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LOS ANGELES ELECTRIC VEHICLE CHARGING INFRASTRUCTURE NEEDS AND IMPLICATIONS FOR ZERO-EMISSION AREA PLANNING

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EXECUTIVE SUMMARY

Los Angeles is taking a great leap with its commitment to increase the percentage of zero-emission vehicles on city roads to 25% by 2025, 80% by 2035, and 100% by 2050. The city's goal to eliminate vehicle emissions is part of its vision to address climate change, improve air quality, and achieve environmental justice. The transition to zero-emission vehicles can be enabled by supporting infrastructure, incentives, and local policies to overcome electric vehicle barriers to ensure equitable zero-emission mobility access to all Angelenos.

This report quantifies Los Angeles' passenger electric vehicle charging infrastructure needs and associated energy demand citywide in 2030 and in some specific areas that are poised to become zero-emission areas or fully fossil fuel free by 2030. To align with Los Angeles' goal for 25% zero-emission vehicle stock by 2025 and 80% by 2035, the analysis incorporates the transition to all new passenger electric vehicles sales before 2030, including the progression from early adopters to a mainstream market. This analysis also incorporates a mode shift to more pedestrian and public transit to quantify reduced charging infrastructure needs. The analysis estimates the fuel and carbon reduction benefits of electrifying Los Angeles' passenger vehicle fleet and provides policy recommendations to help Los Angeles meets its goals. We summarize the findings and implications in the following five conclusions:

Home charging remains a critical component in the infrastructure network. Most electric vehicle charging is likely to continue at home, where it is less expensive and more convenient than public options. Los Angeles will need approximately 536,000 home chargers by 2030 to accommodate roughly 1.3 million electric vehicles. These home chargers make up 90% of the total charger needs and account for 60% of the total electric vehicle energy demand. Los Angeles can provide more access to home charging for its residents by continuing and expanding current programs. Stronger EV-ready building codes, incentives for home and multi-unit dwelling chargers, and strategic and targeted deployment of curbside and streetlight chargers in residential areas can facilitate adequate and equitable home charging access.

Public and workplace charger deployment will need to ramp up quickly to support zero-emission vehicle goals. By 2030, direct current fast chargers in Los Angeles will need to grow by a factor of 33 to about 3,900 chargers, while public Level 2 chargers will need to increase by a factor of 8 to about 21,500 chargers. Workplace charging will need to increase to at least 25,000 chargers by 2030. Intentional infrastructure deployment and complementary outreach and engagement within disadvantaged communities are needed to expand equity and access to electric vehicles, infrastructure, and the associated air quality and economic benefits.

Attainment of Los Angeles' goals for electric mobility and reduced personal vehicle use can greatly reduce charging infrastructure needs. If city interventions are implemented, public and workplace charging needs are reduced by about 45% from approximately 50,000 to 27,000 chargers in 2030, and the annual 2019–2030 growth rate is reduced from 31% to 24%. Figure ES-1 shows how the need for public and workplace charging can be greatly reduced if city interventions are implemented that shift mobility from private vehicle trips to sustainable modes like transit, reduce overall vehicle-miles traveled, and reduce trips to the urban core via congestion pricing. Achieving multiple city goals requires continued data sharing, planning, communication across city agencies, and identification of community mobility needs to develop equitable and inclusive zero-emission mobility technology and policy solutions.

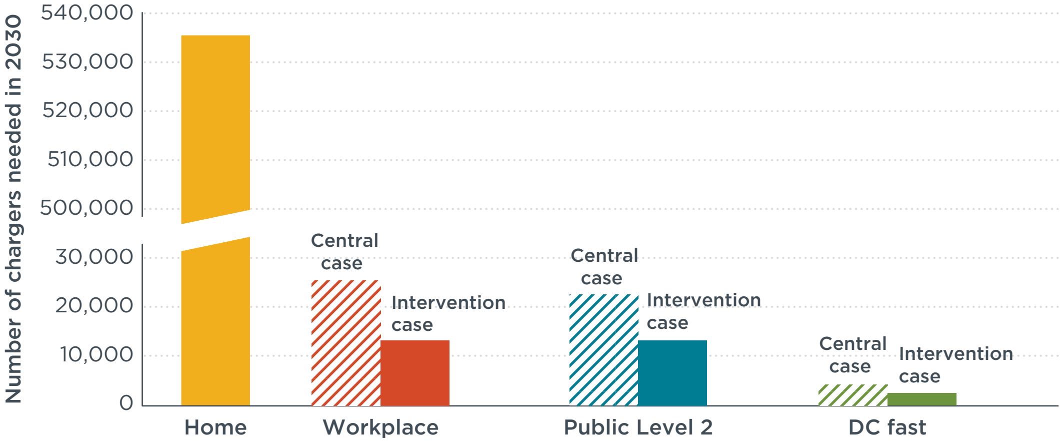

Figure ES-1. Estimated charging infrastructure needed in Los Angeles in 2030. The hashed bars are without city interventions (central case), and the solid bars are with city interventions (intervention case).

Local policies play a key role in supporting electric vehicle and infrastructure growth. Incentives, infrastructure, consumer awareness, and fleet electrification are all needed to meet Los Angeles' electric vehicle goal. Key among these will be continuing and expanding the local electric vehicle rebate program, residential and commercial charger incentives, streetlight and curbside charger programs, BlueLA electric carsharing, and consumer outreach. As electric vehicle uptake increases and the market evolves, increasingly stronger policies will support widespread vehicle adoption and spur private sector investments in infrastructure. These include EV-ready building codes; streamlined permitting; priority zoning and access; and pollution-indexed pricing of roads, vehicles, and fuels. Steering these policies toward serving lower-income residents and underserved communities is key to delivering on environmental justice and equity.

Los Angeles can develop the first zero-emission areas in the United States. A zero-emission area is a geographic boundary where fossil-fueled mobility is restricted for the purpose of reducing environmental pollution. Achieving this requires a comprehensive package of zero-emission mobility options to deliver affordable and reliable transportation choices, including transit, walking and bicycling infrastructure, carsharing, ride-hailing, micromobility, and electric vehicles. For the residents and travelers in zero-emission areas who rely on personal vehicles, electric vehicles and their infrastructure are required. The analysis of four sample zero-emission areas finds that approximately two to four times more public and workplace chargers are needed by 2030 than were in place at the end of 2019. The scale of infrastructure growth needed in the ZEAs is relatively less than growth needed elsewhere in Los Angeles and is due to the significant shift away from private vehicle ownership and travel analyzed in these areas.

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INTRODUCTION

The transition to electric mobility continues, and city governments play a key role in developing policies and building the mainstream electric vehicle market. Driven by an urgency to address climate change and air quality concerns, many cities have set ambitious targets for much greater adoption and are charting out visions for transitioning to all zero-emission vehicles (ZEVs). Los Angeles has set goals to eliminate vehicle emissions as part of its vision to mitigate climate change, improve air pollution, and achieve environmental justice. The global COVID-19 crisis further underscores the importance of transitioning entirely to zero-emission mobility, especially in underserved communities that face disproportionately large adverse health impacts from environmental pollution.

In its 2019 Green New Deal, Los Angeles announced its aim to increase the percentage of ZEVs on city roads to 25% by 2025, 80% by 2035, and 100% by 2050 (Mayor Eric Garcetti Office, 2019). And as a signatory of the Fossil-Fuel-Free Streets Declaration (C40, n.d.), Los Angeles has committed to making a major area of its city zero emissions by 2030. Considering the electric vehicle (EV) share of new passenger vehicle sales in Los Angeles at the end of 2018 was about 7%, and the electric share of its passenger vehicle stock was about 1.7% (California Department of Motor Vehicles, 2020), the transition presents a major challenge.

Widespread electric vehicle adoption requires much greater deployment of charging infrastructure. Although most charging is typically done at home, increased charging options are needed for electric vehicle drivers as the market expands. For example, drivers without home charging, including apartment dwellers or others without off-street parking, will need convenient charging infrastructure elsewhere. More workplace, public Level 2, and direct current (DC) fast chargers near residences and at other key locations are needed to improve electric vehicle functionality and convenience.

Local authorities can help accelerate electric vehicle market growth by proactively identifying how much infrastructure is needed to match electric vehicle adoption goals and planning for its deployment. It will also be necessary to compile data on electric vehicle adoption, infrastructure deployment, and charging behavior to analyze future charging needs, incorporating local-level information for factors like vehicle ownership, housing, commuting patterns, and driver behavior. These data are key to identifying infrastructure gaps, developing policies to fill gaps, and reassessing infrastructure needs with updated data.

This white paper analyzes the number, type, and distribution of passenger electric vehicle chargers needed to meet Los Angeles' electric vehicle goals in its Green New Deal. It quantifies charging infrastructure needs at the ZIP code level across Los Angeles, as well as in four sample neighborhoods that could be potential locations for future zero-emission area (ZEA) implementation. The analysis is focused on the public, workplace, and home charger needs for passenger vehicles, and results are focused primarily on 2030 to quantify the relatively near-term charging needs. It then considers additional city-level interventions to encourage mode shift and reduce vehicle travel demand, to thereby assess their impact on the charging needs. The paper concludes with a discussion of policy opportunities for Los Angeles to meet its electric vehicle goals and deploy the needed infrastructure.

BACKGROUND

This section provides background and context to the electric vehicle and charging infrastructure landscape in Los Angeles. Brief reviews of passenger electric vehicle adoption, deployment of public charging infrastructure, and infrastructure usage patterns are provided to demonstrate progress to date and provide context for the additional planning needed to continue the transition to electric vehicles.

The left side of Figure 1 shows cumulative electric vehicle registrations across Los Angeles by ZIP code through 2018 and the number of public Level 2 and DC fast chargers deployed through 2019 (blue and green data circles, respectively). Areas in lighter shades of yellow have relatively fewer electric vehicle registrations whereas areas in red have relatively more electric vehicle registrations. Labeled areas, based on neighborhood classification from the Los Angeles Department of Neighborhood Empowerment (2017), have relatively high electric vehicle registrations (left) or high daily charging sessions (right).

