California State Assembly

UTILITIES AND ENERGY

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JOINT HEARING WITH SELECT COMMITTEE ON ELECTRIC VEHICLES AND CHARGING INFRASTRUCUTRE

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INFORMATIONAL HEARING

Charging Forward: Identifying Roadblocks to Electric Vehicle Infrastructure Deployment Across California

California has set ambitious policies to decarbonize the transportation sector—which is currently the largest source of greenhouse gas (GHG) emissions in the state—through legislation,[1] regulatory actions,[2,3] and executive orders. These policies establish, among other targets, a goal that 100% of new passenger vehicle sales will be zero-emission vehicles (ZEVs)[4] by 2035[5] and a goal that 1.5 million ZEVs will be purchased in California by 2025.[6] These actions have signaled to ZEV manufacturers that there will be a robust ZEV market in California and encouraged them to rapidly increase production. This elevated production has

[1] CEC; "Past Investment Plans for the Clean Transportation Program"; https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program/clean-transportation-program-investment-0
[2] California Air Resources Board (CARB); "Advanced Clean Cars II"; https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii
[3] CARB; "Advanced Clean Fleets"; https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets
[4] ZEVs include battery electric vehicles (BEVs), plug-in hybrid electric vehicles, and hydrogen fuel cell electric vehicles (FCEVs). EVs will refer exclusively to battery electric vehicles throughout this document.
[5] Executive Order N-79-20
[6] Executive Order B-16-12

been met with rising consumer demand, as was recently reflected by the state surpassing its goal of 1.5 million ZEVs purchased a full two years ahead of the target date.[7]

The rapid deployment of ZEVs, and electric vehicles (EVs) specifically, requires the simultaneous and complementary development of support infrastructure to ensure that EV users are able to reliably and affordably charge their vehicles throughout the state. Coordinating this level of infrastructure development is a significant undertaking and will require cooperation across levels of government, utilities, and the private sector.

The purpose of this hearing is to identify how to efficiently and equitably build out the infrastructure required to charge EVs. If unaddressed, the lack of focus on the needed electric grid infrastructure may delay or potentially discourage the adoption of the EVs themselves in the state.

In order to examine potential challenges, we will follow the electricity upstream from (1) the EV chargers (specifically how they are funded and deployed); to (2) the electric distribution and transmission infrastructure; to (3) the electric generators (specifically how much and of what type is necessary to meet anticipated EV demand). To ensure the speed and sustainability of the EV rollout, as envisioned by California's emissions-reduction goals, each section of this system must keep pace with EV adoption.

Findings

- *There are a variety of funding sources for EV charger installation, as well as a robust charger development industry, but many of those funding streams come with questions: the degree of impact and fairness on electricity ratepayers, the market stability of year-to-year funding amid budget cycles, or whether there will be sufficient focus on deploying EV charging infrastructure equitably throughout the state.*

- *Rapidly deploying EV chargers will require upgrades to the electrical grid to serve the additional demand, and those infrastructure investments must be appropriately resourced and undertaken with urgency to ensure that EV charging deployment is not constrained by insufficient grid capacity.*

- *Informed modelling of future energy demand related to EV charging, alongside coordinated communication and transparency among agencies, utilities, non-utility companies, and stakeholders, will be instrumental in minimizing delays.*

[7] Office of Governor Gavin Newsom; "California Surpasses 1.5 Million ZEVs Goal Two Years Ahead of Schedule"; April 2023; https://www.gov.ca.gov/2023/04/21/california-surpasses-1-5-million-zevs-goal-two-years-ahead-of-schedule/

The Chargers.

Electric vehicles chargers are generally grouped into three categories: Level 1, Level 2, and direct current fast chargers (DCFCs), each with different capabilities, ideal use cases, and implications for the electrical grid.[8] Level 1 chargers take the longest of the three types to fully charge an EV (providing an estimated 3.5-6.5 miles of range per hour of charging), and are used primarily for overnight charging or as a backup option. Level 2 chargers are faster than Level 1, and depending on their power output (typically ranging from 3-19 kilowatts (kW)) can fully charge a 300-mile range battery in 6-8 hours. DCFCs, as the name suggests, are the fastest EV chargers, and can currently provide approximately 540 miles of range per hour of charging, meaning that a 300-mile range battery could be charged to near capacity within 30 minutes.[9]

In California, the majority of public chargers are installed by private companies, with much of that installation cost supported by state grants or subsidized by electric ratepayers.[10] Installation for a standard Level 2 charger typically costs between $7,000 to $11,000, while DCFCs each cost between $100,000 and $120,000 to install.[11] These costs contemplate not only the EV charger itself, but the likely infrastructure needed to energize the charger, inclusive of design, trenching, and electric grid upgrades, among other costs. As an example, a report on Pacific Gas & Electric's (PG&E) EV Charge Network program sets the cost of a Level 2 charger alone at $2,413 each, but the total for the charger and installation[12] at $17,504 per charger.[13]

This difference can be attributed to increased grid capacity requirements with the incorporation of additional load from the EV charger. The more chargers being installed in close proximity and the greater the individual charger power output, the higher the likelihood that upgrades of the utility-side infrastructure will be necessary to serve the additional load arising from the EV charger. The scale of the grid infrastructure upgrades will reflect the amount of additional load. For example, the installation of a handful of Level 2 residential chargers in a neighborhood may require a secondary distribution upgrade at the cost of between $5,000-100,000. A 5 megawatt (MW) DCFC site, however, is highly likely to trigger a secondary distribution upgrade ($150,000), and may additionally require a primary distribution ($6 million) or a substation upgrade ($1-9 million).[14] The results of a 2020 study by the California Electric Transportation Coalition (CalETC) estimate that between 3.8 million and 6 million chargers will be needed to accommodate 5 million EVs in California,

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[8] SDG&E; "Electric Vehicle Charging"; https://www.sdge.com/residential/electric-vehicles/power-your-drive/public-charging

[9] CALeVIP; "EV Charging Basics"; https://calevip.org/electric-vehicle-charging-101

[10] CalMatters; "Can California's power grid handle a 15-fold increase in electric cars?" January 2023; https://calmatters.org/environment/2023/01/california-electric-cars-grid/

[11] CalMatters; "Can California's power grid handle a 15-fold increase in electric cars?" January 2023; https://calmatters.org/environment/2023/01/california-electric-cars-grid/

[12] Average Cost per Charger metric includes Design/Permits, Materials, To-the-Meter construction, Behind-the-Meter construction, Charger where applicable (EV Charge Sponsor sites), and Rebates where applicable (EV Charge Owner sites).

