Summary of Zero Emission Vehicle Readiness Factors Across California Communities

Barriers, Opportunities, and Best Practices for Reaching California's Zero-Emission Vehicle Targets

Overall objectives of report:

- Synthesize best practices for zero-emission vehicle (ZEV) implementation and planning.
- Identify common barriers for creation of zero-emission vehicle ecosystems.
- Outline knowledge gaps in the establishment of zero-emission vehicle ecosystems.
- Summarize resources and tools that can help initiate (or sustain) ZEV Readiness Planning

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Disclaimer

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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Abstract

Currently, transportation activities are a major source of harmful air pollution and the largest source of greenhouse gas emissions in California. To reduce emissions and their potential impacts, California has implemented several policies (e.g., Executive Order (EO) N-79-25, Senate Bill (SB) 100) that aim to achieve full adoption of ZEVs and reduce dependence on single-passenger vehicles. In pursuit of these policy objectives, CARB and other state agencies are working to support ZEV Readiness – the degree to which a local jurisdiction will have (and continue to plan for) appropriate refueling infrastructure, accessible clean mobility, supportive policies and programs, outreach and education, and a skilled workforce to catalyze widespread uptake of ZEVs.

This report aims to support ZEV Readiness planning and evaluation through two primary objectives: 1) summarize best practices, resources, and tools for ZEV implementation and planning; 2) identify common barriers and knowledge gaps in the development of ZEV ecosystems and ZEV Readiness. These objectives were pursued across several themes, including ZEV Readiness Plans and Blueprints, Transportation Needs Assessments, Vehicle-Miles-Traveled Reduction Strategies, Funding Resources, Charging Infrastructure and Electric Utilities, Workforce Development, and Community Engagement and Education.

We used a combination of quantitative and qualitative methods (including stakeholder interviews) to assess the current state of zero-emission vehicle planning, strategies, barriers, and resources across a breadth of sources including county zero-emission vehicle plans, city climate action plans, academic and government literature, community-driven transportation planning, reports, info packets, and toolkits.

Overall, the main barriers to ZEV Readiness and uptake are infrastructure preparedness, lack of awareness of the benefits, upfront cost to consumers for purchase and infrastructure needs, lack of multi-family housing solutions for zero-emission vehicle use, large variability in community involvement and motivation, and lack of detailed planning for meeting state and local goals. Conversely, factors that appear to increase ZEV Readiness and uptake include education and outreach events (e.g., "Ride and Drive" Events), rebates and incentives for used ZEVs, collaboration between local governments and local advocacy groups, funding and incentives for ZEV and infrastructure maintenance, and funding and/or policies that support the installation and upkeep of ZEV charging infrastructure at multi-family dwellings.

Ultimately, understanding the geographic and socioeconomic factors that govern ZEV uptake is critical to enhancing ZEV Readiness. Similarly, it appears that infrastructure and equity-focused solutions play a critical role in enabling collective action and helping California achieve its policy and sustainability goals.

Overview

In California, the transportation sector is important for helping maintain community and economic activity. However, transportation is also responsible for harmful emissions across three critical types: (1) smog-forming emissions (criteria pollutants), (2) air pollutants (toxic emissions) that impact respiratory health, and (3) greenhouse gas emissions that contribute to ongoing climate change. To address these emissions, California has established several laws, policies, targets, and regulations to accelerate the transition away from internal combustion engine vehicles to zero-emission vehicles (ZEVs). Notable among these policies are Advanced Clean Cars II (2022) and Executive Order N-79-20, which requires 100% of new vehicle sales in California to be zero-emission vehicles by 2035 (Gov. Newsom, 2020). Despite changes to federal policy, such as the expiration of federal tax credits for zero-emission vehicles and attempts to revoke California's Clean Air Act waiver for vehicle regulations, the state remains committed to the transition to zero-emission vehicles and the elimination of transportation-related emissions – see EO N-27-25 (Gov. Newsom, 2025). To learn more about California's zero-emission vehicle policies, please see Appendix E – Laws and Regulations.

Generally, the term "zero emission" describes a vehicle that has zero local emissions (also referred to as tailpipe emissions). For this report, most of the discussion relates to plug-in hybrid- electric vehicles and battery-electric vehicles. Plug-in hybrid-electric vehicles, such as the Toyota Prius Prime and the Chevrolet Volt, have both a gasoline-powered engine and an electric motor powered by an on-board battery that is recharged by plugging into the electricity grid. Battery-electric vehicles, such as the Tesla Model 3 and the Nissan LEAF, are powered exclusively by an electric motor and on-board battery that is recharged by plugging into the electricity grid. Hydrogen fuel-cell electric vehicles, such as the Toyota Mirai, are another type of zero-emission vehicle that is periodically discussed in the report. These vehicles use on-board fuel cells to convert hydrogen gas to electricity, which in turn powers an electric motor. To learn more about the types and fundamentals of different zero-emission vehicles, the reader is encouraged to visit the U.S. Department of Energy's (U.S. DOE) "Electric Vehicles" webpage and "Fuel Cell Vehicles" webpage.

In pursuit of advancing zero-emission vehicle uptake in California, this report explores and summarizes the current state of zero-emission vehicle planning, strategies, barriers, and resources across a breadth of sources including county zero-emission vehicle plans, city climate action plans, academic and government literature, community-driven transportation planning, reports, info packets, and toolkits.

Goals and Objectives:

The overarching goal of this report is to provide information and resources that can be used by local government officials and interested stakeholders to develop and/or improve strategies to increase the uptake of zero-emission vehicles in communities across California. In pursuit of this goal, the authors had the following objectives:

1. Search for, identify, and collect existing planning documents and resources related to zero-emission vehicle uptake and implementation.
2. Review collected plans and resources.
3. Synthesize major themes/takeaways/recommendations from plans and resources.

Navigation Guide:

This report contains nine sections -- two sections that provide additional context and recommendations followed by seven sections that focus on specific themes. The title and page location of each theme are listed below.

Additionally, each theme has a set of guiding questions intended to help the reader navigate to information that is most pertinent to them. These questions are listed in the subsequent section titled "Index of Key Questions Explored in this Report." The themes are meant to be somewhat self-contained, but complementary to one another (e.g., a reader should be able to jump straight to a particular theme without needing any context from the other themes). The primary audience for this report is local government officials and stakeholders looking to create and/or enhance conditions conducive to the uptake of zero-emission vehicles and the implementation of vehicle-miles-traveled reduction strategies. Nonetheless, members of the public, state and national government officials, and researchers may also find value in the information contained in this report. Finally, it is worth noting that the report focuses on light-duty (passenger) vehicles. However, where possible and relevant, information about fleets, as well as medium- and heavy-duty vehicles, is also included.

Index of Key Questions Explored in this Report:

    - What funding resources are available to support broader planning, workforce development, and/or education/engagement related to zero-emission vehicle implementation?
- What types of entities provide zero-emission vehicle funding?
- How aligned are the funding resources with identified key strategies and barriers?

Theme 5 - Charging Infrastructure and Electric Utilities | Page 27

- Which barriers/gaps are most prevalent with respect to charging and electrical infrastructure?
- What strategies/plans have state and local governments implemented (or proposed) for enhancing/expanding zero-emission vehicle chargers (and supporting infrastructure)?

Theme 6 - Workforce Development | Page 36

- What strategies/plans have been implemented (or proposed) for supporting workforce development aligned with widespread zero-emission vehicle uptake?
- Which barriers/gaps are most prevalent in zero-emission vehicle workforce development?
- What funding/support is available specifically for workforce development and community engagement/education?

Theme 7 - Community Engagement and Education | Page 39

- What strategies/plans have been implemented (or proposed) for supporting community engagement and education aligned with widespread zero-emission vehicle uptake?
- Which barriers/gaps are most prevalent in community engagement and education related to widespread zero-emission vehicle uptake?

Broader Context and Considerations Related to Zero-Emission Vehicle Ecosystems

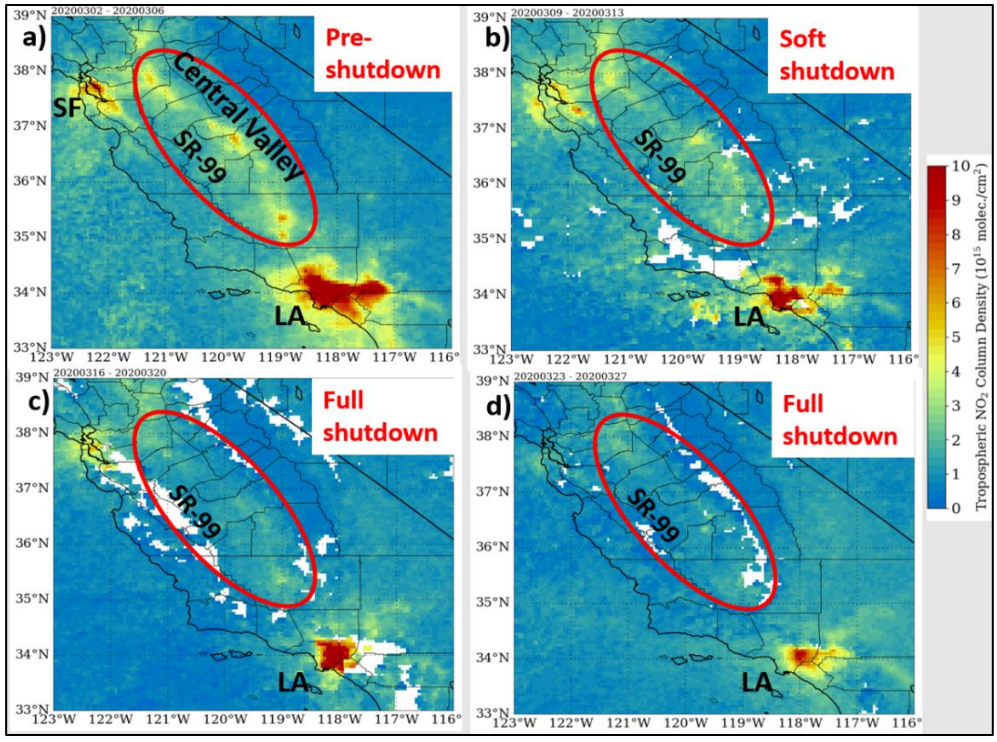
Introduction

The primary benefit of zero-emission vehicle uptake lies in reducing health- and climate-related impacts associated with smog-forming emissions, toxic pollutants, and greenhouse gases. Moving toward zero-emission vehicles and reducing these emissions will result in benefits such as improved air quality and public health, as well as economic savings in operating costs.

Air Quality

Zero-emission vehicles get their name from the fact that they do not produce smog-forming tailpipe emissions and harmful air pollutants. This includes nitrogen oxides (NOx), particulate matter, and additional pollutants that impact air quality and can lead to respiratory issues. As California progresses toward 100% zero-emission vehicle uptake, a marked decrease in nitrogen oxides (NOx) pollution and an improvement in air quality is expected (Yu et al. 2023). To get an idea of what this change could look like, the National Aeronautics and Space Administration (NASA) images in Figure 1 show the significant reduction in NOx experienced in the Central Valley as a result of the shelter-at-home period during the COVID-19 pandemic. Widespread zero-emission vehicle uptake can help us achieve a reduction in air pollution similar to what is seen in Figure 1, where panel (a) shows relatively high levels of air pollution prior to the shutdown and panel (d) shows the relatively low levels of pollution following the full shutdown.

FIGURE 1

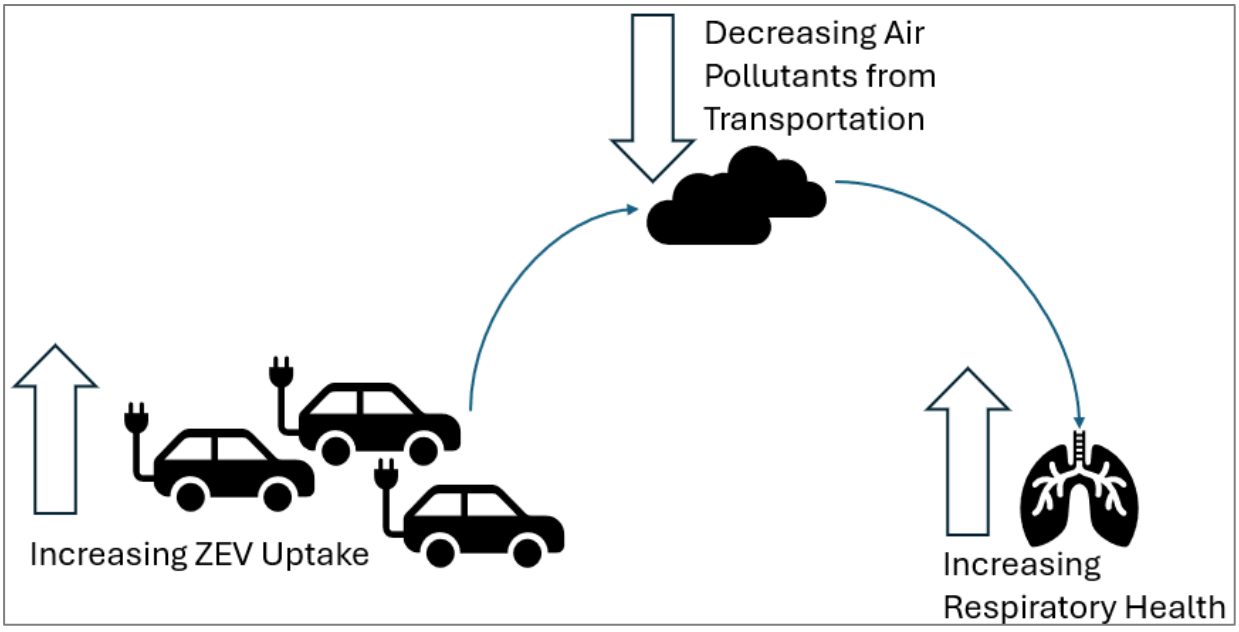


"a) Gridded 0.05 x 0.05° NO2 map from TROPOMI Offline (OFFL) L2 retrievals during 2-6 March 2020 (pre-shutdown) over California. b-d) Same as a), except valid for b) 9-13 March during soft shutdown measures, c) 16-20 March when "shelter in place" orders were announced, d) full period of "shelter in place" orders during 23-27 March. Panel d) generated using near real-time (NRT) product due to 7–10-day lag of OFFL product." (NASASPORT)

Health

Internal combustion engine vehicles produce NOx and particulate matter, including $PM_{2.5}$, which are linked to respiratory diseases and other health impacts. The improved air quality from zero-emission vehicle uptake will lead to lessened exposure to unhealthy air conditions and improved respiratory health (Garcia et al. 2023) – see Figure 2. This benefit will continue to grow as zero-emission vehicles begin to represent a larger fraction of the overall vehicle fleet. Additionally, medium- and heavy-duty zero-emission vehicles offer a respite from in-cabin and surrounding emissions, particularly for long-distance and long-duration drivers (Natural Resources Defense Council (NRDC), 2023).

FIGURE 2



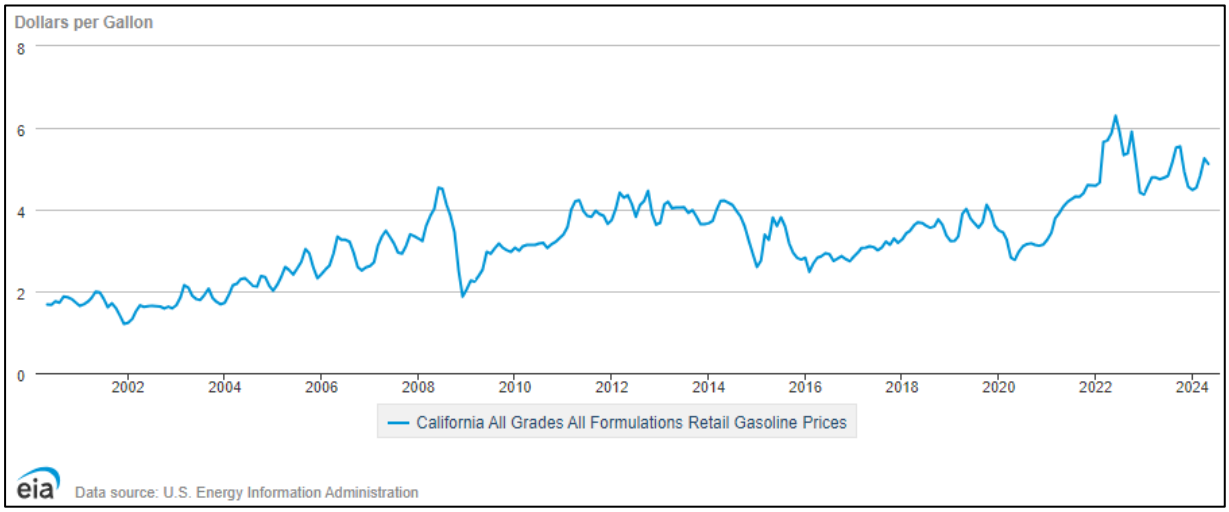
Connection between zero-emission vehicles, air pollution, and health. Figure modified from Garcia et al. 2023.

Operational Savings

Another benefit of zero-emission vehicles is the reduction of operational costs for consumers. Internal combustion engine vehicles (conventional vehicles) require refueling with gasoline or diesel at costs currently sitting close to $6 a gallon (for gasoline) in California (and about $4.00 per gallon nationally, June 2026). Additionally, gasoline prices have been increasing on average since 2000, including a notable spike

in 2022-2023 (Figure 3a). Zero-emission vehicles instead use electricity that is typically much cheaper than gasoline or diesel (California average electricity utility rate of $0.286 per kilowatt-hour average in California and U.S. national average electric utility rate of $0.141 per kilowatt-hour, March 2026). Similarly, zero-emission vehicles' maintenance costs are estimated at almost half that of petroleum-powered vehicles (Figure 3b): 3.6 cents per mile compared to 7.0 cents per mile.

FIGURE 3A



3a) California Retail Gasoline Prices 2000-2024 (estimated Fueling/operation costs comparison between internal combustion engine vehicles and zero-emission vehicles and plug-in hybrid-electric vehicles (International Council on Clean Transportation, 2022).

Vehicle technology	Year	Fuel ($/gallon)	Home charging ($/kWh)	DC fast charging ($/kWh)	Maintenance (cents/mile)
Conventional	2022	$3.46	--	--	7.0
	2025	$3.48	--	--	7.0
	2030	$3.52	--	--	7.0
Plug-in hybrid	2022	$3.46	$0.12	--	5.0
	2025	$3.48	$0.13	--	5.0
	2030	$3.52	$0.13	--	5.0
Battery electric	2022	--	$0.12	$0.28	3.6
	2025	--	$0.13	$0.24	3.6
	2030	--	$0.13	$0.20	3.6
Source		EIA AEO (2022)	EIA AEO (2022)	Kelly and Pavlenko (2020)	Burnham et al. (2021)

3b) Fueling and maintenance cost comparison
(International Council on Clean Transportation, 2022).

Quick Start: Resources for Initiating ZEV Readiness Planning

Summary:

This section provides a set of tools to support zero-emission vehicle planning. As there is likely to be a wide variety of needs concerning next steps, we have aimed to provide a range of tools to aid planners at different steps of the process. Items discussed in this section include an electric vehicle readiness plan template and resources for funding, permitting, and infrastructure mapping.