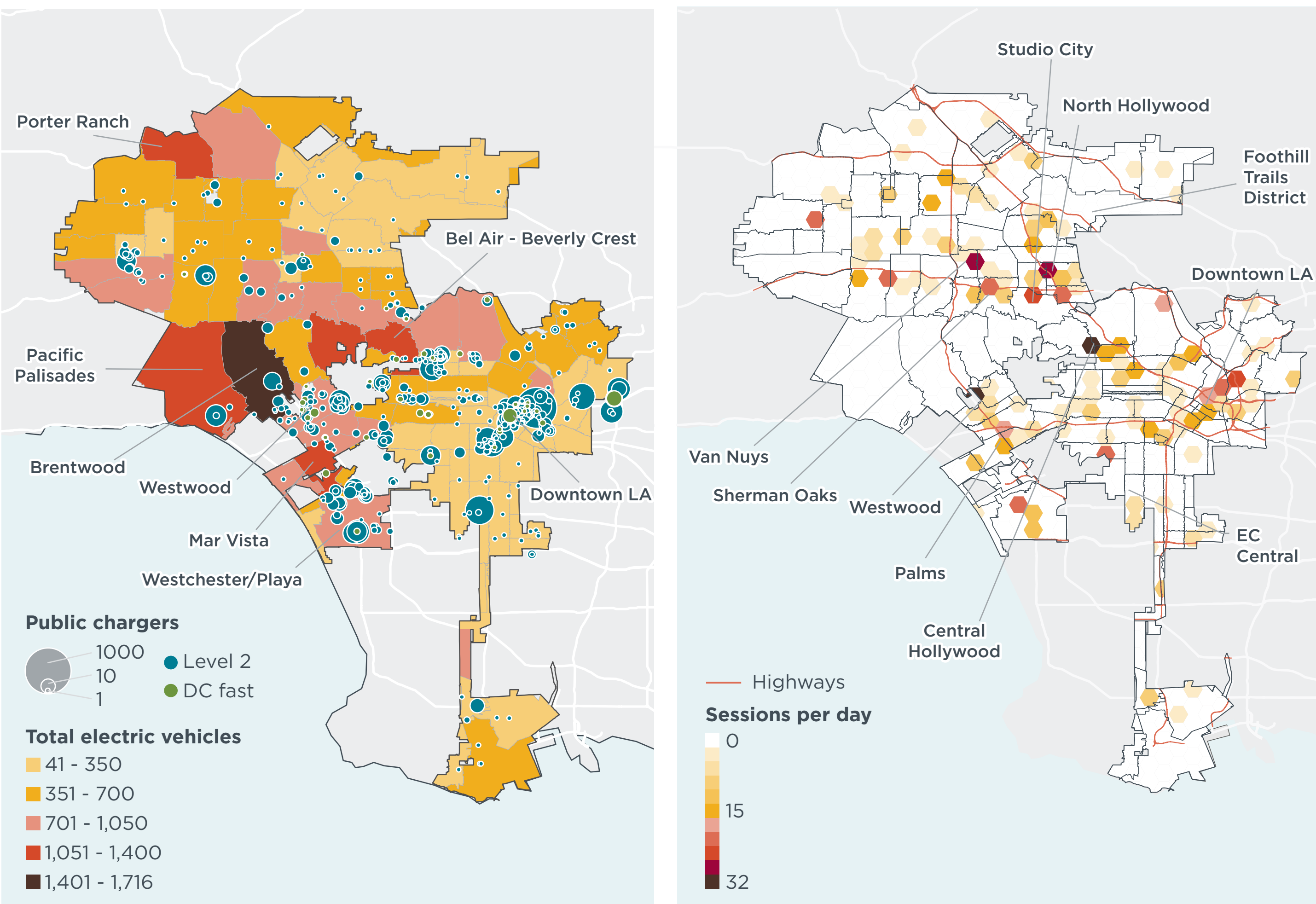

Figure 1. Los Angeles cumulative electric vehicle registrations through 2018 and public charging locations through 2019 (left) and charging sessions per day (right). Data from California Department of Motor Vehicles (2019), U.S. Department of Energy Alternative Fuels Data Center (2020), and City of Los Angeles staff.

Figure 1 shows that several areas on the west side of Los Angeles appear to have more cumulative electric vehicle registrations compared with areas in the northeast and south. ZIP codes with high registrations in Pacific Palisades, Brentwood, Porter Ranch, and Bel Air–Beverly Crest have relatively high numbers of detached homes, which suggests that access to home charging may be relatively more prevalent. In terms of public charging infrastructure, there were about 2,500 Level 2 and DC fast chargers installed by the end of 2019. The figure shows several areas where public chargers are clustered, such as Del Rey, Westchester/Playa, Westwood, West Los Angeles, as well as Downtown Los Angeles where there are relatively lower electric vehicle registrations but high commercial activities.

The right side of Figure 1 illustrates the concentration of public charging sessions per day based on data provided by Los Angeles staff. This charging data includes approximately 500 chargers, which represents roughly 20% of the public chargers installed through 2019, according to the Alternative Fuels Data Center data shown on the left. Areas with high charging sessions per day are generally areas with high commercial activities such as Downtown Los Angeles, North Hollywood, Sherman Oaks, Studio City, and Van Nuys. Chargers with especially high use in these areas had up to 20 sessions per day.

Comparing the electric vehicle and public charger deployment from the left side of Figure 1 with the concentration of charging sessions from the right side of Figure 1 provides additional indications of some underlying dynamics. Overall, the areas with high daily public charging sessions appear to be approximately aligned with the areas that have significant electric vehicle registrations, public charging infrastructure deployment, or both. In some cases, areas with high charger utilization are where there is a high concentration of chargers (Central Hollywood); in others, there appears to be a single charger with high utilization (Palms). The figure also reveals relative gaps. Areas including Empowerment Congress (EC) Central and Foothill Trails District appear to have relatively lower electric vehicle registrations, public charging deployment, and charger utilization.

The following analysis considers this context and quantifies charging infrastructure needs at the ZIP code level to meet Los Angeles' goal of increasing the percentage of electric vehicles citywide to 25% by 2025 and 80% by 2035. The analysis is focused on the public, workplace, and home charger needs for passenger vehicles. It then considers additional city-level interventions aiming to reduce vehicle travel demand and assesses the impacts of those interventions on charging infrastructure needs. Additional electric vehicle and infrastructure analysis is provided for selected areas of Los Angeles that are potential candidates for rollout of zero-emission areas.

ANALYSIS

Adapting a charging infrastructure analytical approach applied at the metropolitan area level (Nicholas, Hall, & Lutsey, 2019) and the city level (Hsu, Slowik, & Lutsey, 2020), we assess charging infrastructure needs from 2021 through 2030 to support Los Angeles' goals for electric vehicle market growth. Electric vehicle stock is informed by the rate of electric vehicle uptake and a vehicle stock-turnover model. Charging behavior in early electric vehicle markets and assumptions regarding increased average charger utilization are used to estimate infrastructure needs. The analysis includes several additional local-level factors such as vehicle ownership, housing, and commuting patterns. Additional city-level interventions intended to reduce vehicle travel demand are included in the analysis to assess their impacts on charging needs. The analysis is conducted citywide at the ZIP code level, as well as across four potential ZEA sites. The following summarizes the key methodological steps.

ELECTRIC VEHICLE FLEET COMPOSITION

Figure 2 shows a hypothetical electric vehicle adoption trend for Los Angeles and the resulting electric vehicle stock. The projected annual vehicle registration data apply Department of Motor Vehicle data and trends through 2018 (California Department of Motor Vehicles, 2018). The figure reflects a rapid increase in electric vehicle sales shares, reaching about 40% by 2025 and 100% by 2030, and resulting in an increase of registered electric vehicles in Los Angeles from about 100,000 in 2020 to more than 2.5 million by 2040. Based on underlying vehicle retirement characteristics, this trend results in 65% of Los Angeles' 2035 light-duty vehicle stock being electric. Electric vehicles include both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), and new sales shift from about 70% BEVs in 2020 to 100% BEVs in the mid-2030s. Electric vehicle uptake in the Los Angeles metropolitan area is assumed to lag the Los Angeles trend by several years and applies to commuters and thus workplace charging.

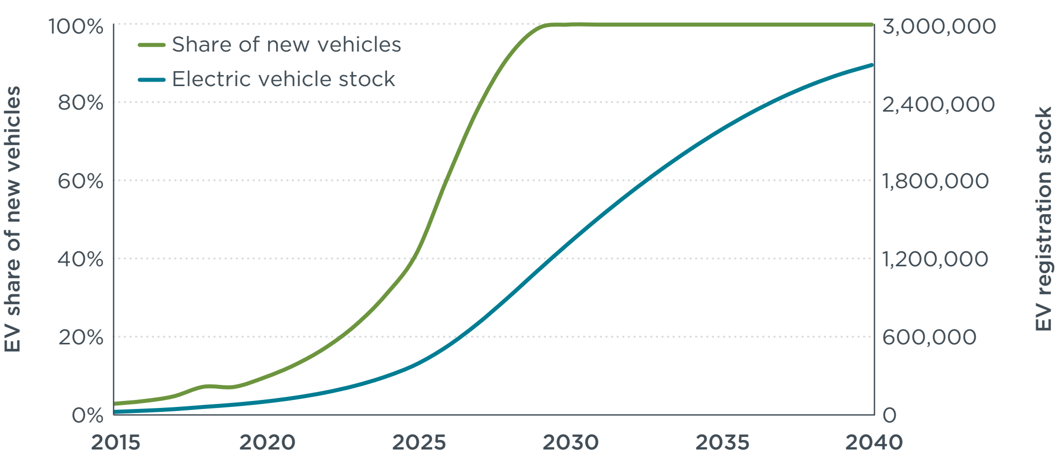

Figure 2. Assumed Los Angeles new electric vehicle share of new vehicles and electric vehicle stock from 2015 to 2040.

Several additional points help put the electric vehicle growth in Figure 2 in context. Based on the vehicle stock-turnover model, the electric vehicle stock lags the Los Angeles fleet-wide goals from the Green New Deal by about two years, indicating that accelerated fleet turnover programs will be important to achieve 80% electric vehicle stock by 2035. Although electric vehicle adoption at the ZIP code level varies across

Los Angeles through 2019, electric shares across all ZIP codes are assumed to reach 40% by 2025, matching the Los Angeles-wide curve in Figure 2. The analysis also assumes a citywide 1% annual decline in new light-duty vehicle registrations from 2019 onwards. Relative vehicle ownership per capita by ZIP code remains identical from 2018 onwards, reflecting overall density, housing, and parking patterns across Los Angeles.

Additional local inputs inform future charging needs by ZIP code. Housing growth is based on Los Angeles' Green New Deal. Housing characteristics, vehicle ownership, and commuting patterns are from the U.S. Census Bureau American Community Survey (U.S Census Bureau, 2019a). Electric vehicles in each ZIP code have varying reliance on public chargers as determined by their home charger access, which is informed by housing characteristics (i.e., detached, attached, and apartments). We assume that electric vehicles are universally adopted by new vehicle buyers across ZIP codes and housing types going forward, such that by 2040 the percentage of new electric vehicle owners by housing type resembles the percentage of the ZIP code residents by housing type in each ZIP code. The analysis is focused on 117 ZIP codes and excludes areas that do not have substantial land mass or housing, university campuses, and some parking lots in Universal Studios that are not readily accessible to the public (Los Angeles GeoHub, 2020; Los Angeles Housing Department, 2007). Additional infrastructure deployment in these areas could potentially reduce the need for chargers in the surrounding ZIP codes.

CHARGING ENERGY DEMAND

Energy demand is assessed based on electric vehicle stock and charging events per vehicle per day, applying data from a California survey (Tal, Lee, & Nicholas, 2018), and an assumed energy consumption per charging event (Nicholas et al., 2019). Energy demand for home and public chargers increases with electric vehicle market growth in each ZIP code. Energy demand for workplace chargers increases as the number of electric vehicles commuting into each ZIP code increases, including both intra-city commuters and commuters from outside of Los Angeles. The non-Los-Angeles-resident commuter count is based on the total jobs in Los Angeles, subtracting Los Angeles residents who commute to jobs outside Los Angeles and Los Angeles jobs held by Los Angeles residents. We assume 80% of the non-Los-Angeles-resident commuters drive into Los Angeles based on Los Angeles County American Community Survey (ACS) data (U.S Census Bureau, 2019a). Job distribution among ZIP codes is calculated using the five-year census tract workers count (Census Transportation Planning Product, 2016). The employment compounded annual growth rate is assumed at 1% across ZIP codes, with each ZIP code maintaining the same job distribution percentage.

Charging events per day varies between BEVs and PHEVs and access to home charging based on housing characteristics (Nicholas et al., 2019). The average number of charging events per day remains constant throughout the analysis, as does the average energy consumption per charging due to the diverging trends of incremental improvements in electric vehicle efficiency and increase of electric crossover and sport utility vehicles in the fleet.

CHARGING INFRASTRUCTURE: PUBLIC, HOME, AND WORKPLACE

Public Level 2 and DC fast infrastructure needs are projected by dividing the daily energy demand projections by the daily maximum amount of energy supplied by chargers. The analysis is primarily driven by the annual electric vehicle stock, per-vehicle electricity demand, and charger utilization assumptions. Public Level 2 and DC fast chargers are assumed to serve the residents within each ZIP as well as the electric vehicle commuters that do not have access to workplace charging. They are quantified based on the energy demand beyond what is supplied by home and workplace chargers divided by the utilization rates of public chargers. The breakdown of public charger usage for workplace charging is shown in the Appendix.

