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Assembly
California Legislature

SELECT COMMITTEE ON
ELECTRIC VEHICLES AND CHARGING INFRASTRUCTURE
PILAR SCHIAVO, CHAIR
ASSEMBLYMEMBER, FORTIETH DISTRICT

JOINT HEARING WITH COMMITTEE ON UTILITIES AND ENERGY

COTTIE PETRIE-NORRIS
CHAIR

Wednesday, February 21st
9:30 a.m. – Sacramento
State Capitol, Room 437

INFORMATIONAL HEARING BACKGROUND

More than a Car: Improving the EV Owner Charging Experience

Introduction

By the end of 2022, there were over one million light duty zero emission vehicles (ZEVs) on the road, the majority being electric vehicles (EVs).[1] For these EVs, there are just under 100,000 chargers with a just under half of those being publicly available.[2] As EV adoption has drastically increased and the charging sector grown, early adopters of EVs have begun to experience hiccups in the charging experience. In their 2023 survey, Plug In America found that, despite over 90% of EV owners likely to purchase an EV as their next vehicle, a greater portion of drivers were running into issues with the charging network than in prior years.[3] For instance, in 2022, around 24% of owners perceived issues with nonfunctional or broken DC Fast Chargers (DCFC) in the public network as compared to 46% in 2023. While certainly satisfaction is much higher in the Tesla Supercharger Network, a similar doubling of respondents experienced issues with nonfunctional or broken chargers occurred (~3% in 2023 compared to ~7% in 2023). While the data directly connecting EV owner experience to potential EV purchaser behavior is lacking, surveys of potential EV owners show that a reliable charging network is the second most important consideration.[4,5]

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[1] California Energy Commission;"Light-Duty Vehicle Population in California":https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/light-duty-vehicle

[2] California Energy Commission;"Electric Vehicle Chargers in California";https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/electric-vehicle

[3] Plug In America;"2023 EV Driver Insights"; https://pluginamerica.org/survey/2023-ev-driver-survey/

[4] ChargeX Consortium;"Customer Experience at Public Charging Stations and Its Effects on the Purchase and Use of Electric Vehicles", https://inl.gov/content/uploads/2023/07/Customer-Experience-at-Public-Charging-Stations_INLRPT-23-74951_12-12-23_Optimized-1.pdf

[5] Plug In America;"The Expanding EV Market"; https://pluginamerica.org/wp-content/uploads/2022/03/2022-PIA-Survey-Report.pdf

As the leader of EV adoption with nearly twice as many EVs per capita than the next closest state, California is at a critical juncture to the model the transportation electrification revolution.[6] How the federal government, state government, industry, and communities proceed and choose to collaborate will not only impact consumer choice, but will be pivotal in California's path to meet its climate and air quality goals.[7] Both the federal government, through the National Electric Vehicle Infrastructure (NEVI) Program and the State, through the Clean Transportation Program (CTP), are making significant investments in public charging infrastructure to reach these goals rapidly. Parallel to these investments, to ensure that the other aspects of consumer frustrations are addressed, both the Federal Highway Administration and California Energy Commission (CEC) are establishing clear baseline standards for operation and maintenance of publicly funded in order to ensure reliability and longevity of the public charging network.

Getting a Charge

At this point, filling up at a gasoline station is a streamlined system of operation and maintenance. Charging an EV involves significantly more steps, including electronic communication between the EV's telematics, charger, and the charging network in some cases in order to recognize the vehicle, manage the charging process, and pay for the charge. Reproduced below is a flow diagram for a general charging event.

Figure 1: Charging ecosystem general architecture[8]

For each link in the above diagram, industry and regulators are contemplating the key failure pathways that lead to customer dissatisfaction and avenues to standardize or minimize disruptions to each link.

