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SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

# Western Riverside County Plug-in Electric Vehicle Deployment Plan

Prepared for the Southern California Association of Governments

June 2013

# Western Riverside County
# Plug-in Electric Vehicle Deployment Plan

## About this Document

This document was prepared for the Southern California Association of Governments (SCAG) by J.R. DeShazo, Ayala Ben-Yehuda, Norman Wong and Vicky Hsu of the UCLA Luskin Center for Innovation. It constitutes the final PEV deployment plan for Western Riverside County as Deliverable 27 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



## Acknowledgements

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## Table of Contents

# Western Riverside County
# Plug-in Electric Vehicle Deployment Plan

## I. Introduction

The market for plug-in electric vehicles (PEVs) is just beginning to emerge in Western Riverside County. At the end of 2012, the subregion was home to 574 PEVs, a number that is expected to grow to over 49,000 by 2022.[1]

The Western Riverside Council of Governments (WRCOG) has engaged in planning studies of PEVs and neighborhood electric vehicles (NEVs). This document supports those efforts with an analysis of the potential supply of, and current demand for, PEV charging opportunities in Western Riverside County.

The Western Riverside County PEV deployment plan is a subregional complement to the Southern California Regional PEV Readiness Plan and Atlas (DeShazo et al. 2012). These regional planning documents introduce examples of spatial analysis of PEV charging supply and demand. They present guidelines for prioritizing PEV planning efforts according to local land use opportunities as well as maps of PEV registrations and travel patterns at the subregional level.

This document and its accompanying Appendix localize these spatial analyses by providing:

- Inventories of land uses at the subregional and municipal level to help prioritize PEV planning efforts at three types of locations: multi-unit dwellings (MUDs), workplaces, and commercial/retail centers;
- An evaluation of the suitability of hundreds of individual parcels to host PEV charging using criteria that represent supply of parking spaces, the relative cost of installing chargers, and parcel-level demand for charging; and
- Maps of PEV registrations and travel patterns to daytime destinations within 17 WRCOG cities.

The Western Riverside County PEV Deployment Plan will also serve as a model for PEV planning in other outer-suburban, less dense and more recently developed areas in Southern California. Subregional planning organizations, also known as councils of government (COGs), have an important role to play in PEV planning. They can provide technical assistance to local governments and even implement PEV plans in the absence of dedicated staff at the local level. They can maximize the benefit of PEV planning to local drivers by leading efforts to standardize, share knowledge, and extend PEV planning to groups of

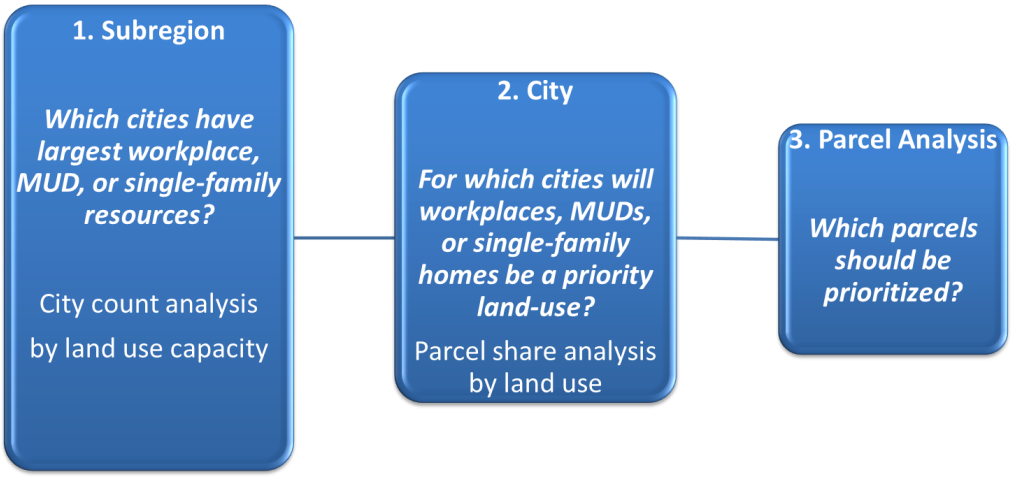
[1] UCLA Luskin Center forecast based on 2012 PEV registrations derived from R.L. Polk & Co. dataset. We define a PEV as any fully electric vehicle (including low-speed neighborhood electric vehicles and electrified trucks) or a plug-in hybrid electric vehicle (PHEV). The PHEV models counted in this analysis are the Chevrolet Volt, Toyota Plug-in Prius, Ford C-Max Energi and Fisker Karma.

neighboring cities. The Western Riverside County PEV deployment plan will demonstrate how COGs can prioritize PEV planning efforts according to dominant land uses and target cities that provide the largest numbers of charging opportunities in those land uses.

Municipal planners can also use the land use inventories and parcel suitability analyses presented here to prioritize PEV planning efforts at the local level. Municipal planners have the ability to target locally-dominant land uses for PEV-ready reforms to building and zoning codes, permitting processes, and parking and signage standards. They can also use the criteria presented here to prioritize specific locations for outreach to employers, property owners and retailers who may wish to provide PEV charging on site. Utilities can also benefit from an understanding of where demand for PEV charging is likely to grow during daytime and nighttime hours so that they can manage electricity loads and prioritize investments in transformer and distribution station upgrades.

Figure 1 describes how planners at different levels of government can use the different levels of analysis provided in this plan.

**Figure 1. Levels of PEV planning supported by the Western Riverside County PEV Deployment Plan**




In addition to informing the placement of charging stations, the land use inventories, parcel suitability analyses and maps presented in this plan support the targeting and prioritization of four major planning activities that can have a significant impact on PEV adoption:

- **Zoning codes.** Land use regulations are the most powerful tool cities have to incentivize certain types of development, including placement of charging stations. Designating PEV charging as a land use will help ensure that different charging levels carry the appropriate type of planning review for the zones in which they are located. Developers can also be encouraged to incorporate PEV charging spaces by allowing the spaces to count towards minimum parking requirements or in exchange for other incentives such as density bonuses.

- **Building codes.** By updating building codes to require PEV-ready wiring in new construction, cities can help meet future demand for charging and reduce or eliminate the costs associated with later retrofitting.

- **Permits and inspections**. Local jurisdictions are instrumental in reducing the cost, time and uncertainty associated with installing PEV charging equipment. Cities should minimize redundant or unnecessary levels of review and notification wherever possible. A streamlined permitting and inspection process can reduce the overall cost of installation and encourage compliance with safe permitting and installation procedures.

- **Parking and signage**. Local jurisdictions have leeway in determining signage on surface streets, providing a certain number of PEV-ready parking spaces, and ensuring disabled access. Parking and signage policies can assist with cost recovery, accessibility to disabled drivers, facilitating turnover at charging stations, and making stations more visible and easy to locate.

The planning exercises described above can be undertaken as part of a continuum, or "ladder," of PEV deployment plan implementation and stakeholder engagement activities. Planners can begin with more passive efforts that grow into more active projects, as shown in Figure 2 below. Each highlighted implementation effort is followed by a supporting activity or analysis, most of which have been undertaken in this document.

**Figure 2. Ladder of PEV planning activities supported by the Western Riverside County PEV Deployment Plan**

**Informational support** 22

- Website/handouts from Building & Safety, Planning, and/or utility

**Prioritize zoning, building, permitting, parking reforms according to dominant land uses**

- PEV demand assessment (using maps)*
- Land use inventory*
  - Planning reforms based on absolute numbers of single-family units, MUDs, and employees
  - Or tailor to relative concentrations of PEV parking/charging opportunities

**Targeted outreach/workshops for workplaces, MUDs, single-family**

- PEV demand assessment*
- Land use inventory*

**Demonstration projects**

- Parcel suitability analysis of PEV density, employees/sales, number of units and other attributes*

* Provided in this document.

