CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Reconnect California Program

Public Plug-In Vehicle Charging Infrastructure Project Update

Prepared for: California Energy Commission

Prepared by: ClipperCreek

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 nonroad 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 Clean Transportation Program Investment Plan Update. The CEC issued solicitation PON-09-006 to provide funding opportunities under the Clean Transportation Program for increasing available public infrastructure for charging plug-in electric vehicles throughout California. In response to PON-09-006, the recipient submitted application number 32, which was proposed for funding in the CEC's Notice of Proposed Awards on June 10, 2010. The agreement was executed as ARV-10-001 on October 15, 2010 in the amount of $2,299,543.

ABSTRACT

The purpose of ClipperCreek's Reconnect California Program was to deploy compliant electric vehicle charging stations according to the society of automotive engineers throughout California. This Final Project Report assesses the success of the program, estimates greenhouse gas reductions, and estimates the increased potential for plug-in vehicle ownership due to the expanded network of public charging infrastructure.

This $3.5 million project was funded by the California Energy Commission and ClipperCreek to update public plug-in vehicle charging infrastructure throughout California without leaving pre-existing plug-in vehicle drivers stranded. Over the course of the project, ClipperCreek installed 762 Level 2 charging stations and 37 Level 1 charging ports at 313 sites throughout California.

ClipperCreek worked with stakeholders, utilities, and clean cities collations to identify the optimal sites to locate the charging infrastructure. The majority of the infrastructure updated through this program was at "legacy" sites, meaning that the sites had pre-existing, but out of date, plug-in vehicle charging infrastructure. This pre-existing infrastructure made the upgrade installation a straight forward process for the "legacy" sites. During planning, ClipperCreek discovered that many "legacy" site hosts were unwilling to accept the new charging equipment at their sites; this was one factor that caused the program time frame to be longer than originally planned and for the program to expand to some new sites (sites that did not previously have complete charging infrastructure).

Overall, the program was successful; ClipperCreek installed more equipment than originally planned while staying within budget. Key recommendations include: 1) Have a set list of where installations will take place (agreeable site hosts) with a list of backup sites, 2) Plan a budget for site outreach, education, and project coordination.

Keywords: California Energy Commission, Electric Vehicles, Plug-In vehicles, Charging Station, ClipperCreek, Level 2 Charging Station

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EXECUTIVE SUMMARY

In this final report for the Reconnect California Program, ClipperCreek describes deployment of Society of Automotive Engineers J1772™ compliant electric vehicle charging stations throughout California. This report assesses the success of the program, estimates greenhouse gas reductions based on energy used for vehicles through these charging stations, and estimates the increased potential for plug-in vehicle ownership due to the expanded network of public charging infrastructure. The report also describes challenging issues and recommendations for similar future projects.

The modern generation of electric vehicles introduced in 2010, like the Nissan Leaf, were designed to use the new SAE-J1772 charger connectors. A small network of chargers had been built with inductive charging paddles to serve the first generation electric vehicles like the General Motors EV1 and Toyota RAV4 that were introduced in the 1990's. This $3.5 million project was funded by the California Energy Commission ($2.3 million) and ClipperCreek ($1.2 million) to update public plug-in vehicle charging infrastructure throughout California, without stranding pre-existing plug-in vehicle drivers using the older induction-style charging paddles. Over the course of the project, ClipperCreek successfully deployed 762 Level 2 (208/240V) charging stations and 37 Level 1 (120V) charging ports at 313 sites throughout California for a total of 799 charging ports. ClipperCreek collected and assessed six months of energy usage data and achieved its goal of not stranding legacy electric vehicle drivers by leaving at least one inductive style "legacy" charging port at each site where one already existed. ClipperCreek also offered a plug adapter that allowed some legacy electric vehicle owners to upgrade their vehicle to the new universal charging standard.

ClipperCreek worked with stakeholders, utilities, and Clean Cities Coalitions to identify the optimal sites to locate the charging infrastructure. The majority of the infrastructure updated through this program were at "legacy" sites, meaning that the sites had pre-existing, but out of date, plug-in vehicle charging infrastructure. This pre-existing infrastructure made the upgrade installation a straightforward process for the "legacy" sites. During planning however, ClipperCreek discovered that many "legacy" site hosts were unwilling to accept the new charging equipment; this caused delays in the project schedule and expansion of the program to new sites (sites that did not previously have complete charging infrastructure).

The program succeeded in installing more equipment than was originally planned while staying within budget. The original goal was to install at least 640 electric vehicle chargers at 300 locations throughout the station of California. Ultimately, the project team installed 762 Level 2 stations and 37 Level 1 ports at 313 sites.

According to the six months of data collection, some stations were heavily used while just two stations were left unused. Over 921 megawatt hours or 921,192 kilowatt hours of energy flowed through the stations into plug-in vehicle battery packs.

