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California State Senate

Select Committee on Transitioning to a Zero-Emission Energy Future
Senator Josh Newman, Chair

Informational Hearing:
Are We There Yet? How Much Longer?
California's Progress on Zero-Emission Vehicle Infrastructure

Wednesday, August 23, 2023, 1:00 PM
1021 O Street, Room 2100

BACKGROUND

Half the Pie: Transportation's Role in Overall Climate Emissions

Having baked under the hottest July in recorded history,[1] California is already grappling with the consequences of climate change. In an effort to stave off the worst effects, the State has set aggressive goals to dramatically reduce its greenhouse gas (GHG) emissions, including achieving a 40% reduction in overall GHG emissions from 1990 levels by 2030,[2] and carbon neutrality by 2045.[3] According to the California Air Resources Board (CARB), transportation accounts for roughly half of California's annual GHG emissions when accounting for fuels production. Tailpipe emissions from light-duty passenger vehicles alone account for 25.5% of annual climate-warming emissions – nearly twice the emissions produced by the state's entire energy grid.[4] Transitioning California's vehicle stock to zero-emissions will be necessary to achieve any substantial reduction in overall emissions, and is expected to play the largest role in reaching carbon neutrality.

To that end, Governor Gavin Newsom issued Executive Order N-79-20 and CARB adopted the Advanced Clean Cars II rule to accelerate the purchase and deployment of zero-emission vehicles (ZEVs) under a gradual phase-out of gas-powered internal combustion engines. These rules require automakers to demonstrate an ever-increasing share of their in-state vehicle sales are zero-emission, reaching 100% ZEV [5] sales by 2035. In anticipation of this expected increase, California will need ubiquitous and reliable

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[1] NASA, Clocks July 2023 as Hottest Month on Record Ever Since 1880
[2] The California Global Warming Solutions Act of 2006 (AB 32; Núñez, Chapter 488, Statutes of 2006)
[3] The California Climate Crisis Act (AB 1279; Muratsuchi, Chapter 337, Statutes of 2022)
[4] CARB, GHG Emission Inventory Graphs
[5] For conciseness, "zero-emission vehicle" and "ZEV" is in reference to light-duty passenger vehicles, unless noted otherwise.

networks of publicly accessible electric vehicle (EV) chargers and hydrogen refueling stations. By accelerating the market adoption of ZEVs to meet the climate crisis, it is the State's obligation to support the rapid buildout of ZEV infrastructure such that consumers may be confident that every Californian will get to where they're going.

Zero Emission Vehicles: Where's the Juice?

There are two zero-emission vehicle technologies available on the market today: battery-electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs).[6] Both technologies have no tailpipe emissions but differ in how energy is derived to power the vehicle. BEVs store energy in an onboard battery pack, typically consisting of thousands of lithium-ion battery cells. FCEVs are powered by converting gaseous hydrogen stored in onboard gas tanks into electricity through a hydrogen fuel cell.

Most BEVs are charged at home, predominantly in single-family detached residences,[7] but drivers traveling long distances or who lack access to at-home residential charging (such as those living in multi-family dwellings) are also supported by publicly accessible charging stations found in workplaces, parking lots, and other commercial areas. Charging infrastructure is generally classified into three categories based on charging speed: Level 1 (a simple 120-volt household outlet), Level 2 (most public chargers), and direct-current fast charging (DCFC) (such as the Tesla Supercharger network). Typical DC fast chargers are capable of topping up a battery to 80% in 15-20 minutes, while Level 2 chargers typically provide 25 miles of range per hour of charging. To utilize these chargers, BEVs are equipped with one of three different connector types (or plugs): CHAdeMO, the Combined Charging System (CCS), and the North American Charging Standard (NACS). These standards are not interoperable. The California Energy Commission (CEC) has begun taking measures phasing out the use of CHAdeMO connectors, which are primarily found in Nissan Leafs. Virtually all other automakers and EV charging service providers utilize the CCS standard, with the notable exception of Tesla, which uses NACS.

Payment options at public EV charging stations vary widely between network operators; payment for Tesla drivers at Supercharger sites is done largely out of the driver's sight, as the vehicle communicates with the charger to automatically bill the card on file. For other charger networks, drivers may pay through a standard point-of-sale system attached to the kiosk, or by downloading and paying via a mobile app. Depending on the model, drivers may be eligible for free charging at select EV charging networks for the first few years of ownership. BMW offers its drivers unlimited DC fast charging on the Electrify America network for up to 3 years, while models like the best-selling Ford Mustang Mach-E offer 250 kWh of complimentary DC fast charging on the Electrify America network. At a price of $0.30 per kWh, that offer has a cash value of $75.

Replenishing an FCEV's onboard hydrogen supply is highly analogous to refueling a gas-powered car. Drivers simply attach the refueling pump to the vehicle's intake nozzle, and like gas, refueling takes approximately 3-5 minutes. The vast majority of hydrogen refueling stations are located at existing gas stations; only 5 of the 63 completed stations are standalone. There are two types of refueling pumps in

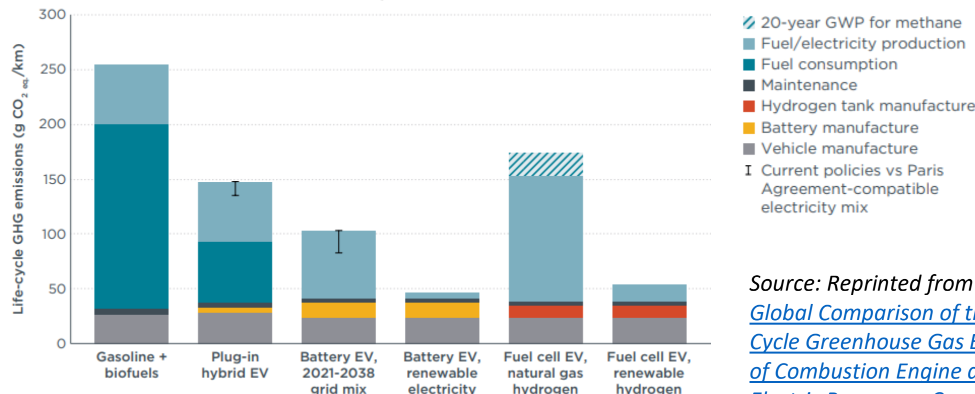
[6] Historically, California has considered plug-in hybrid vehicles within the zero-emission vehicle category. For purposes of this background, plug-in hybrid vehicles are excluded unless where otherwise noted.
[7] ICCT, Quantifying the Electric Vehicle Charging Infrastructure Gap Across U.S. Markets