**Step 1: Informational support.** This serves stakeholders, such as single-family residents and employers, who are already interested in purchasing PEVs or installing charging equipment. Local jurisdictions can provide information on vehicle types, potential cost savings from PEV driving, electrical service, and the charging equipment installation process through passive means such as a website and/or handouts from utilities and the Building & Safety or Community Development Department.

**Step 2: Prioritize planning reforms according to dominant land uses.** Planners wishing to proactively plan for PEVs should use the maps and land use inventories presented in this document to prioritize dominant land uses for planning reforms. Planners at the COG level can target cities based on absolute numbers of parking opportunities at single-family homes, multi-unit dwellings, and workplaces, or target technical assistance to cities with high shares of parking opportunities at particular land uses. Municipal planners can target land uses that dominate locally for planning reforms as well as neighborhoods that demonstrate high PEV charging demand on the maps provided in the Appendix.

**Step 3: Targeted technical assistance, workshops and outreach.** Planners may want to approach high-value stakeholders who may be less aware of the technical or procedural aspects of installing charging and using PEVs or who may require more detailed decision support.

Local jurisdictions can host workshops for general or targeted audiences such as drivers, homeowner associations (HOAs), property owners/managers, and renters for residential charging; or for employees, employers, fleet managers, or retailers for non-residential charging.

Many potential hosts may not be interested in installing PEV charging until their employees, tenants or patrons demand it. Actively engaging large employers or property owners in the decision-making process or providing information specific to their needs can facilitate the installation of charging and use of PEVs at their site as the market matures.

**Step 4: Demonstration projects.** Public agencies and utilities can partner up to install charging equipment via demonstration projects in particularly challenging areas such as multi-unit dwellings.

What follows are an analysis of PEV demand in the Western Riverside County subregion; an estimate of the relative size of the single-family, MUD and workplace charging opportunities in Western Riverside County; and rankings of workplace, retail, and MUD locations across Western Riverside County that are located in neighborhoods of high- and medium-PEV density. The Appendix to this memo contains such rankings for each of the 17 cities in the subregion, as well as maps that display parking opportunities and PEV travel in each WRCOG city.

## II. PEV demand in Western Riverside County

To help planners understand the scale of PEV charging demand in the subregion over the next decade, the Southern California Regional PEV Readiness Plan projected the cumulative number of PEVs that will be registered in the subregion between 2012 and 2022. Table 1 shows the numbers of PEVs registered in the Western Riverside County subregion as of December 2012, followed by growth projections to 2017 and 2022. The numbers were calculated from disaggregated registration data purchased from R.L. Polk & Co., an automotive data vendor. The 2012 counts reflect vehicles newly registered from December 2010, when the Chevrolet Volt and Nissan LEAF were introduced, through December 2012.

The baseline growth estimate is based on the annual North American growth rate of standard Toyota Prius hybrid sales beginning in 2000. This growth rate is the baseline because standard hybrids, a product type dominated early on by the Toyota Prius, can be considered parallel in many ways to plug-in hybrid electric vehicles (PHEVs). PHEVs, which comprised 77% of the PEVs newly registered in the Western Riverside County subregion as of December 2012 according to data from R.L. Polk & Co., are similar to standard Toyota Prius hybrids, except with a plug-in battery. The ability to recharge from the grid represents the potential for significant fuel cost savings above a standard hybrid.

The baseline growth rate is a conservative estimate because PEVs are available in many more models than were standard hybrids in the first years after introduction. Because many more PEV models will become available in the coming years, we also present alternative scenarios in which this growth rate is exceeded by 5% and 10%.

**Table 1. Projected PEVs in Western Riverside County, 2012-2022**

| Year | Cumulative PEV registrations | | |
|---|---|---|---|
| | Low | Moderate | High |
| **2012** | 574 | 574 | 574 |
| **2013** | 1,148 | 1,148 | 1,148 |
| **2014*** | 2,217 | 2,274 | 2,296 |
| **2015** | 3,528 | 3,733 | 3,884 |
| **2016** | 6,472 | 7,035 | 7,512 |
| **2017** | 12,259 | 13,677 | 14,981 |
| **2018** | 17,999 | 20,765 | 23,493 |
| **2019** | 27,678 | 32,969 | 38,476 |
| **2020** | 36,278 | 44,861 | 54,277 |
| **2021** | 43,877 | 56,501 | 71,074 |
| **2022** | 49,454 | 66,507 | 87,215 |

*The +5 and +10% projections begin in 2014, when uncertainty becomes greater.

Source: R.L. Polk & Co., UCLA Luskin Center projections

A closer look at the PEVs in the Western Riverside County reveals that the majority of them are PHEVs, perhaps due to long commutes to work by PEV drivers who live in the subregion. The trends indicate that slower, low-voltage charging may be a cost-effective solution for homes and workplaces where PHEVs are parked long enough to fully charge using standard outlets instead of dedicated charging units.

**Table 2. PEV counts by model and product type in Western Riverside County, 2012**

| Battery-electric vehicles (BEVs) | | | | | | | | Plug-in hybrid electric vehicles (PHEVs) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Azure Transit Connect | BMW Active E | Ford Focus Electric | Nissan LEAF | Tesla Model S | Tesla Roadster | NEVs | **Total BEVs** | Chevrolet Volt | Toyota Plug-in Prius | Fisker Karma | Ford C-Max Energi | **Total PHEVs** | **Total PEVs** |
| 1 | 6 | 1 | 107 | 6 | 1 | 7 | 129 | 261 | 180 | 2 | 2 | 445 | 574 |

Source: R.L. Polk & Co.

Given that PEV consumer studies to date have shown PEV buyers residing almost exclusively in single-family homes, it can be assumed that the current counts largely reflect PEVs charging overnight in this housing type. More than 80% of the housing units in the Western Riverside County subregion are single-family homes.[2] This represents a substantial opportunity to increase PEV ownership, since the physical and institutional barriers and financial costs of charging in single-family homes are the lowest among all location types (DeShazo et al. 2012).[3]

## III. Supply of PEV charging spaces: a land use/parking inventory

Plug-in electric vehicles charge while parked. Parking spaces are distributed over local land uses such as single-family residential, multi-unit residential, workplaces, and retail establishments. These parking spaces represent the potential *supply* of PEV parking spaces. Every city will have a different number of parking spaces available at these different land uses. An inventory of parking opportunities at different land uses will help planners target and prioritize PEV readiness efforts, and siting of charging stations, according to locally dominant location types.

Understanding the distribution of land uses within a jurisdiction is also helpful because different land uses are also associated with distinctive parking, electrical, and building configurations which can greatly and systematically affect the cost of installing charging equipment on that parcel. Attributes such as MUD building age and whether it is a condominium or apartment can be used as proxies for estimating potential costs (both financial and institutional) of supply. Parcel attributes that represent

[2] Residential unit counts are based on U.S. Census 2011 American Community Survey 5-year estimates for units in structure. Single-family homes include detached and attached (rowhouse-type) single-family units as well as mobile homes.

[3] Guidance for planners on single-family home charging is provided in Chapter 5 of the Southern California PEV Readiness Plan http://164.67.121.27/files/Downloads/luskincenter/ev/PEV_Readiness_Plan.pdf.

potential demand, supply and cost of supply are explained in more detail in later sections, where we present specific parcels that may be particularly suitable for PEV charging across the subregion because they combine such attributes.

