and Botanic Garden |
| 12 | Arcadia Community Regional Park |
| 13 | Athens Park |
| 14 | Atlantic Avenue Park |
| 15 | Avenue Park |
| 16 | Avocado Heights Park |
| 17 | Bassett Park |
| 18 | Belvedere Community Regional Park |
| 19 | Bethune Park, Mary M. |
| 20 | Big Rock Creek Wildlife Sanctuary |
| 21 | Blalock Wildlife Sanctuary |
| 22 | Blevins Park, Bill |
| 23 | Bodger Park |
| 24 | Bonelli Regional Park, Frank G. |
| 25 | Butte Valley Wildflower Sanctuary |
| 26 | Campanella Park, Roy |
| 27 | Carver Park, George Washington |
| 28 | Castaic Lake State Recreation Area |
| 29 | Castaic Sports Complex |
| 30 | Cerritos Community Regional Park |
| 31 | Charles White Park |
| 32 | Charter Oak Park |
| 33 | Chester Washington Golf Course |
| 34 | City Terrace Park |
| 35 | Countrywood Park |
| 36 | Crescenta Valley Community Regional Park |
| 37 | Dalton Park |
| 38 | Deane Dana Friendship Park and Nature Center |
| 39 | Del Aire Park |
| 40 | Del Valle Park |
| 41 | Descanso Gardens |
| 42 | Devil's Punchbowl Natural Area |

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|---|---|
| 43 | Dexter Park |
| 44 | Diamond Bar Golf Course |
| 45 | East Rancho Dominguez Park |
| 46 | Eastside Eddie Heredia Boxing Club |
| 47 | Eaton Canyon Golf Course |
| 48 | Eaton Canyon Park & Nature Center |
| 49 | Eaton Canyon Staging Area |
| 50 | El Cariso Community Regional Park |
| 51 | El Cariso Golf Course |
| 52 | El Parque Nuestro |
| 53 | Enterprise Park |
| 54 | Farnsworth Park, Charles S. |
| 55 | Ganesha Park |
| 56 | George Lane Park |
| 57 | George R. Bones Wildlife Sanctuary |
| 58 | Gerhardy Wildlife Sanctuary, Carl O. |
| 59 | Gloria Heer Park |
| 60 | Hacienda Heights Community and Recreation Center |
| 61 | Hart Regional Park, William S. |
| 62 | Hasley Canyon Equestrian Center |
| 63 | Hasley Canyon Park |
| 64 | Helen Keller Park |
| 65 | Highland Camrose Park |
| 66 | Hollywood Bowl |
| 67 | Jackie Robinson Park |
| 68 | Jackrabbit Flats Wildlife Sanctuary |
| 69 | Jake Kuredjian Park |
| 70 | Jesse Owens Community Regional Park |
| 71 | John Anson Ford Amphitheatre |
| 72 | Kenneth Hahn State Recreation Area |
| 73 | Knollwood Golf Course |
| 74 | Knollwood Pool |
| 75 | La Canada Staging Area |
| 76 | La Mirada Community Regional Park |
| 77 | La Mirada Golf Course |
| 78 | Ladera Park |
| 79 | Lakewood Golf Course |
| 80 | Lario San Gabriel River Trail |
| 81 | Lennox Park |
| 82 | Lincoln SPS Staging Area |
| 83 | Loma Alta Park |
| 84 | Longview Sanctuary |
| 85 | Los Amigos Golf Course |

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|---|---|
| 86 | Los Pinetos Staging Area |
| 87 | Los Robles Park |
| 88 | Los Verdes Golf Course |
| 89 | Lyman Staging Area |
| 90 | Maggie Hathaway Golf Course |
| 91 | Magic Johnson Park, Earvin |
| 92 | Manzanita Park |
| 93 | Marshall Canyon Equestrian Center |
| 94 | Marshall Canyon Golf Course |
| 95 | Marshall Canyon Park & Nursery |
| 96 | Marshall Canyon Staging Area |
| 97 | Martin Luther King Jr. Fitness Garden |
| 98 | Martin Park, Allen J. |
| 99 | Martin Park, Everett |
| 100 | Mayberry Park, Amelia |
| 101 | McNees Park |
| 102 | Mescal Wildlife Sanctuary |
| 103 | Michillinda Park |
| 104 | Mira Vista Park |
| 105 | Mona Park |
| 106 | Monteith Parkway |
| 107 | Monument Park |
| 108 | Mountain Meadows Golf Course |
| 109 | Neenach Wildlife Preserve |
| 110 | Obregon Park, Eugene A. |
| 111 | Orange Grove Park |
| 112 | Pamela Park |
| 113 | Park Learning Grove County Park |
| 114 | Parque de los Suenos |
| 115 | Pathfinder Community Regional Park |
| 116 | Pearblossom Park |
| 117 | Peck Road Water Conservation Park |
| 118 | Pepperbrook Park |
| 119 | Phacelia Wildlife Sanctuary |
| 120 | Pickens Canyon Park |
| 121 | Pico Canyon Park |
| 122 | Placerita Canyon Nature Center |
| 123 | Richard H Rioux Memorial Park, Dr. |
| 124 | Rimgrove Park |
| 125 | Roosevelt Park, Franklin D. |
| 126 | Rosas Park, Carolyn |
| 127 | Rowland Heights Community Center |
| 128 | Rowland Heights Park |

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|---|---|
| 129 | Ruben Salazar Park |
| 130 | Rueben Ingold Parkway |
| 131 | San Angelo Park |
| 132 | San Dimas Canyon Community Regional Park |
| 133 | San Dimas Canyon Nature Center |
| 134 | San Dimas Staging Area |
| 135 | San Fernando Regional Pool |
| 136 | San Jose Creek Park |
| 137 | Santa Anita Golf Course |
| 138 | Santa Catalina Island Interpretive Center |
| 139 | Santa Catalina Island Regional Park |
| 140 | Santa Fe Dam Recreational Area |
| 141 | Saybrook Park |
| 142 | Schabarum Regional Park, Peter F. |
| 143 | Sorensen Park |
| 144 | Sorensen Park, Stephen |
| 145 | South Coast Botanic Garden |
| 146 | Steinmetz Park, William |
| 147 | Sunshine Park |
| 148 | Ted Watkins Memorial Park |
| 149 | Tesoro Adobe Historic Park |
| 150 | Theodore Payne Wildlife Sanctuary |
| 151 | Thomas S. Burton Park |
| 152 | Trailview Park |
| 153 | Tujunga Ponds Wildlife Sanctuary |
| 154 | Two Strike County Park |
| 155 | Val Verde Community Regional Park |
| 156 | Valley Center Staging Area |
| 157 | Valleydale Park |
| 158 | Vasquez Rocks Natural Area Park |
| 159 | Veterans Memorial Community Regional Park |
| 160 | Victoria Community Regional Park |
| 161 | Victoria Golf Course |
| 162 | Virginia Robinson Gardens |
| 163 | Walnut Creek Community Regional Park |
| 164 | Walnut Nature Park |
| 165 | Washington Park, Colonel Leon H. |
| 166 | West Creek Park |
| 167 | Whittier Narrows Golf Course |
| 168 | Whittier Narrows Nature Center |
| 169 | Whittier Narrows Recreation Area |