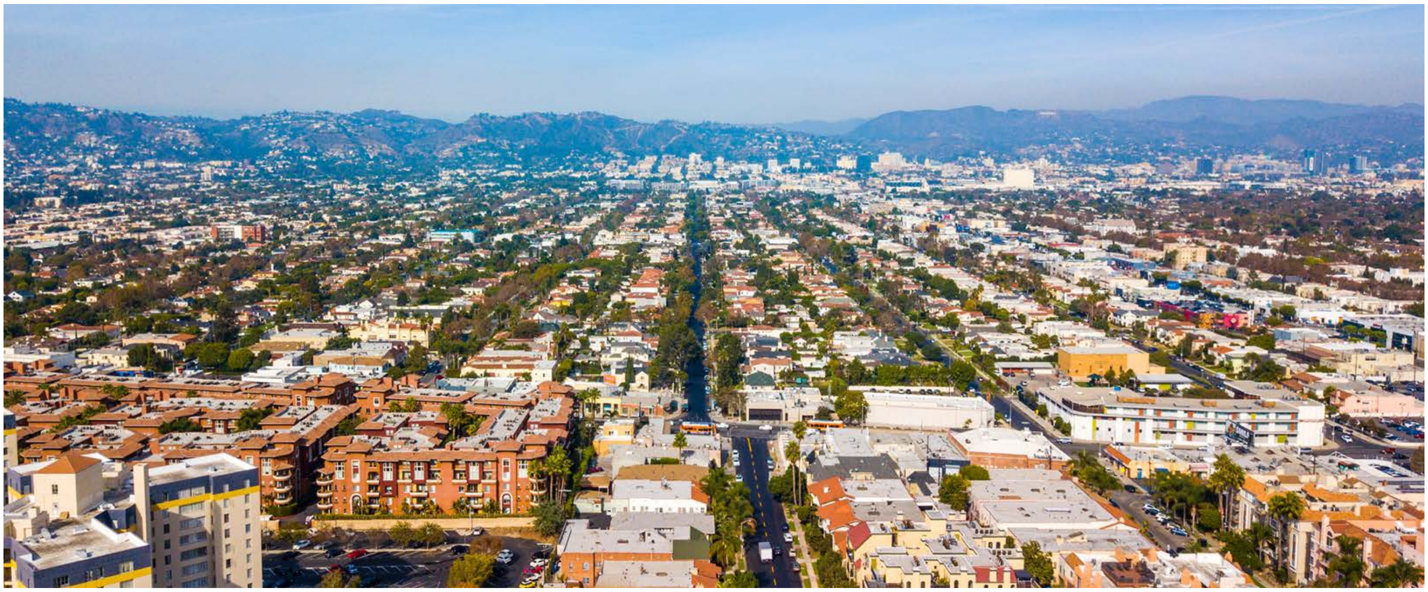
LA100 EQUITY STRATEGIES



Chapter 10: Household Transportation Electrification

FINAL REPORT: LA100 Equity Strategies

Dong-Yeon Lee, Bingrong Sun, Alana Wilson, Megan Day, Patricia-Romero Lankao, Nicole Rosner, Fan Yang, Aaron Brooker, and Jane Lockshin

LA DWP

NREL Transforming ENERGY

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LA100 EQUITY STRATEGIES

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Preface

The Los Angeles 100% Renewable Energy Study, or LA100, revealed that although all communities in Los Angeles will share in the air quality and public health benefits of the clean energy transition, increasing equity in participation and outcomes will require intentionally designed policies and programs. The LA100 Equity Strategies project was specifically designed to help Los Angeles identify pathways to such policies and programs in the form of equity strategies. The project aimed to do this by incorporating research and analysis to chart a course toward specific, community-prioritized, and equitable outcomes from the clean energy transition outlined in the LA100 study.

The Project Partners

The Los Angeles Department of Water and Power (LADWP), the National Renewable Energy Laboratory (NREL), and the University of California Los Angeles (UCLA) partnered on the LA100 Equity Strategies project to develop strategies for engaging communities, funding equitable technology and infrastructure investments, expanding existing programs, and designing new programs and policies to improve equity by incorporating what community members themselves know is needed to achieve a more equitable energy future.