The utilization rate of public Level 2 chargers and DC fast chargers linearly increase from three and two hours a day in 2020, respectively, to eight hours a day in 2025 and thereafter. Relatively lower or higher utilization rates than assumed here would require more or fewer public chargers, respectively. Eight hours is based on a larger, more mature electric vehicle market, where charging deployment has evolved from basic geographic coverage toward greater capacity and is made possible by more electric vehicles and chargers concentrated in a given area. The public Level 2 chargers are assumed to have a constant 6.6 kW power across all years. DC fast chargers are assumed to increase linearly from an average charging power of 50 kW in 2020 to 115 kW in 2030.

Home chargers are estimated based on a charging behavior survey study that indicates the relative deployment of home charging for attached, detached, and apartment housing types, as shown in the Appendix Table A-1 (Tal et al., 2018). We apply the Los Angeles EV-ready building code, which requires 10% of spaces in new construction to have charging installed. We assume a construction rate based on average construction growth between 2013 and 2019, as well as the Green New Deal goal to add 275,000 new units between 2014 and 2035, or approximately 13,000 new units per year (Los Angeles Open Data, 2020; Mayor Eric Garcetti Office, 2019). The percentage of households with home charging incrementally increases as a result.

Workplace charger projections are calculated based on the total workplace charging events per day required by the intra-city and out-of-city commuters and job distribution among ZIP codes. Ten percent of electric vehicle commuters are assumed to have access to workplace chargers in 2019, which increases to 12% by 2030. The Los Angeles resident commuter count is the difference between total active commuters, retrieved from 2017 ACS block group, and the commuters leaving Los Angeles, calculated based on the 2017 Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES) (U.S Census Bureau, 2019a; U.S Census Bureau, 2019b). The total workplace chargers needed is based on each workplace charger supporting an average of 1.5 charging events a day. Each workplace charging event is assumed to deliver an average of 15.5 kWh for BEVs and 7.5 kWh for PHEVs. Workplace chargers are not assumed to be available to the public.

CITY-LEVEL INTERVENTIONS

In addition to the central case described above, an intervention case introduces three city-level policy interventions to assess their impact on charging needs across Los Angeles. The interventions reflect how Los Angeles—along with its electric vehicle adoption goals—seeks to shift mobility to more sustainable modes like transit and pedestrian travel and reduce overall private vehicle travel and traffic congestion. The three interventions are: 1) a sustainable trip goal, 2) a vehicle-mile-traveled (VMT) reduction goal, and 3) congestion pricing. The electric vehicle sales and stock projections are unchanged under the intervention case.

For sustainable trips, the Green New Deal's goal of increasing the percentage of trips made by walking, biking, micromobility, or transit to at least 35% by 2025 and 50% by 2035 is applied to all ZIP codes. The shift to sustainable trips occurs linearly from each ZIP code's 2017 sustainable mode share percentage based on ACS data (U.S Census Bureau, 2019a). Increases in sustainable trips decrease the number of passenger vehicle trips. As an illustrative example, increasing the share of sustainable trips from 20% to 50% reduces the share of vehicle trips from 80% to 50%. The shift to sustainable trips reduces electric vehicle travel, charging demand, and the number of public and workplace chargers needed. For home chargers, the home charging demand is reduced, but the number of home chargers remains the same, as electric vehicle owners are assumed to install home chargers when possible.

For the VMT reduction, Los Angeles' Green New Deal goal of reducing VMT by 13% by 2025 and 39% by 2035 is applied linearly to all ZIP codes. These VMT reduction goals could be met with city programs like expanded transit and shared and micromobility transportation options, transportation demand management for existing and new developments, and parking reforms. Similar to the shift to sustainable trips, VMT reduction reduces trips in passenger vehicles and thus the electric vehicle travel, energy, and infrastructure demand.

For congestion pricing, a hypothetical program that introduces a price on trips heading into selected ZIP codes is assumed starting in 2028 (Southern California Association of Governments, 2019). The applicable ZIP codes are generally in and around Central Hollywood, Downtown Los Angeles, and West Los Angeles and include the following 15 ZIP codes: 90005, 90006, 90012, 90013, 90014, 90015, 90017, 90025, 90028, 90038, 90046, 90057, 90064, 90067, and 90071. Congestion pricing is assumed to reduce applicable passenger vehicle VMT in the congestion-priced zones by 15% and is analytically applied after the citywide VMT reduction introduced above. Congestion pricing reduces electric vehicle travel, charging demand, and the projection of public and workplace chargers needed. The travel patterns and origin-destination matrix for each ZIP code is determined based on LODES data and was used to assess all three city interventions (U.S Census Bureau, 2019b).

ZERO-EMISSION AREAS

In addition to Los Angeles-wide analysis, the electric vehicle and infrastructure needs across four sample ZEA boundaries are analyzed: Central Hollywood, Downtown Los Angeles, Chinatown, and MacArthur Park. Numerous transportation developments are needed to facilitate implementation of a ZEA, such as greatly improved transit access, increased land area for pedestrian and bicycle transportation, and reduced dependence on personal vehicle travel. For these reasons, we assume that the share of sustainable trips in the ZEAs reaches 65%, VMT is reduced by 50%, and vehicle registrations decrease by 25% by 2030.

The applicable ZIP codes within ZEA boundaries are 90005, 90006, 90012, 90013, 90014, 90015, 90017, 90038, 90057, and 90071. For each ZEA, the charging infrastructure is calculated based on the percentage of the core ZIP codes' populations that overlaps with the ZEA boundaries. This approach ensures that the ratio of electric vehicle or infrastructure per population is evenly distributed throughout Los Angeles. Thus, while some ZIP codes such as 90071 are fully within the Downtown Los Angeles ZEA boundary, other ZIPs such as 90013 that are partially within the Downtown Los Angeles ZEA boundary experience partial effects of the ZEA.

ASSESSMENT OF EQUITY FACTORS

Expanding electric vehicle equity and access is a key component in Los Angeles' vision for growth. Designing equitable electric vehicle and infrastructure policies and practices requires adequate and inclusive planning with communities and their organizations to identify mobility needs, understand the unique barriers to electrification, and develop tailored solutions. Focused planning on communities with lower incomes and high environmental pollution burden is among the options to identify and prioritize electric vehicle planning and expand the economic and environmental benefits to those who need them most. This section assesses equity factors related to infrastructure access, electric vehicle rebates, and environmental pollution burden.

We assess public charger deployment in disadvantaged communities or census tracts that score 40 or higher based on California's CalEnviroScreen (CES; California Office of Environmental Health and Hazard Assessment, 2017). These communities are disproportionally burdened by poverty, unemployment, and environmental pollution. Most of these census tracts in Los Angeles (more than 80%) overlap with low-income communities as designated under Assembly Bill AB1550 (California Office of Environmental Health and Hazard Assessment, 2017). By examining disadvantaged census tracts, the analysis helps to partially reveal some areas that would benefit from greater investment.

RESULTS

The results of the charging infrastructure analysis are presented in several ways. Total charging needs for Los Angeles are summarized to convey the scale of increasing infrastructure needs. Charging needs are then presented at the ZIP code level to show variation across Los Angeles. In each, the results are shown for the central case as well as the intervention case where additional goals are met that could greatly reduce charging needs. Following the Los Angeles citywide results, charging needs are summarized for four ZEAs with supporting discussion regarding potential sites for infrastructure deployment and an assessment of equity factors.

CHARGING INFRASTRUCTURE NEEDS ACROSS LOS ANGELES

Meeting Los Angeles' electric vehicle goals will require significant deployment of home, workplace, and public charging infrastructure. Table 1 summarizes the overall public and workplace charging infrastructure needs in Los Angeles for 2025 and 2030, including comparisons with chargers installed through 2019 in both the central and intervention case. The table does not show home charging needs. As shown, by the end of 2019, Los Angeles had installed about 5% of the public and workplace charging infrastructure it needs in 2030. Public chargers would need to increase from about 2,500 in 2019 to approximately 50,000 by 2030. This means about 20 times more charging is needed by 2030, which is a 31% annual growth rate. Charging needs are greatly reduced in the intervention case. If Los Angeles interventions are implemented, the annual public-access charger growth rate is reduced from 31% to 24%, and the infrastructure needed is reduced from 50,000 to 27,000.

Table 1. Los Angeles charging infrastructure required to reach 40% electric vehicle sales by 2025 and 100% electric vehicle sales by 2030.

	Year	Central case	Intervention case
Number of public, workplace, and DC fast chargers	2019[a]	2,516	2,516
	2025	14,548	10,365
	2030	49,839	27,293
Electric vehicle stock	2025	387,879	387,879
	2030	1,313,450	1,313,450
Projected future charging compared with 2019	2025	5.8x	4.1x
	2030	19.8x	10.8x
2019 as percentage of future chargers needed	2025	17%	24%
	2030	5%	9%
Annual increase in chargers from 2019 to meet 2025 and 2030 needs	2025	33%	27%
	2030	31%	24%

[a] 2019 does not include workplace chargers due to lack of data

Table 2 provides a further breakdown of the number of public Level 2, DC fast, workplace, and home chargers needed in 2025 and 2030. Home chargers are the majority, at approximately 90% of all chargers, growing from about 165,000 in 2025 to more than half a million by 2030. By 2030, Los Angeles needs approximately 21,500 public Level 2 and 3,900 DC fast chargers. For context, there were approximately 2,400 public Level 2 and 116 DC fast chargers in Los Angeles at the end of 2019 (U.S. Department of Energy Alternative Fuels Data Center, 2020). The analysis shows that DC fast chargers need deployment at a much faster rate than public Level 2. By 2030, DC fast chargers would need to grow by a factor of about 33, while public Level 2 chargers would grow by a factor of about 8.

Table 2. Estimated charging infrastructure needed in Los Angeles in 2025 and 2030.

Year	Central case					Intervention case				
	Public Level 2	DCFC	Workplace	Home	Total	Public Level 2	DCFC	Workplace	Home	Total
2025	6,152	1,248	7,148	164,618	**179,166**	4,578	904	4,883	164,618	**174,983**
2030	21,516	3,876	24,447	535,109	**584,948**	12,600	2,202	12,491	535,109	**562,402**

Based on the pace and scale of electric vehicle adoption and assumptions around home charging availability and public charger utilization, our central estimate shows that about 25,000 public chargers (Level 2 and DC fast) are needed by 2030. This value is approximately 3,000 chargers lower than Los Angeles' Green New Deal goal of having 28,000 public chargers by 2028. Los Angeles would also need approximately 25,000 workplace chargers by 2030, a 16-fold increase from 2019. Workplace charging has the potential to account for a greater share of total charging counts; the analysis assumes 10% to 12% of electric vehicle commuters have access to workplace charging.

Shifting to more sustainable trips, VMT reduction, and congestion pricing would greatly reduce the number of chargers needed, as shown on the right side of Table 2. Public Level 2, DC fast, and workplace charging counts together are reduced by approximately 29% by 2025 and 45% by 2030. Specifically, compared with the 2030 central case, intervention reduces needed public Level 2 chargers by 41%, DC fast chargers by 43%, and workplace chargers by 49%. Table 3 shows the impact of each intervention for each charger type. We find that the increase in sustainable trips has the highest impact. The total public and workplace charger projection is decreased by 18% in 2025 and by 24% in 2030. A reduction in VMT reduces approximately 13% of total public and workplace chargers needed by 2025, and 26% in 2030. Congestion pricing, assumed here to be implemented in 2028, reduces total public and workplace charger needs by about 3% in 2030.

Table 3. Intervention impacts on charger projections in 2025 and 2030.