Finding a Charger (Link D)

Aside from seeing a charger out of a window, chargers are typically located via an application created by an e-mobility service provider (EMSP) which generally has information on the location of chargers, the type of charger (Level 2 or DCFC), the availability of charging ports, the price, and the ability to pay or initiate a charge. This information is made available by charge point operators (CPOs). Some CPOs are also EMSPs, allowing a single application to provide charger information and payment for a charge. Other EMSPs may rely on agreements with various CPOs to integrate data from multiple charging networks, allowing use or payment of charging regardless of which brand of charger is used so long as it is within a "roaming agreement" between CPO and EMSP. Unfortunately, numerous charging networks with various roaming agreements means a patchwork of information that an EV owner has, leading to many relying on numerous applications

[6] U.S. Department of Energy;"Alternative Fuels Data Center";https://afdc.energy.gov/data
[7] California Air Resources Board,"Climate Goals";https://ww2.arb.ca.gov/resources/documents/climate-goals
[8] California Energy Commission;"Presentation - Staff Workshop on EV Charging Interoperability"; https://efiling.energy.ca.gov/GetDocument.aspx?tn=253418&DocumentContentId=88639

depending on location and vehicle model to find chargers. As both EV ownership and the number of installed chargers increase, it is unclear whether ongoing discussions will lead to simplification of this web of options.

Plugging In (Link A)

Once a charger is located, the first check is whether the charger has a plug that matches with the vehicle's socket. Currently, there are four connectors in the American market. Pictured below, they include the J Plug (SAE J1772 Type 1), Combined Charging System (CCS) Type 1 (SAE J1772 Combo), CHAdeMO, and Tesla (SAE J3400).[9] While standards discussed later in this background require certain connectors be available, numerous vehicle manufacturers have announced shifting toward the Tesla connector, also known as the North American Charging Standard (NACS).[10] New and used electric vehicles will continue to use a mix of these connectors; however, as vehicles with non-NACS sockets phase out, fewer EV owners will need to maintain an adapter or rely on chargers having multiple connector types.

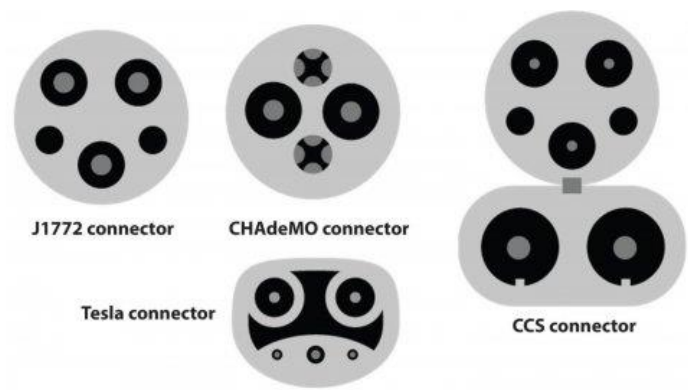

Figure 2: AC and DC plugs for both Level 2 chargers and DCFC.[2]

Once an EV is plugged into a charger, the charger must communicate with the EV to transmit charging parameters, battery state, and other information essential to the charging process. There is a protocol used internationally for communication between EV and charger (ISO 15118), but other proprietary protocols do exist.[11] Layered on top of this baseline communication for charging can be more advanced means of tailoring charging to evolving grid conditions and electricity rates. Though communication protocols exists across the industry, no-charge events are not uncommon for EV owners. Recent studies found that for some brands, no-charge events occurred nearly half of the time with a fraction of no-charge events leading to drivers being stranded.[12,13] These are instances that include when charging does not start, has negligible energy transfer, or terminates

