



Ready to Charge

**Five Ways California Can Improve Charging
to Unleash the Power of Electric Cars**

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Written by:

Alana Miller

Frontier Group

Dan Jacobson

Environment California Research & Policy Center

Emily Rusch

CALPIRG Education Fund

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Correction (Sept. 2019): The original version of this report erroneously cited a 2017 National Renewable Energy Laboratory report as indicating that California would need 35,000 fast-charging plugs to support the state's 5 million zero-emission vehicle goal by 2030. While the citation was incorrect, more recent California-specific data suggest that the state will likely need well more than 35,000 fast chargers to meet its 2030 goals. The report has been corrected and updated accordingly.

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Executive Summary

Global warming is already impacting California in devastating ways. In 2018, wildfires ravaged the state, with the deadliest wildfire in history, the Camp Fire, killing at least 85 people, and the largest wildfire ever recorded in the state, the Mendocino Complex, burning almost half a million acres.¹ For nearly seven years, the state has been experiencing a drought, which has greatly impacted agriculture and water resources.² At the same time, rising sea levels threaten coastal communities with flooding, erosion and mudslides.³

We must accelerate action to reduce emissions in order to protect our state. Transportation is now climate enemy #1, the result of California's dependence on private gasoline-powered cars.⁴ To prevent the worst impacts of global warming, we must reduce our reliance on cars and ensure that the cars we do use run on clean electricity.

Electric vehicles (EVs) offer many benefits for California, including cleaner air and the opportunity to reduce greenhouse gas emissions. Electric vehicles are far cleaner than gasoline-powered cars, and produce less carbon pollution and fewer of the emissions that lead to smog and particulate pollution.⁵

California is a leader in the adoption of electric vehicles, accounting for half of America's EV sales.⁶ The trend is expected to continue as the state works to achieve its goal of 5 million zero-emission vehicles on California streets by 2030, up from 513,000 that had been sold in the state through 2018.⁷

In order to meet these ambitious goals, many more Californians will need to choose electric vehicles over

gasoline-powered cars, which requires that owning an EV become just as easy, if not easier, than owning a gasoline car. **Unfortunately, the day-to-day experience of EV drivers seeking to charge up their vehicles has a long way to go to match the ease and convenience of refueling a gasoline-powered car – especially when it comes to public charging.**

Only 75 percent of the public charging stations in California that are included in a Department of Energy database are open to the public 24 hours a day.⁸ Only about 15 percent (750 stations) function with the ease of how we are accustomed to fueling vehicles – with the station open to the public 24 hours a day, compatible with different car types, and without requiring membership to a specific company's network.⁹

People's habits for charging their electric vehicles will be different from refueling their gasoline cars. Similar to how we charge our cell phones, most EV charging will happen overnight at home and during the day at work. Inconvenient or confusing public charging, however, still threatens to be a barrier to the mass adoption of EVs. California should use public policy tools and state investments in EV infrastructure to improve access to charging for all EV users.

Public charging is essential for the mass adoption of electric vehicles. Most electric vehicle owners need convenient access to public charging during longer trips and occasionally in daily driving. In addition, many residents of California who live in compact urban areas or multi-family housing do not have a driveway or garage and will have to rely on public charging to drive an electric vehicle. For instance, in a 2016 survey by the Union of Concerned Scientists and

Consumers Union, only 54 percent of respondents reported having private off-street parking (like a garage or driveway) with an electrical outlet.¹⁰ Even people with access to charging at home will use public chargers to make up for insufficient range or to provide a range buffer for their trip.¹¹

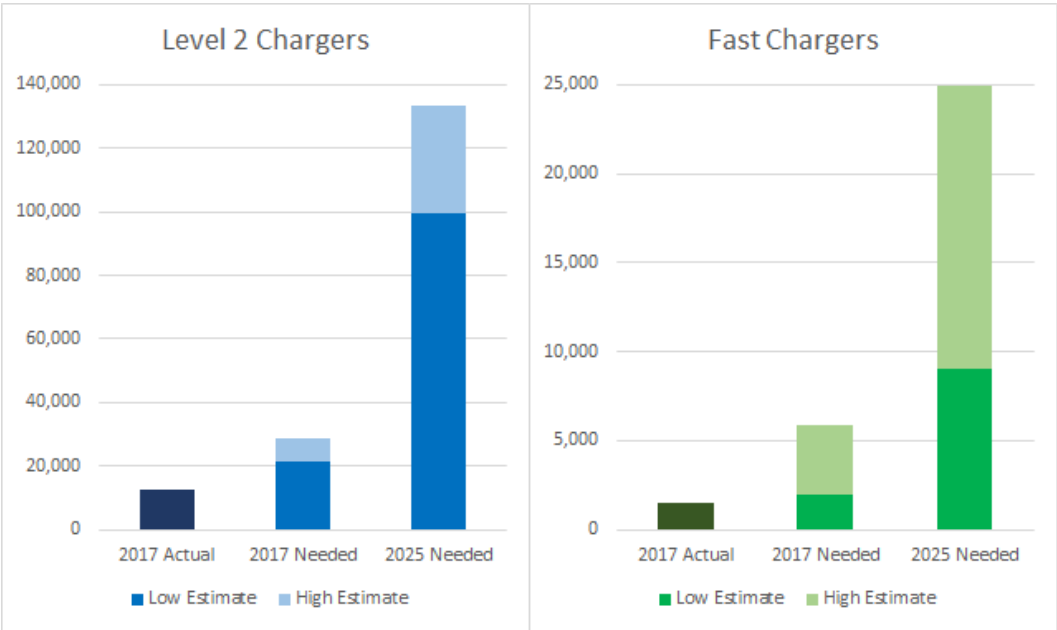
California electric vehicle users often run into road-blocks or confusion when charging away from home. Among the challenges they face are:

Too Few Chargers: Current numbers of electric vehicle chargers are insufficient to meet demand in California. Electric vehicle drivers report that chargers aren’t always in the areas where they need to charge or are often occupied. At the end of 2017, the state had almost 14,000 public chargers, including 1,500 fast charging plugs, serving 350,000 plug-in electric vehicles.¹² However, according to a 2018 California Energy Commission report, California would have needed between 22,000 and 29,000 Level 2 plugs (not including chargers in private workplaces) and

between 2,000 and 5,900 fast chargers to fully support that number of EVs.¹³ Meeting the state’s ambitious goals for growing the electric vehicle market will require even more chargers. The same California Energy Commission report estimated that, to support 1.3 million zero-emission vehicles by 2025, the state would need 99,000 to 133,000 public and workplace Level 2 chargers, and 9,000 to 25,000 fast chargers. If the same ratio of chargers to vehicles were needed to support the state’s goal of 5 million zero-emission vehicles, California would require between 380,000 and 512,000 Level 2 chargers and between 35,000 and 96,000 fast chargers. (See Figure ES-1).¹⁴

Chargers that Are Not Available to the Public: Many charging stations can only be used by patrons of a business, by paying a fee for parking, or during certain hours. According to the Department of Energy’s database on electric vehicle charging stations, only 75 percent of public stations in California are open to the public 24 hours a day.¹⁶

Figure ES-1. Current Charging Infrastructure Versus the Infrastructure Needed to Support Current EV Numbers and 2025 EV Projections in California¹⁵



I need to charge my Chevy Bolt...



1. OK, is there a charger nearby?

Only 75 percent of public charging stations in California are open 24 hours a day



2. Does the station have a plug that is compatible with my car?

Level 2 Charging: Compatible with all EVs



Fast Charging:

- U.S. & European cars: SAE Combo plug
- Asian cars: CHAdeMO plug
- Tesla cars: Tesla-only plugs



3. Do I have access to the station's charging network?

Blink

ChargePoint

EVgo

Greenlots

SemaConnect



4. How can I pay?

Get code online or call

Sign up as a member

Sign up as a member

Open access

Open access

Credit card



Membership fob



Mobile app



5. Is the charger available?

Chargers are frequently blocked by other vehicles

Charging an electric vehicle can be overly cumbersome, particularly compared to how people are used to easily refueling their cars at gas stations.

Incompatible Chargers: Certain chargers are not usable by some types of cars, with some fast-charging plugs (CHAdeMO) only working for Asian cars, others (SAE Combo) working on European and American cars, and Tesla's proprietary connection only working on Teslas (see Figure 2). For instance, in downtown San

Diego, an area with dense multi-family housing, there are only three fast chargers. One charger works with U.S. and European models, one works with Asian car models, and one works for Teslas.¹⁷ Effectively, all electric vehicle owners in downtown San Diego, and those traveling into the city, have access to one fast charger.

Different proprietary networks: There are at least nine networks of EV charging stations in California. For an EV driver to use a network operated charging station, they often must be a member of that system or have the company's app downloaded. This poses a challenge for EV drivers to find and use chargers.

Opaque pricing and multiple payment models: EV networks offer many different payment methods, including through a mobile app, credit card and in-vehicle purchasing. Some networks require purchases to be made within the app. Some stations charge a flat fee, some charge based on the amount of electricity used, and others charge by the length of time the car was charging. The cost of charging is not always clearly marked at the chargers, leaving drivers guessing how much they'll end up paying. Comparison shopping across payment metrics is very challenging for the average EV driver looking for a charge, particularly when compared to the ease of understanding the standard metric of dollars per gallon at gas stations.

In order to meet California's electric vehicle goals and replace gasoline-powered trips with electric-powered trips, people will need more convenient options for public charging.

The good news is that smart public policies can help streamline how we charge EVs, making it easier for more Californians to participate in the electric vehicle revolution.

There are five key strategies California should pursue to improve EV charging in the state and maximize the potential of electric vehicles:

1. Expand access to electric vehicle charging by supporting and requiring the installation of more public stations. The state and local can expand access by installing charging on public property, including parking lots at government buildings, schools and curbsides. Public funds and public property should be used preferentially for stations that are open to the public, operable

by all users regardless of network membership or car manufacturer, and that have clear, fair rate policies. Entities in California can help speed deployment of charging infrastructure by streamlining permitting and expediting utility interconnections. By incentivizing the development of charging stations that are available to the public, people will have access to more chargers, alleviating some of the usability challenges.

