100% Zero

Solutions to Achieve Universal Zero-Emission Vehicle Adoption

September 2018

BerkeleyLaw
UNIVERSITY OF CALIFORNIA

Center for Law, Energy & the Environment

About This Report

This report resulted from a convening with regulators, advocates, experts, and other stakeholders in California's zero emission vehicle industry, organized by UC Berkeley School of Law's Center for Law, Energy and the Environment (CLEE) and sponsored by Coltura. Funding for this report is generously provided by Energy Foundation.

This report and its recommendations are solely a product of the UC Berkeley School of Law and do not necessarily reflect the views of all individual convening participants, reviewers, Coltura or Energy Foundation.

About CLEE

The Center for Law, Energy & the Environment (CLEE) channels the expertise of the Berkeley Law community into pragmatic policy solutions to environmental and energy challenges in California and across the nation. CLEE works with government, business, and communities on initiatives that focus on reducing greenhouse gas emissions, advancing the transition to renewable energy, and ensuring clean water for California's future.

Authorship

Ethan N. Elkind, Director of the Climate Program at CLEE
Ted Lamm, Research Fellow in the Climate Program at CLEE

Acknowledgments

The authors and organizers thank the participants who provided their insight and commentary at the April 2018 convening that informed this analysis, as well as review of this report: Robert Barrosa, Bill Boyce, Linda Brown, Fei Chi, Steven Cliff, Jessie Denver, Tyson Eckerle, Mark Ferron, Jamie Hall, Alan Jenn, Jennifer Kropke, Dan Lashof, Amanda Myers, Deborah Raphael, Alice Reynolds, David Sawaya, Janea Scott, Carrie Sisto, Geof Syphers, Dean Taylor, and John Tillman (see p. 26 for full participant biographies). We also thank Emily Van Camp for designing the report.

CLEE thanks Janelle London, Matthew Metz, and Joe Quintana of Coltura for sponsoring the convening that informed this report and Patricia Monahan at Energy Foundation for supporting this report.

Photos for the report are courtesy of Flickr's Karlis Dambrans (cover), Flickr's www.routexl.com (p. 1), Flickr's Myrtle Beach TheDigitel (p. 5), Flickr's Oregon Departmnet of Transportation (p. 7, p. 10), Flickr's Ed Uthman (p. 12), Unsplash's Sol Mitnick (p. 16), Flickr's Maurizio Pesce (p. 18), Flickr's chucka_nc (p. 20), Flickr's Motor Verso (p. 21), Flickr's Jaguar Mena (p. 22), and Flickr's Brian Doyle (p. 23).

For more information, contact Ethan Elkind at eelkind@law.berkeley.edu or Ted Lamm at tlamm@law.berkeley.edu.

BerkeleyLaw
UNIVERSITY OF CALIFORNIA
Center for Law, Energy & the Environment

Executive Summary

Report Scope

Long-term climate goals will require mass adoption of transportation technologies that eliminate the need to burn gasoline and diesel. Battery electric technologies are currently the most promising and widespread ZEVs and therefore the predominant focus of this report. However, hydrogen is also part of the mix and can benefit from some of the solutions identified here. In addition, this report focuses on passenger vehicles, but some of the policies to promote these vehicles can benefit heavier-duty forms of transportation, such as public transit buses and some trucks that could share charging infrastructure with passenger vehicles.

Some countries and states, including California, are contemplating or making plans for phase-outs or bans on the sale of new internal combustion engine passenger vehicles by a date certain. Such a phase-out would be critical to achieving long-term climate goals and improving public health.

Should a jurisdiction decide to plan for an eventual end for gasoline-powered transportation through internal combustion engines, what would that future scenario look like for drivers, the workforce, utilities, automakers, charging companies, and other stakeholders? What challenges might prevent this scenario from occurring? And what are the key policies that decision makers could enact now to help make this scenario more likely to be realized?

The stakes are high for both the environment and public health. In California, the state will eventually need full consumer adoption of zero-emission vehicles (ZEVs) in order to achieve legislated long-term climate goals. To that end, Governor Brown set a goal of reaching five million zero-emission vehicles on California's roadways by 2030, including 250,000 public chargers by 2025, and as of mid-2018, Californians were driving over 400,000 electric vehicles.

To identify the key challenges and solutions to achieving a scenario in which 100% of new vehicle sales are zero-emission, UC Berkeley School of Law, with sponsorship from the nonprofit Coltura, convened experts from the private and public sectors on April 3, 2018. Convening participants focused on priority barriers and solutions to achieve this 100% deployment scenario. This report is informed by the discussion, offering a vision for the optimal deployment scenario and identifying the top barriers and solutions required to make it a reality in California and beyond.

Top Four Barriers to 100% Zero-Emission Vehicles:

- **Weak business model for automakers and dealers** to produce and sell ZEV models that are competitive on price, range, and performance
- **Lack of public charging infrastructure** to meet current and projected demand
- **Lack of public awareness** of ZEVs to inform purchasing decisions
- Insufficient, ineffective and **uncertain public incentives**

Priority Solutions for Achieving 100% Zero-Emission Vehicles

- A **state charging infrastructure funding package** could deploy the needed infrastructure through 2025, with required grid upgrades and workforce training.
- **New electricity rates**, such as reformed demand charges, for site hosts could minimize fuel and operations costs, particularly for high-speed chargers.
- Federal and state leaders could **improve and expand long-term incentives** for ZEV purchases and infrastructure, with a guaranteed phase-down over time, including reformed tax rules to accelerate depreciation of charging assets and a stronger Low Carbon Fuel Standard, among other tools.
- Industry and public sector leaders could coordinate a **campaign to raise awareness** of ZEV benefits and options by targeting key demographics and using ZEV transportation network company (TNC) fleets as a marketing tool.
- Industry could consider **alternatives to the traditional dealership model** and bolster efforts to educate dealers about ZEVs in order to encourage them to market them.
- State and local regulators could **ease compliance and increase consistency across jurisdictions within California with Americans with Disabilities Act (ADA) requirements for charging infrastructure**, such as through the Division of State Architect's guidelines and code.

This report explores these solutions in more detail below and provides an overview of current electric vehicle technologies and trends, as well as relevant policies at the federal and state level.

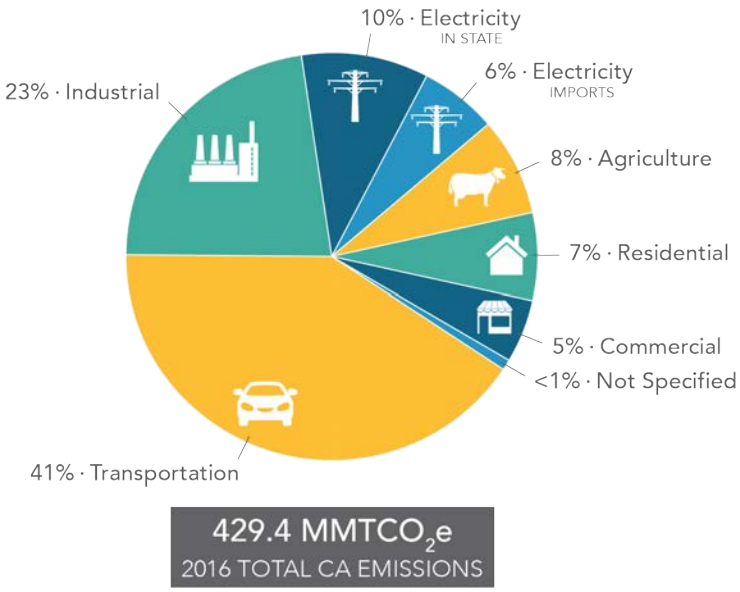
Introduction

Long-Term Climate and Energy Goals Will Eventually Require 100% Deployment of Zero-Emission Vehicles

Meeting California's ambitious environmental and energy goals will require widespread adoption of zero emission vehicles (ZEVs). The state seeks to reduce greenhouse gas emissions to 40 percent below 1990 levels by 2030, per California's Global Warming Solutions Act of 2006, as amended by Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016). Executive orders issued by Governor Schwarzenegger in 2005 (Executive Order S-3-05) and Governor Brown in 2015 (Executive Order B-30-15) both set the state's long-term goal of an 80 percent reduction below 1990 levels by 2050. Meanwhile, Senate Bill 350 (de León, Chapter 547, Statutes of 2015) set goals for accelerating transportation electrification, including through greater utility investments in charging infrastructure. While federal policy has not matched California's emission reduction targets, many other states including Hawaii, Oregon, Massachusetts, New York, and Washington have set similar goals that will rely on significant ZEV adoption.

Meeting these goals will only occur with emissions reductions from the state's transportation sector, which accounts for over 40% of greenhouse gas emissions (not including oil refinery emissions) (see Figure 1).[1] Vehicles will need to switch from petroleum to cleaner transport fuels. Electric vehicle technology in particular reduces pollution from petroleum transportation fuels, with increasing greenhouse gas benefits over time as California's electricity supply becomes more renewable energy-based (under SB 350, the state's electricity generation is required to reach 50 percent renewable sources by 2030, from approximately 35 percent today). The vehicles can moderate demand depending on supply availability and soak up surplus renewables when prices are inexpensive.

Figure 1: California's 2016 Greenhouse Gas Emission Sources



Source: California Air Resources Board

To achieve these environmental benefits, Governor Brown issued Executive Order B-48-18 on January 26, 2018 setting a state goal of five million ZEVs on the road by 2030 (increasing from the prior goal of 1.5 million ZEVs by 2025). The order also requires 250,000 public ZEV chargers by 2025. Previously, Senate Bill 1275 (de León, Chapter 530, Statutes of 2014) created the Charge Ahead California Initiative, which seeks to deploy one million zero- and near-zero-emission vehicles by 2023 and improve access to such vehicles in disadvantaged communities. Through July 2018, Californians were driving approximately 420,000 electric vehicles (out of approximately 25 million total registered passenger vehicles).[2]

Through July 2018, Californians were driving approximately 420,000 electric vehicles, out of approximately 25 million total registered passenger vehicles.

