



Assembly Bill 2127

# Electric Vehicle Charging Infrastructure Assessment

Analyzing Charging Needs to Support Zero-Emission Vehicles in 2030





# Executive Summary

With transportation accounting for more than 50 percent of the state's greenhouse gas (GHG) emissions, more than 80 percent of smog-forming nitrogen oxide pollution, and 95 percent of toxic diesel particulate matter, the full transition to zero-emission vehicles (ZEVs) is a critical step toward carbon neutrality, the equal balance of GHGs emitted into and removed from the atmosphere, by 2045. The State is taking many steps to help California transition to carbon neutral transportation, which will also improve public health and air quality, including those described in this document.



On September 23, 2020, Governor Gavin Newsom signed Executive Order N-79-20, setting the following targets for ZEVs:

By 2035

**100%**  
ZEV sales for new passenger vehicles

**100%**  
ZEV operations for drayage trucks

**100%**  
ZEV operations for off-road vehicles and equipment (where feasible)

By 2045

**100%**  
ZEV operations for medium- and heavy-duty vehicles (where feasible)

Assembly Bill 2127 (Ting, Chapter 365, Statutes of 2018) requires the California Energy Commission (CEC) to prepare a statewide assessment of the charging infrastructure needed to achieve the goal of 5 million ZEVs on the road by 2030 and reducing emissions of greenhouse gases to 40 percent below 1990 levels by 2030. Executive Order N-79-20 directed the CEC to expand this assessment to support the levels of electric vehicle adoption required by the executive order.

Analysis from the California Air Resources Board (CARB) estimates that 8 million light-duty ZEVs and 180,000 medium- and heavy-duty ZEVs will be needed in 2030 to meet the new goal. For passenger vehicles, this report projects that over 700,000 chargers are needed to support 5 million ZEVs and nearly 1.2 million public and shared private chargers are needed to support almost 8 million ZEVs in 2030. For medium- and heavy-duty charging in 2030, modeling analysis suggests that 157,000 chargers are needed to support 180,000 ZEVs. The passenger vehicle charging projections are updated from the original staff report version of this document.

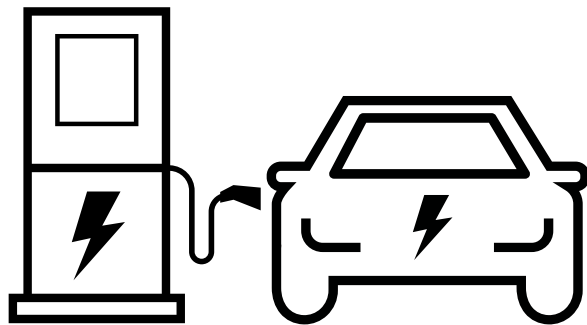
The updated projection reflects stakeholder input and is primarily the result of more aggressive vehicle attributes, including longer ranges, larger batteries, and higher charging powers of EVs coming to market. The rapid improvements in battery prices and vehicle range allow for fewer chargers because drivers will not have to charge as often.

Future reports will reassess charging infrastructure needs through 2035 and potentially project longer-term needs through 2045 as envisioned by Executive Order N-79-20.

Informed by data and input from stakeholders, this report identifies trends and market, technical, and policy solutions that would advance transportation electrification to benefit all Californians. This report outlines a vision where charging is accessible, smart, widespread, and easier than a trip to the gas station.