The Project Approach

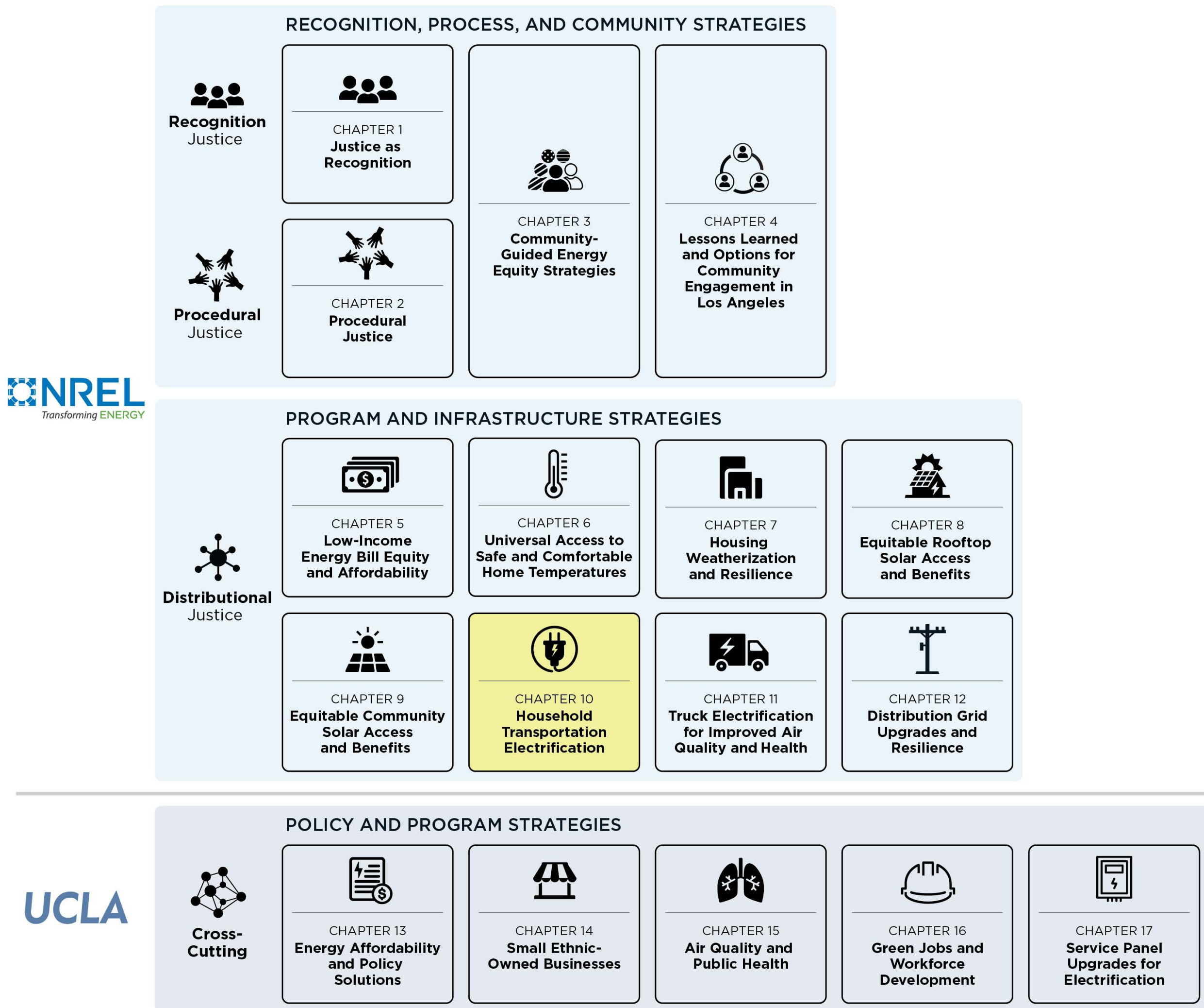
LA100 Equity Strategies employs a unique mixed-methodological approach utilizing three distinct—but connected—research efforts. Through these efforts, NREL and UCLA developed a range of strategy options for increasing equity in LA's transition to 100% clean energy.