[9] Department of Energy;"The Basics of Plugging in an EV";https://www.energy.gov/energysaver/basics-plugging-ev
[10] Consumer Reports;" Automakers Move to a Common Plug Standard to Allow Their EVs to Use Tesla Superchargers"; https://www.consumerreports.org/cars/hybrids-evs/tesla-superchargers-open-to-other-evs-what-to-know-a9262067544/
[11] California Energy Commission;" CEC Recommendation for Deployment of ISO 15118-Ready Chargers";https://efiling.energy.ca.gov/GetDocument.aspx?tn=241955
[12] Gamage T., Jenn A., Tal G.,; " Reliability of Corridor DC Fast Chargers and the Prevalence of no-Charge Events"; http://evs36.com/wp-content/uploads/finalpapers/FinalPaper_Gamage_Tisura.pdf
[13] Karanam V., Tal G.; How Disruptive are Unreliable Electric Vehicle Chargers? Empirically Evaluating the Impact of Charger Reliability on Driver Experience; https://www.researchsquare.com/article/rs-2592351/v1

prematurely. While user error does make up a percentage of these errors, communication errors are the primary errors documented. Addressing these instances where it's not immediately obvious to the user why a charge isn't occurring would certainly improve user experience.

Backend (Link B)

Communication between a charger and an operator generally involves data collection for reporting, for transactions, for charging settings, and for maintenance diagnostics. When malfunctions happen, this link is vital to quickly get the charger operational again. While proprietary protocols exist, open source ones such as Open Charge Point Protocol (OCPP) have been developed and are seeing widespread use.[14] OCPP is a flexible platform for communication; however, recent work has identified one hurdle relevant to the user experience.[15] With OCPP, custom error codes can be created for failures that happen throughout the charging process. These custom error codes add an additional layer of complexity at times, making it difficult to assess where in the process the error is from, potentially prolonging charger outages. Fortunately, work is ongoing between industry, academia, and government through the ChargeX Consortium to develop guidance to simplify error identification and resolution.

Payment (Link C)

Currently, California requires all CSOs to support roaming capability through Open Charge Point Interface (OCPI).[16] As referenced above, this means any EMSP is able to establish an agreement with any CSO such that an EV owner can pay for a charge through the EMSP. However, similar user experience issues arise in having to manage and maintain accounts across a host of applications in order to receive a charge. Separate from applications have been discussions around payment methods required by federal regulations discussed below.

Funding Landscape

The backdrop of regulatory action for charger uptime and access are in the context of hundreds of millions of public dollars focused into the EV charger network buildout. These investments include both federal and state programs each with their own methods of disbursement and eligibility requirements.

Federal Funding

The Bipartisan Infrastructure Law (BIL), which passed in 2021, established NEVI. The program itself dedicates $4.155 billion to EV infrastructure from 2022 to 2026. These funds are apportioned to states, with California to receive an estimated $380 million across five years. In 2022, California received over $56 million, and between 2023-2026 it's estimated California will receive over $81 million per year.[17] Separately, in a boost for electric vehicle reliability, the U.S. Department of

[14] Open Charge Alliance;"Open Charge Point Protocol"; https://openchargealliance.org/protocols/open-charge-point-protocol/
[15] ChargeX Consortium;"Recommendations for Minimum Required Error Codes";https://inl.gov/content/uploads/2023/07/ChargeX_MREC_Rev5_09.12.23.pdf
[16] 13 CCR § 2360.3
[17] Federal Highway Administration;"Bipartisan Infrastructure Law"; https://www.fhwa.dot.gov/bipartisan-infrastructure-law/evs_5year_nevi_funding_by_state.cfm

Transportation has awarded Caltrans $63.7 million from the Electric Vehicle Charger Reliability and Accessibility Accelerator (EVC RAA) grant program to fix and upgrade 1,302 ports across 300 sites statewide.[18] Caltrans will partner with the CEC to implement this funding.