# Light-Duty Plug-In Electric Vehicles Will Need Nearly 1.2 Million Shared Chargers by 2030

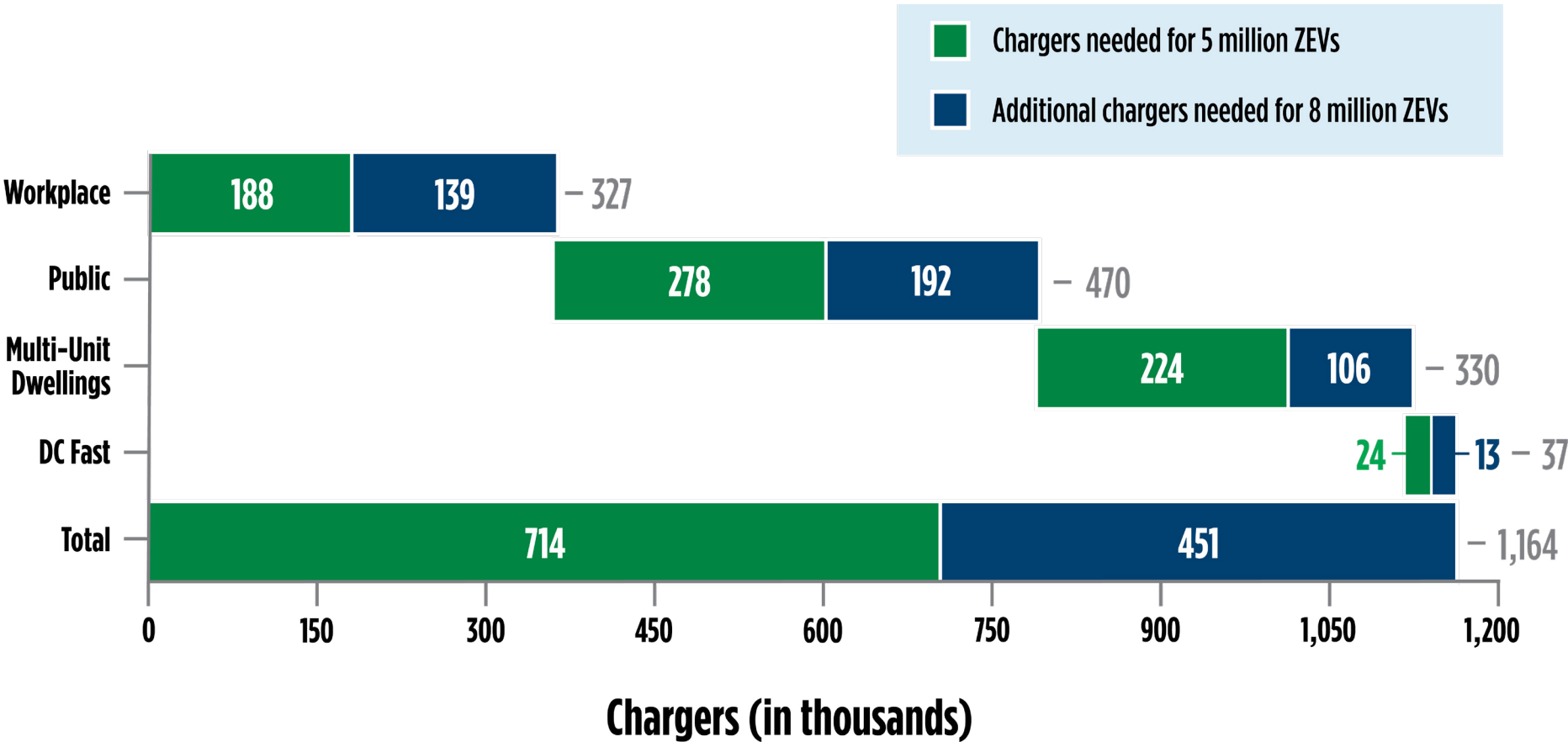


California’s cumulative ZEV sales reached 862,874 through the first quarter of 2021, including more than 60 percent battery-electric vehicles (BEVs), more than 38 percent plug-in hybrid vehicles (PHEVs), and more than 1 percent hydrogen fuel cell electric vehicles (FCEVs). Industry forecasts from Bloomberg New Energy Finance find that BEVs may achieve purchase cost parity with internal combustion engine counterparts as early as 2022 in select vehicle segments. With vehicle costs decreasing and consumer acceptance growing, access to convenient charging infrastructure is critical in generating the exponential growth needed to achieve 100 percent ZEV passenger vehicle new sales by 2035.