In this section, we present a land use and parking inventory of cities in the Western Riverside County subregion. First, we will present the steps and assumptions used in the preparation of the land use inventory. Then we will present the ways in which subregional and municipal planners can use the information provided in the inventory. Finally, we will present the inventory and offer conclusions about the results.

## Steps and assumptions in the land use/parking inventory

First, planners must identify the availability of types of residential, workplace and retail parcels that could host charging infrastructure in their jurisdictions. Second, the number of potential PEV parking spaces at each land use type or parcel must be estimated.

Ideally, planners should estimate the number of parking spaces at each land use type in a jurisdiction based on local zoning and building code history (or, even better, a field survey of parking). However, in the absence of more refined information, we make the following simplified assumptions:

• We assume that the number of on-site parking spaces for both single-family and multi-unit dwellings (MUDs) is equal to the number of residential units on a parcel. That is, we assume the potential for one PEV charging space per dwelling unit. While in reality there may be more than one parking space per dwelling unit, the numbers vary by city. In addition, the likelihood of more than one PEV charging per home is low in the early and middle years of the PEV market.

• We count MUDs in terms of individual units (i.e., apartments or condominiums), not buildings, because each unit represents at least one potential PEV space. For MUDs that do not have parking, workplaces and publicly-accessible sites will become important charging options.

• We also assume that there is a parking space for every employee at a workplace.

• The aggregate land use inventories presented here do not separately consider retail (customer) spaces, as there is no reliable estimate available for the number of retail customer parking spaces in each city.

The third step involves deciding which types of land use and parking resources should be targeted and in which order. The fourth step, which involves evaluating and targeting specific parcels within a land use category, will be discussed in Sections IV, V and VI.

## Subregional and municipal PEV planning with the land use inventory

PEV readiness efforts and siting of charging stations should be prioritized according to the land uses that offer the highest *number* (across the subregion) or highest *share* (within a city) of potential PEV parking spaces.

**Subregional planners** will maximize the effectiveness of their resources by prioritizing PEV-ready reforms to zoning and building codes, permitting and signage standards in jurisdictions with the largest **absolute numbers** of the targeted site hosts and/or drivers. In doing so, the policy reforms that are implemented will affect the largest absolute number of prospective charge station site hosts and/or drivers. In order to know which municipalities to target, Western Riverside County planners will need to know how many parking spaces are located at different land uses across member cities.

**Municipal planners** may wish to know what **share** of parking within their jurisdictions is tied to each land use in order to prioritize PEV planning around those most frequently-encountered land uses. These planning metrics will enable them to assess the relative importance of different land uses within their local PEV readiness plan. For example, a municipality such as Canyon Lake will prioritize single-family charging because this is where more than 80% of all of its parking spaces are by land use. While parking space counts can describe the size of each individual land use opportunity, only data on the shares of land uses can assist the municipal planner in identifying the relative importance of specific land uses.

In the next section, we present both counts and shares of parking by land use within municipalities since these metrics will support both subregional as well as local PEV planning activities.

## Parking opportunities in Western Riverside County

Tables 3 – 8 rank each of the Western Riverside County cities by the estimated **number** of parking spaces in each city by land use (single-family, MUD, and employee) as well as the **share** of parking spaces within each city that are represented by a particular land use. While single-family homes represent the dominant parking opportunity in nearly all cities in Western Riverside County, workplace parking represents the majority of parking spaces in four cities (Riverside, Corona, Temecula, and Norco). All cities except for one (Lake Elsinore) have more than half of all parking spaces in either workplaces or single-family homes.

**Table 3. Estimated parking spaces by single-family *counts*, Western Riverside County[4]**

| | **Single-Family Count** | MUD Count | Employee Count |
|---|---|---|---|
| Riverside | **70,331** | 28,981 | 137,610 |
| Moreno Valley | **45,730** | 8,377 | 25,856 |
| Corona | **36,245** | 9,944 | 56,216 |
| Hemet | **27,931** | 6,936 | 19,839 |
| Murrieta | **27,675** | 5,526 | 18,818 |
| Menifee | **27,369** | 1,158 | 8,776 |
| Temecula | **26,840** | 5,650 | 42,175 |
| Jurupa Valley[5] | **23,467** | 3,244 | 14,666 |
| Perris | **15,834** | 1,912 | 12,419 |
| San Jacinto | **13,397** | 1,384 | 6,546 |
| Lake Elsinore | **13,257** | 2,709 | 10,483 |
| Eastvale | **13,080** | 656 | 3,899 |
| Banning | **12,093** | 1,581 | 4,497 |
| Wildomar | **9,989** | 649 | 3,328 |
| Norco | **7,397** | 268 | 11,616 |
| Canyon Lake | **4,195** | 90 | 893 |
| Calimesa | **3,695** | 70 | 1,632 |

Source: U.S. Census

**Table 4. Estimated parking spaces by single-family *shares*, Western Riverside County**

| | **% Single-Family** | % MUD | % Employee |
|---|---|---|---|
| Canyon Lake | **81%** | 2% | 17% |
| Eastvale | **74%** | 4% | 22% |
| Menifee | **73%** | 3% | 24% |
| Wildomar | **72%** | 5% | 24% |
| Calimesa | **68%** | 1% | 30% |
| Banning | **67%** | 9% | 25% |
| San Jacinto | **63%** | 6% | 31% |
| Moreno Valley | **57%** | 10% | 32% |
| Jurupa Valley | **57%** | 8% | 35% |
| Murrieta | **53%** | 11% | 36% |
| Perris | **52%** | 6% | 41% |
| Hemet | **51%** | 13% | 36% |

[4] Employee counts are based on U.S. Census Longitudinal Employer-Household Dynamics, Area Profile Analysis 2010, All Jobs. MUD and single-family counts are based on U.S. Census 2011 American Community Survey 5-year estimates for units in structure. Single-family homes include detached and attached (rowhouse-type) single-family units as well as mobile homes.

[5] Jurupa Valley numbers are the sum of Glen Avon, Rubidoux, Mira Loma, Sunnyslope, and Pedley Census Designated Places.

| | | | |
|---|---|---|---|
| Lake Elsinore | **50%** | 10% | 40% |
| Norco | **38%** | 1% | 60% |
| Temecula | **36%** | 8% | 56% |
| Corona | **35%** | 10% | 55% |
| Riverside | **30%** | 12% | 58% |

Source: U.S. Census

**Table 5. Estimated parking spaces by MUD *counts*, Western Riverside County**

| | **MUD Count** | Single-Family Count | Employee Count |
|---|---|---|---|
| Riverside | **28,981** | 70,331 | 137,610 |
| Corona | **9,944** | 36,245 | 56,216 |
| Moreno Valley | **8,377** | 45,730 | 25,856 |
| Hemet | **6,936** | 27,931 | 19,839 |
| Temecula | **5,650** | 26,840 | 42,175 |
| Murrieta | **5,526** | 27,675 | 18,818 |
| Jurupa Valley | **3,244** | 23,467 | 14,666 |
| Lake Elsinore | **2,709** | 13,257 | 10,483 |
| Perris | **1,912** | 15,834 | 12,419 |
| Banning | **1,581** | 12,093 | 4,497 |
| San Jacinto | **1,384** | 13,397 | 6,546 |
| Menifee | **1,158** | 27,369 | 8,776 |
| Eastvale | **656** | 13,080 | 3,899 |
| Wildomar | 649 | 9,989 | 3,328 |
| Norco | 268 | 7,397 | 11,616 |
| Canyon Lake | 90 | 4,195 | 893 |
| Calimesa | 70 | 3,695 | 1,632 |