Building an Electric Vehicle Readiness Plan

This section aims to provide guidance for developing an electric vehicle readiness plan. Below is a Readiness Plan Template that can be followed or adapted as needed. Once a readiness plan has been established, jurisdictions may also want to consider applying to the California New Motor Vehicle Board's Zero Emission Vehicle (ZEV) Readiness Awards, which aim to recognize communities that have "demonstrated exceptional progress towards ZEV readiness."

Electric Vehicle Readiness Plan Template

This template, adapted from the former Joint Office of Energy and Transportation, provides a sample of an electric vehicle readiness plan.[1] It can serve as a framework for the development of community-wide electric vehicle readiness plans for light-duty passenger vehicles and may be modified to suit the needs of different communities. It is not comprehensive, and sections may be added or removed for the purposes of a given community. This template is not intended to detail a structure for municipal fleet electrification planning.

I. **Overview:** *This section describes the overall scope and purpose for the electric vehicle readiness plan to ensure clarity and alignment among team members, stakeholders, and readers.*
   a. Description of Planning Area and Stakeholders Involved in the Planning Process
   b. Statement of Existing Electric Vehicle and/or Decarbonization Goals

II. **Electric Vehicle Market: Current Deployment and Forecasted Growth.** *This section describes where you are and where you want to go by detailing current conditions and contrasting those conditions with electric vehicle and electric vehicle charging infrastructure projections or goals.*

[1] Additional examples that can serve as useful templates include the Tahoe-Truckee Plug-in Electric Vehicle Readiness Plan and Bay Area Plug-in Electric Vehicle Readiness Plan, both of which are available on the Alternative Fuels Data Center.

a. Overview of National or State Electric Vehicle Market
b. Understanding Existing and Potential Electric Vehicle Drivers
c. Understanding Existing Charging Infrastructure and Projecting Infrastructure Needs
    i. Single-family Residential Charging
    ii. Multi-family Housing and Workplace Charging
    iii. Opportunity Charging

III. **Policies, Programs, Incentives, and Funding:** *This section describes existing policies and programs that could impact your zero-emission vehicle plans or deployment goals. It identifies potential opportunities and barriers that those policies or programs could present.*

a. Federal-level Electric Vehicle-related Policies and Programs
b. State-level Electric Vehicle-related Policies and Programs
c. Regional Electric Vehicle-related Stakeholders, Policies, and Programs
d. Electric Vehicle-related Grants, Incentives, and Tax Credits

IV. **Existing Barriers to Accelerated Zero-emission Vehicle Uptake (e.g., regional coordination, power grid capacity).** *This section provides a realistic representation of the barriers to increased zero-emission vehicle uptake in the region. To develop a set of zero-emission vehicle readiness strategies, you must first understand existing challenges.*

V. **Strategies for Accelerating Zero-emission Vehicle Uptake.** *This section describes best practices that decision makers can leverage to accelerate zero-emission vehicle uptake within a jurisdiction.*

a. Local Incentives, Programs, and Technical Assistance
b. Revision of Codes
    i. Building Codes
    ii. Permitting and Inspection
    iii. Zoning, Parking, and Other Local Ordinances
c. Consumer Education and Outreach
d. Workplace and Multifamily Housing Stakeholder Education and Outreach
e. Workforce Development
f. Coordination with Electric Utilities.

VI. **Stakeholder Engagement:** *Input from community members and other stakeholders should inform your zero-emission vehicle readiness plans. Your plans will be strengthened by appropriately identifying, approaching, and building relationships and engaging in discussions with these partners.*

Transparency and ongoing communication with these partners will help you build trust.

a. Target Audiences and Partnerships
b. Engagement Strategies and Goals
c. Results of Previous Engagement Activities

VII. (Optional) **Siting Analysis:** *If your organization has already prioritized sites or types of sites for electric vehicle charging, those priorities can be shared in the readiness plan. This section could feature your decision to emphasize certain sites in the near term over others, detail the factors that went into those decisions, and/or highlight relationships you hope to build with site hosts.*

VIII. (Optional) **Lead by Example – Putting Electrification Into Practice with the Municipal Fleet.** *If your organization has plans or goals related to converting your own public fleets to zero-emission vehicles, they can be described here to show your broader commitment to transportation electrification.*

IX. **Transportation Electrification Goals and Implementation of the Plan.** *This section is the culmination of all previous sections. It provides a structure to your implementation plan and details the actions that you recommend or plan to take. Those actions should be listed on a specific timeline that will enable you to meet your electrification goals.*

a. Electrification Goals
b. Short-term (1–2-Year) Actions
c. Medium-term (3–5-Year) Actions
d. Long-term (6–10-Year) Actions

Identifying Funding and Implementation Support

Funding

Acquiring adequate funding is a key part of this process. A few key links for funding search tools are listed below. Additionally, please see the Appendix for two tables highlighting the breakdown of different funding sources, funding amounts, and eligibility requirements across state and federal levels (Appendix, Tables A.2 and A.3).

Resources:

- Federal funding sources from the Alternative Fuels Data Center
- State funding sources from the Alternative Fuels Data Center
- For future federal funding: Grants.gov
- U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy Exchange
- Technical Assistance Funding
    - Example: California Energy Commission Zero-emission Vehicle Infrastructure Grant Application Technical Assistance Funding

Permitting

Installing zero-emission vehicle infrastructure requires the processing and acquisition of appropriate permits. This process has functioned as a barrier to some projects, as seen in Theme 1 and Theme 5 later in this document. Below, we have collected a set of resources for learning about and navigating the permitting process in California. Additionally, Figure 10 provides an overview of the permitting process.

Resources:

- Planning and Zoning for Electric Vehicle Charger Deployment
- Permitting Electric Vehicle Charging Stations: Best Practices
- Electric Vehicle Charger Permit Streamlining
- GO-Biz Hydrogen Station Permitting Guidebook

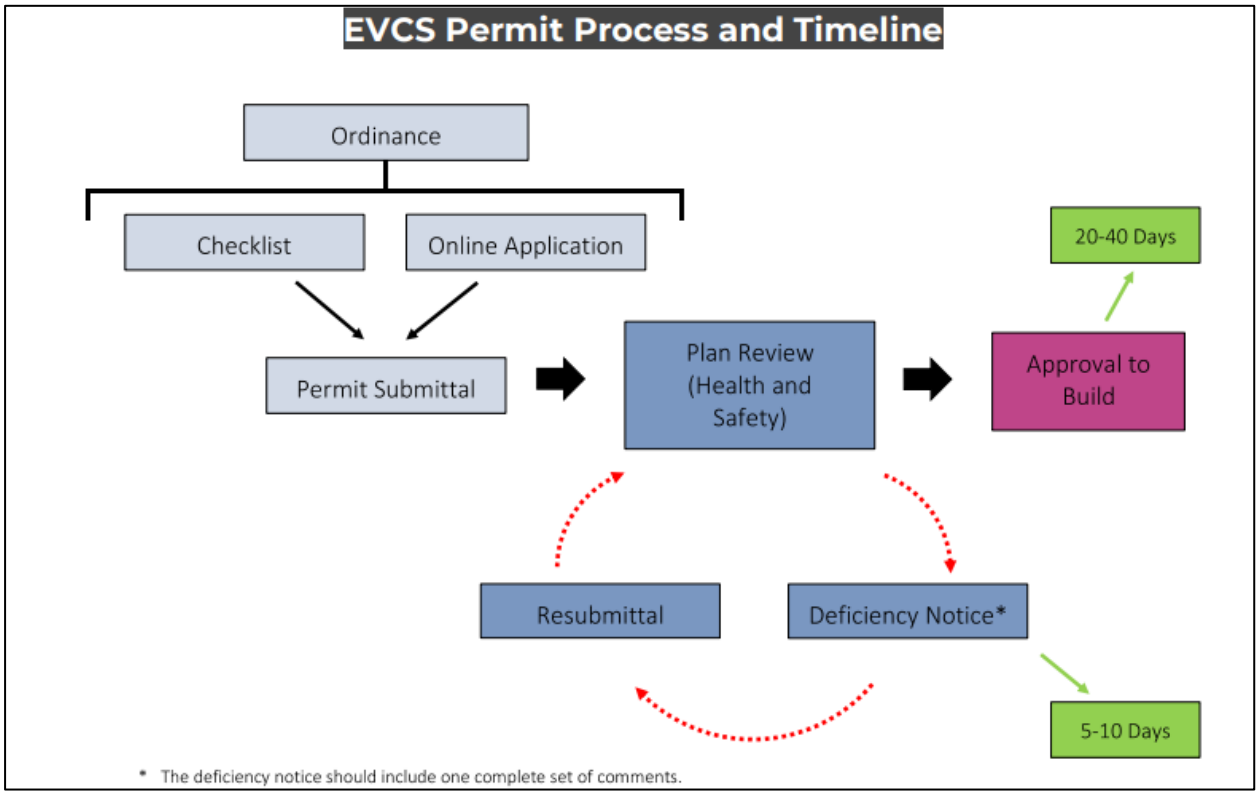
Quick View Permitting:

Key Bills

- **Electric Vehicle Charging Station Permit Streamlining (AB 1236, 2015, revised 2022)**
    - Requires California cities and counties to streamline their EV charging station permitting process.
- **Electric Vehicle Charging Station Permit Approval (AB 970, 2021- 2022)**
    - Jurisdictions are required to limit electric vehicle (EV) charging station review to health and safety requirements.

See Figure 10 for an overview of the permit process.

Figure 4



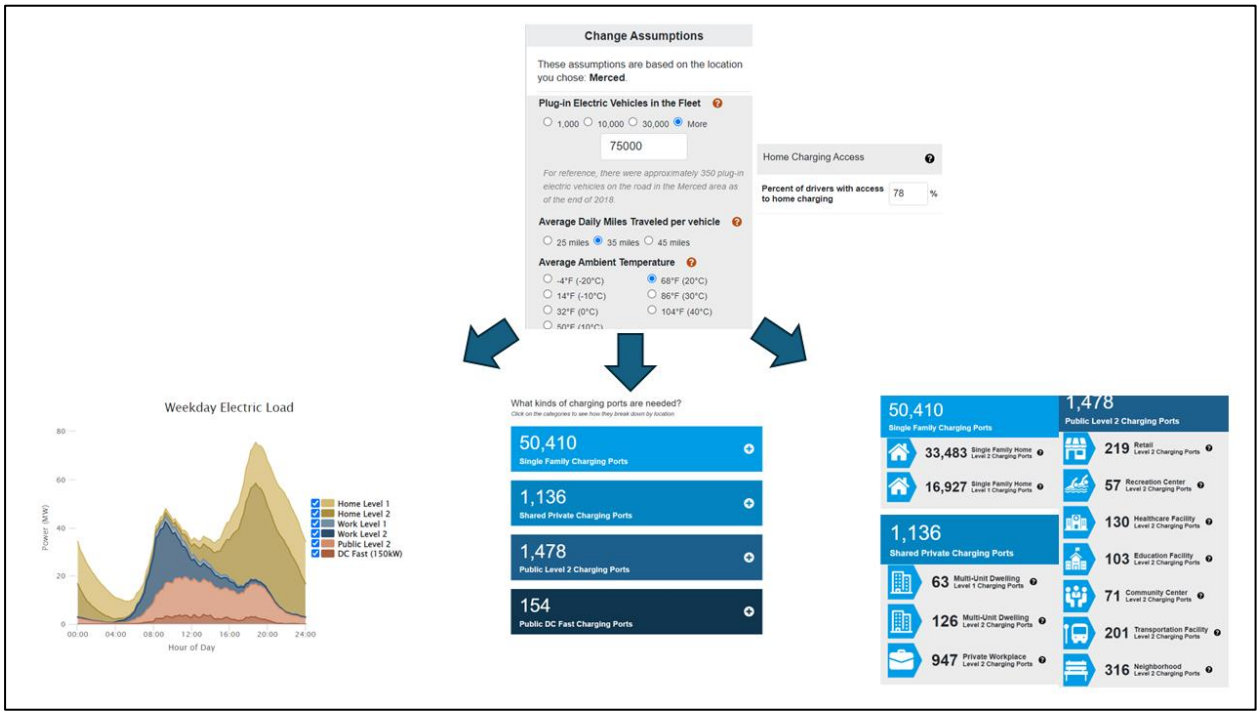
EVCS = Electric Vehicle Charging Station
Overview of the permitting streamlining (Assembly Bill (AB) 1236 Chiu, 2015) and AB 970 (McCarty, 2021) EV charging permit streamlining document

Infrastructure Mapping and Development

With the increased uptake of electric vehicles, local authorities and businesses need to anticipate the future need for electric vehicle charging. The Electric Vehicle Infrastructure (EVI) Toolbox by the U.S. Department of Energy Alternative Fuels Data Center provides cities and communities with an easy-to-use interface to estimate charging demand and inform charging infrastructure planning based on the expected uptake of electric vehicles. For example, users can develop scenarios of future charging demand based on input criteria such as number and type of zero-emission vehicles, average daily miles driven, access to home charging, preference for home charging (relative to public or work charging), and preferred charging strategy (e.g., immediate vs. delayed charging). From these inputs, various results are produced, including total expected power demand for charging, hourly charging profile, and recommendations such as the total number of charge ports needed, the different types of charge ports needed (e.g., Level 1 vs. Level 2 vs. direct current (DC) Fast), and the number of charge ports at different building types (e.g., single-family home, multi-

family housing, retail locations, educational facilities, etc.). Figure 5 contains screenshots of the EVI-Pro Lite tool to illustrate examples of the inputs and outputs of the tool.

Figure 5



Example of inputs and outputs for planning charging stations in Merced for 30% uptake of EVs(tool: EVI-Pro Lite)

Theme 1 – Zero-emission Vehicle Readiness Plans and Blueprints

Introduction

Across a range of zero-emission vehicle plans and blueprints (Table 1), we have collected key strategies, barriers, and gaps identified in zero-emission vehicle uptake planning. We found relevant plans and documentation for 25 counties of California's 58 counties. This section discusses common themes and strategies that were identified across the different counties.

Summary

Zero-emission vehicle plans were selected for review based on public availability and organized by county size (typically divided by population density). Zero-emission vehicle readiness plans typically include sections on local and state policies, community engagement, infrastructure planning, and details related to funding. Additionally, most plans include background sections where they define zero-emission vehicles and describe the policies that are motivating the switch to zero-emission vehicles, as well as provide background on climate change. Finally, some plans include sections on equity, best practices, fleet options, vehicle-miles-traveled reduction strategies, and implementation timelines – though these are less common (see reference section - county, city, and state zero-emission vehicle plans).

Table 1. Zero-emission Vehicle Blueprints/Plans by County Size

Large Metro	Medium	Small/rural	Other
Ventura*	Sacramento	Central Sierra/Tuolumne	City of Oakland*
Alameda	Kern	Kings*	Colorado State plan
Contra Costa	Fresno council*	Upstate (Northern) Counties Joint Plan (Siskiyou, Shasta, and Tehama)	North Carolina State plan
San Diego	Madera	Merced	Energy Commission Planning
San Bernadino	Mendocino	Butte	
Long Beach (medium- and heavy-duty vehicle focused plan)	Tri-county plan for San Luis Obispo, Santa Barbara, and Ventura		

* highlighted for its category based on the plan's readability, inclusion of clearly defined sections, and detailed planning.

Strategies: Common strategies to improve local zero-emission vehicle uptake as identified by zero-emission vehicle plans include:

- Increase existing charging infrastructure.
  - An emphasis on infrastructure development is very prevalent across the plans.

    - Many plans include separate sections devoted to infrastructure planning, mapping, funding, and installation.
    - Infrastructure planning within the zero-emission vehicle plans includes mapping, community surveys, funding summaries, and discussion around permitting and site identification.
- Develop community outreach and education systems.
    - Plans discuss protocols for community involvement in zero-emission vehicle uptake.
    - Community surveys, workshops, and interviews surrounding zero-emission vehicle use, charging convenience, and concerns
    - Plans discuss community participation in infrastructure planning and community engagement programs.
- Acquire funding to support large-scale (city- or county-wide) improvements.
    - Some plans include sections that discuss acquired and/or potential funding to support the development of necessary infrastructure and programs.

Barriers:

The main barriers to zero-emission vehicle uptake in readiness plans are infrastructure preparedness, lack of awareness of the benefits, upfront costs to consumers and jurisdictions for purchase and infrastructure needs, lack of multi-housing solutions for zero-emission vehicle use, large variability in community involvement and motivation, and lack of detailed planning for achieving state and local goals – see Table 2 and Figure 6. In rural areas, there are concerns about range suitability, charger functionality when network access is unavailable, and difficulty reaching chargers, both for use and repair, due to weather (see Tuolumne zero-emission vehicle blueprint).

- Social Barriers
    - The most frequently identified social barriers include lack of education and

Quick View Barriers: Funding, Access, Awareness, Time.

Common barriers across plans

- Lack of awareness and education
- Consumer perceptions
- Permitting issues/lack of support
- Lack of infrastructure in surrounding areas
- Uncertainty for low-income or multi-family dwellings
- Funding availability and suitability

Rural and remote specific barriers

- Inconsistent access to roads, chargers, and repair stations, typically due to large seasonal weather impacts.
- Network access concerns (unavailable or intermittent) due to remote locations.
- Range options and durability of available zero-

awareness, low community input and planning, and negative consumer perception of zero-emission vehicles.

- Technological/Infrastructural Barriers
  - The most frequently identified technical barriers include limited electrical/grid capacity for charging infrastructure, range of currently available zero-emission vehicles, charger infrastructure reliability (rural communities), lack of zero-emission vehicle infrastructure, and issues with permitting, charging or refueling infrastructure, and parking for multi-family buildings.

Table 2. Barriers to Zero-emission Vehicle Uptake

Barriers →	Lack of education resources	Lack of awareness	Cost	Lack of existing infrastructure	Shift from gas station model	Permitting process	Access to payment systems	Reliance on public charging	Lack of appropriate models	Lack of time to prepare to transition	Challenge identifying charging sites	Range anxiety	Lack of regional collaboration
Plans													
Ventura	X	X	X	X		X	X	X		X	X		
Alameda	X	X	X										
Contra Costa	X		X	X		X	X	X				X	
San Diego	X	X	X	X		X		X	X	X	X	X	X
San Bernardino	X	X	X	X		X			X			X	
Long Beach						X							
Sacramento			X	X									
Kern	X	X	X	X			X			X			
Fresno Council	X	X	X	X		X	X	X					
Madera			X						X				
Mendocino			X			X							
Tri-county plan (San Luis Obispo, Santa Barbara, and parts of Ventura)	X	X	X		X	X			X	X			
Central Sierra/Tuolumne			X	X		X	X					X	
Kings			X	X		X	X	X					
Shasta			X	X	X	X							
Merced			X	X		X						X	
Butte			X	X					X			X	
Oakland City	X	X	X	X					X			X	

(*Medium-Duty/Heavy-Duty vehicle plans)

Table 2 identifies barriers that are specified in each zero-emission vehicle plan reviewed. The purpose of this table is to illuminate the most common barriers that zero-emission vehicle plans find, or believe to be, in their communities. In addition to these barriers, "difficulty to get repaired/fix on your own" (San Diego and Kern) and "limited infrastructure related policies and mandates" (San Diego) were also noted; however, they do not appear in this table as they are mentioned rarely and/or fall under one of the other barriers listed.

