CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Public Electric Vehicle Charging Stations at LA Metro Transit Locations

Prepared for: California Energy Commission

Prepared by: EV Connect, Inc.

Gavin Newsom, Governor

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and non-road vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program *Investment Plan Update*. The CEC issued PON-09-006 to provide funding opportunities for electric vehicle charging infrastructure. In response to PON-09-006, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards on May 6, 2011. The agreement was executed as ARV-10-006 on June 16, 2011 in the amount of $415,185.

ABSTRACT

This report, entitled *Public Plug-In Vehicle Charging Stations at Los Angeles Metro Transit Locations,* is the final project report from EV Connect, Inc. for the California Energy Commission grant ARV-10-006. EV Connect teamed with the Los Angeles County Metropolitan Transportation Authority, the Eaton Corporation and Control Module, Inc. to plan and install 20 Level 2 electric vehicle charging stations at five Los Angles Metro transit locations.

The primary objectives of the project were:

- To accelerate plug-in electric vehicle adoption by transit passengers,
- To measure usage of transit passenger plug-in electric vehicle charging stations,
- To advance the sustainability goals of the Los Angeles County Metropolitan Transportation Authority.

The project also sought to understand the habits of electric vehicle drivers and their willingness to pay for electric vehicle charging in concert with riding the Los Angeles Metro system.

Some of the key results:

- The project resulted in more than 1,200 charge sessions over a 6 month period,
- This project reduced greenhouse gas emissions by 8,500 kilograms and saved 1,000 gallons of gasoline, and
- This project provided measurements of the level of charge station use in a commuter setting.

Keywords: Electric vehicles, electric vehicle charging station, electric vehicle service equipment, EVSE high occupancy vehicle, Los Angeles County Metropolitan Transit Authority, greenhouse gas emissions, Open Charge Point Protocol, pollution.

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EXECUTIVE SUMMARY

Los Angeles County is home to nearly 10 million people – more than 25 percent of the state's population – and at least 4 million automobiles. The city is also the historic poster-city for urban traffic, long commutes and vehicle-related pollution.

An increasing number of drivers in greater Los Angeles are combating these stereotypes by moving to electric and hybrid vehicle models. These vehicles can provide shorter commute times by allowing drivers to access high occupancy vehicle lanes while also emitting much less (if any) pollution. Drivers are also using public transit systems, which takes their car off the road and allows for a more leisurely commute. The impetus behind this project was to examine if and how the combination of electric vehicle infrastructure, for example charging stations, and the Los Angeles Metro transit system could be combined to address these issues.

To this end, Los Angeles Metro selected five Metro rail park and ride locations to be equipped with the new charging stations. Los Angeles Metro selected these sites based on commuter traffic, access to Metro bus and Metro train lines, and availability of electric service. The sites selected include

- Union Station (Downtown Los Angeles),
- Willow Station (Long Beach),
- Universal City Station (Universal City),
- El Segundo Station (El Segundo), and
- Sierra Madre Villa Station (Pasadena).

EV Connect installed and commissioned 20 Level 2 electric vehicle charging stations across the five Los Angeles Metro sites; four at each Metro station. All chargers have J1772 connectors. The deployments included hardware manufactured by two different companies, Eaton and Control Module Inc., connected to the EV Connect Network using the Open Charge Point Protocol communication standard. The network allowed remote monitoring and management of the stations as well as recording of information for all charge events that took place at the site.

After six months of usage and data recording, EV Connect identified the following results and benefits:

- The project resulted in more than 1,200 charge sessions over a 6-month period,
- This project reduced greenhouse gas emissions by 8,500 kilograms and saved 1,000 gallons of gasoline, and
- This project provided measurements of the level of charge station use in a commuter setting.

This project provided new insights into the behavior of electric vehicle drivers pertaining to multi-modal commuting. The project also generated new data on how drivers use public transportation when access to affordable electric vehicle charging options is provided.

CHAPTER 1: Project Description

Objectives

The primary objectives of the project were:

- To accelerate the adoption of plug-in electric vehicle (PEV) by transit passengers,
- To measure PEV charge station usage in terms of the number of charge events, and
- To further the sustainability goals of Los Angeles Metro (LA Metro).

In addition to these primary goals, the project team also sought to better understand:

- Charging station utilization in mixed-mode transit situations,
- The commute radius from which drivers might reasonably drive to a charge station for commuting purposes,
- Characteristics of charge station usage including average plug-in time, total connected time and total charging time, and
- Preferences in using electric vehicle (EV) charge stations by EV drivers.

Overview

For this project, five Metro transit locations were selected for electrical vehicle service equipment (EVSE) installation because of their proximity to Los Angeles' high population centers, major transportation hubs (Los Angeles International Airport and Union Station), and major vehicle traffic arteries. LA Metro is the owner of each location, which enabled the project team to have site control. PEV drivers outside the reach of Metro's operations will be able to drive to an equipped transit facility, charge their car, use transit, then return to their point of origin via a charged car. As PEV adoption rates increase and the infrastructure proves to increase LA Metro ridership, LA Metro will evaluate the potential of expanding PEV infrastructure to more LA Metro transit sites.