Electric Vehicle Models

This report focuses on battery electric vehicles (EVs or BEVs), although plug-in hybrid electric vehicles (PHEVs) may represent an important transition technology for achieving long-term transportation emission goals. A high number of models of PHEVs and BEVs are available worldwide, including models from most major auto manufacturers. Notably, sales figures of some vehicles have been significant in other regions and could influence the U.S. market eventually, once consumers can access them. For example, half of the top ten recent highest-selling ZEVs globally – the Chinese models BAIC EC-Series, BYD Song, JAC iEV7S/E, and BYD Qin, and the French Renault ZOE – are not currently available in the U.S.[3]

Examples of BEVs and PHEVs available on the U.S. market as of July 2018 include:[4]

- Audi A3 e-tron
- BMW 530e and i3
- Chevrolet Bolt and Volt
- Chrysler Pacifica
- Fiat 500e
- Ford Focus, C-Max, and Fusion
- Honda Clarity
- Hyundai Ioniq and Sonata
- Kia Niro, Optima, and Soul
- Mercedes-Benz B250e
- Mitsubishi iMiEV and Outlander
- Nissan LEAF
- Smart Fortwo
- Tesla Model 3, Model S, and Model X
- Toyota Prius Prime
- Volkswagen e-Golf
- Volvo S90, XC60, and XC90 T8

The recent launches of the Chevrolet Bolt and Tesla's Model 3, the first two mass-market vehicles in the U.S. to compete with internal combustion vehicles in both driving range and price (each over 200 miles and priced around $37,000 for the Bolt and $49,000 for the initial Model 3 version, before incentives) sparked consumer interest and purchases.[5] Over 150 models of BEVs and PHEVs are currently available worldwide, with an anticipated total of over 400 on the market by 2025.[6]

Federal and state laws boost electric vehicle deployment

Federal and state policy makers have enacted a number of laws and incentives to promote consumer and manufacturer adoption of ZEVs. California's first-in-the-nation Zero Emission Vehicle Program requires vehicle manufacturers to sell an increasing proportion of ZEVs in the state over time. Vehicle manufacturers can generate and bank ZEV credits for compliance based on the percentage of ZEVs out of the total passenger cars and light-duty trucks (e.g., pickup trucks and SUVs) they sell in California.[7] The third phase of the program began in 2018, with the minimum ZEV credit percentage rising from 4.5 percent in 2018 to 22 percent in 2025.[8] Notably, the Zero Emission Vehicle Program operates pursuant to Section 209(b) of the federal Clean Air Act, which allows California a "waiver" to set auto emissions standards that are more stringent than federal regulations. In August 2018, the U.S. Environmental Protection Agency proposed revoking the waiver, which would in turn block California from implementing the Zero Emission Vehicle Program.[9] While EPA could face potentially years-long legal challenges if it took this step, it could dampen deployment of ZEVs in the state by ending available credits and the mandate.

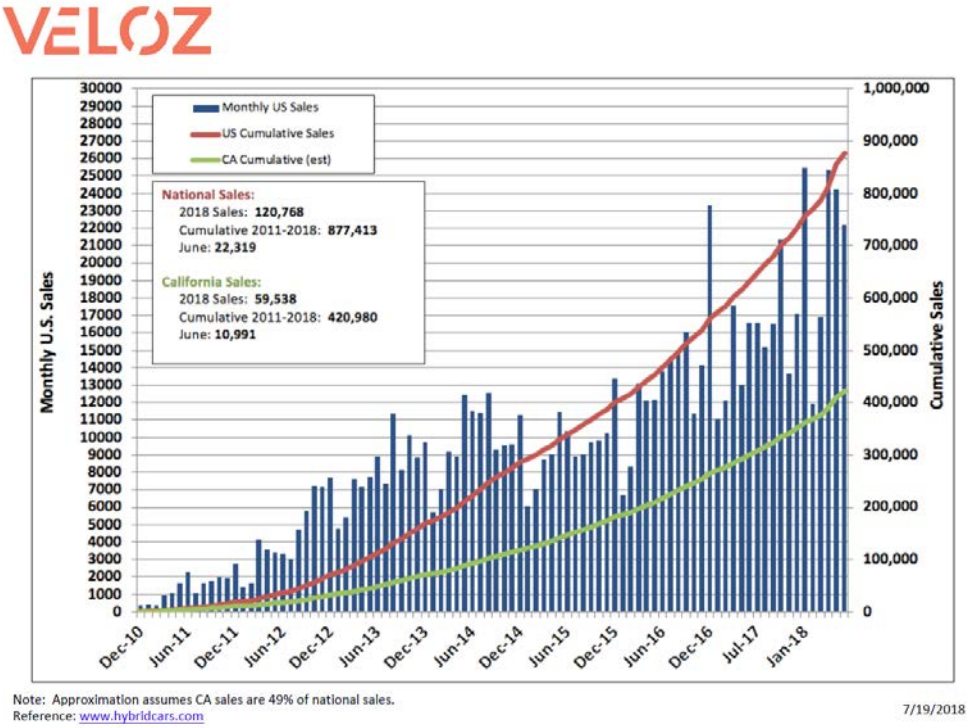
Other financial credits, rebates, and incentives are also available to ZEV purchasers and drivers. California's Clean Vehicle Rebate Project (CVRP) offers cash rebates of between $1,500 and $5,000 for the purchase or lease of certain plug-in hybrid and zero-emission vehicles, depending on the vehicle type and the purchasers' income level.[10] As of July 2018, nearly 250,000 electric vehicle owners received such rebates, totaling nearly $550 million.[11] Meanwhile, the federal government offers a Qualified Plug-In Electric Drive Motor Vehicle Tax Credit upon purchase of a new qualified electric vehicle.[12] The amount of the credit ranges between $2,500 and $7,500, depending on battery capacity and vehicle weight. However, the credit phases out for each manufacturer once it sells 200,000 qualified electric vehicles in the U.S. Some manufacturers, notably Tesla and Chevrolet, have met or are close to meeting this threshold.[13] In addition, California exempts electric vehicles from High Occupancy Vehicle (HOV) lane requirements, issuing special clean air vehicle decals for access to the lanes regardless of the number of passengers.[14]

Current state of electric vehicle deployment in California and the United States

Californians are driving approximately 420,000 electric vehicles, most of which are plug-in electric vehicles.[15] Through July 2018, nearly 250,000 electric vehicle owners had received cash rebates.[16] To meet the five million electric vehicle target by 2030, the state will need to see sharp growth in electric vehicle sales. Meanwhile, U.S. electric vehicle sales amounted to nearly 120,000 vehicles in the first half of 2018, roughly 40% growth compared to the previous year[17] (see Figure 2).

As of July 2018, nearly 250,000 electric vehicle owners received state rebates, totaling nearly $550 million.

Figure 2: National & California Plug-In Electric Vehicle Sales Through July 2018



Source: Veloz

State and utility incentives and programs boost charging infrastructure

California also provides multiple incentives to promote increased ZEV uptake through the development of electric vehicle charging infrastructure. The Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), established by Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) and extended by Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013), directs the California Energy Commission (CEC) to provide grants for the development of transformative vehicle and fuel technologies to help achieve state climate goals.[18] For 2018-19, the Energy Commission proposed

$134 million for electric vehicle charging infrastructure, along with over $100 million more for hydrogen fueling infrastructure, low-carbon fuels, and workforce and manufacturing measures.[19] The California Capital Access Program's (CalCAP) Electric Vehicle Charging Station (EVCS) Financing Program, provides loans of up to $500,000 to landlords and small businesses to install workplace or home chargers.[20] Additional state incentives focus on certain regions of California, such as the Electric Vehicle Supply Equipment (EVSE) Incentives – San Joaquin Valley and the Technology Advancement Funding – South Coast.[21] In addition, as part of the settlement over Volkswagen's use of illegal "defeat devices" to avoid emission standards testing, the California Air Resources Board (CARB) reached a settlement with the automaker to invest $800 million in California over the next 10 years (out of $2 billion nationwide) to support zero-emission vehicle deployment, including for electric vehicle charging infrastructure.[22]

Building on SB 350, California's investor-owned utilities (IOUs) also support increased adoption of electric vehicles by providing charging infrastructure and modifying electricity rates to accommodate charging needs. Following Decision 14-12-079 of the California Public Utilities Commission (CPUC), which promoted a case-specific approach to utility involvement in charging infrastructure development, the state's three largest IOUs (Southern California Edison, San Diego Gas & Electric Company, and Pacific Gas & Electric Company) submitted applications to install light-duty electric vehicle charging infrastructure throughout California. By 2016, the commission approved those plans. San Diego Gas & Electric Company then initiated a $45 million pilot program, known as Power Your Drive, to install 3,500 charging stations at multi-unit dwellings and workplaces, with 10% in disadvantaged communities.[23] Southern California Edison's Charge Ready program includes $22 million for up to potentially 1,500 charging stations at multi-unit dwellings, workplaces, and public places (also with 10 percent in disadvantaged communities).[24] In January 2018, Pacific Gas & Electric Company launched its $130 million EV Charge Network pilot program to install 7,500 level 2 chargers at apartment buildings and workplaces across Northern and Central California, including 15% in disadvantaged communities.[25]

With the passage of SB 350 in 2015, the California Public Utilities Commission directed investor-owned utilities to propose additional investments in transportation electrification. In January 2018, Public Utilities Commission Decision 18-01-024 approved $42 million in ratepayer-funded pilot infrastructure programs to test different utility investments in transportation electrification.[26] Public Utilities Commission Decision 18-05-040 approved four projects totaling over $700 million in investments[27] (see Table 1).

Table 1: California 2018 Investor-Owned Utility EV Charging Investments

Utility	Investment	Amount
PG&E	Support infrastructure for 230 DC fast charging stations at 50 locations (25% in disadvantaged communities)	$22 million
PG&E	Support infrastructure for 6,500 medium and heavy-duty electric vehicles at 700+ sites (25% in disadvantaged communities)	$236 million
SCE	Support infrastructure for 8,500 medium and heavy-duty electric vehicles at 800+ sites (40% in disadvantaged communities)	$343 million
SDG&E	60,000 level 2 chargers at single-family or small multi-family residences (25% in disadvantaged communities)	$137 million

In January 2018, San Diego Gas & Electric Company filed another proposal under SB 350 to invest over $150 million to install infrastructure to support medium- and heavy-duty electric vehicles and implement an electric school bus vehicle-to-grid pilot. In June 2018, Southern California Edison filed a plan with the Public Utilities Commission to expand the Charge Ready program by $760 million, anticipated to cover 48,000 additional charging ports.[28] In July 2018, four utilities (PG&E, SCE, SDG&E, and Liberty Utilities CalPeco) filed applications for a combined $53 million investment in pilot programs to install electric vehicle infrastructure at schools and at state parks and state beaches, as directed by AB 1082 and AB 1083 (Burke, 2017).

Current state of charging infrastructure deployment in California

By the middle of 2018, California had over 16,000 public electric vehicle charging points at more than 4,400 charging sites.[29] While no comprehensive data are available on the number of private home and workplace chargers in the state, the investor owned utility-led programs described previously will add thousands more private stations, while at least 4,000 private charging stations have been installed through California Energy Commission programs.[30] Charging stations are most densely located in major cities and along interregional corridors, although more rural areas of the state have added charging locations in recent years.[31]

Vision for Achieving 100% Zero-Emission Vehicle Deployment Scenario

At the April 2018 convening of zero-emission vehicle experts at UC Berkeley School of Law, participants described a vision for 100% zero-emission vehicle deployment. They discussed the barriers preventing the vision from becoming a reality and the potential solutions to overcome those barriers. The following section is informed by that discussion.

