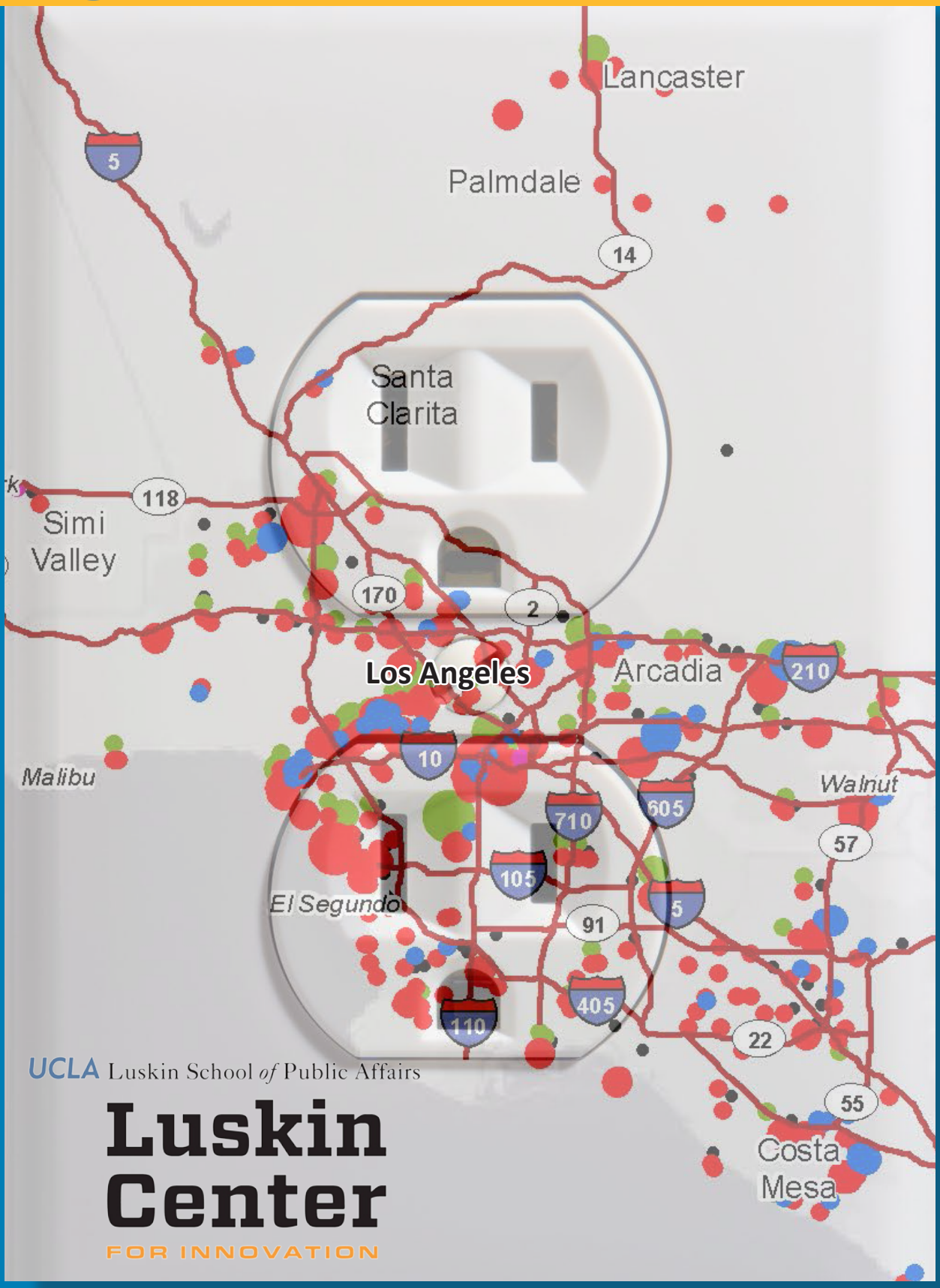
Southern California
Plug-in Electric Vehicle Atlas

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS



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Southern California Plug-in Electric Vehicle Readiness Atlas

About this Document

This document was prepared for the Southern California Association of Governments (SCAG) by the UCLA Luskin Center for Innovation. It constitutes Deliverable 11 of SCAG contract 12-021-C1 to support regional planning for plug-in electric vehicle (PEV) adoption. SCAG is coordinating a multi-stakeholder group of government agencies, utilities, and university researchers to prepare multi-faceted and interdisciplinary regional PEV readiness plans. Among other purposes, these plans will help illuminate and guide strategic infrastructure investment, PEV-related economic development, and supportive policy design in Southern California.