2. Ensure interoperability between stations so EV drivers can seamlessly use and pay at any station, regardless of which company owns or operates it. Interoperability has been standard in Europe for many years, with high competition among companies facilitating connections between stations. California's Electric Vehicle Charging Open Access Act, the implementation of which is being planned now, requires interoperability capabilities on all public charging stations (whereby EV drivers can use any station regardless of network operator).¹⁸ However, the law still depends on individual companies entering agreements with each other to allow cross-network usage, creating a patchwork user experience. Entities in California should encourage interoperability agreements between companies, including by requiring that rate-based utility investments in EV charging and stations using public funding be interoperable.

Drivers also need a standard way to pay at any station. Drivers know that if they pull up to any gas station or parking meter, they can pay by cash or credit card. Drivers similarly need to know they can pay at any charging station with one form of payment, whether it is a fob or card that works at all stations or a credit card. The proposed implementation plan for the Open Access Act requires that all charging stations use credit card readers. The state should continue monitoring EV charging payment options and periodically evaluate other options to ensure that anyone who chooses to drive an EV can easily pay for a recharge.

Finally, the state should improve price transparency at chargers so that consumers can easily make price comparisons, like they can with dollar-per-gallon pricing at gas stations.

3. Require open data from charging companies so EV drivers can find all available charging stations through one site or app and know whether the charger is being used. Companies that receive public funding, utility investment, or install stations in public spaces should be required to disclose real-time information about station availability and pricing so drivers can access that information in one location.

4. Enforce the state law that requires EV charging spaces to be occupied only by charging electric vehicles. Cities should work to enforce California's law that EV charging locations are only for use by charging EVs, not parked EVs, hybrids or gasoline vehicles. That will help ensure that charging stations are available for people who need to charge.

5. Promote mobility options such as electric transit and fleets of shared electric vehicles so people can take advantage of the EV revolution without having to personally own a car.

The goal of California's electric vehicle efforts should not be to sell cars but to expand the number of miles people drive on electric power and reduce the number they drive in gasoline-powered vehicles. The state should encourage and promote programs that give people shared access to electric vehicles when they need them.

Introduction

Imagine you are driving a gasoline-powered car down the road and you notice the fuel tank needle approaching “empty.” You decide to look for a gas station to refuel your car.

But instead of brightly lit gas stations along the side of the road, all gas pumps have been relocated within parking garages or the parking lots of shopping centers and are marked only by small signs. In order to find a station near you, you’ll have to open up an app on your phone.

There aren’t very many stations anymore, either, so you may have to drive well out of your way in order to find a place to refuel. And when you arrive, you might find a car just parked there – not refueling, just parked.

When you do reach an accessible pump, you realize it doesn’t work with your car – it only works with Asian cars, but you drive a Chevy.

You finally arrive at an available pump that works with your car, but before you can get gasoline, you have to download another app and become a member of the gas station. And because every gas station charges for gas in a different way, you end up spending much more than you were anticipating.

This seems like a nearly impossible scenario. Californians have become used to having gasoline acces-

sible when and where they need it, with minimal wait times, and for sale at prices that are mostly consistent across stations, advertised in big numbers visible from the street. However, scenarios like this are the daily reality for many electric vehicle drivers who need to charge their cars in public.

Electric vehicle charging will differ greatly from refueling gasoline cars: most electric vehicle charging will take place overnight at home and at work during the day – similar to how most people charge their cell phones. However, every cell phone owner knows the stress of having a low battery and struggling to find an available outlet in a public place. Charging from an outlet in public, like at the airport, is not how people primarily charge their phones, but it is sometimes a necessity.

Similarly, to facilitate rapid electric vehicle adoption in California, car owners will need access to charging at home, at work, and on the go. Overcoming the obstacles of public EV charging will be critical for California to meet its zero-emission vehicle goals and to combat climate change.

This report seeks to improve understanding of the current system for electric vehicle charging in California and to identify policies and systems that could help simplify public charging of electric vehicles.

Convenient Access to Charging Is Key to Achieving California's Electric Vehicle Goals

A revolution is happening on California's streets. More than 500,000 electric vehicles have been sold in the state in the past eight years, making up about half of the nation's EV sales.¹⁹ In January through August of 2018, EVs made up 7 percent of all new car registrations in California – double the market share in 2016.²⁰

The growth of electric vehicles in California has been spurred by strong policy – the state has a goal of 5 million electric vehicles on the road by 2030, and a variety of EV rebates and incentives are available to Californians.²¹ Cities are also taking charge. Los Angeles, for instance, has a goal that 25 percent of cars in the city are electric by 2035.²²



Two electric vehicles charge in front of San Francisco's city hall. Credit: Flickr user mariordo59 (CC BY-SA 2.0).

To support new electric vehicles, California will need to invest in the infrastructure to power them. Instead of gas stations, EVs will need charging stations. And because EV charging often takes place overnight, cities will need to ensure that people have access to charging near their homes, as well as at work and in other places where people spend time.²³

The number one hesitation people have about buying an electric car is lack of charging stations, with 47 percent of respondents in a 2018 survey citing that as the reason they were unlikely to buy or lease an EV, according to a survey by Axios and Survey Monkey.²⁴

In January 2018, Governor Brown announced an executive order to use \$2.5 billion to build a quarter million new EV charging stations and other EV infrastructure across the state by 2025, supporting a goal of having 5 million EVs on California streets by 2030.²⁵ A 2018 study from the California Energy Commission estimated that, to support 1.3 million zero-emission

vehicles by 2025, the state would need 99,000 to 133,000 public and workplace Level 2 chargers, and 9,000 to 25,000 fast chargers.²⁶ If the same ratio of chargers to vehicles were needed to support the state's goal of 5 million zero-emission vehicles, California would require between 380,000 and 512,000 Level 2 chargers and between 35,000 and 96,000 fast chargers.²⁷

The state understands the need for rapid, widespread investment in charging infrastructure. However, the complexity of the current charging system represents an additional hurdle that could limit mass adoption of EVs. To make the biggest impact as new charging infrastructure comes on line, EV charging stations should expand access for most California consumers. Smart policy measures can help ensure that the stations not only exist, but they are intuitive, affordable and accessible to anyone who chooses to drive an electric vehicle.

EV Drivers Need Access to Convenient Public Charging

Meeting California's climate change goals will require that we not only accelerate the transition to electric vehicles, but also that those vehicles help replace every trip that can currently be easily made with a gasoline-powered vehicle. Access to convenient, affordable and easy-to-use public EV charging can help to achieve that goal.

Most electric vehicle owners will need to charge their vehicles through a combination of chargers at home, work, school, shopping, and on-the-go during longer trips. Even people with access to charging at home will use public chargers, most frequently to make up for insufficient range or to provide a range buffer for their trip.²⁸ By expanding public charging options, more people can replace trips they currently make with gasoline-powered vehicles with zero-emission plug-in electric vehicles.

Access to public EV charging can be the deciding factor in the decision of two-car families to abandon gasoline powered cars entirely. In households with electric cars, many people still feel they need their gasoline-fueled car for long trips because they are not confident in charging infrastructure along the way. For instance, a 2017 UC Davis survey of EV owners in California found that households with battery electric vehicles with shorter ranges still rely on internal combustion engine vehicles for longer trips.²⁹ Some plug-in electric vehicle owners who had

charging available outside of their house, particularly at work, greatly increased the share of miles they traveled on electric power as opposed to gasoline.³⁰ In another survey, less than 3 percent of 34,000 users ever took a trip in their electric vehicle that was longer than their EV's range, though more than half said they would be willing to, if they knew they would be able to charge.³¹ This anxiety about access to charging infrastructure means that people are unable to rely on electric vehicles for all their trips and keeps Californians reliant on fossil-fuel powered vehicles.

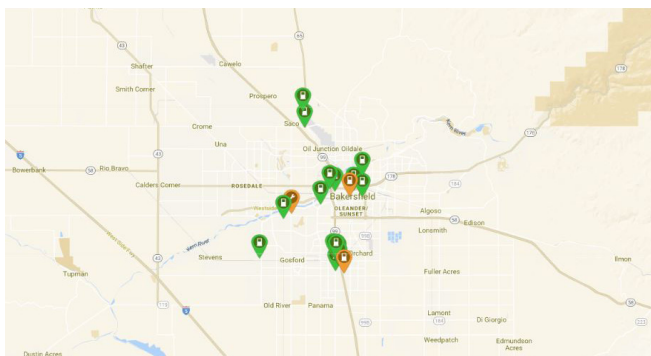
Mara Leong-Maguinez is a 30-year-old Pasadena resident who drives her all-electric Fiat to work in downtown Los Angeles, about 9 miles each way. The car's range allows her to make the trip without charging during the day, though she and her husband still rely on internal combustion cars for longer trips. She heard there are enough stations to drive up the coast to Northern California and they've considered trying it as "an adventure challenge," but so far, their nervousness leads them to continue to use their gasoline car for such trips. Mara is disappointed they still have to own both cars, saying "the short range works 99% of the time; it feels crazy to have a gasoline car for just the 1% of the time, but with the charging infrastructure, we don't feel confident we can only have electric cars right now."³²

Jeff Mathias owns a solar company in Sonoma County and drives a plug-in hybrid Chevrolet Volt instead of an all-electric EV because he can't depend on adequate charging infrastructure to meet his needs. Sonoma has a high concentration of electric vehicles and the county has prioritized charging infrastructure, but Jeff says the "current infrastructure isn't enough to meet demand... The charging stations at local grocery stores or the movie theater are often full and you can't count on them."³³

Public Charging Infrastructure Doesn't Meet Current, or Future, Demand

Currently, a lack of adequate public charging in California makes it more difficult for residents to shed their gasoline-powered cars and make the leap to electric vehicles.

There are three primary levels of electric vehicle chargers – Level 1 (L1), Level 2 (L2) and DCFC (often referred to as "fast charging") – that provide varying speeds of charging. Level 1 chargers, which supply a slow trickle charge, can serve as a low-cost option at homes, workplaces, and some public parking areas (like airports) where drivers will be parked for long periods of time. Most public chargers – on curbs, at workplaces or businesses, and in parking garages – however, will need to be Level 2 and fast charging (DCFC). (See Figure 2.)



