DRISI
Caltrans Division of Research, Innovation and System Information

# Research Notes

Design

NOVEMBER 2022

Project Title:
Evaluate Zero-Emission Vehicle Charging Station at Caltrans Facilities

Task Number: 3302

Start Date: June 1, 2019

Completion Date: March 31, 2023

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## Evaluate Zero-Emission Vehicle Charging Stations at Caltrans Facilities

Research Direct Current Fast Charging (DCFC) installation cost, challenges, and opportunities for process improvements for future installations.

### WHAT IS THE NEED?

Governor's Executive Order B-16-2012 mandates to reduce greenhouse gas emission. Electric vehicles (EV) offer a clean fuel alternative to meet above mandate. However, range anxiety and charging frequency and gaps between existing charging stations challenges adoption.

California Department of Transportation (Caltrans) is deploying charging stations to fill in gaps between existing charging stations. This effort will provide the data needed for planning process improvement for future installment.

### WHAT ARE WE DOING?

The research team will:

1. Identify the types of data to be collected, including usage patterns, vandalism, concerns by the public, non-recoverable electricity costs, maintenance and operations costs.
2. Monitor the usage monthly and collect and summarize data of the charging stations for a period of two years after construction.

### WHAT IS OUR GOAL?

This research will collect data on the implementation, maintenance, and utilization of new charging facilities being deployed to increase the charging coverage throughout California. This information will assist Caltrans to develop policy and procedures regarding the deployment of future charging stations.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system

## WHAT IS THE BENEFIT?

This project will measure the use of the charger stations and help identify user needs. The demonstrated user demand will validate continued infill of EV service gaps and reduce inconvenience to highway system users. With the information obtained, encouraging movement towards EV infrastructure will provide business opportunity for future providers of charging stations and services.

One of the limitations of zero-emission vehicles is the time required to charge them. Expanded EV infrastructure featuring DCFCs will make EV a practical option for long-distance travel and encourage consumers to move away from internal combustion engines. Usage patterns revealed in this study will help direct future development of facilities in convenient locations, improving the availability of services and quality of travel for EV users.

## WHAT IS THE PROGRESS TO DATE?

### Task 1: Project Launch and Construction Phase Evaluation

University of California, Davis (UCD), Institute of Transportation Studies (ITS) team is evaluating the progress of the California Department of Transportation (Caltrans) DC Fast Charger project construction and launch. All the sites have finished the construction and project launch phase. However, some rest areas have planned closures for maintenance and repairs such as the John "Chuck" Erreca Safety Roadside Rest Areas (SRRA) in Merced and Camp Roberts SRRAs in Monterey. The charging stations shared in red appear to need repair to the best of our knowledge. Table 1 below is a summary of the status of each of the sites. Sites Under maintenance/ planned closure or in need of attention are highlighted in blue.