[13] PG&E; "EV Charge Network Quarterly Report"; Report Period: January 1, 2022 – March 31, 2022.

[14] CalETC; "The Infrastructure Needs and Costs for 5 Million Light-Duty Electric Vehicles in California by 2030"; June 2020.

amounting to a cost of $5.5-25.4 billion for customer-side and utility-side infrastructure.[15] The large majority of these chargers are forecasted to be installed in single-family residences and would be suitable for Level 1 or Level 2 chargers. Should DCFCs, instead, be the market direction in the coming years, these cost projections are likely to grow significantly.

Progress Toward California's Charger Deployment Goals. To support rapid EV adoption, the governor set a goal in 2018 of having 250,000 chargers, including 10,000 DCFCs, operating in California by 2025.[16] California currently has more than 88,000 public and shared private EV chargers,[17] classified as either Level 1 (560), Level 2 (78,500), or DCFCs (9,200), distributed throughout the state. The chargers are clustered most densely around large metropolitan areas: Los Angeles County has the greatest number of DCFCs with more than 1,800, while four counties (Alpine, Lake, Plumas, and Sierra) have zero DCFCs.[18] The California Energy Commission (CEC) projects that, by 2030, nearly 1.2 million public and shared private chargers will be needed to support the charging needs of the 7.5 million passenger EVs projected to populate California's roads.[19] An additional 157,000 chargers will be needed to support the 180,000 medium- and heavy-duty EVs anticipated for 2030.[20] California's overall EV charger need by 2030, counting public chargers, shared private chargers, and those required to serve medium- and heavy-duty EVs, will total approximately 1.35 million. Given current installation of roughly 88,260 chargers, nearly 1.27 million additional chargers will be needed within the next decade, a rapid buildout requiring operational efficiency at all levels of electric grid development to ensure success.

National Context. A nationwide study by the National Renewable Energy Laboratory (NREL) found that a national network of 26–35 million EV chargers would be necessary to support a fleet of 30–42 million EVs. For a mid-adoption scenario of 33 million EVs, a national charging network of 28 million chargers was projected to be sufficient.[21] These projections were modeled by charger type and location to reflect EV drivers' preferences for convenient and cost-effective charging, primarily at home, supplemented by a network of high-power public chargers. The study projected that 1.2 million public chargers—including 182,000 DCFCs located along highways or in communities and 1 million Level 2 chargers in publicly accessible locations (near neighborhoods, office buildings, and shopping centers)—would be required alongside 26.8 million Level 1 and Level 2 chargers in privately accessible

[15] CalETC; "The Infrastructure Needs and Costs for 5 Million Light-Duty Electric Vehicles in California by 2030"; June 2020.
[16] Executive Order B-48-18
[17] Public chargers are located at parking spaces designated to be available to and accessible by the public, while shared private chargers are located at parking spaces designated to be available to employees, tenants, visitors, and residents. Level 1 chargers are not included in these metrics.
[18] CEC; "Electric Vehicle Chargers in California"; Accessed on 8/8/23; https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/electric-vehicle
[19] CEC; "Report Shows California Needs 1.2 Million Electric Vehicle Chargers by 2030"; June 2021; https://www.energy.ca.gov/news/2021-06/report-shows-california-needs-12-million-electric-vehicle-chargers-2030
[20] CEC; "Electric Vehicle Charging Infrastructure Assessment - AB 2127"; July 2021.
[21] National Renewable Energy Laboratory; "The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure"; June 2023.

locations (single-family homes, multifamily housing, and workplaces). [22] These national estimates reflect the scale of buildout that is being planned within California to ensure adequate EV charger deployment.

How Are Chargers Funded and Deployed? Installing EV chargers and making the requisite grid upgrades to support the additional load is expensive. There are a few funding sources which are primarily responsible for covering those costs in California: utilities, which pass on those cost to ratepayers; the CEC, which draws funding from state budget appropriations as well as vehicle and vessel registration, vehicle identification plates, and smog-abatement fees;[23] and the Volkswagen settlement administered by the California Air Resources Board (CARB).[24] An influx of federal funding from the Infrastructure Investment and Jobs Act (IIJA), which began distributing funding in the 2022 fiscal year,[25] and the Inflation Reduction Act (IRA) will supplement existing sources to support EV charger deployment across California.

Ratepayers. The potential cost impact on ratepayers from EV charging buildout is uncertain. A study by Boston Consulting Group analyzed the cost impact of EV charging on utility ratepayers, examining the upward cost pressures of needed investments in transmission and distribution infrastructure as well as new generation resources needed to provide power, alongside the potential downward cost pressure arising from EV charging increasing customer usage and thus producing additional revenue for the utility. The study concluded that a model utility would need to invest between $1,700 and $5,800 in grid upgrades for each EV operating in their territory through 2030, depending on charging patterns, which would be passed on to ratepayers. The study found the cost of these investments outweighed the additional utility revenue from EV charging and, in most of the scenarios modeled, exerted upward pressure (i.e. *increasing* costs) on electricity rates.[26]