use: the higher-pressure H70 and the older, lower-pressure H35. Because gases naturally move from higher to lower pressures, hydrogen refueling depends on the transfer of gaseous hydrogen from the highly pressurized station to the lower-pressure vehicle. Thus, while all consumer FCEVs are compatible with both H70 and H35, most modern FCEVs will only receive a partial refill when using an H35 pump. Payment is made through a point-of-sale system within the fuel dispensing kiosk, and for most drivers, paid using a pre-loaded, complementary fuel card provided by the automaker at the time of purchase or lease signing. This fuel card, valued at $15,000 of hydrogen fuel, is intended to defray the cost of fueling for the first three years of ownership.

Tailpipe vs. Lifecycle Emissions: How Clean are Clean Cars?

While both BEVs and FCEVs have no tailpipe emissions, the production of the vehicle, its components, and the electricity or hydrogen fuel used to power it all emit carbon, though at considerably lower intensities than gas-powered cars. The manufacture of BEVs and FCEVs is estimated to generate 50-70% more lifecycle GHG emissions than the production of a comparable gas-powered car, though that difference is more than made up for in the lower carbon intensity of electricity and hydrogen when compared to gasoline.[8] As illustrated in Figure 1 below,[9] the total lifecycle GHG emissions of BEVs and FCEVs are most sensitive to how the electricity and hydrogen fuel are produced, with both technologies capable of attaining one-fifth of the total carbon emission of gas-powered cars.

Figure 1. Life-cycle GHG emissions of passenger car segment gasoline ICEVs, PHEVs, BEVs, and FCEVs registered in the United States in 2021.



Source: Reprinted from ICCT, A Global Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars p. 28

Fossil fuels – primarily natural gas – produced 45.8% of the electricity in California's grid in 2022.[10] That number can jump to between 58-73% in the overnight hours[11] when most BEV owners charge their vehicles.[12] Thus, the full carbon footprint of a BEV is highly contingent upon the energy mix of the grid when the vehicle is charged. To address this, the Renewables Portfolio Standard requires increasing shares of California's retail electricity sales be served by renewable sources, reaching 90% by 2036 [13] and 100% by 2045.[14] Additional efforts by the CEC to optimize EV charging habits to accommodate grid demands may further allow for greater BEV utilization of daytime solar capacity.

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[8] MIT Energy Initiative, Insights into Future Mobility
[9] ICCT, A Global Comparison of the Life-Cycle GHG Emissions of Combustion Engine and Electric Passenger Cars
[10] CEC, 2022 Total System Electric Generation
[11] Supply trend data for 9 PM, August 14, 2023 and 4 AM, August 15, 2023 from the California Independent System Operator
[12] Charging infrastructure access and operation to reduce the grid impacts of deep electric vehicle adoption
[13] Clean Energy, Jobs, and Affordability Act of 2022 (SB 1020; Laird, Chapter 361, Statutes of 2022)
[14] SB 100 (De León, Chapter 312, Statutes of 2018)

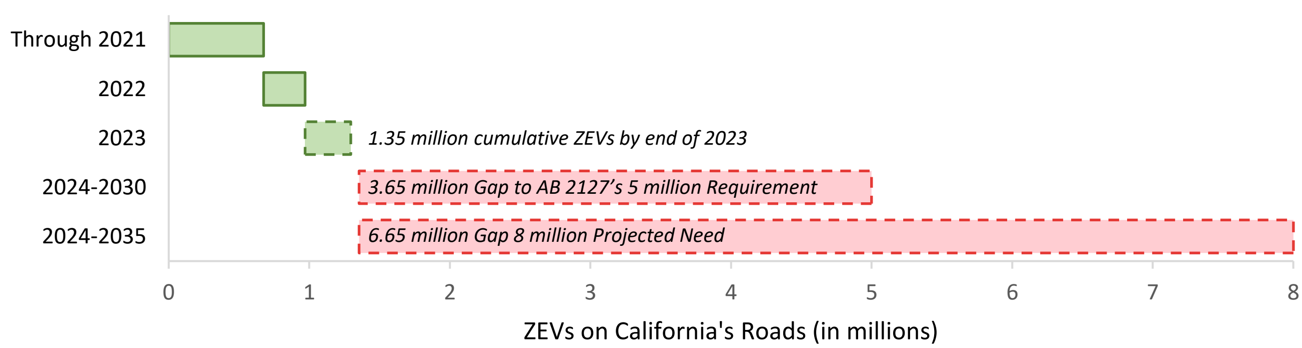
FCEVs are similarly only as clean as the carbon intensity of their hydrogen fuel. Hydrogen can be produced through several pathways, including renewably-powered electrolysis, which has little to no GHG emissions. The overwhelming majority of hydrogen produced today, however, is through steam methane reformation, which uses natural gas. These emissions can be mitigated with the use of carbon capture technologies, but hydrogen produced through alternative, more renewably sourced means is necessary to achieve more substantial carbon reductions. To that end, SB 1505 (Lowenthal, Chapter 877, Statutes of 2006) required at least 33% of the hydrogen fuel dispensed at publicly funded refueling stations be from renewable sources, with the CEC later increasing that mandate to 40%. Reporting data from Q1 of 2022 indicates California's hydrogen refueling network has exceeded those requirements, with a renewable content of 59-65%.[15] These requirements are complemented by two market-side initiatives from GO-Biz to create an economically sustainable renewable hydrogen market: the Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) and the recently announced Hydrogen Market Development Strategy.[16] Under ARCHES, California is seeking to leverage upwards of $1 billion in federal funding from the United States Department of Energy's Hydrogen Hubs program, which is expected to provide $8 billion total to catalyze a national economy of renewably produced hydrogen.