Table1: Status of the sites as of 08/01/2022

| Location | Caltrans District | County | Route | Description | Number of DCFC Stations | Status |
|---|---|---|---|---|---|---|
| 1 | 01 | Lake | 20 | Clear Lake Oaks Maintenance Station | 1 | Completed on 9/29/20. Charger is operating slower than rated capacity |
| 2 | 01 | Humboldt | 96 | Willow Creek Maintenance Station | 1 | Completed 12/31/20 |
| 3 | 02 | Siskiyou | 5 | Randolf Collier Safety Roadside Rest Area | 1 | Completed in October 2020 |
| 4 | 02 | Trinity | 299 | Moon Lim Lee Safety Roadside Rest Area | 1 | Completed in November 2020 |
| 5 | 03 | Glenn | 5 | Willows Safety Roadside Rest Area (Northbound) | 1 | Completed. But currently closed for construction. |
| 6 | 03 | Glenn | 5 | Willows Safety Roadside Rest Area (Southbound) | 1 | Completed. But currently closed for construction. |
| 7 | 03 | Colusa | 5 | Maxwell Safety Roadside Rest Area (Northbound) | 1 | Completed and operational |
| 8 | 03 | Colusa | 5 | Maxwell Safety Roadside Rest Area (Southbound) | 1 | Completed and operational |
| 9 | 03 | Nevada | 80 | Donner Summit Safety Roadside Rest Area (Eastbound) | 1 | Completed. But currently in need of repairs. |
| 10 | 03 | Nevada | 80 | Donner Summit Safety Roadside Rest Area (Westbound) | 1 | Completed. Currently in need of repairs. |
| 11 | 05 | Monterey | 101 | Camp Roberts Safety Roadside Rest Area (Northbound) | 1 | Completed. But rest area is under repairs. |
| 12 | 05 | Monterey | 101 | Camp Roberts Safety Roadside Rest Area (Southbound) | 1 | Completed. But rest area is under repairs. |
| 13 | 05 | San Luis Obispo | 46 | Shandon Safety Roadside Rest Area | 1 | Completed. But equipment maybe in need of repair. |
| 14 | 06 | Madera | 99 | Madera Maintenance Station | 2 | Completed |
| 15 | 06 | Fresno | 99 | Caltrans District 6 District Office | 4 | Completed. Possible equipment damage |
| 16 | 06 | Kings | 5 | Kettleman City Maintenance Station | 2 | Completed. Possible equipment malfunction |
| 17 | 06 | Tulare | 99 | C.H. Warlow Safety Roadside Rest Area | 2 | Completed |
| 18 | 06 | Tulare | 99 | Philip S. Raine Safety Roadside Rest Area (Northbound) | 2 | Completed |
| 19 | 06 | Tulare | 99 | Philip S. Raine Safety Roadside Rest Area (Southbound) | 2 | Completed |
| 20 | 06 | Kern | 99 | Delano Maintenance Station | 2 | Completed |
| 21 | 06 | Kern | 58 | Route 58/184 Park & Ride | 2 | Completed. Possible equipment damage |
| 22 | 06 | Kern | 5 | El Tejon Safety Roadside Rest Area (Southbound) | 2 | Completed. One of more EVSE units maybe damaged. |
| 23 | 06 | Kern | 5 | El Tejon Safety Roadside Rest Area (Southbound) | 2 | Completed. One of more EVSE units maybe damaged. |
| 24 | 08 | San Bernardino | 15 | Clyde V. Kane Safety Roadside Rest Area (Northbound) | 1 | Completed |
| 25 | 08 | San Bernardino | 15 | Clyde V. Kane Safety Roadside Rest Area (Southbound) | 1 | Completed |
| 26 | 08 | San Bernardino | 15 | Valley Wells Safety Roadside Rest Area (Northbound) | 1 | Completed |
| 27 | 08 | San Bernardino | 15 | Valley Wells Safety Roadside Rest Area (Southbound) | 1 | Completed |
| 28 | 09 | Kern | 58 | Boron Safety Roadside Rest Area (Eastbound) | 1 | Completed |
| 29 | 09 | Kern | 58 | Boron Safety Roadside Rest Area (Westbound) | 1 | Completed |
| 30 | 09 | Inyo | 395 | Coso Junction Safety Roadside Rest Area | 1 | Completed |
| 31 | 09 | Inyo | 395 | Division Creek Safety Roadside Rest Area | 1 | Completed |
| 32 | 09 | Inyo | 395 | Caltrans District 9 District Office - Bishop | 1 | Completed |
| 33 | 10 | Stanislaus | 5 | Westley Safety Roadside Rest Area (Northbound) | 1 | Completed |
| 34 | 10 | Stanislaus | 5 | Westley Safety Roadside Rest Area (Southbound) | 1 | Completed |
| 35 | 10 | Merced | 5 | John "Chuck" Erreca Safety Roadside Rest Area (Northbound) | 1 | Completed in December 2021, but rest area closed from April 4th, 2022 |
| 36 | 10 | Merced | 5 | John "Chuck" Erreca Safety Roadside Rest Area (Southbound) | 1 | Completed in December 2021, but rest area closed from April 4th, 2022 |
| 37 | 10 | San Joaquin | 99 | Lodi Park & Ride | 1 | Completed |

***Shading color codes:**

- Green indicates completed sites or almost completed
- Blue: Under maintenance/planned closure
- Red: EVSE Equipment needs attention.

**Zen 30_30 Project Timeline:**


**Task 2: Charger Operation Data and Analysis**

UC Davis ITS team is receiving charger usage data Caltrans every few months. The latest dataset we received contains charger usage data until mid-July 2022. ITS team is in the process of organizing the information and analyzing the usage session data to better understand and study the infrastructure performance including down time, power performance, energy dispensed, charging profiles, etc. Below is a brief summary of some operational data for policymakers: The data includes all successful charging events from the start of operations to July, 2022. Only successful charging events where users were able to charge their plug-in electric vehicles (energy dispensed > 0 kW) are included.