As of January 4, 2021, there are more than 70,000 public and shared private chargers available across the state. This report finds that an additional 123,000 chargers are planned (through state grants, approved utility investments, and settlement agreements), bringing the total to 193,000 chargers. To meet the 2025 goal of 250,000 public and shared chargers, the state will need about 57,000 more than are already installed or planned.

Modeling results in this report project that the state will need nearly 1.2 million public and shared private chargers in 2030 to support the number of light-duty vehicles needed to achieve the goals of the Executive Order N-79-20. Figure 1 illustrates the projected breakdown of charger type and count. Green bars indicate the charger need for 5 million ZEVs as called for in AB 2127, blue bars represent the additional charger need for 8 million ZEVs, and text labels at the rightmost end of each bar indicate the total charger need for 8 million ZEVs.

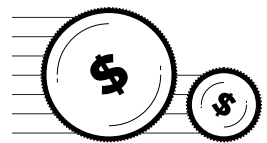
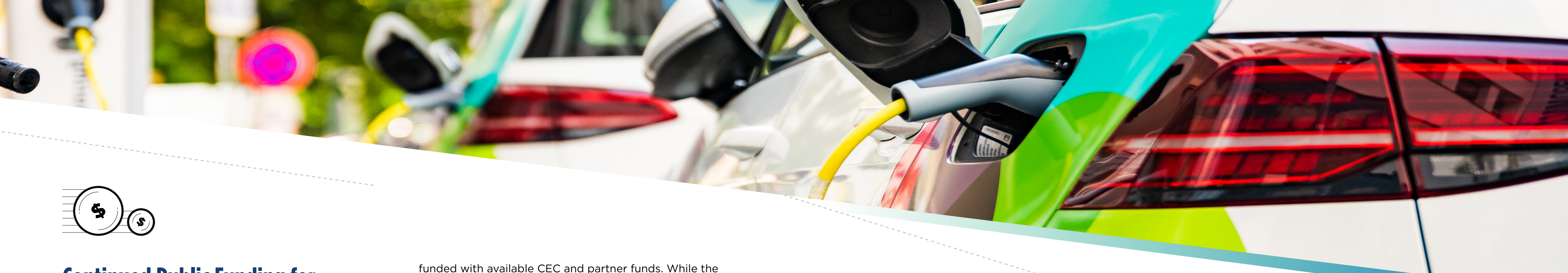
Figure 1: Projected 2030 Charger Counts to Support 5 Million and 8 Million Light-Duty Zero-Emission Vehicles



Models project that California will need more than 700,000 shared private and public chargers in 2030 to support 5 million ZEVs as called for in AB 2127 and nearly 1.2 million chargers to support 8 million ZEVs to achieve the goals of the Executive Order N-79-20. Counts for chargers at workplaces, public destinations, and multi-unit dwellings generally indicate the number of Level 2 chargers needed. In some cases, Level 1 chargers may be sufficient at select multiunit dwellings. These values do not include chargers at single-family homes.

Source: CEC and National Renewable Energy Laboratory





## Continued Public Funding for Charger Deployment Is Essential to Meeting State ZEV Goals

Continued growth in the PEV market will depend on driver confidence in charging infrastructure. Widely available charging will reduce range anxiety and give drivers confidence that PEVs are as convenient to fuel as conventional vehicles. The state must continue to invest in charging infrastructure to achieve its ZEV goals. As demonstrated by the sheer number of chargers needed by 2030, the immediate need is great. The CEC's California Electric Vehicle Infrastructure Project (CALeVIP), which provides incentives for the purchase and installation of public chargers throughout California, is oversubscribed by hundreds of millions of dollars. During the project, applicants have requested more than \$300 million in rebates, but only about one-third of those could be

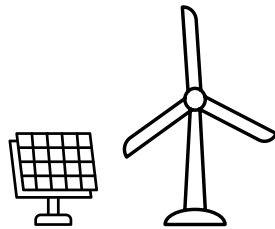
funded with available CEC and partner funds. While the public investment share will fall as PEV numbers increase and the private market becomes more financially viable, significant public investment is needed now.