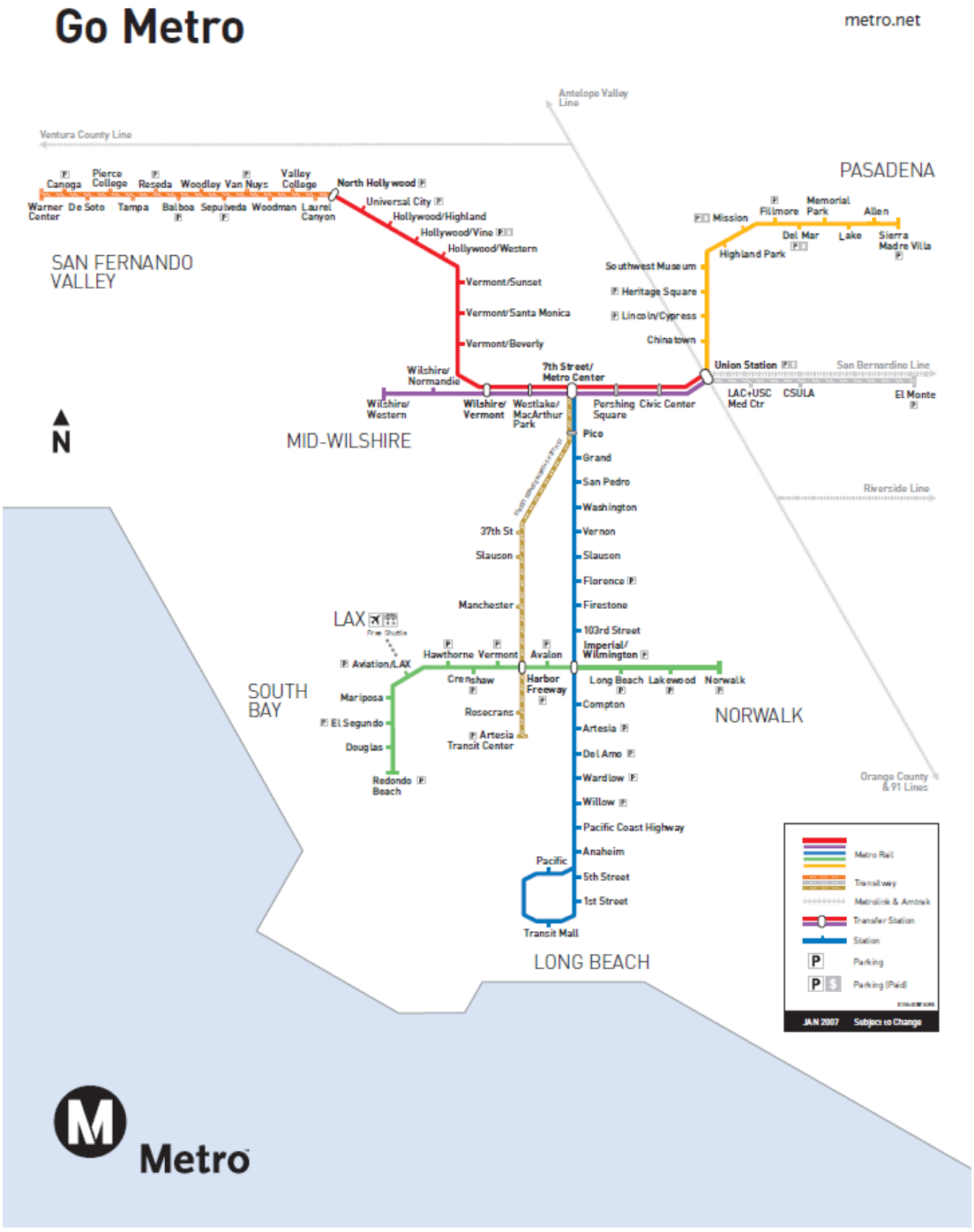
Transit agencies such as LA Metro have a unique opportunity to leverage their real estate investments and connection to passengers (more than 300,000 light rail passengers and 1.6 million bus passengers daily) who can use future PEV infrastructure in their service areas.

Metro's charge station network will provide infrastructure to PEV users and it will provide those users with connectivity to Metro's other modes of transportation. This connection will enable consumer behavioral changes by blending two low carbon emission transportation options, PEV usage and public transportation via rail and alternative fuel buses.

The five project sites for this project are Universal City, El Segundo, Union Station, Willow, and Sierra Madre Villa LA Metro transit stations. The Union Station activity involved an upgrade of four legacy charge stations to four charge stations compliant with the Society of Automotive Engineers International's (SAE International) Electric Vehicle and Plug-In Hybrid Electric Vehicle Conductive Charge Coupler J1772 plug standard. The four other project sites required new construction for EVSE. They are also compliant with SAE J1772.

The five station sites can be located on the following transit map from LA Metro.

Figure 1: Map of the LA Metro System



Source: LA Metro

Project Sites

Following are detailed descriptions of each site.

Universal City

The Universal City Station is located at Lankershim Blvd. and Universal Terrace Pkwy, North Hollywood, CA 91608. It has the following site characteristics:

- Free On-site Parking – 779 Spaces
- Paid Reserved On-site Parking – 125 Spaces
- 16 Bike Rack Spaces
- 30 Bike Lockers
- Kiss & Ride Drop-Off

Universal City provides the center for much of the entertainment industry and Los Angeles tourist visitors. The EVSE is located near Universal Studios, 10 Universal City Plaza (a 36-floor office building for Universal and NBC), the Sheraton Universal, the Universal Hilton, Universal Studios Hollywood, Universal City Walk (a shopping and entertainment center), and the Gibson Amphitheatre. The Metro Rail Red Line station that serves Universal City is also located across the street from 10 Universal Plaza.

El Segundo

The El Segundo station is located at 2226 E El Segundo Blvd., El Segundo, CA 90245. It has the following site characteristics:

- Free On-site Parking – 91 Spaces
- 14 Bike Rack Spaces
- 8 Bike Lockers

The El Segundo station benefits from its proximity to the Los Angeles International Airport, connecting Metro transit passengers with one of the largest airports in the world. With nearly 60,000,000 passengers in 2009, Los Angeles International Airport is the seventh busiest airport in the world and the busiest airport in California in terms of flight operations, passenger traffic and air cargo activity.

In addition to the adjacency to Los Angeles International Airport, the El Segundo Station lies in close proximity to a number of major aerospace corporations near the end of the Metro Green line. From this location, riders can access downtown in under an hour.

Union Station

The Union Station is located at 801 North Vignes St, Los Angeles, CA 90012. It has the following site characteristics:

- Nearby Paid Parking (Independent)
- Union Station - 8 Bike Rack Spaces
- Gateway - 16 Bike Rack Spaces/32 Bike Lockers

The Union Station is the southern terminus of the Metro Gold Line and the beginning point for both the Red and Purple Lines. Passengers are close to connections with Metrolink, Amtrak, Metro Bus, DASH shuttles and other municipal bus lines. LA Metro provides service to Union Station with rail lines and several bus routes at the Gateway Transit Center. Its headquarters are located in the nearby Gateway Plaza. Amtrak and Metrolink serve the station as well. Both Metrolink and Amtrak trains provide direct rail service to and from Burbank-Bob Hope Airport - the region's only direct rail connection between an airport and downtown.

The Union Station currently has 14 train tracks and hosts nearly 400 weekday train departures: 182 on the Purple/Red Line subways; 102 on Gold Line light rail; 59 on Metrolink commuter rail; and 35-36 on Amtrak. The attached Patsaouras Transit Plaza serves several bus lines including Metro Rapid and Metro Local lines, as well as downtown DASH shuttles, many municipal bus lines, and University of Southern California campus shuttles. A FlyAway express bus service has recently been added at the Patsaouras Transit Plaza to provide a direct service between Union Station and Los Angeles International Airport.