**Summary of Operational Data:**

Figure 1 indicates the distribution of charging time from 22,000 charging events at the BTCPower charging stations. On average, a plug-in electric vehicle driver at a Caltrans BTCP charges their vehicle for 38 minutes.

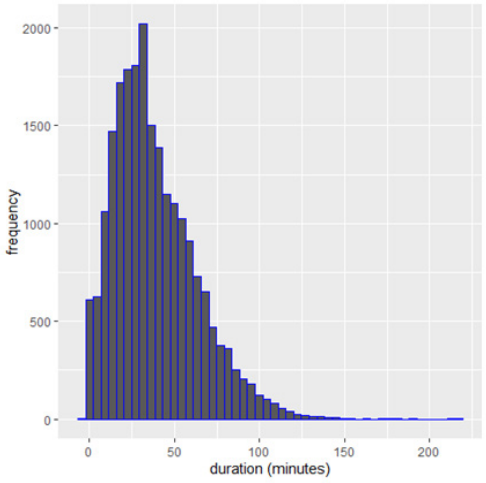



Figure 1: Distribution of charging time at BTCPower locations

Figure 2 indicated the distribution of energy usage at BTCPower charging stations from 22,000 successful charging events. An average driver consumes 21.7 kWh of energy per successful charging event.

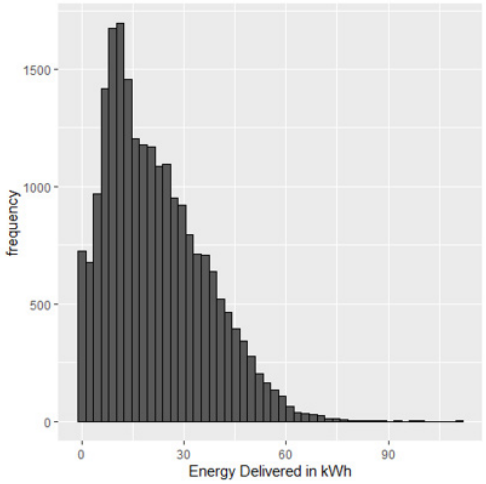



Figure 2: Distribution of energy usage per successful charging event

Figure 3 is a summary of how drivers use the chargers. We identify that more drivers will use the BTCPower chargers between 10 am and 7 pm on average.

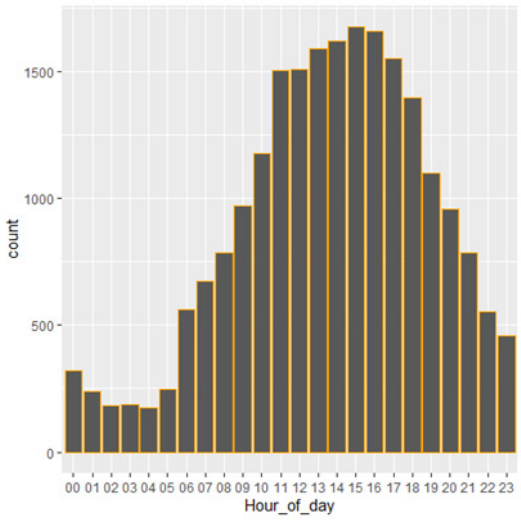



Figure 3: Charging distribution during the day

**Usage Data at select charging stations:**

**District 1 - Clear Lake Oaks Maintenance Station – Serving Route 20**

The charging station at Clear Lake Oaks maintenance station has been in operation since October 2020.


Figure 4: Location of Clear Lake Oats maintenance station (Image from Google under fair use)

The y-axis includes the count of all the successful and unique charging events within a given month. The data and public comments from the Plugshare app indicate some recent equipment malfunction and that charger is possibly operating at a power level below the designed capacity.