Lessons-Learned

ClipperCreek offers the following lessons-learned for future charger deployment programs:

1. Develop a pre-identified list of station sites with agreeable site hosts, along with a list of backup sites. The project team assumed that all site hosts would be interested in receiving a no cost infrastructure upgrade, but this assumption was incorrect. More than half of the sites proposed for the equipment upgrades declined to participate in the Reconnect California program. This unexpected outcome required hundreds of unplanned labor hours to overcome. As a result, ClipperCreek was not able to complete all of the upgrade installations within the original timeline. Ultimately, ClipperCreek was able to install more stations than originally planned. The added labor requirements resulted in three new positions created at ClipperCreek; these positions have since transitioned to permanent full time positions outside of the grant program.
2. Budgets and schedules should include sufficient resources for outreach and education to site hosts. Outreach and education takes time, especially with new technologies. When this program began in late 2010, plug-in electric vehicles were just beginning to enter the market. Many site hosts who had had plug-in vehicle charging infrastructure at their properties for years were not aware of this newly emerging technology and how it might affect them. Their questions included: "What are plug-in vehicles and what makes and models are available?"; "Is the popularity of the plug-in vehicles expected to increase?"; and "What is electric vehicle supply equipment (EVSE)?" The project team needed to educate potential site hosts on the emerging market for electric vehicles. Through outreach and site education process, ClipperCreek quickly learned that customers needed current information before they would agree to have new equipment installed at their site.
3. When using subcontractors for installation work, employ multiple vendors to ensure the best pricing and execution for the program. ClipperCreek learned that sourcing a single subcontractor to manage the installation portion of the project was not the best approach. This became apparent early in the project, and ClipperCreek hired a second company to ensure the best pricing and execution. In early 2012, ClipperCreek brought on an additional installation subcontractor and took full control of managing and scheduling the installers used for this program. This was a major factor in completing more sites than planned within the budget.
4. Plan for ongoing technology advancements that can complicate or delay electric vehicle supply equipment installations. During the grant period, the project was expanded to include the development and deployment of a new Smart Grid connected the module with integrated Smart Grid connectivity and communications. This technology was cutting edge when the development began in 2011 and is still cutting edge technology today. The Smart Grid Module allowed the station to be connected to a utility's grid for load management events, and allowed for direct reporting of energy use. ClipperCreek used this technology to collect energy use information from all of the stations installed through this program. The Smart Grid Module that was created was an important advancement in systems-level charging technologies, but it took longer to complete than originally planned. Several issues involved with this new technology included:

a. Communications standards for Smart Grid connectivity;
b. Suppliers that over-promised features of their existing technology that was ultimately incorporated into the module; and
c. Supply chain delays for a new technology that was just beginning production

Ultimately, the development and deployment of the Smart Grid meter and communications module was a success, although it did require a time extension to complete the grant project.

CHAPTER 1: Project Purposes, Approach, Management, and Implementation

Overview of Project Purposes, Approach, Management, and Implementation

Purposes

- Expand California's network of plug-in vehicle (PEV) charging stations to meet early market demand and technical standards for newly introduced electric vehicles (EVs) while leveraging existing infrastructure wherever possible.
- Update and install at least 640 publicly accessible Society of Automotive Engineers J-1772™ Electric Vehicle Supply Equipment (EVSEs) at 300 sites throughout California.
- Do not leave "legacy" EV drivers stranded by the infrastructure upgrade to the new standard.
- Collect six months of energy usage information from the EVSEs installed through the Reconnect California program.

Approach

ClipperCreek used the following strategies to achieve the project purposes and goals:

1. Identify sites with pre-existing paddle-style EV charging infrastructure by using the *EV Charger News* database of pre-2011 EV charging sites throughout California.
2. Select candidate legacy sites for grant-funded equipment upgrade awards using the following criteria:
   a) Site hosts' willingness to accept the J-1772 upgrade and maintain public accessibility to the charging infrastructure.
   b) Location of the site based on feedback from the EV driver community, utilities, local Air Quality Management Districts, the CEC, and cities throughout the state.
3. ClipperCreek approached all candidate sites with the Reconnect California program offering.

After all of the initially identified sites had been contacted, ClipperCreek adjusted the approach to include sites not on the initial database list, focusing on sites that had available electrical infrastructure, but that may not have had EVSEs in the past.

At the start of the project, ClipperCreek's contractor managed removal of the old equipment and installation of the updated J-1772 equipment.

ClipperCreek adjusted this approach after the first 6 months of the installation portion of this project by bringing on a second subcontractor. After that time, ClipperCreek managed the subcontractors' schedule.

This management approach proved to be more efficient and cost effective.

ClipperCreek deployed the Smart Grid communications and metering modules in two phases.

1. Deployment of the Smart Grid Modules started in late 2012. At this point, over 400 stations had already been installed, so the ClipperCreek team performed retrofits in the field.
2. ClipperCreek used a single contractor for the Smart Grid upgrades and installations. This contractor planned trips to test all of the stations and add modules to the stations that had been upgraded without the Smart Grid modules.
3. When the modules were available, all equipment sets for the upgrade stations were shipped with the modules pre-installed, which simplified the upgrades.

The Smart Grid meter and communications modules facilitated data collection from the installed stations. The modules metered the energy used through the station and accumulated the total as a kWh reading for each station.

Data from the Smart Grid Modules was collected by a single contractor visiting all of the program sites and downloading wireless data from the Smart Grid Modules. At the same site visit, all of the stations were tested for proper functionality.

Management

ClipperCreek managed the Reconnect California program. At the beginning of the construction and implementation phase of the project, ClipperCreek engaged its subcontractor to manage installations and conduct technical support. However, after six months this was changed and ClipperCreek assumed management on all aspects of the program, including field support, contractor selection, and scheduling.