However, a recent analysis from the Natural Resources Defense Council of the EV-related costs and revenues in PG&E, Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) service territories from 2012-2021 found that EV drivers paid approximately $1.7 billion more than the associated infrastructure costs. The study concluded that, as the revenue arising from EV charging-electricity usage exceeded the cost of related infrastructure investment, the expansion of EV charging in a utility's territory would have a net effect of *decreasing* rates across the customer base.[27] How universal this finding might

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[22] National Renewable Energy Laboratory; "The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure"; June 2023.
[23] CEC; "2021–2023 Investment Plan Update for the Clean Transportation Program"; December 2021.
[24] CARB; "California to Receive $153M in Final Settlement with Volkswagen"; July 2017; https://ww2.arb.ca.gov/news/california-receive-153m-final-settlement-volkswagen
[25] Federal Highway Administration; "5-year National Electric Vehicle Infrastructure Funding by State"; September 2022; https://www.fhwa.dot.gov/bipartisan-infrastructure-law/evs_5year_nevi_funding_by_state.cfm
[26] Boston Consulting Group; "The Costs of Revving Up the Grid for Electric Vehicles"; December 2019; https://www.bcg.com/publications/2019/costs-revving-up-the-grid-for-electric-vehicles
[27] Natural Resources Defense Council; "Electric Vehicles Are Driving Rates Down"; December 2022; https://www.nrdc.org/bio/miles-muller/electric-vehicles-are-driving-rates-down

prove as more EVs enter the market and more chargers demand more electrical grid upgrades, especially in traditionally underserved areas, remains to be determined.

Given the divergent conclusions from these two studies, more analysis is needed to understand the long-term impacts on electric ratepayers from these EV investments to ensure they occur as equitably as possible. In California, electricity rates are less progressive than the state's tax structure.[28] For that reason, any increase in electricity rates—particularly to facilitate the adoption of vehicles which have, to date, seen more widespread adoption in more affluent and less racially diverse communities[29]—raises equity concerns with ratepayer-funded charger deployment.

The ratepayer-funded buildout of EV chargers in California is largely directed by the California Public Utilities Commission (CPUC), except for investments made in publicly owned utility (POU) territory such as Los Angeles Department of Water and Power, which currently supports over 1,500 public charging stations.[30] The CPUC has approved programs by the large investor-owned utilities (IOUs; PG&E, SDG&E, and SCE) to fund and facilitate charger installation in IOU territories, including PG&E's EV Charge Network, SDG&E's Power Your Drive, and SCE's Charge Ready program.[31] PG&E's EV Charge Network program has facilitated the installation of more than 4,800 chargers since its inception.[32] Under the program, PG&E installs and maintains make-ready infrastructure (electrical equipment necessary to install and operate EV charging stations) and provides rebates to charging site hosts to cover between 25% and 100% the cost of the charger and installation, depending on whether the charger is located in a disadvantaged community.[33] The program also provides an option in which PG&E may, upon request by a site host, install, own, and maintain up to 35% of the EV charging stations originally forecasted to be deployed at a site, though this option is limited to multi-unit dwellings or workplaces located in disadvantaged communities. Similarly, SDG&E operates a suite of charging infrastructure programs, collectively named "Power Your Drive," to facilitate charger installation in apartments, schools, parks, and workplaces, as well as charging depots for fleets of medium- and heavy-duty EVs.[34]

POUs have also launched initiatives to increase EV charging availability in their territories, including the Sacramento Municipal Utility District's offer of a $1,000 incentive toward residential EV charger installation[35] and a variety of incentives for publically available and

[28] Borenstein *et al.*; "Designing Electricity Rates for An Equitable Energy Transition"; February 2021.
[29] CalMatters; "Who buys electric cars in California — and who doesn't?"; March 2023; https://calmatters.org/environment/2023/03/california-electric-cars-demographics/
[30] Energy5; "LADWP Charging Stations: A Comprehensive Guide"; March 2023; https://energy5.com/ladwp-charging-stations-a-comprehensive-guide
[31] CPUC; "Key CPUC Transportation Electrification Decisions and Resolutions"; https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/key-cpuc-te-decisions-and-resolutions
[32] PG&E; "EV Charge Network Quarterly Report"; Report Period: January 1, 2022 – March 31, 2022.
[33] D. 16-12-065
[34] SDG&E; "SDG&E Clean Transportation Initiatives"; https://www.sdge.com/residential/electric-vehicles/electrification-projects-overview
[35] SMUD; "Residential Electric Vehicles"; https://www.smud.org/en/Going-Green/Electric-Vehicles/Residential

commercial use EVs charging equipment.[36] Community choice aggregators (CCAs) have also developed programs to facilitate EV charger deployment, including Peninsula Clean Energy's (PCE) EV Ready program.[37] The EV Ready program provides incentives for EV charger installation with a focus on "right-sizing" (i.e., installing a charger with the power to satisfy the needs of the customer but not an excessively powerful, and costly, charger). This strategy of PCE's likely stems from their operational control of the charger investment, but not the associated grid infrastructure upgrades that may be needed with larger chargers; to connect those, they would need to coordinate closely with their incumbent IOU.

CEC. The CEC has taken a leading role in funding EV charger deployment in California. In December 2022, the CEC approved an investment plan which included $900 million for light-duty EV charging infrastructure, and $1.7 billion for medium- and heavy-duty ZEV infrastructure over the next four years.[38] The plan is estimated to create 90,000 new EV chargers across the state. While a significant and welcome investment, this plan is still far short of the nearly 1.27 million additional EV chargers projected to be needed by 2030 to meet our transportation electrification goals. [39]

The CEC's California Electric Vehicle Infrastructure Project (CALeVIP), implemented by the Center for Sustainable Energy, provides rebates for up to 75% of installation costs for publically available EV chargers as well as relevant planning and technical assistance.[40] CALeVIP reserves certain tranches of funding for disadvantaged community (DAC) or low-income community (LIC) census tracts, as well as other specific parts of the state. CALeVIP has facilitated the installation of more than 1,300 EV chargers to date and, in September 2023, $38 million in total rebate funding, allocated by the CEC, will be available through CALeVIP 2.0 for the installation of DCFCs in specified counties in Northern California and coastal Southern California.[41,42] The funding covers up to 50% of the project cost and prioritizes projects deemed "shovel-ready" to maximize the pace of charger installation. These types of funding programs allow for the prioritization of equity by community income level, disadvantaged community classification, tribal status, or charger location concentration. These actions seek to overcome barriers which have hindered EV adoption in