Electricity sales alone may be insufficient to maintain sustainable business operations or cover capital costs for planning and constructing charging stations. Many companies have introduced or are exploring models that include complementary revenue streams, for example, through coordinating the charging of many vehicles to support grid stability, integration with local retail and marketing, or subscription-based business models. Public investments in charging infrastructure, including through CALeVIP, will remain critical to encouraging continued market experimentation, growth, and maturation. Public investments have already attracted large amounts of private follow-up capital. Policy makers can encourage greater private investment and business model innovation by exploring financing mechanisms that offer incentives for high charger use, diverse revenue streams, reduced charger costs, and minimization of grid upgrades.





# The State Must Seek to Align PEV Charging With Renewable Energy Generation



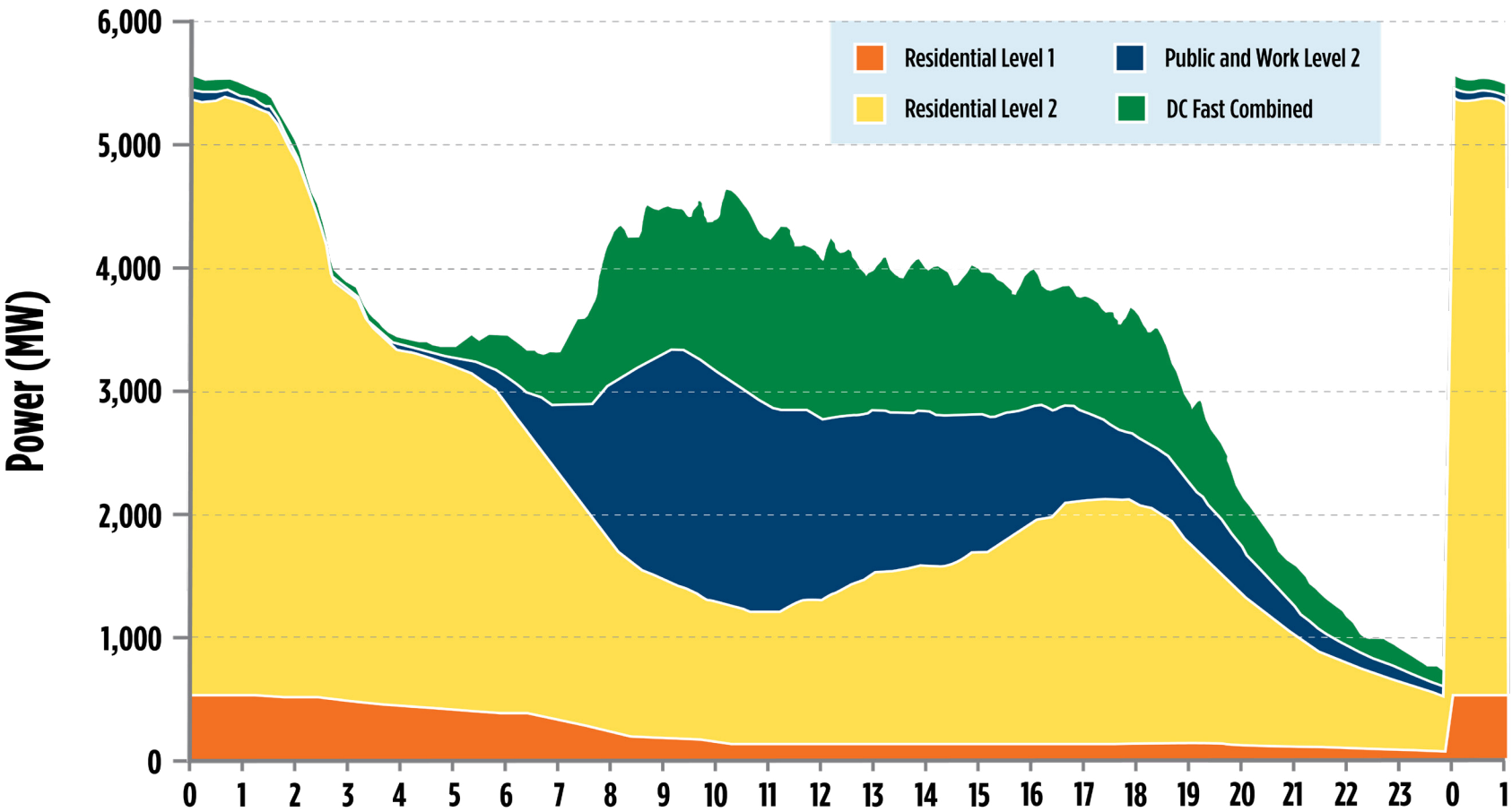
Charging millions of PEVs will introduce significant new load onto the electric grid. CEC models project that electricity consumption in 2030 from light-duty vehicle charging will reach around 5,500 megawatts (MW) around midnight and 4,600 MW around 10 a.m. on a typical weekday, increasing electricity demand by up to 25 and 20 percent at those times, respectively (Figure 2). While current results indicate that nonresidential charging demand will generally align with daytime solar generation, more than 60 percent of total charging