Implementation

ClipperCreek successfully deployed 762 Level 2 (208/240V) charging stations and 37 Level 1 (120V) charging ports at 313 sites throughout California. ClipperCreek also achieved its goal to not leave "legacy" EV drivers stranded by leaving at least one functional inductive paddle-style station at each legacy site. This ensured the charging public with first generation EVs that they could still use the "legacy" chargers.

ClipperCreek also offered a plug adapter or conversion kit, which allowed some legacy EV owners to upgrade their vehicle to the new J-1772 universal charging standard.

Reconnect California Program – Sample Project Sites

Following are images illustrating some of the sites updated through the Reconnect California Program. The Program was available to any site host with compatible electrical infrastructure who would allow public access to the upgraded charging stations. Eligible host sites included retail locations, recreation destinations, universities and government facilities. Each site photograph includes locational information in the titles of Figures 1 through 8.

Figure 1: Cal Poly Pomona - Site 91768_1

Photo Credit: Reconnect California Program

Figure 2: CalPERS Garage, Sacramento - Site 95811_1

Photo Credit: Reconnect California Program

Figure 3: CVS Pharmacy, Granite Bay - Site 95746_3

Photo Credit: Reconnect California Program

Figure 4: Lowes, Elk Grove - Site 95624_1

Photo Credit: Reconnect California Program

Figure 5: Marriott Hotel, Palm Springs - Site 92260_1

Photo Credit: Reconnect California Program

Figure 6: Home Depot, San Louis Obispo - Site 93405_10

Photo Credit: Reconnect California Program

Figure 7: Leo Carrillo State Park, Malibu - Site 90265_81

Photo Credit: Adopt a Charger

Figure 8: Squaw Valley Ski Resort, Olympic Valley - Site 96146_81

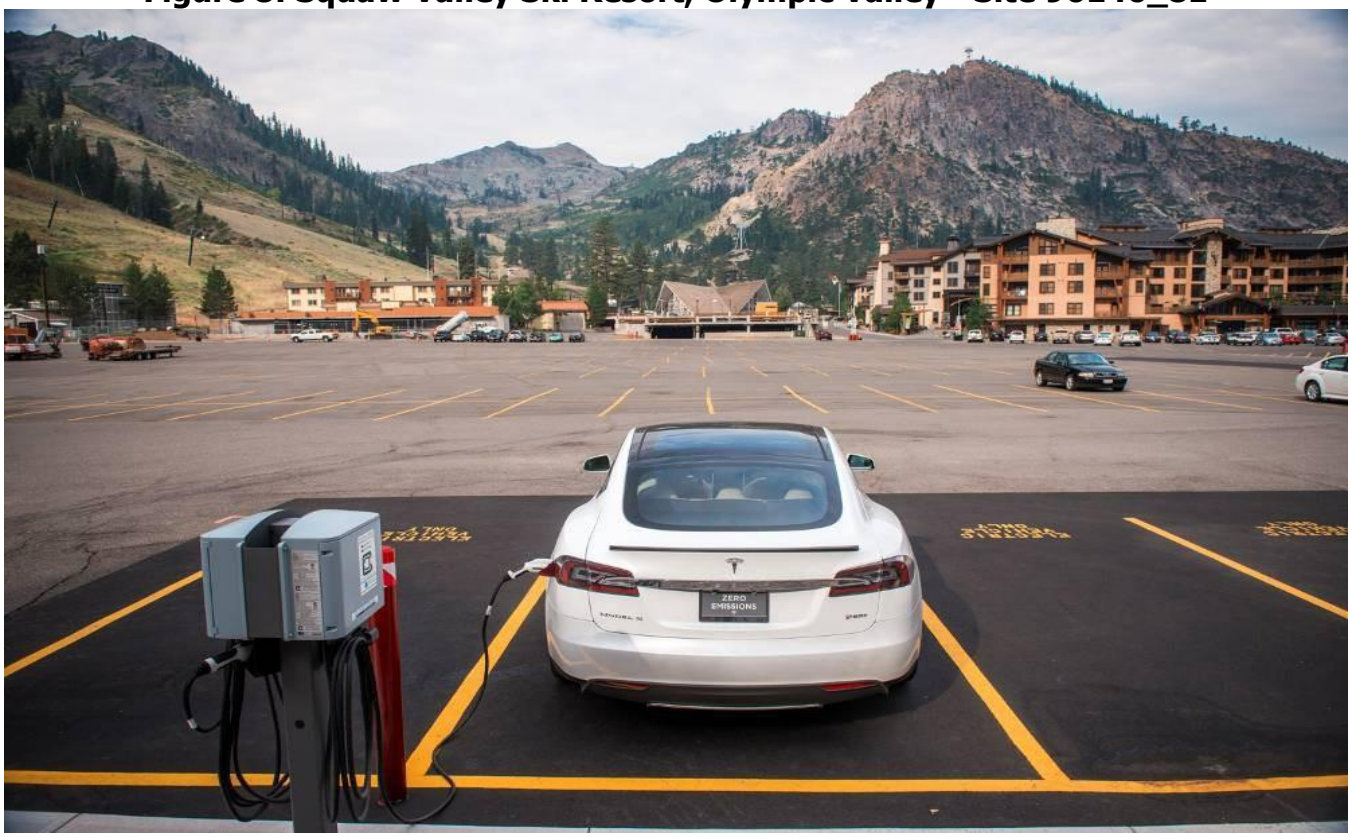

Photo Credit: Adopt a Charger

CHAPTER 2: Site Identification, EV Charging Infrastructure, Installation and Data Collection

Site Identification Activities

The starting point for this project was to identify site hosts interested in updating pre-existing EV Charging infrastructure to the new SAE-J1772™ standard, and then to get those site hosts to sign up for a no-cost equipment upgrade through the Reconnect California Program. ClipperCreek obtained a pre-existing database of sites that had been maintained over the years by one of the project consultants, Tom Dowling, and began reaching out to the 812 sites identified in the database.