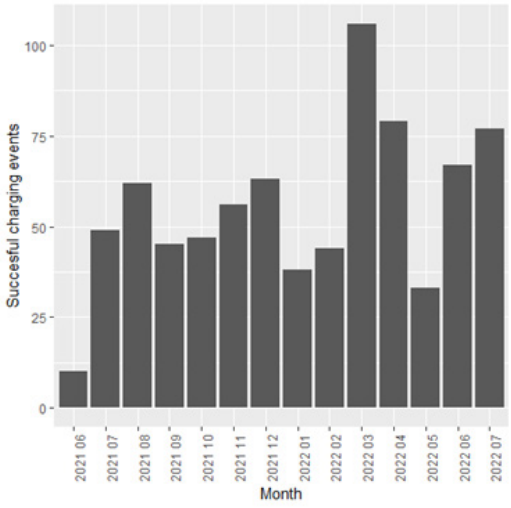



Figure 5: Monthly charger usage at Clear Lake Oats Maitenance Station

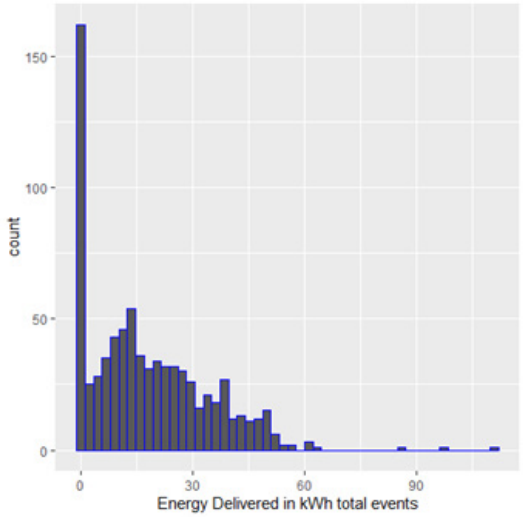
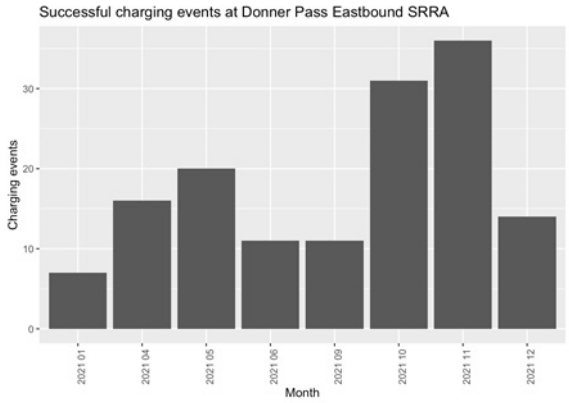



Figure 6: Comparing distribution of energy delivered per charge for 2022(left) and lifetimes events (right)

After data cleaning to rule out unsuccessful charging events, according to Figure 6, charging data from Clear Lake Oats Maintenance station indicates an unusual number of charging events that consumed very limited amount of electricity closer to 0.01 kWh. Perhaps the BTCPower EVSE unit installed here is operating at a sub-optimal speed and we recommend inspection.

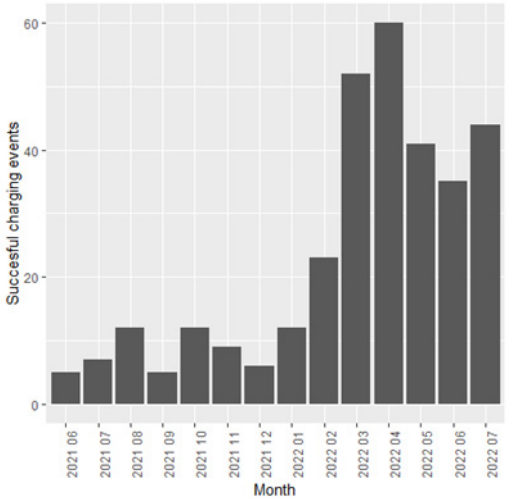
**District 3 – Donner Pass Maintenance Stations – Serving Interstate 80**


Figure 7: Location of Donner Pass SRRA's (Image from Google under fair use)

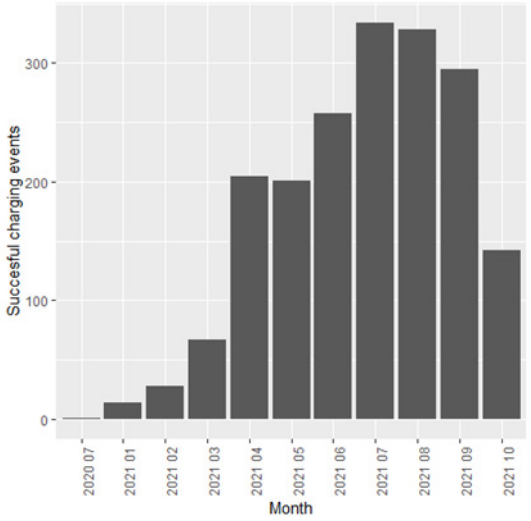



Charging stations at Donner Pass SRRAs were operational since 2021. However, the data indicates that no successful charging event has taken place since December of 2021. Public comments from Plugshare app indicates the stations are in immediate need of repair and maintenance.