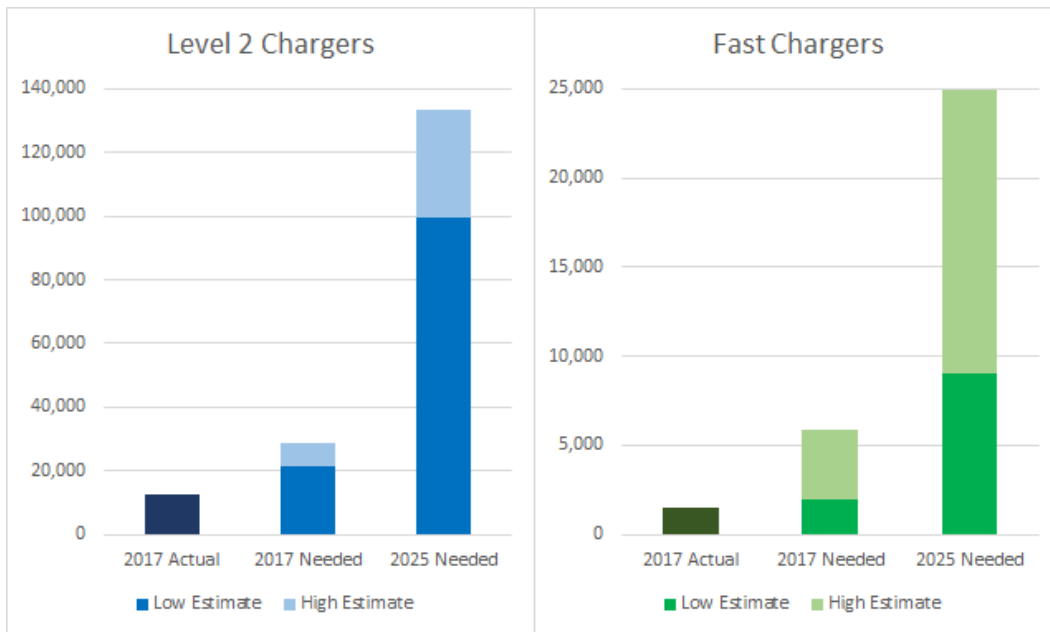
Charging stations that a Chevrolet Bolt EV can use, within about 20 miles of Bakersfield. Credit: PlugShare screenshot.

While the state has made strides installing EV chargers, the current number of EV chargers is inadequate to support a rapid, widespread expansion of electric vehicles in California.³⁴ According to the U.S. Department of Energy, every 1,000 battery electric vehicles in cities require around 36 public and workplace Level 2 charging plugs and about 1.5 fast charging plugs (a charging station may have more than one plug so multiple cars can charge at the same time).³⁵

At the end of 2017, the state had almost 14,000 public chargers, including 1,500 fast charging plugs, serving 350,000 plug-in electric vehicles.³⁶ However, according to a 2018 California Energy Commission report, California would have needed between 22,000 and 29,000 Level 2 plugs (not including chargers in private workplaces) and between 2,000 and 5,900 fast chargers to fully support that number of EVs.³⁷ Meeting the state's ambitious goals for growing the electric vehicle market will require even more chargers. To support 1.3 million zero-emission vehicles by 2025, the state would need 99,000 to 133,000 public and workplace Level 2 chargers, and 9,000 to 25,000 fast chargers. If the same ratio of chargers to vehicles were needed to support the state's goal of 5 million zero-emission vehicles, California would require between 380,000 and 512,000 Level 2 chargers and between 35,000 and 96,000 fast chargers. (See Figure 1).³⁸

Fast charging plays a particularly important role for some EV owners who need to charge outside of their homes. A 2017 study out of UC Davis found that half of the fast charging that drivers paid for was located just 6-8 miles away from their home, suggesting the need for fast charging in people's daily lives, not just on long trips.³⁹ Over half of the survey participants said they would not have used their electric vehicle without fast charging options.⁴⁰ Furthermore, nearly half said they shopped at a store, spending an average of \$30 while shopping, in order to access charging, perhaps indicating a lack of options in public places.⁴¹ The unavailability of affordable, convenient and easy-to-use public charging may be a high enough barrier to dissuade Californians from purchasing an electric vehicle or abandoning a gasoline-powered car.

Figure 1. Current Charging Infrastructure Versus the Infrastructure Needed to Support Current EV Numbers and 2025 EV Projections in California⁴²



Residents Without At-Home Charging Need Public Charging

Public charging is particularly critical for EV owners without the opportunity to charge their vehicles at home, especially in the denser parts of cities. In a survey of people who use fast charging, 61 percent of respondents living in apartments said they do not have access to charging at home.⁴³ In a 2016 survey by the Union of Concerned Scientists and Consumers Union, only 54 percent of respondents reported having private off-street parking (like a garage or driveway) with an electrical outlet.⁴⁴

Will Gray is an assistant high school principal in Long Beach who now drives a plug-in hybrid, but previously had an all-electric Tesla. When he and his wife first got the Tesla and were looking for a new place to live, they “actually picked the apartment complex because it had an electric car charger.”⁴⁵ Will said with current charging infrastructure, he couldn’t “imagine having an electric vehicle without some kind of overnight charging.”⁴⁶

Unfortunately, many residents lack access to convenient public charging that could replace or supplement at-home charging needs. In a 2017 survey of CleanTechnica readers by CarMax and CleanTechnica, 32 percent of respondents said the nearest public charging station is more than 5 miles from their home.⁴⁷ Only around half of the respondents said there are convenient public charging stations near their home.⁴⁸

In Los Angeles, for instance, the apartments at the sprawling Park La Brea complex (one of the largest housing developments west of the Mississippi, with more than 4,000 units) don’t have an electric vehicle charger in their parking lots.⁴⁹ Within about a mile of the apartments, there is only one fast charging location – at the automotive museum where charging is only available from 10 am to 6 pm, which is unlikely to work for most peoples’ schedules. There are nine other publicly available charging locations within a mile, though most of them are in paid parking lots at museums or shopping centers.⁵⁰ Lack of public charging in residential areas makes owning an EV inaccessible to people who do not have charging opportunities at home.

Thousands of California's EV Chargers Are Not Available to Everyone

Many charging stations that are outside of people's homes are not effectively open to the public. Charging stations may be located at hotels or other businesses where you have to be a guest or customer, or be inside garages where an EV driver could have to pay a high fee to park even if they are just looking to charge their vehicle. Other stations are only available during certain hours, which may limit how useful they are for an EV driver in need of a charge.

Of electric vehicle charging stations in the Department of Energy's database, 14 percent of California's "public stations" require that EV drivers be patrons of a business to use the station, while nearly 8 percent require a parking fee or are restricted by hours, leaving only about 3,600 stations across the state (75 percent) open to the public 24 hours a day.⁵¹

Available chargers do not work with all types of cars, and may be restricted to members of certain charging networks. Many chargers offer different prices, complex rate structures, different payment options and a lack of price transparency. Finally, an insufficient number of chargers means that chargers are frequently occupied or unavailable when drivers need them.

Not Every Charger is Compatible with Every Car






Every electric vehicle can charge at a Level 1 station, which is a standard wall outlet, and Level 2 stations are uniform so that any EV can charge there (including Tesla vehicles, with an adapter). Fast chargers, however, are not compatible with all cars. (See Figure 2).

The incompatibility of fast-charging stations with certain car makes, combined with the low numbers of fast chargers, poses a large barrier for electric vehicle adoption – particularly in areas without at-home charging, or for longer trips.

In downtown San Diego, for example, an area primarily with dense multi-family housing, there are only three fast chargers. One charger works with US and European models, one works with Asian car models, and one works for Teslas.⁵² Effectively, all electric vehicle owners in downtown San Diego who lack a charging option in their house, and those driving into the area, have access to one fast charger.

Someone living in downtown Fresno in an apartment without a charger at home or work would similarly struggle to own an electric vehicle. There isn't a single fast charger in downtown (and the only Level 2 charger in downtown is reserved for hotel guests), requiring at least a five-mile trip to Whole Foods, the mall or the university (CSU Fresno) to access a fast charger.⁵³ However, numerous PlugShare users have complained that those stations aren't working or are frequently inaccessible due to non-electric vehicles

Figure 2. Charging Stations by Type

Type	Level 1	Level 2	Fast Charging
Plug⁵⁴	Standard wall outlet 	J1772 connector 	 SAE Combo – American and European cars  CHAdeMO – Asian cars  Tesla
Compatibility	All EVs	All EVs (including Tesla with an adapter)	Varies by car manufacturer
Approximate Time to Add 50 Miles	10 hours	2-4 hours	Half an hour
Best Usage	At home and overnight	At home; in public garages or on curbs; at work; public spaces like shopping centers	Gas stations; rest stops; public places

parked in the spaces.⁵⁵ The stations at the university are only accessible after 8:30 am and are CHAdeMO plugs, which only work with Asian model cars.

Fast chargers are also particularly important for EV drivers on the go, when they won't be stopping for long periods of time. For instance, someone driving east from San Diego to Phoenix in a Chevy Bolt doesn't have access to a compatible fast charger for nearly 350 miles (there are several Tesla Superchargers on the route), far beyond the car's range of approximately 230 miles.⁵⁶ For people looking to purchase an electric vehicle but who may need to drive long distances occasionally, lack of fast charging options can pose an obstacle to adoption. (Access to shared vehicles can help alleviate some of these concerns, see page 26.)



This fast charger in Dunsmuir, CA, has an SAE Combo connector, so it is only compatible with American and European car models. Credit: Staff.

Finding a Charger May Require Belonging to Many Networks (And Using Many Apps)

Only a small minority of public electric vehicle charging stations in California allow an EV driver to pull up, pay (or use for free), and start using the station like they would at a gas station. Instead, payment at charging stations is typically collected by companies that often require drivers to be members in order to use their stations. If a driver arrives at a station that is operated by a membership network they are not part of, the driver may need to download an app and create an account, or call a 1-800 number to get charging access. Furthermore, Tesla-run stations only work for Tesla vehicles.

As a reporter for the tech site *Engadget* described, “I’ve seen the same scenario play out over and over again. A person pulls up to a station, looks at the instructions, curses under their breath and pulls out their phone. Five minutes later they start charging.”⁵⁷

The companies with the most stations in California are:

blink **Blink:** The company operates around 300 publicly accessible stations in California, primarily in San Diego, Los Angeles and San Francisco.⁵⁸ EV drivers do not need to be members of the network to use the charging stations, however, members receive discounts.⁵⁹ Non-members can use a Blink station by acquiring a guest code online or calling a phone number.⁶⁰


-chargepoint+ **ChargePoint:** This global network operates approximately 2,200 charging plugs across California.⁶¹ To charge at a station, you need to be a ChargePoint member.