Willow Station

The Willow Station is located at 2750 American Ave., Long Beach, CA 90806 and has the following site characteristics:

- Free On-site Parking – 863 Spaces
- Paid Reserved On-site Parking – 36 Spaces
- 16 Bike Rack Spaces
- 8 Bike Lockers

The Willow station on the Blue Line offers ample facilities and parking to service passengers that drive into the station from Long Beach and northern Orange County. It serves as an important connecting point for commuters to downtown Los Angeles.

Sierra Madre Villa

The Sierra Madre Villa Station is located at 149 N Halstead, Pasadena, CA 91107 and has the following site characteristics:

- Free On-site Parking – 950 Spaces
- Paid Reserved On-site Parking – 60 Spaces
- 16 Bike Rack Spaces

The Sierra Madre Villa station is the northern terminus of the Metro Gold Line. It serves as an intermodal transportation hub connecting travelers to local and regional transit services provided by Metro, Foothill Transit, and Pasadena ARTS buses.

Charge Stations

As part of the project, EV Connect deployed two different types of charge stations. The first is manufactured by Eaton Corporation is an industrial model largely devoid of any special features. The second, manufactured by Control Module Inc. (CMI) is a higher-end station that includes active cable management. Both charging systems provide Level 2 service, which delivers 220 volts. Figure 2 shows both pieces of equipment.

Both charge stations included standard features such as:

- 20 foot charge station cables
- Standard SAE J1772 connectors
- radio frequency identification (RFID) readers to control access and authenticate drivers

EV Connect installed four CMI charge stations at the Sierra Madre Villa site and four Eaton charge stations at Union Station. EV Connect installed two of each charger at the Universal City, El Segundo and Willow Metro stations.

The charge stations were connected to the EV Connect Network via cellular telephone gateways/modems with the exception of Union Station, which connected to the network via a dedicated DSL line. The reason for the different network strategy at Union Station was primarily due to the lack of cellular signal in the Union Station underground parking garage.

Figure 2: EV Charge Station Models. Control Module, Inc. (left) and Eaton Pow-R-Station (right)

Photo Credit: EV Connect, Inc.

CHAPTER 2: Project Execution

The Project Execution phase included planning, installation, and commissioning.

Planning

Planning included the following:

- EVSE specification preparation and approval,
- Remote Data System specification preparation, approval, and delivery,
- Joint site visits; selection of final site locations,
- Provide EVSE Install process to design package,
- Preparation of construction drawings and documents,
- Approval of construction drawings and documents by Metro engineering teams,
- California Environmental Quality Act (CEQA) compliance and Notice of Exemption (NOE) for new sites,
- Budget and schedule confirmation,
- Project schedule review and approval,
- Data Plan review and approval,
- EV Connect subcontractor approval,
- EV Driver Subscription Program definition, documentation and approval,
- Customer sign up process plan documentation and setup, payment method setup/test,
- EVSE Acceptance Test procedures and approval plans,
- Revenue Plan review and approval,
- Enforcement Plan review and approval,
- Signage Plan review and approval, and
- Maintenance & Inspection Plan review and approval.

Each of these activities was completed per the terms of the agreement and documentation was provided at the time of Critical Design Review on October 12, 2012.

Installation and Commissioning

Installation and commissioning included the following tasks:

- Ordering the EVSE
- Site preparation, which included cement cutting and trenching
- Installing and routing the electrical and communication conduit
- Cement pouring
- Forming and pouring of reinforced concrete foundations for the sites with transformer installations

- Pre-installation inspection of cement
- Electric service upgrades, including transformers, panels, and cutoffs
- EVSE installation
- Signage installation
- Final inspection and approval
- Network commissioning
- Final testing

At the end of the entire process, a final review meeting was held at each site where every charge station was tested end-to-end including specific tests of the ability of the charge stations to:

- Read and accept a RFID
- Turn on and provide power to a vehicle or test device
- Automatically turn off in response to a major fault
- Continue a charge session or reset in the case of a minor fault
- Connect to the network and update network data on the charge session in real time

Final acceptance was formalized on an Acceptance Form signed by EV Connect, LA Metro Electrical Engineering and Metro Management.

Union Station

The installation at Union Station included four Eaton Level 2 EVSE. The units were installed in the underground garage near a column identified as P2D.

Final unit test and verification was performed and acceptance completed on February 11, 2013.

Figure 3: EVSE Installation at Union Station

Photo Credit: EV Connect

Sierra Madre Villa

The installation at Sierra Madre Villa included four CMI Level 2 EVSE. The units were installed in the parking structure on the first floor on the south side of the structure, directly adjacent to the bus depot. Final unit test and verification was performed and acceptance completed on January 31, 2013.