Thus, while neither BEVs nor FCEVs are powered through fully renewable means today, both are capable of achieving carbon reductions of 80% over comparable gas-powered cars with a renewable grid and renewably produced hydrogen. Parallel efforts by the State to achieve those targets are ongoing, though outside the scope of this hearing.

ZEV Sales Ahead of Schedule

Q2 of 2023 set a new record for ZEV sales, with ZEVs comprising 25.4% of all in-state vehicle sales,[17] well above the 2022 national average of 5.8%. This significant upswing allowed California to achieve its 1.5 million ZEV goal two years ahead of schedule, though those numbers include plug-in hybrid vehicles. Should sales continue at their current rate, 2023 may see 385,000 new BEVs and FCEVs added to the state's vehicle stock, a 30.5% increase year-over-year. Although strong, consumer adoption will still need to grow considerably if California is to attain its statutorily mandated goal of 5 million ZEVs by 2030, much less the projected need for 8 million ZEVs that same year.

Figure 2. Additional ZEVs Needed to Reach 5 million by 2030 and 8 million by 2035



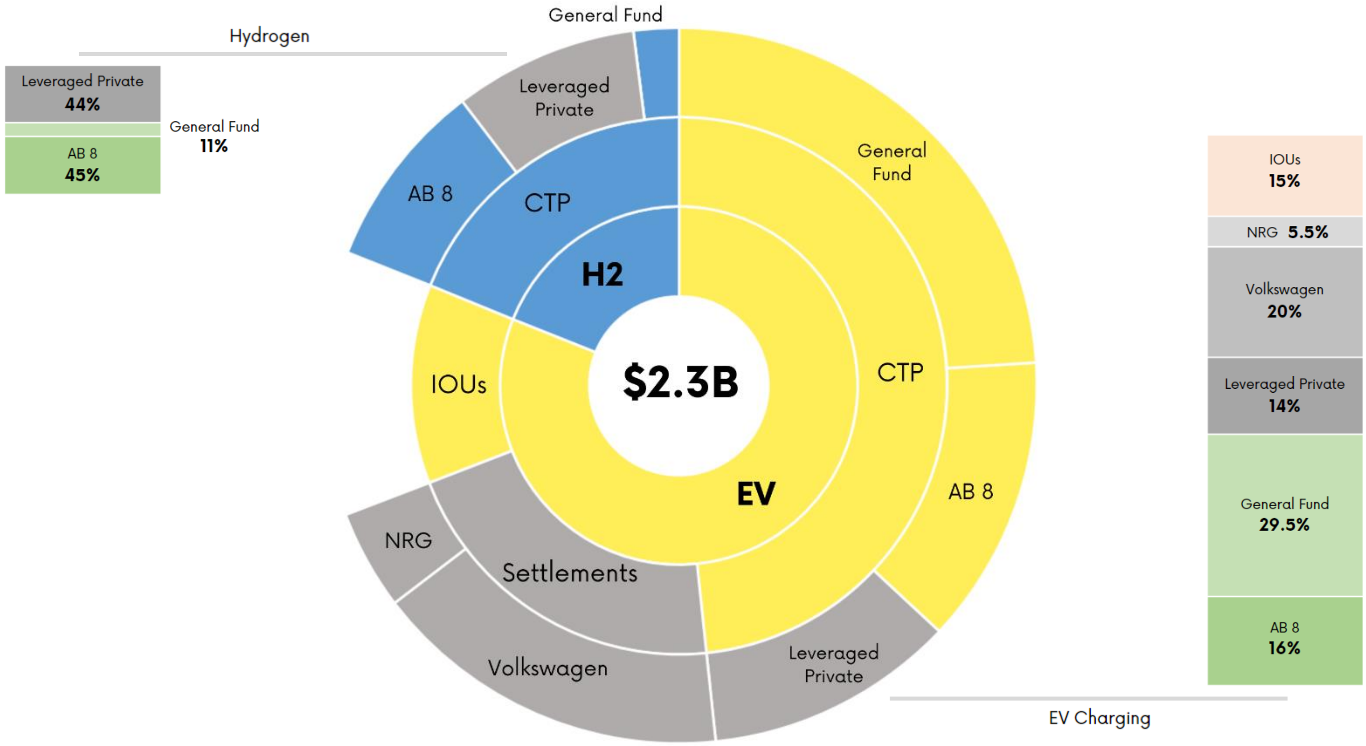
Excludes plug-in hybrids. Data Source: CEC

[15] CARB, 2022 Annual Hydrogen Evaluation Report p. 21
[16] Office of the Governor, Governor Newsom Announces New Strategy to Develop a Hydrogen Economy of the Future
[17] Office of the Governor, MILESTONE: 1 in 4 New Cars Sold in California Were Zero-Emission

Public Funding Sources for ZEV Infrastructure

State funding for ZEV infrastructure has historically drawn from three sources: ratepayer funds from investor-owned utilities, the Clean Transportation Program, and settlement funds with Volkswagen and NRG Energy. Additional federal funding has recently been made available under the National Electric Vehicle Infrastructure Formula Program (NEVI).