Through these outreach efforts, ClipperCreek was able to make contact with about 77 percent of the sites identified through the original database search of pre-existing EV Charging infrastructure sites.

ClipperCreek contacted 624 of the original charging site hosts identified in the database. An additional 53 previously unknown site hosts contacted ClipperCreek based on program marketing efforts and word of mouth from other site hosts and agencies that had participated in or were aware of the program. Through direct outreach efforts, the Program achieved a 46 percent acceptance rate for the equipment upgrades. Table 1 provides an overview of ClipperCreek's outreach efforts.

Table 1: Summary of Outreach Activities

Original Database Sites	No. of Contacts from Original Database	Percent of Site Contacts Made From Original List	No. of Original Database Site Hosts that Participated Through Direct Outreach	No. of New Site Hosts That Reached Out To ClipperCreek (Not On Original List)	Total No. Of Sites Contacted (Original + New)	Total Sites Updated Through Reconnect California Program	Final Percentage of Site Acceptance
812	624	77	269	53	677	313	46

Source: Reconnect California Program Outreach Tracking

This acceptance rate is successful and it enabled ClipperCreek to install more charging station upgrades than originally planned.

Outreach Challenges

ClipperCreek faced numerous challenges during the outreach efforts for the Reconnect California Program. Here is a recap of some of the major challenges and how they were overcome:

The number of sites contacted proactively by ClipperCreek for the Reconnect California Program was a large number at 624. In most cases, these sites required multiple contact attempts to ultimately reach the site owner or manager.

Early on, ClipperCreek realized the workload involved in outreach and management was more than their resources could accommodate. The company created a new position and brought on a new team member specifically for outreach and management related to the Reconnect California Program. ClipperCreek added a total of three new staff to support the Program. The team members hired for this project task are still with the company performing other duties. These are three of the permanent jobs created as a result of the Reconnect California Program.

Customer Education

Customer education was the next challenge during the outreach process. A level of education was expected from day one in the project; however, the project team underestimated the number of people needing education about the new generation charging technologies. ClipperCreek determined that the best approach was to have one person combine education and sign-up efforts. With a single point of contact, ClipperCreek was able to secure more sites during the education and sign up process.

EV Charging Infrastructure Installation

Site outreach was the first step towards installing updated EV Charging infrastructure across the state, once sites started signing up, an installation queue was created. The queue was filled with sites that were ready for EVSE upgrades. Outreach was an ongoing process, so installations were started as soon as the queue reached 20 sites. The process for upgrade installations was as follows:

Our subcontractor would schedule an agreeable time with the site host for a site assessment.

- Whenever possible installations were grouped in similar geographic regions to allow for multiple sites to be installed in the same day.
- All installation contractors used for this program were local to the area of installation. Installations for the Reconnect CA program provided temporary work for 3 subcontracting firms in California.
- The subcontractor would go to the site with all of the equipment that was expected to be required for the upgrade.
- The subcontractor would perform the site assessment and if everything was as expected, the upgrade would be performed on the first visit to the site.
- If the upgrade site conditions were not as expected, the contractor would return with any additionally required material.

Grouping the site assessment and installation into the same visit was the most efficient use of funding for installations. Subcontractors charge for travel time in addition to the labor for installation, so reducing travel time was necessary for this program. As the program

progressed, ClipperCreek refined the pre-site visit process to provide subcontractors with all the information needed to perform the upgrade installation on the first visit to the site. This included pictures of the existing installation and the service panel at the site.

EV Charging Infrastructure Locations

Table 2 summarizes the number of sites and stations updated through the Reconnect California Program by county.

Table 2: Number of Charger Installations by County

County	Number of Sites	Number of Level 2 EVSE	Number of Level 1 EVSE	Percent of Level 2 EVSE by County	Percent of Level 1 by county
Alameda	10	24	1	3.1	2.7
Amador	2	2	0	0.2	0.0
El Dorado	3	4	0	0.5	0.0
Fresno	1	2	0	0.3	0.0
Humboldt	1	1	0	0.1	0.0
Lake	1	1	0	0.1	0.0
Los Angeles	81	275	9	36.1	24.3
Marin	3	4	1	0.5	2.7
Mendocino	1	1	0	0.1	0.0
Monterey	1	1	0	0.1	0.0
Nevada	2	4	0	0.5	0.0
Orange	8	13	3	1.7	8.1
Placer	12	22	2	2.9	5.4
Riverside	27	64	1	8.4	2.7
Sacramento	32	93	10	12.2	27.0
San Bernardino	17	32	2	4.2	5.4
San Diego	4	6	0	0.8	0.0
San Francisco	5	15	2	1.9	5.4
San Joaquin	6	7	0	0.9	0.0
San Luis Obispo	8	14	0	1.8	0.0