FIGURE 6: BARRIERS TO ZERO-EMISSION VEHICLE UPTAKE

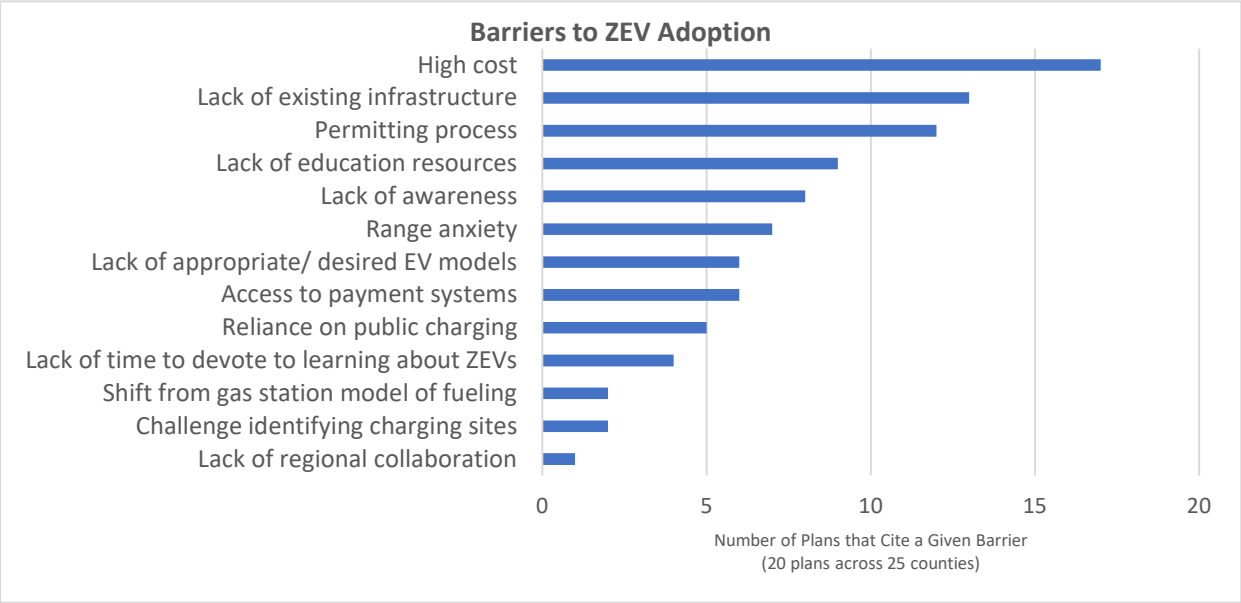
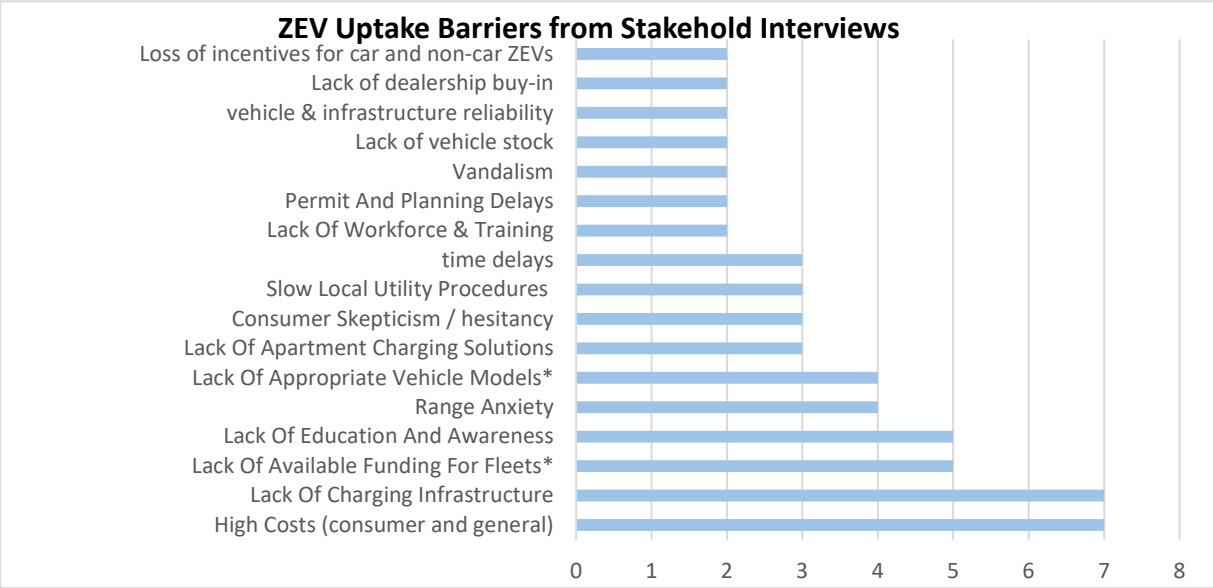


Figure 6 shows the frequency of specific barriers across the reviewed zero-emission vehicle plans (visual representation of Table 2). These barriers are identified at the county level as issues witnessed in their county either from direct experience or information from community members. Three additional plans were reviewed for comparison (California Energy Commission, North Carolina, and Colorado) but do not appear here as they have a statewide focus and lack specific information for California counties.

Bonus: Stakeholder Interviews - Barriers and Boosts to Zero-emission Vehicle Uptake:

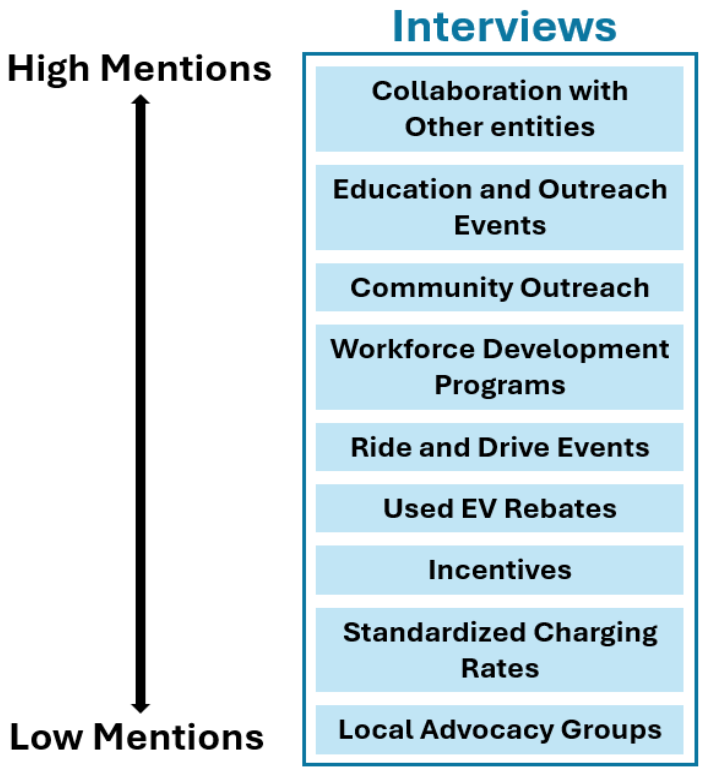
Along with reviewing academic literature and county plans, we interviewed stakeholders across California who work in the zero-emission vehicle space across a wide range of expertise. Across our interviews with ZEV planners and specialists, the primary barriers to uptake were lack of charging infrastructure, high costs, and lack of multifamily dwelling ZEV solutions. In addition, range anxiety and lack of funding and options for medium- and heavy-duty fleets were common issues. In comparison, in the ZEV planning literature, cost was by far the leading barrier listed, followed by lack of existing infrastructure, issues with the permitting process, and lack of education and awareness.

FIGURE 7A ZEV ADOPTION BARRIERS FROM INTERVIEWS



The stakeholder interviews provided high-level insight into the factors that can improve ZEV uptake. These include collaboration, outreach, and financial policy alterations – see Figure 7B.

FIGURE 7B STRATEGIES THAT BOOST ZEV UPTAKE FROM STAKEHOLDER INTERVIEWS



Theme 2 – Transportation Needs Assessments – Small-scale focus

Introduction:
Transportation planning and transportation needs assessments are necessary components of preparing for and reaching widespread zero-emission vehicle uptake. Across California, Transportation Needs Assessment Plans and general Transportation Plans are developed by community groups, local governments, and/or Metropolitan Planning Organizations. These entities take different approaches and often have different priority rankings. For example, community Transportation Needs Assessment plans focus more on community concerns and vulnerable communities, and government or Metropolitan Planning Organizations' plans share a broader focus on public transportation, infrastructure, and environmental implications. This section explores transportation plans from different planning groups and discusses common approaches.

Quick View Transportation Planning:

Community Transportation Needs Assessments:
- Community led
- Small scale focus
- Most concerned with public transportation and community barriers

Metropolitan Planning Organization Transportation Plans:
- Larger county/citywide assessment of transportation environment
- More focus on infrastructure

Transportation Planning within Zero-emission Vehicle Blueprints:
- Broad assessments of transportation environment
- Limited infrastructure mapping and community surveying

<u>Community</u> Transportation Needs Assessments Plans and Zero-emission Vehicle Planning:
Zero-emission vehicles are rarely mentioned in community Transportation Needs Assessment plans, and when they are, it is typically when discussing future possibilities for car-sharing options and local public transportation options. Additionally, zero-emission vehicle language is scarce throughout the plans. If any zero-emission planning is discussed, it is solely concerning hybrid- and battery-electric passenger vehicles and zero-emission buses. To enhance discussion and consideration of zero-emission vehicles within these plans, additional outreach and education activities appear warranted – especially activities like ride-and-drive events that give community members a chance to experience zero-

emission vehicles first-hand. Readers are encouraged to explore Transportation Needs Assessments from Stanislaus County, Kings County, and San Diego County.

<u>Metropolitan Planning Organizations'</u> Regional Transportation Plans, Transportation Needs Assessments, and Zero-emission Vehicle Planning:

Within transportation plans developed by Metropolitan Planning Organizations, there is more acknowledgement of zero-emission vehicles. However, there is often a lack of large-scale planning, such as city-wide charging infrastructure plans or county-wide developments for zero-emission vehicle travel. Zero-emission vehicles are discussed in these plans in a variety of ways: pilot programs for fleets and public transport options, authorizing funding for studies, and concerns surrounding how to counteract the reduction in gasoline taxes as zero-emission vehicle uptake increases. Examples of these types of plans are available from the San Diego Metropolitan Planning Organization, Tuolumne Regional Transportation Planning Agency, and the Stanislaus Metropolitan Planning Organization.

<u>Local Transportation Commission</u> Transportation Plans and Zero-emission Vehicle Planning:

Local transportation commissions typically include more details surrounding zero-emission vehicles and related infrastructure within their planning documents, often devoting a chapter or section to the projects planned or in progress in their communities. These plans also focus more on zero- and low-emission public transportation rather than private or small-scale options such as individual charger installation locations and consumer planning. However, as the Metropolitan Planning Organization and community Transportation Needs Assessment plans show, there is often a lack of detail regarding implementation. Ventura County and San Bernardino County have examples of transportation plans by local transportation commissions.

Community Transportation Needs Assessment Plans vs. Zero-emission Vehicle Blueprints:

Community transportation plans align with zero-emission vehicle blueprints in the areas of barrier assessment and concerns for community equity. Both the zero-emission vehicle blueprints and community Transportation Needs Assessment plans identify low-income and rural communities as those facing the highest barriers to zero-emission vehicle uptake and lacking adequate transportation options. Additionally, community Transportation Needs Assessments focus on public transportation needs, which aligns with the zero-emission vehicle plans and their vehicle-miles-traveled strategies. Unlike the zero-emission vehicle blueprints, community Transportation Needs Assessments lack much planning and discussion surrounding zero-emission

vehicle uptake and infrastructure preparedness. Kings County has examples of Community Transportation Needs Assessments and Zero-Emission Vehicle Blueprints.

Across the various transportation plans and assessments, several common barriers and strategies emerged.

Strategies for Zero-emission Vehicles Within Transportation Planning:

Among the different categories of transportation needs assessments and transportation plans, the primary focus is on infrastructure and transit planning. In these plans there is reduced focus on zero-emission vehicle readiness. However, a few shared strategies for zero-emission vehicle deployment do appear. The most common strategy relates to zero-emission public and shared transportation options. This includes zero-emission bus/shuttle services, zero-emission car-sharing options, and zero-emission vehicle 'loop' services that transport travelers between different public transit hubs. Most of the transportation plans lack planning for charging infrastructure and passenger zero-emission vehicles. Many jurisdictions with these plans have separate zero-emission vehicle plans/blueprints listed on their websites. However, they are rarely mentioned in the transportation plans (San Diego Transportation Plan, Ventura Local Transportation Commission's plan, San Bernardino Local Transportation Commission's plan). While transportation and zero-emission vehicle plans have different primary focuses, there appears to be an opportunity for better coordination and alignment between the goals and the strategies that they set forth.

Barriers Identified Within Transportation Assessments and Plans:

The majority of transportation assessments and plans reviewed focus on either community access to transportation or the future of local public and private transportation. Both community and Metropolitan Planning Organization transportation plans identify several barriers to local transportation and zero-emission vehicle uptake. The most frequently listed barriers are (lack of sufficient) funding, time constraints, and local preparedness. Local planners are concerned about securing sufficient and timely funding for substantial zero-emission vehicle infrastructure, as well as potential reductions in local funds from a declining gasoline tax. The San Diego Community Transportation Needs Assessment speaks to concerns about obtaining long term and/or large-scale funding, as well as the limitations of some funding sources such as from Clean Mobility Options. Specifically, concerns are expressed about the amount of funding available over the time needed for planning and construction (San Diego Community Transportation Needs Assessment).

Theme 3 – Vehicle-Miles-Traveled (VMT) Reduction Strategies

Introduction

Vehicle-miles-traveled, known as VMT, reduction strategies are commonly incorporated into local climate action plans to reduce transportation emissions from vehicles. Many plans set specific vehicle-miles-traveled reduction targets and outline a suite of land use and transportation policies to achieve those targets.

Context and Strategies

In addition to switching to ZEVs, air pollution, greenhouse gas emissions, and fuel consumption can also be reduced by vehicle miles traveled reduction strategies. However, vehicle-miles-traveled reduction plans and zero-emission vehicle readiness plans often do not explicitly connect to each other.

Highlighted Case: Reducing vehicle-miles traveled associated with transporting municipal solid waste.

City: Sacramento

Context: Sacramento's Climate Action Plan details many vehicle-miles traveled reduction strategies, including some that are not commonly found in other climate action plans. They also include metrics that track how much vehicle-miles traveled is reduced.

Example Action: Transport waste generated by residents and businesses to landfill facilities within the region rather than out of state, which will result in a reduction of over 1.2 million vehicle miles traveled per year.

Metric: Reduction of approximately 1,279,389 VMT per year

Quick View VMT Reduction Strategies:

- Improving pedestrian/bicycle infrastructure and connectivity (bike lanes, trails, traffic calming)
- Promoting transit-oriented development and increasing density around transit hubs
- Improving and expanding public transit services (more routes, frequency, bus rapid transit)
- Transportation demand management programs (ridesharing, telecommuting, parking management)
- Mixed-use and infill development to reduce distances traveled
- Parking management strategies (pricing, permits, reducing or eliminating minimum parking standards)
- Encouraging alternative modes like walking, biking, transit through education and incentives

Common vehicle-miles-traveled reduction strategies identified within climate action plans often relate to one of the following categories: 1) public transportation; 2) multimodal transportation; 3) car-sharing, ride-sharing, and shuttle services; 4) urban planning; and 5) traffic and parking management. Illustrative examples of strategies under these categories are included below, and a larger collection of examples is included in the Vehicle-Miles-Traveled Strategies Table in the Appendix.

- Public transportation
    - Provide bus stops with safe and convenient bicycle and pedestrian access, and essential improvements such as lighting, seating, and shading
    - Pilot and/or expand subsidized transit access for various communities (e.g., students, elderly, lower income, residents of certain locations, employees of certain sectors, etc.)
- Multimodal transportation
    - Expand and/or improve infrastructure for bicycles and e-bikes near public transit stops
    - Expand and/or enhance lanes and zones dedicated exclusively to bikes and/or pedestrians
    - Expand and/or enhance availability of bicycle and e-bike share infrastructure
    - Provide rebates and incentives for the purchase and use of e-bikes
- Car-sharing, ride-sharing, and shuttle services
    - Develop design standards for streets and parking lots to accommodate increased ride-share (e.g., dedicated pick-up and drop-off zones)
    - Implement strategies that prioritize lanes and parking for high-occupancy vehicles (e.g., carpools, vanpools and transit vehicles)
    - Tax breaks and/or incentives for employers to develop shuttle and carpooling services for their employees
- Planning
    - Transit-oriented development: "compact, mixed-use communities where people enjoy easy access to jobs and services" (Federal Transit Administration, 2024)
    - Complete streets: "...streets and networks that prioritize safety, comfort, and connectivity to destinations for all people who use the street network" (including drivers, pedestrians, cyclists, and transit users) (Federal Highway Administration, 2024)
    - Traffic calming: "physical design and other measures put in place on existing roads to reduce vehicle speeds and improve safety for pedestrians and cyclists." (U.S. Department of Transportation, 2019)
- Traffic and parking management

- Parking Cash-out Program: Commuters offered subsidized parking by employers are also offered the cash equivalent if they use alternative travel modes
- Reduce or eliminate minimum parking standards (i.e., the minimum number of parking spaces buildings are required to have), establish parking standard maximums (i.e., the maximum amount of parking spaces that buildings can have), and/or public parking fees that disincentivize individual driving
- Pilot and/or expand locations and/or times when traffic is limited or prohibited (e.g., New York City's Congestion Pricing Program, Siclovia/CicLAvia/Cyclovia Events)

Highlighted case: Equity-Centered Approach

City: Cupertino

Context: The city of Cupertino's climate action plan (CAP) outlines various strategies to reduce VMT. Many of their strategies include considerations for low-income populations through grants and incentives. The direct consideration for underserved communities stands out compared to other CAPs.

Example Action: In addition to general public outreach, conduct targeted outreach to students, low-income and fixed-income people, historically underserved communities, elders, and disabled individuals with access needs during analysis of transportation policies to understand the community's potential concerns.

Example Action II: Define equity metrics for implementation of incentives based on feedback from local students, low-income and fixed-income people, historically underserved communities, elders, and disabled individuals with access needs and structure the incentive programs to meet these metrics.

The applicability of vehicle-miles-traveled reduction strategies varies across urban versus rural contexts. Urban areas have more opportunities for effective transit, density, and non-motorized transport strategies. Rural areas might rely more on transportation demand management.

Common barriers/gaps include funding limitations, requiring coordination across agencies, and public acceptance of measures like parking pricing or land use changes. Equity considerations are highlighted in some plans (see Cupertino Climate Action Plan call-out box) in terms of ensuring accessibility and avoiding disproportionate impacts on low-income or disadvantaged communities. There also appears to be an opportunity for better coordination between vehicle miles-traveled-reduction strategies and zero-emission vehicle strategies. For example, policies and incentives

could be put in place to ensure that multimodal transportation, car-sharing, ride-sharing, and shuttle services prioritize zero-emission vehicles (and the appropriate underlying infrastructure). Additionally, if fewer parking spaces are mandated for newly constructed commercial buildings and apartment buildings, there will likely be a growing need for public/shared charging at those locations.