Disclaimer

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Plug-in Electric Vehicle Readiness Atlas

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Plug-in Electric Vehicles (PEVs) may provide a range of important benefits. For drivers, PEVs are a way to save money on fuel, avoid trips to the gasoline station, contribute to energy independence, and improve local air quality. For utilities, PEVs represent a new source of demand for power even as they support efficient use of energy produced during overnight hours. For state and regional air-quality regulators, PEVs help reduce criteria air pollutants and greenhouse gas (GHG) emissions.

To fully realize the benefits of PEVs, planners must coordinate and facilitate the growth of two complementary markets: one for PEVs and another for the electric charging opportunities that these vehicles need to refuel. This Atlas describes how many PEVs are in a given neighborhood and how their spatial concentrations vary over the course of a day as their drivers travel to workplaces and retail destinations. This Atlas also projects PEVs growth over the next ten years within neighborhoods and municipalities in each of the 15 councils of government (COGs) within the Southern California Association of Governments region.

This Atlas also maps potential charging infrastructure opportunities to support and complement growth in the PEV market. It identifies the locations and sizes of workplaces, multi-unit residences and retail establishments that could potentially host PEV charging. Lastly, the Atlas includes maps of other resources that support PEV charging, such as existing publicly-accessible charging stations and stand-alone parking facilities.

This spatial information enables to planners to know where PEVs are currently and where growth will occur in the future. This will help them prioritize the municipal planning reforms such as those described in the Southern California PEV Readiness Plan. It describes where latent PEV demand is constrained because of the challenges of installing charging opportunities in multi-unit residences. It also describes the locations of workplaces and retail establishments that are in neighborhoods with a higher density of PEVs during the day and evening. With this information, planners can take the next steps to provide the targeted technical assistance to these sites as described in the Southern California PEV Readiness Plan.

The technical appendix that follows the Atlas provides detailed information on data sources and analyses used to generate each map. This Atlas features the following maps of the neighborhoods and municipalities within each COG in the SCAG region:

1. **PEV registration density as of 2012.** Knowing how many PEVs are currently registered in a given area will indicate the location of current and near-future demand for residential charging. By extension, this information can help planners and utilities anticipate locations that will carry additional nighttime electrical load.

2. **PEV morning travel to work, providing spatial daytime PEV density at or near workplaces.** Understanding where PEVs are concentrated during morning peak hours (6:00 a.m. to 9:00 a.m.) can help planners and utilities identify neighborhoods where there will be demand for daytime charging.

3. **Workplaces identified by numbers of employees.** Planners can target the largest employers for workplace charging initiatives, as they presumably host the largest numbers of parking spaces on-site and can potentially serve the highest numbers of employees.

4. **Workplaces overlaid with morning peak PEV density.** Planners and utilities can use these maps to assess the potential utilization of workplace charging by comparing the spatial distribution of employers and weekday morning peak travel destinations for PEVs.

5. **Publicly-accessible charging locations, identified by power level and number of stations per location.** Planners can use these maps to compare the location of existing publicly-accessible charge stations with the locations of employment centers, retail centers and PEV daytime destinations, also mapped at the COG level in the Atlas. The maps can also be used to identify where there are gaps in meeting demand for charging. For MUDs that do not have parking, publicly-accessible sites will become important charging options. The maps identify the number of charging units/cords available at each location along with the level of service (Level 1, Level 2, etc., or "Unknown" where there is charging available but the quantity of connectors and their level of service could not be immediately determined). The maps are based on information collected during the summer and fall of 2012.