**District 6 – Madera Maintenance Station – Route 99**




**Caltrans District 6 Office – Route 99**




**Kettleman City maintenance station – Route 41**

Public comments from Plugshare indicates that the charger at Kettleman city maintenance station may not be functioning at optimal speeds. A further inquiry into energy output per charging (figure below) indicates that charging may be at very slow speeds, well below the EVSE rated capacities.

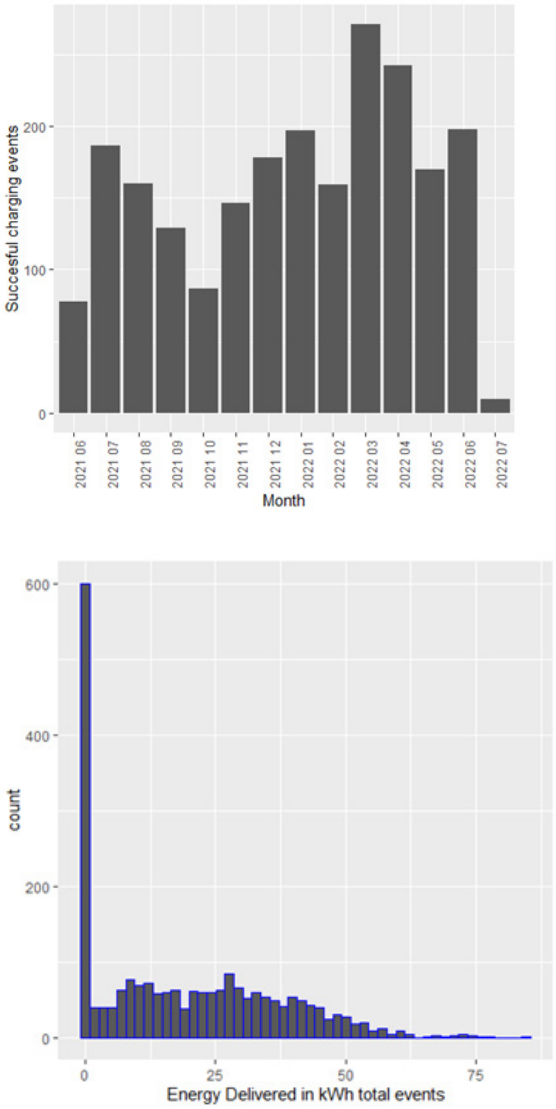



Figure 7: Figure: Distribution of energy consumer per charger at Kettleman city maintenance station

**C.H. Warlow SRRA – Route 99**

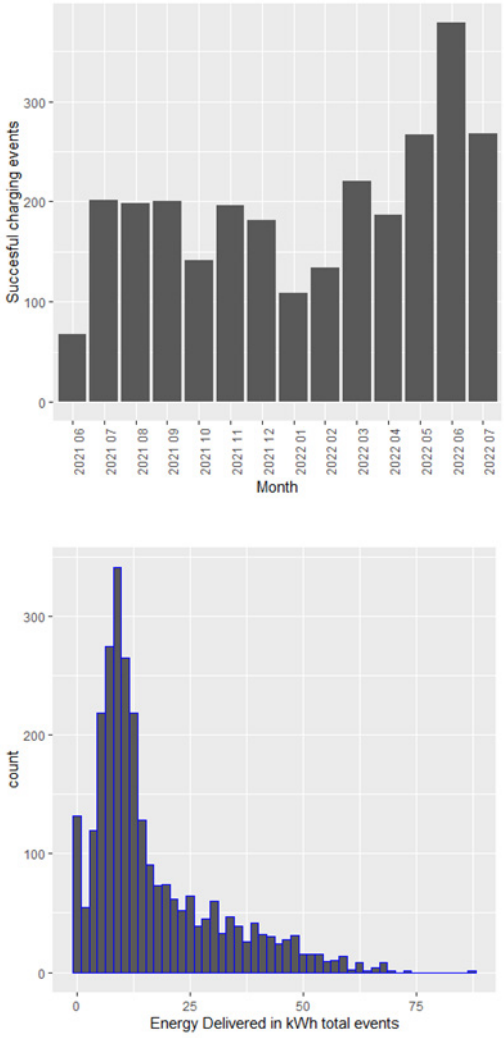
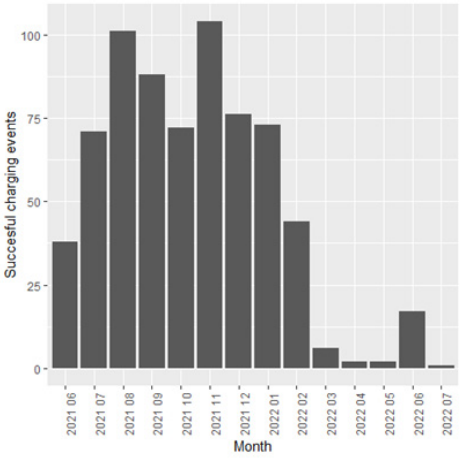