EVgo **EVgo Network:** EVgo specializes in fast chargers, operating around 290 stations in California.⁶² You have to be a mem-

ber to use an EVgo station and can choose to either pay a monthly fee of \$10 (which includes \$10 of charging) and get lower rates, or not pay a fee and pay higher rates per charge.⁶³

greenlots **Greenlots:** Operating approximately 180 stations in California, Greenlots does not offer membership plans and instead lets any EV driver plug-in and pay via credit card, mobile app or phone.⁶⁴ The location that hosts a Greenlots station sets the fees associated with charging and drivers can see the costs to charge at any station on the Greenlots app.⁶⁵

SemaConnect **SemaConnect:** With more than 200 stations in the state, SemaConnect calls themselves an open network of charging stations, allowing any driver to charge an EV through their app, over the phone, a third-party app called PlugShare, or through a SemaConnect pass.⁶⁶

 The car manufacturer **Tesla** also owns and operates a vast network of EV charging stations across the country – with about 600 in California – that are only compatible with Tesla cars.⁶⁷

Given the complexity of the proprietary networks and platforms, a driver on the go looking for a charge may have a hard time finding a station they can use. Drivers of any gasoline-fueled car can pull up to any gas station and reliably pay. Electric vehicle drivers, on the other hand, must use several apps to find a charging station that works with their particular car and their preferred network.

A number of third-party sites have developed to help EV drivers find stations across all networks. The most popular is PlugShare, an app and website that crowdsources data from users on the location, status, price and other details of EV charging stations. PlugShare is run by California-based company Recargo and relies on EV driver input to populate its map and app. Given its dependence on voluntary

I need to charge my Chevy Bolt...



1. OK, is there a charger nearby?

Only 75 percent of public charging stations in California are open 24 hours a day



2. Does the station have a plug that is compatible with my car?

Level 2 Charging: Compatible with all EVs



Fast Charging:

- U.S. & European cars: SAE Combo plug
- Asian cars: CHAdeMO plug
- Tesla cars: Tesla-only plugs



3. Do I have access to the station's charging network?

Blink

ChargePoint

EVgo

Greenlots

SemaConnect



4. How can I pay?

Get code online or call

Sign up as a member

Sign up as a member

Open access

Open access

Credit card



Membership fob



Mobile app



5. Is the charger available?

Chargers are frequently blocked by other vehicles

Charging an electric vehicle can be overly cumbersome, particularly compared to how people are used to easily refueling their cars at gas stations.

crowdsourcing, despite the tremendous amount of information on the app, it isn't always accurate. For instance, although a Level 2 charger at the Hotel Rosedale in Bakersfield populates the map as a public charger, user input says the charger is for hotel guests only.⁶⁸ Other stations don't have user feed-

back or haven't been updated in years, which could mean the information for that charger is unreliable.⁶⁹

All of these variables pose a real barrier to current and potential EV drivers. Will Gray said he's "lost track of how many companies run the stations now. It's not like

“It’s not like a parking meter or a gas station where you know you can always use it”

a parking meter or a gas station where you know you can always use it... The system has to be ‘me proofed’ so I can easily figure out how to charge at 5:30 in the morning on the way to work.” Mara Leong-Maguinez, a somewhat tech-savvy Millennial and all-electric Fiat owner, has found the membership and payment system at network-owned chargers “so complicated and convoluted” that she hasn’t even tried to use one, instead relying on her at-home charging, free stations in Pasadena, and her second (gas-powered) car.

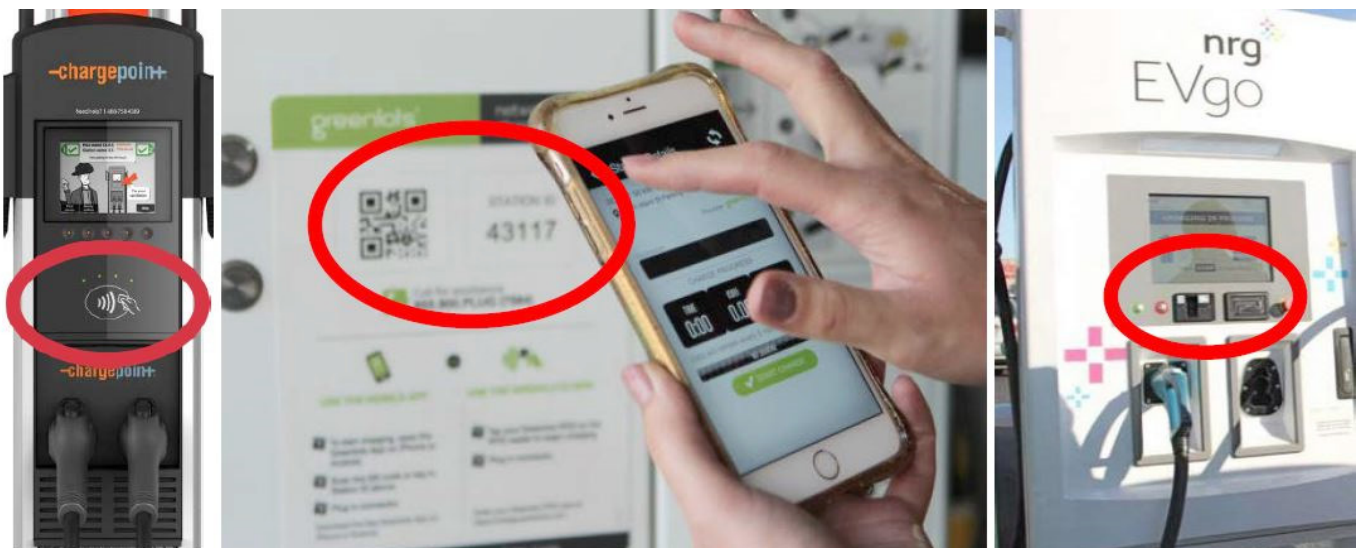
Chargers Lack Pricing Clarity and Use Different Payment Mechanisms

At gas stations, prices are transparently advertised on large signs and at each pump with a standard pricing mechanism (dollars-per-gallon). The driver of a

gasoline-powered car can reliably fuel up any vehicle using cash or credit card at any station.

Paying for electric vehicle charging, on the other hand, is far more complicated. Charging stations and network companies offer different pricing structures, which could include fees for parking, energy usage, time usage, and monthly membership in a charging network. Some EV charging stations allow people to pay with a credit card, though others, like those in the ChargePoint and Blink networks, don’t. Instead, users pay on an app or with a membership card. EVgo allows users to pay by credit card, but most EVgo users pay with their membership card, while a “small but growing portion use the app” and a marginal number pay by credit card.⁷⁰ The lack of consistency across stations makes it hard for EV drivers to be prepared to pay for charging.

Prices can also change dramatically depending on demand or time of day. Orange County-based EV owner Juan Barnett, for instance, posted on Twitter an email that he received from his network, ChargePoint, after plugging into a station. The email read, “We wanted to let you know that at 9:16 a.m., the parking fee set by the property owner increases from



Different charging stations accept different payment methods, including a fob for network members (left), access by a downloaded app (center), and credit cards (right). Credit: California Air Resources Board.

\$0.00/min to \$0.25/min.”⁷¹ If the driver had been planning to charge for two hours for free, they would now be paying \$30 unexpectedly.

Pricing by Network: Some charging networks set prices, often by state, for all their customers. For instance:

- In California, Blink members pay \$0.49 per kilowatt hour, and guests pay \$0.59/kWh, for Level 2 charging, and \$0.10/kWh more for fast charging, while the car is plugged in.⁷²
- For EVgo’s fast chargers in California, members who pay a monthly fee (\$10, which includes \$10 of charging) pay \$0.18 - \$0.21 per minute and sessions are capped at 45 minutes during the day and 60 minutes at night; members who don’t pay a monthly fee pay \$0.25 - \$0.35 per minute for charging.⁷³
- Tesla charges \$0.26 per kWh in California for supercharging, along with “a small fee.”⁷⁴

Pricing by Site Host: Other networks, however, operate the station but it is owned and prices are set by the site.

- ChargePoint chargers are independently owned and have prices set by the owner. Determining how much any particular station will cost requires visiting the company’s website. For example, charging at a Level 2 ChargePoint station by San Diego’s baseball stadium, Petco Park, costs \$0.59/kWh.⁷⁵ The station at Huntington Beach’s pier

costs \$0.29/kWh, and at a parking garage by the Oakland Public Library, charging costs a flat \$1 fee plus \$0.20/kWh.⁷⁶

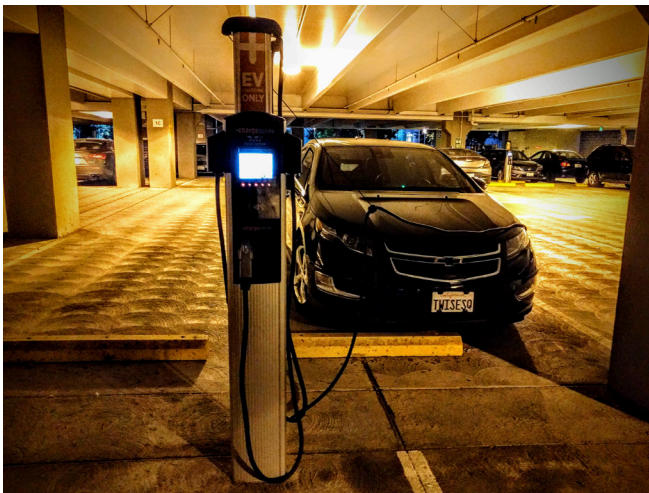
- Greenlots lets station hosts set the price for charging. At the fast charger at Sacramento’s Amtrak station, for instance, there is a \$0.35 access fee and a \$0.25 charge per kWh. Charging is limited to one hour.⁷⁷ At a Level 2 charger at an outlet mall outside of Bakersfield, a Greenlots charger costs \$0.27 per kilowatt hour, with free parking.⁷⁸ A Level 2 charger near the John Wayne Airport in Irvine costs \$4 per hour for the first three hours, and \$12 per hour after that, along with a \$6 per hour parking charge.⁷⁹
- SemaConnect charging stations are owned and operated by the site host, who sets the price for charging. A Level 2 charger at the Kaiser Permanente medical office in Davis, for instance, costs \$1.35 per hour of charging, while a Level 2 charger at a shopping center outside of Fresno costs \$2 per hour for the first two hours and \$5 per hour after.⁸⁰
- Tesla will install Level 2 chargers at businesses that want them, commonly hotels or restaurants, and the price to use the charger is at the discretion of the site host. In an online forum for Tesla drivers, several users had received free charging while staying at hotels or eating in restaurants with Tesla destination chargers, and other users reported paying up to a \$15 fee to use a charger at a location where they were not a customer.⁸¹

Company	Priced by	L2 Member Price	L2 Guest Price	Fast Member Price	Fast Guest Price
Blink	kWh	\$0.49	\$0.59	\$0.59	\$0.69
Evgo	minute	NA	NA	\$0.18 - \$0.21	\$0.35
Tesla	kWh	“Destination Charging” – usually free	NA	\$0.26	NA

In an attempt to provide a more seamless experience for EV drivers, PlugShare offers a payment option through its app, designed to work at any station, regardless of network, if the station's network or operator has opted into the system. In 2017, Sema-Connect opened its stations for payment through PlugShare, though most other stations do not appear to accept it.⁸²

Paying for Parking in Addition to Charging:

Publicly available stations are frequently located in parking lots where EV drivers must pay for parking in order to charge their vehicle. The price for parking is often not clear when users look at different apps to find a charging location.