6. **Multi-unit dwellings (MUDs) by number of units and density.** City planners can use these maps to identify specific buildings and/or MUD owners that could potentially host charging on-site. Planners can use the maps to compare spatial distributions of MUD density with employment and commercial density, publicly accessible charging stations, and stand-alone parking areas to assess the potential for these other PEV sites to serve the charging needs of MUD residents. Mapping the precise location of MUDs and knowing the density of units on a site will be of particular use in utility planning. Utilities can use such maps to anticipate where upgrades may be needed for transformers and distribution stations to accommodate PEV charging at MUDs.

7. **Retail destinations, from strip development to regional centers.** Many PHEV drivers find it valuable to charge when visiting retail destinations in order to maximize electric miles driven. After locating general categories of retail charging opportunities on the map, planners can turn to Chapter 8 of the Southern California PEV Readiness Plan for more detailed descriptions of how long cars are typically parked at specific types of retail destinations.

8. **Retail destinations overlaid with PEV mid-day travel, providing spatial retail PEV density at or near retail centers.** Planners and utilities can use these maps to assess potential for retail charging by comparing the spatial distribution of retail centers and mid-day travel destinations (9:00 a.m. to 3:00 p.m.) for PEVs.

9. **Stand-alone parking facilities.** Publicly-accessible parking facilities can fill a gap in PEV charging, particularly in older urban cores where retail stores and even some workplaces and multi-unit dwellings do not have dedicated parking. Park and ride lots in particular may substitute for Level 1 workplace charging if workers leave their PEVs parked all day. Parking lots and structures greater than 2.5 acres that are not attached to other land uses are mapped at the COG level.

The Atlas provides this suite of spatial tools for PEV readiness planning for the following COGs:

- Arroyo Verdugo Subregion
- City of Los Angeles
- Coachella Valley Association of Governments
- Gateway Cities Council of Governments
- Imperial County Transportation Commission
- Las Virgenes Malibu Council of Governments
- North Los Angeles County
- Orange County Council of Governments
- San Bernardino Associated Governments
- San Fernando Valley Council of Governments
- San Gabriel Valley Council of Governments
- South Bay Cities Council of Governments
- Ventura County Council of Governments
- Western Riverside Council of Governments
- Westside Cities Council of Governments

Utility PEV growth projections

The Southern California Plug-in Electric Vehicle Atlas also provides projections of PEV growth and electric miles driven over 10 years by utility service territory for the following utilities[1]:

- Azusa Light and Power
- Burbank Water and Power
- Cerritos Electric Utility
- Glendale Water and Power
- Pasadena Water and Power
- Vernon Light and Power
- Anaheim Public Utilities Department
- City of Banning Electric Utility
- City of Colton Utilities Services
- Imperial Irrigation District
- Los Angeles Department of Water and Power
- Riverside Public Utilities
- Southern California Edison
- Anza Electric Cooperative
- City of Industry Electric Utility Service
- Moreno Valley Electric Utility
- Rancho Cucamonga Municipal Utility
- San Diego Gas & Electric (portion within SCAG)

These projections are designed to help regional planners and utilities locate current and future demand for PEV charging and coordinate efforts to meet that demand.

1 Utilities not represented by the Southern California Public Power Authority and that have less than 2 PEVs attributable to their service territories have been excluded from this analysis. They are Bear Valley Electrical Service, Corona Water and Power, Needles Public Utility Authority, and Victorville Municipal Utility Services.

Technical Appendix

This appendix describes the methods, assumptions and data sources used to create the maps and projections in this Atlas. They are presented in the same order in which the maps and projections appear.

Council of government-level maps

PEV growth

The Southern California Plug-in Electric Vehicle (PEV) Readiness Plan and Atlas define a PEV as any fully electric vehicle (including low-speed neighborhood electric vehicles and electrified trucks) or a plug-in hybrid electric vehicle (PHEV). The PHEV models counted in this analysis are the Chevrolet Volt, Toyota Plug-in Prius and Fisker Karma. The scope only includes PEVs registered as new in the SCAG region between December 2010 and September 2012 inclusive. PEV registrations are presented for each subregion or council of government (COG) as aggregated from data supplied at the 2010 Census tract level by R.L. Polk & Co.