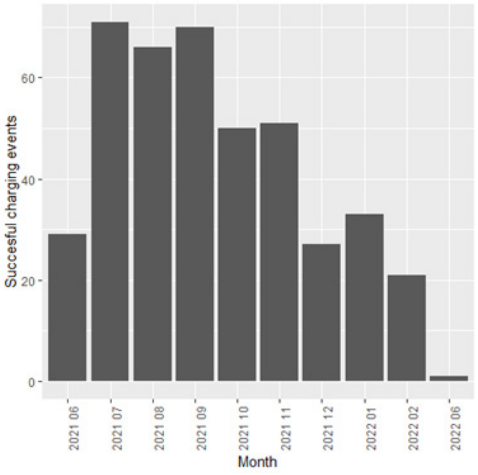

Figure 8: Distribution of energy consumer per charger at C.H. Warlow SRRA

**Philip S. Raine Northbound SRRA – Route 99**

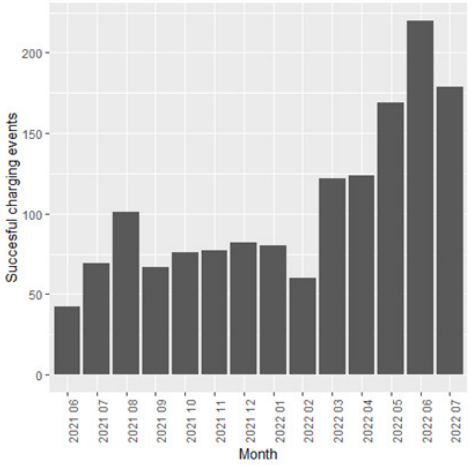
Philip S. Raine rest area on State Route 99 (both directions) have begun planned closures from February 2022, for water, wastewater, landscape and building infrastructure upgrades and is anticipated to be closed till June 2023 . This is consistent with the usage data indicated below.




**Philip S. Raine Southbound SRRA – Route 99**




**Delano maintenance station**



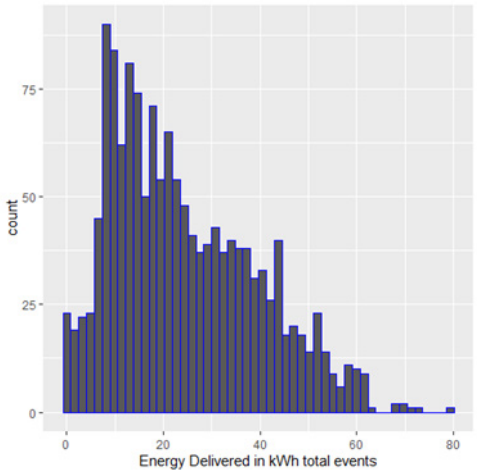
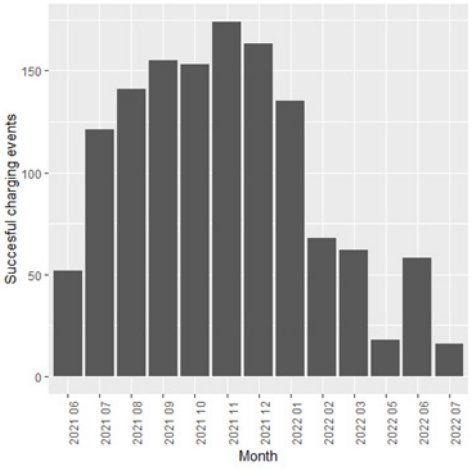