Principles and Vision for 100% Zero-Emission Vehicles

To achieve long-term climate goals in California and nationwide, first and foremost, land use policies should encourage development oriented around transit, biking, and walking to minimize driving miles. However, to the extent that residents need vehicles for trips, they should have easy, zero-emission access to all of their destinations.

Zero-emission transportation modes should be shared as much as possible to improve efficiency, lower costs, and potentially reduce overall vehicle miles traveled. The model should be vehicle "usage" and not "ownership." Ultimately, fewer total vehicles in operation will save residents money and reduce environmental impacts.

Consumers of all income levels should have access to a broad range of affordable zero-emission models:

- *ZEVs should be competitive with internal-combustion engine (ICE) vehicles on performance, price and range;*
- *Financing should be available to help offset any higher upfront costs of the vehicles, to be repaid through lower total lifetime cost of operations and maintenance;*
- *More ZEV SUVs should be available on the market; and*
- *Marketing and awareness campaigns should continue to promote the vehicles among those unaware of ZEV performance and benefits.*

For electric vehicles, the charging infrastructure should:

- *Be adaptable to replace or upgrade, in the event that the technology changes, such as to induction charging or higher-powered chargers;*
- *Support electrical grid needs, such as by soaking up surplus renewable energy, minimizing charging during times of constraints, and incorporating on-site solar generation and energy storage where practical;*
- *Be seamless, ubiquitous, and cheap so that charging is as or more convenient and affordable than fueling with gasoline;*
- *Offer equitable access to all Californians, including those in low-income and disadvantaged areas and those without dedicated home charging options;*
- *Be resilient in the face of blackouts and extreme weather events; and*
- *Include opportunities for public sector entities, like schools, universities, state and local governments, and transit districts, to host sites and earn a return on fuel.*

Finally, state and local governments and auto manufacturers seeking to increase adoption of ZEVs should:

- *Implement protocols for EV battery repurposing or recycling that include facilitating access in disadvantaged communities and rural areas, in order to reduce costs and expand economic benefits and local support;*
- *Require new homes and businesses to include charging infrastructure, or at least be built installation-ready, including with access to affordable electricity; and*
- *Maximize workforce development benefits through training programs and other support to increase economic gains and support for ZEV deployment.*

"Taking and supporting public transportation is part of the solution. We need to encourage people to take transit. But if you have to drive, drive electric."

Alice Reynolds
Office of Governor Jerry Brown

Top Barriers and Solutions to Achieving 100% Zero-Emission Vehicle Deployment

Key Barrier #1: Weak business model for automakers and dealers to produce and sell ZEV models that are competitive on price, range, and performance

The advent of zero-emission vehicles could challenge the business model for the auto industry. Producing automobiles is capital intensive and often with low margins, and traditional automakers have extensive legacy investment and expertise in internal combustion engines. Likewise, auto dealers may lack incentive to promote these vehicles if they lose revenue opportunities with reduced maintenance work associated with zero-emission vehicles. Furthermore, if the future of ZEVs becomes autonomous and/or shared, automakers may have fewer vehicles to sell, undermining their profitability.

Solution:

Industry leaders could consider alternatives to the traditional dealership model. Traditional auto dealerships may lack incentives to promote zero-emission vehicles to customers. One factor may be reduced auto dealer revenue from regular vehicle maintenance, which could decline given that ZEVs require substantially less maintenance than ICE vehicles, as battery technology eliminates many of the highest-stress engine and drivetrain components.[32] Furthermore, if policy and market trends result in an increasing share of vehicles that are owned by shared platforms and services, the traditional dealer model may not be viable for automakers anymore. Tesla, for example, sells their vehicles directly to customers (although franchise laws in many states may prevent automakers from engaging in direct sales). Automakers and dealers may want to find an optimal way to manage drop-in service opportunities for dealers, as opposed to long-term maintenance contracts.

Automakers, utilities, and other stakeholders can increase efforts to educate dealers about ZEVs in order to encourage dealers to market them. With ZEV sales still a small fraction of overall sales and ICEs still profitable, dealers may not have incentives to market ZEVs. But as ZEV prices decline, charging infrastructure becomes more ubiquitous, and adoption increases, consumers may become more motivated, and dealers will need access to information on the technology. Auto manufacturers and others could accelerate adoption of ZEVs by enhancing efforts to provide dealers with support and training on the capabilities of new vehicles that are increasingly competitive with traditional vehicles.

Key Barrier #2: Lack of charging infrastructure to meet current and projected demand

Electric vehicle drivers do not have sufficient public charging infrastructure available to meet their needs, as installations lag compared to vehicle adoption. The result is that many drivers are unable to take longer road trips, use the vehicles conveniently to get their destinations, or own the vehicles at all if they do not have dedicated charging at home or at work.

As of mid-2018, California had roughly 16,000 publicly accessible charging ports.[33] The California Energy Commission estimated that to achieve the goal of 1.5 million electric vehicles by 2025, the state will need between 229,000 to 279,000 new chargers, not including at single-family homes. That total includes 99,000 to 133,000 "destination chargers," such as at workplaces and public locations, 9,000 to 25,000 fast chargers, and enough chargers at multi-unit (or multifamily) dwellings to supply an estimated 121,000 electric vehicles by 2025.[34] Notably, approximately 40% of Californians live in multifamily housing, for whom a lack of public charging represents a major barrier to EV adoption.[35] Thus, even while the vast majority of needed charging points will be located at private homes, a significant increase in public infrastructure, particularly high-speed charging, will be needed for the state to reach five million ZEVs by 2030 (notably, Governor Brown's previously referenced executive order B-48-18 required 10,000 of the 250,000 charging stations be high speed).

High costs thwart charging infrastructure deployment

High installation costs of charging infrastructure can deter investment. Costs for securing property (particularly in public and multi-unit residential locations), architectural and electrical design, obtaining necessary permits, and operation and maintenance, in addition to the basic costs of acquiring equipment and constructing and installing it, can meet or exceed the cost of a vehicle for the most advanced chargers. Other factors can include the availability of tax credits or other incentives and the opportunity cost of carrying out the project.[42] For example, the hardware installation cost of installing DC fast chargers has generally ranged from $8,500 to $50,000, while public Level 2 chargers have ranged from $600 to as high as $12,660.[43] Architectural and design work, new utility connections, and permitting costs can also vary by charging type and location and can add tens of thousands of dollars more to a project (see Table 2).

"We need to look forward to the shift from a vehicle ownership model to a usage model. It may not be about the owner or even the driver of the vehicle, but about the passenger."

Steven Cliff
California Air Resources Board

"When you drive a gas car, you don't have to think about where gas stations are. We need to get to a point where chargers are so ubiquitous that you don't think about it."

John Tillman
Nissan Motors USA

Types of Electric Vehicle Charging

Electric vehicle owners have four options for charging their batteries, involving increasing levels of power and speed:

Level 1 charging uses 110 to 120 volt alternating current (AC) power found in most household outlets, which can power most electric vehicles overnight at approximately 3 to 5 miles of range per hour. Many electric vehicle owners use Level 1 charging today at home because the technology does not require installing new infrastructure.

Level 2 charging entails 208- to 240-volt alternating current, which can replenish a battery with up to 25 miles of range per hour and can fully charge a 200+ mile-range battery overnight (8-10 hours). Many homes and businesses may require added electrical capacity to enable Level 2 charging, which will likely constitute the bulk of charging infrastructure going forward.

Direct Current (DC) Fast Charging with today's technology involves 208 to 480 volts charging an 85-mile range battery to 80 percent capacity in 30 minutes or less, although it varies depending on multiple factors. The technology generally requires dedicated charging infrastructure, typically located in public access areas for drivers on extended trips. While Level 1 and Level 2 charging use a standard J1772 plug, with a standardized charging protocol, DC fast charging has multiple standards. The typical DC fast charging plugs used in the U.S. include:

Table 2: Installation Costs of Electric Vehicle Charging Stations

Type of Charging Station	Minimum Installation (non-hardware)	Maximum Installation (non-hardware)	Mean
Workplace Level 2	$624	$5,960	$2,223
Public Level 2	$600	$12,660	$3,108
Blink DC Fast Charger	$8,500	$50,000	$22,626

Source: Idaho National Laboratory

For public charging located in potential fast-charge corridors, the California Energy Commission recommended planning for costs between $135,000 and $220,000 for sites with between three and six Level 2 and DC fast chargers.[44] Similarly, these estimates are based solely on construction and equipment costs and do not include other variables such as signage, permitting, customer service and maintenance, warranties, or site host negotiation costs. These costs present significant business model challenges for non-residential charging, as they can frequently exceed revenues once factors such as electricity use and cost, depreciation, availability of tax credits and other subsidies, revenue sharing arrangements, and financing costs are considered.[45]

Current commercial electricity rates can hinder electric vehicle charging deployment

Commercial charging typically occurs in four settings: DC fast charging locations, workplaces, retailers/malls, and some multi-unit dwellings (with common meters). Commercial electricity rates for these sites in California are typically based on time of use: the amount the utility charges per kilowatt-hour depends on the time of day electricity is drawn from the grid, with rates highest when overall demand is highest. Many utilities also institute "demand charges" for large commercial and industrial users. Demand charges are designed to cover the additional strain on the electrical distribution and transmission system caused by particularly high peak usage, as well as to encourage high-demand customers to reduce peak power usage, if possible, to reduce overall stress on the grid. Facilities that use a significant amount of power in short bursts are most negatively affected by demand charges since the accompanying spike in usage triggers a higher rate bracket, which represents a greater proportion of overall costs. Many EV charging sites can have high but infrequent or inconsistent demand and usage and face high exposure to demand charges as a result, undercutting the business case for installing EV charging infrastructure. This dynamic can be particularly acute at sites that otherwise do not have high electricity utilization; in extreme cases, demand charges can be responsible for over 90% of site electricity costs.[46] Existing commercial rate structures, including time-of-use-billing and demand charges, were designed for customers with steady energy usage and are not ideally suited to the unpredictable, high-usage environment of commercial charging (and DC fast charging in particular). Reforms are necessary to support increased installations of commercial and public infrastructure.