	Charger type	2025	2030
Sustainable trips	Public Level 2	-891	-4,100
	DCFC	-209	-851
	Workplace	-1,535	-7,000
Vehicle-miles-traveled reduction	Public Level 2	-800	-5,594
	DCFC	-162	-1,008
	Workplace	-929	-6,356
Congestion pricing	Public Level 2	0	-508
	DCFC	0	-71
	Workplace	0	-764

Note: Sustainable trips, VMT reduction, and congestion pricing are independent of one another. When both sustainable trips and VMT reduction are enacted, the VMT reduction further impacts the sustainable trip reduced vehicle travel demand. Similarly, when sustainable trips, VMT reduction, and congestion pricing are enacted, the VMT reduction is applied to the reduced demand from sustainable trips, and congestion pricing further impacts the sustainable trip and VMT reduced travel demand.

Charging infrastructure needs at the ZIP code level are also estimated. Figure 3 illustrates the projected electric vehicle stock and the number of public Level 2 and

DC fast chargers across each ZIP code in 2030 in the central case. The ZIP codes with the darkest shading have relatively higher electric vehicle stocks, whereas areas with lighter orange shade have relatively lower electric vehicle stocks. Public charger counts are shown by the blue data circles. ZIP codes with more public chargers needed are generally those with more electric vehicle registrations, higher concentration of jobs and thus commuters, or a combination of both. Because public chargers are assumed to serve both residents and commuters, higher electric vehicle adoption corresponds with higher public charging needs. The ZIP codes with the highest public charger needs are 90045, 90012, 90015, 90017, 91367, and 91342. ZIP code 90045, with the most electric vehicles (55,000) and chargers needed (1,100) in 2030, includes Westchester and Los Angeles International Airport. The areas of 90012, 90015, and 90017 in Downtown and 91367 in the Warner Center area all have high commuter counts. The Sylmar Neighborhood Council, or ZIP code 91342, has high housing counts.

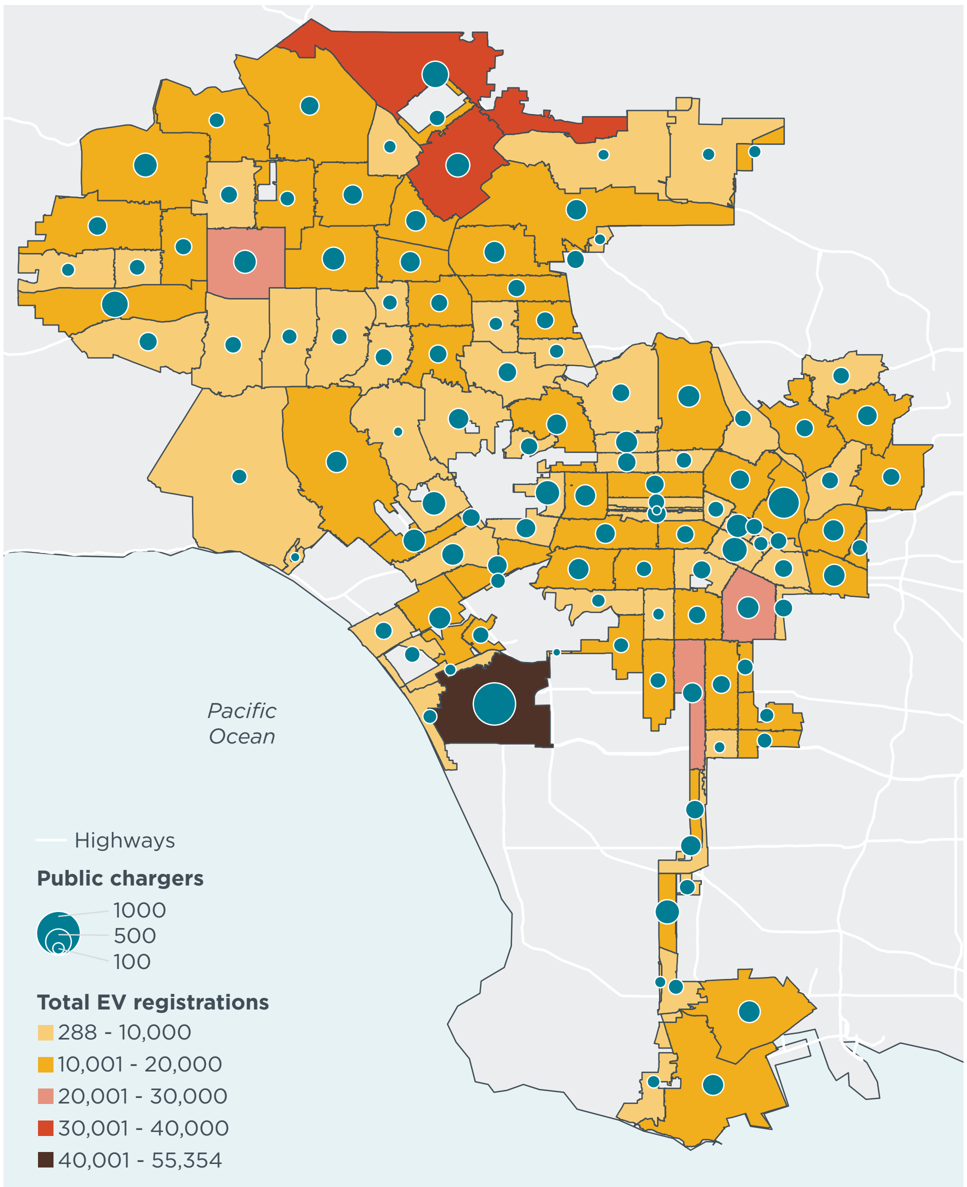

Figure 3. Public Level 2 and DC fast chargers needed and the electric vehicle stock in each Los Angeles ZIP code in 2030.

Due to their smaller areas, relatively lower car ownership per household, and high percentage of the population who use sustainable transportation, downtown ZIP codes have lower electric vehicle stocks than ZIP codes with more detached and attached housing, high car ownership rates, and low share of sustainable transportation modes. However, some ZIP codes such as 90012, 90015, and 90017, which includes Chinatown and Downtown Los Angeles, have some of the highest job counts, leading to high public charging infrastructure needs due to electric vehicle commuters who do not have charging at work.

A mix of public Level 2 and DC fast chargers is needed to meet diverse electric vehicle travel patterns, charging behavior, and price sensitivities. DC fast chargers are roughly 11% to 20% of total public charger counts among all ZIP codes. The ratios reflect the different charging needs of electric vehicle owners, based on unique housing characteristics, home charging availability, and commuting behavior. The ratios assessed here are based on observed charging behavior data (Tal et al., 2018) and observed infrastructure deployment across U.S. metropolitan areas (Nicholas et al., 2019), updated for local characteristics in Los Angeles.

Figure 4 shows the workplace chargers needed in 2030 to serve commuters entering each ZIP code (red data circles) and the projected number of electric vehicle commuters that originate in each ZIP code (green shading), in the central case. For workplace charging, 12% of electric vehicle commuters are assumed to have access to workplace charging in 2030. Overall, ZIP codes with higher percentages of Los Angeles' jobs attract more commuters and are projected to have more workplace chargers. ZIP code 90045, home to many residences and Los Angeles International Airport, is a hotspot for both public and workplace chargers. Downtown area ZIP codes, such as 90012, 90015, and 90017, have some of the highest workplace charger counts due to the high concentration of jobs and commercial activities. Some non-downtown neighborhoods with relatively high workplace chargers are 91367 (Warner Center area), 90048, and 90024 (both surround Beverly Hills).

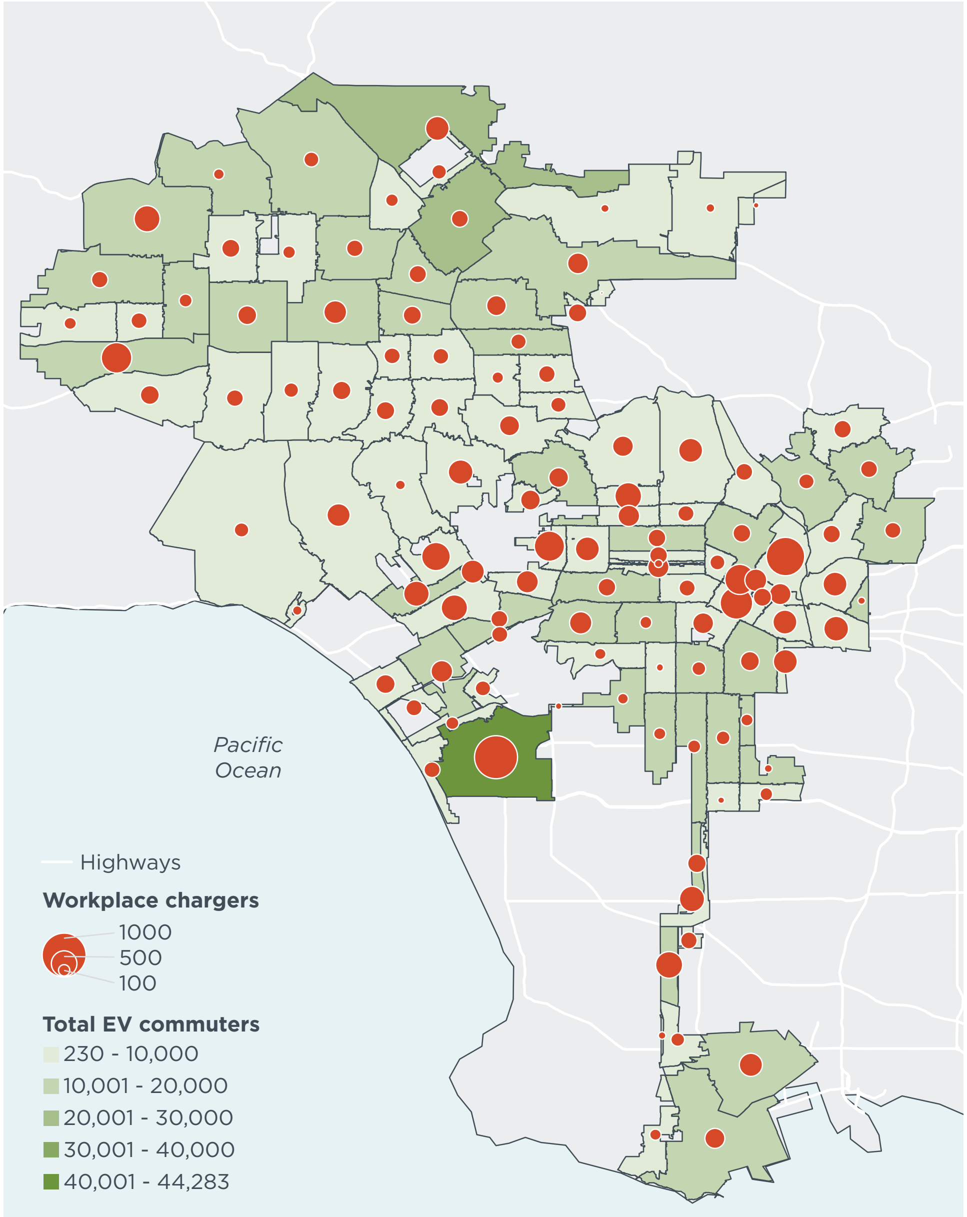

Figure 4. Workplace chargers needed and electric vehicle commuter residence locations by Los Angeles ZIP code in 2030.

Transitioning to electric vehicles will require significant daily energy demand. The analysis indicates 3.2 gigawatt-hours (GWh) and 11.2 GWh are needed daily by 2025 and 2030, respectively, up from an estimated 0.6 GWh in 2019. By 2030, the city grid would serve approximately 1.4 million electric vehicles, including 1.3 million residents and 110,000 out-of-city commuters. For context, the average daily electricity consumption in Los Angeles was approximately 63.8 GWh per day in fiscal year 2015-2016 (Los Angeles Department of Water and Power, 2017). Home charging accounts for about 60% of the total electric vehicle energy demand in both the central and intervention cases. Workplace chargers account for about 5% of total electric vehicle energy demand while public charging accounts for about 35%. By 2030, total electric vehicle energy demand in the intervention case is approximately half of the energy demand in the central case. A detailed summary of electric vehicles' energy demand is shown in the Appendix.