A Project Summary

To get a high-level overview of the project, you can dive into the executive summary, interactive data visualizations, and more on the LA100 Equity Strategies website at maps.nrel.gov/la100/equity-strategies.

The Full Report

NREL's final full report for the LA100 Equity Strategies project encompasses seventeen chapters. The first twelve chapters, authored by NREL, are organized around the three tenets of justice. Chapters 1–4 address recognition and procedural justice, while Chapters 5–12 address distributional justice. The final five chapters, authored by UCLA, provide crosscutting policy and program strategies. Each chapter provides data, methods, insights, and strategies to help LADWP make data-driven, community-informed decisions for equitable investments and program development.



NREL Chapters

Chapter 1: Justice as Recognition

Chapter 2: Procedural Justice

Chapter 3: Community-Guided Energy Equity Strategies

Chapter 4: Lessons Learned and Options for Community Engagement in Los Angeles

Chapter 5: Low-Income Energy Bill Equity and Affordability

Chapter 6: Universal Access to Safe and Comfortable Home Temperatures

Chapter 7: Housing Weatherization and Resilience

Chapter 8: Equitable Rooftop Solar Access and Benefits

Chapter 9: Equitable Community Solar Access and Benefits

Chapter 10: Household Transportation Electrification

Chapter 11: Truck Electrification for Improved Air Quality and Health

Chapter 12: Distribution Grid Upgrades for Equitable Resilience and Solar, Storage, and Electric Vehicle Access

UCLA Chapters

Chapter 13: Energy Affordability and Policy Solutions Analysis

Chapter 14: Small Ethnic-Owned Businesses Study

Chapter 15: Air Quality and Public Health

Chapter 16: Green Jobs Workforce Development

Chapter 17: Service Panel Upgrade Needs for Future Residential Electrification

List of Abbreviations and Acronyms

ADOPT	Automotive Deployment Options Projection Tool
BAU	business as usual
BEV	battery electric vehicle
CA	California
Caltrans	California Department of Transportation
CEC	California Energy Commission
CSTDM	California Statewide Travel Demand Model
CY	calendar year
DCFC	direct current fast charger
EIA	U.S. Energy Information Administration
ES	equity scenario
EV	electric vehicle
FPL	federal poverty level
GWh	gigawatt-hours
HCA	home charging access
ICEV	internal combustion engine vehicle
LADWP	Los Angeles Department of Water and Power
LEAD	Low-Income Energy Affordability Data
NHTS	National Household Travel Survey
NREL	National Renewable Energy Laboratory
PEV	plug-in electric vehicle
PHEV	plug-in hybrid electric vehicle
SB	California Senate Bill
TAZ	transportation analysis zone
VMT	vehicle miles traveled
ZVHH	zero-vehicle households

Executive Summary

The LA100 Equity Strategies project integrates community guidance with robust research, modeling, and analysis to identify strategy options that can increase equitable outcomes in Los Angeles' clean energy transition. This chapter focuses on residential electric vehicle (EV) incentive programs and multimodal electrified transportation services as means to increase equity in household transportation electrification.

Specifically, NREL modeled EV adoption and affordability under business-as-usual and enhanced low-income incentives scenarios and transportation-related energy burdens under multimodal electric travel scenarios, including shared EVs, e-bikes, and improved transit services.

In the context of this chapter of LA100 Equity Strategies:

- *Electric vehicle* refers to a personal light-duty (plug-in) EV.
- *Micromobility* refers to the use of e-bikes and e-scooters.
- *Multimodal* includes shared EVs, shared micromobility, and improved transit services.
- *Low-speed EVs* refers to electric low-speed vehicles, also referred to as neighborhood EVs or electric micro-cars. Low-speed EVs are less than 3,000 pounds gross weight.

Based on our analysis and community guidance, we identified strategies for 1) increasing equity in new and used light-duty EV adoption and EV charging infrastructure distribution, focused on household used EV ownership and home charging access and 2) affordable, time-efficient, and equitable multimodal electrified transportation options, specifically considering the non-vehicle-owning population.

Research was guided by input from the community engagement process, and associated equity strategies are presented in alignment with that guidance.