EV drivers frequently need to pay for parking to access charging stations in garages and other locations with paid parking. Credit: Flickr user Travis Wise (CC BY 2.0)

For instance, within a 10-minute walk of Oakland City Hall, there are four locations with charging – all of which involve paying for parking. None of the stations are fast chargers (see Figure 2), so an electric vehicle would need to charge at least two hours to add 50 miles of range. According to the PlugShare map, the closest location to the city hall has paid parking, but it does not specify the cost of the parking, though charging there is free.⁸³ The ChargePoint app says the rate at that location is free, which presumably refers to the charging price and does not mention the cost of parking.⁸⁴ The Blink, EvGo, Sema-Connect and Tesla maps do not show this charging station (since it is a ChargePoint station). The next closest station, according to PlugShare, costs \$2 for 15 minutes with a \$40 max.⁸⁵ An EV driver looking for charging in the area may have to search several apps to find a station and still not have any idea how much they would pay to park and charge once they found one.

Paying for Services or Products in Exchange for Charging: Some charging stations that are labeled as publicly available restrict who can use the station, typically reserving charging for customers or guests, like the Marriot in Long Beach or Ram's Gate Winery in Sonoma.⁸⁶ Others, like the Whole Foods in Sherman Oaks, offer free charging for customers, so EV drivers may effectively be paying for a charge by shopping at that business.⁸⁷

Lack of Chargers Means Competition for Those that Exist

Compared to the number of people with electric vehicles, there aren't enough public chargers to meet demand – particularly with the limitations on which chargers people can use. While any particular charger may often be available, a blocked charger can pose a big problem for an EV driver in need of a charge.

Sometimes charging stations are unavailable because they are occupied by another charging EV. Not having accurate information on which stations are currently open means EV drivers may drive to a station and be unable to use it, forcing them to start their search over. As Will Gray put it, knowing the availability of a charger before someone gets to it is critical – “if you go to a gas station and the pumps are busy, you know it might take five minutes max before you can fill up. If all the EV chargers are taken, it can be an hour easily.” Some apps, like Blink and ChargePoint, show the real-time status of their stations, but no app aggregates the availability of stations across networks.

Another challenge is when stations are blocked for prolonged periods of time, either by other electric vehicles or by gasoline-powered cars (EV drivers have even coined the term “ICEd” for when an internal-combustion engine vehicle blocks access to an EV charger by parking in front of it).⁸⁸

“If you go to a gas station and the pumps are busy, you know it might take five minutes max before you can fill up. If all the EV chargers are taken, it can be an hour easily.”



Electric vehicles parked and charging at Point Reyes National Seashore. Credit: staff.

Smart Policies Can Make It Easier to Charge Electric Vehicles

To facilitate the widespread adoption of electric vehicles, California must implement policies that expand and improve access to EV charging. EV drivers should have the same access to affordable, easy-to-use and convenient refueling as drivers of gasoline-powered vehicles. Public policy decisions can help make that possible.

There are five key strategies California should pursue to improve EV charging in the state and maximize the potential of electric vehicles:



Cities around the world, like Rotterdam, Holland, pictured here, have facilitated EV curbside charging in dense neighborhoods. Credit: Flickr user M. Appelman, CC BY-SA 2.0.

1. Expand Access to EV Charging Stations

Much of the tension around charging electric vehicles centers on charger scarcity. People are hesitant to rely on all-electric vehicles for fear that they will not be able to find a station that works with their car, their membership, or that is available at the time. By expanding the number of stations in public places, particularly in dense residential areas and locations where people frequently travel, California can support the adoption of more electric vehicles.

Utilities in California already intend to spend hundreds of millions of dollars expanding electric vehicle charging infrastructure, including by installing the electrical infrastructure that will facilitate charging station installation and through rebates for customers to install chargers in residential areas.⁸⁹

Charging infrastructure will also be installed with Volkswagen settlement money. After Volkswagen was discovered to have equipped half a million diesel cars with emissions-cheating devices, allowing the cars to emit 40 times the legal amount of pollution, the company entered into a settlement that allocated \$2.7 billion across all 50 states.⁹⁰ The settlement money can be used on clean transportation programs, and 15 percent of the funds can be allocated for zero-emission charging or fueling infrastructure.⁹¹

California will receive \$800 million of the settlement, based on how many of the polluting cars were sold in the state. In June 2018, the state released its plan for

how to spend the settlement money, with \$5 million going to EV charging stations, primarily to fill in gaps from other programs.⁹² The plan will fund up to 100 percent of the cost of stations that are publicly accessible on government property, up to 80 percent for public stations on private property, and up to 60 percent of non-public stations at workplaces and in multi-family residential buildings.⁹³ The plan, however, does not detail how the stations should be operated or mandate standards of service.

After the settlement, Volkswagen also created Electrify America, a company dedicated to expanding electric vehicle charging infrastructure. Electrify America will invest \$2 billion in EV infrastructure and education programs in the United States through 2027, with \$800 million flowing to California.⁹⁴ The state, through the Air Resources Board, is responsible for reviewing and approving Electrify America's plans



With minimal signage, many EV charging stations are easy to miss. Someone driving on an adjacent road likely wouldn't notice the presence of charging stations in parking lots, like this one in Santa Rosa. Better signage can increase charger visibility. Credit: Staff

in California; in December 2018, the Board approved Electrify America's second \$200 million investment, which includes fast charging in additional metro areas, charging on regional routes and charging stations to support electric buses and ride-hailing.⁹⁵

As public money flows to build more charging stations, it is critical that they are as openly accessible as possible. Public funds should be used preferentially for stations that are open to the public, operable by all users regardless of network membership or car manufacturer, and have clear, fair rate policies. By setting standards on public access, interoperability and service levels for stations that benefit from public funds, the funds will have a bigger impact – allowing more people to access more charging stations. As California allocates state funds to charging infrastructure and approves utility and Volkswagen plans, it should ensure open access and fair, transparent pricing at funded stations.

Additionally, entities in California can help speed the deployment of charging infrastructure by streamlining permitting and expediting utility interconnections. Local and state governments can expand access to installing charging on public property, including parking lots at government buildings, schools and curbside.

Finally, while installing more charging stations, Californians would benefit from increased signage and visibility of EV charging locations. Whereas gas stations are typically very visible on the sides of roads and highways with large signs, EV chargers can be hidden in parking lots. By increasing the visibility of stations, EV drivers will have a better sense of where stations are. Better visibility for charging stations can also help reduce concerns around owning an electric vehicle for potential EV owners.

Removing Barriers to Installing Charging Infrastructure

At the same time that California expands charging infrastructure in public places, it is important to remove barriers that hinder the installation of charging stations at residences and workplaces, while ensuring that electric vehicle expansion meets the state's other transportation goals. Current policies around parking and development may stand in the way of EV infrastructure expansion. For instance:

- **EV charging spaces are not considered parking spaces and therefore are seen as adding to the amount of parking required for new development.** California code defines spaces with EV charging infrastructure as “charging spaces,” as opposed to “parking spaces.” While the definition is designed to ensure that chargers are not occupied by cars that are not actively charging, it effectively disincentivizes the installation of charging stations in addition to required parking minimums.⁹⁶ Furthermore, this policy encourages the allocation of more space to parking when the state should instead be facilitating non-vehicular travel. Supporting EVs should not run counter to the state's other transportation or land-use needs.
- **Many California residents lack dedicated off-street parking and cannot install charging infrastructure.** Particularly in dense neighborhoods, many residents rely on on-street parking and lack a spot where they might charge an electric vehicle overnight. By reconsidering parking policies to enable residents to install on-street charging infrastructure at curbsides, or facilitating partnerships with neighborhood parking lots at city buildings, schools and other locations, cities can ensure that all Californians have access to residential charging.
- **New construction isn't usually designed with future EV charging in mind.** It is much easier and cost-effective to install EV charging infrastructure when the proper electrical infrastructure is put in place during construction, rather than retrofitting an area after a building is completed. California, within its 2016 green building code, requires that 6 percent of spaces in nonresidential lots with more than 10 parking spaces be “EV ready,” having all the electrical infrastructure except for the actual EV charger. The state also requires 3 percent of parking be EV ready at residential buildings with 17 or more units. The California Air Resources Board, however, proposed in April 2018 eliminating the unit size threshold and increasing the requirement to 10 percent of spaces in multifamily residential buildings.⁹⁷ Cities can pass ordinances requiring a higher percentage of parking spaces at new residential, commercial and municipal buildings be wired and have the capacity to support EV chargers at a later date. San Francisco (100 percent EV ready or flexible, meaning they have the potential for chargers later), Oakland, Palo Alto (100 percent residential units) and other cities have ordinances that go beyond the state's requirements.⁹⁸
- **Permitting and approval for utility interconnections can be cumbersome and time-consuming.** By streamlining permitting and expediting utility interconnection requirements, the state can help speed EV charging deployment.

2. Require Interoperability Between Stations

The “wish list” for many EV drivers, including Will Gray in Long Beach, consists of “one app or one log-in to access any charger, and a way of knowing if there is availability before going somewhere.” Drivers explain that by having those two things, they would feel more confident driving their electric vehicle instead of a gasoline vehicle, or committing to an all-electric car instead of a plug-in hybrid that has a gasoline option.