Source: U.S. Census

**Table 6. Estimated parking spaces by MUD *shares*, Western Riverside County**

| | **% MUD** | % Single-Family | % Employee |
|---|---|---|---|
| Hemet | **13%** | 51% | 36% |
| Riverside | **12%** | 30% | 58% |
| Murrieta | **11%** | 53% | 36% |
| Moreno Valley | **10%** | 57% | 32% |
| Lake Elsinore | **10%** | 50% | 40% |
| Corona | **10%** | 35% | 55% |
| Banning | **9%** | 67% | 25% |

| | | | |
|---|---|---|---|
| Jurupa Valley | **8%** | 57% | 35% |
| Temecula | **8%** | 36% | 56% |
| San Jacinto | **6%** | 63% | 31% |
| Perris | **6%** | 52% | 41% |
| Wildomar | **5%** | 72% | 24% |
| Eastvale | **4%** | 74% | 22% |
| Menifee | **3%** | 73% | 24% |
| Canyon Lake | **2%** | 81% | 17% |
| Norco | **1%** | 38% | 60% |
| Calimesa | **1%** | 68% | 30% |

Source: U.S. Census

Riverside has the highest absolute numbers of parking opportunities at both single-family homes and MUDs, with Moreno Valley, Corona and Hemet also appearing more than once in the top five positions for both single-family and MUDs. However, due to high numbers of employees, both single-family and MUD parking spaces represent much smaller *shares* of parking opportunities in Riverside and Corona.

In contrast, the vast majority of parking opportunities in Canyon Lake, Eastvale, Menifee, Wildomar, Calimesa, Banning, and San Jacinto are located at single-family homes. Even in Hemet, which has the highest share of its parking opportunities at MUDs (13%), the parking spaces available at MUDs are far outweighed by single-family and employee parking.

The same five cities that rank highest in terms of MUD counts also rank highest in employee counts, as shown in Table 7.

**Table 7. Estimated parking spaces by employee *counts*, Western Riverside County[6]**

| | **Employee Count** | Single-Family Count | MUD Count |
|---|---|---|---|
| Riverside | **137,610** | 70,331 | 28,981 |
| Corona | **56,216** | 36,245 | 9,944 |
| Temecula | **42,175** | 26,840 | 5,650 |
| Moreno Valley | **25,856** | 45,730 | 8,377 |
| Hemet | **19,839** | 27,931 | 6,936 |
| Murrieta | **18,818** | 27,675 | 5,526 |
| Jurupa Valley[7] | **14,666** | 23,467 | 3,244 |
| Perris | **12,419** | 15,834 | 1,912 |
| Norco | **11,616** | 7,397 | 268 |

[6] Employee counts are based on U.S. Census Longitudinal Employer-Household Dynamics, Area Profile Analysis 2010, All Jobs. MUD and single-family counts are based on U.S. Census 2011 American Community Survey 5-year estimates for units in structure. Single-family homes include detached and attached (rowhouse-type) single-family units as well as mobile homes.

[7] Jurupa Valley numbers are the sum of Glen Avon, Rubidoux, Mira Loma, Sunnyslope, and Pedley Census Designated Places.

| | | | |
|---|---|---|---|
| Lake Elsinore | **10,483** | 13,257 | 2,709 |
| Menifee | **8,776** | 27,369 | 1,158 |
| San Jacinto | **6,546** | 13,397 | 1,384 |
| Eastvale | **3,899** | 13,080 | 656 |
| Banning | **4,497** | 12,093 | 1,581 |
| Wildomar | **3,328** | 9,989 | 649 |
| Calimesa | **1,632** | 3,695 | 70 |
| Canyon Lake | **893** | 4,195 | 90 |

Source: U.S. Census

The City of Riverside contains by far the highest number of employee parking spaces out of any city in Western Riverside County, with more than twice the number of employee parking spaces as Corona and more than three times as many as are found in Temecula. However, the city of Norco, while having a fraction of the workplace parking spaces found in Riverside, is also a strong candidate for workplace charging. This is because workplace parking comprises a higher share of parking spaces in Norco than it does in any other city.

**Table 8. Estimated parking spaces by employee *shares*, Western Riverside County**

| | **% Employee** | % Single-Family | % MUD |
|---|---|---|---|
| Norco | **60%** | 38% | 1% |
| Riverside | **58%** | 30% | 12% |
| Temecula | **56%** | 36% | 8% |
| Corona | **55%** | 35% | 10% |
| Lake Elsinore | **40%** | 50% | 10% |
| Perris | **41%** | 52% | 6% |
| Hemet | **36%** | 51% | 13% |
| Murrieta | **36%** | 53% | 11% |
| Jurupa Valley | **35%** | 57% | 8% |
| Moreno Valley | **32%** | 57% | 10% |
| San Jacinto | **31%** | 63% | 6% |
| Calimesa | **30%** | 68% | 1% |
| Banning | **25%** | 67% | 9% |
| Wildomar | **24%** | 72% | 5% |
| Menifee | **24%** | 73% | 3% |
| Eastvale | **22%** | 74% | 4% |
| Canyon Lake | **17%** | 81% | 2% |

Source: U.S. Census

The land use inventories presented here and the parcel tables presented in the next section were created using different data sources, including Census estimates and county assessor databases. Planners should keep in mind that some level of error exists in every data source, and should view the tools presented in this deployment plan as guidelines that complement each other and that should be validated with local knowledge.

## IV. MUD charging opportunities: a parcel-level analysis

PEV ownership is in its infancy in Western Riverside County. Most neighborhoods have few or no PEVs registered to residences. Because there are fewer barriers to charging in single-family homes, most early adopters of PEVs have been single-family residents (CCSE 2012). MUDs represent less than 20% of the housing units in Western Riverside County. These factors combined would predict that relatively few PEVs are registered in neighborhoods where the largest MUDs are located. In fact, of the largest MUDs in Western Riverside County, none were located in neighborhoods with more than 12 PEVs registered. Due to the significant physical and institutional barriers to MUD charging, encouraging PEV adoption in this housing type will require a focused planning effort to establish PEV-ready wiring by code, by negotiation with developers, or through targeted outreach and demonstration projects.

While the planning metrics discussed in Section III can help characterize MUD charging potential at the subregional and city level, they do not show exactly where such opportunities are located spatially. This section presents the largest MUDs across Western Riverside County that are located in neighborhoods in which a moderate number of PEVs (6-12) were registered in 2012.[8] The maps and tables in the Appendix show the neighborhoods and parcels in each of the 17 cities in Western Riverside County with the highest suitability to host PEV charging based on MUD size (number of units), PEV density, and other criteria discussed below.

Planners can use the maps and tables to identify specific MUDs or owners that could potentially host on-site charging. Utilities can use this information to anticipate where upgrades may be needed for transformers and distribution stations to accommodate PEV charging at MUDs.

The maps and tables below and in the Appendix are designed to help answer the following questions:

- What are the largest MUD buildings and where are they located?
- Which MUDs are located in neighborhoods where there are registered PEVs?
- What other attributes may affect demand or the cost to supply PEV charging at the MUD?

Larger MUDs are better candidates for hosting more PEV charging, given that they have more parking spaces (including visitor spaces). Landlords and condominium associations may also be better-

[8] High PEV density would indicate 13 or more PEVs registered in a neighborhood in which an MUD is located, according to the distribution of PEV registrations in SCAG subregions analyzed by the UCLA Luskin Center. The largest MUDs in Western Riverside County are all located in areas of moderate (6-12) PEV density.

positioned to achieve economies of scale and recover their costs with more residents using the charging units. Table 9 lists the 20 largest MUD developments in Western Riverside County by number of units.