Theme 4 - Funding Resources

Introduction

Across levels of federal government, state government, electric utilities, and private entities, there are many opportunities for funding and incentives related to zero-emission vehicle uptake. However, as noted in Theme 1, cost and lack of funding are often cited as barriers to zero-emission vehicle planning and uptake. This section provides a sample of funding sources across different levels and for different purposes. Additionally, we have highlighted several tools that are focused on helping consumers search for and identify funding sources to support zero-emission vehicle planning and purchase. More resources and examples are also available in the Appendix.

Federal Funding

Federal funding is most typically available for larger projects covering infrastructure (fueling/charging) planning and installation. Some funding is available for public transit transition projects.

Highlighted source: National Electric Vehicle Infrastructure, or NEVI, Formula Program

The NEVI Formula Program provides funding to states for fiscal years 2022-2026 to procure and install electric vehicle chargers with the goal of building a national network of chargers along corridors and Interstates.

State Funding

California has resources available for funding zero-emission vehicles at the state level. As with federal funding, there are specific

Highlighted source: Alternative Fuel and Vehicle Incentive

Funding for projects supporting zero-emission vehicle uptake. This includes electric vehicle charging infrastructure, hydrogen vehicles and refueling infrastructure, medium/ heavy-duty vehicles, and workforce development.

Quick View Funding:

Federal and State Funding:

Incentives, rebates, loans, exemptions applicable to a range of ZEV enterprises including

- Charging and fueling infrastructure
- Fleet purchase
- Vehicle exchange
- Workforce development and training

Utilities/Private funding:

Acquired from local utilities or private sources such as

- Pacific Gas & Electric
- Southern California Edison
- Local government water and power divisions

Tax Credits:

Eligible entities include

- Individuals
- Businesses
- Fleets

eligibility requirements for each source. However, state funding tends to support a wider range of projects across governments, businesses, and individual consumers.

Utilities and Private Funding:
There are a variety of incentives and rebates available from electric utilities and private funding sources. Funding from these entities is often county/city specific, so there is much more locational variability in available resources.

> Highlighted source: Southern California Edison's Charge Ready Program
>
> This program offers rebates for businesses, government, and multifamily dwellings for electric vehicle charger installations. Additional funding is available for disadvantaged communities.

Tax Credits:
Individuals and businesses that acquire and install electric vehicle charging equipment before June 30, 2026, may be eligible for federal tax credits:

- ***Consumers*** can receive a tax credit of up to $1,000 for electric vehicle chargers installed at their primary residence.
- ***Businesses, fleets, and tax-exempt entities*** can receive a tax credit of up to $100,000 for each charging port (and accompanying energy storage units) installed. Fueling and storage infrastructure for hydrogen, natural gas, propane, E85, or biodiesel blends of at least 20%, known as B20, may also be eligible for this credit.

Additional details about these tax credits (including eligibility requirements) can be found at the Alternative Fuels Data Center website.

Online Funding Resources and Tools:

Multiple online tools and resources can help prospective zero-emission vehicle buyers learn more about the technology, as well as find suitable vehicles, charging infrastructure, and relevant funding incentives. A few of these resources are highlighted in the call-out box below.

Highlighted Sources:

- DriveClean (CARB tool)
  - Allows consumers to search for vehicles, applicable incentives, vehicle types, and charging and fueling information. Additionally, DriveClean provides learning guides about zero-emission vehicles and local options for zero-emission vehicle support.
- Plug In America
  - Runs programs like PlugStar to help consumers learn about zero-emission vehicles and how to make the switch. PlugInAmerica also runs campaigns such as Drive Electric Earth Month and National Drive Electric Week to help increase awareness and provide zero-emission vehicle educational resources.
- Electric For All
  - A consumer facing tool for learning about zero-emission vehicles including different funding options, vehicle model information and comparisons, and resources about vehicle chargers.

Figures 8 and 9 provide some illustrative examples of these services.

Figure 8. Example of search for eligibility for tax credits and rebates (source: ElectricForAll)

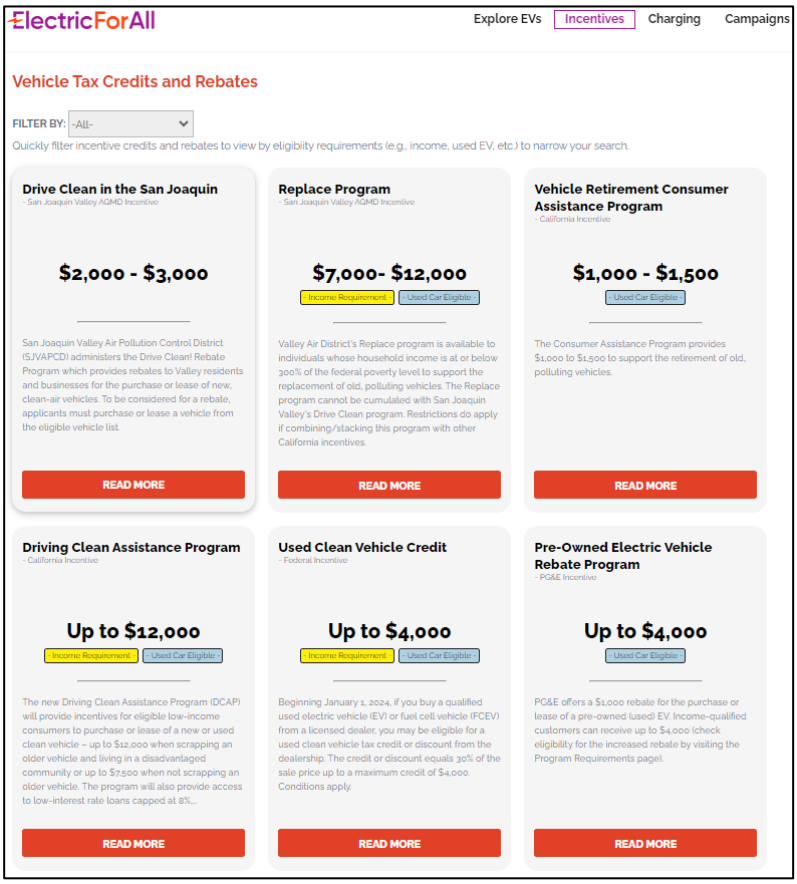
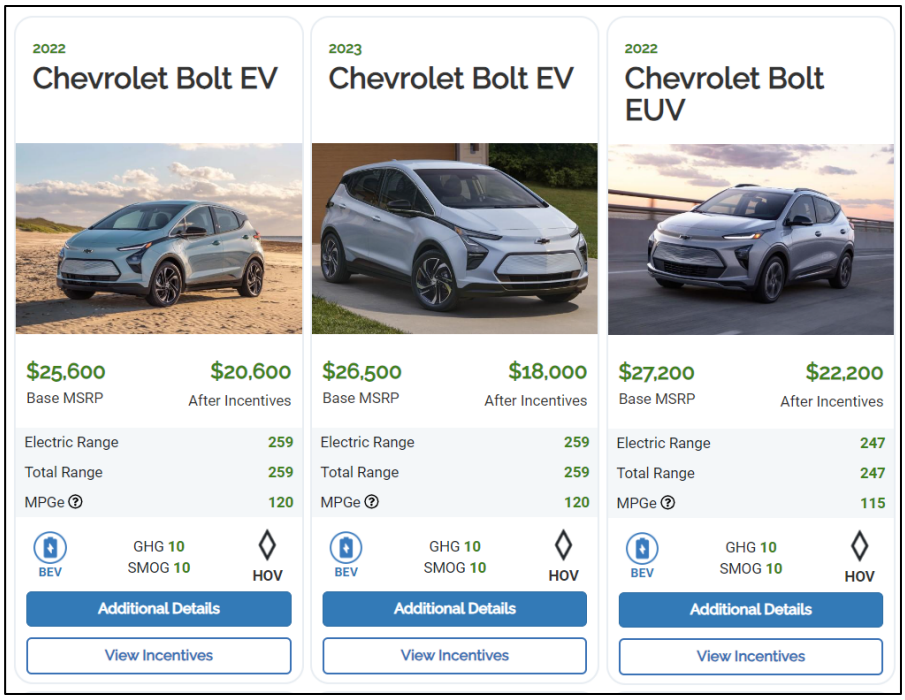
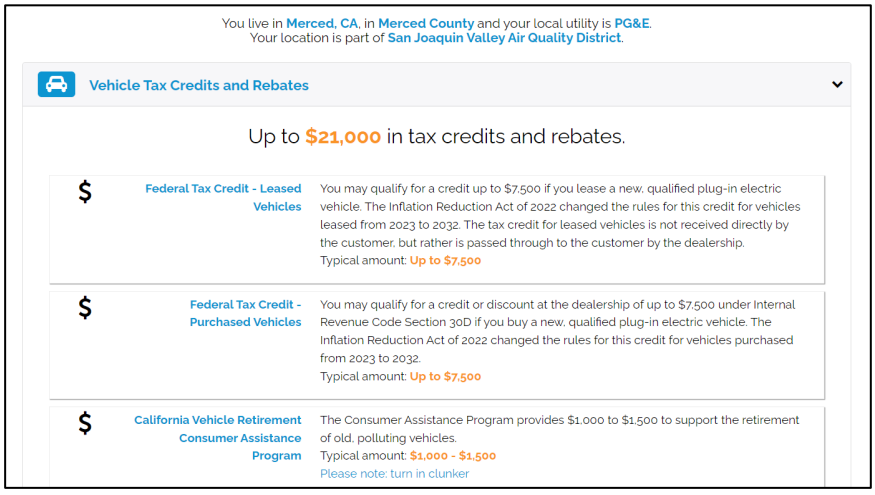


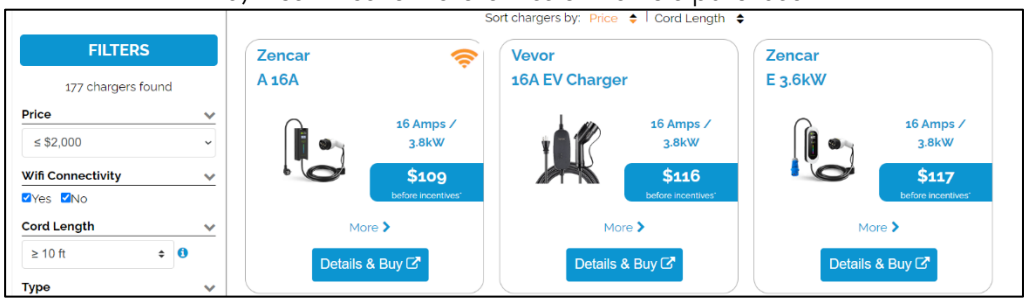
FIGURE 9



a) Some of the most affordable zero-emission vehicles available on the market



b) Incentives for zero-emission vehicle purchase



c) Home charger cost example

Figure 9 (a,b,c) provides an example of the information provided by tools like DriveClean, PlugStar, and Plug In America that consumers can use to identify zero-emission vehicles, incentives, and at-home charging.

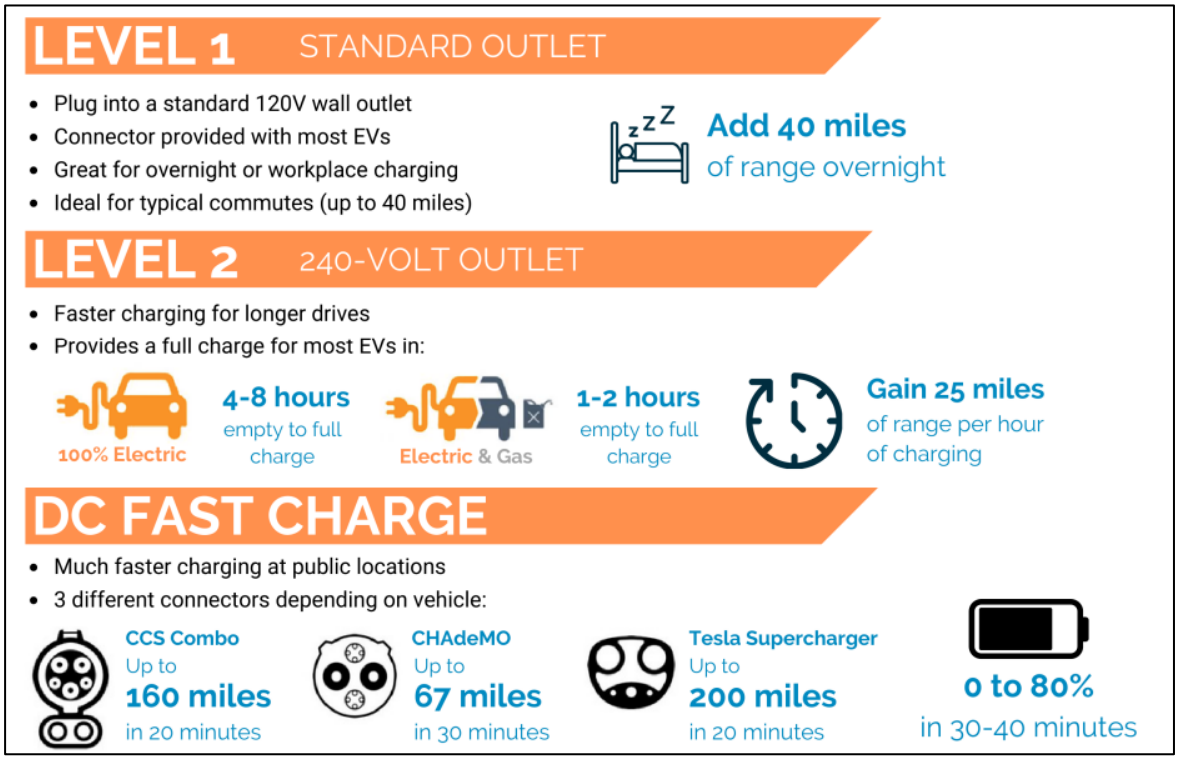
Theme 5 – Charging Infrastructure and Electric Utilities

Introduction

This section discusses key issues, challenges, considerations, and potential solutions related to zero-emission vehicle charging infrastructure and integration with the electricity grid. Specific topics of discussion in this section include equitable access to charging, permitting considerations and other soft costs, reliability and compatibility of charging infrastructure, and connectivity with the electricity grid.

When procuring and installing electric vehicle charging infrastructure, there are several factors to consider, including the type of charger (e.g., slower charging vs. faster charging), user interfaces, compatibility with different vehicle types, payment systems, siting, permitting, and data collection. Figure 10 provides an overview of different charging categories and the typical charge times associated with them. A detailed discussion of charging equipment and infrastructure is included in the Appendix.

FIGURE 10



*Overview of the Charging Options and Speeds available (*Plug In America*)*

Equitable Access

A key difference between electric vehicles and internal combustion engine vehicles is the option to refuel them in many locations (e.g., home, work, public charging station) rather than relying on dedicated gas stations or fuel depots. This flexibility can be

beneficial. However, questions arise about whether these benefits can be accessed and shared relatively equitably across all communities and user groups. The remainder of this section describes some of the key issues that may inhibit equitable access to charging, as well as some potential solutions for addressing these challenges.

Challenges

1. Limited private parking: Multi-family homes and rental units without private off-street parking may not support home-based electric vehicle charging for residents.
2. Infrastructure barriers: Existing electrical infrastructure in older buildings often cannot support high-power charging, necessitating costly upgrades.
3. Regulatory and policy barriers: Local regulations and building codes may not support or facilitate the installation of electric vehicle charging stations.
4. Economic disparities: Economic constraints among residents in multi-family units can limit access to electric vehicle charging due to the high costs of installation and usage. Additionally, the cost of charging in public is often higher than charging at home, thereby creating a potential economic disparity between electric vehicle drivers with and without access to at-home charging.

Potential Solutions

1. Policy initiatives: Local government initiatives and amendments to building codes can facilitate the installation of electric vehicle chargers in multi-family dwellings. This includes incentives for building developers and owners to install charging stations and policies ensuring that new buildings are electric vehicle ready. For example, the City of Burbank has adopted electric vehicle charging codes for new (dwelling) construction that specify 40% of the total number of parking spaces in new multi-family development project shall have Level 2 electric vehicle charging receptacles, and 15% of the total number of parking spaces in dwellings with at least 20 units should have Level 2 electric vehicle charging equipment (local energy codes map). Similarly, the City of Angels Camp has proposed a reach code that requires 50% of parking spaces in new/remodeled commercial developments to install Level 2 electric vehicle chargers (City of Angels Proposal). For additional examples of electric vehicle charging equipment ordinances across different jurisdictions, as well as a template reach code for electric vehicles, readers are encouraged to visit the electrification tab of the California Energy Codes and Standards website.
2. Technical solutions: The integration of smart technology in electric vehicle charging systems, such as contactless payments and grid-responsive charging systems, can manage usage and help reduce overall costs. Technologies like

battery storage systems are mentioned as beneficial for managing demand spikes and reducing load on the electrical grid.

3. Community and curbside charging: For buildings where installing individual chargers is impractical, community charging hubs and curbside charging are proposed as viable alternatives. These solutions can provide access to charging without the need for extensive individual infrastructure. The Central Sierra Zero Emission Vehicle Readiness Plan details some of the benefits, considerations, and specifications associated with curbside electric vehicle charging in the public right-of-way. For instance, curbside electric vehicle charging can benefit residents who might not have access to at-home and/or off-street parking. Additionally, the high visibility of curbside electric vehicle charging might assuage concerns over charging access that some residents may have when considering whether to lease or buy an electric vehicle. To enhance the potential benefits of curbside electric vehicle charging, municipalities should consider protocols for fining and/or towing non-electric vehicles that park in the spaces designated for charging. Additionally, protocols for user payment systems, data management, operations, and maintenance are also beneficial.

Permitting and Other Soft Costs

Electric vehicle charging hardware, installation, and labor costs are often the most visible costs when installing charging equipment. However, there are other soft costs to consider, including permitting delays, electric utility interconnection requests, and regulatory compliance. The following is a brief description of some of the key soft costs that may inhibit zero-emission vehicle implementation and readiness, as well as some potential solutions for addressing these challenges.

Challenges

1. Delays associated with limits on electricity grid capacity: Candidate sites for installing electric vehicle chargers, especially DC Fast (Level 3) chargers, may require new and/or upgraded electrical distribution infrastructure. However, the timeframe for electric utilities to provide adequate electricity to a site is often several months and can sometimes take multiple years. Causes for these long timeframes range from shortages of critical electrical equipment (e.g., transformers) to regulatory and implementation issues associated with installing new transmission and distribution lines.
2. Limited staff capacity: The permit review process associated with new electrical distribution infrastructure and electric vehicle charging equipment can face delays due to staffing shortages, challenges with coordinating across departments, and competing priorities and responsibilities among staff.

3. Variability and complexity across projects: Electric vehicle charging stations can vary considerably with respect to their complexity (e.g., installing DC Fast chargers and supporting electrical infrastructure in a dense urban area), location, charger type, and size. This variability can inhibit the ability to establish a standardized permitting and review process.
4. Ensuring compliance with the Americans with Disabilities Act (ADA): The process of ensuring accessible pathways to electric vehicle chargers, appropriate signage, and sufficient compliance review can add costs and complexity to the project.
5. Ensuring sufficient safety precautions are in place: Due to the larger equipment and higher amounts of electricity drawn by DC Fast chargers, additional health and safety reviews and precautions may be required.
6. New or revised planning codes may be needed for stand-alone charging stations: In cases where a stand-alone electric vehicle charging station (like a gas station) is proposed, a jurisdiction's existing planning code may not apply or provide sufficient guidance. In such cases, the planning department may need to propose new and/or revised codes. Note: this is less of an issue if the chargers are installed as an accessory to sites where the primary purpose is retail, workplace, or residence.
7. Obtaining funding for electric vehicle charging stations: Grant funding is often the primary – if not only – mechanism available for electric vehicle charging stations in smaller, lower-income, and rural locations that may not align with the business model of private installers. In these cases, the grant programs are often oversubscribed and/or have a high burden to apply, which may reduce and/or delay the funding that is ultimately obtained by local jurisdictions. Many jurisdictions also may lack staff with the requisite expertise and experience to develop competitive grant applications. Additional discussion of funding-related issues is included in Theme 4.