As of September 2012, there were 8,321 PEVs in the SCAG region. It is important to note that the San Fernando Valley Council of Governments (SFVCOG) is an overlay of portions of the City of Los Angeles, the Arroyo Verdugo Subregion, and North Los Angeles County. There is no unique area within SFVCOG that is not included in another COG.

Once the 2012 PEV counts were obtained, a reasonable growth rate was needed to predict how PEVs would grow to the year 2022. We used the annual percentage increases in standard Toyota Prius hybrid sales from 2000 to 2010 to compute the lower bound of the estimates[2] beginning in 2013. The projection is a PEV count for each COG for each year between 2012 and 2022. A moderate bound was projected by scaling up each annual percentage growth rate by 5% (without exceeding 100%) in each year and repeating the same calculation on each year's lower-bound estimate. The high bound was calculated identically to the moderate bound but with a 10% scaling factor over the low bound.

The Southern California PEV Atlas also provides COG-specific cumulative PEV count projections for each year between 2012 and 2022. A potential limiting factor on the actual growth of PEVs is the high percentage of Southern California residents that live in multi-unit dwellings (MUDs). Unless steps are taken to facilitate charging in MUDs, PEV ownership may not grow as projected.

PEV registration maps

The maps provided in the Southern California PEV Atlas show the numbers of PEVs registered in the COGs by Tier 1 travel analysis zone (TAZ). TAZs closely follow 2000 Census tract boundaries and are used by the Southern California Association of Governments (SCAG) to estimate travel within and between neighborhoods. There are 4,109 Tier 1 TAZs in the SCAG region. The map colors move from lighter in areas with no or few PEVs registered to darker in areas with more PEVs registered. PEV registration data supplied at the 2010 Census tract level by R.L. Polk & Co. was harmonized with TAZ boundaries.

2 Prius sales derived from Toyota press release: http://www2.toyota.co.jp/en/news/10/10/1007.html

PEV morning peak destinations

Using surveys of household travel behavior, SCAG's travel demand model estimates the number of trips from home to work, school, and other destinations by time of day[3]. By counting the number of PEVs from each *origin* TAZ that feed into each of the daytime *destination* TAZs, we were able to map the locations and densities of PEVs traveling to work on weekdays from 6:00 a.m. to 9:00 a.m. We used the outputs from SCAG's 2008 Regional Model[4]. It is important to note that these morning peak destination TAZs receive vehicles from outside the COG.

Employment density

The maps of employment density were prepared using commercially available Infogroup data from 2008 on employer size (i.e., number of employees) and location. Each circle on the map represents one workplace. The circles move from small to large and from yellow to red as the number of employees per workplace increases as described.

PEV morning peak destinations and employment density

This is an overlay of the previous two maps. The maps show both where PEVs driving to work are likely to be during the daytime hours and where there are many employers and potentially high demand for workplace charging depending upon how charging is priced.

Publicly-accessible charging stations

The Southern California PEV Atlas includes maps of publicly-accessible charging stations for each COG in the SCAG region. "Publicly-accessible" refers to stations that are owned by either the government or private businesses but that are available for use by the general public. The maps identify the number of charging units/cords available at each location along with the level of service (Level 1, Level 2, etc., or "Unknown" where there is charging available but the quantity of connectors and their level of service could not be immediately determined). The maps are based on information collected during the summer and early fall of 2012.

The information was compiled using online databases maintained the U.S. Department of Energy (DOE) (http://www.afdc.energy.gov/fuels/electricity_locations.html) as well as Recargo (www.recargo.com), PlugShare (www.plugshare.com), and Car Stations (www.carstations.com), which contain information posted by users of the charging stations. The precise number of connectors or charging units that are operational at any given time and location are subject to maintenance and upgrade schedules. Some stations designated as "legacy" in the Atlas may have since been upgraded to current connector standards under the Reconnect CA program.