State Funding

In 2023, AB 126 (Reyes) was signed into law, extending and recasting the Clean Transportation Program. Receiving funding from vehicle funding registration fees, the CTP receives on average $100 million per year. After the passage of the CTP reauthorization, the CEC opened Docket 23-ALT-01 in order to determine the allocation of these funds. With the most recent Lead Commissioner Report, the proposed funding for light-duty charging will include $42.6 million in 2023-2024.[19] This is in addition to $250 million that previously dispersed through CTP for programs such as Communities in Charge, which provides rebates for public and private Level 2 chargers.[20] Another EV infrastructure program funded by the CEC is the most recent iteration of the California Electric Vehicle Infrastructure Project (CALeVIP 2.0). In 2021, the Center for Sustainable Energy was awarded a $250 million block grant to administer CALeVIP 2.0. Funding through CALeVIP 2.0 is dedicated to public DCFC in disadvantaged communities or low-income communities.[21] Finally, the Greenhouse Gas Reduction Fund (GGRF), which receives funding from Cap-and-Trade auction proceeds, is allocated towards programs that reduce greenhouse gas emissions and benefit disadvantaged communities and low-income communities. The Governor's 2023-2024 proposes a fund shift of $218.5 million for the purposes of ZEV fueling infrastructure grants through the GGRF.[22]

Regulatory Landscape

<u>Federal Regulations</u>

As part of the BIL, the Federal Highway Administration was required to establish minimum standards relating to the installation, operation, and maintenance; interoperability; signage; data collection; network connectivity; and real-time availability of EV chargers funded by NEVI.[23] The regulation was finalized in February 2023, detailing such minimum standards while clarifying that States may establish more stringent EV charging infrastructure requirements towards building a convenient, affordable, reliable, and equitable national charging network.[24,25] For all of the requirements discussed below, there is a five year requirement to adhere to these standards.

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[18] Caltrans; "California Investing in EV Charging Reliability Statewide with $63 Million in Federal Funding"; https://dot.ca.gov/news-releases/news-release-2024-002
[19] California Energy Commission;"2023–2024 Investment Plan Update for the Clean Transportation Program January 2024"; https://efiling.energy.ca.gov/GetDocument.aspx?tn=254223&DocumentContentId=89583
[20] Communities in Charge;https://thecommunitiesincharge.org/
[21] CALeVIP;https://calevip.org/
[22] Office of the Governor;"Governor's Budget Summary"; https://ebudget.ca.gov/2024-25/pdf/BudgetSummary/ClimateChange.pdf
[23] 135 Stat. 1424, https://www.govinfo.gov/link/plaw/117/public/58
[24] 23 CFR Part 680
[25] Federal Register, National Electric Vehicle Infrastructure Standards and Requirements, https://www.federalregister.gov/documents/2023/02/28/2023-03500/national-electric-vehicle-infrastructure-standards-and-requirements#footnote-1-p12724

Charging Stations

For projects funded by NEVI, DCFC stations along specified transportation corridors must have four network-connected ports able to charge four EVs at the same time. For other areas, either DCFC or Level 2 chargers can be used, though they must still be able to charge at least four cars at once. In addition to port requirements, chargers must be able to charge CCS-compliant vehicles.

Uptime

Aiming to improve the reliability of the charging network, NEVI standards require an uptime for each charging port – one port per EV – of 97%. The below equation details how the uptime percentage (μ) is calculated. Every month, uptime percentage must be calculated using a rolling 12-month window on a minute-by-minute basis. The number of minutes that either hardware or software are offline (T_{outage}) are subtracted from the total number of minutes in that 12 months which certain exceptions ($T_{excluded}$) for a number of reasons. These exceptions include changes in charger operator, power outages, vehicle-side issues, scheduled maintenance, vandalism, and time outside of hours of operation.

$$\mu = \frac{525{,}600 - (T_{outage} - T_{excluded})}{525{,}600} \times 100$$

Data Sharing and Reporting

Locating a charger is currently dependent upon roaming agreements and the willingness of chargers to share specified data with third-party applications. As part of NEVI regulations, both states and recipients of NEVI funds must make data about the location, operator, charger status, charger type, payment methods, and real-time pricing freely available to third-party software through OCPI.

Interoperability

Included in the rulemaking are specified standards of communication across various stages of the charging process. Additionally, many of the standards for interoperability must be included in chargers deployed after March of 2024. These include how an EV communicates with the charger (ISO 15118-2/ISO 15118-20), the ability to use Plug and Charge, how chargers communicate with the charger network (OCPP), and how one charging network communicates with another (OCPI).