Solutions:

State legislators could develop a charging infrastructure funding package to deploy the needed infrastructure through 2025 (beyond existing and planned utility investments), with required grid upgrades and workforce training. Automakers, charging companies, utilities, and other stakeholders could promote to the legislature a vision of charging infrastructure for a funding package through 2025, incorporating and moving forward on utility investments through SB 350 and Alternative and Renewable Fuel and Vehicle Technology (ARFVT) Program funds through 2023. They need to explain the connection between improved vehicle sales and more infrastructure. The package could include incentives, such as financing and permit streamlining, to offset the costs of installing, maintaining, and operating charging infrastructure. The investment would have to build in future-proofing and upgradeability to ensure that technology changes in future years will not make the work obsolete.

The package could include investments to upgrade distribution circuits ahead of time and could require charging interoperability. In addition, the package could include workforce development, such as upskilling existing workers to learn to install and maintain charging infrastructure and providing pathways for new entry into deploying and maintaining the infrastructure. The package could also revise electrical licensing requirements (level-2 charging equipment installations may be simple enough not to require the current C-10 electrical contractor certification). Finally, the policy must be equitable and work for different communities, including urban and rural areas and communities of both low and high incomes. The funding must also cover not only infrastructure and equipment but also administration and staff time to coordinate public-private investments and actual deployment.

Policy makers could help installers identify potential site hosts through better data disclosure and coordination. Before introducing incentives or requiring new construction to include make-ready or charging infrastructure, policy makers could first help installers identify the most convenient charging locations based on data on existing and forecasted demand. Leaders at the Public Utilities Commission or the Energy Commission could facilitate more coordination among the parties involved with installing ZEV infrastructure or convene a working group to ensure that deployment fills critical gaps and reaches all communities equitably. Agency websites could provide a central forum for maps showing where charging infrastructure is installed.

Policy makers could encourage "aggregators" to bundle existing incentives and offer group maintenance contracts to encourage multiple site hosts to install charging infrastructure. These incentives include existing credits such as from California's Low Carbon Fuel Standard program, along with contracts to maintain the infrastructure.

State regulators could help design and approve special electricity rates, such as reformed demand charges, for site hosts to minimize operational costs. High demand charges for electricity (imposed at times of especially high usage as a means to reduce system stress) constitute a major economic hurdle for site hosts and charging companies to operate high-powered charging infrastructure. For

Types of Electric Vehicle Charging, Continued

- The Tesla connector, currently supported solely by Tesla;
- The SAE J1772 combo or Combo Charging System (CCS) plug, supported by automakers such as Audi, BMW, Daimler, Ford, General Motors, Honda, Hyundai Porsche, Volvo and Volkswagen;
- The CHAdeMO plug, supported in the U.S. market by Renault-Nissan, Kia and Mitsubishi.

These technologies have their own charging protocols, resulting in limited interoperability. However, some manufacturers are offering adaptors and increasing efforts to promote common charging infrastructure. While Tesla's "Supercharger" network boasts over 1,300 Tesla-only locations nationwide, the company joined the CCS consortium in 2016. The EVgo fast charging network, which supports both the CHAdeMO and the CCS standards, now includes over 1,000 DC fast chargers across the U.S.

Technologies in development

Multiple charging technologies in development may leapfrog the current charging infrastructure landscape. Supporters of all three DC fast charging formats announced plans to improve the charging power and speed possible using their charging solutions. The CHAdeMO coalition, whose chargers are especially popular in Japan and Europe, recently announced a new 400 kilowatt (kW) "ultra-fast" charging protocol (eight times faster than the currently predominant 50 kW version). Electrify America, which Volkswagen launched following the diesel "defeat device" settlement described above, has begun installing a network of 350 kW chargers on two major U.S. highways. Tesla has announced plans to introduce a V3 Supercharger at 200 kW. It may be years before batteries capable of receiving such high-powered charges are widely available, but these new formats are also capable of charging at the lower speeds (50-120 kW) current vehicles can handle.

"Technology obsolescence is going to be part of the cycle. Future charging infrastructure may use induction coils and not have plugs at all. We need a strategy that involves a least-regrets approach."

Mark Ferron
California Independent System Operator

example, a bank of DC fast chargers with many vehicles charging together may trigger a demand charge, which boosts prices for everyone. Regulators can restructure demand charges, such as through volumetric rates that capture the increased consumption of charging stations without penalizing them based on timing, to encourage better utilization of existing grid infrastructure. Some utilities are considering a demand charge grace period to allow charging utilization to increase over time by reducing costs in the early years, and then phasing the charges back in once sufficient adoption is achieved. Waiving demand charges altogether could otherwise mean other non-participating customers have to pay more to make up for the lost revenue to support grid infrastructure.

Utilities are already moving toward commercial rate reform to support grid services provided by charging stations. California Public Utilities Commission Decision 18-05-040, which approved the utilities' proposals for over $700 million in charging infrastructure investments under SB 350, also approved rate modification proposals. Southern California Edison will institute a five-year suspension of demand charges for qualifying commercial customers, with volumetric rates substituted instead. San Diego Gas & Electric received approval for a new Residential Grid Integration Rate exclusively for EV charging that includes more defined and granular price signals to encourage optimal charging times.[47]

State policy makers could encourage energy storage deployment with charging to minimize demand charges and optimize grid usage. On-site energy storage deployment would minimize grid impacts from charging, as technologies like stationary batteries can power vehicle charging when the grid is constrained. The state could develop energy storage incentives similar to the California Solar Initiative and Self-Generating Incentive Program (SGIP), which provides customer rebates for installation of renewable energy and energy storage infrastructure, to kick-start the deployment with ZEVs. Otherwise, high costs and space constraints may hinder this deployment.

As discussed, utilities apply demand charges to large and many medium commercial and industrial customers to recover costs associated with grid component wear-and-tear and transmission, which are usually predicated on the maximum capacity needed at any given facility. Some electric vehicle charging can have high but infrequent demand and inconsistent and low overall energy utilization, particularly at smaller-load commercial sites that are often adversely impacted by demand charges. Larger commercial sites with significantly more load and energy utilization typically can absorb or mask spikes in usage from fast chargers or spread the associated demand charges over many kilowatt-hours, but smaller sites may not have such flexibility. At the same time, utility leaders may be concerned that alleviating demand charges could lead to a loss of revenue needed to fund distribution grid components, while ratepayer advocates may fear that removing demand charges could lead to inequitably higher electricity prices for other customers. Ultimately, the demand charge issue for DC fast charging may be a short-lived problem for sites where overall utilization is expected to increase, but less so for chargers in remote locations that serve only to complete a long-distance charging network.

State and local regulators could streamline compliance with California's interpretation of the federal Americans with Disabilities Act (ADA) requirements for charging infrastructure, such as through the guidelines and code of the Division of the State Architect. Participants noted California's interpretation of the federal ADA requirements for EV charging spots, implemented on January 1, 2017 by the Division of the State Architect, can be onerous and not effective, if the primary goal is to install more charging in public places. Under this current California policy, for installations of four or fewer chargers, at least one charger must be ADA accessible.[48] This requirement affects parking space width, striping, aisle, signage, and access-to-site-entrance requirements and may necessitate pouring new concrete and making new entrances. California regulation gives local building inspectors room for interpretation at the local level, creating a lack of consistency across various California jurisdictions. Furthermore, ADA compliance may increase project costs or trigger developer concerns about potential litigation, creating a disincentive to install charging infrastructure. In addition, participants noted that local jurisdictions do not always count a charging station as a "parking spot," instead classifying them as part of a separate category called "charging spots." As a result, adding one may count as removing a parking spot, which may make a site host unable to deliver their legally required parking availability. State officials can help address this challenge by connecting local officials with the Division of the State Architect to help them evaluate challenging projects, highlight case studies for local officials to examine for guidance, and suggest changes to the code in the future.

"We need to think of charging infrastructure in terms of onsite renewable energy generation and battery storage. The ability to site these components is important, alongside environmental justice and access concerns."

Jennifer Kropke
IBEW Local 11

"ADA compliance may require significant upfront additional project costs, such as pouring new concrete or building new entrances, in addition to width, striping, aisle, signage, and access to site entrance requirements."

Amanda Myers
ChargePoint

"When you talk about eliminating gas cars, it sounds like you're eliminating choices. We need to make it clear that we're expanding them."

Dan Lashof
World Resources Institute (formerly NextGen Policy Center)

"The campaign will need to stay one step ahead of critic responses and industry opposition."

Jessie Denver
San Francisco Department of the Environment

"There is a perception problem that EVs are only for rich people. So we need to promote the counter-narrative that these vehicles are for everyone."

Janea Scott
California Energy Commission

Key Barrier #3: Lack of public awareness of ZEVs to inform purchasing decisions

The general public is often unaware of electric vehicles as a beneficial and viable technology option. Furthermore, they often harbor misconceptions about the negatives of electric vehicles, in terms of their convenience, price, and environmental impact. Public knowledge of EVs has improved in recent years, with the highly public release of Tesla's Model 3 in particular increasing awareness. But participants still emphasized the substantial gap in consumer comfort relative to familiar internal combustion engine models. As manufacturers develop more EVs that are competitive with traditional gas-powered cars in terms of price, battery range, and range of models, public and private stakeholders will need to promote these options to ensure maximum consumer uptake.

Solutions:

Industry and public sector leaders could coordinate a campaign to raise awareness of ZEV benefits and options by targeting key demographics. Notably, electric utilities are authorized to participate in this education and marketing effort through SB 350. The campaign, such as the current advertising effort "Electric for All" by the nonprofit Veloz, should consider targeting vehicle purchasers, drivers, and passengers, as well as policy makers and key staff, auto dealers, and future drivers.[49] The campaign will then have to prepare different stories for different population and market segments. The goal should be to increase awareness so that consumers add EVs to the list of options when they are making the decision to buy a vehicle.

The campaign should raise awareness, inspire interest, and dispel myths. The messaging should involve new narratives about the vehicles, tap into existing motivations for vehicle purchasers (such as performance, reliability and maintenance costs), rely on direct contact and test-driving opportunities, and promote availability of charging infrastructure. The campaign should market by psychographic, focusing on solving people's problems as they are today.

The campaign could launch through key public and private institutions that reach the target audiences. Examples include outreach through state driver's education programs at the Department of Motor Vehicles or through faith-based organizations. It should also target state and local decision-makers on vehicle purchases and funding, with messages from experts in the nonprofit and academic fields.

Policy makers and industry should consider ZEV usage in TNCs and at workplaces as a form of marketing. As an example, GM's Maven program, which provides vehicles for individuals to use in car-sharing and TNC programs, has given roughly 1,000,000 passengers (according to company estimates) the opportunity to ride in a Chevrolet Bolt. By placing EVs into general usage and giving some consumers an effective "test drive" outside the vehicle purchase context, the program builds public awareness and acceptance naturally. Workplace charging can also accomplish that end, as seeing a peer driving an EV can spark interest and normalize the technology. These programs are like a "second showroom" for EVs.