Figure 3. Approximate Sources of ZEV Infrastructure Funds Spent in California through 2023/2024



Data Sources: CARB, CEC, CPUC, GO-Biz, Volkswagen

Ratepayer Funds from Investor-Owned Utilities (IOUs): Estimated to have funded 29% of California's operational EV chargers, [18] the California Public Utilities Commission (CPUC) has authorized IOUs to invest $803 million of ratepayer funds in light-duty EV charging infrastructure, $275 million of which has already been expended. Initial pilot programs from 2016 resulted in the installation of 10,534 Level 2 chargers by the three major IOUs, and recently authorized programs are expected to produce an additional 42,600 EV chargers, primarily at multi-family dwellings and workplaces.[19]

Clean Transportation Program (CTP): Established by AB 118 (Núñez, Chapter 750, Statutes of 2007) and reauthorized through the end of 2023 under AB 8 (Perea, Chapter 401, Statutes of 2013), the CEC administered grant program is funded through a variety of vehicle registration and smog abatement fees, generating between $100 and $110 million annually. Further, the Budget Acts of 2021, 2022, and 2023 provided the program with an additional $550 million for EV charging and $20 million for hydrogen refueling stations. Having invested over $1.5 billion since its inception, the program represents roughly 40% of all EV charging investments and 50% of all hydrogen refueling investments in California.

[18] CEC, Zero-Emission Vehicle Infrastructure Plan p. 8
[19] CPUC, Charging Infrastructure Deployment and Incentives

Figure 4. Clean Transportation Program Funds for ZEV Infrastructure *(in millions)*					
Fund Origin	**ZEV Technology**	**Through FY 21-22**	**FY 22-23**	**FY 23-24**	**TOTAL**
AB 8	EV Charging	256	30	14	300
	Hydrogen	166 *+ 86**	20	10	196 *+ 282***
General Fund	EV Charging	535	15	0	550
	Hydrogen	27	0	20	47

Excludes medium- and heavy-duty. Only reflects investments in public or shared-private infrastructure.
** CEC staff indicate an additional $83 million is available under a previous grant solicitation for additional hydrogen refueling stations. If those funds are awarded, the state's investment could rise to $279 million under existing funds.*[20]
*** $282 million is the result of data from the December 2022 Zero-Emission Vehicle Infrastructure Plan* [21] *The December 2022 Joint Agency Staff Report on AB 8 uses the alternate figure of $279 million.*[22]

The Clean Transportation Program has provided $836 million for light-duty EV charging since 2013, with General Fund augmentations in FY 21-22 and FY 22-23 providing an additional $550 million. $189 million of the CTP's AB 8 funds have been disbursed under the California Electric Vehicle Infrastructure Project (CALeVIP) to complete 3,395 chargers, with an additional 8,216 in progress. The CEC reports CALeVIP has been oversubscribed, with more than $300 million in requested rebates. The program had a leveraged funding share of 60% for Level 2 chargers and 35% for DC fast chargers.[23]

Through March of 2023, the Clean Transportation Program has provided nearly $166 million for the development of 78 hydrogen refueling stations, 63 of which have opened for public use. The CEC reports that an additional $85.9 million is available to existing awardees under GFO-19-602, and $27 million under the recently awarded GFO-22-607, such that public investment under previously appropriated funds may reach $326 million. Collectively, these grant solicitations have succeeded in leveraging a private share of 70%, a reversal from the 70% public share in 2016.[24]

Settlement Agreements: Under the terms of its 2016 settlement with the State of California, Volkswagen paid $423 million to the Volkswagen Mitigation Trust Fund and committed to investing $800 million in EV charging infrastructure, public education, and workforce development over 10 years through its subsidiary, Electrify America. Through the end of Q2 2024, it is estimated VW will have spent roughly $363 million on public, light-duty EV charging infrastructure as part of its ZEV Investment Commitment, with an additional $10 million available through the CARB-managed Mitigation Trust Fund. Additionally, as part of its 2012 settlement agreement with the CPUC, NRG Energy agreed to invest $102.5 million in EV charging infrastructure under its subsidiary EVGo for the company's role in the 2000-2001 California Energy Crisis. Used to construct approximately 561 DC fast chargers across 250

[20] 2023–2024 Investment Plan Update for the Clean Transportation Program p. 58
[21] CEC, Zero-Emission Vehicle Infrastructure Plan p. 51
[22] Joint Agency Staff Report on AB 8: 2022 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California p. 3
[23] AB 2127 Electric Vehicle Charging Infrastructure Assessment p. 88
[24] Approaches to Assessing ZEV Funding Program Benefits

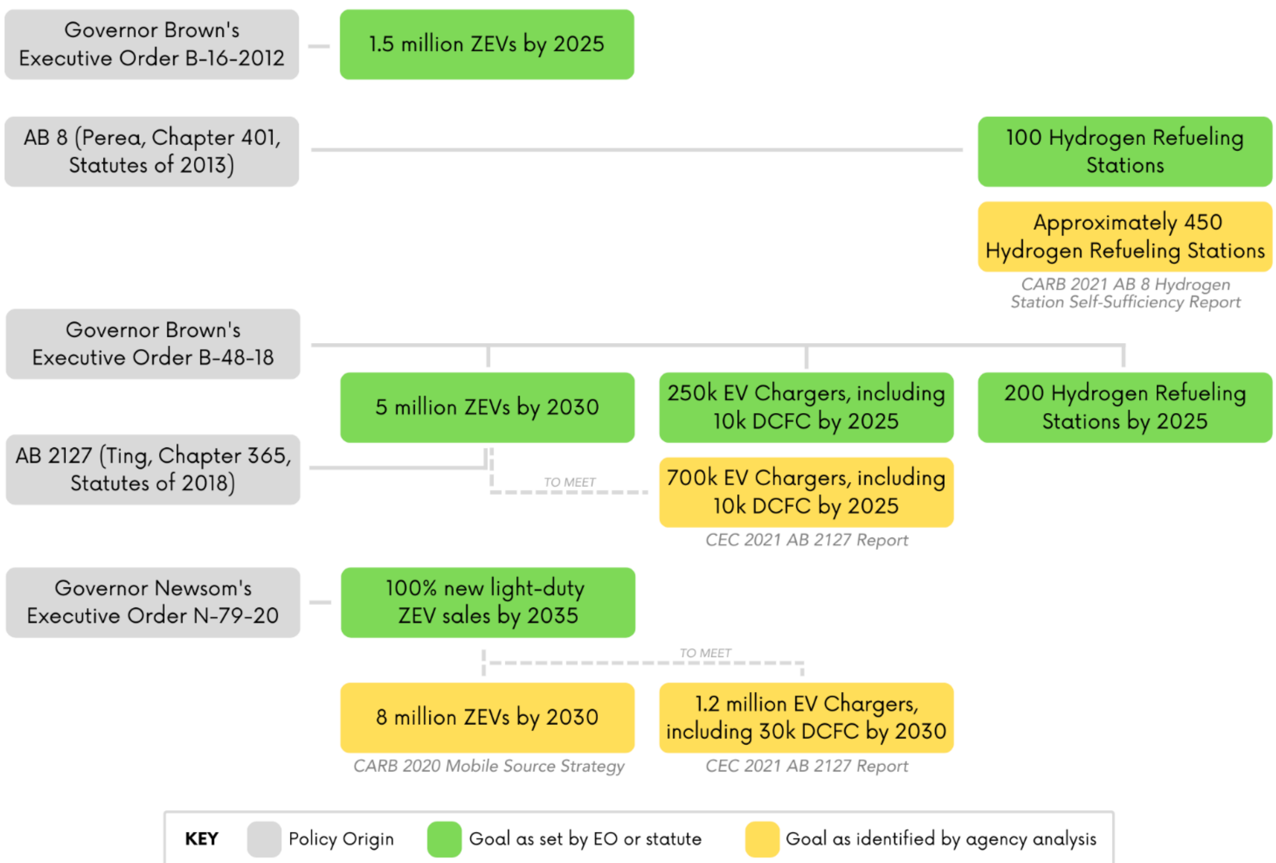
sites and nearly 6,900 make-ready stubs (or the wiring needed to support the later installation of an EV charger), all settlement funds have been expended as of January 2020.