<u>State Regulations</u>

Standards

In 2022, the Legislature passed AB 2061 (Ting), which required the CEC to develop recordkeeping and reporting standards. On top of reporting, SB 123 outlined requirements for charging protocols and AB 126 (Reyes, 2023) requires the CEC to adopt tools to increase uptime requirements. Through Docket 22-EVI-04, the CEC has published draft regulations for uptime and reporting for publicly funded chargers.[26] The draft regulations reflect some of the regulations within NEVI with greater specificity on uptime and downtime limitations; however, finalized regulations have not been released. In addition to uptime regulations, the CEC has opened Docket 22-EVI-06 to discuss vehicle-grit integration, having expanded to begin conversations on the various facets of interoperability.[27] These include discussions of communication protocols, roaming, and Plug & Charge that will be integral to a charging network experience that is as seamless as possible for EV owners.

Oversight

As part of 22-EVI-04, the CEC has additionally announced a statewide research project to take a snapshot of the reliability of public charging in California. The proposed project will sample thousands of chargers, both Level 2 and DCFC, across multiple vehicle types and charging manufacturers.[28] An important point of this program is ensuring testing of chargers that span socioeconomically and geographically diverse areas. The findings will provide a view into interoperability that uptime data alone cannot evaluate. Final testing protocol will be released in the near future with a final report on the study anticipated for June of 2026.

Oversight Outside of Regulation

Where is Downtime Occurring

In the prior hearing, the Committee delved into access to a charger, what communities readily had access to charging, and the lack of charger access in low-income communities and in communities of color. When it comes to public funding for the charger network, an important question is whether the investments are reaching those would most benefit from public funding. In the context of reliability, 97% is important, but similarly important is whether there are chargers in the network that are habitually part of the 3%, whether there are communities that, despite having access to a charger, will be faced with inoperable chargers. The CEC and UC Davis study will be an important first step, and data to be collected from companies on uptime will expand on this, but the committee may wish to consider how the state can ensure data collected can be used to mitigate the potential for underinvestment in charger maintenance in communities where access to the charging network is already inequitable.

Limited Time and Scope of Regulatory Oversight

Currently both federal and state regulations are limited to chargers that receive public funding. This does not capture privately funded chargers even if available to the public. Further, the reporting requirements in both are time-limited. As EV ownership grows, charging stations will become critical infrastructure for the state's transportation system. Considering parallels to gas stations, the state has historically ensured customers receive the services advertised or paid for.

[26] California Energy Commission; Docket 22-EVI-04
[27] California Energy Commission; Docket 22-EVI-06
[28] University of California Davis;"EV Charger Field Testing Workshop PowerPoint";https://efiling.energy.ca.gov/GetDocument.aspx?tn=253390&DocumentContentId=88608

Though longer-term, the committee may contemplate the role of the state in monitoring and ensuring minimum quality standards for all chargers regardless of state support.

Enforcement

While the transparency improvements from the CEC's reliability regulations will encourage a more reliable system over time, the CEC's ability to enforce these regulations hinges on the existence of a direct contractual relationship with the charging entity. This leaves a percentage of chargers outside of the primary enforcement tool agencies currently wield.

No-Charge Events and More

In the calculation of uptime, there are a number of aspects of the charging experience missing. This can include communication errors, vehicle issues, vandalism, charger blockages, and more. The ChargeX Consortium has begun looking into these other factors which impact user experience. The Consortium has three workgroups delving into defining the charging experience, reliability/usability triage, and solutions to scaling reliability.[29] The committee may consider inquiring the progress of these conversations and possible avenues to support rapid evaluation or adoption of Consortium findings to improve user experience.

[29] ChargeX Consortium; "Framework for the National Charging Experience Consortium"; https://inl.gov/wp-content/uploads/2023/05/ChargeX-Consortium-Framework-5-11-2023.pdf