Industry actors could help fund the campaign. For example, automakers selling vehicles in California could contribute money into a coordinated pot proportional to their sales of internal combustion engine vehicles to fund the statewide campaign – or receive credit for their existing marketing expenditures. Money spent on a public information campaign could help bolster existing incentives, given that public understanding is so low. The improved awareness may generate more new consumers. Public entities or nonprofits could help coordinate, such as Veloz.

"Just getting someone to try an EV means they will buy one if they can. This is a pretty cool technology. Selling them on the environmental principle doesn't necessarily get us new people, but selling them as fun, quality vehicles does."

Geof Syphers
Sonoma Clean Power

"Half of the vehicles on the road are light-duty trucks and SUVs. There has to be EV product for those types of vehicles."

Bill Boyce
Sacramento Municipal Utility District

"Performance-based incentives need to be really well thought out in order to avoid unintended consequences. We need incentives to get chargers in corridors and in low-income communities."

David Sawaya
Pacific Gas & Electric

Key Barrier #4: Insufficient, ineffective, and uncertain public incentives

Existing incentives for electric vehicle drivers are often uncoordinated, inefficient, and potentially insufficient. Incentive programs may be hard to access for electric vehicle purchasers or face delays or uncertain funding. Financing may not be available to cover the higher upfront costs for some models, despite the potential long-term savings on operations and maintenance. State rebates for EV purchasers lack long-term funding. And proposed rollbacks of federal fuel economy standards and other programs supporting zero-emission vehicles may hurt states' abilities to promote ZEV adoption. Meanwhile, the federal tax incentives that benefitted early pioneers of ZEVs are capped based on sales within a company, thereby hurting companies with strong historic EV sales and distorting the market for the most popular models.

Solutions:

Federal leaders could raise or eliminate the manufacturer caps on the existing federal tax credit and accelerate federal tax depreciation of charging assets. Congress recently maintained the federal $7,500 EV purchase credit but did not lift the individual manufacturer caps of 200,000 vehicle credits. The result is that manufacturers of the most popular models may be effectively penalized for their success, while some consumers will be led to less-popular models due to the availability of a credit. Others may opt out of the ZEV market altogether. State and industry leaders could press Congress to simply eliminate the individual manufacturer caps altogether or institute a single market-wide cap (instead of specific to each manufacturer) to facilitate consumer choice. Similarly, allowing owners of charging infrastructure to claim accelerated depreciation of that infrastructure for tax purposes would make installation more financially advantageous and may properly reflect the potential for charging equipment to become obsolete as technologies develop further. Notably, the U.S. Environmental Protection Agency's August 2018 proposal to revoke California's waiver and freeze fuel efficiency standards for post-2020 model years could work against these goals by dampening automaker willingness to invest in ZEVs.

Federal and state leaders should consider innovative ways to modify and extend existing incentives. The importance of incentives for EV purchasers is changing over time. Early adopters of EVs may have been higher-income individuals and families who would have purchased an electric vehicle regardless of the availability of credits or rebates. Thus, the availability of incentives is becoming more important over time as the market broadens and incorporates more income groups. Examples of innovations or modifications include:

- Phasing down incentives over time based on a certain schedule or as a function of total sales (as opposed to an individual manufacturer cap), which could help to incentivize sales now;
- Creating a tax credit for charging infrastructure hosts;
- Increasing HOV lane use privileges for ZEVs (and advertising those privileges

clearly to help non-ZEV-driving highway users to see the benefits of switching); and

- Designing funding incentives to be multi-year in nature to avoid a "start/stop" dynamic that makes it challenging for auto dealers to advertise them.

State leaders could strengthen the Low Carbon Fuel Standard by providing higher credit for zero carbon power. The legislature could increase the Low Carbon Fuel Standard (LCFS) to require a 25% reduction in the carbon intensity of fuels (compared to the current 10%), which would directly increase fuel providers' incentives to replace gasoline and other greenhouse gas-generating fuels with electricity. Since the LCFS functions through the generation of credits for production of low-carbon fuels, issuing higher-value credits for zero carbon fuel (e.g., EV charging from renewable generation) could increase the value proposition of building and supplying energy to EV charging infrastructure, as proposed in revised regulations currently before the California Air Resources Board for approval.[50]

State regulators could consider "decoupling" utility revenue from transportation electricity sales to encourage installation of more charging infrastructure. Since 1982, the California Public Utilities Commission has decoupled electrical utility revenues from total electricity sales, a departure from the traditional revenue model that has allowed the utilities and the state to actively encourage energy conservation while maintaining financial viability.[51] This policy has allowed the state to advance its greenhouse gas emission reduction goals through policies such as AB 32 and SB 350. However, participants noted that two core emphases of these laws—reducing gross electricity consumption and cutting emissions—come into direct conflict in the context of electric vehicles. Replacing internal combustion vehicles with EVs will reduce emissions while increasing overall electricity consumption, and yet under current state policies the IOUs are required to reduce total electricity sales. The Public Utilities Commission could consider regulatory changes to ensure that IOUs are not penalized for consumption increases due to installation of charging infrastructure or clarify that

SB 350's requirement to double building energy efficiency does not conflict with adding more EV chargers.

State regulators could allow performance-based incentives for utilities. Performance-based incentives that base investor-owned utility rate increases in part on installing high-use charging infrastructure could spur a significant rise in utility-led charging programs such as Charge Ready and Power Your Drive. However, these incentives need to avoid unintended consequences. For example, if incentives are purely performance-based, then utilities may locate the majority of new charging only in affluent communities where EV adoption has been highest. Performance-based measures can include equity considerations or disadvantaged community requirements to ensure that charging infrastructure is well distributed throughout the state.

State leaders could improve financing for ZEVs, such as through greater access to on-bill utility financing for ZEV purchases. On-bill financing allows a utility customer to pay for a capital purchase, such as rooftop solar panels or energy efficiency retrofits, via monthly payments on a utility bill, helping customers undertake energy improvements for which they may not have the cash or credit readily available. However, use of on-bill financing is somewhat limited due to state laws and regulations restricting the ability of utilities to effectively lend money to customers. The Public Utilities Commission could approve use of on-bill financing for EV purchases and installation of associated charging infrastructure at a home or business, based on the grid benefits that EVs can provide. Additionally, the legislature could consider tax incentives for employers to install free charging infrastructure at workplaces or implement EV ride share services for employees.

State leaders could increase funds available for ZEV incentives. For example, the state could require that cap-and-trade auction proceeds that are returned to utilities be used for EV incentives, as currently done with low carbon fuel standard credits. "Feebates" that charge fees for new vehicle purchases and provide a rebate for high-fuel efficiency vehicles (funded by the fees from low-fuel efficiency vehicles)

could increase ZEV uptake in a potentially revenue-neutral way. In addition, public dollars could be focused more on infrastructure incentives than on vehicle rebates, except for in low-income communities, given that the biggest barriers to wide-scale adoption may involve infrastructure.

State leaders could provide fiscal incentives for charging infrastructure. For example, the state could ensure that property tax appraisals take EV infrastructure into account, while tax assessments disregard it. State and local leaders could offer construction permit fee waivers for EV infrastructure installation, and the state could offer a tax credit for charging infrastructure.

State leaders could provide incentives for dealers and salespersons. As a possible model, the Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) program, initiated in 2014, combines consumer cash rebates for EV purchases with a dealer credit for each rebate issued. A 2017 study by the Center for Sustainable Energy found that the $300 credit generally motivated dealers to increase EV sales, although clearer program definitions and splitting of credits between dealerships and salespeople could improve performance.[52] The state legislature could consider a similar program to match existing consumer incentives with dealer incentives as a means to increase dealer uptake. State and local officials could also coordinate to share procurement and bulk purchasing to receive discounts on individual ZEVs.

State, local, and industry leaders could encourage TNC drivers to use ZEVs. The state could provide incentives to leasing companies that work with TNCs such as Uber and Lyft to purchase ZEVs and then give incentives to drivers (i.e., lower rates) to lease the ZEVs from them. The state could also encourage TNCs to reward drivers who operate ZEVs with priority placement and customer access, particularly where charging infrastructure exists to support this type of usage. Currently, the number of vehicles that are appropriate for TNC use is limited. But as the market develops there will be more options for vehicles that satisfy TNC range and size needs.

Conclusion:

Making an Ideal Scenario Achievable

Achieving a long-term goal of having 100% of new passenger vehicles be zero-emission will require short-term policy actions as a start. While technology will improve and costs will likely decrease, the public sector and industry can take steps today to ensure that this scenario is achievable, cost-effective, and beneficial to all residents. As countries around the globe move to legislate for similar goals, California could similarly provide a powerful example for other states and jurisdictions that are committed to eliminating (or at least greatly reducing) greenhouse gas emissions from transportation. This long-term effort will require smart policies today on charging infrastructure, public awareness, and continued incentives to foster innovation and greater adoption.

Glossary of Terms

Americans with Disabilities Act (ADA): A federal law requiring the installation of accessible infrastructure and components for new construction and renovation, including in connection with electric vehicle charging installations.

California Air Resources Board (CARB): An organization within the California Environmental Protection Agency responsible for providing and maintaining clean air, including enforcement of the state's greenhouse gas reduction laws (AB 32 and SB 32).

California Energy Commission (CEC): The state's primary energy policy and planning agency, which includes supporting energy research, developing renewable energy resources, and advancing alternative and renewable transportation fuels and technologies.

California Global Warming Solutions Act of 2006 (AB 32): California state law that sets out the greenhouse gas emissions reduction goal to be achieved by 2020.

California Public Utilities Commission (CPUC): California's agency in charge of regulating investor-owned utilities.

Charging Types:

- **Level 1 charging:** uses a 120-volt alternating current (AC) plug that is found in most standard household outlets.
- **Level 2 charging:** uses a 240-volt AC plug that requires installation of additional charging equipment.
- **DC fast charging**: uses a 480-volt direct current (DC) plug that enables rapid charging at public charging stations along heavy traffic routes. Charging stations at up to 350 kilowatts will far exceed current 50-kilowatt CHAdeMO and SAE Combo public chargers or Tesla 120 kilowatt Superchargers.

Investor-Owned Utility (IOU): A privately-owned electric company that in California is regulated by the California Public Utilities Commission.

Low Carbon Fuel Standard (LCFS): a state program, pursuant to AB 32, that created a performance-based market and mandate for transportation fuels with reduced carbon intensity.

"Make-Ready": A parking space wired with all the electrical infrastructure necessary to support the installation of a customer-purchased charger.