Figure 4: EVSE Installation at Sierra Madre Villa Station

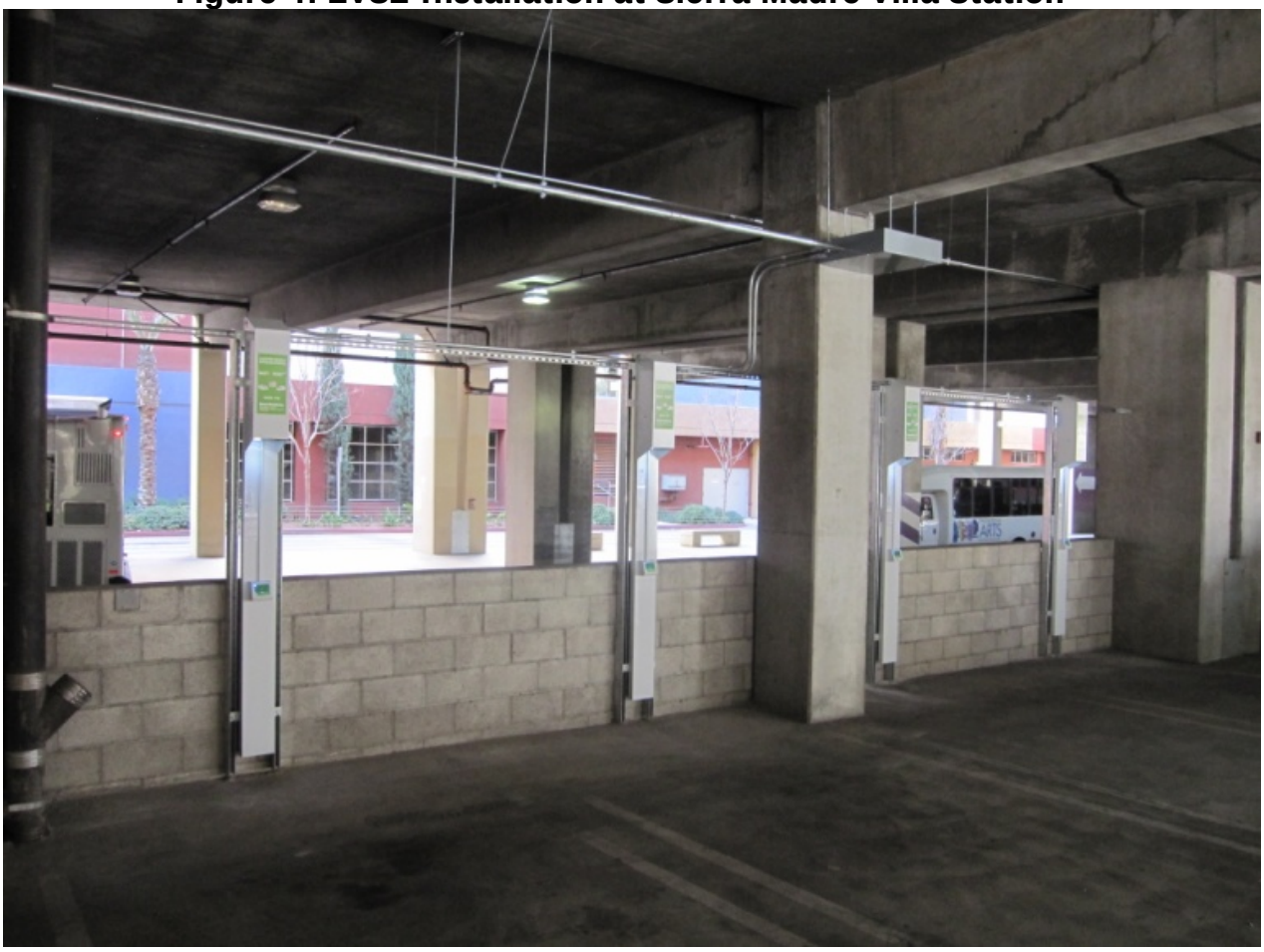


Photo Credit: EV Connect, Inc.

El Segundo

The installation at El Segundo included two Eaton and two CMI Level 2 EVSE. The units were installed in the outdoor parking lot directly adjacent to the entrance to the Green Line train.

Final unit test and verification was performed and acceptance completed on April 25, 2013.

Figure 5: EVSE Installation at El Segundo Station

Photo Credit: EV Connect, Inc.

Willow

The installation at the Willow Station in Long Beach included two Eaton and two CMI Level 2 EVSE. The units were installed in the in the southwest corner of the first floor of the parking garage.

Final unit test and verification was performed and acceptance completed on February 28, 2013.

Figure 6: EVSE Installation at Willow Station

Photo Credit: EV Connect, Inc.

Universal City

The installation at the Universal City station included two Eaton and two CMI Level 2 EVSE. The units were installed in the center of the outdoor parking lot adjacent to the bus depot.

Final unit test and verification was performed and acceptance completed on April 23, 2013

Figure 6: EVSE Installation at Universal City

Photo Credit: EV Connect, Inc.

CHAPTER 3: Data and Analysis

This section details the technical findings from the project. It includes site specific as well as aggregate information and is based on a complete set of recorded charge event data.

The project team collected and analyzed data for the five following categories:

- Vehicles charged per station per day
- Charge station utilization
- Greenhouse gas (GHG) savings
- Estimated gallons of gasoline displaced
- Month over month changes in metrics over the course of the project

Aggregate Data Analysis

Overview

As discussed previously, EV Connect installed a total of 20 EV charging stations across five (5) sites in the LA Metro transit system. The project team monitored use of the chargers for six months following installation between May 2013 and October 2013, in conformance with the terms of the grant. Table 1 provides a summary of the aggregated data collected during the recording period.

Table 1: Summary Project Data (May-October 2013)

Aggregate Measurement	Value
Total charge sessions	1,226 sessions
Total energy provided	13,819 kilowatt hour (kWh)
Total connected time	7,294 hours
Total charging time	2,585 hours
Total fees collected	$2,973
Total drivers signed-up[1]	359 drivers
Total unique users	122 drivers
Average Measurements (6 month period)[2]	**Value**
Charge sessions per day	6.6
Charge sessions per EVSE per day	0.3
Energy provided per session	11.3 kWh
Connected time per charge session	5.9 hours
Charging time per charge session	2.1 hours
Utilization[3]	35 percent
Revenue per day	$16.16
Revenue per EVSE per day	$0.81

Data Credit: EV Connect, Inc.

1 Active drivers are considered to be those who have signed up for an account and then funded their account to utilize the charge stations. A total of 359 individuals signed up for accounts during the reporting period. A total of 248 of these individuals funded their accounts indicating an intention to use the charge station. A total of 122 drivers actually used the charge stations.

2 Average measurements include consideration of weekends, although weekend usage across the system was considerably less than weekday usage.

3 Utilization is a measure of how much "dead" time there is in the average charge event. It defined as the total charging time divided by the total connected time. It does not have any relationship to the total available time of the charge station (presumably 24 hours per day).

Changes in Use During the Recording Period

The average values presented in Table 1 do not capture use levels at the end of the recording period, where usage in month 6 would presumably be higher than just after installation. The Table 1 values represent the average use levels across the entire 6-month measurement period. It also does not take into account the number of users signed up or the charge sessions prior to the recording period.

As anticipated, the total number of users, sessions, power provided and revenues all increased significantly from program launch in May 2013 to the end of the reporting period in October 2013. Table 2 shows the changes in key metrics over the span of the project.

Table 2: Month-over-Month Changes in Key Project Metrics

	May	June[4]	July	August	September	October
Active Drivers	124	169	189	204	227	248
Stations Active	20	20	20	20	20	20
Unique Drivers Using Stations	37	39	56	53	59	63
Power Supplied (Kwh)	1,629	1,281	1,827	1,947	2,347	3,098
Revenue Collected	$421	$408	$544	$546	$555	$695

Data Credit: EV Connect, Inc.