[36] SMUD; "SMUD Commercial Electric Vehicle Procedures and Rebates Handbook"; May 2023.
[37] PCE; "EV Ready Program"; https://www.peninsulacleanenergy.com/ev-ready/
[38] CEC; "CEC Approves $2.9 Billion Investment for Zero-Emission Transportation Infrastructure"; December 2022; https://www.energy.ca.gov/news/2022-12/cec-approves-29-billion-investment-zero-emission-transportation-infrastructure
[39] CEC; "Report Shows California Needs 1.2 Million Electric Vehicle Chargers by 2030"; June 2021; https://www.energy.ca.gov/news/2021-06/report-shows-california-needs-12-million-electric-vehicle-chargers-2030
[40] CALeVIP; "EV Charging for All"; https://calevip.org/
[41] CALeVIP; "About CALeVIP"; https://calevip.org/about-calevip
[42] CALeVIP; "Golden State Priority Project"; https://calevip.org/incentive-project/gspp-incentive-north-south

underserved communities throughout the state, including limited access to public chargers and lower availability of at-home charging for renters.[43,44,45]

Federal. Two landmark pieces of federal legislation passed during the Biden administration, the Infrastructure Investment and Jobs Act (IIJA) in 2021 and the Inflation Reduction Act (IRA) in 2022, are poised to contribute significantly to the development of EV charging infrastructure in California.

The IIJA established the National Electric Vehicle Infrastructure (NEVI) Formula Program and the Charging and Fueling Infrastructure (CFI) Discretionary Grant Program. The NEVI Formula Program will distribute $5 billion in funding to states to strategically deploy EV charging infrastructure to create an affordable, reliable, and equitable network of chargers throughout the U.S.[46] California is expected to receive $384 million in federal funding over five years through the NEVI Program.[47] The federal NEVI funding comes with requirements on state recipients including technical specifications for EV chargers, customer-facing operational standards, and standardized practices for installation, operation, and maintenance of charging stations.[48]

California's NEVI Deployment Plan, which was developed jointly between the CEC and the California Department of Transportation, and received federal approval in 2022, focuses on bringing charging infrastructure to communities of concern and rural areas throughout the state.[49] The plan outlines an approach that focuses on federally-designated "Alternative Fuel Corridors" and identifies gaps in charging coverage along those corridors. The corridors are clustered around major population centers, including Los Angeles and San Francisco, but are also distributed throughout more rural or isolated areas of the state, including corridors from Redding to Eureka and Indio to Calexico. The plan divides those coverage gaps into segments and allows grant funding applicants to apply to install charging stations on a segment of those gaps.[50] According to the CEC, this funding structure will contribute to the construction of a 6,600-mile statewide charging network and the deployment of 1.2 million

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[43] POWERGRID; "New programs underway to accelerate EV adoption in underserved CA communities"; July 2023; https://www.power-grid.com/der-grid-edge/electric-vehicles/new-programs-underway-to-accelerate-ev-adoption-in-underserved-ca-communities/
[44] The Greenlining Institute; "Achieving Electrification Equitably: Principles for Building EV Charging Infrastructure For Everyone"; October 2022; https://greenlining.org/2022/achieving-electrification-equitably/
[45] CalMatters; "Will California's push on electric vehicles reduce inequality — or deepen it?"; August 2023; https://calmatters.org/newsletters/whatmatters/2023/08/california-electric-vehicles/
[46] US Department of Transportation; "National Electric Vehicle Infrastructure Standards and Requirements"; February 2023; https://www.federalregister.gov/documents/2023/02/28/2023-03500/national-electric-vehicle-infrastructure-standards-and-requirements
[47] CEC; "National Electric Vehicle Infrastructure Program (NEVI)"; https://www.energy.ca.gov/programs-and-topics/programs/national-electric-vehicle-infrastructure-program-nevi
[48] US Department of Transportation; "National Electric Vehicle Infrastructure Standards and Requirements"; February 2023; https://www.federalregister.gov/documents/2023/02/28/2023-03500/national-electric-vehicle-infrastructure-standards-and-requirements
[49] US Joint Office of Energy and Transportation; "State Plans for Electric Vehicle Charging"; https://driveelectric.gov/state-plans/
[50] CleanTechnica; "What Are States Planning To Do With Federal EV Charging Funds?"; August 2022; https://cleantechnica.com/2022/08/04/what-are-states-planning-to-do-with-federal-ev-charging-funds/

chargers by 2030, though California's NEVI deployment plan does not specify how many of the 1.2 million chargers will be installed using the federal funding.[51,52]

California is also pursuing funding under the CFI, which received $2.5 billion over five years from the IIJA to fund a federal competitive grant program to deploy publicly accessible EV charging.[53,54] Finally, the IRA extended the federal tax credit on EV charging equipment through 2032. The tax credit remains at 30%, up to $1,000, for residential uses. For commercial uses, the tax credit is 30% per charger,[55] up to $100,000, to cover infrastructure upgrades and installation, representing a substantial increase from the previous cap of $30,000.[56]

The Electrical Grid.