Community Guidance

Guidance from the LA100 Equity Strategies Steering Committee, listening sessions with community members co-hosted with community-based organizations, and community meetings included the following, organized under three themes:

- Tailor LADWP incentives and outreach to meet community needs.
    - Develop and use culturally informed, transparent, community-tailored, and consistent outreach and communication related to Los Angeles Department of Water and Power (LADWP) transportation electrification program benefits.

East LA Resident:

"As of right now, **gas prices are so expensive**, so … I'm choosing to not … go to certain places, like **sometimes even skip work because I work so far away, like a cost-benefit is [not going to work]. It's really impacting my financial decisions.** Right? Will it be affordable for everybody?"

- Simplify application materials and methods for LADWP transportation-related incentives; for example, by partnering with community-based organizations to adapt applications to local communities, increasing accessibility, and providing organizational support throughout the application and implementation process.

> **Steering Committee member:**
> "Pacoima received a DWP grant for emissions reduction: 100 e-bikes to rent out to people for the whole year. This is the way to go—piloting projects."

- Expand accessible electric mobility infrastructure.
  - Ensure EV charging stations are sited in locations that meet daily household routines and community needs.
  - Co-design and implement low-income community infrastructure for transportation electrification without adding environmental and socioeconomic burdens.
  - Build inclusive electric mobility (e-mobility) infrastructure for charging household EVs, shared EVs, e-bikes, and other electric options (e.g., electric public transit, low-speed EVs).
- Expand e-mobility options.
  - Co-develop affordable, reliable, and accessible electric mobility options with local communities to improve access and affordability and reduce pollution.
  - Tailor strategies to access affordable e-mobility technologies based on user needs, similar to the current Los Angeles Department of Transportation Universal Basic Mobility Pilot in South LA.
  - Expand existing e-bike, e-scooter, and EV-sharing programs.
  - Improve the quality of public transit.
  - Increase street safety (e.g., street lighting, shaded transit stops, protecting people on bikes).

The following sections of this executive summary discuss the distributional equity baseline, key modeling and analysis findings, and equity strategies.

Distributional Equity Baseline

Analysis of distributional equity in LADWP's residential EV incentive programs—a used EV rebate program and a residential EV charging station rebate program[1]—found that only 23% of incentives went to disadvantaged communities (DACs)[2] (based on the number of incentives and normalized by the number of customers in each census tract). In addition, the approximately $5.4 million in LADWP incentive investments disproportionately benefited predominantly White, non-Hispanic, home-owning, and wealthier neighborhoods (Figure ES-1).

[1] "Electric Vehicles (EVs)," LADWP, https://www.ladwp.com/ladwp/faces/ladwp/residential/r-gogreen/r-gg-driveelectric.

[2] Based on the 2022 disadvantaged community designations from California Senate Bill 535 (https://oehha.ca.gov/calenviroscreen/sb535).

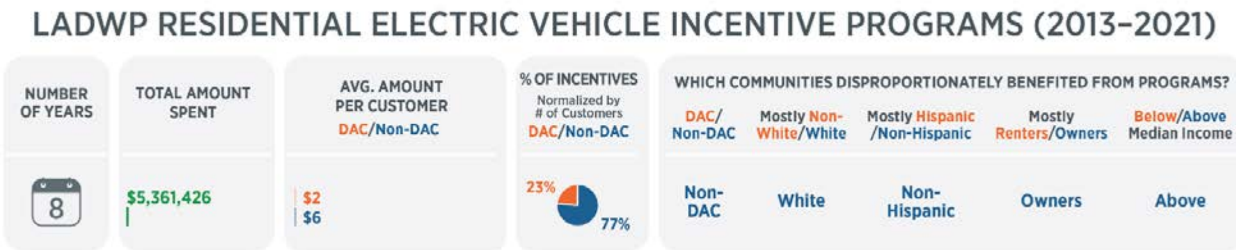


Figure ES-1. Statistical analysis of distributional equity in LADWP residential used EV and EV charging rebates (2013–2021) using SB 535 definition of "disadvantaged community" (DAC)

Percentages and benefits based on the number of rebates distributed within census tracts normalized by the number of residential customers in the tract.