**Table 9. Largest 20 MUDs, Western Riverside County**

| Address | City | Number of units | Year built[9] |
|---|---|---|---|
| 10250 W COUNTRY VILLAGE RD | Jurupa Valley | 1228 | 1965 |
| 5464 W HOMECOMING CIR | Eastvale | 738 | 2005 |
| 12640 MEMORIAL WAY | Moreno Valley | 552 | 2006 |
| 590 N MCKINLEY ST | Corona | 492 | |
| 25100 VISTA MURRIETA RD | Murrieta | 492 | 2006 |
| 24375 JACKSON AVE | Murrieta | 460 | 1989 |
| 3887 PIERCE ST | Riverside | 440 | |
| 7450 NORTHROP DR | Riverside | 432 | |
| 24850 HANCOCK AVE | Murrieta | 420 | |
| 1530 VIA SANTIAGO ST | Corona | 412 | 1987 |
| 29405 RANCHO CALIFORNIA RD | Temecula | 400 | |
| 13933 CHAGALL CT | Moreno Valley | 384 | 1987 |
| 42200 MORAGA RD | Temecula | 344 | 1986 |
| 30000 RANCHO CALIFORNIA RD | Temecula | 344 | |
| 2235 TREEHOUSE LN | Corona | 336 | |
| 24909 MADISON AVE | Murrieta | 329 | 2002 |
| 342 DALE ST | Perris | 324 | 2003 |
| 890 HOTSPRING ST | Corona | 320 | |
| 551 SANTA FE ST | Hemet | 320 | |
| 36491 YAMAS DR | Wildomar | 320 | |

Source: Riverside County Assessor

Knowing the age of a building, in conjunction with other attributes such as size of the electrical panel and parking configuration, can help planners assess the hard and soft costs involved in providing charging at that MUD. Building age may be correlated with panel size and distance between the electrical panel and where vehicles are parked. Building age may also indicate the likelihood of an MUD not having any on-site parking as well as other parking, construction or electrical features that may be typical of MUDs built in a city at a certain point in time. An understanding of MUD building vintages may help planners consider potential permitting and installation streamlining measures that may be needed.

A forthcoming study by California Department of Housing and Community Development will address the relationship between MUD parking configurations and installation cost of PEV-ready wiring. Below are

[9] Information is omitted where parcel identification numbers could not be matched to construction years in the Assessor databases or to year-built information on web sites such as ForRent.com, LoopNet.com, Homes.com, or developer web sites. Due to the inconsistency in the availability of year-built data from the Riverside County Assessor, planners interested in this information should examine city building and planning department records.

some general guidelines about how to assess the PEV charging suitability of an MUD along certain attributes.

## Panel size

Cities generally adopt state or national model codes for building and electrical standards, sometimes with changes that reflect local conditions and preferences. These codes specify minimum requirements for electrical panel sizes in certain types of buildings. Because the first full statewide building code for California was not published until 1989, individual California cities adopted or adapted standards from the National Electrical Code at different times over the years. It is therefore difficult to use year of construction as a definitive indicator of the cost of supplying PEV charging. Even if the year of construction is known, a site visit or permit search may be required to verify the building's actual electrical panel size, as it may have been upgraded over the years.

A study by PEV consulting firm Clean Fuel Connection sampled single-family homes in Southern California Edison's service territory to describe charging installation cost as a function of factors including building age and existing panel size. The results indicated that homes built in 1970 or later faced lower installation costs (Joffe 2010). In a sample of 192 single-family homes, 20% - 30% of customers with 100 amperes of service needed an upgrade to accommodate a PEV. However, none of those with 200 amperes needed an upgrade.[10] The small sample size and the fact that these results were for single-family homes may limit their applicability to MUDs.

## Energy efficiency

Most MUD parking area panels are sized to serve the minimum lighting, HVAC, or other electrical needs of the parking area, without enough extra capacity to provide Level 2 charging. Buildings constructed prior to 1978, when California's first energy efficiency standards for new buildings went into effect, may benefit from energy efficiency upgrades that would free up electrical capacity to provide Level 2 charging.

## Parking configuration

Other information about an MUD, such as the type of parking (subterranean, podium, carport, or detached), may also help determine the hard and soft costs of PEV charging at that location. Subterranean and podium parking structures are frequently built with some 120V outlets for general maintenance and service needs, even where not required by code. These outlets could be available for Level 1 charging and may circumvent the need (in the short run) to install a Level 2 charger and the accompanying panel upgrade that may be needed for Level 2. Carports, on the other hand, are not

[10] Enid Joffe, personal communication, June 18, 2013.

usually built with electrical outlets.[11] Installing a charger in a detached garage is often more expensive than installing one in an attached garage, due to the increased length of conduit needed to connect to the electricity source (Clean Fuel Connection, Brazell & Co. 2011).

However, number of units and building age are not the only factors that may affect demand for and cost (financial and logistical) to supply PEV charging. While most early PEV adopters reside in single-family homes due to the lower physical and institutional barriers associated with single-family charging, MUDs could represent middle-market PEV demand. The number of PEVs registered in the neighborhood where the MUD is located may indicate unmet demand for PEVs by MUD residents that may be similar to nearby single-family homeowners but for the difficulty in charging at an MUD. Moderate PEV density indicates the relative quantity of PEVs (6-12) that are registered to residences in the neighborhood where the MUD is located.[12]

Whether the MUD is a condominium could indicate possible institutional barriers to installing PEV charging due to deeded or assigned parking. However, condominiums experience less turnover than rental properties and unit owners may be more likely than landlords to install hardware for their long-term use. High unit values may also indicate higher demand for PEV charging.[13]

**Table 10. Largest MUDs in neighborhoods of moderate PEV registration, Western Riverside County**

| Address | | | City | Number of units | Year built | Condo? | Unit value |
|---|---|---|---|---|---|---|---|
| 31237 | HIGHWAY 79 | | Temecula | 180 | | N | $221,226 |
| 39930 | WHITEWOOD | RD | Murrieta | 180 | 1989 | N | $199,268 |
| 26900 | WINCHESTER CREEK | AVE | Murrieta | 175 | | N | $168,441 |
| 2660 | CLARK | AVE | Norco | 40 | | N | $67,559 |
| 39060 | AGUA VISTA | | Murrieta | 36 | 1986 | N | $89,327 |
| 39011 | AGUA VISTA | ST | Murrieta | 32 | 1989 | N | $92,974 |
| 38981 | CALLE HERMOSA | | Murrieta | 24 | | N | $51,536 |
| 28239 | VIA PRINCESSA | | Murrieta | 16 | | N | $54,611 |
| 39078 | AGUA VISTA | RD | Murrieta | 12 | | N | $23,384 |

Source: Riverside County Assessor, R.L. Polk & Co.

[11] Interview with Osama Younan, chief of the Green Building and Mechanical Engineering Section, Los Angeles Department of Building and Safety, June 13, 2013.

[12] Registration data was purchased from R.L. Polk & Co., an automotive data vendor. The counts in the maps and parcel-specific tables reflect vehicles newly registered from December 2010, when the Chevrolet Volt and Nissan LEAF were introduced, through September 2012.

[13] Information on ownership type, year-built and unit value were obtained from the Riverside County Assessor tables extracted in April 2013 by the Riverside County Transportation and Land Management Agency. Average unit values for non-condos were obtained by dividing the assessed value of the property by the number of units. Unit values for condos are the assessed value of one example condo unit on the property and may not be representative of all the units on the property. For developments in which each unit has a separate address, one address is given to stand for the development as a whole.