CHARGING INFRASTRUCTURE NEEDS IN ZERO-EMISSION AREAS

The implementation of ZEAs is a key element in Los Angeles' long-term vision to tackle problems related to air pollution, greenhouse gas (GHG) emissions, and congestion. Numerous transportation developments are needed to facilitate implementation of a ZEA. They include greatly improved transit access, increased land area for pedestrian and bicycle transportation, expanded shared mobility options, and reduced dependence on personal vehicle travel. To realize ZEAs fully, residents who rely on personal vehicles—or for whom transit, pedestrian, bicycle, or shared mobility options are not made readily available—need electric vehicles and their infrastructure.

To assess charging infrastructure needs in ZEAs, we assume that the share of sustainable trips in the ZEAs reaches 65%, VMT is reduced by 50%, and vehicle registrations decrease by 25% by 2030. For context, the share of sustainable trips in ZIP code 90028 that contains the Central Hollywood ZEA was approximately 28% in 2017 (U.S Census Bureau, 2019a). Increasing the sustainable trip share to 65% by 2030 would mean that approximately 13,000 trips per day in the ZIP code are done by transit, walking, or biking in 2030, which is approximately aligned with the goals for increasing Metro ridership in Central Hollywood.

Figure 5 illustrates the electric vehicle registrations and the breakdown of public Level 2, DC fast chargers, and workplace chargers needed by 2030 in the four sample ZEAs: Central Hollywood, Chinatown, Downtown Los Angeles, and MacArthur Park. Based on this analysis, ZEAs need approximately two to four times more public and workplace charging infrastructure than they had in place at the end of 2019. Although more infrastructure is needed in these ZEAs, the total public and workplace charger needs were reduced by 65% and home charger needs were reduced by 25% compared with the central case defined above. Home charging, although critically important, is not depicted in the chart on public and workplace charging needs. The Downtown Los Angeles ZEA has the highest total public and workplace charger needs with 950 public and workplace chargers, of which about 60% are workplace, 36% are public Level 2, and 4% are public DC fast chargers, to support approximately 12,000 resident and commuter electric vehicles in the area by 2030. Overall, in these areas, about 50% of the chargers are workplace chargers, based on the relative number of jobs in each area.

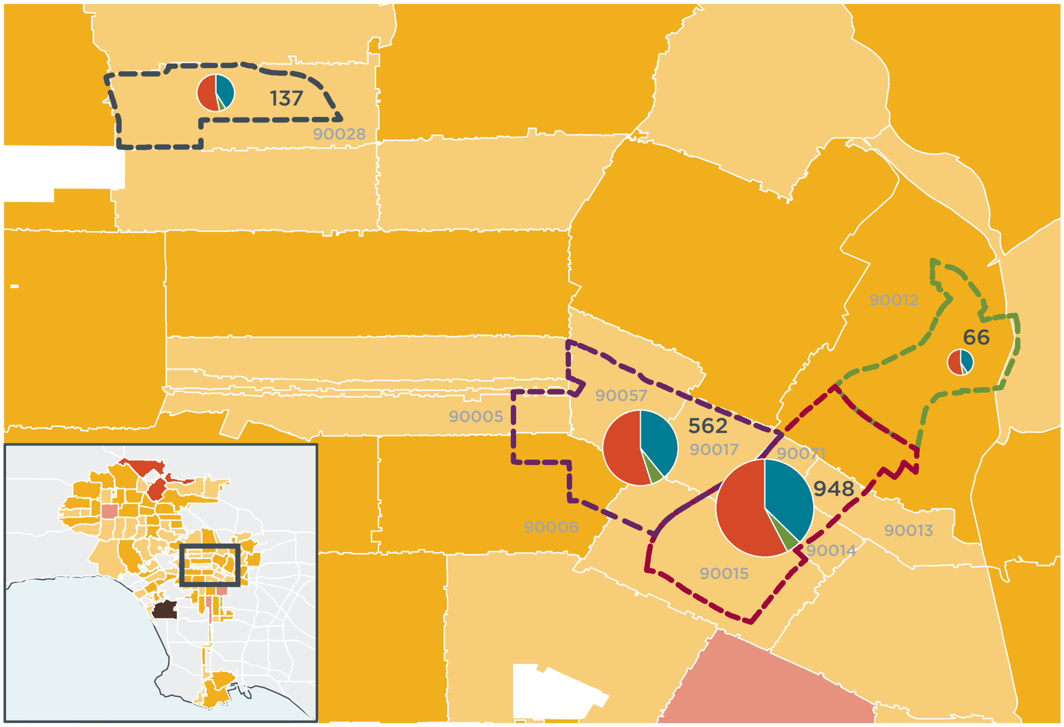

Figure 5. Total public and workplace chargers needed in the sample ZEAs in 2030.

Charging infrastructure in 2019 and charging needs for 2025 and 2030 for each ZEA are shown in Figure 6. Expanding on Figure 5, estimates of home chargers needed is included. The figure underscores the importance of home charging, which represent more than 70% of total chargers needed in all ZEA sites through 2030. In 2030, MacArthur Park would require about 6,000 total chargers (home, public, and workplace), while Downtown Los Angeles needs roughly 5,000 total chargers. As shown, MacArthur Park and Downtown Los Angeles ZEAs need many more chargers than the Central Hollywood and Chinatown ZEAs, which require approximately 1,400 and 900 total chargers in 2030, respectively. Including home and public charging, the sample ZEAs will need at least four to eight times the amount of infrastructure in 2030 compared with 2019. The difference is primarily due to the greater overall population, the number of vehicles registered in the area, and job concentration in Downtown Los Angeles and MacArthur Park. Downtown Los Angeles requires more public and workplace chargers than MacArthur Park due to the higher concentration and number of jobs.

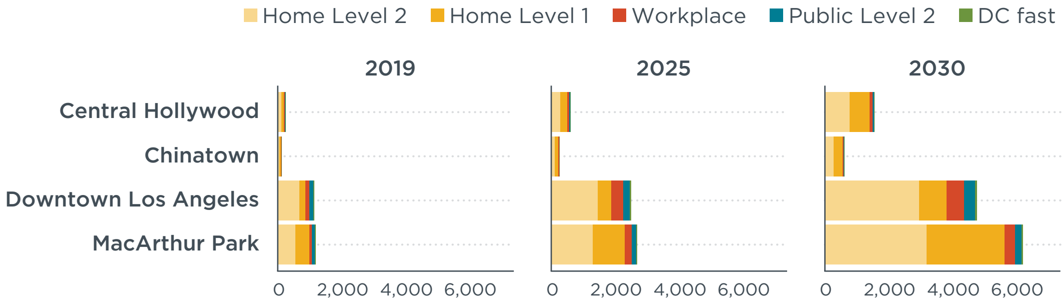

Figure 6. Charging infrastructure needed in the sample ZEAs.

Some of the parking spaces in these ZEAs can be converted into public charger locations, further increasing awareness and access. Based on the 2010 Los Angeles city census tract parking data, we find that there are roughly 330 on-street parking spaces in Central Hollywood, 800 in Chinatown, 2,400 in Downtown Los Angeles, and 2,000 in MacArthur Park (Transportation Life-Cycle Assessment Center, 2010). If all public chargers projected by 2030 are deployed in existing parking spaces, they would make up approximately 7% to 30% of the total parking spaces in these areas. Further insights are discussed below on the location and supports needed for charging infrastructure planning in the sample ZEAs, using Chinatown ZEA as an example.

Figure 7 shows some potential locations for public charging within Chinatown. The image is a selected area of the larger Chinatown, making up about 8% of ZIP code 90012's land area and containing approximately 40% of its population. Supermarket (shown in white parking symbology) and mall parking lots are destinations where consumers often park for several hours at a time, and thus are suitable for slower and lower cost public charging like public Level 2 chargers. Continued deployment of chargers at curbsides and attached to streetlight poles are also ideal (City of Los Angeles Public Works Bureau of Street Lighting, n.d).

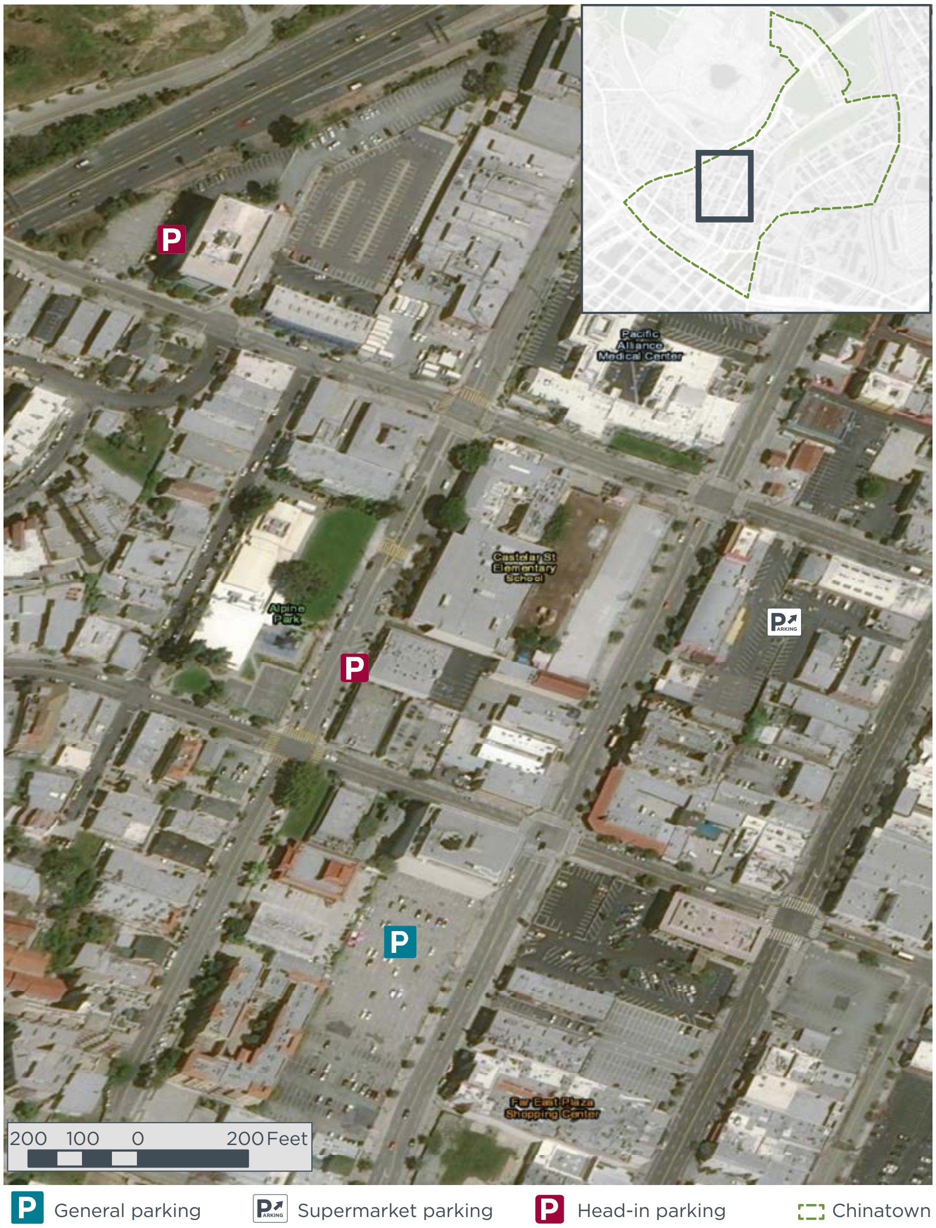

Figure 7. Example of potential public charger locations in Chinatown, Los Angeles.