Analysis of the geographic distribution of incentives (Figure ES-2) of the two programs found that areas including South LA and the San Fernando Valley did not receive EV and EV charging incentives proportional to their populations. Areas including West LA received more incentives than their share of the population. California Senate Bill (SB) 535-designated disadvantaged communities, identified with the black border, are overwhelmingly underrepresented in incentive distribution (orange areas), while non-DACs received disproportionately more incentives relative to the number of customers in these communities (green areas).

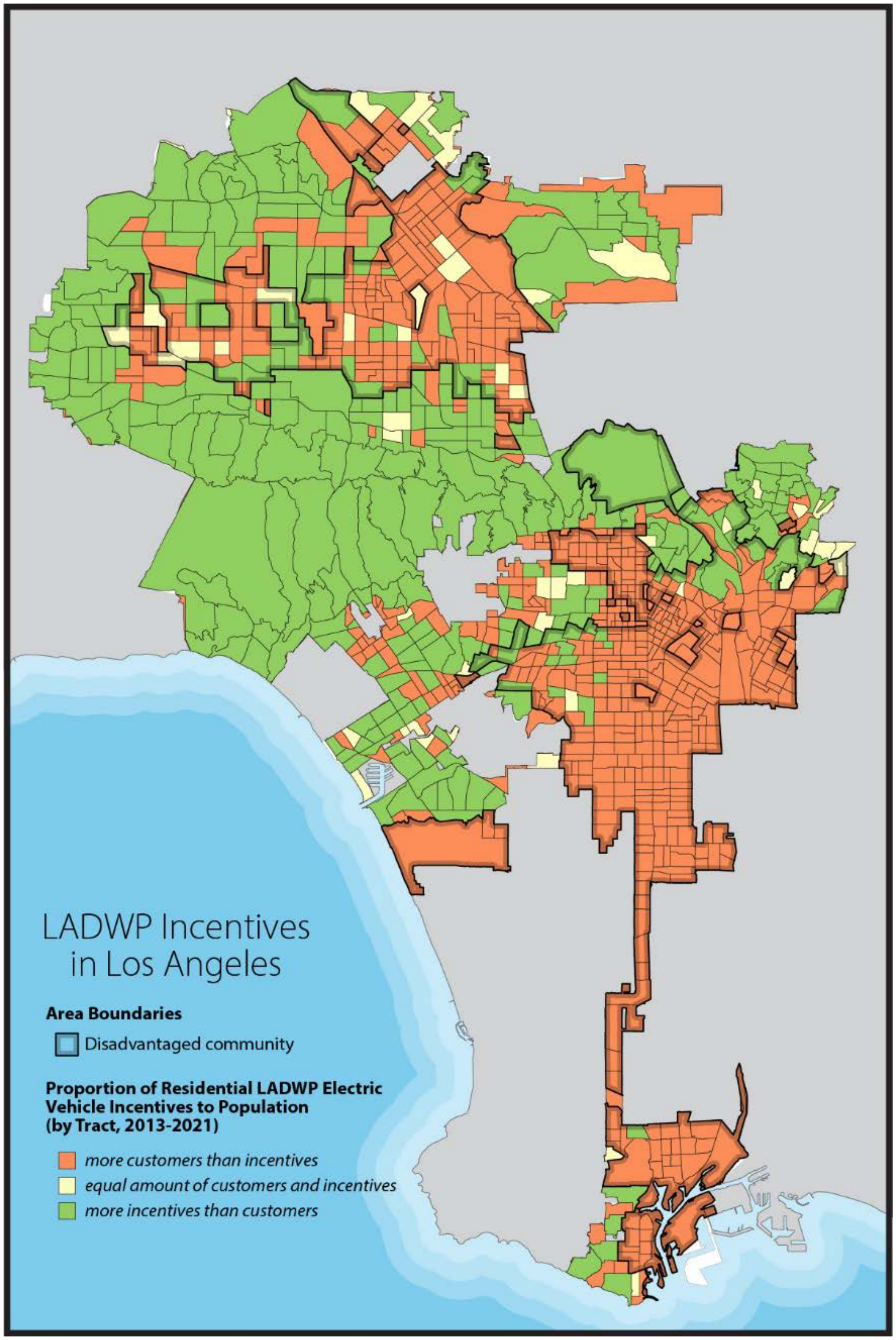


Figure ES-2. Distribution of LADWP Residential EV incentives (2013–2021)

Analysis of public EV charging station locations (Figure ES-3) indicates mostly non-Hispanic communities have more charging stations than mostly Hispanic communities, while no statistically significant disparities are found in distribution across income, race, or disadvantaged community status.