### Conclusions

Although the City of Riverside has the highest absolute numbers of MUD units compared to other cities in Western Riverside County, it does not frequently contain the largest MUDs, nor does it contain the ones in neighborhoods of moderate PEV registration density. This suggests that less dense cities are home to larger MUD developments, and that some of these developments are located in neighborhoods that have current demand for PEVs.

The largest MUDs in medium-PEV density neighborhoods are located in three cities: Temecula, Murrieta and Norco. Given that only 11% of the overall parking opportunities in Murrieta are at MUDs, the fact that there are several MUD developments in areas where PEVs are registered could indicate latent demand for MUD charging in Murrieta. Five developments in Murrieta—the properties on Agua Vista, Calle Hermosa and Via Princessa—are located within a few blocks of each other. Targeting clusters of MUDs that show potential demand for PEV charging may help planners efficiently employ outreach and demonstration efforts.

It is possible that some large MUDs have the same owners or developers, which would allow planners to focus planning efforts even further. For example, Assessor records reveal that the properties at 39060 and 39011 Agua Vista Street have the same owner, as do the properties at 26900 Winchester Creek in Murrieta and 29405 Rancho California in Temecula. Ownership information is available for most properties from the Assessor's office. Large MUD developers that are generally active in Western Riverside County may also be good targets.

Many developments in Western Riverside County are considered MUDs for tax purposes but otherwise resemble single-family homes in that garages are attached to individual units. Such developments have been excluded from our MUD ranking because they do not require the same type of planning effort as do MUDs with common parking areas that are not physically attached to individual units. However, MUDs that otherwise resemble single-family homes may benefit from outreach to homeowner associations and owners of rental developments, as well as from PEV-ready building and zoning codes that are similar to those that apply to single-family homes.

## V. Workplace charging

Workplaces present a significant, and largely untapped, opportunity for PEV charging. After residences, they are the single most important environment for electric refueling. Vehicles are generally parked at workplaces for several hours every weekday, making it possible for them to completely recharge before the commute home. This is especially important for maximizing the electric miles driven by PHEVs, which use gasoline when their batteries are depleted. The ability to charge at work may also encourage PEV adoption by those for whom residential charging is cost-prohibitive or logistically difficult, particularly residents of multi-unit dwellings. Workplace charging thus represents the "missing link" between residential and publicly accessible charging.

This section will help planners assess workplace charging opportunities across and within local jurisdictions. It will describe how planners can use the tables that accompany this document to prioritize parcels for targeted workplace charging assistance.

## Assessing the workplace charging opportunity

After conducting the land use inventory (Section III), planners can further target specific employers based on number of employees at the workplace and PEV density in the employer's neighborhood during weekday morning rush hour. Additionally, white-collar employees and high-tech workplaces may indicate PEV charging demand by employees.

The subregional table in this section and the city-level tables that accompany this document will help planners and utilities answer 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?

Workplaces with large numbers of employees may be better-positioned than small businesses to recover costs from offering PEV charging due to higher potential usage. Determining which employers are the largest will help planners target outreach efforts and help utilities prioritize locations for transformer and power distribution upgrades.

Tables 11 and 12 rank the largest workplaces in high-PEV and medium-PEV areas in the Western Riverside County subregion by number of employees. High PEV density means that there are 13 or more PEVs that are parked during morning rush hour (6:00 a.m. to 9:00 a.m.) in the neighborhood where the workplace is located. Medium PEV density means there are 6-12 PEVs parked in the employer's neighborhood during that time. Where available, information is provided about whether an employer is in a high-tech or related sector or if at least 50% of its employees are white-collar. These attributes could further indicate potential demand, as high-tech firms have been early adopters of PEV workplace charging and studies indicate PEV ownership is currently correlated with higher incomes and levels of education.

Employer data was obtained from 1) the South Coast Air Quality Management District's April 2013 database of employers subject to Rule 2202, which mandates that workplaces of at least 250 employees take measures to reduce emissions from employee commutes; and 2) commercially available Infogroup data from 2008 on employer size (i.e., number of employees), location, and information on whether the business is in a high-tech sector and whether its employees are mostly white-collar (where available).[14]

[14] The UCLA Luskin Center has made an effort to reclassify certain companies along these attributes where appropriate.

PEV density is predicted according to SCAG's 2008 regional travel model[15] as applied to registration data from R.L. Polk & Co. 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.[16] By counting the number of PEVs from each *origin* TAZ that feed into each of the daytime *destination* TAZs, we were able to predict the locations and densities of PEVs traveling to work on weekdays from 6:00 a.m. to 9:00 a.m. It is important to note that these morning peak destination TAZs receive vehicles from outside the city.

**Table 11. Largest workplaces in neighborhoods of high PEV density during weekday mornings, Western Riverside County**

| City | Company | Address | Employees | High-Tech | White-Collar |
|---|---|---|---|---|---|
| Temecula | Professional Hospital Supply, Inc. | 41980 Winchester Rd | 1100 | N | Y |
| Corona | Watson Laboratories | 132 Business Center Dr | 960 | Y | Y |
| Temecula | Hexfet America | 41915 Business Park Dr | 663 | Y | Y* |
| Corona | Fender Musical Instruments | 1163 Pomona Rd | 653 | N | N |
| Corona | Dart Container Corp of California | 150 S Maple St | 426 | N | Y |
| Corona | Thermal Structures, Inc. | 2362 Railroad St | 271 | Y | N |
| Temecula | Millipore Inc. | 28820 Single Oak Dr | 270 | N | N |
| Temecula | Abbott Cardiovascular Systems | 42301 Zevo Dr | 256 | | |
| Corona | Circle Seal Controls Inc | 2301 Wardlow Cir | 250 | Y | N |
| Corona | R W Lyall & Co Inc | 2665 Research Dr | 220 | N | N |
| Murrieta | Temecula Valley Drywall | 41228 Raintree Ct | 220 | N | N |
| Corona | Brasscraft Manufacturing Co | 215 N Smith Ave | 200 | N | N |
| Corona | Appa Fine Foods Inc | 135 Klug Cir | 200 | N | N |
| Corona | Minka-Aire | 1151 Bradford Cir | 200 | N | N |
| Temecula | Chemicon International Inc | 28820 Single Oak Dr | 200 | N | N |
| Temecula | Molding International Enginrng | 42136 Avenida Alvarado | 200 | N | N |
| Temecula | Opto 22 | 43044 Business Park Dr | 200 | N | Y |
| Temecula | Keller Williams Realty | 27290 Madison Ave # 200 | 198 | N | Y |
| Corona | ATK Space Systems & Sensors | 250 Klug Cir | 185 | Y* | Y* |
| Murrieta | Star Trac Strength Inc | 41180 Raintree Ct | 150 | N | N |
| Temecula | Cutting Edge Staffing Inc | 41750 Winchester Rd # L | 150 | N | Y |

*Reclassified by Luskin Center

Sources: South Coast Air Quality Management District, Infogroup, Luskin Center application of data from R.L. Polk & Co. and SCAG regional travel model

**Table 12. Largest workplaces in neighborhoods of medium PEV density during weekday mornings, Western Riverside County**

| City | Company | Address | Employees | High-Tech | White-Collar |
|---|---|---|---|---|---|
| Riverside | County of Riverside | 4080 Lemon St | 3222 | N | N |
| Riverside | Riverside Community Hospital | 4445 Magnolia Ave | 1865 | N | N |