General parking lots (shown in blue parking symbology) that attract many consumers for many purposes require diverse charging options, including public Level 1, Level 2, workplace, and DC fast chargers. This busy mixed-use public and commercial area contains several big employers such as Far East Plaza shopping center, Dynasty shopping center, and Bank of America Financial Center. Large public parking lots that effectively serve as off-street home or workplace parking are also good candidates for lower cost, lower power chargers. Head-in curbside parking locations (shown in pink parking symbology) are potential locations for charging infrastructure, although there may be practical challenges around deploying DC fast chargers at these locations, potentially including physical limitations and necessary electrical upgrades. Potential sites for DC fast chargers include parks, rest stops, corridors, and commercial settings with shorter dwell time and code-compliant infrastructure (California Energy Commission, 2015).

Many more home chargers are needed to support future electric vehicle adoption, and access to regular overnight charging at home is key to overall system affordability in terms of energy costs and infrastructure hardware and installation costs. Chinatown will need approximately 800 home chargers by 2030. Most of the residential housing in the area is located on the west side of the ZEA boundary, southwest of Dodger Stadium (Los Angeles City Zone Information Map Access System, n.d). Community engagement and outreach in these areas would complement the city's residential electric vehicle charging station rebate program. Figure 7 is just one snapshot of potential locations for home, public, and workplace charging, and much deeper engagement with communities, businesses, and charging providers is needed to identify the most appropriate locations for infrastructure deployment that comply with local codes and have suitable power capacity. Examples of installed charging infrastructure in Chinatown are shown in Appendix Figure A-1.

FUEL AND CARBON BENEFITS

The carbon and fuel benefits of Los Angeles' transition to electric vehicles based on the above analyses are quantified based on previous analysis (Lutsey, 2015). Figure 8 shows the GHG emissions reduction as electric vehicles make up an increasing percentage of all vehicles on Los Angeles roads from 2020 to 2050, based on Figure 2. The blue wedge shows the GHG reduction in thousand metric tons of CO_2 per year. The green dash line corresponds to the change in percentage compared with a reference scenario, which is based on the federal Obama Administration GHG emissions and fuel efficiency standards as established in 2012, which include combustion vehicle improvements and electric vehicles reaching only 3% of new vehicle sales in 2025 (Final Rule for 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 2012). In other words, the benefits are based on just electric vehicle penetration, excluding benefits from efficiency that are coming in parallel. The Figure 8 analysis is based on the electric vehicle transition outlined in Figure 2, such that the share of new vehicles that are electric reaches 41% by 2025, and 100% in 2030. The GHG emissions intensity of electricity to charge electric vehicles in Los Angeles is assumed to decrease from about 115 grams CO_2/megajoule (gCO_2/MJ) in 2020 to about 15 gCO_2/MJ in 2050, reflecting parallel developments to decarbonize the power sector.

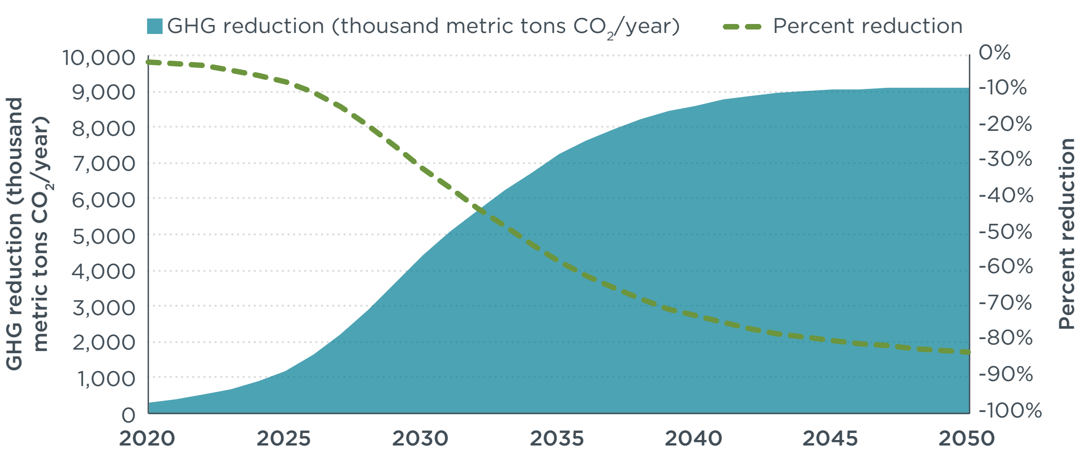

Figure 8. Greenhouse gas emissions reduction from transitioning to electric vehicles in Los Angeles, 2020 through 2050.

Figure 8 shows that, by 2030, when all new vehicle registrations are electric in Los Angeles, the GHG emissions reduction is approximately 4.5 million metric tons CO_2 per year, or a 30% reduction from the reference case. By 2050, when almost all vehicle stock is electric, the reduction doubles to approximately 9 million metric tons CO_2 per year, or an 85% reduction from the reference case. This analysis assumes the central case (i.e., without complementary action to increase sustainable trips and reduce VMT). The reductions shown include the impact of the incremental improvements to combustion vehicles and the transition to electric vehicles as indicated by Los Angeles' goals. The analysis does not consider the recent developments with the Safer Affordable Fuel-Efficient regulations, which have been released but are under litigation (The Safer Affordable Fuel-Efficient Vehicles Rule, 2019, 2020).

There are also substantial associated fossil fuel reduction benefits from transitioning to 100% electric vehicle sales by 2030. The reduction in fuel consumption is about 500 million gallons per year, a 35% reduction from the reference case in 2030. By 2050, this number is approximately 900 million gallons per year, approximately a 90% reduction from the reference case. As above, the fossil fuel reduction benefits include the impact of incremental improvements to combustion vehicles and the transition to electric vehicles in Los Angeles.

ASSESSMENT OF EQUITY FACTORS

Although the analysis above is built on approaching universal access to electric vehicle use over time, a complete consideration of equity would need to include more accessible charging, additional electric vehicle incentives, and proactive identification and addressing of the other transportation needs of underserved city residents.

An equitable transition to 100% electric vehicles relies heavily on the accessibility of home charging. Although electric vehicle adoption is growing across the city, many residents in low-income communities and multi-unit dwellings face greater challenges to home charging access. Developing home or near-home charging solutions for these communities is a key factor in improving access to affordable and practical charging. By 2030, Los Angeles needs more than half a million home chargers, which is more than 90% of total chargers needed by 2030 (see Table 2). Where residents have less access to home charging, prioritizing robust public charging deployment is critical. Identifying areas that need additional support is the first step toward equitable access to charging. This includes development of infrastructure support programs in the areas that are least likely to receive private sector investment, including areas with lower electric vehicle uptake, low-income and disadvantaged communities, and less populated areas (Canepa, Hardman, & Tal, 2019; Hsu & Fingerman, 2020).

Figure 9 shows the distribution and count of public Level 2 and DC fast chargers across Los Angeles and in the illustrative ZEA sites that were installed through 2019. The blue data circles represent public Level 2 chargers, and the green data circles represent public DC fast chargers. Areas with the most public charging installed through 2019, ranging from 20 to 100 chargers, include Central Hollywood, Downtown Los Angeles, Westchester/Playa, and West Los Angeles area (consists of Westwood, West LA, and Westside Neighborhood Councils). The figure also shows the pollution and socioeconomic burden across Los Angeles by census tract. Census tracts with the darkest red shade have higher CES scores, whereas areas with lighter red shades or white have lower CES scores. Disadvantaged communities are those that have CES scores above 39. Overall, the areas with the highest CES scores tend to be concentrated in the northeast and south sides of Los Angeles.

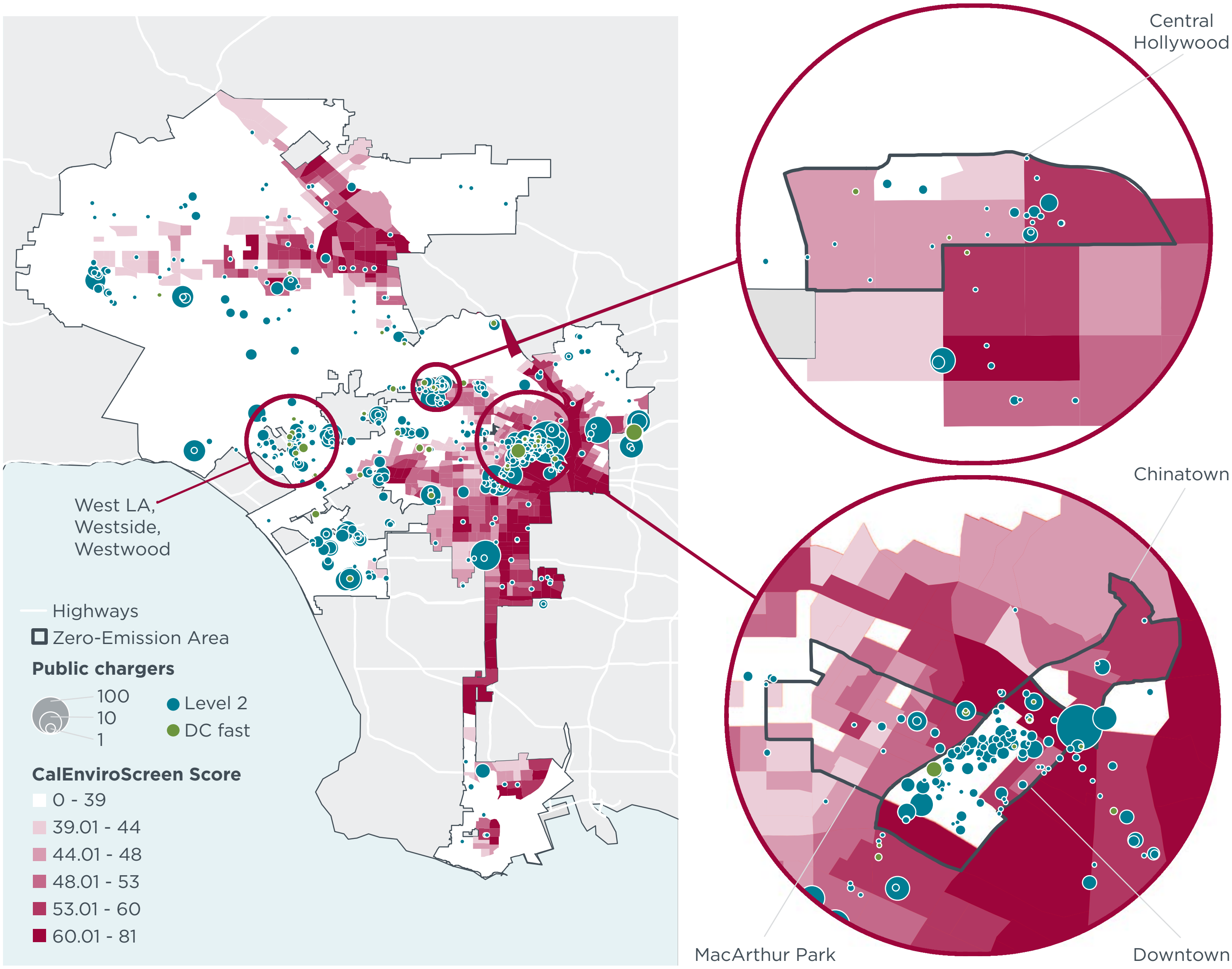

Figure 9. Public Level 2 and DC fast chargers and the CalEnviroScreen score across Los Angeles census tracts and potential ZEA sites. Data are from the U.S. Department of Energy Alternative Fuels Data Center (2020) and California Office of Environmental Health and Hazard Assessment (2017).

Viewing the public charging infrastructure and CES score data together in Figure 9 reveals relative gaps and opportunities to guide future infrastructure deployment. Overall, about 45% of public charging infrastructure deployed through 2019 is located in disadvantaged communities, where nearly 50% of Los Angeles' population resides. However, the distribution of blue and green data circles shows that public charging deployment through 2019 is relatively limited in many areas, disadvantaged community or otherwise. Continued and expanded efforts to deploy public charging in disadvantaged communities are needed to fill gaps in the red areas of Figure 9, including South Los Angeles and areas in the San Fernando Valley. Local policies and programs that intentionally target disadvantaged communities are needed to advance equitable access.