The aggregate data shows a steady increase across all key metric categories during the recording period. Registered drivers increased by 100 percent while unique users increased by 70 percent. Power supplied to vehicles nearly doubled, and revenues increased by 65 percent.

Greenhouse Gas Emission Savings

The monthly GHG reductions are calculated using information from various sources. The calculation approach is to convert the kwh consumed by the EVSE to the equivalent number of gallons of gasoline saved and number of tons of carbon dioxide (CO_2) reduced. Several calculations and conversion factors are required:

- Calculate the miles per kwh for representative EV's. For this project, the Nissan Leaf and the Chevrolet Volt are used as examples.
- Calculating the all-electric miles range per kWh for the Volt: Assume 38 miles in all electric range powered by 16.5 kWh. This results in 2.3 miles per kWh for the Volt.
- Calculating the electric miles range per kWh for the Leaf: Assume 75-mile range powered by 24 kWh. This results in a value of 3.1 miles per kWh for the Leaf.

4 The four charge stations at Sierra Madre Station in Pasadena were out of commission for approximately 17 days in June due to a hardware failure. The reduction in power supplied and revenue during the month of June is likely tied to this outage.

- Assuming an equal mix of Volts and Leafs in the fleet, the average will be approximately 2.7 miles per kWh.[5]
- The average CO2 emissions for an internal combustion engine (ICE) vehicle is 450 gallons per mile. Likewise, the average CO2 emissions for a plug-in EV is 225 grams per mile assuming power is generated using an efficient mix of fossil and renewable power generation.[6]
- The difference in CO2 (or CO2 savings using an EV) between an internal combustion engine and an EV is (450 – 225) = 225 grams per mile CO2 reduced.

Therefore, the GHG reduction calculation is as follows:

(kwh consumed x miles per kwh) x 225 grams per mile = Grams of CO2 reduced by using EVs

For the entire project, this calculation is:

(13,819 x 2.72) x 225 grams per mile = 8,457,228 g = 8,457 kilograms
of CO2 reduced by using EVs charged by the project.

Monthly Gasoline Savings

Monthly savings of gasoline is calculated by using the U.S. Environmental Protection Agency's (U.S. EPA) conversion rate.[7] Under the heading "Gallons of Gasoline Consumed" a value for the conversion of a gallon of gasoline to tons of GHG is presented: 0.00892 tons/gallon of gasoline.

Therefore:

(grams CO2 x 0.0000011 tons/gram)/(0.00892 tons/gallon) = gallons of gasoline saved

For the entire project, this calculation is:

(8,457,228 x 0.0000011)/.00892 = 1,043 gallons of gasoline saved by the project.

Additional Findings from Aggregate Data

Detailed analysis of the data also indicates the following high level trends:

- Early adopters (those who started using the charge stations early in the recording period) tended to continue their use of the charge stations. In many cases, the Early

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5 Volt vehicle data from Chevrolet (http://www.chevrolet.com/volt-electric-car/specs/options.html); Leaf data from Nissan- Nissan Leaf range, charging and battery data (http://www.nissanusa.com/electric-cars/leaf/charging-range/) and Nissan Leaf Specs (http://www.nissanusa.com/electric-cars/leaf/versions-specs/)

6 EPRI, NRDC, and Charles Clark Group: Nationwide Greenhouse Gas Emissions 2007.

7 The United States EPA conversion rate is found at (http://www.epa.gov/cleanenergy/energy-resources/calculator.html)

Adopters increased their usage over the recording period (as measured by the frequency of charge sessions).

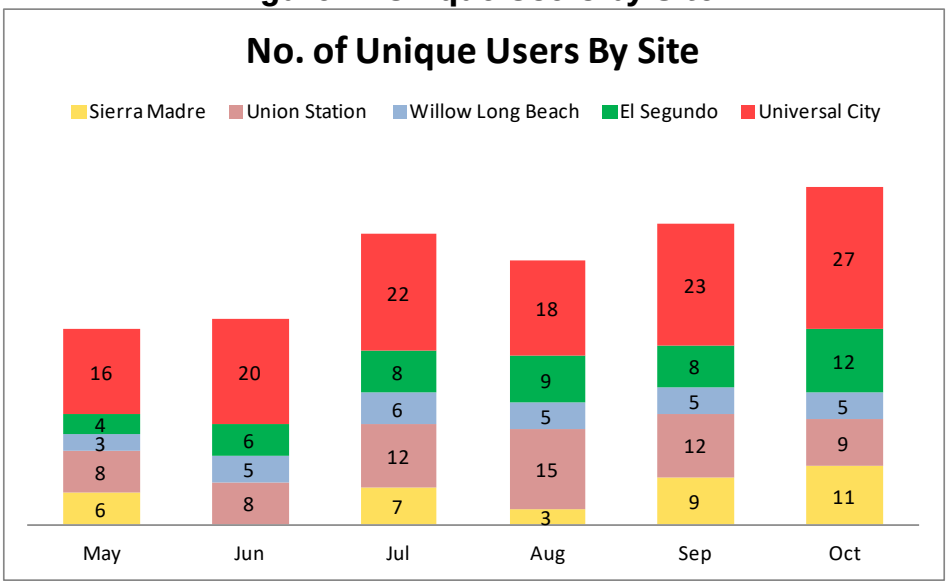
- Approximately 70 percent of drivers who signed up over the entire term of the program pre-funded their account (denoting intention to use the stations). Approximately 50 percent of drivers who funded their accounts actually used the charge stations. Thus, only 35 percent of drivers who signed up actually used the charge station. However, this trend appeared to be decreasing late in the recording period as an increasing number of drivers signed-up, funded and used their accounts.
- The average charging time at each site changed little across the period, indicating that usage patterns corresponded to regular events (daily commutes, regular meetings, et al) instead of exceptional events (entertainment, sporting events, et al).
- Average charge duration per site was fairly consistent, ranging from a minimum of 1.1 hours to a maximum of 3.9 hours, suggesting regular and repeated use. Charging time also provided an indication of the radius from which each station drew its users.
- There was virtually no cross-site usage occurrences, meaning that EV drivers were not using the EV charge locations on an ad hoc basis. Rather, drivers tended to use the same LA Metro location for each charging event.

Site Specific Data & Analysis

Unique Users by Site

Figure 7 shows the unique users by site per month over the recording period.

Figure 7: Unique Users by Site



Data Credit: EV Connect, Inc.