Interoperability allows EV drivers to use charging stations regardless of which company owns or operates the station. Instead of having to rely on multiple accounts or downloading many apps, interoperability allows drivers to see where stations are on a comprehensive map, use any station they chose, and easily pay for the charge.

In 2014, the European Union issued a directive to member countries to put policies in place that would support high goals for electric vehicle adoption. The countries could interpret the directive differently, but most decided to include a high level of interoperability. Norway and the Netherlands, in particular, are leaders. In the Netherlands, EV drivers can use any public charging station in the country with a fob or key card from any network, as the system is entirely interoperable.⁹⁹



The EVBox charge card or fob is one of the charge cards that allows users to charge at any public station in the Netherlands.¹⁰⁰

The “wish list” for many EV drivers, including Will Gray in Long Beach consists of “one app or one log-in to access any charger, and a way of knowing if there is availability before going somewhere.”

Most countries don’t have a prescriptive policy for how interoperability should happen, but rely on open charging standards and market forces to shape their networks.¹⁰¹ This has created global competition among companies facilitating connections between stations. For instance, Hubeject, a company founded by auto companies, utilities, and hardware and software manufacturers, allows EV drivers to roam among more than 100,000 charging points in 27 countries.¹⁰² The platform allows users to access any charging station by connecting operators and networks on the backend, allowing a seamless experience for the driver. Ladenetz is another interoperability service formed by municipal utilities, charging operators and universities, with stations throughout Germany, the Netherlands and central Europe.¹⁰³

There is momentum in the United States towards interoperability as well. In October 2018, Electrify America (the Volkswagen subsidiary created after the company’s “Diesel-gate” emissions cheating scandal) announced an interoperability agreement with Greenlots, EV Connect and SemaConnect. The deal allows customers of any of those networks to use a station operated by any other company in the agreement, starting in late July 2019. The interoper-

ability announcement effectively opens up a network of 12,500 stations nationwide, including the \$2 billion network Electrify America is building as part of the Volkswagen settlement. Brendan Jones, vice president of Electrify America, said, “It will be seamless for EV owners that you can charge when you need one – comparable to getting cash at an ATM machine when it’s not your bank.”¹⁰⁴

California is now working to implement legislation that was passed in 2013, the Electric Vehicle Charging Open Access Act, that requires interoperability capabilities, whereby EV charging stations are equipped with software that allows drivers to use stations under different networks.¹⁰⁵ The law also requires reporting of station location data to the National Renewable Energy Laboratory and more transparent price labeling on the charging stations.¹⁰⁶ However, the law still depends on individual companies entering into agreements with each other to allow cross-network usage, which creates a patchwork user experience. Entities in California should encourage interoperability agreements between companies, including by requiring that rate-based utility investments in EV charging and stations using public funding be interoperable.

In 2017, Massachusetts signed into law legislation that allows the Department of Energy Resources to adopt interoperability that facilitates payment between EV charging stations.¹⁰⁷

Utilities in different regions of the country have also weighed in on interoperability. For instance, Pepco submitted a proposal to the Maryland Public Service Commission to work with a third party that will oversee payment transactions at utility operated stations. Pepco will also work with network operators, such as ChargePoint and Blink, to allow EV drivers to use the utility’s stations through their preferred network account.¹⁰⁸ In Washington, the state utilities commission instructed utilities to include an interoperability analysis with their proposals to the commission and the commission said interoperability would be a key factor in its evaluation of utility proposals.¹⁰⁹

Interoperability policy should:

- Allow an EV driver to use and pay for any station, regardless of network membership or charger ownership
- Include location data that is accessible through any network’s app or website
- Include real-time information to identify the availability of a station
- Enable users to choose from several payment options
- Include service level agreements between network providers to ensure a reliable and consistent charging experience for users
- Standardize pricing metrics so customers can compare costs across stations

Interoperability should play a key role in the implementation of the 2013 Open Access Act, the approval of utility investments in electric vehicle charging, and the allocation of Volkswagen settlement money.

3. Require Open Access to Data

EV drivers should be able to find charging stations in one source, instead of having to check multiple apps. By requiring charging companies to make their data available, ideally in real-time, EV users could find stations from a single platform and know whether or not the station was available, if it was compatible with their car, and understand how many miles of charge they could get over what time period, as well as how much that might cost. The public would also be able to use the data to evaluate the state’s progress on developing EV charging infrastructure, identify areas in need of more infrastructure, and propose new policies to address problems during rollout.

Currently, the National Renewable Energy Laboratory (NREL) publishes data about electric vehicle charging stations in the United States. However, the collection

of the data is ad hoc and cumbersome. NREL says it updates its station data from information in news articles, coordinators in cities, a feedback form on its website, industry groups, charging infrastructure providers, and others. The agency then checks its data against published data on industry sites.¹¹⁰

The most robust dataset for chargers in the U.S. is PlugShare, which shows stations on a publicly accessible map. The underlying data, however, is not available to the public and relies on users submitting information to keep the map up-to-date with station locations, reliability and payment information.¹¹¹

This hodgepodge of information makes it hard for EV drivers to know whether a station is on public property, if they have to be a guest or customer of the location, if the station is occupied, or if it is compatible with their network membership and payment options. The lack of comprehensive information makes it difficult for would-be EV purchasers to have confidence that sufficient charging infrastructure exists in their area to support their daily activities.

With connected stations and open data, EV drivers could have access to comprehensive station maps, as well as real-time information, allowing them locate stations more easily, determine whether they are in use, reserve stations if needed, and help identify problems.

While the U.S. currently lacks a comprehensive system, globally there are examples of shared information platforms that give EV drivers more complete information. For instance, the company Hubeject collects real-time charging station data from its network of partners and offers that aggregated data back to providers, allowing apps run by individual companies (like EVgo or an auto company) to show available

charging stations in real time, regardless of which company runs the station.¹¹²

California's Electric Vehicle Charging Open Access Act, for which the Air Resources Board is now developing implementation rules, proposes that EV service providers report public station location data in a standardized format on a continuous basis to the National Renewable Energy Laboratory in order to help EV drivers find stations through one map or app.¹¹³

Real-time information, however, is unlikely to be made available through this requirement and should be pursued through other avenues.

Cities, states and federal regulators should require open access to charging station locations, particularly if the stations are funded with public money or located on public property. Utilities should be encouraged to ask for open data with proposals from charging station operators.

Finally, improved signage on charging stations could help demystify EV charging by clearly telling users what kind of cars the station is compatible with and how long it will take to add a certain number of miles to your car's range. For instance, the startup company Chargeway has designed a system of colors (based on car type) and numbers (based on charging speed), similar to how colors and numbers are used at gas stations to designate different fuel types. The symbols could be used on charging stations, on interactive maps on phone apps, and potentially at dealership showrooms to help people understand charging options when purchasing an EV.¹¹⁴ In the summer of 2018, Chargeway launched a pilot program in Oregon. Utilities and other entities in California should consider standardizing similar signage models to help simplify and explain charging to current and potential EV drivers.

4. Ensure EV Spaces Are Open for EVs

If public charging stations are occupied by non-electric vehicles, the purpose of the public's investment in EV charging infrastructure is defeated.

It is illegal to park a non-electric vehicle in an EV charging space in nine states, including California, and D.C. (WA, OR, CA, AZ, HI, IL, MA, RI, FL), although city-level enforcement varies.¹¹⁵ California's law, passed in 2011, states that vehicles not in the act of charging may be towed from privately owned off-street spots and each charging location must have a sign indicating that.¹¹⁶ Los Angeles is in the process of developing a local ordinance to allow the citation or towing of vehicles illegally parked in electric-vehicle charging spaces on streets and public property.¹¹⁷

Oslo, for example, levies a fine on non-electric vehicles that occupy the spots, and allows EV owners to request the towing of such vehicles.¹¹⁸ Amsterdam restricts the use of almost all public parking spaces with charging infrastructure to electric vehicles, and grants free parking to EVs for the entirety of the



Ensuring that charging stations are open for electric vehicles that need a charge is an important part of expanding charging access. Credit: Flickr user Dave Reid, CC BY-NC 2.0.

time the vehicles spend plugged in to the charging point.¹¹⁹

A few U.S. cities also enforce time limits on the use of EV parking spaces (even for EVs). In Boulder, CO, for example, it is illegal to charge your EV or occupy an EV charging space for more than four hours, and overstaying results in a \$50 fine.¹²⁰

Rates at charging stations can also help ensure EVs only park in spaces for the time they need to charge. For instance, Tesla Superchargers have an idle fee which charges customers \$0.50 per minute after the car is fully charged if a station is at least 50 percent occupied, and charges \$1.00 per minute if a station is 100 percent full.¹²¹

5. Promote Shared Mobility and Mobility Options to Expand Access to Electric Vehicles

The goal of California's electric vehicle efforts should not be to sell cars but to expand the number of miles people drive on electric power and reduce the number they drive in gasoline-powered vehicles. Carsharing and other forms of shared mobility can reduce the need for private car ownership by providing city residents with access to a car without having to own one. Sharing programs can allow people to enjoy the benefits of electric vehicles for most trips, while having the ability to access bigger gasoline-powered cars for the occasional trips where it might be necessary.

For instance, someone who regularly commutes by bus but who likes to have access to a vehicle for grocery trips once a week could forgo car ownership and instead use electric carsharing to take an electric vehicle to the store. Someone could also choose to purchase an electric vehicle for their day-to-day car, knowing they have access to shared 4-wheel drive cars to go away for a ski trip.

Shared electric vehicle programs are starting to operate in California. In Los Angeles, BlueLA Carsharing, in partnership with LA Department of Transportation, plans to operate 100 shared electric vehicles, supported by 200 chargers, in 40 locations across the city.¹²² Electrify America is supporting two carsharing programs in Sacramento, the first of which launched in November 2018. That program, operated by Envoy, will offer 142 Volkswagen e-Golfs at 71 locations in Sacramento, while the company Gig plans to operate 260 shared electric vehicles in 2019.¹²³

New mobility modes will require flexibility and forward-thinking planning. As the transportation landscape changes rapidly, decision-making and capital investment in EV charging infrastructure should be flexible enough to support new and developing systems.