The CEC's assessments of the infrastructure needed to support the ZEV transition acknowledge that ZEV deployment will increase electric load.[57] Medium- and heavy-duty EVs have greater load impacts than light-duty EVs, as their large batteries currently require extended periods of time and substantial power output (i.e., the amount of electricity drawn at any given time) to charge. There is generally a tradeoff for EV chargers in which the more rapidly the charger is able to charge an EV, the greater the power output must be, and the more likely that electrical grid upgrades will be needed to serve the chargers. The ability for DCFCs to transfer large amounts of electricity quickly will be critical to effectively electrifying transportation, particularly heavy-duty trucking and other use cases in which large vehicles are expected to function with minimal downtime. However, DCFCs can currently be rated up to 360 kW,[58] meaning a much higher electrical capacity is needed to power them than Level 2 chargers, which are currently rated between 3-19 kW. For context, the electrical load from a single depot with 27 DCFCs—not an outrageous quantity if contemplating interstate traffic needs—would reach approximately 9.7 MW, exceeding the 9.5 MW peak electrical usage of the Empire State Building.[59] A recent report, focused on New York State, suggests that certain high-traffic charging sites may be expected to near 40

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[51] CalMatters; "Can California's power grid handle a 15-fold increase in electric cars?" January 2023; https://calmatters.org/environment/2023/01/california-electric-cars-grid/

[52] Caltrans and CEC; "California's Deployment Plan for the National Electric Vehicle Infrastructure Program"; August 2022.

[53] Caltrans and CEC; "California's Deployment Plan for the National Electric Vehicle Infrastructure Program"; August 2022.

[54] The White House; "The Biden-Harris Electric Vehicle Charging Action Plan"; December 2021; https://www.whitehouse.gov/briefing-room/statements-releases/2021/12/13/fact-sheet-the-biden-harris-electric-vehicle-charging-action-plan/

[55] The 30% tax credit is contingent on requirements for prevailing wage and apprenticeship programs and, if those requirements are not met, the tax credit drops to 6%. Pacific Energy Concepts; "What Does The IRA Mean For Commercial EV Charging?"; https://www.pecnw.com/blog/what-does-the-ira-mean-for-commercial-ev-charging/

[56] Electrification Coalition; "Inflation Reduction Act Impact on Electric Vehicles"; https://electrificationcoalition.org/work/federal-ev-policy/inflation-reduction-act/

[57] CEC; "Assembly Bill 2127 Electric Vehicle Charging Infrastructure Assessment"; July 2021.

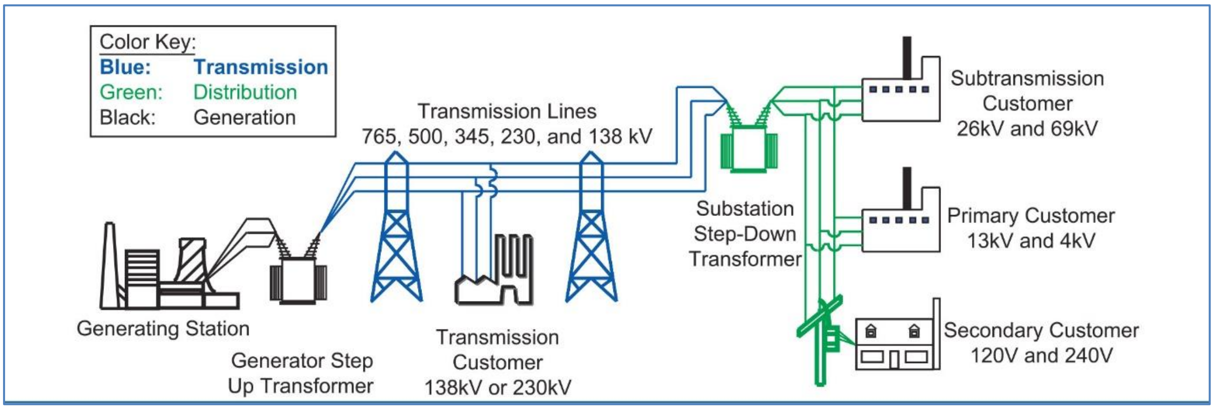
[58] CALeVIP; "EV Charging Basics"; https://calevip.org/electric-vehicle-charging-101

[59] Scientific American; "Making the Big Apple Green Starts with the Empire State Building"; August 2010; https://www.scientificamerican.com/article/making-big-apple-green/

MW each of charging power output by 2045.[60] This level of localized load growth will require substantial upgrades to distribution and transmission infrastructure.

Grid Layout. In traditional utility organization, electric power flows in one direction from centralized generation resources over wires that gradually decline in voltage before reaching end-use customers. As shown in Figure 1, infrastructure operating at higher voltages comprises the transmission grid (in blue), while those at lower voltages comprises the distribution grid (in green). Transmission lines are connected to substations that "step-down" the power to a lower-voltage so that it can be delivered to customers through distribution lines, although some large industrial customers receive their electricity at transmission or sub-transmission voltage. The distinction in voltage level between the transmission and distribution grid differ across the utilities, and are set at the discretion of the utility. Nevertheless, the typical range for transmission infrastructure is 220 kilovolts (kV) or higher, while distribution infrastructure ranges anywhere below 50 kV, with the bulk of the distribution grid in California operating at 12 kV.[61] By the time the power reaches a typical residence in California the voltage is even lower, roughly 0.24 kV, and is split at the home's main circuit breaker into 0.12 kV. Most EV chargers are anticipated to be installed at the distribution level, at homes, businesses, or public spaces operating at or below 12kV. However, some fleet charging hubs, as mentioned above, may seek to directly connect at the transmission or sub-transmission level depending on their total power output.