Figure 9: Distribution of energy delivered per charging event at Delano maintenance station

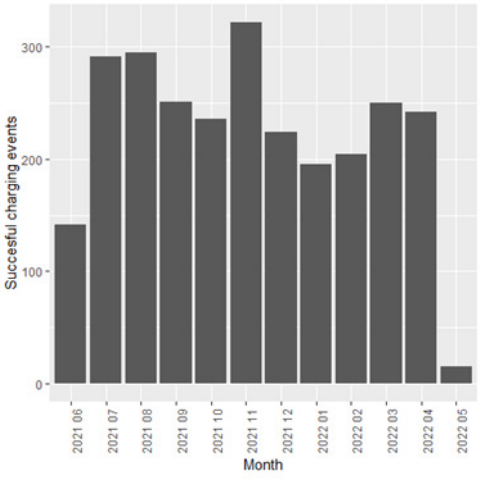
**Park & Ride at Route 58/184**

Possible equipment damage to the charging equipment here. Almost no charging activity in April 2022 and limited so far in the summer, 2022 (May – July).




**El Tejon Southbound SRRA – Interstate 5**

Charging events conducted at the 4 fast chargers were included into the graph below. No successful charging activities have been recorded since May 2022 according to the data we have.



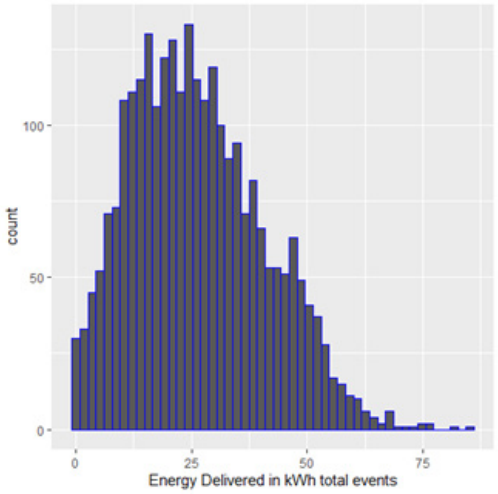
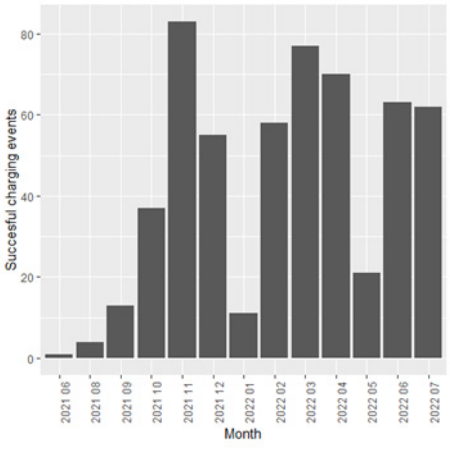
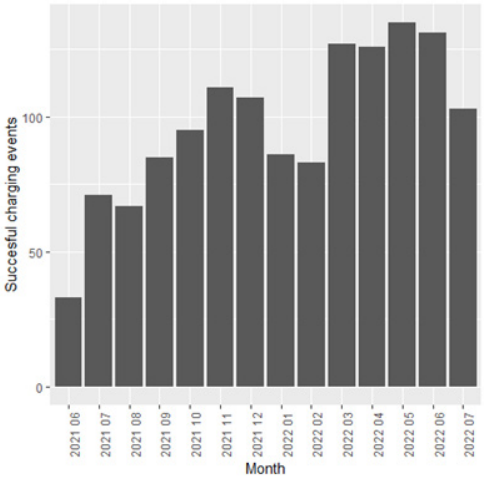




Figure 10: Distribution of energy delivered per charging event at El Tejon SRRA

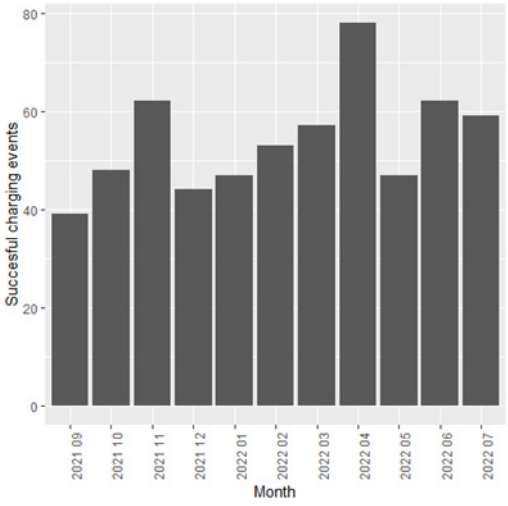
**District 8 - C.V. Kane Northbound SRRA – Interstate 15**