The DOE database's station location feature allows one to search electric vehicle charging stations by state and then download the data into a spreadsheet. The California state list was filtered to include only those located with the six-county SCAG region. The DOE list contains charging stations from a variety of sources, including trade media, Clean Cities coordinators, a form on the AFDC website, and through collaboration with charging equipment providers. The data is updated twice per month and stations that are no longer in service are regularly removed. There are additional stations not captured on the DOE list that were found on the other sites listed above.

3 http://www.scag.ca.gov/modeling/index.htm
4 http://www.scag.ca.gov/modeling/pdf/MVS08/MVS08_Chap05.pdf

Multi-unit residences

This data is obtained from SCAG's 2005 Existing Land Use Dataset, which includes information on the concentration of all residential units other than single-family in the SCAG region. The land use data was developed by Aerial Information Systems, Inc. as a Modified Anderson Land Use Classification. The designations were determined by using aerial photography to estimate the land use at the parcel level. Each residential parcel in the dataset is assigned a code that best describes the composition of residential unit types. The factors that contribute to a parcel's residential designation are the height of the buildings, the square footage, and the concentration of multi-unit dwellings per parcel[5]. The densities of units per acre increase from yellow at the duplex, triplex and townhouse level all the way up to high-rise MUDs in red.

CODE	DESCRIPTION	DENSITY
1121	Mixed Multi-Family Residential	NA
1122	Duplexes, Triplexes, and 2- or 2-Unit Condominiums and Townhouses	2 units or less
1123	Low-Rise Apartments, Condominiums, and Townhouses	4+ units. 10 to 18 units per acre
1124	Medium-Rise Apartments and Condominiums	Greater than 18 units per acre
1125	High-Rise Apartments and Condominiums	Greater than 18 units per acre

Commercial (retail) destinations

This map data is obtained from SCAG's 2005 Existing Land Use Dataset, which includes information on the concentration of retail centers in the SCAG region. The land use data was developed by Aerial Information Systems, Inc. as a Modified Anderson Land Use Classification. The designations were determined by using aerial photography to estimate the land use at the parcel level.

The Southern California PEV Atlas contains maps of retail and small business destinations (such as beauty salons and small offices) within each COG in the region. They highlight four types of retail centers that are likely to attract many of the non-work related vehicular trips. These four categories are as follows:

5 Southern California Association of Governments. 2002. Southern California 1990 Aerial Land Use Study: Land Use Code Descriptions and Key Signatures, Level III/IV.

CODE	DESCRIPTION	KEY ATTRIBUTE
1221	Regional Shopping Center	Department store with surrounding parking
1222	Retail Centers (Non-Strip With Contiguous Interconnected Off-Street Parking)	Magnet store with in-front parking
1223	Modern Strip Development	Small businesses with parking on-street and on one side
1224	Older Strip Development	Small businesses with on-street parking

Land use Code 1221, Regional Shopping Center, contains large retail centers with at least one major department store and a range of other smaller retail establishments. These shopping centers are generally enclosed malls with parking surrounding the one to three story building. This also includes factory outlet malls.

Land use Code 1222, Retail Centers, is comprised of at least one large magnet store, a large off-street parking lot, and additional detached commercial stores, including small retail stores, gas stations, and restaurants. All structures are generally one story tall. Retail Centers are often located conveniently off major highways or highly trafficked surface streets.

Land use Code 1223, Modern Strip Malls, designates parcels which contain retail stores, restaurants, service shops, and offices, and are often located along major traffic corridors. Parking is available on-street as well as off-street either in front, on the side, or behind the structures. Included in this category are gas stations, auto repair shops, convenience stores, liquor stores, small bank branch offices, clothing stores, restaurants, furniture stores, discount stores, novelty stores, car dealerships or auto centers, drug stores, small corner markets, auctions, and smaller malls which do not contain a large magnet store.