The Universal City Station consistently showed the highest number of users across the five project sites. Union Station and El Segundo also showed relatively high numbers of unique monthly users. Sierra Madre Station and Willow Station were lowest in terms of unique monthly users.

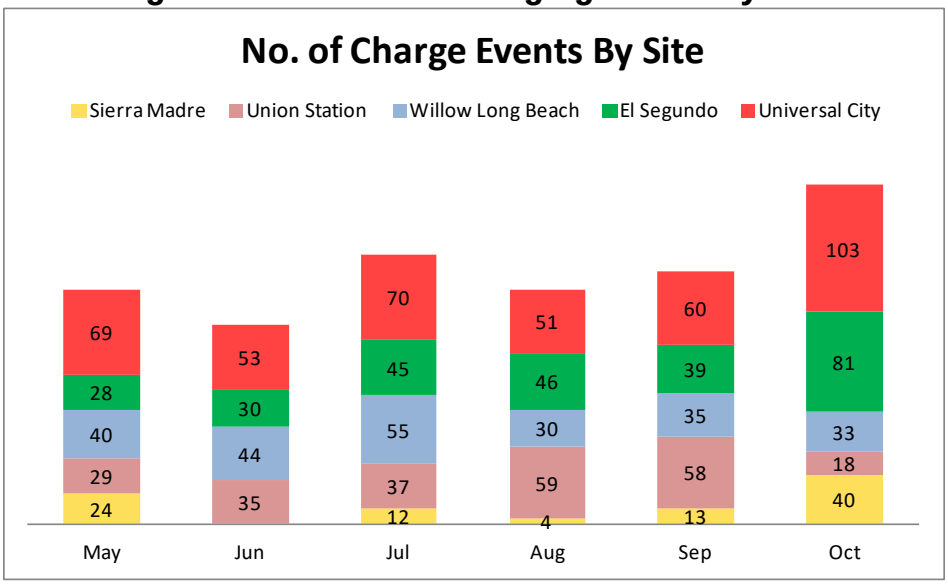
Anecdotal data from encounters with drivers charging at Universal City Station suggests that several of these regular users were not using LA Metro transit, but rather were employees at the NBC Universal or other businesses in the area. It is also possible that some of these drivers were visiting the entertainment venues at Universal City Walk or Universal Studios.

Although the number of unique users at Willow Station in Long Beach was low, the loyalty of these unique users was very high with just 11 users accounting for all of the charging sessions. Five drivers accounted for more than 70 percent of all the charging sessions.

Charge Events by Site

Figure 8 shows the total number of charge events by site per month over the recording period.

Figure 8: Number of Charging Events by Site



Data Credit: EV Connect, Inc.

The Universal City station showed the highest number of monthly charge sessions, peaking at over 100 total charge sessions in October 2013. El Segundo, Willow and Union Station all showed similar usage, while Sierra Madre exhibited the lowest usage until an uncharacteristic usage spike in the October period.

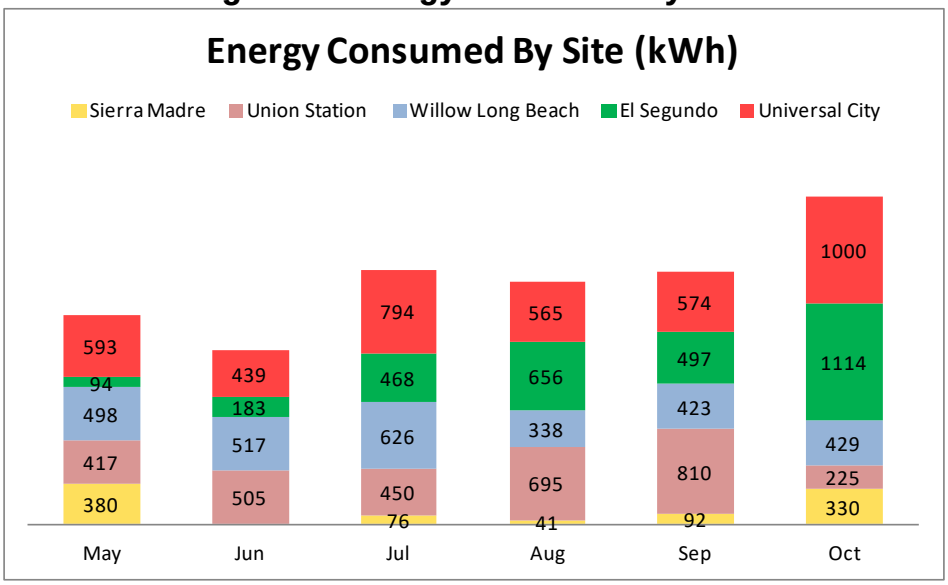
Energy Consumed by Site

Figure 9 shows the total of charge events by site per month over the recording period.

Given the overall usage of the charge stations at Universal City, it is not surprising that that site provided the most power for EV drivers for the majority of the recording period.

El Segundo was a slight surprise in that by the end of the recording period it provided more power on a monthly basis than Universal City. In-depth analysis at El Segundo revealed the regular presence of larger battery electric vehicles (BEV), including Tesla, Toyota RAV-4 and several Nissan Leaf's. These larger batteries consume a disproportionate amount of electricity during a standard charge session than could be expected from the plug-in hybrid EVs (PHEVs) that were more prevalent at other sites.

Figure 9: Energy Consumed by Site

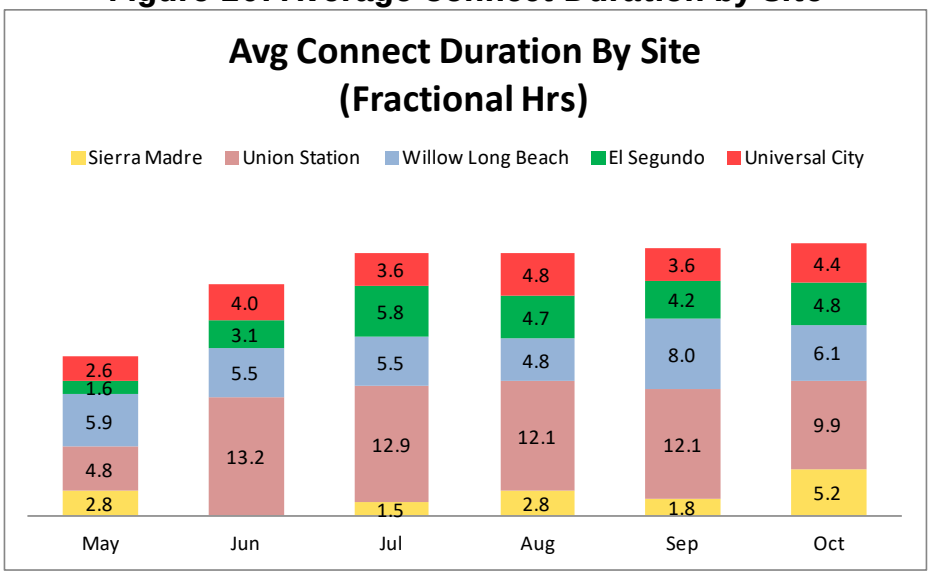


Data Credit: EV Connect, Inc.