**Valley Wells Northbound SRRA**




**Westly Northbound SRRA**




**Westly Southbound SRRA**

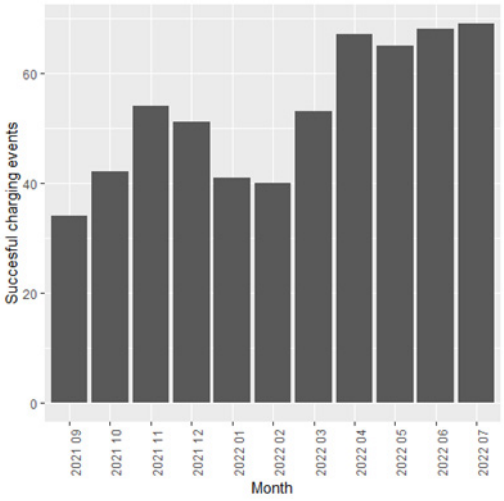



Figure 11: Brand of Charging Station installed in each Caltrans location

| BTC Power | ChargePoint |
|---|---|
| Clear Lake Oaks Maintenance Station | Randolf Collier Safety Roadside Rest Area |
| Willow Creek Maintenance Station | Moon Lim Lee Safety Roadside Rest Area |
| Willows Safety Roadside Rest Area | Camp Roberts Safety Roadside Rest Area (Northbound) |
| Maxwell Safety Roadside Rest Area | Camp Roberts Safety Roadside Rest Area (Southbound) |
| Donner Summit Safety Roadside Rest Area | Shandon Safety Roadside Rest Area |
| Madera Maintenance Station | |
| Caltrans District 6 District Office | |
| Kettleman City Maintenance Station | |
| C.H. Warlow Safety Roadside Rest Area | |
| Philip S. Raine Safety Roadside Rest Area | |
| Delano Maintenance Station | |
| Route 58/184 Park & Ride | |
| El Tejon Safety Roadside Rest Area | |

| | |
|---|---|
| Clyde V. Kane Safety Roadside Rest Area | |
| Valley Wells Safety Roadside Rest Area | |
| Boron Safety Roadside Rest Area | |
| Coso Junction Safety Roadside Rest Area | |
| Division Creek Safety Roadside Rest Area | |
| Caltrans District 9 District Office - Bishop | |
| Westley Safety Roadside Rest Area | |
| John "Chuck" Erreca Safety Roadside Rest Area | |
| Lodi Park & Ride | |

## Task 3: Maintenance and Operation Phase

We identify the need for repairs and maintenance at the following charging station locations. One of more equipment is damaged and/or there is damage to the charging capable. The usage data confirms that damage to equipment has made the chargers inoperable.

| Location | Caltrans District | County | Route | Description | Number of DCFC Stations | Status |
|---|---|---|---|---|---|---|
| 9 | 03 | Nevada | 80 | Donner Summit Safety Roadside Rest Area (Eastbound) | 1 | Completed. But currently in need of repairs. |
| 10 | 03 | Nevada | 80 | Donner Summit Safety Roadside Rest Area (Westbound) | 1 | Completed. Currently in need of repairs. |
| 13 | 05 | San Luis Obispo | 46 | Shandon Safety Roadside Rest Area | 1 | Completed. But equipment maybe in need of repair. |
| 16 | 06 | Kings | 5 | Kettleman City Maintenance Station | 2 | Completed. Possible equipment malfunction |
| 15 | 06 | Fresno | 99 | Caltrans District 6 District Office | 4 | Completed. Possible equipment damage |
| 21 | 06 | Kern | 58 | Route 58/184 Park & Ride | 2 | Completed. Possible equipment damage |
| 22 | 06 | Kern | 5 | El Tejon Safety Roadside Rest Area (Southbound) | 2 | Completed. One of more EVSE units maybe damaged. |
| 23 | 06 | Kern | 5 | El Tejon Safety Roadside Rest Area (Southbound) | 2 | Completed. One of more EVSE units maybe damaged. |

A no-cost extension for 3 months has been filed for this task for researchers to complete the evaluation of data and prepare a final report.