Finally, land use Code 1224, Older Strip Development, contains parcels of land with little or no off-street parking. This category is commonly found in older city and town business corridors. Units are small retail establishments, restaurants, and offices with storefronts without setback, adjacent to the sidewalk. Units are often attached to the neighboring unit creating and uninterrupted streetscape. Units with commercial space on the first floor and residential units on upper floors can be considered Older Strip Development.[6]

PEV mid-day destinations and commercial (retail) locations

After mapping retail destinations, the UCLA Luskin Center mapped the locations where currently-registered PEVs travel during weekdays from 9:00 a.m. to 3:00 p.m. The data on PEV registrations comes from automotive data vendor R.L. Polk & Co., which provided the number of PEVs registered as new within each 2010 Census tract from December 2010 through September 2012.

Census tracts closely follow the boundaries of travel analysis zones (TAZs), which are the geographic areas used by SCAG to model vehicle travel. SCAG's travel demand model estimates the number of trips from home to work, school, and other destinations by time of day. By counting the number of PEVs from each *origin* TAZ that feed into each of the mid-day *destination* TAZs, we are able to map the locations and densities of PEVs traveling to neighborhoods from 9:00 a.m. to 3:00 p.m. We used the outputs from SCAG's 2008 Regional

6 Southern California Association of Governments. 2002. Southern California 1990 Aerial Land Use Study: Land Use Code Descriptions and Key Signatures, Level III/IV.

Model[7]. It is important to note that these morning peak destination TAZs receive vehicles from outside the COG.

Stand-alone parking facilities

This map data is obtained from SCAG's 2005 Existing Land Use Dataset, which includes information on the concentration of stand-alone parking facilities in the SCAG region. The land use data was developed by Aerial Information Systems, Inc. as a Modified Anderson Land Use Classification. The designations were determined by using aerial photography to estimate the land use at the parcel level.

Parking lots and structures greater than 2.5 acres that are not attached to other land uses are mapped at the COG level in the Southern California PEV Atlas. They highlight three types of stand-alone parking classified by SCAG:[8]

Description	Key Attribute
Attended Pay Public Parking Facilities	Stand-alone public parking areas and parking structures that have an attendant-cashier present
Non-Attended Public Parking Facilities	Free or metered public parking areas where no attendant-cashier is present
Park and Ride Lots	Cal Trans park and ride lots provided for commuter ridesharing, buspooling, vanpooling, and carpooling purposes

The "Attended Pay Public Parking Facilities" classification does not distinguish between privately-owned commercial parking facilities available for public use and municipal or other parking facilities owned by the public sector that are available for public use.

7 http://www.scag.ca.gov/modeling/pdf/MVS08/MVS08_Chap05.pdf

8 Southern California Association of Governments. 2002. Southern California 1990 Aerial Land Use Study: Land Use Code Descriptions and Key Signatures, Level III/IV.

Utility projections

Current counts and growth projections of PEVs in utility service territories in the SCAG region were calculated using the same sources, methods and assumptions as the COG-level counts and projections. The PEV counts are based on 2010 Census tract-level data from R.L. Polk & Co. on PEVs newly registered from December 2010 to September 2012. Only Census tracts that fall within the SCAG region were counted.

The data was aggregated into utility service territories using municipal boundaries (for municipal utilities) as well as individual utility maps and the California Electric Utility Service Areas map published in 2011 by the California Energy Commission.[9]

Utilities not represented by the Southern California Public Power Authority and that have less than 2 PEVs attributable to their service territories have been excluded from this analysis. They are Bear Valley Electrical Service, Corona Water and Power, City of Needles, and Victorville Municipal Utility Services.

The three factors most likely to influence electric (e-)miles driven are travel distance, charging opportunities, and PEV battery range. Of these, only travel distance can be estimated with some certainty. We used Krumm (2012)[10] to estimate daily average travel (regardless of vehicle type) of about 30 miles. We assumed the average number of daily *electric* miles driven per PEV to be 20 miles, although in practice this number would vary according to battery range and charging opportunities. The product of the number of PEVs in each utility territory and the estimated average number of daily electric miles driven per PEV (20 miles per PEV) resulted in the predicted daily e-miles driven.

9 http://www.energy.ca.gov/maps/serviceareas/Electric_Service_Areas_Detail.pdf

10 http://research.microsoft.com/en-us/um/people/jckrumm/Publications%202012/2012-01-0489%20SAE%20published.pdf

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