Focusing on the ZEA sites shown on the right-hand side of Figure 9, the public chargers in Central Hollywood (top) are located in some of the highest CES score tracts. In Downtown Los Angeles (bottom), many public chargers have been installed, both within and outside of disadvantaged community census tracts. Public charging infrastructure deployment in Chinatown and MacArthur Park appears limited relative to deployment in nearby Downtown. These sample ZEA sites and the surrounding areas are home to several disadvantaged community census tracts. As quantified above, much more charging is needed in these areas.

In addition to charging infrastructure deployment, well-designed financial incentives and outreach campaigns remain important to overcome electric vehicles' higher upfront costs and expand access beyond early adopters. Some equity-focused incentive and outreach programs in California have had early success in diversifying ZEV access (Slowik, 2019). One example is the Replace Your Ride (RYR) program, which provides a broad range of clean mobility options to help low-income residents in the Greater Los Angeles area scrap older polluting vehicles (South Coast Air Quality Management District, n.d.). Qualified applicants can receive up to $9,500 upfront cost reduction to upgrade their vehicle to a hybrid or electric vehicle or get vouchers for carsharing or public transit.

Funding community engagement and outreach is critical to complement financial incentive programs. Valley Can, the organization that operates RYR in the San Joaquin Valley, offers several community clinics to showcase electric vehicle benefits and in-person assistance to community members to apply for the RYR program. As a result, 90% of disadvantaged community census tracts in the San Joaquin Valley have received RYR benefits through a complete vehicle purchase since its inception in 2015 (Pierce & Connolly, 2019). In Los Angeles County, recent data from the Empower outreach campaign that connects low-income households with environment-related financial assistance programs, including RYR, have shown success in reaching vulnerable and underserved communities (Pierce & Connolly, 2020). These accomplishments highlight the need for strategic planning that includes community outreach and engagement. Learning and building on these early successes will be crucial for Los Angeles to expand equitable zero-emission mobility access for all Angelenos.

DESIGNING ELECTRIC VEHICLE AND INFRASTRUCTURE POLICIES

There are many policy options regarding consumer incentives, infrastructure deployment, codes, permitting, zoning, and parking that can be utilized to encourage electric vehicle adoption and industry infrastructure investment. The following sections list several example near-term (2021–2022), mid-term (2023–2025), and longer-term (2026–2030) policy actions to overcome consumer cost, infrastructure, and awareness barriers, and provides examples of exemplary policies implemented in other leading markets where applicable. The actions identified are intended to be representative of the major opportunities to support electric vehicle and infrastructure deployment and are not comprehensive. Any efforts intended to expand electric vehicle equity and access would ideally consult with disadvantaged communities about their mobility needs and then work backward to develop policies and programs to solve them (Slowik, 2019). The policies identified here would ideally be implemented alongside joint initiatives to shift mobility toward transit, shared mobility, and other sustainable modes.

NEAR-TERM (2021–2022) POLICY SUPPORT ACTIONS

Los Angeles has been highly active in supporting electric vehicle uptake through programs focused on vehicle and charger incentives and customer awareness. In the near-term, as shown in Table 4, continuing and greatly expanding on existing programs is critical to continued market growth. These include electric vehicle rebates, residential and commercial charger incentives, streetlight and curbside charger programs, BlueLA electric carsharing, and outreach.

Table 4. Near-term (2021–2022) policy actions to promote electric vehicle uptake.

Category	Example actions
Consumer incentives	• Continue and expand on the Charge up LA! electric vehicle rebate program with Los Angeles Department of Water and Power (LADWP)
Charging infrastructure	• Continue and expand on Charge up LA! residential and commercial chargers rebate program (LADWP, n.d.) • Continue and expand on streetlight, curbside, and multi-unit dwelling charger program, especially in disadvantaged communities (City of Los Angeles Public Works Bureau of Street Lighting, n.d.; Austin Energy, 2019) • Inventory city-owned assets and assess which are good infrastructure candidates (City of Stockholm, 2020) • Develop charging infrastructure strategy, identify key partners and stakeholders, define stakeholder roles, and identify needed city policy actions (The London Mayor's Electric Vehicle Infrastructure Task Force, 2019)
Consumer awareness	• Support and expand upon local ride and drive efforts to reach more communities, especially low-income and disadvantaged communities (Watts Neighborhood Council, 2018) • Raise awareness about available programs and incentives, including the Clean Vehicle Rebate Project, Clean Vehicle Assistance Program, Charge up LA!, and Blue LA! in disadvantaged communities • Link to city and utility EV informational materials on LADWP ratepayer bills • Provide crystal clear information and multi-language support (Southern California Edison, n.d.)

Category	Example actions
Complementary pricing	• Waive parking fees for electric vehicles at city-owned locations and meters (Park San Jose, n.d.; Madrid City Council, n.d.) • Enact and enforce penalties for combustion cars using designated EV spaces • Exempt electric ride-hailing trips from $4 LAX pickup/drop-off fee • Lobby state agencies for authority to implement local ride-hailing fees (City and County of San Francisco, 2019)
Phase-in access restriction	• Phase in preferential lane or parking access for electric vehicles (European Alternative Fuels Observatory, n.d.) • Phase in preferential pickup and drop-off curb access for ZEVs in select fleets (e.g., ride-hailing, taxi, urban delivery) (Mayor of London & Transport for London, 2018)
Fleets	• Develop and expand on electric ride-hailing, taxi, carsharing, and zero-emission delivery pilot programs with high-impact fleets and their stakeholders (Atlas Public Policy, 2020a; 2020b; 2020c). • Procure electric vehicles in government fleets, set targets, share lessons learned (Mayor Eric Garcetti, 2019)

Continuing and expanding on the initiatives underway will be key to continued market growth in Los Angeles. Consumer incentives, charging infrastructure, and awareness measures remain important. Continued public-private collaboration among city agencies, utilities, and electric vehicle charging providers will be important to identify and address areas that need charging more quickly and, conversely, areas that are less urgent, depending on electricity demand and grid considerations (e.g., charging behavior, power demand dynamics, and grid upgrade timing). Several indicators could help illustrate the areas that may need charging more quickly, such as the relative stock of electric vehicles, the number of electric vehicle drivers without access to home charging, and direct feedback from residents. Similarly, working with community-based organizations can help identify and develop zero-emission mobility solutions for the groups and individuals that stand to benefit most.

Los Angeles could also develop additional financial incentives through various complementary pricing measures that both incentivize zero-emission vehicles and deter polluting vehicles, as well as take early steps to phase in priority access for ZEVs and restrictions on polluting vehicles. Such pricing measures and access policies could apply to parking, lanes, or specific areas within the city. These programs could apply to fleets and privately owned vehicles alike. While electrification of ride-hailing has unique barriers, announcements by Lyft and Uber to go all electric by 2030 means momentum is only growing (Slowik, Pavlenko, & Lutsey, 2019; Lyft, 2020; Uber, 2020). Los Angeles could capitalize on these developments with supporting incentive, infrastructure, access, and pricing policies to position itself as a global leader in electric ride-hailing adoption.

MID-TERM (2023–2025) POLICY SUPPORT ACTIONS

Policy will need to evolve as the electric vehicle market grows and uptake increases, as shown in Table 5. As electric vehicles reach ownership cost parity, incentives can be increasingly targeted to hard-to-reach segments, including Angelenos with lower incomes and in disadvantaged communities. Continuing incentives for used electric vehicles will be important in diversifying the market.

Infrastructure programs can evolve from early coverage toward greater capacity. Los Angeles can continue to use its authority over building codes, zoning, permitting, right-of-way, and taxation to enforce or continue the momentum of earlier policies and increasingly shift infrastructure costs toward the private sector. Public-private partnerships among city agencies, utilities, and electric vehicle charging providers are important to identify and fill charging needs more quickly, and Los Angeles could initiate a program for electric vehicle drivers to submit requests to install public chargers near their residences. Los Angeles Department of Wind and Power's programs can evolve to focus primarily on the areas that are least likely to receive private sector investment, including in multi-unit dwellings (MuDs) and disadvantaged communities. Further growth can be supported by updating and strengthening the municipal EV-ready building code for developers of residential, MuD, and commercial buildings to construct 100% EV capable parking spaces and to allocate a greater share of spaces to be fully "turnkey ready" for installation. More workplace charging can offset the need for more public chargers, provide reliable charging options, and utilize vehicles' parked time.

Table 5. Mid-term (2023–2025) policy actions to promote electric vehicle uptake.

Category	Description and example actions
Consumer incentives	• Modify Charge up LA! program to restrict eligibility based on key criteria including vehicle price, consumer income, or vehicle technology (i.e., BEV only) (California Clean Vehicle Rebate Project, 2016; Oregon Department of Environmental Quality, n.d.)
Charging infrastructure	• Upgrade EV-ready building code to ensure home charging for all Angelenos • Issue RFPs to develop innovative charging solutions, including head-in curbside DC fast chargers (DCFCs) (City of Sacramento, 2020a) • Reconfigure curbside parking locations to be suitable for DCFC deployment (City of Sacramento, 2020b) • Develop an online portal where residents can submit requests for where additional chargers are needed (City of Stockholm, 2020; Township Amsterdam, n.d.)
Consumer awareness	• Assess who is buying electric vehicles and why to understand the barriers and opportunities going forward (City of Sacramento, 2020c) • Identify community needs through community engagement to determine charging sites that best serve them • Encourage developers and private sector to advertise electric vehicles and charging infrastructure
Complementary pricing	• Implement emissions-based fees for all vehicles in congestion pricing pilot (City of Chicago, n.d.) • Implement emissions-based fees on ride-hailing (Transport for London, n.d.-a)
Phase-in access restriction	• Implement zero-emission delivery with private sector partners (Los Angeles Cleantech Incubator, 2020)
Fleets	• Evaluate early successes and key challenges; design incentive, infrastructure, pricing approaches to address barriers (Fleets for the Future, 2016)

Table 5 also shows that, to accelerate adoption, much greater efforts are likely needed through 2025 to dramatically increase consumer awareness and outreach by bringing many electric vehicle touchpoints and first-hand experiences to Angelenos. Expanding and strengthening complementary pricing programs and combustion vehicle access restrictions will complement the incentive, infrastructure, and awareness actions above with a more comprehensive series of carrots and sticks to promote electrification. Revenues from a pollution-index pricing policy could be directed toward improving transit or the municipal electric vehicle rebate and infrastructure programs (Slowik, Wappelhorst, & Lutsey, 2019). As Los Angeles aims for 25% of the vehicle stock to be electric by 2025, converting a similar share of parking spaces in the city to be electric-vehicle-only would align with this goal.

LONG-TERM (2026–2030) POLICY SUPPORT ACTIONS

City and local utility policy will need to continue to evolve as the market moves from early adopters to the majority market and market laggards over the longer term (2026–2030). Table 6 shows potential support actions that Los Angeles can adopt. With over 90,000 new electric vehicle sales per year from 2026, financial incentives are not sustainable, nor are they as critically needed, as electric vehicles reach initial upfront purchase price parity with combustion alternatives (Lutsey & Nicholas, 2019). However, a vehicle retirement incentive program targeting the oldest and most polluting vehicles, which helps low-income communities purchase electric vehicles, could accelerate uptake, reduce emissions, and support Angelenos who stand to benefit most. Charging infrastructure will need to shift toward greater capacity for widespread uptake, with about 535,000 home, 25,000 workplace, 21,500 public Level 2, and 3,900 DC fast chargers needed by 2030. The implementation of near-term and mid-term policies will have laid the groundwork for the private sector to deploy an increasing share of the needed infrastructure while motivating individuals and fleets to electrify.

Table 6. Longer-term (2026–2030) policy actions to promote electric vehicle uptake.