[15] http://www.scag.ca.gov/modeling/pdf/MVS08/MVS08_Chap05.pdf

[16] http://www.scag.ca.gov/modeling/index.htm

| | | | | | |
|---|---|---|---|---|---|
| Riverside | Riverside City Hall | 3900 Main St | 739 | N | N |
| Riverside | County of Riverside | 4050 Main St | 543 | N | N |
| Riverside | Press-Enterprise | 3512 Fourteenth St | 461 | N* | Y* |

*Reclassified by Luskin Center

Sources: South Coast Air Quality Management District, Infogroup, Luskin Center application of data from R.L. Polk & Co. and SCAG regional travel model

### Conclusions

The 21 largest employers located in neighborhoods of high PEV travel during morning rush hour are found in only three cities: Temecula, Corona, and Murrieta. This suggests that employers in these cities may be early adopters of workplace charging. Only Riverside employers are located in areas of medium PEV travel during morning rush hour, suggesting locations where employers may adopt workplace charging as the market matures. Employers in health care, technology, and the public sector may find that PEV charging aligns with sustainability goals, a green- or tech-friendly image, or a desire to attract or retain employees that drive PEVs.

The County of Riverside ranks among the largest employers in seven WRCOG cities. Although only two County workplaces are located in an area of moderate PEV density (both in Riverside, as shown in Table 11), the County may be a suitable employer to target for workplace charging. This is because of the high number of parking spaces hosted by the County and a potential desire to meet sustainability goals.

## VI. Retail charging

Most plug-in electric vehicle (PEV) charging occurs at home, followed by charging at the workplace. However, the proliferation of plug-in hybrid electric vehicles (PHEVs) has increased the demand for more sporadic charging outside of home or work. To maximize their electric miles driven, many PHEV drivers find it valuable to charge when visiting retail destinations.

Whether charging at public-sector and retail sites is cost-effective for PEV drivers and financially viable for charge station operators will depend upon several factors. These include where stations are located, how much demand there is for charging, and how much it costs to use or own the charge station.[17] This section will help planners assess retail charging opportunities across and within jurisdictions. We present a streamlined process for screening potential retail PEV charging sites and then present more specific information that retailers and planners should obtain about parking on the site to determine actual suitability for PEV charging.

Planners can use the subregional maps provided in the Southern California PEV Atlas or the city-level maps in the Appendix of this document to identify the retail parcels in their respective jurisdictions. The

[17] Guidance on pricing use of retail charging stations is provided in Chapter 8 of the Southern California PEV Readiness Plan http://164.67.121.27/files/Downloads/luskincenter/ev/PEV_Readiness_Plan.pdf.

maps also overlay retail centers of different sizes with densities of PEVs traveling between 9:00 a.m. and 3:00 p.m. Planners and utilities can use these maps to compare the spatial distribution of retail centers and mid-day travel destinations for PEVs. Those retail locations are classified by store type (from regional mall to small storefront) and parking configuration as described in Table 13. Planners can then conduct a land use inventory to estimate how large a share of parking spaces in their jurisdiction are made up by those retailers.

**Table 13. Southern California Association of Governments retail land use classifications (as mapped in the Southern California PEV Readiness Plan and the Appendix to the Western Riverside County PEV Deployment Plan)**

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

Another way to evaluate the potential of a site host to supply PEV charging is by ranking retailers by annual sales volume. Retailers with higher annual sales may be better equipped to absorb the upfront infrastructure investment of providing PEV charging. Higher annual sales may indicate higher aggregate demand for PEV charging, though the amount of time customers spend parked at the site will be of key importance in determining how much PEV charging is used and whether it can be provided at a price that is cost-effective for both the retailer and the driver.

Table 14 below is designed to help answer the following questions:

- What are the largest retailers by sales and where are they located?
- Which retailers are located in neighborhoods where PEVs are parked during mid-day hours?

Table 14 lists the top retailers in Western Riverside County by annual sales (in thousands) as provided in Infogroup's 2008 database.[18] Retailers are defined as businesses classified under the following North American Industrial Classification System descriptions: retail trade; arts, entertainment and recreation; accommodation and food services; and other services (i.e., dry cleaners and beauty salons). PEV density indicates the relative quantity of PEVs that are parked during mid-day hours (9:00 a.m. to 3:00 p.m.) in the neighborhood in which the retailer is located. A high PEV density indicates that at least 13 PEVs are

[18] Significant retailers not listed in Infogroup's database are also listed separately by city in the Appendix. These include gyms, big-box retailers, etc.

parked in the neighborhood, while medium density indicates the presence of 6-12 PEVs. None of the top retailers in Western Riverside County were located in areas of high PEV presence at mid-day.

We estimated mid-day PEV density by applying Census tract-level PEV registration data to SCAG's 2008 regional travel model. 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 midday *destination* TAZs, we are able to predict the number of PEVs traveling to neighborhoods from 9:00 a.m. to 3:00 p.m.

**Table 14. Top retailers in medium-PEV neighborhoods at mid-day, Western Riverside County**

| City | Company | Address | Annual Sales (in thousands) |
|---|---|---|---|
| Corona | Corona Nissan | 2575 Wardlow Rd | $76,451 |
| Corona | Aircraft Spruce & Specialty Co | 225 Airport Cir | $39,060 |
| Temecula | Wal-Mart Supercenter | 32225 US Highway 79 S | $35,640 |
| Corona | C & R Systems Inc | 1835 Capital St | $32,300 |
| Temecula | Stater Bros Markets | 31813 US Highway 79 S | $29,640 |
| Corona | Victor Buick GMC | 2525 Wardlow Rd | $26,000 |
| Corona | Power Volkswagen | 2603 Wardlow Rd | $25,770 |
| Corona | Mighty Mover Trailers | 224 N Sherman Ave | $25,600 |
| Corona | Giant RV | 180 N Sherman Ave | $25,600 |
| Temecula | Henry's Market Place | 32413 State Highway 79 | $20,995 |
| Corona | Bosch Kia Isuzu of Corona | 2683 Wardlow Rd | $14,603 |
| Corona | Giant RV | 1301 Pomona Rd | $14,080 |
| Eastvale | Fritschnet Inc-Hostgo | 6934 Cottonwood Cir | $1,628 |
| Eastvale | Eagle Memory Products | 7111 Tawny Owl Ct | $1,372 |
| Eastvale | Cinematec Home Theater | 13430 Cascade Ct | $1,292 |
| Eastvale | Net Runner Global | 7318 Silverwood Dr | $1,141 |
| Eastvale | Stork News-the Inland Empire | 12752 Hungarian St | $644 |
| Eastvale | Sashi Bear LLC | 6310 Golden Bit St | $603 |
| Eastvale | A G Organics | 7215 Woodpigeon Rd | $546 |

Sources: R.L. Polk & Co., Infogroup

The retailers listed above tend to fall into three categories: car dealerships, large retail chains, and small businesses. These retailers may have different customer demographics, vehicle dwell times, and energy costs associated with their typical operation. Planners and retailers should consider these and other factors that will help determine demand and relative cost-effectiveness for each potential PEV charging location after initially screening retailers by annual sales and mid-day PEV density. These additional criteria are described in the next section.