County	Number of Sites	Number of Level 2 EVSE	Number of Level 1 EVSE	Percent of Level 2 EVSE by County	Percent of Level 1 by county
San Mateo	2	3	4	0.4	10.8
Santa Barbara	9	18	0	2.3	0.0
Santa Clara	9	20	2	2.6	5.4
Santa Cruz	4	6	0	0.8	0.0
Solano	20	41	0	5.4	0.0
Sonoma	1	1	0	0.1	0.0
Tulare	1	3	0	0.4	0.0
Tuolumne	2	2	0	0.2	0.0
Ventura	23	60	0	7.8	0.0
Yolo	17	23	0	3.0	0.0
Total	**313**	**762**	**37**	**100**	**100**

Source: Reconnect California Program Install Tracking

EVSE Usage Data

ClipperCreek collected EVSE usage data through the Smart Grid communications and metering modules that were installed into the grant-funded stations throughout the state. Six months of accumulated kWh readings were collected through a Smart Grid network emulator that subcontractors took into the field when they visited each site between January and February of 2014. Table 3 shows a county-level summary of the energy utilization through the EVSEs and the associated greenhouse gas (GHG) reductions when compared to vehicles with internal combustion engines.

Table 3: Six-Month Energy Use Data Collection with GHG Offset by County

County	kWh Total	Percent kWh Utilization	GHG Offset in Metric Tons
Alameda	29,054	3.1	30.4
Amador	0	0	0.0
El Dorado	7,629	0.8	7.8
Fresno	5,451	0.6	5.7
Humboldt	1,425	0.1	1.5
Lake	274	0.0	0.3
Los Angeles	293,308	31.8	307.0
Marin	8,125	0.9	8.5
Mendocino	1,379	0.1	1.4
Monterey	68	0.0	0.1
Nevada	1,138	0.1	1.9
Orange	43,617	4.8	45.6
Placer	16,992	1.8	17.8
Riverside	63,305	6.8	66.3
Sacramento	172,872	18.8	181.0
San Bernardino	30,112	3.3	31.5
San Diego	17,500	1.9	18.3
San Francisco	4,272	0.5	4.47
San Joaquin	3,854	0.4	4.04
San Luis Obispo	22,724	2.5	23.8
San Mateo	4,689	0.5	4.9
Santa Barbara	8,183	0.9	8.6
Santa Clara	67,092	7.3	70.2
Santa Cruz	5,458	0.6	5.7
Solano	24,408	2.6	25.5

County	kWh Total	Percent kWh Utilization	GHG Offset in Metric Tons
Sonoma	224	0.0	0.2
Tulare	94	0.0	0.1
Tuolumne	55	0.0	0.1
Ventura	58,095	6.3	60.8
Yolo	29,786	3.2	31.2
Total	**921,192**	**100**	**964.4**

Source: Reconnect California Program Install Tracking

ClipperCreek collected the kWh data above from 264 of the 313 sites updated through the Reconnect California Program; this represents an 84 percent success rate in data collection across the program. While collecting usage data in the field, the ClipperCreek team encountered Smart Grid Module connectivity issues at 39 sites.

The Los Angeles Department of Water and Power (LADWP) received EVSEs through the Reconnect California Program and the stations were placed across 10 sites in the LADWP service territory. LADWP will be providing meter read information for those sites after the equipment has been installed and used for six months. The usage data from the 10 LADWP sites will be added to this report in an update version once the data is available. With the addition of usage data from LADWP, the project will have achieved an 88 percent success rate in data collection.

Electric Miles Driven Based on Energy Usage

Table 4 below shows the approximate electric powered miles that could be achieved, as well as gallons of gasoline and GHG emissions offset by the usage of electricity, as a fuel compared to gasoline. The[1] table assume that 1 kWh = 3.33 miles of range on average.[1]

[1] Based on research report by NETL (http://www.afdc.energy.gov/pdfs/hev_ev_ghgreductions.pdf)

Table 4: Six-Month Use Data Showing Avoided GHG Emissions and Petroleum Reduction by County

County	Electricity Use (kWh)	Estimated Electric Miles	Avoided GHG Emissions (Metric Tons)	Petroleum Reduction (Gallons of Gasoline)*[2]
Alameda	29,054	96,750	30.4	4,521
Amador	0	1	0.0	0
El Dorado	7,629	25,407	8.0	1,187
Fresno	5,451	18,153	5.7	848
Humboldt	1,425	4,748	1.5	222
Lake	274	912	0.3	42
Los Angeles	293,308	976,718	307.0	45,641
Marin	8,125	27,059	8.5	1,264
Mendocino	1,379	4,592	1.4	214
Monterey	68	226	0.1	10
Nevada	1,138	3,792	1.2	177
Orange	43,617	145,247	45.6	6,787
Placer	16,992	56,586	17.8	2,644
Riverside	63,305	210,806	66.3	9,850
Sacramento	172,872	575,664	181.0	26,900
San Bernardino	30,112	10,0273	31.5	4,685
San Diego	17,500	58,275	18.3	2,723
San Francisco	4,272	14,227	4.5	665
San Joaquin	3,854	12,836	4.0	600

[2] In 2011, the weighted average combined fuel economy of cars and light trucks combined was 21.4 miles per gallon (FHWA 2013). – (http://www.epa.gov/cleanenergy/energy-resources/refs.html)