The National Electric Vehicle Infrastructure Formula Program (NEVI): Established under the Infrastructure Investment and Jobs Act (IIJA), also referred to as the Bipartisan Infrastructure Law, California is expected to receive approximately $384 million in federal NEVI funding over the next 5 years, with $2.5 billion available in the form of competitive grants. Caltrans, in partnership with the CEC, expects to deploy 291 DC fast chargers across 28 sites adjacent to interstate highways.[25]

Where Are We Going? Outline of California's Various ZEV Infrastructure Goals

With over 29.5 million passenger vehicles – between one-quarter and one-third of the nation's total – transitioning California's light-duty vehicle fleet to zero-emissions has been a long and daunting endeavor. To catalyze the market development of zero-emission vehicles and their supporting charging and refueling infrastructure, the State has set several goals for ZEV deployment and ZEV infrastructure buildout, outlined in Figure 5.

Figure 5. California's Various ZEV and ZEV Infrastructure Deployment Goals



Source: Senate Select Committee on Transitioning to a Zero-Emission Energy Future

It's estimated 5 million ZEVs by 2030 will allow California to reduce its statewide GHG emissions to 40% below 1990 levels. In forecasting the number of ZEVs needed to meet Executive Order N-79-20, the *2020 Mobile Source Strategy* estimates California will require approximately 8 million

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[25] 2023–2024 Investment Plan Update for the Clean Transportation Program p. 9

ZEVs by 2030. Its primary scenario assumes a ZEV ratio of 90% BEVs and 10% FCEVs in 2030, scaling up to 75% and 25% respectively by 2045.[26] In modeling the state's projected EV charging infrastructure needs in 2030, the CEC utilizes an alternative ZEV ratio of 95% BEVs and 5% FCEVs.[27] Using either ratio, it is likely California will require supporting infrastructure for between 7.2 and 7.6 million BEVs and 400,000 and 800,000 FCEVs by 2030.

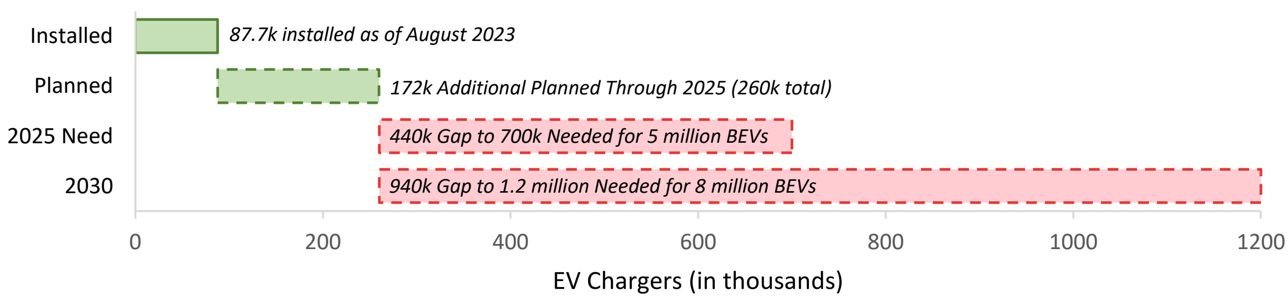
To support these vehicles, AB 2127 directed the CEC to estimate the future need for public EV charging stations. Although Executive Order B-48-18 set an EV charger deployment goal of 250,000 chargers to support 5 million ZEVs by 2030, the inaugural AB 2127 Electric Vehicle Charging Infrastructure Assessment projects California will require nearly three times as many – 700,000 – by 2030.[28] That need will grow to 1.2 million EV chargers by 2035 if the State is to achieve the 8 million ZEVs identified by CARB to meet Executive Order N-79-20.

Governor Schwarzenegger's 2004 Executive Order S-07-04 is the first policy directive declaring the State's intention to achieve "the rapid commercialization of hydrogen and fuel cell technologies." AB 8 (Perea, Chapter 401, Statutes of 2013) expanded California's commitment by dedicating $20 million or up to 20% of total Clean Transportation Program funds annually until the establishment of at least 100 hydrogen refueling stations. Governor Brown doubled the State's goal in 2018 to 200 stations as part of Executive Order B-48-18's target of 5 million ZEVs by 2030. This network would be able to support an estimated 274,000 FCEVs,[29] or 5% of a 5 million ZEV population in 2030, consistent with previously noted ratios, but is only two-thirds of the projected need to achieve Executive Order N-79-20.