Average Connection Duration

The average connection duration by site is provided in Figure 10.

Figure 10: Average Connect Duration by Site



Data Credit: EV Connect, Inc.

Average connection duration is a strong indicator of the type of usage at a charge station. Long average duration indicates a place where drivers park for a prolonged period of time – either overnight or during their daily commute.

For this reason, it is not surprising that Union Station showed the longest connection duration. Detailed data analysis shows that Union Station was the site with the most frequent overnight

or multi-night connections, indicating more frequent occupied parking stalls for electric vehicles.

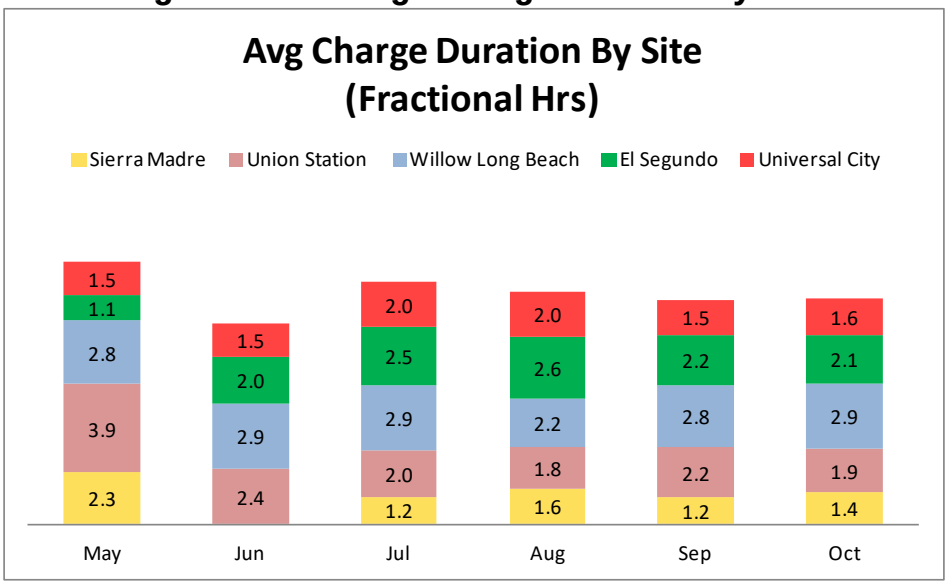
Willow Station also showed relatively long connection durations, again indicating that the drivers using these stations were commuters using the LA Metro Blue Line to access locations in downtown Los Angeles.

The relatively short average connection and charge durations at Universal City are indicative of drivers not occupying a stall for prolonged periods of time, enabling charging for a greater number of drivers.

Average Charge Duration by Site

Figure 11 shows the average charge duration by site.

Figure 11: Average Charge Duration by Site



Data Credit: EV Connect, Inc.

Charge duration is a good indication of the average commute distance for drivers from their residences to the LA Metro transit stations.

Willow Station, with El Segundo Station a close second, showed the longest charge duration, perhaps suggesting that its drivers may have come from the farthest distance to park at the station, or that those drivers may be using the station as their primary means of charging their vehicle.[8]

8 An average 2.9-hour charge time corresponds to approximately 19kWh of energy provided to the vehicle during its charging cycle. The average EV gets about 3.5 miles per kWh, so it can be calculated that the average miles between charges for drivers to Willow Station is on the order of 66 miles. Given that this is nearly the full range of a Nissan Leaf, it is possible that the drivers at Willow are actually commuting multiple times on a single charge and using the charge stations as their sole source of charging.

The low average charge duration at Sierra Madre Station is an indication that it draws primarily from the San Gabriel Valley and that it is likely not used as the primary charge location for the vehicles that use it regularly.[9]

Charging Station Preference

Two brands and styles of EVSE were used for this project, Eaton and CMI. EV Connect chose these two brands was to determine user preference for different types of charge stations with different features. This preference data would help determine which charge stations would be preferred during future system expansions.

Table 3: Charge Station Brand Usage Comparison

Station	Charge Sessions on Eaton EVSE	Charge Sessions on CMI EVSE
El Segundo	162	103
Sierra Madre Villa	N/A10	90
Union Station	263	N/A11
Universal City	217	182
Willow	167	69
Total	**782**	**444**

Data Credit: EV Connect, Inc.

The data above show a preference for the Eaton EVSE over the CMI EVSE at station locations where both were available to drivers. The basis for this preference is unclear from the data, but it could have to do with the plugs being readily available for connection to the vehicle on the Eaton models versus the retracted plugs of the CMI models appearing less readily available. Further research is required to form conclusions about the customer's Eaton preference.

9 An average 1.4 hour charge time corresponds to approximately 9 kWh of energy provided to the vehicle during its charging cycle. The average EV gets about 3.5 miles per kWh, so it can be calculated that the average commute to Sierra Madre Station is on the order of 30 miles or that drivers are making multiple commutes on a single charge.

10 Only CMI charge stations were deployed at Sierra Madre Villa Station.

11 Only Eaton charge stations were deployed at Union Station due to physical constraints at the installation site.

CHAPTER 4: Summary and Conclusion

The project concluded with the following results:

- The project resulted in more than 1,200 charge sessions over a 6-month period.
- This project reduced greenhouse gas emissions by 8,500 kilograms and saved 1,000 gallons of gasoline.
- This project measured use levels of EV chargers in a light rail transit setting.
- The project team delivered the expected results on budget and within revised schedules.

In addition, during the course of this project, EV Connect interviewed and interacted directly with a significant number of the EV drivers. These conversations allowed EV Connect to gain a series of insights into EV drivers, their motivations and hot-button issues. Specifically, EV Connect found the following:

First, EV drivers value charging convenience and are not adverse to paying to charge their vehicles if the costs are reasonable and known in advance.