energy will still be demanded when sunshine is not abundantly available. Further, a projected surge of charging demand around midnight when off-peak electricity rates take effect may strain local distribution infrastructure. To fully realize the economic, air quality, and climate benefits of electrification, California must pursue greater vehicle-grid integration, or the coordination of charging with grid needs, to ensure that charging is better aligned with clean, renewable electricity without sacrificing driver convenience.

Image Credit: innovation.energy.ca.gov



Figure 2: Projected Statewide Power for Light-Duty Charging for 8 Million ZEVs on a Typical 2030 Weekday



Charging management strategies beyond time-of-use rates, including those that reflect wholesale prices and carbon intensity, will be needed to align electric vehicle loads with daytime solar generation. Demand for DC fast charging, as well as public and work Level 2 charging, occurs mostly during the day. Residential charging technologies should be coordinated with distribution systems to lessen the impact of charging timed to begin at midnight, illustrated with a 25th hour on the right.

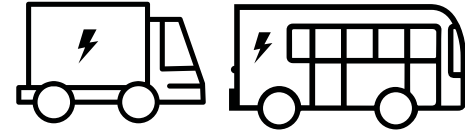
Source: CEC, National Renewable Energy Laboratory, and UC Davis



## Electrification of Medium- and Heavy-Duty Vehicles Is Accelerating

Medium- and heavy-duty vehicles and equipment are critical to California's businesses, freight operations, and transit systems, but they are also responsible for 68 percent of the nitrogen oxide emissions and 91 percent of the diesel soot statewide. Electrifying the state's medium- and heavy-duty sectors will be crucial to meeting the state's climate goals and improving air quality, especially in disadvantaged communities.

In the next five years, medium- and heavy-duty vehicles such as delivery vans, Class 8 trucks, and cargo handling equipment will rapidly electrify because of market developments, regional air quality implementation plans, and state ZEV goals. While private light-duty vehicles typically see extended periods of downtime that allow flexible charging patterns, medium- and heavy-duty vehicles tend to adhere to rigid operating schedules, making infrastructure planning for these vehicles unique. While set operating schedules may ease infrastructure



planning and present opportunities for vehicle-grid integration, less downtime and the resultant need for higher-power charging also present challenges.