Potential Solutions

1. Address electricity grid capacity and energization delays: There is an opportunity for state agencies and electric utilities to work together to reduce delays associated with installing and/or upgrading electrical infrastructure to support expansion of electric vehicle chargers. For example, SB 410 (The Power Up Californians Act) requires the California Public Utilities Commission to set timelines and track compliance with respect to expanding and upgrading electricity distribution capacity and capabilities. Additionally, state agencies can develop tools and resources such as the California Energy Commission's (CEC's) Electric Vehicle Supply Equipment Deployment and Grid Evaluation tools to

help local jurisdictions learn about and implement best practices for charging siting and installation.

2. Alleviate staff capacity challenges: One possible approach for addressing some of the staffing shortages and competing priorities amongst staff could be to explore, develop, and implement processes for automating aspects of permitting. For example, a platform called Solar APP+ developed by the National Laboratory of the Rockies automates aspects of the permit process for residential solar energy and has been found to reduce the amount of time staff spend by 15-60 minutes per permit (Williams et al. 2022). Using Solar APP+ as a template for a similar platform related to electric vehicle charging infrastructure permitting might yield a comparable increase in staff and process efficiency. Additionally, local jurisdictions might benefit from adjusting their organizational structure and management practices to reduce barriers to coordination across staff and departments.
3. Implement planning codes that support electric vehicle charging as a primary use: Adapting or developing planning codes that allow for electric vehicle charging as a stand-alone site use can eliminate the need for these sites to be considered on a case-by-case basis. For example, in 2022, San Francisco updated its planning code to include electric vehicle charging stations under the "Automotive Use" category. This change enables stand-alone charging stations to be sited anywhere where gas stations and parking lots are allowed.
4. Remove hurdles and uncertainty associated with grant applications: State agencies and funding providers can give additional technical assistance during the proposal process to ease the burden of application on local jurisdictions – especially for smaller, lower-income, and rural locations. Additionally, as an alternative to competitive grants, two-step grant processes and/or formula-rated grants might reduce some of the uncertainties and burdens associated with the application process.
5. Dashboards for tracking progress and learning about best practices: Tools such as the CEC's Electric Vehicle Infrastructure Project Tracker (currently in development) can help with the collection and public sharing of data and information related to on-ground electric vehicle charging infrastructure, including turnaround time on permits *(CEC, 2023b).*

For further information on permitting issues and other soft costs, readers are encouraged to review the policy brief, "Overcoming roadblocks to California's public EV charging infrastructure" by Conrad, Hehmeyer, and Cain.

Electric Vehicle Charger Reliability

Electric vehicle users express frustration over parking at a charging station only to find out that the charger is not working. A recent report found that 25% of DC Fast charging

stations in the Bay Area are non-functional [article on functionality of Bay Area chargers (Rempel et al., 2022)]. This issue relates to the earlier topic of equitable access to charging. If lower-income residents and those who live in multi-family housing are less likely to have access to dedicated charging at their residence, then access to reliable public electric vehicle charging is paramount. Other issues that can arise include lengthy wait times, difficulty initiating charging sessions, slow charging speeds, identifying and navigating to a charging location, finding clear information about a charging location (e.g., location, port availability, pricing, payment methods, amenities, etc.), accessing quick and reliable help if an issue arises, and lack of personal safety and comfort while at the charging location (charging tips webpage). As discussed below, there are several possible causes and challenges associated with charger reliability, as well as some potential strategies for reducing reliability issues.

Challenges

- Charger/network errors: This can occur due to charger hardware, software, or network provider failures. These issues are exacerbated if site hosts that operate chargers lack the resources and/or knowledge to provide proper maintenance.

- Internal payment system failures: This can happen when a charger/charging network provider's smartphone app does not work when the user attempts to pay for a charging session. For additional information about challenges and best practices associated with payment systems, readers are encouraged to review "Best Practices for Payment Systems at Public Electric Vehicle Charging Stations" developed by the National Charging Experience Consortium (ChargeX Consortium).

- External payment system failures: This can occur when the payment using a third-party payment processor (e.g., credit card) does not work, or the payment terminals that read card payment slots are broken (see Figure 11).

Figure 11

Example of Non-functional Card Reader. Image from Wall Street Journal

- Charge initiation/interoperability failures: This can arise due to a communication failure between the charger and the electric vehicle when exchanging charging parameters. The complexity of interoperability sometimes produces errors that do not allow the electric vehicle to charge.

- Unmonitored failures: This may be physical damage to chargers that may not be remotely detected by the network operator and may require customer reports to find out about an issue (e.g., screen fade, bent connector, damaged cable) (see Figure 12).

Figure 12

Example of broken connector. Image from SpeakEV

- Unclear metrics for tracking reliability: One obstacle to the reliability of electric vehicle chargers is defining the metric of uptime (the percentage of time that the charger is properly functioning). California and other states have minimum uptime requirements. However, more specificity may be needed in terms of uptime ownership (i.e., establishing which stakeholders are responsible for monitoring uptime and taking corrective action if/when uptime drops below the required threshold).

Potential Solutions

- Develop standardization across jurisdictions: A standard across jurisdictions is needed to clarify which stakeholders are responsible for maintaining and keeping the proper uptime for chargers. Many stakeholders are involved with charging equipment, including the local electric utility, the installer, the site host, the charge point operator, or the servicing company. Clarification through

regulations on what each stakeholder must do to maintain the minimum regulated uptime could lead to improved charger reliability.

- Support and require preventative maintenance: Once an electric vehicle charger is installed, it must be properly maintained to prevent charging failures. To support this, manufacturers should work on creating a standard error code system that alerts owners of issues with the charger. This standard error code can help clarify which parts are subject to failure and may need replacement. Additionally, a workforce of trained technicians that can respond in a timely manner will be needed. (Charger Reliability | EnergyTech, 2023).

- Establish standards and/or requirements for charging infrastructure: Given the broad and often complex landscape of electric vehicle charging equipment types, electric vehicle types, charging systems operators, system users, and the interaction between all of the above, local governments will likely benefit from establishing clear standards and requirements for charging infrastructure in their jurisdictions. This can be supported by uptime record-keeping and reporting standards developed by the California Energy Commission and the California Public Utilities Commission (e.g., California Public Resources Code 25231.5)

  For instance, localities might choose to align with the National Electric Vehicle Infrastructure Standards and Requirements rule (23 Code of Federal Regulations (CFR) Part 680; Federal Highway Administration (FHWA) Docket No. FHWA-2022-0008; Reference Identification Number (RIN) 2125-AG10) established by the United States Department of Transportation's (U.S. DOT) Federal Highway Administration (vehicle infrastructure standards website).

  Relatedly, when choosing charging infrastructure providers, local jurisdictions might prioritize organizations that incorporate the Open Charge Point Protocol (OCPP) and support Minimum Required Error Codes that aim to simplify troubleshooting when electric vehicle charging does not function as expected, and help increase overall reliability and satisfaction with electric vehicle charging. For additional details about Minimum Required Error Codes, readers are encouraged to review the recommendations guide and implementation guide developed by the ChargeX Consortium.

  Finally, voluntary conformance testing and certification, such as that conducted at the Vehicle Interoperability Testing Symposium (VOLTS) in May 2023, could help enhance interoperability between different electric vehicles and electric

vehicle charging equipment (VOLTS Details). This type of testing and conformance can contribute to the establishment and implementation of communication standards (e.g., Plug & Charge communication standards such as DIN SPEC 70121 and ISO 15118-2) that are vehicle-based, simplify charging, and reduce payment failures. Local, state, and federal officials may also consider requiring these communication standards for new public charging infrastructure. For additional information, readers are encouraged to review Meetings and Workshops for Advanced Clean Cars II (ACC II) Amendments (Advanced Clean Cars II workshop page) – especially the workshop presentation (Advanced Clean Cars II presentation) and public comments (document with public comments) associated with the June 2024 meeting.

- Develop key performance indicators for user-experience at public charging points: Local jurisdictions can encourage and support electric vehicle charging equipment providers and charging station operators to collect, track, improve, and share data related to the most important factors associated with charging reliability and satisfaction: finding a charger, accessing a charger, starting a charge, completing a charge, personal safety/comfort, and getting help. For additional information about user-oriented key performance indicators, readers are encouraged to review "Customer-Focused Key Performance Indicators for Electric Vehicle Charging" developed by the National Charging Experience Consortium (ChargeX Consortium).

For further information on electric vehicle charger reliability, readers are encouraged to review the 2024 staff report titled "Tracking and Improving Reliability of California's Electric Vehicle Chargers: Regulations for Improved Electric Vehicle Charger Recordkeeping and Reporting, Reliability, and Data Sharing" prepared by the CEC.

Theme 6 – Workforce Development

Introduction

As zero-emission vehicle uptake increases to meet California's goals, it is imperative to develop a strong, broad, and well-equipped workforce to support this new transportation model. This includes jobs in sales, electrical, construction, repair, technology, and more. This development will be best supported by a coinciding program of community engagement and education that helps boost knowledge and awareness surrounding zero-emission vehicles and broader transportation initiatives. This section contains examples across training, funding, and community resources pertaining to zero-emission vehicle workforce development and support.

Training/certification programs

Training and certification programs have been developed for several aspects of the zero-emission vehicle landscape. This includes electrical and charging infrastructure, consumer relations (sales), and vehicle maintenance. For example, the California New Motor Vehicle Board's EV Expert Pledge, which encourages car dealerships to adopt best practices related to the sale of EVs. Below is a sample of training and certification programs (see Appendix for more information).

- *Electric Vehicle Infrastructure Training Program (EVITP training program page)*
    - The EVITP program is focused on training certified electricians on how to install charging equipment in North America. The course focuses on providing trainees with a well-rounded knowledge base of the electric vehicle industry and market. A large list of industry partners (e.g., General Motors, BMW, Pacific Gas & Electric, etc.) collaborate with the program. Partners come from the automotive, electric utility, and charging equipment manufacturing industries, where their up-to-date knowledge and resources provide the program with an updated curriculum.
    - Users of the program must be state-licensed or certified electricians, meaning this program is for individuals in the workforce who have good experience with electrical systems. Within the course, topics such as customer relations, charging station fundamentals, and national safety and electrical codes are covered. This is an online course, allowing easy access for workers. Individuals must apply online to get into the training program.
- *Medium- and Heavy-duty Training Hub from the Electric Truck Research and Utilization Center (eTRUC main information page)*
    - Gathers information, resources, and stakeholders to advance the deployment of high-power charging infrastructure along critical freight corridors and support the overall development of heavy-duty zero-emission trucks. Efforts include a Workforce Development Mapping Tool and a report on workforce development.

- *Alternative Fuels Data Center Electric Vehicle Safety Training Resources for First and Second Responders (Resources for first and second responders)*
    - To train and educate first and second responders for electric vehicle-related emergencies, the Department of Energy compiled a series of training resources. These resources span different organizations and groups and consist of different modes of learning. There are specific resources targeting firefighters, law enforcement, and emergency medical services officials. Provided resources include online training courses, videos, and reports that educate responders on what to do in emergencies when an electric vehicle is involved.
- *Battery Workforce Challenge (Battery Workforce Information)*
    - The U.S. DOE and Stellantis have recently initiated the Battery Workforce Challenge Competition, known as BattChallenge. This initiative, a collaboration between public and private sectors, aims to cultivate a new generation of engineers, technicians, and workers to meet the growing needs of the domestic electric vehicle and battery industry. Managed by Argonne National Laboratory and supported by industry leaders in the electric vehicle and battery sectors, BattChallenge is a key component of the larger Battery Workforce Challenge Program. This comprehensive program also incorporates regional training through vocational and community colleges, youth education in science, technology, engineering, and mathematics, known as STEM, and an online platform for career and technical education.
    - Launched in October 2023, the competition series within the Battery Workforce Challenge engages 12 North American universities and various vocational schools, such as the University of California, Merced (UCM), Merced Community College (MCC), California State University, Los Angeles (UCLA), and Cerritos College. These institutions are tasked with the design, construction, testing, and integration of advanced electric vehicle batteries into future Stellantis vehicles. The participating universities are expected to establish productive partnerships with community colleges, trade schools, and other vocational education providers to tackle complex battery engineering and manufacturing challenges. This cooperative effort ensures that all participating institutions maximize their potential, bringing innovative solutions and enhancing workforce training in the sector.

Funding for Education and Workforce Development

In addition to the funding resources listed in Theme 4, there are sources of funding devoted to building and improving zero-emission vehicle workforce strategies and

programs. These sources typically fund other organizations, such as schools and colleges, to develop training programs.

- *CEC Clean Transportation Program* (Energy Commission Program)
    - Investing in manufacturing and workforce training and development
    - Partnerships include California Community Colleges Advanced Transportation and Logistics program, California Community Colleges Chancellor's Office, Employment Development Department, and Employment Training Panel.
- *CEC Zero-Emissions Vehicle High School Pilot Project* (Energy Commission high school pilot project)
    - Funding awarded to 51 high school programs offering clean fuel technology training
- *CEC Zero-Emissions Vehicle Training Enhancement Program* (Energy Commission training program)
    - Funded 15 community colleges to support workforce technical training needs
- *CARB Adult Education and Vocational School Zero-Emission Vehicle Technology Training Project (CARB training project)*
    - $1.5 million available for entities that support and/or offer education and workforce training for zero-emission vehicles and charging and fueling equipment education

Theme 7 – Community Engagement and Education

Introduction

General education and awareness about zero-emission vehicles is an important contributor to ZEV Readiness. Additionally, higher levels of education and awareness on the topic can also facilitate higher levels of community involvement in zero-emission vehicle plans and blueprints. This section highlights some core issues, examples, and resources related to community engagement and education surrounding zero-emission vehicles.

There are a wide range of efforts to identify and support key community outreach and education across California and beyond. Here, we describe some of the common barriers and solutions that arise from these efforts:

Barriers

Some of the most identified social barriers are lack of education and awareness, low community input and planning, consumer perception of zero-emission vehicles, and issues with charging infrastructure and its permitting, and parking/charging access for multi-family buildings.

Solutions

Invest in education and engagement, design media campaigns and information sharing, support tax credits for zero-emission vehicle and hybrid-electric vehicle owners, increase infrastructure maintenance funding, improve collaboration with community-based organizations, and more. Furthermore, some plans suggest establishing a trade union and/or partnerships with local high schools and community colleges.

Highlighted examples:

Sacramento has developed a community Mobility Hub. At this hub, they offer zero-emission vehicle car sharing so community members can use and test vehicles, as well as use the chargers at the mobility hub. Additionally, their 'Plan, Share, Go' program offers a fleet of eight hydrogen fuel cell vehicles to transport community members for job interviews and trainings, grocery shopping, medical assistance, and more.

The Port of Long Beach developed the *Zero Emissions Workforce Development Report,* where they identified electricians, solar photovoltaic installers, automotive specialty technicians, electrical engineers, and electrical power-line installers and repairers as the five occupations most critical to zero-emission vehicle implementation at the port.

Zero-emission Vehicle Misinformation and Myths

As zero-emission vehicles have entered and grown in the consumer market, they have been accompanied by misinformation, myths, and misunderstandings. Some of the most referenced myths include using old or inaccurate figures for assessing zero-emission vehicle range potential, overestimating the cost over time, and incorrect estimates for greenhouse gas emissions over a vehicle's lifetime.

Additionally, lack of education and awareness surrounding zero-emission vehicles has been identified as a major barrier to zero-emission vehicle uptake (see Theme 1). Persistent myths and misinformation are factors in this barrier. Incorrect or outdated information can be spread and lead to consumer confusion or distrust concerning zero-emission vehicle facts. Additionally, misinformation and myths can impact salespeople at car dealerships, mechanics, and individuals in other vehicle-focused careers as well.

Call-out Box: Community engagement in ZEV Blueprints

Sacramento Region Zero Carbon Transportation Initiatives plan features well written community and workforce development and support sections.

For more examples, you can explore the San Bernardino Zero-emission Vehicle plan and the Angels Camp Climate Action Plan.

Resources for factchecking and combatting misinformation.

- Veloz's ElectricForAll Electric Vehicle Myth Busting handout
- U.S. News & World Report article
- Ecology Action's EVs for Everyone Myth Busting Sheet
- UK Based Carbon Brief EV fact list
- Environmental Protection Agency EV fact sheet for Zero-emission Vehicle Myths

References

Overview section

[1] *Governor Newsom Announces California Will Phase Out Gasoline-Powered Cars & Drastically Reduce Demand for Fossil Fuel in California's Fight Against Climate Change | Governor of California*. Retrieved June 1, 2024, from https://www.gov.ca.gov/2020/09/23/governor-newsom-announces-california-will-phase-out-gasoline-powered-cars-drastically-reduce-demand-for-fossil-fuel-in-californias-fight-against-climate-change/

[2] *Inventory of U.S. Greenhouse Gas Emissions and Sinks | U.S. EPA*. (2022) Retrieved April 19, 2024, from https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

[3] *Alternative Fuels Data Center: Electric Vehicles*. Retrieved August 21, 2024, from https://afdc.energy.gov/vehicles/electric

[4] *Alternative Fuels Data Center: Fuel Cell Electric Vehicles*. Retrieved August 21, 2024, from https://afdc.energy.gov/vehicles/fuel-cell

Theme 1 – Zero-emission Vehicle Plans

[5] Alameda County. *Climate Action and Resiliency Plan*. Retrieved September 5, 2023, from https://www.alamedaca.gov/CITYWIDE-PROJECTS/Climate-Action-and-Environmental-Sustainability-in-Alameda/Climate-Action-and-Resiliency-Plan

[6] California Energy Commission. *Zero-Emission Vehicle Infrastructure Plan (ZIP)*.

[7] California Energy Commission. *City of Long Beach Blueprint for Medium- and Heavy-Duty Zero-Emission Vehicle Infrastructure*. Retrieved March 19, 2024, from https://buildmomentum.io/

[8] Central Sierra. *Central Sierra ZEV Readiness Plan | tctc*. Retrieved August 29, 2023, from https://www.tuolumnecountytransportationcouncil.org/centralsierrazevplan

[9] City of Oakland. *City of Oakland | Zero Emission Vehicle Action Plan*. Retrieved September 5, 2023, from https://www.oaklandca.gov/projects/zero-emission-vehicle-action-plan

[10] Colorado. *2023 Colorado EV Plan | Colorado Energy Office*. Retrieved September 5, 2023, from https://energyoffice.colorado.gov/transportation/ev-education-resources/2023-colorado-ev-plan

[11] Contra Costa. (2019). *Contra Costa Electric Vehicle Readiness Blueprint*.

[12] County, S. B. *Zero-Emission Vehicle Readiness and Implementation Plan San Bernardino Council of Governments*.

[13] *FINAL 2023 BUTTE ZERO EMISSION VEHICLE READINESS PLAN PRESENTED BY: BUTTE COUNTY ASSOCIATION OF GOVERNMENTS 326 HUSS DRIVE, SUITE 150, CHICO, CA 95928*.