Category	Description and example actions
Consumer incentives	• Establish city-based vehicle retirement and scrappage program (Transport for London, n.d.-b; South Coast Air Quality Management District, n.d.)
Charging infrastructure	• LADWP rate-based MuD and public infrastructure deployment • Install infrastructure at designated EV-only parking spaces • Require workplaces to provide EV charging infrastructure
Consumer awareness	• Leverage industry groups to fund or cost share ride-and-drives and awareness campaigns (Go Ultra Low, n.d.)
Complementary pricing	• Enforce emissions-based access charges in priority areas • Enforce citywide emissions-based fees or taxes on priority fleets
Phase-in access restriction	• Expand EV-only parking for ZEVs consistent with adoption goals • Expand geographic coverage of pilot ZEAs (Transport for London, n.d.-c) • Implement fully ZEAs by 2030
Fleets	• Enforce all electric for all government, carsharing, ride-hailing, taxi, construction, and last-mile delivery vehicles (Shih, 2019; Mayor of London, 2017; The City of New York Office of the Mayor, 2020; Lyft, 2020; Uber, 2020)

Continued efforts to dramatically increase consumer awareness and outreach and expose all Angelenos to the benefits of electric vehicles is needed to achieve 100% sales share by 2030. Los Angeles could leverage private sector stakeholders to co-develop and co-fund local consumer awareness campaigns and ride-and-drive events. Over the 2026–2030 time frame, Los Angeles could require all government fleets to be fully electric, including specialty fleets like construction and service vehicles, thus demonstrating its leadership and commitment to ZEVs while providing proof of concept and publishing key lessons learned from early and mid-term policies.

Los Angeles could also increasingly require private fleets (e.g., ride-hailing, taxi, carsharing, corporate, and urban delivery) to go all electric through actions such as local regulations, public-private agreements, access restrictions, or increasingly EV-friendly pricing measures. There is also a major opportunity to expand on combustion vehicle access restrictions and implement ZEAs so that a greater share of the city is emissions-free. Similarly, the share of EV-only parking spaces can continue to increase in alignment with Los Angeles' electric vehicle goals.

Successful and inclusive implementation of ZEAs will depend on far more efforts than vehicle electrification alone. Interventions that focus on improving public transit accessibility, safe walking and bicycling infrastructure, micromobility-friendly redesign, and other innovative shared and electric modes are key to establishing a broader mobility ecosystem that facilitates the implementation of ZEAs. These areas would ideally prioritize large-scale infrastructure and network improvements from Metro and transit-oriented communities that align dense and mix-used development with frequent transit services, street redesigns that put people first, and mobility hubs where different sustainable modes of transportation are integrated.

CONCLUSIONS

Although the transition to zero-emission vehicles is underway, many questions remain about the number, type, and distribution of charging infrastructure needed to support widespread adoption in cities and beyond. This paper assesses the case for Los Angeles, where the pace and scale of electric vehicle and charging infrastructure growth to reach over a million electric vehicles on city roads by 2030 would be unprecedented. It also assesses the charging required if the city implements zero-emission zones in select locations. Achieving these goals will have profound effects on reducing greenhouse gas emissions, improving local air quality, and delivering on environmental justice. We draw the following five conclusions from the analysis.

Home charging remains a critical component in the infrastructure network. Most electric vehicle charging is likely to continue at home, where it is less expensive and more convenient than public options. Los Angeles will need approximately 536,000 home chargers by 2030 to accommodate roughly 1.3 million electric vehicles. These home chargers make up 90% of the total charger needs and account for 60% of the total electric vehicle energy demand. Los Angeles can provide more access to home charging for its residents by continuing and expanding current programs. Stronger EV-ready building codes, incentives for home and multi-unit dwelling chargers, and strategic and targeted deployment of curbside and streetlight chargers in residential areas can facilitate adequate and equitable home charging access.

Public and workplace charger deployment will need to ramp up quickly to support zero-emission vehicle goals. By 2030, DC fast chargers in Los Angeles will need to grow by a factor of 33 to about 3,900 chargers, while public Level 2 chargers will need to increase by a factor of 8 to about 21,500 chargers. Workplace charging will need to increase to at least 25,000 chargers by 2030. Intentional infrastructure deployment and complementary outreach and engagement in disadvantaged communities are needed to expand equity and access to electric vehicles, infrastructure, and the associated air quality and economic benefits.

Attainment of Los Angeles' goals for electric mobility and reduced personal vehicle use can greatly reduce charging infrastructure needs. If city interventions are implemented, public and workplace charging needs by 2030 are reduced by about 45% from approximately 50,000 to 27,000 chargers, and the annual 2019–2030 growth rate is reduced from 31% to 24%. Figure 10 shows how shifting mobility from private vehicle trips to sustainable modes, reducing overall vehicle-miles traveled, and reducing trips to the urban core via congestion pricing greatly reduce the need for public and workplace charging. Achieving multiple city goals requires continued data sharing, planning, communication across city agencies, and identification of community mobility needs to develop equitable and inclusive zero-emission mobility technology and policy solutions.

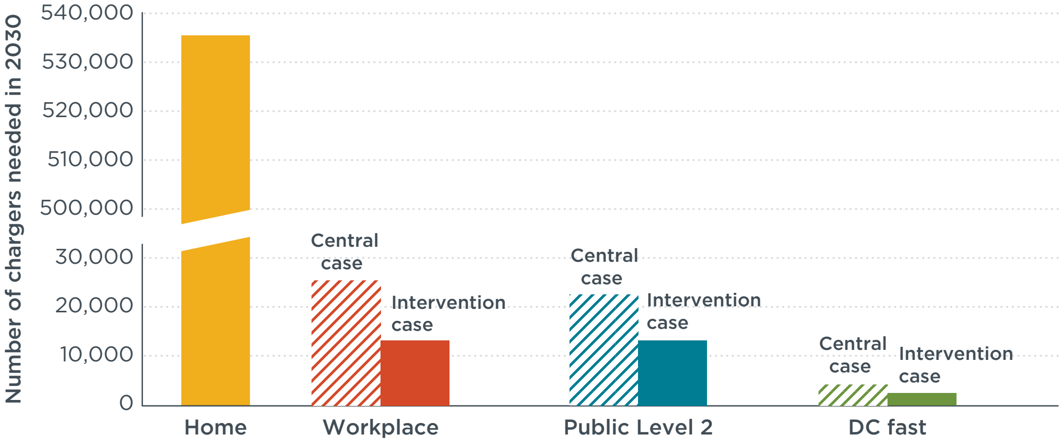

Figure 10. Estimated charging infrastructure needed in Los Angeles in 2030. The hashed bars represent the central case, and the solid bars represent the intervention case.

Local policies play a key role in supporting electric vehicle and infrastructure growth. Incentives, infrastructure, consumer awareness, and fleet electrification are all needed to meet Los Angeles' electric vehicle goal. It will be key to continue and expand the local electric vehicle rebate program, residential and commercial charger incentives, streetlight and curbside charger programs, BlueLA electric carsharing, and consumer outreach. As electric vehicle uptake increases and the market evolves, increasingly stronger policies like EV-ready building codes, streamlined permitting, priority zoning and access, and pollution-indexed pricing of roads, vehicles, and fuels support widespread electric vehicle adoption and spur private sector investment in infrastructure. Steering these policies toward serving lower-income residents and underserved communities is key to delivering on environmental justice and equity.

Los Angeles can develop the first zero-emission areas in the United States. A zero-emission area is a geographic boundary where fossil-fueled mobility is restricted for the purpose of reducing environmental pollution. Achieving this requires a comprehensive package of zero-emission mobility options to deliver affordable and reliable transportation choices, including transit, walking and bicycling infrastructure, car-sharing, ride-hailing, micromobility, and electric vehicles. For the residents and travelers in zero-emission areas who rely on personal vehicles, electric vehicles and their infrastructure are required. The analysis of four sample zero-emission areas finds that approximately two to four times more public and workplace chargers are needed by 2030 than were in place at the end of 2019. The scale of infrastructure growth needed in the ZEAs is relatively less than growth needed elsewhere in Los Angeles and is due the significant shift away from private vehicle ownership and travel analyzed in these areas.

Meeting Los Angeles' electric vehicle goals will require significant investments and deployment in charging infrastructure. As electric vehicle and charger deployment goals are implemented, re-examination and adaptation to underlying trends, local factors, and limitations is warranted. The weakening vehicle regulations, waning federal tax credits, and COVID-19 crisis combined have created an uncertain environment for electric vehicle investments. However, the COVID-19 crisis has further emphasized the need for better air quality, especially in disadvantaged communities that are heavily impacted by pollution and congestion. Local governments, including in Los Angeles, have an opportunity to continue to adopt stronger policies and tools to bolster electrification transportation. The Slow Streets LA program—a new initiative prompted by the COVID-19 pandemic that temporarily creates safe space for Angelenos to remain active on public streets by limiting vehicle traffic—has gained momentum and growing interest from many communities, and could be a first step toward implementing permanent ZEAs. As the government continues to make critical steps toward a greener, cleaner, and more inclusive city, Los Angeles can continue and expanding on programs like Slow Streets LA and look to similar programs underway in other cities around the world to implement a sustainable, healthy, zero-emission, and inclusive mobility system for all.

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APPENDIX

Table A-1 shows the charging access types according to housing types in 2019 for battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) drivers. Beyond 2019, the percentage of EV owners in apartments that have home Level 2 chargers slightly increases as a result of Los Angeles' EV-ready building codes. For example, in 2030, 18% of BEV drivers in apartments have access to Level 2 home charging (up from 13% in 2019).

Table A-1. Breakdown of home charging access by housing type and EV technology in 2019.

Housing type	BEV			PHEV			
	Home Level 2	Home Level 1	Use public only	Home Level 2	Home Level 1	Use public only	No regular charging
Detached house	58%	30%	12%	27%	63%	4%	6%
Attached house	41%	33%	25%	16%	63%	11%	10%
Apartment	13%	20%	67%	7%	30%	32%	32%

Table A-2 demonstrates how Los Angeles resident commuter energy demand is allocated to public Level 2 and DC fast charger, depending on electric vehicle type and access to home charging.

Table A-2. Type of electric vehicles and their commuting charging demand allocation to public chargers.

EV types	Home charging access	Public Level 2	DC fast	Home
PHEV	Yes	14.4%	0%	85.6%
PHEV	No	100%	0%	0%
BEV	Yes	8.7%	17.2%	74.1%
BEV	No	35.2%	64.8%	0%

Note: Adapted from Tal, Lee, & Nicholas (2018)

Table A-3 shows the electricity consumption by charger types in the central and intervention cases from 2021 to 2030.

Table A-3. Projected daily EV charging electricity demand (MWh) from 2021 to 2030.

	Year	Public Level 2	DC fast	Workplace	Home	Total
Central case	2021	108	181	46	692	1,027
	2025	325	716	149	2,025	3,215
	2030	1,136	2,894	555	6,707	11,292
Intervention case	2021	98	161	41	587	886
	2025	242	518	106	1,316	2,183
	2030	665	1,644	310	3,247	5,866
Change from central to intervention	2021	-10%	-11%	-11%	-15%	-14%
	2025	-26%	-28%	-27%	-35%	-32%
	2030	-41%	-43%	-44%	-52%	-48%

Figure A-1A and Figure A-1B show examples of curbside chargers installed in Chinatown, Los Angeles. The figure on the left (A) shows a Flo level 2 charger mounted on a streetlight, and the figure on the right (B) shows an LADWP power pole charger. Both figures are illustrative examples of successful programs established by Los Angeles and the utility. Continuing and greatly expanding Los Angeles' curbside and streetlight charger programs will be key to accelerating public charger deployment.

Figure A-1. A Flo streetlight charger (A) and LADWP's power pole charger (B) in Chinatown, Los Angeles. Photos taken by Anh Bui, ICCT.