For instance, new models of car ownership can result in different charging needs. Vehicles used in carsharing and ridesourcing systems, for example, may travel hundreds of miles per day, and need to have access

to fast charging. If shared mobility were to reduce the number of privately-owned vehicles in a city, fast charging could become relatively more important. Fleets of electric vehicles also provide the opportunity to expand access to charging stations if they are made available to the general public. And as more people seek to live in cities and compact neighborhoods where they can more easily access amenities, public charging and charging in multi-family residences will become increasingly important.¹²⁴

The state and California cities should encourage the development of more shared electric vehicle programs and include them in plans and forecasts for public EV charging needs. Policies that accommodate the needs of shared electric vehicles – such as allowing the installation of curbside charging stations – could help expand the services, while also providing charging opportunities for privately owned electric vehicles. Finally, cities should work with carsharing companies to reach agreements to allow the public to benefit from charging stations that are installed for carsharing fleets.



Shared electric vehicles, like this car2go Smart car in Vancouver, allow people to live without owning a car, while having access to one when they need to drive. Credit: Flickr user Paul Krueger, CC BY-NC 2.0



A blueLA electric carshare vehicle in Los Angeles. Credit: Los Angeles Mayor Eric Garcetti.

Conclusion

As wildfires, droughts, mudslides, and other devastating impacts of global warming hit California each year, it is clear we must act as quickly as possible to reduce emissions. Addressing our transportation system will be critical, and electrifying our vehicles will be a key component.

If California wishes to meet its electric vehicle goals and obtain the environmental, public health and quality of life benefits of electric vehicles, it must rapidly expand the availability of EV charging infrastructure so Californians can charge their cars at home, at work and in public. At the same time, we need to implement smart policy measures to ensure that stations not only exist, but they are also intuitive, affordable and accessible to anyone who chooses to drive an electric vehicle.

Cities should plan for this transition to electric vehicles in the context of an overall mobility transition

that encourages the use of public transportation, shared mobility services, bicycling and walking. A transition that reduces demand for parking from private vehicles – while creating new charging opportunities for both privately owned and shared electric vehicles – can deliver a powerful “win-win” for cities and help propel California toward a clean, efficient, zero-carbon transportation system.

Without thoughtful development of new policies to simplify and improve electric vehicle charging, California risks losing out on the tremendous momentum and support for electric vehicles. By adopting comprehensive EV plans that streamline the user experience for electric vehicle drivers, California can help residents replace gasoline-powered travel with electric travel, reducing climate emissions and air pollution – while setting an example for the rest of the nation to follow.

Notes

1 Deadliest: CAL FIRE, *Top 20 Deadliest California Wildfires*, accessed 7 December 2018, archived at http://web.archive.org/web/20181204061326/calfire.ca.gov/communications/downloads/fact_sheets/Top20_Deadliest.pdf; Largest: Michael McGough, "Mendocino Complex, Biggest Wildfire in California History, Now 100 Percent Contained," *The Sacramento Bee*, 19 September 2018, archived at <http://web.archive.org/web/20180926031857/www.sacbee.com/news/state/california/fires/article218655210.html>.

2 The National Drought Resilience Partnership, *Drought in California*, accessed 7 December 2018, archived at <http://web.archive.org/web/20181023195817/www.drought.gov/drought/states/california>.

3 Anne Mulkern, "Rising Sea Levels Will Hit California Harder Than Other Places," *Scientific American*, 27 April 2017, archived at <http://web.archive.org/web/20181205034029/www.scientificamerican.com/article/rising-sea-levels-will-hit-california-harder-than-other-places>.

4 California Air Resources Board, "California Greenhouse Gas Emission Inventory – 2018 Edition," archived at <http://web.archive.org/web/20181110123720/www.arb.ca.gov/cc/inventory/data/data.htm>.

5 U.S. Department of Energy, Alternative Fuels Data Center, *Emissions from Hybrid and Plug-In Electric Vehicles*, accessed 6 October 2017, archived at https://web.archive.org/web/20180214212424/www.afdc.energy.gov/vehicles/electric_emissions.php.

6 Veloz, *Sales Dashboard*, accessed 10 October 2018, at <http://www.veloz.org/sales-dashboard>.

7 Goal: Office of Governor Edmund G. Brown, *Governor Brown Takes Action to Increase Zero-Emission Vehicles, Fund New Climate Investments* (press release), 26 January 2018; Sold: Including plug-in hybrids and battery electric vehicles. Veloz, *Sales Dashboard*, 11 November 2018, available at http://www.veloz.org/wp-content/uploads/2018/12/11_nov_2018_Dashboard_PEV_Sales_veloz.pdf.

8 Stations may have multiple charging plugs. Alternative Fuels Data Center, *Alternative Fueling Station Locator*, accessed 12 October 2018, archived http://web.archive.org/web/20181012002402/www.afdc.energy.gov/fuels/electricity_locations.html

9 Ibid.

10 Consumers Union and Union of Concerned Scientists, *Survey Methodology and Assumptions: Driving Habits, Vehicle Needs, and Attitudes toward Electric Vehicles in the Northeast and California*, May 2016.

11 Michael Nicholas and Gil Tal, *Survey and Data Observations on Consumer Motivations to DC Fast Charge*, EVS30 Symposium, Germany, 9-11 October 2017.

12 Abdulkadir Bedir, et al., California Energy Commission, *California Plug-In Electric Vehicle Infrastructure Projections: 2017-2025*, publication CEC-600-2018-001, March 2018.

13 Ibid.

14 Ibid.

15 Ibid.

16 See note 8.

17 PlugShare, *Locations 59159, 167951, and 15872*, accessed 25 October 2018 at <https://www.plugshare.com>.

18 California Air Resources Board, *SB 454 Electric Vehicle Charging Stations Open Access Public Workshop* (presentation), 30 May 2018.

19 Including plug-in hybrids and battery electric vehicles. Veloz, *Sales Dashboard*, 11 November 2018, available at http://www.veloz.org/wp-content/uploads/2018/12/11_nov_2018_Dashboard_PEV_Sales_veloz.pdf.

20 Includes plug-in hybrids and battery electric vehicles; Auto Alliance, *Advanced Technology Vehicle Sales Dashboard*, accessed 3 January 2019, available at <https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard>.

21 California Public Utilities Commission, *Zero-Emission Vehicles*, accessed 10 October 2018, archived at <http://web.archive.org/web/20180402161720/www.cpuc.ca.gov/80/zev>.

22 City of Los Angeles, *pLAn: Transforming Los Angeles*, 8 April 2015.

23 Alana Miller and Teague Morris, Frontier Group, Michelle Kinman, Environment California Research & Policy Center, *Plugging In: Speeding the Adoption of Electric Vehicles in California with Smart Local Policies*, February 2018.

24 Ben Geman, "Exclusive Poll: Electric Cars Show Growth Potential Despite Doubts," *Axios*, 1 June 2018.

25 Office of Governor Edmund G. Brown, *Governor Brown Takes Action to Increase Zero-Emission Vehicles, Fund New Climate Investments* (press release), 26 January 2018.

26 See note 12.

27 Ibid.

28 See note 11.

29 Michael A. Nicholas, et al., *Advanced Plug-in Electric Vehicle Travel and Charging Behavior - Interim Report*, January 2017.

30 Ibid.

31 See note 11.

32 Mara Leong-Maguinez, personal communication, 20 October 2018.

33 Jeff Mathias, personal communication, 30 October 2018.

34 See note 23.

35 Based on numbers from Eric Wood et al., U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, *National Plug-In Electric Vehicle Charging Infrastructure Analysis*, September 2017.

36 See note 12.

37 Ibid.

38 Ibid.

39 See note 11.

40 Ibid.

41 Ibid.

42 See note 12.

43 See note 11.

44 See note 10.

45 Will Gray, personal communication, 20 October 2018.

46 Ibid.

47 CarMax, *2017 Hybrid & Electric Cars Survey Results*, 18 July 2018, archived at <http://web.archive.org/web/20170807122340/www.carmax.com/articles/hybrid-electric-2017-survey-results>.

48 Ibid.

49 Largest: R. Daniel Foster, "Park La Brea, 70-year-old Design Still Feels the Love (and Hate)," *Los Angeles Times*, 24 February 2012, archived at http://web.archive.org/web/20180521021407/latimesblogs.latimes.com/home_blog/2012/02/park-la-brea-reviews.html; charging stations: Crystal Loporto, Leasing Agent, Park La Brea Apartments, personal communication, 29 October 2018.

50 PlugShare, *Locations 165945*, accessed 29 October 2018 at <https://www.plugshare.com>.

51 See note 8.

52 PlugShare, *Locations 59159, 167951, and 15872*, accessed 25 October 2018 at <https://www.plugshare.com>.

53 PlugShare, *Locations 71737, 62831, 64075*, accessed 3 January 2018 at <https://www.plugshare.com>.

54 Icon credits: Wikimedia user GreatDrok.

55 Non EVs and incompatible cars reported to be blocking spaces on December 21, 22, and 24, 2018; PlugShare, *Location 62831*, accessed 3 January 2018 at <https://www.plugshare.com>.

56 Charging location: PlugShare, *Location 153487*, accessed 25 October 2018 at <https://www.plugshare.com/location/153487>; range: Chevrolet, *Bolt EV – 2019*, accessed 25 October 2018, archived at <http://web.archive.org/web/20180929091642/www.chevrolet.com/electric/bolt-ev-electric-car>.

57 Roberto Baldwin, "Driving an EV Means Changing the Way You Think About "Refueling," *Engadget*, 24 May 2018, archived at <https://web.archive.org/web/20181019232301/www.engadget.com/2018/05/24/driving-ev-charging-apps>.

58 See note 8.

59 Blink, *Frequently Asked Questions*, accessed 10 October 2018 at <http://www.blinkcharging.com/ev-drivers-faq>.

60 Ibid.

61 See note 8.

62 Ibid.

63 EVgo, *Go Farther For Less Money With Our New Pricing*, accessed 19 October 2018, archived at <http://web.archive.org/web/20180822061841/www.evgo.com/charging-plans>.

64 ChargeHub, *Greenlots*, accessed 11 October 2018, archived at <https://web.archive.org/web/20181011225648/chargehub.com/en/networks/greenlots.html>.

65 Ibid.

66 SemaConnect, *FAQ*, accessed 2 November 2018, archived at <http://web.archive.org/web/20170827020151/www.semaconnect.com:80/faq>.

67 See note 8.

68 PlugShare, *Location 100431 – Hotel Rosedale*, accessed 30 October 2018 at <https://www.plugshare.com/location/100431>.