[14] Fresno Council of Governments. (2021). *Fresno Council of Governments ELECTRIC VEHICLE READINESS PLAN*.

[15] Kern County. (2023). *Kern COG Blueprint for Medium-and Heavy-Duty Zero-Emission Vehicle Infrastructure Kern County Blueprint for MD/HD ZEV*

Infrastructure Kern COG Blueprint for Medium-and Heavy-Duty Zero-Emission Vehicle Infrastructure.
[16] *KINGS COUNTY ELECTRIC VEHICLE READINESS PLAN*. (2020).
[17] Madera County. *MADERA COUNTY ZERO EMISSION VEHICLE READINESS AND I MP LEMENTATI ON PLAN ERA CTC*.
[18] *Merced County Association of Governments MCAG EV Readiness Plan Report FINAL*. (2023).
[19] North Carolina. (2019). *NORTH CAROLINA ZEV PLAN A Strategic Plan for Accelerating Electric Vehicle Adoption in North Carolina*.
[20] of Alameda City Council, C., Garland, L., Smith, E., & Director, D. (2019). *Alameda Climate Action and Resiliency Plan (CARP)*.
[21] Sacramento. *Sacramento Region Zero Carbon Transportation Initiatives*.
[22] San Diego. (2023). *San Diego Regional Zero Emission Vehicle (ZEV) Strategy ACCELERATE TO ZERO EMISSIONS A Regional Collaboration to Curb Air Pollution and Climate Change through Transportation Electrification*.
[23] Vcrea. (2019). *Ventura County Electric Vehicle Ready Blueprint*.

Theme 2 – Transportation Assessment Planning

[24] *2022 Regional Transportation Plan-Sustainable Communities Strategies I.* (2022).
[25] *Clean Mobility Options Voucher Pilot Program La Presa and Spring Valley Community Transportation Needs Assessment*.
[26] *Community Transportation Needs Assessment - Bystrom and Empire | Stanislaus Council of Governments, CA*. Retrieved May 7, 2024, from https://www.stancog.org/321/Community-Transp-Needs-Assessment
[27] County Mobility Coalition, K. (2021). *KING COUNTY COMMUNITY TRANSPORTATION NEEDS ASSESSMENT Needs, gaps, and emerging trends for transportation-disadvantaged populations in King County's mobility system*.
[28] *SANDAG - Coordinated Plan*. Retrieved May 19, 2024, from https://www.sandag.org/projects-and-programs/transit/coordinated-plan
[29] *SBCTA Member Jurisdictions SBCTA Mission Statement*.
[30] *VENTURA COUNTY COMPREHENSIVE TRANSPORTATION PLAN. This study was prepared with financial support from the Caltrans Sustainable Transportation Planning Grant Program. Ventura County Transportation Commission*.
[31] Yaney, A. (2016). *Tuolumne County Transportation Council 2 Green Street (mailing) 48 W 2016 Final Regional Transportation Plan*.

Theme 3 – Vehicle Miles Traveled Reduction Strategies

[32] *CicLAvia*. Retrieved August 21, 2024, from https://www.ciclavia.org/
[33] *Complete Streets | FHWA*. Retrieved August 21, 2024, from https://highways.dot.gov/complete-streets
[34] *Cyclovia Encinitas | City of Encinitas*. Retrieved August 21, 2024, from https://www.encinitasca.gov/government/departments/parks-recreation-cultural-arts/recreation-programs/special-events/cyclovia-encinitas

[35] *Siclovia | YMCA of Greater San Antonio*. Retrieved August 21, 2024, from https://www.ymcasatx.org/programs/community/siclovia
[36] *Traffic Calming to Slow Vehicle Speeds | US Department of Transportation*. Retrieved August 21, 2024, from https://www.transportation.gov/mission/health/Traffic-Calming-to-Slow-Vehicle-Speeds
[37] *Transit-Oriented Development | FTA*. Retrieved August 21, 2024, from https://www.transit.dot.gov/TOD
[38] *2020-2040 Climate Action and Adaptation Plan (CAAP) | City of Davis, Calif*. Retrieved June 10, 2024, from https://www.cityofdavis.org/sustainability/2020-climate-action-and-adaptation-plan-caap
[39] *A People-Centered Plan for a Low-Carbon City*.
[40] *ACTION CLIMATE*. (2010).
[41] *Am Canyon 2022 Climate Action Plan-Interim Report*.
[42] By, P. (2022). *Cupertino Climate Action Plan 2.0*.
[43] *CicLAvia*. Retrieved June 12, 2024, from https://www.ciclavia.org/
[44] *City of Albany Climate Action and Adaptation Plan*. (2019).
[45] *City of Blythe: Climate Action Plan: 2013 Climate Action Plan: leadership in energy efficiency. - Climate Action Plans - Digital Resources for Law and Public Policy*. Retrieved June 12, 2024, from https://cdm16255.contentdm.oclc.org/digital/collection/p16255coll1/id/128/
[46] *City of Burbank Greenhouse Gas Reduction Plan Update*.
[47] *City of Calistoga: Climate Action Plan. - Climate Action Plans - Digital Resources for Law and Public Policy*. Retrieved June 12, 2024, from https://cdm16255.contentdm.oclc.org/digital/collection/p16255coll1/id/135
[48] *City of Dublin Climate Action Plan Update Letter from the Mayor*. (2013).
[49] *City of Elk Grove Climate Action Plan*. (2013).
[50] *City of Fremont Climate Action Plan*. (2012).
[51] *City of Gardena ENERGY EFFICIENCY CLIMATE ACTION PLAN*. (2015).
[52] *City of Hermosa Beach ENERGY EFFICIENCY CLIMATE ACTION PLAN*. (2015).
[53] *City of Inglewood ENERGY EFFICIENCY CLIMATE ACTION PLAN*. (2015).
[54] *CITY OF LA HABRA Climate Action Plan*.
[55] *City of Lancaster Climate Action Plan*.
[56] *City of Monterey Park*.
[57] *CITY OF MORENO VALLEY Greenhouse Gas Analysis*. (2012).
[58] *CITY OF NATIONAL CITY FINAL CLIMATE ACTION PLAN City of National City*. (2011).
[59] *City of Oakland | Oakland 2030 Equitable Climate Action Plan (ECAP)*. Retrieved June 10, 2024, from https://www.oaklandca.gov/projects/2030ecap
[60] *City of Roseville Greenhouse Gas Emissions Reduction Action Plan Analysis Final Report*. (2009). http://www.cpuc.ca.gov/PUC/energy/Renewables/
[61] *CITY OF SAN DIEGO CLIMATE ACTION PLAN The City of San Diego in consultation with*.

[62] *City of San Mateo Climate Action Plan ADOPTED CAP*. (2015). www.pmcworld.com
[63] *City of Santa Clara Climate Action Plan*.
[64] *City of Santa Clarita Climate Action Plan Final Report CONTENTS*. (2012). www.greensantaclarita.com
[65] *City of Stockton Climate Action Plan*. (2014).
[66] *City of Vallejo Climate Action Plan Final*. (2012).
[67] *City of Visalia, California CLIMATE ACTION PLAN Prepared for the City of Visalia, Calif. by Strategic Energy Innovations City of Visalia: Climate Action Plan*. (2013).
[68] *Climate Action Plan - Planning & Community Development Department*. Retrieved June 10, 2024, from https://www.cityofpasadena.net/planning/planning-division/community-planning/climate-action-plan/
[69] *CLIMATE ACTION PLAN CITY OF SANTA ROSA*. (2012). www.pmcworld.com
[70] *Climate Action Plan Initial Framework City of Newark*. (2010).
[71] *Climate Action Plan*. (2009). www.CityofBerkeley.info/sustainable
[72] *CLIMATE ACTION PLAN*. (2021).
[73] *Climate Action Plan*. (n.d.-a). Retrieved June 10, 2024, from https://planning.saccounty.gov/PlansandProjectsIn-Progress/Pages/CAP.aspx
[74] *Climate Action Plan*. (n.d.-b).
[75] *Climate Action Resilience Plan – City of Antioch, California*. Retrieved June 10, 2024, from https://www.antiochca.gov/pscr/environmental-resources/climate-change/climate-action-resilience-plan/
[76] *Complete Streets | FHWA*. Retrieved June 12, 2024, from https://highways.dot.gov/complete-streets
[77] *Cyclovia Encinitas | City of Encinitas*. Retrieved June 12, 2024, from https://www.encinitasca.gov/government/departments/parks-recreation-cultural-arts/recreation-programs/special-events/cyclovia-encinitas
[78] *Daly City's Green Vision: A Climate Action Plan for 2011-2020 and Beyond*.
[79] Dean, B.-M., Chiang - Vice, J., Garrett, M., Jeff, K.-C., Margaret, W.-C., Abe, F.-C., Councilmember, F.-F., Administrator, G. G.-C., & Rosenberg - Director, L. A. (2010). *CITY OF PIEDMONT CLIMATE ACTION PLAN City Council City Staff Consultants to the City*. www.aecom.com
[80] *General Plan Update Climate Action Plan*.
[81] Lewis, E., Council Liaison, T., Gardner, V., Rakas, J., Larson, J., Merrill, F., Joseph, H., Kupperman, D., Advani, S., Yu, W., Lempres, M., Mayor, V., DeGolia, R., Widmer, B., & Wiest, C. *Environmental Programs Committee Town of Atherton Town Council*.
[82] Llc, Z. (2018). *Gonzales Climate Action Plan 2018 Update A "Gonzales Grows Green" Sustainable Community Initiative Prepared for the City of Gonzales*.
[83] Lundstrom, J., Chu, L., Hartzell, K., Hillmer, D., & Rifkind, L. *CREDITS AND ACKNOWLEDGEMENTS City Council*.

[84] *Manhattan Beach: Working Towards a Sustainable Community Climate Action Plan*. (2010).
[85] Martin, C., Small, C., Hunter, S., Russell, R., & Strauss, R. *Credits and acknowledgements, Town Council*.
[86] Members, C., Atkin, R., Residents, N. D., Badhia, D., Foushee, S., Green, S., Hooper, P., Koch, J., Orden, A., Scheuerman, J., Webb, C., Lang, M., Lee, B., Strunin, J., Zahner, A., Org -Staff, S., Kaufman, D., Eade, T., & Sullens, W. (2008). *City of Emeryville Climate Action Plan Acknowledgements City of Emeryville Climate Change Task Force Members: ICLEI-Cities for Sustainability-Staff Timothy Burroughs (former)*.
[87] of Alameda City Council, C., Garland, L., Smith, E., & Director, D. (2019). *Alameda Climate Action and Resiliency Plan (CARP)*.
[88] of Simi Valley, C. *General Plan EIR Volume II: Appendix D - Climate Action Plan*.
[89] of Sunnyvale, C. (2019). *CLIMATE ACTION PLAYBOOK*.
[90] *Ontario Community Climate Action Plan Greenhouse Gas Emissions Screening Tables*. (2023).
[91] *Palm Springs 2013 Climate Action Plan*.
[92] Portland, P., Diego, S., Francisco, S., Cruz, S., & Tampa, S. *CITY OF HUGHSON Climate Action Plan*. Retrieved June 12, 2024, from www.esassoc.com
[93] *Rancho Cucamonga*.
[94] *Redwood City Community Climate Action Plan*.
[95] *San Francisco Climate Action Plan | San Francisco Environment Department (SFE)*. Retrieved June 10, 2024, from https://www.sfenvironment.org/climateplan
[96] *San Francisco Transportation Plan | SFCTA*. Retrieved June 10, 2024, from https://www.sfcta.org/projects/san-francisco-transportation-plan#panel-reports-documents
[97] *Siclovia | YMCA of Greater San Antonio*. Retrieved June 12, 2024, from https://www.ymcasatx.org/programs/community/siclovia
[98] Stone, C., Kim, D., Hurt, D., Lieberman, W., Reed, E., Belmont, C., Manager, C., Scoles, G., City, B., Carlos De Melo, S., Didonato, D., Nolfi, M., Fil, T., Voelker, N., Rose, J., Desmidt, D., Cook, T., Gervais, J., Oskoui, A., … Dunning, C. *Acknowledgements Belmont City Council*.
[99] *Sustainable City Action Plan Table of Contents*.
[100] *Traffic Calming to Slow Vehicle Speeds | US Department of Transportation*. Retrieved June 12, 2024, from https://www.transportation.gov/mission/health/Traffic-Calming-to-Slow-Vehicle-Speeds
[101] *Transit-Oriented Development | FTA*. Retrieved June 12, 2024, from https://www.transit.dot.gov/TOD
[102] *TRANSPORTATION AND CONNECTIVITY: REGIONAL COORDINATION*.
[103] Transportation Plan, R., & Communities Strategy, S. *2022 Regional Transportation Plan/Sustainable Communities Strategy FINAL Regional*

Transportation Plan Sustainable Communities Strategy for Merced County 2022 Regional Transportation Plan/Sustainable Communities Strategy.

Theme 4 - Funding Resources

[104] *Alternative Fuels Data Center: California Laws and Incentives*. Retrieved June 10, 2024, from https://afdc.energy.gov/laws/state_summary?state=ca

[105] *Alternative Fuels Data Center: State Planning and Funding for Electric Vehicle Charging Infrastructure*. Retrieved June 10, 2024, from https://afdc.energy.gov/fuels/electricity-infrastructure-state-planning

[106] *Alternative Fuels Data Center: Tax Credits for Electric Vehicles and Charging Infrastructure*. Retrieved June 10, 2024, from https://afdc.energy.gov/laws/ev-tax-credits

[107] *Charge Ready*. Retrieved May 9, 2024, from https://www.sce.com/evbusiness/chargeready

[108] *EERE eXCHANGE: Funding Opportunity*. Retrieved June 10, 2024, from https://eere-exchange.energy.gov/

[109] *Electric For All - Veloz*. Retrieved August 21, 2024, from https://www.veloz.org/electric-for-all/

[110] *Home - Plug In America*. Retrieved June 10, 2024, from https://pluginamerica.org/#

[111] *Incentive Search | DriveClean*. Retrieved June 6, 2024, from https://driveclean.ca.gov/search-incentives?field_zipcode_target_id=95340

[112] *NEVI - Environment - FHWA*. Retrieved June 10, 2024, from https://www.fhwa.dot.gov/environment/nevi/

[113] *PlugStar Shopping Assistant*. Retrieved June 6, 2024, from https://plugstar.com/

[114] *Search Grants | Grants.gov*. Retrieved June 4, 2024, from https://www.grants.gov/search-grants

Theme 5 - Charging Infrastructure and Electrical Utilities

[115] Borlaug, B., Salisbury, S., Gerdes, M., & Muratori, M. (2020). Levelized Cost of Charging Electric Vehicles in the United States. *Joule*, *4*(7), 1470–1485. https://doi.org/10.1016/j.joule.2020.05.013

[116] *Charger Reliability: The Greatest Threat to EV Adoption | EnergyTech*. Retrieved June 13, 2024, from https://www.energytech.com/emobility/article/21274827/charger-reliability-the-greatest-threat-to-ev-adoption

[117] *Download "The EV Transition Explained" E-book for Free - IEEE Spectrum*. Retrieved June 13, 2024, from https://spectrum.ieee.org/ev-transition-explained-ebook

[118] *EV Guide - Plug In America*. Retrieved June 13, 2024, from https://pluginamerica.org/learn/guide/

[119] *Overcoming roadblocks to California's public EV charging infrastructure | Stanford Institute for Economic Policy Research (SIEPR)*. Retrieved June 13, 2024, from https://siepr.stanford.edu/publications/policy-brief/overcoming-roadblocks-californias-public-ev-charging-infrastructure

[120] Rempel, D., Cullen, C., Matteson Bryan, M., & Vianna Cezar, G. (2022). *Reliability of EV Direct Current Fast Chargers Reliability of Open Public Electric Vehicle Direct Current Fast Chargers Reliability of EV Direct Current Fast Chargers*.
[121] Schell, D. L. R. D. Michael. (2024). *Tracking and Improving Reliability of California's Electric Vehicle Chargers*. https://efiling.energy.ca.gov/GetDocument.aspx?tn=255597

Theme 6 – Workforce Development

[122] *About the Battery Workforce Challenge – Advanced Vehicle Technology Competitions*. Retrieved June 13, 2024, from https://avtcseries.org/about-the-battery-workforce-challenge/
[123] *Adult Education & Vocational School Zero-Emission Vehicle Technology Training Project | California Air Resources Board*. Retrieved May 27, 2024, from https://ww2.arb.ca.gov/our-work/programs/adult-education-vocational-school-zero-emission-vehicle-technology-training/about
[124] *Alternative Fuels Data Center: Electric Vehicle Safety Training Resources for First and Second Responders*. Retrieved June 12, 2024, from https://afdc.energy.gov/vehicles/electric-responders
[125] *Cal State LA receives grant from state's primary energy agency for workforce development | Cal State LA Newsroom*. Retrieved May 24, 2024, from https://news.calstatela.edu/2022/12/03/cal-state-la-receives-grant-from-states-primary-energy-agency-for-workforce-development/
[126] *Electrify America Invests Over $1.6 Million in STEM Programs and Workforce Development to Drive Brand-Neutral Zero Emission Vehicle Education - LACI*. Retrieved May 24, 2024, from https://laincubator.org/electrify-america-invests-over-1-6-million-in-stem-programs-and-workforce-development-to-drive-brand-neutral-zero-emission-vehicle-education/
[127] *ZEV Training Programs - eTRUC*. Retrieved May 27, 2024, from https://etruc.org/engagement/workforce-development-advisory-committee-wdac/zev-training-programs/
[128] *ZEV Workforce Portal*. Retrieved May 24, 2024, from https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program/clean-transportation-funding-areas-4/zev

Theme 7 – Community Engagement and Education

[129] *12 Reasons People Don't Buy Electric Cars (and Why They're Wrong) | U.S. News*. Retrieved August 21, 2024, from https://cars.usnews.com/cars-trucks/advice/why-people-dont-buy-electric-cars?slide=2
[130] *About - Veloz*. Retrieved May 24, 2024, from https://www.veloz.org/about/
[131] *Consumer Awareness Grant - California Governor's Office of Business and Economic Development*. Retrieved August 21, 2024, from https://business.ca.gov/industries/zero-emission-vehicles/consumer-awareness-grant/
[132] County, S. B. *Zero-Emission Vehicle Readiness and Implementation Plan San Bernardino Council of Governments*.

[133] *Electric For All - Veloz*. Retrieved May 24, 2024, from https://www.veloz.org/electric-for-all/
[134] *Electric Vehicle Myths | US EPA*. Retrieved August 21, 2024, from https://www.epa.gov/greenvehicles/electric-vehicle-myths
[135] *EV Mythbusting - Electric For All*. Retrieved August 21, 2024, from https://www.electricforall.org/ev-myths/
[136] *Factcheck: 21 misleading myths about electric vehicles - Carbon Brief*. Retrieved August 21, 2024, from https://www.carbonbrief.org/factcheck-21-misleading-myths-about-electric-vehicles/
[137] Mobility Hub. Retrieved August 21, 2024, from https://www.airquality.org/Our-Community-CarShare/Mobility-Hub
[138] O'brien, T., Reeb, T., & Shepherd, G. *PORT OF LONG BEACH ZERO EMISSIONS WORKFORCE DEVELOPMENT REPORT*.
[139] Raggio, M., & Associates, H. &. *City of Angeles Greenhouse Gas Reduction Plan*.