## Evaluative criteria for the selection of retail charging sites

Planners will want to consider a variety of criteria when prioritizing a site or group of sites. Many of these criteria relate to a site's potential demand for charging or its relative cost-effectiveness in hosting a station. These factors include:

- Potential demand for PEV charging
- Frequency of visits per week
- Time of day when charging
- How long cars are parked (a.k.a. "dwell time")
- Cost of electricity (and demand charges)
- The value of non-PEV parking spaces to the site host
- Driver's cost of waiting
- "Green" reputation for site host

### Sites and areas with high potential demand for charging

One of the most important criteria is that the site be a place where PEVs are or will be parked. Several types of current driver-specific, site-specific, and neighborhood-specific criteria can be used to assess current- and near-term potential **demand** for charging. The most reliable evidence on potential charge station utilization comes from those drivers currently using parking at a site. Indeed, the best site-specific evidence is the actual presence of PEVs parked on or adjacent to the site. Customer surveys (or driver surveys in the case of public-sector sites) of PEV ownership and the intent to purchase a PEV can also be a good predictor. Future demand for PEVs is often associated with the current ownership of hybrids, so a higher-than-average concentration of hybrids in a parking lot may be a good predictor. Planners could also use demographics associated with early-market PEV adopters. These characteristics include customers with higher educational achievement, moderate to higher incomes, willingness to innovate, and often attitudes that are pro-environment or pro-oil independence (CCSE 2012; Nixon and Saphores 2011; Landy 2011).

The **frequency** and **total level of visitation** to a site can also be an important factor. Planners might also ask where the site supports parking for 1) routine daily travel (work, school, gyms, etc.), 2) routine weekly travel (stadiums, theaters, churches, etc.) or 3) occasional travel (hotels, major vacation destination charging or freeway-adjacent stations). We discuss specific site types in greater detail in the following sections.

Other site-specific characteristics, such as size and location, may be useful but should be used to make a choice between competing sites that have been prioritized based on customer- or driver-specific evidence of potential demand. With all else equal, sites with larger parking capacity (for example, big-box retailers such as Walmart) are more likely to host PEVs. Similarly, prioritizing sites near high-volume freeways or arterials might incrementally increase site utilization.

Selecting sites that offer the lowest possible cost of charging will benefit not only the site host (by increasing utilization rates) but also PEV drivers (who will pay lower prices for charging). Sites that provide the lowest possible cost per kilowatt-hour (kWh) to PEVs will typically have the following features:

Sites on which PEVs are ***parked for longer periods of time*** (longer "dwell times") enable slower rates of charging, which may enable the use of less costly Level 1 charging rather than more costly Level 2 or fast charging. The longer the dwell time, the more miles of electric range can be added. At Level 1, an hour of charge can add five to 10 miles of range, depending on the capacity of the vehicle's onboard charger. At Level 2, an hour of charge adds between 10 to 20 miles of range, depending on the capacity of the vehicle's onboard charger. Longer PEV dwell times also enable multi-armed smart chargers to deliver lower costs per kWh delivered over a larger numbers of vehicles. Slower charging, enabled by long dwell times, may also help site owners to avoid electricity demand charges.

Planners may also want to balance factors like average trip distance and frequency of travel to a site with the dwell time for each particular site type. While routine destinations may see greater use, shorter trips may benefit less from charging than would longer trips with longer dwell times. Drugstores, for example, would have shorter dwell times than theaters or recreational areas, but may have more patrons on an average day.

Some car dealerships may allow PEV drivers to charge their vehicles even if the driver did not purchase the vehicle that particular dealership, though the service may not be available to drivers of other PEV makes. Unless the driver is bringing a vehicle to the dealer for service, he or she would likely only be using the site for charging, similar to a DC Fast station.

A feature related to the land use or type of site is time of PEV arrival at the site, which determines the t***ime of day when charging would occur***. Charging that occurs before 12:00 p.m. and after 9:00 p.m. will enable most site hosts to provide lower-cost electricity to PEVs because of electricity rates that are lower during these periods. Charging between 12:00 p.m. and 9:00 p.m. is not only the most expensive, but more likely to incur demand charges for the site host.[19] Unfortunately, many types of retail sites are only open between 10:00 a.m. and 9:00 p.m., which is the period when electricity costs are highest and demand charges are most likely. In addition, dwell times are often the lowest for many types of retail destinations, making them the least cost-effective type of land use to host charging. Supermarkets, which already have high energy use during peak daytime hours due to refrigeration, may be inclined to provide PEV charging if it does not significantly increase their electricity cost.

The ***value of regular parking spaces to the site host*** is another factor to consider. For many sites, there is no value lost by replacing a regular parking space with a charging space, because most sites have many unused parking spaces. On sites where there is a shortage of parking, charging stations can also be located in places within parking facilities that are the last to fill up in order to avoid the appearance (to

[19] Demand charges are added to the electricity bills of non-residential customers to reflect the additional cost of delivering power to them during the customer's peak usage times.

the other employees or customers) of displacement.[20] Sites can also experiment with dual-use and time-of-day split use of spaces for both parking and charging. For example, charging spaces intended for government employees during the day can be made available to the general public at night.

The second type of cost that may vary across public-sector and retail sites is the ***driver's time*** while charging. In most instances, PEV drivers will not choose to charge at a site unless there is no additional time associated with charging. Planners should expect the PEV driver will be busy with whatever motivated his or her visit to that destination. Only in the rare case that a PEV driver is in danger of running out fuel are they likely to be willing to spend time refueling, and then they are likely to choose to refuel quickly with gasoline if they own a PHEV. Chargers should be located at sites where drivers would normally stop for at least 1 to 2 hours or more unless they are refueling along interstate corridors during inter-regional travel.

Two other factors may affect the value proposition of hosting a charge station at retail sites. The first is that, for a few types of retail sites that price charging lower than what drivers would pay at home, charging stations may attract customers that would have otherwise gone to another retail site. Second, some site hosts want to support or be associated with "**green**" values or energy independence. These are likely to be retail establishments that incorporate these values into the corporate brand identities.

### Typical dwell times

Based on the above criteria, we identify several broad categories of sites. We use an analysis of 2009 National Household Transportation Survey data (Krumm 2012) to common travel destinations that tend to require at least moderate travel distance. Based on this analysis, the list below features some examples of retail site types where vehicles tend to be parked for about two hours on average:

Commercial parking facilities

Major retail malls

Sporting events and arenas

Major pedestrian-oriented commercial thoroughfares

Bars and evening entertainment venues

Gyms and sports clubs

Finally, Table 15 describes retail sites that have been documented to have relatively shorter travel distances and shorter dwell times (Krumm 2012).

[20] Placement of the first charging space may be constrained by disabled access requirements.

**Table 14. Retail sites with short dwell times**

| Destination | Average dwell time (minutes) |
|---|---|
| Gas stations | 10 |
| Video rental/cleaners/post office/bank | 19 |
| Coffee/ice cream/snacks | 20 |
| Grocery, hardware, clothing store | 36 |
| Attorney/accountant office | 41 |
| Meals/restaurants | 46 |
| Day care | 65 |
| Grooming, hair, nails | 67 |
| Medical/dental services | 68 |

Source: Krumm (2012)

### Charging in stand-alone parking facilities

Areas rich in small stores and businesses may represent demand for charging curbside or in stand-alone parking structures. Operators of stand-alone parking facilities will have different cost recovery goals depending on whether they are government-owned or commercial pay parking lots. 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.

### Conclusions

Due to potentially short dwell times and high charges for electricity during peak daytime hours, it may be a challenge for many retailers to provide PEV charging at a price that is cost-effective for both the host and driver. Planners and retailers must consider many factors in evaluating retail locations for PEV charging, including current demand, vehicle dwell times, level and frequency of visitation, and electricity costs. Retailers with high sales may be in the best position to supply a higher number of parking spaces and absorb the upfront cost of providing PEV charging.

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