CARB's Draft 2020 Mobile Source Strategy projects that the state will need 180,000 medium- and heavy-duty ZEVs in 2030 to achieve state climate and air quality goals and comply with Executive Order N-79-20. Preliminary modeling, which considered 50-kilowatt (kW) and 350-kW charging power levels, suggests that to charge these vehicles, 157,000 DC fast chargers will be needed, of which 141,000 are 50 kW and 16,000 are 350 kW.

Although there is significant variation in energy demand timing among vehicle types, this charging network corresponds with a load in excess of 2,000 MW around 5 p.m. on a typical weekday, highlighting the importance of concerted effort to manage load. Among off-road applications, significant infrastructure planning and investment are needed to support near-term electrification of transport refrigeration units, cargo-handling equipment, and airport ground-support equipment.

## Charging Solutions Must Be Tailored to Local and Community Needs to Ensure ZEV Access for All Californians

While this report provides a high-level view of the infrastructure required to support California's ZEV future, charger deployment projects must be thoughtfully tailored to local needs. Effective charging solutions depend greatly on community needs, land use, space constraints, grid capacity, vehicle duty cycles, and other factors. Simply put, there is no one-size-fits-all solution for how charging should fit into the built environment. Planning charging infrastructure for medium- and heavy-duty vehicles introduces additional complexities given the broad range of vehicle uses and often-inflexible operating patterns.

Historically, transportation planning and projects have insufficiently considered the needs of local communities, particularly low-income and disadvantaged communities suffering disproportionate health impacts. To ensure the benefits of electrification are equitably distributed, policy makers must involve communities in identifying and planning high-quality charging solutions that address community transportation needs and yield direct local benefits, including through strategies such as participatory budgeting, inclusive community outreach, and community centric planning.

Policy makers and electric vehicle stakeholders recognize that electrifying California's diverse mobility landscape requires solutions fitted to local constraints and needs, and that effective infrastructure deployment requires various charging solutions and metrics. Charger funding programs should include those that address or avoid the need for grid upgrades, improve resiliency, enable high charger usage, or are uniquely suited to particular built environments.





## Prioritize Charging Standards and Innovation

Charger connectors, which determine whether a vehicle can charge when it arrives at a charging station, remain fragmented across all PEV sectors. DC fast charging connectors for passenger cars are split among three designs, and lack of connector standardization is even more prevalent among medium- and heavy-duty vehicles. Encouraging greater standardization of charging connectors promotes greater driver convenience and helps ensure that chargers installed today are not stranded in the future.

Beyond the physical connector, for networked charging, deploying chargers with the capability to speak a common “language” with vehicles will ensure that chargers and vehicles can exchange necessary information to realize critical customer and electricity system benefits at scale. These benefits include automatically aligning charging with surplus renewable energy generation to save customers money and integrate more renewable energy into the grid, enabling plug-in vehicles to power homes and businesses during outages to improve resilience, and streamlining the charging experience for the driver.





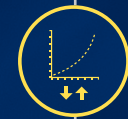
# THE ROAD AHEAD

Widespread, accessible, and convenient charging infrastructure is critical to transportation electrification and California's ability to address climate change and air pollution. The state will need more than 1.3 million public and shared chargers by 2030 (for passenger vehicles and medium- and heavy-duty vehicles), necessitating significant public support and investment. Industry, working closely with the CEC, state agencies, and local governments, must quickly close the gap to provide drivers and fleets confidence that their mobility needs can be served by electric vehicles.



This report identifies several actions to support the widespread deployment of charging infrastructure:

**Continue public support for charger deployment, using public funds to leverage private funds, and eventually transition to a self-sustaining private market.**



**Continue modeling efforts to project the quantities, locations, and load curves of chargers needed to meet statewide travel demand.**



**Support innovative charging solutions and financing mechanisms.**



**Support local efforts to prepare for transportation electrification.**



**Ensure equitable distribution of charger deployment throughout the state.**



**Align charging with renewable generation and grid needs.**



**Prioritize standardized charger connectors and, for networked charging, prioritize hardware capable of standardized communications protocols.**





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