Broader Context and Considerations Related to Zero-emission Vehicle Ecosystems

[140] *Assessment of light-duty electric vehicle costs and consumer benefits in the United States in the 2022–2035 timeframe - International Council on Clean Transportation*. Retrieved June 13, 2024, from https://theicct.org/publication/ev-cost-benefits-2035-oct22/
[141] *Breathing Easy: Truckers' Health and the Rise of Zero-Emission Trucks*. Retrieved June 12, 2024, from https://www.nrdc.org/bio/guillermo-ortiz/breathing-easy-truckers-health-and-rise-zero-emission-trucks
[142] *California All Grades All Formulations Retail Gasoline Prices (Dollars per Gallon)*. Retrieved June 13, 2024, from https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_sca_dpg&f=m
[143] Garcia, E., Johnston, J., McConnell, R., Palinkas, L., & Eckel, S. P. (2023). California's early transition to electric vehicles: Observed health and air quality co-benefits. *Science of The Total Environment*, *867*, 161761. https://doi.org/10.1016/J.SCITOTENV.2023.161761
[144] *New-generation satellite observations monitor air pollution during COVID-19 lockdown measures in California – The Wide World of SPoRT*. Retrieved June 12, 2024, from https://nasasport.wordpress.com/2020/04/04/new-generation-satellite-observations-monitor-air-pollution-during-covid-19-lockdown-measures-in-california/
[145] Yu, Q., He, B. Y., Ma, J., & Zhu, Y. (2023). California's zero-emission vehicle adoption brings air quality benefits, yet equity gaps persist. Nature Communications 2023 14:1, 14(1), 1–14. https://doi.org/10.1038/s41467-023-43309-9

Quick Start: Resources for Initiating ZEV Readiness Planning

[146] *Alternative Fuels Data Center: California Laws and Incentives*. Retrieved August 21, 2024, from https://afdc.energy.gov/laws/state_summary?state=ca
[147] *Alternative Fuels Data Center: Electric Vehicle Infrastructure Toolbox (EVI-X Toolbox)*. Retrieved August 21, 2024, from https://afdc.energy.gov/evi-x-toolbox#/evi-pro-ports?region_type=cbsa&charging-state=CA&cbsa-id=32900&vehicles=10000
[148] *Alternative Fuels Data Center: State Planning and Funding for Electric Vehicle Charging Infrastructure*. Retrieved August 21, 2024, from https://afdc.energy.gov/fuels/electricity-infrastructure-state-planning
[149] *Bill Text - AB-970 Planning and zoning: electric vehicle charging stations: permit application: approval.* Retrieved August 21, 2024, from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB970
[150] *EERE eXCHANGE: Funding Opportunity*. Retrieved August 21, 2024, from https://eere-exchange.energy.gov/
[151] *Electric Vehicle Charging Station Permit Streamlining Fact Sheet) Requirements for Cities and Counties EVCS Permit Streamlining Overview Permit Streamlining Law Applicability*.
[152] *Home | Grants.gov*. Retrieved August 21, 2024, from https://grants.gov/
[153] Joint Office of Energy and Transportation. EV readiness plan template.
[154] *Law section*. Retrieved August 21, 2024, from https://leginfo.legislature.ca.gov/faces/selectFromMultiples.xhtml?lawCode=GOV&sectionNum=65850.7.
[155] *Permitting Electric Vehicle Charging Stations: Best Practices - California Governor's Office of Business and Economic Development*. Retrieved August 21, 2024, from https://business.ca.gov/industries/zero-emission-vehicles/plug-in-readiness/permitting-electric-vehicle-charging-stations-best-practices/
[156] *Planning and Zoning for Electric Vehicle Charger Deployment - Sustainable Energy Action Committee*. Retrieved August 21, 2024, from https://sustainableenergyaction.org/resources/planning-and-zoning-guidance-for-electric-vehicle-charger-deployment/
[157] *Pre-Solicitation Workshop for ZEV Infrastructure Grant Application Technical Assistance Funding*. Retrieved August 21, 2024, from https://www.energy.ca.gov/event/workshop/2024-03/pre-solicitation-workshop-zev-infrastructure-grant-application-technical

APPENDIX

Appendix A. Theme 3 – Vehicle Miles Traveled

Table A.1: Examples of Vehicle-Miles-Traveled Reduction Strategies by Category. All examples represent strategies that were mentioned in California Climate Action Plans from locations across the state.

Public Transit	Carsharing/shuttles	Multimodal	Planning	Other
Increase public transit use.	Ride-share or bus program (including for employee commuting)	Improve bike/e-bike network (invest in and broaden bicycle infrastructure)	Promote job growth, housing, and other development along transit corridors	Encourage employees and employers to reduce commute trips by teleworking
Improve public transit and expand transit, including bus rapid transit and light rail.	Car-sharing (establish community carshare program)	Improve pedestrian network	Improve walkability and transit-supportive densities by locating new residential development within Transit Priority Areas.	Traffic signal synchronization
Provide clean, affordable, and accessible public transit	Encourage local carpool programs	Infrastructure improvements including complete streets	Promote policies, programs, and services that support the local availability and movement of goods to reduce the need for longer-distance freight travel	Local, low-emission transportation education (provide public education regarding reducing motor vehicle-related greenhouse gas emissions and air pollution).
Continue supporting public transit infrastructure.	Provide financial incentives for city employees to encourage ride-sharing and public transit (encourage employers to do the same)	Improve street safety	Provide sufficient and affordable housing and coordinate with local/regional transit network.	Anti-idling: Pass an ordinance that restricts idling of greater than 5 minutes for all commercial vehicles in specific zones. In accordance with CARB rules regarding idling of commercial vehicles

Improve bike/e-bike infrastructure near public transit stops to improve and expand access to transit.	Provide public shuttles, shuttle services from campus/school to downtown, pilot shuttle services to support existing public transportation.	Safe bikes to school program/safe routes to school	Create more local jobs	Provide bicycles for city employees to use for city operations (provide secure covered bicycle parking for city employees to encourage bicycling to work)
Provide bus stops with safe and convenient bicycle and pedestrian access, and essential improvements	Attract car-sharing companies to the city	Build more pedestrian/bike routes	Transit-oriented development	Parking Cash-Out Program: Commuters offered subsidized parking are also offered the cash equivalent if they use alternative travel modes
Conduct a free public transit pilot program	Develop design standards for streets and parking lots to accommodate increased rideshare	Increase the purchase of bikes/e-bikes (provide e-bike rebates)	Consider in-fill neighborhoods	Police bikes: Promote use of bicycles for police use through training and operations support
Advance long-range transit projects	Visitor shuttles: Collaborate with local hotels and resorts to support and establish effective point-to-point transportation for visitors, e.g., shuttles to airport, hotels, business district	Encourage non-motorized travel	Establish minimum building heights in certain transit-rich areas such as the downtown to prevent the underuse of transit-served areas	Participate in regional planning to reduce traffic congestion, smog, air pollution, and greenhouse gas emissions
Encourage, promote, incentivize or expand use of the pass transit system or other transit services		Increase current bike requirements	Establish parking {space} maximums/ public parking fees	Transportation demand management
Provision of free transit passes for onsite residents or tenants for a period of 5 years after		Traffic calming	Take action to reduce and prevent displacement of residents and businesses	

completion of construction				
Subsidized transit commute program			Diversity and Destination Accessibility Plan for a variety of complementary land uses within walking distance of each other, such as housing, neighborhood-serving retail, and recreational facilities, to decrease the need for vehicular travel	
			Create walkable neighborhoods	
			Coordinate siting of new schools at optimal locations and timing	
			Maintain a compact downtown	
			Require new multi-family developments to install a car-share program or provide e-bikes/e-scooters for tenants	
			Implement strategies that prioritize parking for high-occupancy vehicles – carpools, vanpools and transit vehicles	

Appendix B. Theme 4 - Funding Resources

This section summarizes some different funding resources (Federal and State) available to support various aspects of ZEV uptake. This is meant to be a representative, not comprehensive compilation. The information represented here is as of Fall 2025. Some of the funding sources may have changed/expired by the time readers are reviewing this information. Nonetheless, the examples provided still provide insights into the types of funding that have been (or can be) made available to support ZEV uptake and readiness. Additional details and information about incentives and funding resources (including utilities and private entities offering incentives) can be found at the U.S. Department of Energy Alternative Fuels Data Center California Laws and Incentives site.

Table A.2 Examples and summary of some Federal funding resources

Program	Amount	Administering Agency	Summary
National Electric Vehicle Infrastructure (NEVI) Formula Program	$5 billion	U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA)	The NEVI Formula Program provides funding to states from fiscal years (FY) 2022-2026 to procure and install electric vehicle chargers with the goal of building a national network of chargers. The NEVI Formula Program targets charging along corridors and interstates.
Alternative Fuel Corridor Grants	$1.25 billion	FHWA	The Corridor Charging Grant Program provides funding from FY 2022-2026 to strategically deploy publicly accessible electric vehicle charging infrastructure and hydrogen, propane, and natural gas fueling infrastructure along FHWA-designated Alternative Fuel Corridors.
Community Alternative Fuel Infrastructure Grants	$1.25 billion	FHWA	The Charging and Fueling Infrastructure Grant Program provides funding from FY 2022- 2026 to install electric vehicle charging and alternative fuel in locations on public roads, schools, parks, and in publicly accessible parking facilities. These grants will give priority to projects in rural areas, low- and moderate-income neighborhoods, and communities with low ratios of private parking, or high ratios of multi-unit dwellings—also called multi-family buildings.
Public Transportation Research, Demonstration, and Deployment Funding	$5.6 billion	DOT Federal Transit Administration (FTA)	The Low- or No- Emission Bus Grants provide capital funding from FY 2022-2026 to help transit agencies transition to low- or zero-emission transit buses and purchase fueling and maintenance infrastructure. For more information, visit the FTA Low or No Emission Vehicle Program website.
Clean School Bus Program	$5 billion	U.S. Environmental Protection Agency (EPA)	The Clean School Bus Program provides grant funds from FY 2022-2026 for zero-emission and low-emission school buses. For more information,

			visit the EPA Clean School Bus Program Funding website.
Carbon Reduction Program	$6.4 billion	FHWA	From FY 2022-2026, states may use formula grants through the Carbon Reduction Program for projects that support the reduction of transportation emissions.
Battery Manufacturing and Recycling Grants	$3 billion	DOE's Office of Energy Efficiency and Renewable Energy (EERE) and Office of Manufacturing and Energy Supply Chains (MESC)	Battery Manufacturing and Recycling Grants are available from FY 2022 until funding is expended to support a North American battery supply chain, including demonstration projects, construction of commercial-scale facilities, and retrofit or retooling of existing facilities for battery component manufacturing, advanced battery manufacturing, and recycling. For more information, see the funding opportunity announcement.
Battery Materials Processing Grants	$3 billion	EERE and MESC	Battery Materials Processing Grants are available from FY 2022 until funding is expended to support a North American battery supply chain, including demonstration projects, construction of commercial-scale facilities, and retrofit or retooling of existing battery material processing facilities. For more information, see the funding opportunity announcement.
Electric Drive Battery Recycling and Second-Life Applications	$200 million	EERE	Funding for Battery Recycling and Second-Life Applications is available from FY 2022 until funding is expended for research, development, and demonstration of electric vehicle battery recycling and second-life applications for vehicle batteries. For more information, see the funding opportunity announcement.

Table A.2 – List of federal funding programs

- Future federal funding opportunities are usually announced on Grants.gov,
- The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) eXCHANGE is a good resource for federal grants.

Table A.3 Examples and summary of some State funding resources

Program	Amount	Administering Agency	Summary
California's National Electric Vehicle Infrastructure (NEVI) Planning	$384 million	Federal funding with Caltrans partnered with the Energy Commission	Part of the Infrastructure Investment and Jobs Act. Funds to build out a network of DC Fast chargers throughout California. California's NEVI Deployment Plan
Bus Replacement Grant	$192-480K	DOE's Office of Energy Efficiency and	Purchase of zero-emission buses to replace gasoline, diesel, compressed natural gas, or

		Renewable Energy	propane buses. Eligible applicants include owners of transit, school, and shuttle buses.
Heavy-Duty Low-Emission Vehicle Replacement and Repower Grants	$3 million	EERE	Grants to support replacement and repowering of class 7 and 8 heavy-duty vehicles with low oxides of nitrogen models. Information and application through Volkswagen Trust.
Low Emission Truck and Bus Purchase Vouchers	$30-120K	EERE	Vouchers to reduce incremental cost of zero-emission and hybrid-electric trucks and buses. Funding Updates from California HVIP.
Vehicle Replacement Program - Bay Area	$1,200	EERE	Bay Area residents only. Funding awarded in return for residents turning in operable, registered 1998 or older vehicles for scrapping.
Electric Vehicle Charging Station Incentive Program Support	$100K cap	California Energy Commission (CEC), EERE	California Electric Vehicle Infrastructure Project, or CALeVIP, provides guidance and funding for property owners developing electric vehicle charging station incentive programs for level 2 and direct current fast chargers. General eligibility and requirements: Property owner, business, nonprofit organization, California Native American tribe, or public or government entity at properties located in California. For further eligibility information, see CALeVIP.
Alternative Fuel and Vehicle Incentives	$100 million	CEC	Funding for projects supporting zero-emission vehicle uptake. Includes charging infrastructure, hydrogen vehicles and refueling infrastructure, medium- and heavy-duty vehicles, and workforce training and development.
Voluntary Vehicle Retirement and Replacement Incentives	$1,000	California Bureau of Automotive Repair	Provide an incentive to retire personal motor vehicles and purchase replacement vehicles meeting emission and fuel economy requirements.
Emissions Reductions Grants	$60 million /year	CARB	Funding support to cover incremental costs of purchasing engines and equipment that are cleaner than required by law. For more information, see the Carl Moyer Program.
Heavy-Duty Vehicle Emissions Reduction Grants	$50 million	CARB	Funding for projects that reduce emissions from goods movement operations (freight). Program Announcement.

Charging Infrastructure for Government Fleets	$12K-$100K per port	CEC	Grants for installation of electric vehicle fast chargers. Must install at least 100 charging ports to be eligible.
Electric Vehicle Charging Station Program – Antelope Valley	50-70% of total costs	Antelope Valley Air Quality Management District	Charging infrastructure incentive for local entities within Antelope Valley Air Quality Management District.
Residential Electric Vehicle Charging Station Financing Program	$10,500 + additional	Office of the Treasurer	Supports property owners who borrow funds to finance energy improvements. Funding received will be 15% of the first $700K of property value and 10% of the remaining.
Electric Vehicle and Fuel Cell Electric Vehicle Grant - Bay Area	$9,500 +$2,000	Bay Area Air District	Funding support for income-eligible residents to replace a vehicle eligible for retirement with an electric-, hybrid-electric, plug-in hybrid-electric, or fuel cell electric vehicle.
Alternative Fuel Vehicle Incentives - San Joaquin Valley	$20,000	San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD)	SJVUAPCD offers funding to cities, counties, special districts, and public educational institutions for the purchase of new alternative fuel vehicles, including electric, hybrid-electric, natural gas, and propane vehicles.
Charge Up! Electric Vehicle Charger Incentive Program	$5,000 - $25,000	SJVUAPCD	Funding for public agencies, businesses, and property owners of multi-unit dwellings for the purchase and installation of new charging stations. For eligibility, see Charge Up! program.
Heavy-Duty Truck Emission Reduction Grants - San Joaquin Valley		SJVUAPCD	Truck replacement program provides funding for vehicle replacements for heavy-duty vehicles.
Alternative Fuel Mechanic Technical Training - San Joaquin Valley	$15,000	SJVUAPCD	Funding for alternative fuel mechanic training and education.
Air Quality Improvement Program Funding - Ventura County	Project dependent	Ventura County Air Pollution Control District	Funding to support qualified air quality improvement projects in Ventura County.
Air Quality Improvement Program Funding - San Luis Obispo County	Project dependent	San Luis Obispo County	The Clean Air Fund provides grants for projects that reduce emissions or support air pollution reduction technologies, including

		Air Pollution Control District	the purchase of alternative fuel school buses or alternative fuel infrastructure development.
Zero Emission Transit Funding	$1 million	Clean Mobility Options	Voucher program that supports purchase of zero-emission vehicles, infrastructure, planning, outreach, and more projects.
Driving Clean Assistance Program	Up to $7,500	CARB	Grants for individuals to purchase or lease an electric, plug-in hybrid-electric, or fuel cell electric vehicle. Subject to income restrictions
CalCAP Zero-Emission Heavy Duty Programs		State of California Office of the State Treasurer	"Loan loss reserves for financial institutions lending to California businesses for the purchase of zero-emission heavy-duty and medium-duty vehicles and infrastructure"
Medium- and Heavy-Duty Zero-emission Vehicle and Infrastructure Grants	$25K - $4 million	CEC	Grants for purchase and installation of zero-emission infrastructure for medium- and heavy-duty electric vehicles and hydrogen fuel cell vehicles. Eligible groups include commercial fleets and station owners. For more, see EnergIIZE.
Zero-Emission School Bus Grants	$285K-$395K	CARB	Grants for purchase of new zero-emission school buses. Award value based on vehicle type.
Rebates			
Plug-In Hybrid and Zero-Emission Light-Duty Public Fleet Vehicle Fleet Rebates	**$1,000-7,500**	**EERE**	Rebates to eligible state and local public entities for purchase of light-duty fleet vehicles (electric, plug-in hybrid-electric, or fuel cell electric vehicle). Fleets within disadvantaged communities are eligible for increased incentives.
Alternative Fuel Vehicle Incentive Program – Antelope Valley	$500	Antelope Valley Air Quality Management District	Rebate for Antelope Valley residents to purchase or lease an electric vehicle from a dealership within the Antelope Valley.
Clean Vehicle Rebate - El Dorado County	$599	El Dorado County Air Quality Management District	Provision of a rebate of up to $599 to residents toward the purchase or lease of a new zero-emission vehicle or partial-ZEV. To be eligible, vehicle must have been owned or leased for a minimum of 3 years.
Exemptions			

Zero Emission Vehicle and Near-Zero-Emission Vehicle Weight Exemption	N/A	N/A	Electric vehicles and near-zero-emission vehicles may exceed the state's gross vehicle weight limits by an amount equal to the difference of the weight of the near-zero-emission or zero-emission powertrain and the weight of a comparable diesel tank and fueling system, up to 2,000 pounds.
Fuel-Efficient Vehicle Tax Exemption	N/A	N/A	Zero-emission vehicles purchased with funds from the Clean Cars 4 All Program are exempt from sales tax.
Advanced Transportation Tax Exclusion	N/A	California Alternative Energy and Advanced Transportation Financing Authority	Provides a sales and use tax exclusion for qualified manufacturers of advanced transportation products, components, or systems that reduce pollution and energy use and promote economic development.
Compressed Natural Gas and Electricity Tax Exemption for Transit Use	N/A	N/A	Compressed natural gas and electricity that local agencies or public transit operators use as motor vehicle fuel to operate public transit services is exempt from applicable user taxes.

Appendix C. Theme 5 – Electric Vehicle Charging Infrastructure and Electrical Utilities

Charging Equipment (Classification and Costs)

This section reviews the basic terminology of electric vehicle chargers, as well as their classification and interoperability. It may be useful for readers who are unfamiliar with this type of equipment.