Senate Bill 350 (de León, 2015) or Clean Energy and Pollution Reduction Act of 2015: California climate and clean energy legislation that encourages electric vehicle charging station deployment in part through more investor-owned utility investment.

Senate Bill 32 (Pavley, 2016): A California law requiring statewide

greenhouse gas emissions to be reduced 40% below 1990 levels by 2030.

Transportation Network Company (TNC): A company such as Uber or Lyft that provides automobile transportation services by matching drivers with passengers via mobile app.

Vehicles:

- **Battery Electric Vehicles (BEVs)** use a battery to store the electric energy that powers the motor. BEV batteries are charged by plugging the vehicle into an electric power source. BEVs are sometimes referred to simply as electric vehicles (EVs).
- **Hybrid Electric Vehicles (HEVs)** are primarily powered by an internal combustion engine that runs on conventional or alternative fuel and an electric motor that uses energy stored in a battery. The battery is charged through regenerative braking and by the internal combustion engine and is not plugged in to charge.
- **Internal Combustion Engines (ICE)** generate power by burning gasoline, oil, or other fuels with air inside the engine.
- **Plug-in Electric Vehicle (PEV)** is any vehicle that runs at least partially on battery power and the battery of which can be recharged from the electricity grid. In California, the term PEVs includes both BEVs and PHEVs.
- **Plug-In Hybrid Electric Vehicles (PHEVs)** are motor vehicles powered by a battery that can be recharged by plugging it into an external source of electricity but which also incorporate the use of a combustion engine when the battery is depleted to power the vehicle.
- **Zero Emission Vehicles (ZEVs)** are vehicles that are capable of travelling certain distances without emitting tailpipe pollutants from their onboard power sources.

Vehicle-Grid Integration (VGI): A broad term that encompasses the numerous ways in which a vehicle can provide benefits or services to the grid, to society, the EV driver, or parking lot site host by optimizing PEV interaction with the electrical grid. VGI includes both active management of electricity (e.g., bi-directional management, such as vehicle-to-grid [also known as V2G] or unidirectional management such as managed charging [also known as V1G]) and/or active management of charging levels by ramping up or down charging. VGI also includes passive solutions such as customer response to existing rates, design of improved utility rates (e.g., time-of-use (TOU) charges, demand charges and customer fees), design of the grid to accommodate EVs while reducing grid impacts to the degree possible, and education or incentives to encourage charging technology or charging level (e.g., rebates for lower level charging, modifying current allowance policy).[53]

Glossary of Terms

Participant Biographies

Robert Barrosa – Electrify America

Robert Barrosa is the Director of Utility Strategy and Operations for Electrify America. In this role, he is responsible for strategy and business development with a special focus on the California region. Rob has over 10 years of experience in the EV infrastructure industry. He served as vice president of OEM Strategy & Business Development for EVgo and as an executive with AeroVironment Inc. in product development, engineering and business development.

Bill Boyce – Sacramento Municipal Utility District

Bill Boyce has led SMUD's Electric Transportation Program for over 15 years. He has a broad technical background that includes aerospace, environmental, mechanical, and mining engineering along with his electric utility experience. Prior to working at SMUD, Bill spent 15 years working in the liquid rocket industry. He currently serves on the Board of Directors for CalETC and is active in many industry initiatives including the U.S. DOE EV Everywhere Utility Working Group, Electric Drive Technology Association and the Electric Power Research Institute.

Linda Brown – San Diego Gas & Electric

Linda Brown is Senior Director of Clean Transportation at SDG&E. Her educational background includes a Bachelor of Science degree in Electrical Engineering from Southern Illinois University, Carbondale, Illinois and a Community College Teaching Credential in Engineering. She is a licensed Professional Engineer in Electrical Engineering in the State of California. She has more than 20 years of experience with SDG&E which includes various positions in distribution, operations, transmission and regulatory affairs. She also taught in the Electronics Department at Mesa College from 1986 through 1990. In addition, she currently represents SDG&E on the Planning Coordination Committee of the Western Electricity Coordinating Council (WECC). She has testified numerous times before the California Public Utilities Commission, most recently on the Sunrise Powerlink. Linda has been a subject matter expert on the need for transmission projects including Mission Miguel, Sunrise, Otay Metro Powerlink and Valley Rainbow. She also serves as member on the Steering Committees for both the RETI and CTPG forums.

Fei Chi – Tesla

Fei Chi is Manager of Business Development & Government Affairs at Tesla. She covers vehicle and fuel regulations in North America and government affairs for Tesla's Asia Pacific markets. Previously, she worked in leveraged finance at Antares Capital and in corporate development and corporate finance at GE Capital. She holds a BS in Business Administration from the University of North Carolina at Chapel Hill.

Steven Cliff – California Air Resources Board

Steven Cliff was appointed Deputy Executive Officer at the California

Air Resources Board in the summer of 2017. Steve is responsible for overseeing programs to reduce emissions from mobile sources and the statewide monitoring and laboratory programs. These include the vehicle emissions testing and compliance programs, mobile source regulations, engine certification programs, the ambient air quality monitoring network, small engine regulations, and incentive programs. Steve started at CARB in 2008 where he working on the first climate change scoping plan under AB 32, and led the development of the greenhouse gas cap-and-trade program. In 2014, Governor Brown appointed Steve to Caltrans as the inaugural director for sustainability, and in 2016 appointed Steve back to CARB as Senior Advisor to Chair Mary Nichols. Steve earned his Bachelor's and Doctoral degrees in Chemistry at the University of California, San Diego.

Jessie Denver – San Francisco Department of the Environment

Jessie Denver is the DER Program Manager for the City and the County of San Francisco's Department of the Environment. In this role she leads a diverse team working on energy efficiency, renewables, energy storage and zero emission vehicle program and policy development and implementation. Prior to joining the City of San Francisco, Jessie served as Program Director at the nation's leading solar policy think tank, Vote Solar. With 22 years of experience developing energy policy and programs, she also served as the City of San Jose's Energy Officer, and began her career at the U.S. Environmental Protection Agency as an Environmental Scientist. Jessie has held adjunct faculty positions in the Environmental Studies Department at San Jose State University and taught sustainable energy courses at the University of California, Berkeley. She holds a Master's degree in Environment and Community Planning and a Bachelor's degree in Environmental Studies with minors in Appropriate Technology and Environmental Ethics.

Tyson Eckerle – Governor's Office of Business and Economic Development

Tyson Eckerle serves as the Deputy Director of Zero Emission Vehicle Infrastructure in the Governor's Office of Business and Economic Development (Go Biz). In this role, he focuses on coordinating resources to streamline the development of hydrogen and plug-in electric vehicle stations. Prior to joining Go Biz, Tyson served as Executive Director of Energy Independence Now (EIN), where he and his team developed the Hydrogen Network Investment Plan with input from multiple stakeholders. Tyson holds a B.A. in Biology from the University of California, Davis and a Master of Environmental Science and Management (MESM) from the Bren School of Environmental Science and Management from the University of California, Santa Barbara.

Mark Ferron – California Independent System Operator

Mark Ferron is a leader in the intersection of energy, the environment, finance, and philanthropy. Mark currently serves on the Board of Governors of the California Independent System Operator, which manages the high-voltage electricity system in California and parts of the West. He is also a member of the Board at Rocky Mountain Institute, and is active with a number of environmental and other mission-driven organizations. Before moving to California in 2009, Mark spent 25 years in global finance, banking, and operations. From 2001 to 2009, he worked as chief operating officer for the Global Markets Division of Deutsche Bank in London, where he had responsibility for all operational activities globally across fixed income, currency, commodity, and equity markets. Mark holds a bachelor of science degree in mathematics from the University of Notre Dame and a master's degree in economics from Stanford University.

Jamie Hall – General Motors

Jamie Hall is Manager of Advanced Vehicle and Infrastructure Policy at General Motors, where he develops and implements commercialization programs and policies for GM's advanced vehicle portfolio, and supports cross-functional activities related to advanced vehicles, alternative fuels, and infrastructure. He previously served as Policy Director at CALSTART, where he managed legislative and regulatory efforts in California, including strategy development, stakeholder management and coalition-building, and advocacy. He received his MPP from the University of California, Berkeley and an AB from Princeton University.

Alan Jenn – University of California, Davis

Alan Jenn is a professional researcher in the Plug-in Hybrid & Electric Vehicle (PH&EV) center and the Sustainable

Transportation Energy Pathways (STEPS) center at the Institute of Transportation Systems (ITS) at the University of California, Davis. He received his PhD from the department of Engineering and Public Policy at Carnegie Mellon University and undergraduate degrees in Molecular and Cell Biology, Music, and Energy and Resources from the University of California, Berkeley. His research focuses on the policy issues in the realm of alternative fuel vehicles such as battery electric vehicles, plug-in hybrids, and hydrogen fuel cell vehicles. In particular, he investigates the role of policies in assisting the adoption of new vehicle technologies and infrastructure, as well as the implications of these vehicles on oil use, energy use, and greenhouse gas emissions in the US.

Jennifer Kropke – International Brotherhood of Electrical Workers Local 11

Jennifer Kropke works to advance careers in clean, renewable energy; specifically large scale, renewable energy; transportation and heavy machinery electrification and distributed energy resources (DER), as well as transportation and construction projects advancing the increasing role of renewable energy, energy storage, energy efficiency, and DER technologies. Ms. Kropke is currently the Director of Environmental and Workforce Engagement for the International Brotherhood of Electrical Workers, Local Union Eleven. She is a frequent speaker on the role of workforce development language and professional skilled, craft training for careers in renewable energy and large-scale electrification projects. Ms. Kropke was sent by the United States Department of State to speak in Rio de Janeiro, Brazil on renewable energy workforce development in 2017. Ms. Kropke is an attorney and holds a Juris Doctorate from the University of California, Los Angeles School of Law, and is licensed to practice law in the states of California and New York and United States Federal Court.

Dan Lashof – World Resources Institute (formerly NextGen Policy Center)

Dan Lashof is the Director of World Resources Institute, United States. He coordinates WRI's work in the United States across climate, energy, food, forests, water and the sustainable cities programs. This includes overseeing the work of the U.S. climate team, which aims to catalyze and support climate action by states, cities, and businesses while laying the groundwork for federal action in the coming years. Dan has been working to promote solutions to climate change for more than two decades. Before the World Resources Institute, Dan was the Chief Operating Officer of NextGen Policy Center and previously served as the Director of the Climate and Clean Air Program at the Natural Resources Defense Council. His focus is developing federal and state regulations to place enforceable limits on carbon dioxide and other heat-trapping pollutants. He has participated in scientific assessments of global warming through the Intergovernmental Panel on Climate Change and has monitored international climate negotiations since their inception. He was a member of Governor McAuliffe's Climate Change and Resiliency Update Commission, and has testified at numerous Congressional and California legislative hearings. Dan earned his Bachelor's degree in Physics and Mathematics at Harvard and his Doctorate from the Energy and Resources Group at the University of California, Berkeley.