County	Electricity Use (kWh)	Estimated Electric Miles	Avoided GHG Emissions (Metric Tons)	Petroleum Reduction (Gallons of Gasoline)*
San Luis Obispo	22,724	75,671	23.8	3,536
San Mateo	4,689	15,614	4.9	729
Santa Barbara	8,183	27,251	8.5	1,273
Santa Clara	67,092	223,417	70.2	10,440
Santa Cruz	5,458	18,177	5.7	849
Solano	24,408	81,279	25.5	3,798
Sonoma	224	747	0.23	35
Tulare	94	313	0.1	14
Tuolumne	55	185	0.0	8
Ventura	58,095	193,457	60.8	9,040
Yolo	29,786	99,188	31.2	4,635
Total	**921,192**	**3,067,570**	**964.4**	**143,344**

Source: Reconnect California Program Install Tracking

*Table Note: Assumes 21.4 combined MPG

The avoided greenhouse gas emission calculation for the above tables is based on the differential between the carbon emissions from electricity and the carbon emissions from gasoline. Carbon emissions from California grid electricity are 0.0003506419 metric tons CO2e per kWh.[3] Carbon emissions from a regular gasoline-powered passenger vehicle are 0.0004196855 metric tons per mile[4].

3 CEC Almanac shows CA electricity usage for 2009 - 298,310 GWH CARB report shows total GHG for energy generation and transmission (2009) - 104.6 MMTCO2e (http://www.arb.ca.gov/cc/inventory/pubs/reports/ghg_inventory_00-09_report.pdf)

4 Based on EPA advanced energy resources – (http://www.epa.gov/cleanenergy/energy-resources/refs.html)

The above data show that over 3 million miles were driven on the electricity delivered through the Reconnect California Program charging stations. These electric miles resulted in over 140,000 gallons of avoided gasoline and nearly 1,000 metric tons of avoided CO2e.

Formula for CO2e created by generation and transmission of 1 kWh of California grid electricity:

104,600,000 Metric Tons CO2e / 298,310,000,000 KWH = 0.0003506419 Metric Tons CO2e per kWh

Formula for CO2e created per mile driven in US passenger car:

4.75 Metric Tons CO2e / 11,318 miles driven = 0.0004196855 metric tons per mile

Formula for electric miles driven on Reconnect California Program electricity:

921,192.10 kWh * 3.33 Miles per kWh = 3,067,570

Formula for GHG offset:

0.0004196855 metric tons CO2e per mile * 3,067,570 miles = 1287.41 Metric tons CO2e (standard passenger car)

0.0003506419 metric tons CO2e per kWh * 921,192.10 kWh = 323.01 Metric tons CO2e (electric vehicle)

1287.41 metric tons CO2e – 323.01 metric tons CO2e = 964.41 Metric tons CO2e offset

Formula for gallons of gas offset:

3,067,570 miles / 21.4 miles per gallon = 143,344 gallons

Extrapolating energy use from the 84 percent of the sites that reported use data to all 100 percent of the sites yields moderate increases in the estimates of energy used, avoided petroleum and avoided CO2e. Total electricity use increases to just over 1 million kWh (1,000 MWh). Electric miles increases to 3.6 million. Avoided GHG emissions increases to 1,148 metric tons CO2e and avoided gasoline to over 170,000 miles.

Disposition of Removed and Outdated EVSEs

Through the course of the Reconnect California Program, ClipperCreek removed hundreds of outdated EVSEs that were not able to service the new generation plug-in vehicles coming into the California market. All removed equipment was either processed through authorized E-Waste recycling centers or provided to the Electric Auto Association California chapters for the purpose of keeping public inductive style EVSEs functional and available for use. Removed

equipment provided to the Electric Auto Association will be used as spare parts or in some cases replacements for inductive style EVSEs that fail in the field.

CHAPTER 3: New Technologies and Project Successes

Smart Grid Communication and Meter Module

ClipperCreek collected EVSE energy usage data for the Reconnect California Program through a new module that ClipperCreek designed and manufactured during the project. The module is called the Smart Grid Communications and Metering Module. ClipperCreek installed these modules into the Reconnect California Program stations throughout the state. Six months of accumulated kWh readings were collected from these modules through a Smart Grid network emulator that the subcontractor took into the field during site visits during January – February of 2014.

The Smart Grid Communications and Metering Module allows the EVSE owner to connect their EVSE directly to their utility meter. This direct connectivity could provide the opportunity for site hosts to participate in special Smart Grid Demand Response programs that utilities will likely implement in the future, once the Smart Grid is fully established in their area. Utilities around California have had and will likely continue to offer Smart Grid pilot programs for EV Charging. Site hosts that received equipment through the Reconnect California Program will be ready to participate in these programs. The Smart Grid module has an integrated meter (3 percent accurate), and is ZigBee 1.1 Communications Certified with the ability to reduce the electrical load through the station, during peak demand periods, based on a command from the utility.

New technology development and deployment is exciting, but the challenges can be substantial. During the development of the Smart Grid Communications and Metering Module, ClipperCreek faced several challenges, from unexpected supply chain delays to seemingly endless software re-configuration and re-testing as the communications standards fluctuated for this new technology. ClipperCreek satisfactorily met these challenges and is proud to have successfully delivered 762 Smart Grid Communications and Metering Modules through the Reconnect California Program. ClipperCreek brought a new engineer on staff in order to overcome the development challenges, creating a fourth permanent position in the company.

ClipperCreek experienced a slightly higher than expected failure rate on the deployed modules. In spite of this higher than expected failure rate, ClipperCreek successfully collected data from 84 percent of the new charger installations. Given that the Smart Grid Communications and Metering Module is on the cutting edge of a new communications and control network topology, ClipperCreek is satisfied with the success of the data collection portion of the project.