Second, the thirst for EV charging goes well beyond the few locations that were part of this initial project. During the course of the project, we EV Connect received inquiries and suggestions for EV charging stations at at least five other Metro transit centers, including:

- La Cienega / Jefferson Station (Expo line)
- Norwalk Station (Green line)
- Aviation / Los Angeles International Airport Station (Green line)
- North Hollywood Station (Red line)
- Fillmore / Del Mar Station (Gold line)

Third, EV Connect found that the rate of adoption and use of the EV charge stations was significant during the six month data reporting period, and that it increased over time. Therefore, it is reasonable to expect that increasing EV sales in the greater Los Angeles region will rapidly lead to higher use of these installed EVSE over time.

CHAPTER 5: Next Steps

At the conclusion of this project, EV Connect will turn over rights and responsibilities for monitoring and maintenance to LA Metro. LA Metro currently has a Request for Proposal to select the next operator of these charging stations. LA Metro is considering additional deployment of electric vehicle chargers at other locations as funding becomes available.

DISCLAIMER

Los Angeles County Metropolitan Transit Authority Disclaimer

This report was prepared as the result of collaboration with the Los Angeles County Metropolitan Transportation Authority (LA Metro). It does not necessarily represent the views of LA Metro, its employees or its Board of Directors. LA Metro makes no warrant, express or implied representation, and assumes no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights.

LA Metro will prepare a separate staff report for its Board of Directors using the information contained in this report.

GLOSSARY

BATTERY ELECTRIC VEHICLE (BEV) - Also known as an “All-electric” vehicle (AEV), BEVs utilize energy that is stored in rechargeable battery packs. BEVs sustain their power through the batteries and therefore must be plugged into an external electricity source in order to recharge.

CALIFORNIA ENERGY COMMISSION (CEC) - The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The Energy Commission's five major areas of responsibilities are:

- Forecasting future statewide energy needs
- Licensing power plants sufficient to meet those needs
- Promoting energy conservation and efficiency measures
- Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels
- Planning for and directing state response to energy emergencies.

CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA) - Enacted in 1970 and amended through 1983, established state policy to maintain a high-quality environment in California and set up regulations to inhibit degradation of the environment.

CARBON DIOXIDE (CO2) - A colorless, odorless, non-poisonous gas that is a normal part of the air. Carbon dioxide is exhaled by humans and animals and is absorbed by green growing things and by the sea. CO2 is the greenhouse gas whose concentration is being most affected directly by human activities. CO2 also serves as the reference to compare all other greenhouse gases (see carbon dioxide equivalent). The major source of CO2 emissions is fossil fuel combustion. CO2 emissions are also a product of forest clearing, biomass burning, and non-energy production processes such as cement production. Atmospheric concentrations of CO2 have been increasing at a rate of about 0.5% per year and are now about 30% above preindustrial levels. (EPA)

Control Module Inc. (CMI) – is a global provider of innovative systems and solutions for workforce data collection, EV charging and fleet management.[12]

ELECTRIC VEHICLE (EV) – A broad category that includes all vehicles that are fully powered by electricity or an electric motor.

ELECTRIC VEHICLE CHARGING STATION (EVSE) - Infrastructure designed to supply power to EVs. EVSE can charge a wide variety of EVs including BEVs and PHEVs.

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12 Control Module, Inc main page (http://controlmod.com/)

GREENHOUSE GAS (GHG) -- Any gas that absorbs infra-red radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), halogenated fluorocarbons (HCFCs), ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs). (EPA)

INTERNAL COMBUSTIION ENGINE (ICE) - An engine in which fuel is burned inside the engine. A car's gasoline engine or rotary engine is an example of an internal combustion engine. It differs from engines having an external furnace, such as a steam engine.

KILOWATT-HOUR (kWh) – The most commonly used unit of measure telling the amount of electricity consumed over time, means one kilowatt of electricity supplied for one hour. In 1989, a typical California household consumed 534 kWh in an average month.

NOTICE OF EXEMPTION (NOE) (§ 15062)(a) - When a public agency decides that a project is exempt from CEQA pursuant to Section 15061, and the public agency approves or determines to carry out the project, the agency may, file a notice of exemption.[13]

OPEN CHARGE POINT PROTOCOL (OCPP) - an open communication protocol that allows electric vehicle charging stations and central management software to communicate with each other. The protocol has been adopted by dozens of leading charging station providers and auto manufacturers around the world. Open protocols are crucial for the budding EV charging market. They enable interoperability between charging stations, vehicles, and station management services.[14]

LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY (LA Metro) – [The] transportation planner and coordinator, designer, builder and operator for one of the country's largest, most populous counties. More than 9.6 million people – nearly one-third of California's residents – live, work and play within our 1,433-square-mile service area.[15]

PLUG-IN ELECTRIC VEHICLE (PEV) - is a general term for any car that runs at least partially on battery power and is recharged from the electricity grid. There are two different types of PEVs to choose from - pure battery electric and plug-in hybrid vehicles.

PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV) - PHEVs are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. The vehicle can be plugged in to an electric power source to charge the battery. Some can travel nearly 100 miles on electricity alone, and all can operate solely on gasoline (similar to a conventional hybrid).

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13 California Governor's Office of Planning and Research, *Proposed Updates to the CEQA Guidelines*. 2017. http://opr.ca.gov/docs/20171127_Comprehensive_CEQA_Guidelines_Package_Nov_2017.pdf

14 ChargeLab Website: Open Charge Point Protocol explained (https://www.chargelab.co/what-is-ocpp)

15 Los Angeles County Metropolitan Transportation Authority Website: (https://www.metro.net/about/about-metro/)

RADIO FREQUENCY IDENTIFICATION (RFID) - refers to a wireless system comprised of two components: tags and readers. The reader is a device that has one or more antennas that emit radio waves and receive signals back from the RFID tag. Tags, which use radio waves to communicate their identity and other information to nearby readers, can be passive or active. Passive RFID tags are powered by the reader and do not have a battery. Active RFID tags are powered by batteries.[16]

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) -- SAE International, formerly the Society of Automotive Engineers, is a U.S.-based, globally active professional association and standards organization for engineering professionals in various industries.

16 United States Food and Drug Administration, Radiation Emitting Products, Radiation Safety. FDA Website: (https://www.fda.gov/radiation-emitting-products/electromagnetic-compatibility-emc/radio-frequency-identification-rfid)