Amanda Myers – ChargePoint

Amanda Myers is a Public Policy Manager at ChargePoint, the leading electric vehicle (EV) charging network in the world. In this role, she works on policies that promote the deployment of EV infrastructure and adoption of EVs, including EV ready building codes across North America, clean fuels markets, and local EV policies. Before joining ChargePoint, Amanda worked at SolarCity on the Public Affairs team. Prior to SolarCity, Amanda worked at Oracle, the Environmental Law & Policy Center in Chicago, and the White House Council on Environmental Quality. Amanda holds a BA in Political Science from Northwestern University.

Deborah Raphael – San Francisco Department of the Environment

Debbie Raphael is the Director of the San Francisco Department of the Environment. A scientist by training and public servant by profession, Debbie has spent most of her career working in government to ensure that everyone has an equal right to a safe and healthy environment. At the City of Santa Monica and City of San Francisco, Debbie crafted first-in-the-nation policies on toxics reduction, green building, Integrated Pest Management (IPM), healthy nail salons, and the precautionary principle -- a decision-making framework that protects the public from exposure to harm even in the face of scientific uncertainty. In 2011, Governor Edmund G. Brown appointed Debbie as the Director

of the California Department of Toxic Substances Control (DTSC). In her tenure with DTSC, Debbie implemented the state's groundbreaking Safer Consumer Products Law to better regulate which chemicals can be used in products sold or manufactured in California. As Director of the San Francisco Department of the Environment, Debbie works in close partnership with other City agencies and community stakeholders to implement San Francisco's ambitious greenhouse gas reduction goals while advancing policies and programs that are inclusive of diverse communities and build on the city's innovative and pioneering spirit. Debbie holds a Bachelor's degree in biology from the University of California, Berkeley and a Master's Degree in Physiological Plant Ecology from UCLA.

Alice Reynolds – Office of Governor Jerry Brown

Alice Reynolds was appointed senior advisor to the Governor for climate, the environment and energy in the Office of Governor Edmund G. Brown Jr. on February, 10, 2017. She served as Deputy Secretary for Law Enforcement and Counsel at the California Environmental Protection Agency since 2011 and as a deputy attorney general at the California Department of Justice, Office of the Attorney General from 2002 to 2011. She was an attorney at Sonnenschein, Nath and Rosenthal LLP from 1998 to 2001 and at Furth, Fahrner and Mason from 1995 to 1998. Ms. Reynolds served as a research attorney at the Santa Clara County Superior Court from 1993 to 1995. She earned a Juris Doctor degree from Santa Clara University School of Law in 1993.

David Sawaya – Pacific Gas & Electric

David Sawaya is responsible for clean transportation strategy at Pacific Gas and Electric Company (PG&E). This includes long-term planning related to PG&E's customer offerings and infrastructure activities as well as Federal and State policy and legislative matters. Prior to working at PG&E, David worked on energy and technology policy and strategy at the World Bank, Ernst and Young, and the Organization for Economic Cooperation and Development. He received his BS in Civil Engineering from Santa Clara University.

Janea Scott – California Energy Commission

Janea A. Scott is one of five Commissioners on the California Energy Commission. Ms. Scott was appointed by Governor Edmund G. Brown Jr. in February 2013 and reappointed in January 2016 to serve as the Commission's public member. She is the lead Commissioner on transportation and western regional planning, and in 2014 Ms. Scott led the 2014 Integrated Energy Policy Report Update. Ms. Scott serves as the chair of the California Plug-In Electric Vehicle Collaborative, a public/private organization focused on accelerating the adoption of PEVs to meet California's economic, energy and environmental goals. She is also a member of the California Fuel Cell Partnership and the U.S. Department of Energy's Hydrogen and Fuel Cell Technical Advisory Committee. Prior to joining the California Energy Commission, Ms. Scott worked at the U.S. Department of the Interior in the Office of the Secretary as the Deputy Counselor for Renewable Energy and at Environmental Defense Fund in both the New York and Los Angeles offices as a senior attorney in the climate and air program. Ms. Scott was also an AmeriCorps member working at the San Francisco Urban Service Project from 1996-1997. Ms. Scott earned her J.D. from the University of Colorado Boulder Law School and her M.S. and B.S. in Earth Systems from Stanford University.

Carrie Sisto – California Public Utilities Commission

Carrie Sisto is an Electric Vehicles Analyst at the California Public Utilities Commission, where she helps develop and oversee the implementation of utilities' plans to expand electric vehicle infrastructure in California. She previously worked as a regulatory and market analyst for DTE Energy Trading, where she provides guidance to DTE's Environmental Commodities Trading desk on upcoming and developing regulatory changes and collaborated in building out the new desk's business operations, initial fundamentals modeling and portfolio development. She also worked as an environmental market analyst at Amerex Brokers, a market analyst and senior editor at Argus Media, and outreach and volunteer coordinator at Bluegrass PRIDE. She holds BS and MA degrees from the University of Kentucky.

Geof Syphers – Sonoma Clean Power

Geof Syphers is the Chief Executive Officer of Sonoma Clean Power, a position he has held since the program's inception in

2013. Under his leadership, SCP now serves 600,000 people throughout Sonoma and Mendocino counties with cleaner power at competitive rates. Prior to his current position, Mr. Syphers worked for 20 years as an energy consultant to utilities, public agencies and private companies. His work has spanned micro grid design, zero-carbon community design and energy efficiency program implementation. He served as the Chief Sustainability Officer for Codding Enterprises and was the founding Director of DNV's Green Building Group. He holds an MS from the University of Massachusetts Lowell and a BS from Sonoma State University.

John Tillman – Nissan Motors USA

John Tillman is Manager of Regulatory Affairs at Nissan Motors USA. He has over 14 years of experience with advanced electric drive and alternative fuel vehicle technologies including interpreting, communicating and advocating for modifications to the regulations and legislation that drive their market introduction. He has extensive technology market penetration analysis and strategy development experience for regulations affecting advanced transportation technologies, and one-on-one experience with CARB regulatory staff in the interpretation, negotiation and industry stakeholder development of proposed modifications to the ZEV, LCFS, CFO and LEV emissions regulations. He has been involved in development of vehicle roll-out scenarios, including fleet infrastructure requirements planning and action plan development for public policy related to regulations and fuels mandates. He received his BS from the University of California, Davis.

Endnotes

1 California Air Resources Board (CARB), "California Greenhouse Gas Emission Inventory - 2018 Edition." Available at: https://www.arb.ca.gov/cc/inventory/data/data.htm (accessed July 19, 2018).

2 Veloz, "Sales Dashboard – Detailed Sales Chart," July 2018. Available at: http://www.veloz.org/wp-content/uploads/2018/07/6_june_2018_Dashboard_PEV_Sales_veloz.pdf (accessed July 19, 2018). *See also* California Department of Motor Vehicles, "Statistics for Publication, January through December 2017." Available at: https://www.dmv.ca.gov/portal/wcm/connect/5aa16cd3-39a5-402f-9453-0d353706c-c9a/official.pdf?MOD=AJPERES (accessed July 25, 2018).

3 Mark Kane, "Global Plug-In Electric Car Sales Hit 140,000 in March." *InsideEVs*, April 30, 2018. Available at https://insideevs.com/global-plug-in-electric-car-sales-increased-to-over-140000-in-march/ (accessed July 19, 2018).

4 *See* California Clean Vehicle Rebate Project (CVRP), "CVRP Eligible Vehicles." Center for Sustainable Energy. Available at: https://cleanvehiclerebate.org/eng/eligible-vehicles (accessed July 19, 2018)

5 *See* Keith Naughton and David Welch, "GM's Electric Bolt Slows While Tesla Model 3 Sales Pick Up." *Bloomberg*, May 2, 2018. Available at https://www.bloomberg.com/news/articles/2018-05-02/gm-s-electric-bolt-slows-as-tesla-model-3-sales-pick-up-speed (accessed July 19, 2018). *See also* Eric Kulisch, "GM to hike Bolt output in drive for EV future," *Automotive News*, March 7, 2018. Available at: http://www.autonews.com/article/20180307/OEM/180309567/gm-to-hike-bolt-output-in-drive-for-ev-future (accessed July 19, 2018).

6 Frost & Sullivan, *Global Electric Vehicle Market Outlook, 2018*. Available at https://cds.frost.com/p/72699/#!/ppt/c?id=MDAB-01-00-00-00 (accessed July 19, 2018).

7 *See* CARB, "2016 Zero Emission Vehicle Credits." Available at: https://www.arb.ca.gov/msprog/zevprog/zevcredits/2016zevcredits.htm (accessed July 19, 2018).

8 *See* 13 CCR § 1962 et seq.

9 *See* Ann Carlson, "Wheeler EPA Looking to Freeze Auto Standards, Revoke California's Waiver," *Legal Planet*, July 23, 2018. Available at: http://legal-planet.org/2018/07/23/wheeler-epa-looking-to-freeze-auto-standards-revoke-california-waiver/ (accessed July 25, 2018).

10 CVRP, "CVRP Eligible Vehicles." *See* Governor's Interagency Working Group on Zero-emission Vehicles, "2016 ZEV Action Plan – An updated roadmap toward 1.5 million zero-emission vehicles on California roadways by 2025," October 2016, p. 7. Available at: https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf (accessed July 19, 2018). *See also* California Air Resources Board, "Clean Air Vehicle Rebate Project." webpage. Available at: https://www.arb.ca.gov/msprog/aqip/cvrp.htm (accessed July 19, 2018).

11 CVRP, "CVRP Rebate Statistics." Available at: https://cleanvehiclerebate.org/eng/rebate-statistics (accessed July 19, 2018).

12 *See* Internal Revenue Service, "Plug-In Electric Drive Vehicle Credit (IRC 30D)." Available at: https://www.irs.gov/businesses/plug-in-electric-vehicle-credit-irc-30-and-irc-30d (accessed July 19, 2018).

13 *See* EVAdoption, "Federal EV Tax Credit Phase Out Tracker by Automaker." Available at: http://evadoption.com/ev-sales/federal-ev-tax-credit-phase-out-tracker-by-automaker/ (accessed July 19, 2018). *See also* "What You Need to Know about the Federal EV Tax Credit Phase Out," Tesla Motors Blog, August 10, 2018. Available at: https://www.tesla.com/blog/what-you-need-know-about-federal-ev-tax-credit-phase-out (accessed August 16, 2018)

14 Cal. Vehicle Code § 21655.9. *See* CARB, "Eligible Vehicle List – Single Occupant," available at: https://www.arb.ca.gov/msprog/carpool/carpool.htm (accessed July 20, 2018).