Progress on EV Charger Deployment

As of August 2023, there are an estimated 87,700 public and shared private [30] EV chargers in California, 9,200 (or 10%) of which are DC fast chargers, with the remaining being Level 2. This represents just 35% of the 250,000 chargers required by 2025 under Executive Order B-48-18, 12.5% of the 700,000 chargers projected to support AB 2127's 5 million BEVs by 2030, and 7% of the 1.2 million chargers needed to facilitate a BEV population of between 7.2 to 7.6 million, as required to comply with Executive Order N-79-20.

Figure 6. EV Charger Needs for 5 million BEVs by 2025 and 8 million BEVs by 2035



Data Source: CEC

[26] 2020 Mobile Source Strategy p. 93
[27] AB 2127 Electric Vehicle Charging Infrastructure Assessment p. 31
[28] Ibid. p. ii
[29] 2023–2024 Investment Plan Update for the Clean Transportation Program p. 58
[30] A "shared private" charger is defined by the CEC to be those that are accessible only to authorized users, like residents, employees, or visitors. Examples include workplace chargers and chargers at multi-family dwellings.

As illustrated in Figure 6, the CEC anticipates meeting the goal of 250,000 EV chargers by 2025,[31] but this represents just one-third of the 700,000 needed. As previously noted, California is continuing to expend significant amounts of public funds in building out the state's EV charging network, but it remains unclear how much more additional State support will be needed to achieve the market trajectory toward 1.2 million EV chargers by 2030. The Select Committee may wish to consider whether additional research is needed to identify when public investment in EV charging infrastructure is no longer necessary to achieve our ZEV deployment goals.

Further, gaps continue to exist in consumer access within the existing network. As required under SB 1000 (Lara, Chapter 368, Statues of 2018), the CEC's 2022 Report found roughly one in five Californians lack sufficient access to a publicly accessible DC fast charger, defined as no more than a 10-minute drive.[32] This lack of sufficient or accessible EV charging infrastructure has been consistently ranked by prospective EV buyers as among the top 3 reasons for concern, alongside price and range.[33]

Moreover, the lack of interoperability between the various BEV charging connector standards presents significant challenges for consumer use and has the practical effect of reducing the network's real capacity. Recent developments have offered new opportunities for standardization around a single connector. NACS had been Tesla's proprietary charging standard until November 2022, when the company announced it was opening the standard for use by other automakers and EV charging service providers. That change, coupled with a deal reached with the Biden-Harris Administration to open Tesla's proprietary charging network to use by non-Tesla vehicles, has prompted other automakers to adopt the NACS standard in future EV models. Given California's existing public EV charging network almost exclusively uses CCS (with the exception of Tesla's Supercharger network), the Select Committee may wish to consider how the State and industry will facilitate the transition of the existing EV charging network from CCS to NACS.

Progress on Hydrogen Refueling Station Deployment

Despite a decade of investment, California remains woefully short of its statutorily obligated 100 stations. As of March 2023, 63 stations have attained open retail status, though as of August 15, 2023, only 58 are available for public use. This network supports the population of roughly 11,900 FCEVs registered in California,[34] though it has a theoretical fueling capacity of up to 51,000 FCEVs.[35] Barring additional delays, CARB estimates California's 100th station will open in 2024, thereby achieving the minimum number of stations required under AB 8.[36] In fact, the CEC anticipates existing funds will allow for the construction of up to 176 stations by 2027, with a nameplate capacity of up to 238,000 FCEVs.

Station development has matured considerably since the enactment of AB 8. Total station costs declined 60% from 2016 to 2020, and development time has shortened with each grant term. And despite

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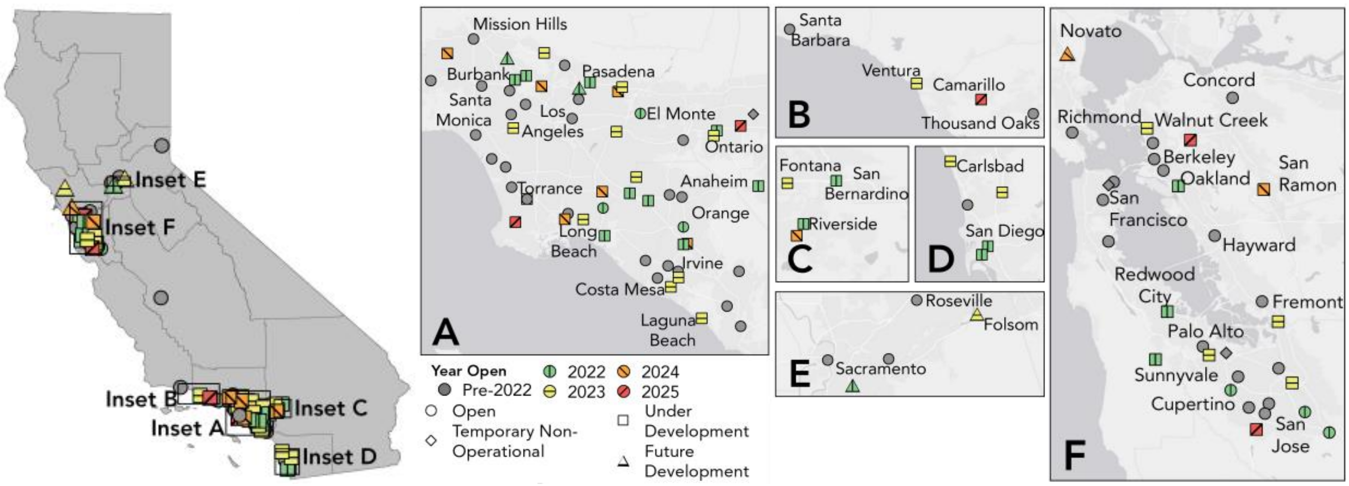
[31] 2023–2024 Investment Plan Update for the Clean Transportation Program p. 42
[32] SB 1000 Electric Vehicle Charging Infrastructure Deployment Assessment
[33] Autolist, Survey: Price, range and weak charging network are top reasons consumers avoid EVs
[34] Although 16,300 FCEVs have been sold in California through 2023, CEC and DMV data show only 11,900 remain registered.
[35] Joint Agency Staff Report on AB 8: 2022 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California p. 14
[36] CARB, 2022 Annual Evaluation of FCEV Deployment and Hydrogen Fuel Station Network Development p.xii