69 The charger at the Bonanza King Resort in northern California is the only non-Tesla charger for about 50 miles and hasn't had a comment on PlugShare since June 2016: PlugShare, *Location 86535 – Bonanza King Resort*, accessed 30 October at 2018, at <https://www.plugshare.com/location/86535>; The Evergreen Valley College charger hasn't had a PlugShare user check in since December 2016: PlugShare, *Location 88708 – Evergreen Valley College Auto Tech*, accessed 30 October at 2018, at <https://www.plugshare.com/location/88708>.

70 Jonathan Levy, EVgo, as reported by Roberto Baldwin, "Driving an EV Means Changing the Way You Think about "Refueling," *Engadget*, 24 May 2018, archived at <https://web.archive.org/web/20181019232301/www.engadget.com/2018/05/24/driving-ev-charging-apps>.

71 Twitter user @DCCarGeek, 30 October 2018, archived at <https://web.archive.org/web/20181031172737/twitter.com/DCCARGEK/status/1057298099033403392>.

72 Blink, *EV Charging Fees*, accessed 19 October 2018, available at <http://www.blinkcharging.com/ev-charging-fee>.

73 See note 63.

74 Tesla, *Support – Supercharging*, accessed 19 October 2018, archived at <http://web.archive.org/web/20180912192122/www.tesla.com/support/supercharging>.

75 ChargePoint, *1040PARKADE STATION 02*, accessed 19 October 2018 at https://na.chargepoint.com/charge_point.

76 Pier: *HUNTINGTONBEACH PIER PLAZA 1*; Library: *ALCO STATIONS*; ChargePoint, *Locations*, accessed 19 October 2018 at https://na.chargepoint.com/charge_point.

77 PlugShare, *Location 100508 – Sacramento Amtrak Station*, accessed 19 October 2018 at <https://www.plugshare.com/location/100508>.

78 PlugShare, *Location 156531 – Outlets at Tejon*, accessed 19 October 2018 at <https://www.plugshare.com/location/156531>.

79 PlugShare, *Location 159268 – Hutton Centre*, accessed 19 October 2018 at <https://www.plugshare.com/location/159268>.

80 Kaiser: *Location 122865 – Kaiser Permanente Davis Medical Offices*; Fresno: *Location 109318 – Buchanan Crossroads Shopping Center*; PlugShare, *Locations*, accessed 19 October at <https://www.plugshare.com>.

81 Tesla, *Forums – Destination Charging Fees*, 14 March 2017, archived at <https://web.archive.org/web/20181019231457/forums.tesla.com/forum/forums/destination-charging-fees>.

82 Bethany Villarreal, “PlugShare Users on Android Can “Pay With PlugShare” at SemaConnect EV Charging Stations” (press release), *SemaConnect*, 31 July 2017, archived at <https://web.archive.org/web/20181030233603/www.semaconnect.com/blog/plugshare-users-on-android-can-pay-with-plugshare-at-semaconnect-ev-charging-stations>.

83 PlugShare, *Location 145025 – Frank H. Ogawa Plaza Parking*, accessed 29 October 2018 at <https://www.plugshare.com/location/145025>.

84 ChargePoint, *City of Oakland Frank Ogawa1*, accessed 29 October 2018 at https://na.chargepoint.com/charge_point.

85 PlugShare, *Location 7498 – City Center Garage*, accessed 29 October 2018 at <https://www.plugshare.com/location/7498>.

86 See note 8.

87 Ibid.

88 Take Charge and Go, *The 6 Steps of What To Do If Your Charging Spot is ICed*, 7 December 2014, archived at <http://web.archive.org/web/20180312174901/www.takechargeandgo.com:80/2014/12/07/the-6-steps-of-what-to-do-if-your-charging-spot-is-iced>.

89 Rob Nikolewski, “California Utilities Commission Oks \$776.5 Million to Boost Electric Vehicle Use,” *San Diego Union-Tribune*, 31 May 2018, archived at <http://web.archive.org/web/20180904001732/www.sandiegouniontribune.com/business/energy-green/sd-fi-cpuc-electrification-20180531-story.html>.

90 Mary Lunetta, Sierra Club, *If We Build It, They Will Charge: How Volkswagen Settlement Funds Are Advancing Electric Vehicles*, 8 June 2018, archived at <http://web.archive.org/web/20181017085355/www.sierraclub.org/compass/2018/06/if-we-build-it-they-will-charge-how-volkswagen-settlement-funds-are-advancing>.

91 Ibid.

92 State of California, California Air Resources Board, *Beneficiary Mitigation Plan for the Volkswagen Environmental Mitigation Trust*, June 2018.

93 Ibid.

94 Electrify America, *Our Investment Plan*, accessed 13 November 2018, archived at <http://web.archive.org/web/20181006230207/www.electrifyamerica.com/our-plan>.

95 Electrify America, *Electrify America Receives Go Ahead for its Second \$200 Million Investment in California* (press release), 13 December 2018.

96 Division of the State Architect, *Electric Vehicle Charging Stations, Accessibility: FAQs*, 20 September 2017, accessed at https://www.documents.dgs.ca.gov/dsa/access/EVCS_FAQ_09-20-17.pdf.

97 California Air Resources Board, *Electric Vehicle Charging Infrastructure: Multifamily Building Standards – CARB Technical and Cost Analysis: 2019 Code Cycle*, 13 April 2018.

98 San Francisco: Office of the Mayor, City of San Francisco, *Mayor Lee Signs New Ordinance to Make San Francisco Electric Vehicle Ready* (press release), 27 April 2017; Oakland: City of Oakland, *Electric Vehicle Infrastructure Requirements for New Multi-Family and Nonresidential Buildings* (factsheet), 2017, accessed at www2.oaklandnet.com/oakca1/groups/pwa/documents/report/oak063669.pdf; Gennady Sheyner, “Palo Alto Speeds Ahead with New Electric-Vehicle Requirements,” *Palo Alto Weekly*, 3 July 2014, archived at web.archive.org/web/20180118201817/www.paloaltoonline.com/news/2014/07/03/palo-alto-speeds-ahead-with-new-electric-vehicle-requirements

99 Dale Hall and Nic Lutsey, The International Council on Clean Transportation, *Emerging Best Practices for Electric Vehicle Charging Infrastructure*, October 2017.

100 EVBox, *Charging in Public*, accessed 12 November 2018, archived at <http://web.archive.org/web/20180902200025/www.evbox.com/products/charge-cards>.

101 See note 99.

102 Chrisoph Steitz, “Germany’s Hubject Enters Cooperation With Star Charge China,” *U.S. News & World Reports*, 1 October 2018.

103 See note 99.

104 Chris Randall, “Electrify America Sets Up Interoperability Alliance,” *Electrify.com*, 20 October 2018, archived at <https://web.archive.org/web/20190228194005/www.electrify.com/2018/10/20/electrify-america-sets-up-interoperability-alliance/>

105 The law was passed in 2013 but required a delay of two years to wait for potential federal action on the issue. When none was taken, CARB began a process of hiring staff and beginning implementation planning. SB 454, *An Act to Add Chapter 8.7 to Part 5 of Division 26 of the Health and Safety Code, Relating to Air Resources*, 28 September 2013.

106 See note 18.

107 The Commonwealth of Massachusetts, *Senate Bill No. 2505 – An Act Promoting Zero Emission Vehicle Adoption*, 10 November 2016.

108 PC44 Electric Vehicle Work Group, *Petition for Implementation of a Statewide Electric Vehicle Portfolio – To State of Maryland Public Service Commission*, 19 January 2018.

109 Washington Utilities and Transportation Commission, *Docket UE-160799 Draft Policy and Interpretive Statement Concerning Commission Regulation Of Electric Vehicle Charging Services*, 13 January 2017.

110 National Renewable Energy Laboratory, *About the Alternative Fueling Station Data*, accessed 2 November 2018 at www.afdc.energy.gov.

111 Recargo, *Plugshare Data-on-Demand*, accessed 2 November 2018, archived at <http://web.archive.org/web/20180826053007/recargo.com/data.html>.

112 Hubject Inc., *Intercharge*, accessed 3 December 2018, archived at <http://web.archive.org/web/20180214062602/www.hubject.com/intercharge>, translated by Google.

113 See note 18.

114 Bengt Halvorson, “Chargeway’s Plan to Make Recharging as Easy as Refueling Gets the Green Light,” *Car and Driver*, 13 July 2018.

115 PlugInSites, *Legislation Reference – Reserved Parking for Plug-In Vehicle Charging*, accessed 13 November 2018, archived at <http://web.archive.org/web/20181110074726/pluginsites.org/plug-in-vehicle-parking-legislation-reference>.

116 Ibid.

117 Los Angeles City Council, Transportation Committee, *File No. 14-0079-S3*, accessed 8 February 2018 at http://clkrep.lacity.org/online/docs/2014/14-0079-S3_rpt_tran_1-24-18.pdf.

118 Oslo Kommune Bymiljøtaten (Urban Environment Agency), *EV Charging Points in Oslo*, 2012, archived at web.archive.org/web/20170915170940/urbact.eu/sites/default/files/import/Projects/EVUE/outputs_media/LAP_Electric_vehicle_charging_points_in_Oslo_Final_01.pdf, pg 10.

119 Municipality of Amsterdam (Gemeente Amsterdam), *Plan Amsterdam, The Electric City*, September 2016.

120 See note 131.

121 Kim Fernandez, *Parking.org, Power Struggle*, accessed 20 October 2017, archived at web.archive.org/web/20171020162716/www.parking.org/2016/01/20/tpp-2014-08-power-struggle/.

122 Tesla, *Supercharger Idle Fee*, accessed 3 January 2018, archived at <http://web.archive.org/web/20180818001140/www.tesla.com/support/supercharger-idle-fee>.

123 BlueLA, *About BlueLA*, 12 February 2019, archived at <http://web.archive.org/web/20181116182414/www.bluela.com/about-bluela>.

124 *Sacramento City Express*, “New, Massive Electric Car-Sharing Program Launches in Sacramento,” 2 November 2018, archived at <https://web.archive.org/web/20190212204916/sacramentocityexpress.com/2018/11/02/new-massive-electric-car-sharing-program-launches-in-sacramento>.

125 National Association of Realtors, *Millennials and Silent Generation Drive Desire for Walkable Communities*, *Say Realtors* (press release), 19 December 2017, archived at <http://web.archive.org/web/20181024001911/www.nar.realtor/newsroom/millennials-and-silent-generation-drive-desire-for-walkable-communities-say-realtors>.