15 *See* Veloz, "Sales Dashboard – Detailed Sales Chart." (accessed July 19, 2018). *See also* California Energy Commission (CEC), "Tracking Progress – Zero-Emission Vehicles and Infrastructure," July 2017. Available at: http://www.energy.ca.gov/renewables/tracking_progress/documents/electric_vehicle.pdf (accessed July 19, 2018).

16 "CVRP Rebate Statistics."

17 InsideEVs.com, "Monthly Plug-In Sales Scorecard." Available at: http://insideevs.com/monthly-plug-in-sales-scorecard/ (accessed July 19, 2018).

18 CEC, "Tracking Progress," p. 5.

19 CEC, "2018-2019 Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program," May 2018, p. 7. Available at: http://www.energy.ca.gov/altfuels/2017-ALT-01/documents/ (accessed July 25, 2018).

20 California Office of the State Treasurer, "California Capital Access Program (CalCAP) – Electric Vehicle Charging Station (EVCS) Financing Program." Available at: http://www.treasurer.ca.gov/cpcfa/calcap/evcs/ (accessed July 20, 2018).

21 *See* USDOE, "Alternative Fuels Data Center – California Laws and Incentives for Electricity." Available at: http://www.afdc.energy.gov/fuels/laws/ELEC/CA (accessed July 20, 2018).

22 CARB, "California Air Resources Board's Guidance to Volkswagen on First 30 Month Electric Vehicle Infrastructure Investment Plan of the 2.0 Liter Diesel Engine Partial Consent Decree Settlement," Volkswagen Settlement: California Zero Emission Vehicle Investment Commitment, February 2017, p. 4. Available at: https://www.arb.ca.gov/msprog/vw_info/vsi/vw-zevinvest/documents/carb_guidance_021017.pdf (accessed July 20, 2018). *See also* CEC, "Tracking Progress."

23 San Diego Gas & Electric (SDG&E), "Power Your Drive." Available at: https://www.sdge.com/residential/electric-vehicles/power-your-drive (accessed July 20, 2018. *See also* California Public Utilities Commission (CPUC), Decision 16-01-045, issued February 4, 2016. Available at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K241/158241020.PDF (accessed July 20, 2018).

24 Southern California Edison (SCE), "Charge Ready." Available at: https://www.sce.com/wps/portal/home/business/electric-cars/Charge-Ready/ (accessed July 20, 2018). *See also* CPUC, Decision 16-01-023, issued January 25, 2016. Available at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M157/K835/157835660.PDF (accessed July 20, 2018).

25 Pacific Gas & Electric (PG&E), "PG&E Launches New Program to Accelerate Electric Vehicle Adoption in Northern and Central California," January 17, 2018, available at: https://www.pge.com/en/about/newsroom/newsdetails/index.page?title=20180117_pge_launches_new_program_to_accelerate_electric_vehicle_adoption_in_northern_and_central_california (accessed July 20, 2018). *See also* CPUC, Decision 16-12-065, issued December 21, 2016. Available at: http://docs.cpuc.ca.gov/SearchRes.aspx?DocFormat=ALL&DocID=171539218 (accessed July 20, 2018).

26 California Public Utilities Commission, D.18-01-024. Available at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M204/K670/204670548.PDF (accessed August 16, 2018). *See* summary of the approved pilot programs, available at: http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442457607 (accessed August 16, 2018).

27 CPUC, "Summary of Decision on Transportation Electrification Program Proposals from the Investor-Owned Utilities," May 31, 2018. Available at: http://www.cpuc.ca.gov/sb350te/ (accessed July 20, 2018).

28 SCE, "SCE Files Plan to Expand Charge Ready EV Charging Program," June 26, 2018. Available at: https://www.insideedison.com/stories/sce-files-plan-to-expand-charge-ready-ev-charging-program (accessed July 22, 2018).

29 USDOE, "Alternative Fuels Data Center – Alternative Fueling Station Counts by State." Available at: http://www.afdc.energy.gov/fuels/stations_counts.html (accessed July 20, 2018).

30 CEC, "Tracking Progress," p. 7.

31 *See* USDOE, "Alternative Fuels Data Center – Alternative Fueling Station Locator." Available at https://www.afdc.energy.gov/stations/#/find/nearest (accessed July 20, 2018).

32 *See* Kate Palmer et al., "Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan," *Applied Energy* 209, 108-119 (2018). Available at: https://www.sciencedirect.com/science/article/pii/S030626191731526X (accessed July 21, 2018). *See also* Constance Douris, "The Bottom Line on Electric Cars: They're Cheaper to Own," *Forbes*, October 24, 2017. Available at https://www.forbes.com/sites/constancedouris/2017/10/24/the-bottom-line-on-electric-cars-theyre-cheaper-to-own/ (accessed July 21, 2018).

33 USDOE, "Alternative Fuels Data Center – Alternative Fueling Station Counts by State."

34 Abdulkadir Bedir, Ph.D., Noel Crisostomo, Jennifer Allen, Eric Wood and Clément Rames (National Renewable Energy Laboratory), "California Plug-In Electric Vehicle Infrastructure Projections: 2017-2025," California Energy Commission staff report, March 2018, p. ii. Available at: https://efiling.energy.ca.gov/GetDocument.aspx?tn=223286 (accessed August 24, 2018).

35 Max Baumhefner, Roland Hwang and Pierre Bull, "Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles," Natural Resources Defense Council, June 2016, p. 4. Available at: https://www.nrdc.org/sites/default/files/driving-out-pollution-report.pdf (accessed July 22, 2018).

36 USDOE, "Alternative Fuels Data Center – Developing Infrastructure to Charge Plug-In Electric Vehicles." Available at: http://www.afdc.energy.gov/fuels/electricity_infrastructure.html (accessed July 22, 2018).

37 David Herron, "Tesla joins 150 kW CCS Forces, CHAdeMO's Days are Numbered in EV Fast Charging," Longtailpipe.com, April 18, 2016. Available at: https://longtailpipe.com/2016/04/18/tesla-joins-150-kw-ccs-forces-chademos-days-are-numbered-in-ev-fast-charging/ (accessed July 22, 2018).

38 EVgo, "EVgo is the Largest Public Fast Charging Network in the U.S." Available at: https://www.evgo.com/about/ (accessed July 22, 2018).

39 Fred Lambert, "CHAdeMO is pushing for faster electric vehicle charging with new 400 kW protocol," *Electrek*, June 15, 2018. Available at: https://electrek.co/2018/06/15/chademo-faster-electric-vehicle-charging-400-kw-protocol/ (accessed July 22, 2018).

40 Eric C. Evans, "Electrify America maps out charging network to rival Tesla Superchargers," *Green Car Reports*, April 23, 2018. Available at: https://www.greencarreports.com/news/1116375_electrify-america-maps-out-charging-network-to-rival-tesla-superchargers (accessed July 22, 2018). *See also* Fred Lambert, "Electrify America Opens Another Ultra-Fast EV Charger and Announces New Partner for Locations," Electrek, May 22, 2018. Available at: https://electrek.co/2018/05/22/electrify-america-ultra-fast-ev-charger-new-partner-locations-simon/ (accessed August 24, 2018).

41 Fred Lambert, "Tesla pushes Supercharger V3 to 'end of the year,' says it will be 'zombie apocalypse-proof,'" *Electrek*, June 6, 2018. Available at: https://electrek.co/2018/06/06/tesla-pushes-supercharger-v3-expansion-batteries-solar/ (accessed July 22, 2018).

42 UCLA Luskin School of Public Affairs and Anderson School of Management, "Financial Viability of Non-Residential Charging Stations," August 2012. Available at: http://luskin.ucla.edu/sites/default/files/Non-Residential%20Charging%20Stations.pdf (accessed July 22, 2018).

43 Idaho National Laboratory, "Plugged In: How Americans Charge Their Electric Vehicles," 2015. Available at: https://avt.inl.gov/sites/default/files/pdf/arra/PluggedInSummaryReport.pdf (accessed July 22, 2018).

44 John Clint, Billy Gamboa, Brandon Henzie, and Akane Karasawa (Alternative Energy Systems Consulting, Incorporated), "Considerations for Corridor Direct Current Fast Charging Infrastructure in California," California Energy Commission, December 2015. Available at: http://www.energy.ca.gov/2015publications/CEC-600-2015-015/CEC-600-2015-015.pdf (accessed July 22, 2018).

45

46 Garrett Fitzgerald and Chris Nelder, "EVgo Fleet and Tariff Analysis," Rocky Mountain Institute, April 2017, at p. 1. Available at: https://www.rmi.org/wp-content/uploads/2017/04/eLab_EVgo_Fleet_and_Tariff_Analysis_2017.pdf (accessed July 22, 2018).

47 CPUC, "Summary of Decision on Transportation Electrification Program Proposals from the Investor-Owned Utilities."

48 *See* California Department of General Services, Division of the State Architect, "Access California: New Accessibility Regulations for Electric Vehicle Charging Stations (EVCS)," 2016. Available at: https://www.documents.dgs.ca.gov/dsa/access/EVCSPresentation_04-07-17.pdf (accessed July 22, 2018).

49 *See* Veloz, "Electric for All." Available at: http://www.veloz.org/initiatives/electric-for-all/ (accessed July 22, 2018).

50 "Proposed Amendments to the Low Carbon Fuel Standard Regulation and to the Regulation on Commercialization of Alternative Diesel Fuels," California Air Resources Board website. Available at: https://www.arb.ca.gov/regact/2018/lcfs18/lcfs18.htm (accessed August 24, 2018).

51 *See* CPUC, "Actions to Limit Utility Cost and Rate Increases," May 2017, at p. 8. Available at http://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Utilities_and_Industries/Energy/Reports_and_White_Papers/CPUC%202016%20Section%20913-1%20and%20SB695%20LEG%20report.pdf (accessed July 22, 2018).

52 Center for Sustainable Energy, "Evaluating the Connecticut Dealer Incentive for Electric Vehicle Sales," June 2017. Available at: http://energycenter.org/sites/default/files/docs/nav/research/CT-Dealer-IncentiveEvaluation-CSE-2017.pdf (accessed July 22, 2018).

53 *See* "VGI Definition," California Public Utilities Commission. Available at: http://www.cpuc.ca.gov/vgi/ (accessed August 16, 2018)

Center for Law, Energy & the Environment (CLEE)
UC Berkeley School of Law
390 Simon Hall
Berkeley, CA 94720-7200
www.clee.berkeley.edu

BerkeleyLaw
UNIVERSITY OF CALIFORNIA

Center for Law, Energy & the Environment