Project Success Compared to Goals

The main project goals were as follows:

- To increase California's network of plug-in vehicle charging stations while leveraging existing infrastructure wherever possible.
- To update/install at least 640 publicly accessible SAE J-1772™ EVSEs at 300 sites throughout California.
- To not leave "legacy" EV drivers stranded by the infrastructure upgrade to the new standard.
- Collect six months of energy usage information from the EVSEs installed through the Reconnect CA program.

ClipperCreek successfully expanded public charging infrastructure throughout the State, installing 762 EVSEs at 313 sites. This added infrastructure helps with the adoption of plug-in vehicles by showing potential new owners that they have a place to charge their vehicles while traveling around town or to recreation destinations. The added charging infrastructure made available through this program can also increase existing plug-in vehicle drivers' electric range, further reducing GHG emissions compared to standard internal combustion engine vehicle.

ClipperCreek was able to exceed the goal of installing at least 640 publicly accessible SAE J-1772™ EVSEs through the program. With a total of 762 EVSEs installed at 313 sites throughout the state, ClipperCreek exceeded the goal of 640 EVSEs by 19 percent and the goal of 300 sites by 4.3 percent while staying within the program budget.

No legacy drivers were left behind in these efforts. This was a difficult sell for some site hosts, but ClipperCreek was firm in its requirement to leave at least one functional "legacy" inductive style EVSE in place where one existed previously. In addition, program-subsidized adapters and conversion kits were made available to drivers of some models of older style plug-in vehicles.

Twenty two adapters and conversion kits were subsidized through the Reconnect California Program; these kits primarily went to Ford Ranger EV drivers.

Gathering six months of energy usage data from the EVSEs installed through the Reconnect California Program was challenging. ClipperCreek did not achieve 100 percent success on the data collection, but did achieve an 84 percent success rate.

CHAPTER 4: Observations, Conclusions, and Recommendations

Observations

Clipper Creek installed 762 EVSEs through the Reconnect California Program and collected energy usage information from 84 percent of the sites. Based on the energy usage information, an estimated 3,067,570 electric miles were driven on the energy provided through the EVSEs installed. Averaged across all 762 stations, this results in approximately 4,025 miles per station (3,067,570 / 762 = 4025.6).

The total electric mileage figure of 3,067,570 is substantial. In comparison, the distance from Sacramento to New York City is about 2,820 miles. With the charging energy from this project, 100 people could drive from Sacramento to New York and back almost 5.5 times or one person could do it 543 times.

2,820 miles x 2 = 5,640 miles round trip

5,640 x 100 cars = 564,000 miles round trip for 100 cars

3,067,570 / 564,000 = 5.4

Active Charging Time

Based on the energy usage data, ClipperCreek was able to calculate an average "active charging time" for the EVSEs installed for the program.

a. 921,192 kWh passed through the EVSEs;
b. Maximum power transfer rate: 7.2 kW (240V * 30A) – using 240V because it is the maximum service feed available for EVSEs, the vast majority of this equipment is likely installed on commercial power feeds (208V) but we will use 240V to be conservative;
c. Minimum vehicle power acceptance rate: 3.3 kW;
d. Maximum vehicle power acceptance rate: 7.2 kW;
e. Average power acceptance rate: 5.25 kW – This assumes the mix of vehicle acceptance rates is even;
f. Total time the stations were active: 921,192 kWh / 5.25 kW = 175,465.14 Hours across all 762 stations;
g. Time per station: 175,465.14 / 762 = 230 hours average per station; and
h. Usage per day over 6 months: 230 hours / 180 = 1.3 hours per day.

ClipperCreek estimates that on average, each charger is used 1.3 hours per day.

Conclusions

Based on the energy usage data set, ClipperCreek concludes that the EVSEs deployed through this program are being used on a regular basis and are increasing the electric miles driven across California. There are now 313 sites across the state that have EV Charging infrastructure that will serve Californians for years to come. The first six months of energy usage data indicates that 921,192 kWh of charging power resulting in an estimated 3,067,570 electric miles driven.

With 313 new charging locations and 799 charging ports installed across the state, the Reconnect California Program provided a critical compliment to the commercial introduction of electric vehicles on California's roadways. The 313 station upgrades were completed in late 2013. Plug-in vehicles continued to be delivered in increasing numbers and the expanded charging infrastructure appears to be facilitating increasing demand. As the number of plug-in vehicle owners grows across the state, the charging infrastructure needs to grow as well.

New Job Creation

ClipperCreek sourced its installation subcontractors from California-based companies, and purchased the majority of unfinished goods from California companies as well. The installation subcontractor jobs were temporary, but many personnel were needed for the 762 installations at 313 sites throughout the state. ClipperCreek used three California installation subcontractor firms that dispatched installers from their own staffs. ClipperCreek also had one paid project consultant who is also a California resident. ClipperCreek brought on four staff members to accomplish this program, and all four positions resulted in permanent and ongoing employment with ClipperCreek. In total, there was a steady stream of installation work for two years for three subcontractor firms and one consultant, and four people now have permanent jobs with ClipperCreek.