Figure 1: Diagram of the standard North American electric grid.[62]



Distribution. The process of upgrading distribution infrastructure is complex, often costly, and increasingly lengthy, particularly given the substantial scale of the anticipated buildout required to support widespread EV charging. Accurately modelling the demand anticipated from EV charging can provide advanced notice to utilities of where distribution upgrades may be needed.[63] The CEC leads this demand forecasting effort in California and has

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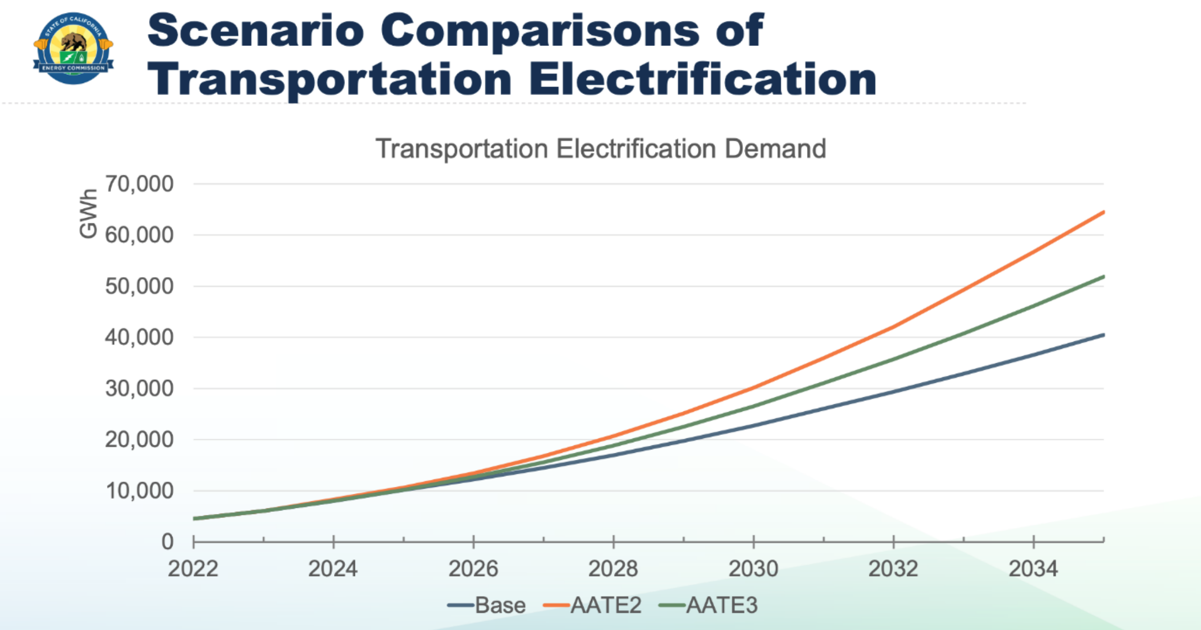
[60] RMI, Calstart, National Grid, Geotab, and Stable Auto; "Electric Highways: Accelerating and Optimizing Fast-Charging Deployment for Carbon-Free Transportation"; November 2022.
[61] Some utilities, including SCE, classify infrastructure with voltage from 66-115 kV as "sub-transmission".
[62] National Park Service website, "Electrical Power Transmission and Distribution," accessed in May 2023; https://www.nps.gov/subjects/renewableenergy/transmission.htm
[63] PNNL; "Electric Vehicles at Scale – Phase II Distribution System Analysis"; March 2022.

incorporated anticipated load growth from EV charging into its demand forecasts.[64] The CEC has revised projections to account for the trajectory of the EV market, as well as recent regulatory changes, resulting in a projected range of electricity demand from transportation electrification from 40,000-65,000 gigawatt hours (GWh) by 2035, as shown in Figure 2.

Figure 2: Scenario comparisons of transportation electrification with a baseline forecast in blue alongside two additional achievable transportation electrification (AATE) forecasts; AATE2 in orange and AATE3 in green.[65,66]



The utilities will be instrumental in ensuring that the distribution grid can support EV charging, particularly the high demand associated with fleets of heavy-duty vehicles. Recent efforts to improve communication and data-sharing between the companies with heavy duty fleets and the utilities highlight the importance of ensuring that these entities are working in concert. AB 2700 (McCarty, Chapter 354, Statutes of 2022), which requires certain state agencies to collect and distribute data related to fleet electrification to better inform infrastructure planning by the utilities, is indicative of this effort to improve communication and minimize delayed or stranded infrastructure.[67]

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[64] CEC; "Demand Side Modeling"; https://www.energy.ca.gov/data-reports/california-energy-planning-library/forecasts-and-system-planning/demand-side-modeling

[65] CEC; "Additional Achievable Transportation Electrification (AATE)"; December 2022.

[66] The baseline is an econometrically-driven forecast that considers consumer demand data to develop a standard forecast of consumer and industry demand for vehicles. The baseline forecast incorporates some, but not all, policies, programs, and regulations. The additional achievable transportation electrification 3 (AATE3) scenario builds onto the baseline forecast by incorporating additional policies, including the CARB Advanced Clean Cars II and Advanced Clean Fleets regulations. The AATE3 scenario is used for transportation electrification planning by IOUs and the CPUC. The additional achievable transportation electrification 2 (AATE2) scenario partially incorporates the policies in AATE 3 into the baseline forecast. CEC; https://www.energy.ca.gov/media/8108

[67] Canary Media; "How quickly can trucking decarbonize? California is about to find out"; May 2023; https://www.canarymedia.com/articles/electric-vehicles/how-quickly-can-trucking-decarbonize-california-is-about-to-find-out

Analyses for costs for distribution system upgrades in PG&E territory alone have been modeled to range from $1 billion to more than $10 billion in total cost by 2050.[68] The level of variability in the modeled estimates is driven by cost uncertainty related to the potential for technological advances and workforce or supply shortages, as well as uncertainty around the pace and degree of EV adoption. The CPUC initiated a Rulemaking in July 2021 to evaluate preparations for increased adoption of distributed energy resources (DERs), including EV chargers required for transportation electrification.[69] A study on the cost of distribution upgrades related to DERs, which would ultimately be borne by ratepayers, estimated that the statewide cost would eclipse $50 billion by 2035 unless significant measures are taken to manage load and otherwise reduce costs.[70] The CPUC has directed the state's three largest IOUs to devote $1 billion in funding for make-ready infrastructure related to EV-charging over five years, with 70% dedicated to support medium- and heavy-duty vehicles.[71,72]

However, recent study of two utilities in New York State by the Environmental Defense Fund found that ongoing electricity sales to medium- and heavy-duty EV fleets can exceed the upfront investment in charging infrastructure.[73] In New York, the costs of grid upgrades to support fleet electrification fall largely on individual fleet owners, raising concern that high upgrade costs may disincentivize and delay fleet electrification. The study finds that spreading these costs across all ratepayers may accelerate fleet electrification and, by producing significant additional utility revenue from the sale of electricity to charge EV fleets, that ratepayer-funded make-ready investment for fleet electrification would yield a neutral or positive effect on ratepayers through 2045.[74] Whether shifting the cost of grid upgrades from fleet owners to ratepayers, as is proposed in the study, would be effective or appropriate in California, where to the knowledge of this committee the costs of fleet-related grid upgrades are also predominantly borne by fleet owners, is unclear.