some commissioned stations reverting to temporary non-operational status, California's light-duty hydrogen refueling network is dispensing twice as much hydrogen today than before the pandemic.[37] Nevertheless, the pandemic resulted in significant delays to station development, such that the expected date for attaining 100 stations was pushed back to 2024 in CARB's latest analysis. Station developers have attributed delays to technical problems with equipment, energization taking longer than expected, slowed testing from hydrogen supply disruptions, and slower permitting by local authorities.[38] The Legislature previously addressed the issue of permitting delays with SB 1291 (Archuleta, Chapter 373, Statutes of 2022), which accelerated hydrogen station development by requiring administrative review of new stations by local permitting authorities. The Select Committee may wish to request an update from GO-Biz on implementation of SB 1291 and whether the measure has helped to reduce permitting times.

Figure 7. Map of Known Hydrogen Station Locations with Site-Specific Open Date and Development Status as of June 30, 2022



Source: Reprinted from [CARB 2022 Annual Evaluation of FCEV Deployment and Hydrogen Fuel Station Network Development](#) p. 27

As noted in Figure 8, there remains a 24 station gap between the 200 station goal outlined in Executive Order B-48-18 and the total number of planned station developments funded by the CEC. It is possible the $20 million General Fund augmentation provided by the Budget Act of 2023, in combination with other previously appropriated funds, may be enough to reach 200 stations.

In its 2022 analysis of automaker deployment plans, CARB estimated there may be 34,500 FCEVs on California's roads in 2025 and 65,600 by 2028. While the expected refueling network of 175 stations has a nameplate capacity sufficient to support these vehicles, vehicle sales and leases have historically trended with station buildout. As a result, new stations remain a critical factor in facilitating public adoption, which as previously noted, may be between 400,000 and 800,000 FCEVs by 2030, with that number projected to rise to roughly 2.5 million by 2035, when CARB estimates BEV penetration levels off and drivers of the remaining gas-powered vehicles adopt FCEVs due to comparable ownership experiences. Thus, without additional stations to fill in coverage gaps or to expand capacity within a given catchment area, real FCEV deployment is likely to fall significantly short of the projected need.

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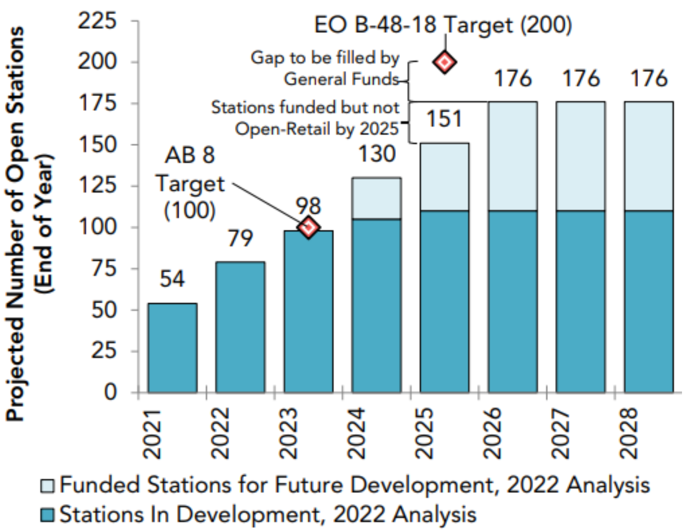
[37] Joint Agency Staff Report on AB 8: 2022 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California p. 15
[38] Ibid. p. 36

Figure 8. Projected Station Deployment Compared to AB 8 and EO B-48-18 Goals



Source: Reprinted from *CARB 2022 Annual Evaluation of FCEV Deployment and Hydrogen Fuel Station Network Development* *p. xiv*

In addition to the static requirement of 100 stations, AB 8 directed CARB to identify the point at which the market becomes profitable and public investment is no longer necessary. In its 2021 report,[39] CARB found a self-sufficient light-duty hydrogen market is achievable under most scenarios between 2027 and 2030 with an additional $300 million beyond previously allocated funds, or $253 million after accounting for the additional $47 million provided under recent budget acts. It's estimated this additional investment could result in a network of between 450 and 650 stations, which at a utilization rate of 30% may support between 210,000 and 331,000 FCEVs.[40] The Select Committee may wish to consider whether additional goals for hydrogen refueling infrastructure deployment may be warranted to support continued FCEV deployment at rates sufficient to meet the state's climate goals.

This One's a Dud. Reliability Issues within California's ZEV Infrastructure Network