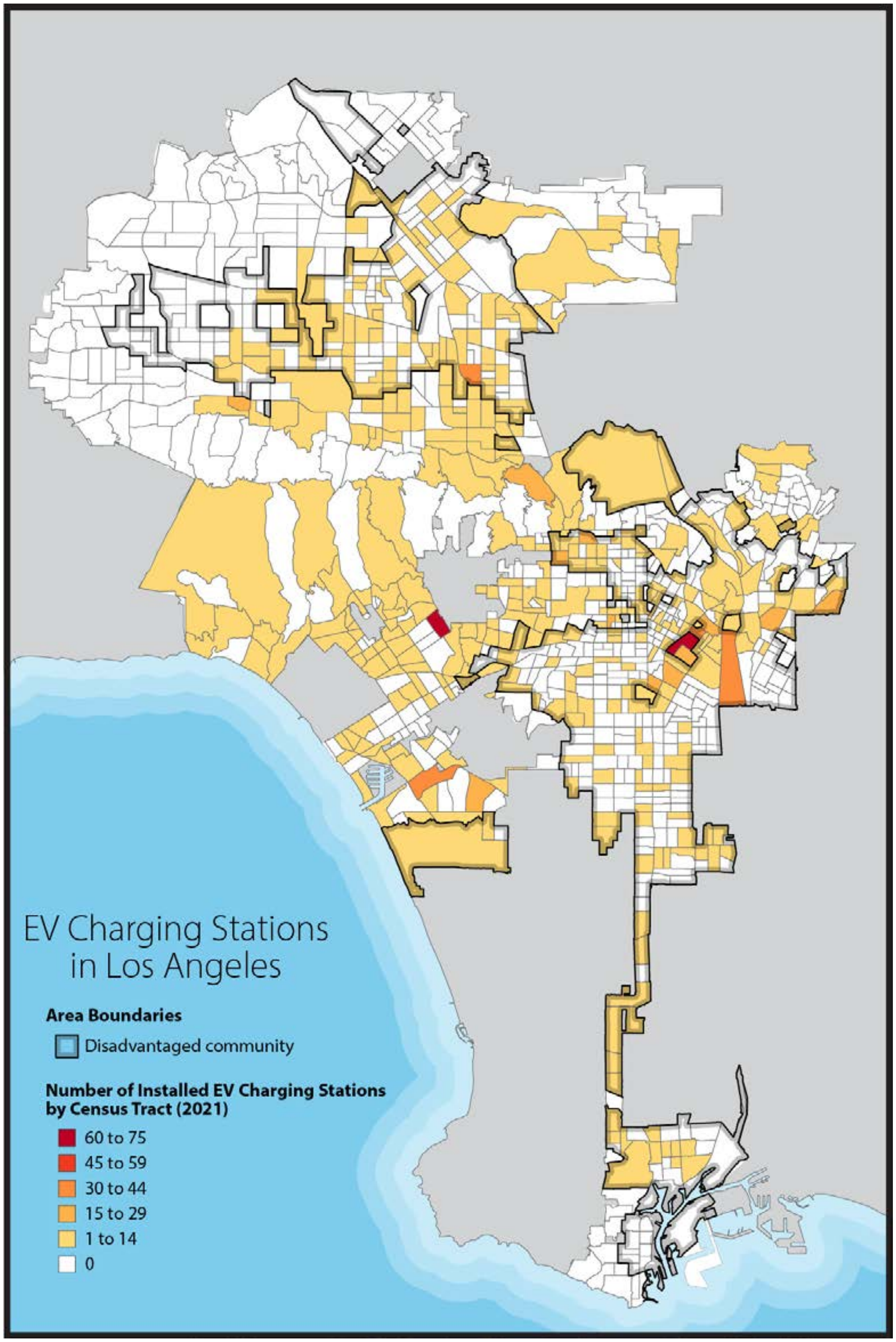


Figure ES-3. Public EV charging stations in Los Angeles (2021)

Source: Alternative Fuels Data Center

Key Findings

We used community guidance and baseline data to conduct modeling and analysis, then identify strategies to improve equity in EV adoption, charging access, and multimodal transportation electrification, including e-bikes, public transit, and shared EVs. Key takeaways are described in the following sections regarding used EV adoption and affordability, EV charging access, and multimodal transportation electrification.