Another important driver of distribution upgrade costs may be the location of EV chargers. For instance, many of the chargers required to create an effective, reliable charging network throughout the state will be located along highways running through rural areas. The existing distribution infrastructure may have lower capacity than infrastructure closer to population centers and therefore require more substantial upgrades. The NEVI program requires at least four high-speed charging stations supplying at least 150 kW of charging, totaling 0.6 MW per site, along every 50 miles of major highway corridors, many of which traverse remote

[68] Salma Elmallah *et al.*; "Can distribution grid infrastructure accommodate residential electrification and electric vehicle adoption in Northern California?"; November 2022.
[69] R. 21-06-017
[70] Kevala; "Electrification Impacts Study Part 1: Bottom-Up Load Forecasting and System-Level Electrification Impacts Cost Estimates"; May 2023.
[71] D. 22-11-040
[72] Canary Media; "How quickly can trucking decarbonize? California is about to find out"; May 2023; https://www.canarymedia.com/articles/electric-vehicles/how-quickly-can-trucking-decarbonize-california-is-about-to-find-out
[73] Canary Media; "EV trucks and buses need costly grid updates. Should utilities pay?"; April 2023; https://www.canarymedia.com/articles/clean-fleets/ev-trucks-and-buses-need-costly-grid-updates-should-utilities-pay
[74] Synapse Energy Economics, Inc.; "Distribution System Investments to Enable Medium- and Heavy-Duty Vehicle Electrification"; April 2023.

areas.[75] Similar issues may arise with the electrification of vehicles used in the agricultural industry, from heavy-duty trucks to forklifts. Forklifts used in the agricultural industry are clustered in warehouses, often located in rural areas, and may be used in shift work schedules which will require rapid charging to effectively electrify. This presents a situation where a substantial increase in capacity is required in a rural area that traditionally experienced minimal load growth over the past decades. This shift in potential infrastructure needs to rural communities is occurring amid ongoing, statewide energization delays, with many of the most extreme examples of delays being reported in rural areas.[76]

However, energization challenges are not unique to rural areas and are instead persistent throughout the state. Applications for upgrades to existing distribution lines have been increasing statewide, whether to support EV charging, electrify buildings, or serve new load, from housing development to new businesses.[77] These delays may be partially attributed to workforce and budgetary constraints of the IOUs, particularly with the emergence of wildfire mitigation as a critical, immediate, and resource-intensive concern in recent years.[78] Additionally, the COVID-19 pandemic created supply shortages affecting many sectors of the economy, including limiting access to electrical equipment, such as transformers, needed to connect new customers or expand energy capacity.[79] The CPUC recently took action to address the delays in EV charging station energization by issuing Resolution E-5247 in December 2022, which established an interim 125-business day average service energization timeline for projects taking service in IOU territories under the EV Infrastructure Rules, with some exceptions.[80] This resolution may accelerate the energization of EV charging stations, but potentially to the detriment of efforts to rapidly energize other projects, including new housing developments and businesses.

Transmission. The challenges presented by EV charger-driven load growth are likely to extend beyond the distribution level to the scale of electrical transmission, requiring additional investment in transmission infrastructure.[81] The demand growth, particularly at sites with multiple high-capacity chargers producing a total capacity comparable to a professional sports stadium, may surpass the delivery capacity of traditional distribution

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[75] Canary Media; "Highway EV charging will need a ton of power — sooner than you think"; December 2022; https://www.canarymedia.com/articles/ev-charging/highway-ev-charging-will-need-a-ton-of-power-sooner-than-you-think

[76] See this committee's informational hearing on this topic from May 24th, 2023; "Electrical Distribution Planning: How Addressing Current Delays in Connecting to the Distribution Grid may Ensure Readiness for an Electrified Future." https://autl.assembly.ca.gov/content/informationaloversight-hearings

[77] California Energy Markets; "Interconnection Delays Disrupting Housing Markets, Causing 'Chaos'"; March 2023; https://www.newsdata.com/california_energy_markets/regional_roundup/interconnection-delays-disrupting-housing-markets-causing-chaos/article_a577776a-c4fc-11ed-9e15-5ffc130cbd98.html

[78] Utility Dive; "PG&E, SCE detail plans to spend more than $23B through 2025 to prevent wildfires in their footprints"; March 2023; https://www.utilitydive.com/news/pge-sce-vegetation-management-resilience-california-wildfires/646163/

[79] Bakersfield Californian; "Power connection work delays local development projects"; November 2022; https://www.bakersfield.com/news/power-connection-work-delays-local-development-projects/article_8bc9ed88-6d0f-11ed-b3ee-973f5213928a.html

[80] Resolution E-5247

[81] Boston Consulting Group; "The Costs of Revving Up the Grid for Electric Vehicles"; December 2019; https://www.bcg.com/publications/2019/costs-revving-up-the-grid-for-electric-vehicles

infrastructure and require interconnection directly into the transmission system.[82] Transmission infrastructure has historically been costly to build and the transmission planning process is complex and can take years to forecast, plan, permit, and develop. The anticipated demand increases from EV charging are incorporated into agency modeling for both generation resources and transmission needs, but more work remains to ensure that transmission infrastructure development can keep pace with load growth.[83]

Generation Resources. The increase in electricity demand from EVs most acutely impacts distribution infrastructure, and to a certain extent transmission capacity. However, the sheer amount of electricity forecasted to be consumed by EVs also merits adequate planning and response. If a Level 2 charger is rated for 19 kW, then a charging depot with 20 Level 2 chargers, operating for 12 hours per day, would use 4,560 kilowatt-hours per day, equivalent to the daily usage of 228 average homes.[84,85] Even the addition of the comparatively low-power Level 1 chargers, which have been compared to household microwaves in their power output, present a significant increase in electricity demand when contemplated at scale, equating to the effect of adding an additional appliance to millions of homes across California.