Recommendations for Future Projects

ClipperCreek offers the following recommendations based on lessons learned from the project:

1. Develop a predetermined list of planned installation sites and a list of backup sites. ClipperCreek initially assumed that all site hosts would be interested in receiving a no-cost infrastructure upgrade. This assumption was incorrect. With more than half of the initial sites declining to participate, ClipperCreek expended hundreds of unplanned labor hours to identify new upgrade sites. As a result, ClipperCreek was not able to complete all of the upgrade installations within the original timeline. Ultimately, ClipperCreek was able to install more stations than originally planned and the added labor requirements resulted in a total of four new positions at ClipperCreek which have since transitioned to permanent full time positions outside of the grant program.
    a. Advanced allocations with the site host agreement could have expedited the deployment of this infrastructure project.

2. Budget planning should include time and resources for site outreach and education. Outreach and education takes time, especially with new technologies. When this program began in late 2010, plug-in commuter vehicles were just entering the market and the public was generally unaware of this emerging technology. Many site hosts were also unaware of the new EV market. Consumers and site hosts did not know which makes and models were available, how vehicle popularity was expected to increase, or even what an EVSE was. Through outreach and site education, the ClipperCreek team quickly learned that customers needed to be educated before they would agree to have new equipment installed at their site. The most effective mechanisms for general program and industry educations were:
    - PowerPoint presentations
    - Fact sheets with "frequently asked questions"
    - Face to face or over the phone conferences with decision makers and facilities staff
3. When using subcontractors for installation work, hire multiple companies to ensure the best pricing and execution for the program. ClipperCreek learned that using a single subcontractor to manage the installations was not the best approach and made adjustments to bring a second company on-board to ensure the best pricing and execution. In early 2012, ClipperCreek brought on a third installation subcontractor and took full control of managing and scheduling the installers used for this program. This was a major factor in completing more sites than planned within the budget. Key problem areas were:
    a. Prices slowly rising for what appears to be similar work
    b. Slowdowns in scheduling
    c. Low reporting quality
4. Assume that new technology development projects will likely take longer than originally planned. During the course of ARV-10-001, the project was expanded to include the development and deployment of a new Smart Grid connected EVSE module that had integrated Smart Grid connectivity and communications with an internal energy meter. This technology was cutting edge when the development began in 2011 and is still innovative technology today. This Smart Grid Module allowed for the station to be connected to a utility smart grid for load management events as well as direct reporting of kWh utilization through the smart grid. ClipperCreek also utilized this technology to collect energy usage information from all of the stations installed through this program. The Smart Grid Module advanced charging technologies for EVSEs and for utilities to actively manage EVSE load on their systems, but it took longer to complete than originally planned. ClipperCreek encountered into several uncertainties, including:
    a. Communications standards for Smart Grid connectivity fluctuating

b. Suppliers who over-promised features of their existing technology that were ultimately incorporated into the module, but were not complete when first promised.
c. Supply chain delays for new technology that was in low production.

In the future, ClipperCreek would build in contingency time into the project schedule to accommodate unforeseen delays like those listed above. Ultimately, the development and deployment of the Smart Grid meter and communications module was a success, even though a time extension was needed.

Final Thoughts

ClipperCreek is honored to have participated in this historic infrastructure upgrade and expansion program. The installations are proving successful and the new equipment will serve California for years to come. ClipperCreek thanks the CEC for this opportunity.

GLOSSARY

AIR QUALITY MANAGEMENT PLAN (AQMP) -- A plan prepared by an APCD/AQMD, for a county or region designated as a non-attainment area, for the purpose of bringing the area into compliance with the requirements of the national and/or California ambient air quality standards. AQMPs are incorporated into the State Implementation Plan (SIP).

CARBON DIOXIDE EQUIVALENT (CO2e). A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents (MMTCDE)" or "million short tons of carbon dioxide equivalents (MSTCDE)" The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. MMTCDE= (million metric tons of a gas) * (GWP of the gas) For example, the GWP for methane is 24.5. This means that emissions of one million metric tons of methane is equivalent to emissions of 24.5 million metric tons of carbon dioxide. Carbon may also be used as the reference and other greenhouse gases may be converted to carbon equivalents. To convert carbon to carbon dioxide, multiply the carbon by 44/12 (the ratio of the molecular weight of carbon dioxide to carbon). (EPA)

ELECTRIC VEHICLES (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.

GREENHOUSE GAS -- 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)

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

LADWP - The acronym for Los Angeles Department of Water and Power an electric, municipal utility serving the greater Los Angeles, California, region

MEGAWATT HOUR (MWh) - One-thousand kilowatt-hours, or an amount of electrical energy that would supply 1,370 typical homes in the Western U.S. for one month. (This is a rounding up to 8,760 kWh/year per home based on an average of 8,549 kWh used per household per year [U.S. DOE EIA, 1997 annual per capita electricity consumption figures]).

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.

SOCIETY OF AUTOMOTIVE ENGINEERS ELECTRIC VEHICLE AND PLUG IN HYBRID ELECTRIC VEHICLE CONDUCTIVE CHARGE COUPLER J1772 (SAE J1772).This SAE Recommended Practice covers the general physical, electrical, functional and performance requirements to facilitate conductive charging of EV/PHEV vehicles in North America. This document defines a common EV/PHEV and supply equipment vehicle conductive charging method including operational requirements and the functional and dimensional requirements for the vehicle inlet and mating connector[5].

5 Society of Automotive Engineers Standards Website. (https://www.sae.org/standards/content/j1772_201001/)