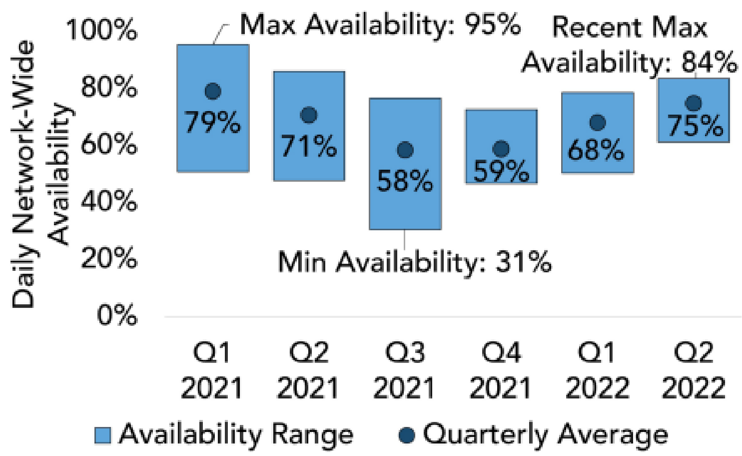
Despite tremendous public investment in putting EV chargers and hydrogen refueling pumps in the ground, both networks suffer from severe issues with reliability. A 2022 study from the University of California, Berkeley of every public DC fast charger in the San Francisco Bay Area found more than 28% to be non-functional, with outages persisting even after 8 days.[41] A 2023 survey by J.D. Power found customer satisfaction with public Level 2 chargers declined for the second straight year in a row, with 1 out of every 5 reporting they recently visited an EV charger only to leave without actually charging – either because of nonfunctional equipment or excessive wait times.[42] And respondents in a 2022 survey by Plug In America rated nonfunctional or broken equipment as one of BEV drivers' top challenges.[43] Commonly reported issues include connectors that don't charge, broken or nonresponsive touch screens, failed payment, or slower than expected charging.

FCEV drivers have similarly suffered from unreliable stations and equipment, with two system-wide disruptions so far in 2023. Beginning on December 23, 2022, the Sacramento region suffered from a month-long outage after all 3 hydrogen refueling stations went offline due to unrelated technical issues at each, stranding the region's more than 500 FCEV drivers. To mitigate the outage, automakers reportedly offered drivers complementary gas-powered rental cars while repairs were made. On August 13, 2023, three of California's four major hydrogen station operators announced an indefinite, major disruption to

[39] Hydrogen Station Network Self-Sufficiency Analysis per Assembly Bill 8
[40] The 2022 Joint Agency Staff Report on AB 8 found an average utilization of 22% in Q2 of 2022. At full capacity, this 450 and 650 stations may have a nameplate capacity of 700,000 and 1.1 million, respectively.
[41] UC Berkeley, Reliability of Open Public Electric Vehicle Direct Current Fast Chargers
[42] J.D. Power, Public Charging Issues May Short-Circuit EV Growth, J.D. Power Finds
[43] Plug In America, The Expanding EV Market Observations in a year of growth

the hydrogen supply chain would shut down nearly 20 stations in Southern California. An informal analysis of stations' weekday operational status over eight months by staff for the Chair found California's hydrogen refueling network had a system-wide uptime of just 68%, with 7 stations experiencing less than 25% uptime for at least one refueling nozzle.[44] Figure 9 displays similar historical data from CARB. In diagnosing the issue, the National Renewable Energy Laboratory found 61% of unscheduled maintenance events were due to equipment failures. Dispenser failure events were the most common at about 50%, followed by compressor failures.[45]

Figure 9. SOSS Station Availability Data



Source: Reprinted from [CARB 2022 Annual Evaluation of FCEV Deployment and Hydrogen Fuel Station Network Development](#) p. 46

Unreliability presents a serious risk to mass ZEV adoption. Nonoperational chargers and pumps reduce the real capacity of our networks, and more importantly, frustrate drivers who would not experience the same issues driving a gas-powered car. Compared to the ubiquity of the current gasoline network, which has more than twice the number of pumps and no significant downtime, it is no surprise that 18% of early BEV adopters have switched back to a traditional gas-powered car, most often citing their mistrust in public EV chargers and lack of at-home charging.[46]

The Legislature has taken steps to address issues around EV charger reliability. AB 2061 (Ting, Chapter 345, Statutes of 2022), directed the CEC to begin devising uniform standards for what constitutes EV charger uptime and to collect data on publicly funded EV chargers. By establishing an industry-wide metric for defining uptime, California may have better insight into the severity and causes of unreliability. A draft of the proposed regulation is expected from the CEC within the coming weeks. The Select Committee may wish to consider whether additional state-level policies are needed to improve EV charger and hydrogen refueling station reliability, and if so, in what form those policies might take. Potential solutions worth additional research include requiring in-person site checks to ensure operability, investing in equipment that allows for remote identification of nonoperational or vandalized stations, improved data-sharing to allow consumers to see in advance whether certain sites are operational, and

[44] Reflects weekday data from January 5, 2023 to August 15, 2023. During this period, staff recorded each station's operational status between the hours of 9 and 10 AM, as reported by the Hydrogen Fuel Cell Partnership's Station Operational Status System.
[45] Next Generation Hydrogen Station Composite Data Products: Retail Stations
[46] Understanding discontinuance among California's electric vehicle owners

roaming agreements between EV charging service providers so as to increase network integration and reduce consumer friction.

Charging Forward

California will require ubiquitous, reliable, and accessible charging and refueling networks if it is to succeed in achieving carbon neutrality by 2045. Attainment of the previously outlined ZEV deployment goals alone may not be sufficient to have a completely light-duty ZEV stock by 2045. Further, unreliable infrastructure and poor customer experience may begin to adversely affect the rate of ZEV adoption. Resolving the systemic issues of unreliability and providing certainty for future investment will be necessary to gaining meaningful progress toward a cleaner, more sustainable transportation sector.

Acronyms and Abbreviations

Acronym/Abbreviation	**Original Term**
AB	Assembly Bill
ARCHES	Alliance for Renewable Clean Hydrogen Energy Systems
BEV	Battery-electric vehicle
CALeVIP	California Electric Vehicle Infrastructure Project
CARB	California Air Resources Board
CCS	Combined Charging System
CEC	California Energy Commission
CTP	Clean Transportation Program
CPUC	California Public Utilities Commission
DCFC	Direct current fast charging
EV	Electric vehicle
FCEV	Fuel cell electric vehicle
GO-Biz	Governor's Office of Business and Economic Development
GHG	Greenhouse gas emission
H2	Hydrogen
ICCT	International Council on Clean Transportation
IIJA	Infrastructure Investment and Jobs Act
kWh	Kilowatt hour
NACS	North American Charging Standard
NEVI	National Electric Vehicle Infrastructure Formula Program
SB	Senate Bill
VW	Volkswagen
ZEV	Zero-Emission Vehicle