Terminology

When talking about electric vehicle chargers, it is useful for stakeholders to have a common understanding of the terminology employed when installing charging equipment. Some of the key definitions include:

- ***Station location (or site host)****:* represents a site that provides access to one or more charging ports. This may include parking garages, mall parking lots, workplace charging, etc.
- ***Port*** capable of providing electrical energy only to one vehicle at a time. It may have more than one connector, but only one connector is active at one time. Ports may be integrated into a charging post (that provides multiple connectors) – see figure A1.
- ***A connector*** or a plug is connected to the electric vehicle and charges it. A wide range of connectors, such as Tesla's NACS, CCS, etc., may be available on one charging port.

Figure A1: Diagram of connectors and ports at an electric vehicle charging station

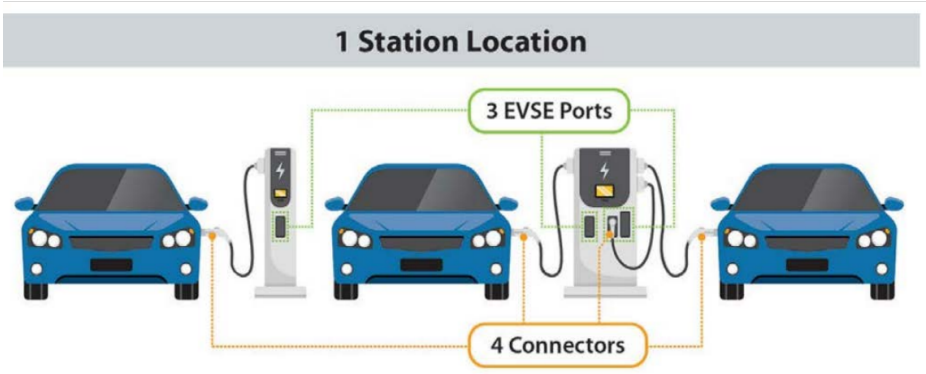


Figure adapted from the U.S. DOE Alternative Fuels Data Center Electricity Stations site

Classification of Electric Vehicle Charging

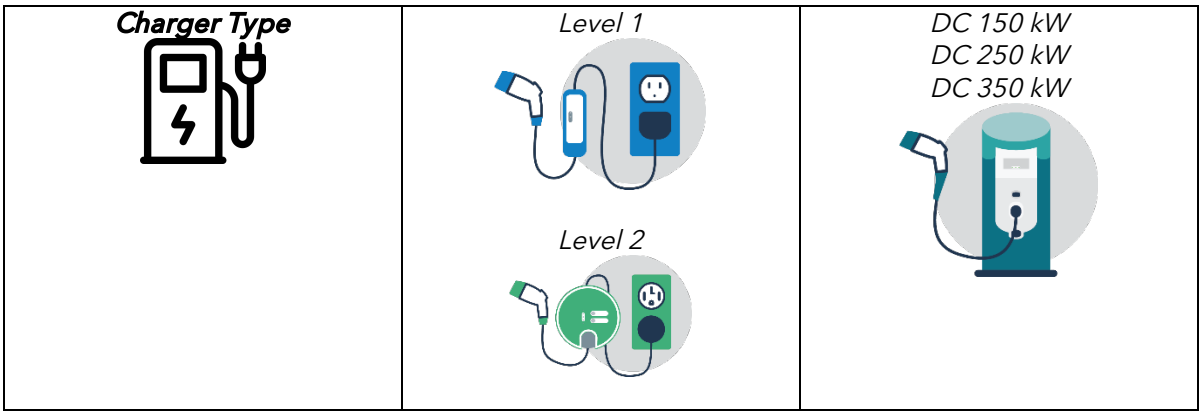
There are different types of charging equipment, in terms of access type (public vs. private), location (home, workplace, school, recreation, etc.), and charging speeds (Level 1, Level 2, DC Fast, etc.) – see Figure A2.

- *Access type*: There are two categories: public and private access. Public access to chargers allows anyone to use the charger regardless of their relationship to it. Private access is a bit more selective in terms of individual use. This type of access is dependent on who owns/operates the charging equipment. This means that access to the charger may be limited to individuals or people who are related to the charging equipment through ownership, employment, or membership.
- *Location type*. Installation of charging equipment is open to many locations. Examples of general locations include homes, neighborhoods, workplaces, schools, etc. The location of installed charging equipment does not automatically classify its access type. Presently, most charging done at locations such as offices or workplaces is assumed to be classified as private access. Alternatively, retail and neighborhood locations are more commonly classified as public access.
- *Electric vehicle charging speed and connectors.* The charging stations and connectors come in different forms, ranging from slow charging (Level 1) to fast charging (DC Fast or Level 3). Connectors are an important aspect, often overlooked. The electric vehicle charger needs to be compatible with the connectors available in the charging equipment. The next bullet points provide an overview of the three different charging levels and the connectors that are usually found in the charging equipment.
    - *Level 1 charging equipment* gets approximately 5 miles of range per 1 hour of charging for a mid-sized electric vehicle. It uses alternating current (AC) from a 120-volt source to charge an electric vehicle. Level 1 equipment consists of a cord with a standard National Electrical Manufacturers Association (NEMA) connector on one end and an SAE J1772 connector on the other. Level 1 charging is usually done by the owner at home because most homes can provide a 120-volt outlet.
    - *Level 2 charging equipment* gets approximately 25 miles of range per 1 hour of charging. It uses AC from a 240-volt or 208-volt source to charge an electric vehicle. It can typically charge an electric vehicle battery overnight and can be installed in an owner's house. According to the U.S. Department of Energy, "As of 2022, nearly 80% of public electric vehicle charging ports in the United States were level 2." Like Level 1 charging, a standard J1772 connector is used. Additionally, Tesla vehicles, which use a J3400 connector, can use their J1772 adapter to use non-Tesla Level 2 chargers. Multiple types of Level 2 chargers can be installed. Figure A3 shows the physical differences between each type. The main differences rely on how the charger is mounted and supported.

- *Direct Current (DC) Fast* charging gets approximately 100-200+ miles of range per 30 minutes of charging. It is focused on rapidly charging electric vehicles, often along heavily trafficked corridors. It focuses on providing direct power to the battery, bypassing the on-board charger that converts the AC during Level 1 and Level 2 charging. According to the U.S. DOE, "As of 2022, more than 20% of public EV charging ports in the United States were DC fast chargers." DC Fast charging connectors include CCS, Charge de Move (CHAdeMO), and J3400.

Figure A2: Overview of electric vehicle charging types categorized by access, location, and charging speed

Access Type	***Private*** 	***Public*** 
Location Type 	*Home*  *Neighborhood*  *Workplace*  *Office*  *Retail* 	*Recreational*  *Health Care*  *School*  *Community Center*  *Transit Hub* 



Information in this figure was adapted from the National Lab of the Rockies' Charging Equipment Taxonomy and Charge Up New Jersey's Charging Basics site. Many of the icons in the figure were sourced from Flaticon.

Figure A3: Common connectors available for electric vehicle charging stations.

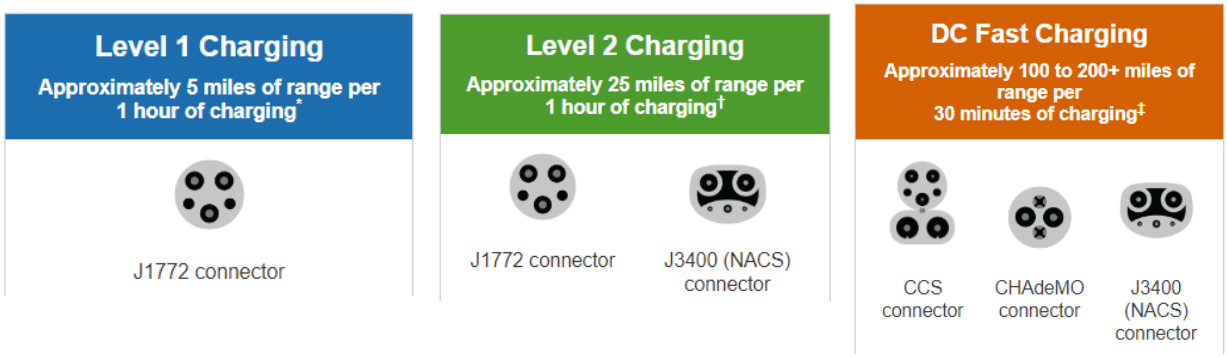


Image adapted from U.S. EPA "Plug-in Electric Vehicle Charging: The Basics"

Cost of Electric Vehicle Chargers

In recent years, many studies have evaluated the estimated cost of electric vehicle chargers, including equipment and installation costs – see Figures A4 and A5. In an article published by ICF International (consulting firm), data from multiple studies were organized and compared. In general, higher power chargers cost more -- Level 2 chargers are cheaper to install than DC Fast chargers, but there was significant variability in costs. In addition to the four studies that were compared, the ICF International article found the average total equipment and installation costs from the California Energy Commission by looking at the California Electric Vehicle Infrastructure Project cost data. They found that Level 2 chargers' average total cost was $14,914 and the DC Fast charger average total cost was $103,185. Additionally, variability.

Figure A4: Comparison of equipment and installation costs for electric vehicle charging infrastructure across four studies

Cost element	Study	Level 2	DCFC			
			50 kW	150 kW	350 kW	800 kW
Equipment cost	ICCT (2019)	$3,127	$28,401	$75,000	$140,000	
	NREL (2020)	$3,500	$38,000	$90,000		
	RMI (2020)	$2,500 - $4,900	$20,000 - $35,800	$75,600 - $100,000	$128,000 - $150,000	
	EDF & GNA (2021)			$136,540		$481,299
Installation cost	ICCT (2019)	$2,837 - $4,148	$17,692 - $45,506	$18,577 - $47,781	$25,654 - $65,984	
	NREL (2020)	$2,500	$20,000	$60,000		
	RMI (2020)	$7,000	$62,700	$75,500	$138,200	
	EDF & GNA (2021)			$35,000		$175,000

Figure is reproduced from [ICF International Comparison of Costs of Electric Vehicle Chargers Across 4 Studies.]

Figure A5: Range of capital costs for different types of EV charging hardware

Charger Hardware		Unit Cost per Port	Install Cost per Port [a]	References
L1 residential	Low: High:	$0 $0 [b]	$100 $1,000	(Fixr.com 2022; Courtney 2021; HomeAdvisor 2022)
L2 residential	Low: High:	$400 $1,200	$500 $1,700	(Borlaug et al. 2020; Fixr.com 2022; Courtney 2021; HomeAdvisor 2022)
L2 commercial	Low: High:	$2,200 $4,600	$2,200 $6,000	(Nicholas 2019; Nelder and Rogers 2019; Borlaug et al. 2020; Bloomberg New Energy Finance 2020; Pournazeri 2022)
DC 150 kW	Low: High:	$66,400 $102,200	$45,800 $94,000	(Nicholas 2019; Nelder and Rogers 2019; Borlaug et al. 2020; Bloomberg New Energy Finance 2020; Borlaug et al. 2021; Gladstein, Neandross & Associates 2021; Bennett et al. 2022)
DC 250 kW	Low: High:	$91,400 $134,800	$54,750 $105,950	Inferred from DC 150-kW and 350-kW costs
DC 350+ kW	Low: High:	$116,400 $167,400	$63,700 $117,900	(Nicholas 2019; Bloomberg New Energy Finance 2020; Borlaug et al. 2021; Gladstein, Neandross & Associates 2021; Bennett et al. 2022)

[a] These ranges do not span the set of all possible situations. They are meant to be plausible optimistic (low) and pessimistic (high) estimates for assessing network capital costs at scale. In some cases, it was not possible to verify exactly what was included within each study's estimate for installation costs, thus some discrepancies may be present across sources.

[b] L1 chargers tend to be included with the purchase of a PEV and are thus excluded as an infrastructure cost from this analysis.

Figure is reproduced from NLR "The 2030 National Charging Network" report.

Deployment Strategies for Electric Vehicle Charging Stations

Some key questions for local practitioners to consider when determining *electric vehicle* needs and locations include:

General Questions

- *What are your top priorities for public electric vehicle charger deployment (e.g., equity, economics, access for people living in multifamily housing, electrification of multimodal options)?*
- *Where do public electric vehicle chargers currently exist in your area? You can use the Preliminary Site Assessment Worksheet and the Alternative Fuels Data Center Electric Vehicle Charging Station Locator.*
- *Where are public electric vehicle charging stations planned in your area? Review your state's National Electric Vehicle Infrastructure (NEVI) Formula Program plan to see where your state department of transportation is planning to deploy stations. Visit the Alternative Fuels Data Center's State NEVI Planning website. Visit the Federal Highway Administration's Alternative Fuel Corridors webpage to see what interstates and highways in your state are designated as electric corridors.*
- *Where are the electric vehicle charging gaps in your area?*
- *What is your strategy for determining which locations should have DC Fast charging stations versus Level 2 charging stations?*
- *What charging options will best help you reach your goals (e.g., workplace charging, curbside charging, chargers at retail locations, electric car-share depots, municipally owned chargers in areas with lower revenue potential)?*
- *Are there opportunities to leverage electric vehicle charging stations and associated infrastructure to support other e-mobility strategies such as multimodal hubs, e-bike-share stations, and/or e-car-share, or to support shared-use fleets or services?*
- *How will you involve community members to prioritize strategies for electrification and electric vehicle charging deployment? (See the Engagement module with guiding questions and resources for community and stakeholder engagement.)*
- *If your area has a significant amount of demand (e.g., high seasonal visitor traffic or other high traffic), how will you deploy charging stations to meet this demand?*
- *What is the backup plan if private sector charging infrastructure deployment is less than anticipated/needed? Is it possible to add more municipally owned public charging infrastructure as an alternative? Are there incentives that can encourage private sector investment?*

Site Identification

- *How can you involve community members to prioritize areas or sites for electric vehicle charging station deployment?*
- *For electric vehicle charging stations in public rights of way, who will own/operate the station (e.g., municipality or third party)?*
- *How will you engage your utility during the electric vehicle charger site selection process (e.g., the electric utility will help identify locations with three-phase power and capacity for DC Fast charging or the utility will map substation locations and overlay with future electric vehicle charging demand to forecast electricity demand)?*
- *For potential municipally owned charger sites, complete an assessment to determine the feasibility of installing charging stations at those locations. Refer to the Public EV Charging Station Site Selection Checklist to assess feasibility.*
- *For potential municipally owned charger sites, consider safety and accessibility. Review the U.S. Department of Energy's physical site safety best practices resource for additional considerations.*
- *What barriers or challenges to installing electric vehicle charging infrastructure do you anticipate at the identified sites (e.g., minimal demand, cost, supply chain issues, policy challenges such as needing a zoning variance, permit approval process)?*
- *How can you as the municipality help overcome these barriers? Are there others with whom you need to work?*

Private Sites

- *What strategies will encourage electric vehicle charger deployment by private stakeholders or other entities in your jurisdiction (e.g., stakeholder engagement and meeting with key businesses to discuss the benefits of electric vehicle charging, updating policies/codes to streamline approvals, mandating that new construction include electric vehicle-ready infrastructure)?*
- *How will you reach out to private site owners, such as multifamily housing or workplaces, to encourage them to install electric vehicle chargers for their residents, employees, and/or visitors?*
- *What resources or materials will you need to effectively connect with private site owners about electric vehicle chargers?*

Appendix D. Theme 6 - Workforce Development, Community Engagement and Education

Examples of Workforce Programs

- Department of Energy's Alternative Fuels Data Center Maintenance and Safety of Electric Vehicles
    - This Alternative Fuels Data Center resource briefly compares the maintenance of electric vehicles to conventional vehicles. Typically, all electric vehicles require much less maintenance than conventional vehicles since there are fewer fluids in the system to worry about overall. Hybrid-electric and plug-in hybrid-electric vehicles' maintenance is more closely related to conventional vehicles because of their internal combustion engine. Electric vehicle batteries do, however, expire, and the price of replacement is costly.
    - Additionally, the Alternative Fuels Data Center briefly discusses safety requirements and emergency response training for electric vehicles. All electric vehicles are subject to the same safety regulations as conventional vehicles. The main danger of electric vehicles lies in the high-voltage battery pack. Manufacturers release response guides so that first responders can respond appropriately to emergencies. Furthermore, emergency response resources are widely available.
- U.S. Department of Transportation – ideal workforce
    - The U.S. Department of Transportation provides a list of important objectives necessary to meet for their transportation workforce and labor grants. It highlights the core pieces of an ideal workforce and provides through provoking questions to applicants so they can address topics they may not have included in their grant application. Key requirements include good-paying jobs with choice of unionization, expansion of training for underrepresented groups, use of apprenticeships, and collaboration with state and local transportation agencies.
- Apprenticeships
    - The 2022 Inflation Reduction Act allowed for new clean energy tax credits and deductions to be enacted for businesses that met registered apprenticeship requirements. This resource provides information for FAQ on related apprenticeship requirements. New tax incentives for industry will promote the growth of good-paying apprenticeship jobs in clean energy sectors to develop a workforce for the future. The new legislation provides apprenticeship support through the following clean energy incentives: Alternative Fuel Refueling Property Credit,

Production Tax Credit, Credit for Carbon Oxide Sequestration, Credit for Production of Clean Hydrogen, Clean Fuel Production Credit, Investment Tax Credit, Advanced Energy Project Credit, and Energy Efficient Commercial Buildings Deduction.

- Workforce Program for National Electric Vehicle Infrastructure Formula Program,
    - The National Electric Vehicle Infrastructure (NEVI) Formula Program, known as NEVI, provides funding for deployment of electric vehicle charging stations across the country. The NEVI Formula Program final rule requires that the technicians installing electric vehicle charging equipment are either electricians certified by the EVITP or by the registered apprenticeship program focused on charger-specific training. NEVI funds can be used to fund workforce training to install new charging stations. It can also be used to fund a pipeline of training infrastructure that will create more certified electricians.
    - In California's Deployment Plan for the NEVI Formula Program, the California Energy Commission is focused on collaboration with the California Employment Training Panel to have more electricians become EVITP certified. Funding will be offered to train journey-level electricians and C-10 licensed electricians.
- Alternative Fuel Vehicle Institute
    - The Alternative Fuel Vehicle Institute provides training for service technicians so they can learn the essentials of electric and hydrogen vehicles. Both in-person and online training is offered. The electric vehicle essentials course focuses on teaching technicians about preventative maintenance, safety, and electric vehicle charging equipment. The hydrogen vehicle essentials course teaches technicians about the hydrogen fuel system, how to service hydrogen vehicles, and proper safety methods. Both courses teach about charging/fueling stations.

Education

- Clean Energy to Communities, Peer -Learning Cohorts

Appendix E. Laws and Regulations

Additional details and information about laws and regulations related to ZEVs can be found at the U.S. Department of Energy Alternative Fuels Data Center California Laws and Incentives site.

Appendix F. Additional Resources

- DOE EV Champion Training Series
- DOE Public Electric Vehicle Charging Infrastructure Playbook
- DOE Community Charging: Emerging Multifamily, Curbside, and Multimodal Practice
- DOE Technical Assistance and Resources for Communities
- DriveElectric – List of tools
- DOE – Advanced Fuels Data Center – EV Stations
- DOE - AFDC – EV readiness level
- DOT Urban Mobility Toolkit
- DOT Rural Mobility Toolkit
- Electrifying Transportation in Municipalities: A Policy Toolkit for Electric Vehicle Deployment and Adoption at the Local Level