The number of EVs in California is expected to increase more than tenfold by 2035 and the amount of electricity consumed will increase accordingly, with EVs forecasted to account for nearly 22% of baseline annual consumption by 2035.[86] However, according to CEC estimates, the amount of power used during peak hours, when the grid is most stressed, will increase from 1% in 2022 to 10% in 2035, remaining a notable but manageable contributor to total load during times of peak demand.[87] Central to this CEC analysis is the alignment of price signals so that EVs across California are not all charging during peak times. Such alignment will be critical to ensuring that EVs do not overly stress the grid during times of peak demand.[88]

A suite of time-of-use electricity rates, offered by IOUs and approved by the CPUC, financially incentivize residential and commercial EV owners to charge their vehicles during times of low demand.[89] Methods of "Smart Charging" can shift the electricity demand from EV charging to off-peak times, reducing grid stress and more effectively utilizing renewable

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[82] RMI, Calstart, National Grid, Geotab, and Stable Auto; "Electric Highways: Accelerating and Optimizing Fast-Charging Deployment for Carbon-Free Transportation"; November 2022.
[83] See this committee's informational hearing on this topic from June 14th, 2023; "Building Transmission for a Clean Energy Transition." https://autl.assembly.ca.gov/content/informationaloversight-hearings
[84] CALeVIP; "EV Charging Basics"; https://calevip.org/electric-vehicle-charging-101
[85] The Washington Post; "Electric vehicles can now power your home for three days"; February 2023; https://www.washingtonpost.com/climate-environment/2023/02/07/ev-battery-power-your-home/
[86] CalMatters; "Can California's power grid handle a 15-fold increase in electric cars?" January 2023; https://calmatters.org/environment/2023/01/california-electric-cars-grid/
[87] CalMatters; "Can California's power grid handle a 15-fold increase in electric cars?" January 2023; https://calmatters.org/environment/2023/01/california-electric-cars-grid/
[88] Utility Dive; "EVs will bring 'unprecedented' power demand, but their flexibility can improve grid reliability, utilities say"; July 2023; https://www.utilitydive.com/news/ZETA-evs-will-bring-unprecedented-new-electric-demand/688850/
[89] CPUC; "Electricity Vehicles Rates and Cost of Fueling"; https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/electricity-rates-and-cost-of-fueling

energy generation.[90] According to NREL, the benefits of shifting EV charging load to off-peak times and optimizing charging location would also reduce the requirements for additional investment in distribution and transmission infrastructure by 70% through 2030, from $5,800 per EV in the nonoptimized charging scenario to $1,700 in an optimized model.[91] Vehicle to grid (V2G) applications of EVs purport to, rather than further stress the grid, route electricity back to the grid during peak times to alleviate grid stress. The CPUC has undertaken multiple pilot programs to evaluate the efficacy of V2G and the feasibility of widespread application of the technology,[92] some of which are ongoing,[93] while the pilot programs which have been completed leave critical questions about the scalability of V2G unresolved.[94]

Conclusion. Rapidly developing EV charging infrastructure throughout California will be crucial to successfully electrifying the transportation sector and achieving the state's emission reduction goals. Maximizing the speed of charger installation will put pressure on existing funding streams, particularly in the context of an uncertain budgetary outlook and concern about rising electricity rates. Yet the prioritization of speed must not come at the expense of equity in EV charger deployment throughout the state. Expanding EV charging will also challenge existing pathways for upgrading grid infrastructure to keep pace with the additional demand, particularly when those processes are already showing signs of strain through energization delays. The funding for grid upgrades must be balanced with other critical investments like wildfire mitigation, and ideally aligned such that investments for one purpose may also support the other. The existing regulatory framework is predicated on multi-year planning and predictability rather than the ability to quickly respond to emerging issues. These challenges highlight the importance of transparency and communication during utility funding requests and the infrastructure planning process so that bottlenecks, whether related to financial limitations, lack of data-sharing, or a variety of other factors not addressed here (e.g., limited workforce or permitting issues), may be identified as early as possible and addressed to ensure that the transportation sector remains on track for California to reach its climate goals.

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[90] National Renewable Energy Laboratory; "Electric Vehicle Smart Charging at Scale"; https://www.nrel.gov/transportation/managed-electric-vehicle-charging.html
[91] Boston Consulting Group; "The Costs of Revving Up the Grid for Electric Vehicles"; December 2019; https://www.bcg.com/publications/2019/costs-revving-up-the-grid-for-electric-vehicles
[92] CPUC; "VGI Policy, Pilots, and Technology Enablement"; https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/vehicle-grid-integration-activities
[93] PG&E; "PG&E to Launch New Pilots Studying Electric Vehicle Bidirectional Charging Technology at Homes, Businesses and with Microgrids"; May 2022; https://investor.pgecorp.com/news-events/press-releases/press-release-details/2022/PGE-to-Launch-New-Pilots-Studying-Electric-Vehicle-Bidirectional-Charging-Technology-at-Homes-Businesses-and-with-Microgrids/default.aspx
[94] SCE; "Southern California Edison Company's Department of Defense Vehicle-To-Grid Final Report".