Used EV Adoption and Affordability

- In 2035, households making $75,000 or less (2019 dollars) are predicted to comprise a significant portion of EV owners. These households are more likely to rely on used EVs, compared to households making more than $75,000 a year. Achieving equitable EV adoption for these households requires providing both financial and logistical support for the purchase of used EVs.
- Projections for 2035 indicate that, on average, households in Los Angeles that make $75,000 or less annually and adopt *used* EVs will reduce their average household expenditures by 3%, scaled by income, compared to the case adopting *new* EVs.
- Increasing used EV rebates for low-income households from the current $2,500 to $4,000 could result in a 2% increase in used EV adoption among low-income households in Los Angeles, or approximately 50,000 vehicles.

Household transportation electrification equity metrics include:

- Used EV affordability as a percentage of household expenses
- Access to home and public charging
- Household vehicle ownership rates, public transit access, time and cost of shared EV, e-bike, and transit options
- Proximity to bike lanes
- Income and disadvantaged community status

EV Charging Access

- Approximately 20% of EV owners in Los Angeles in 2035 are predicted to lack at-home charging access, of which about 80% are those living in multifamily buildings. Improving equitable EV adoption requires expanding charging opportunities for EV owners who lack home charging access. Alternative charging options include building code modifications, financial support for EV charging infrastructure installments in multifamily buildings, and curbside or other public chargers.
- Because public charging is typically more expensive than home charging, lack of home charging access results in higher charging costs and leads to an average 1% increase in household expenditures, scaled by income, compared to households with home charging access. This is equivalent to $300 per year for a household with an annual income of $30,000. Public charging vouchers or subsidies could reduce the cost burden and help increase EV adoption for households who lack home charging access.
- Neighborhoods including Little Tokyo, Crenshaw, Leimert Park, Central City, and Hollywood are projected to have high EV adoption potential with low home charging access. Neighborhood chargers can compensate for the lack of home charging access and enable increased low-income EV adoption and affordability.

- In a 2035 Business-as-Usual scenario that continues current EV adoption trends, residential EV home charging occurs predominantly in West LA (wealthier neighborhoods are more likely to have home charging access), indicating EV adoption and charging access and benefits will continue to be heavily inequitable without a deliberate program that includes partnership between the local government and utility and incentive equity focus.

Multimodal Transportation Electrification

- More than 11% of LA households do not currently own a vehicle (American Community Survey 2015–2019), including 16% of households in SB 535-designated DACs (American Community Survey 2015–2019). These households and many others are not likely to adopt a new or used personal EV in the next 10 years in a Business-as-Usual EV adoption scenario. To identify transportation electrification strategies best suited to these households, we identified 19 transportation disadvantaged communities (Figure ES-4) with high rates of zero-vehicle households, low-quality transit, and SB 535-designated DACs (California OEHHA 2022).
- Modeling indicates that providing shared EV programs, shared e-bike programs, and improved transit service could reduce trip travel time up to 12%, save up to 18% in transportation costs, and increase access to destinations up to 3% in neighborhoods with very low car ownership rates, with the optimized multimodal solution varying across communities (see Figure ES-4).
- Geospatial analysis found that fewer than 50% of households eligible for California Air Resources Board e-bike incentives (up to 300% of the federal poverty level) are within 1,000 feet of existing bike lanes or paths (not including sharrows, which are road markings indicating which part of a roadway shared with motor vehicles should be used by cyclists).
- Widespread access to e-bikes could reduce total vehicle miles traveled in Los Angeles by an estimated 4.7%, saving 316,000 tons of CO_2e annually relative to gasoline-powered cars and avoiding 187 gigawatt-hours (GWh) of electricity demand, relative to those miles being traveled in light-duty EVs.

Shared e-bike access | Shared EV access | Improved transit

Transportation Analysis Zone ID & Neighborhood	Most affordable	Most time efficient	Access to most opportunities	Transportation Analysis Zone ID & Neighborhood	Most affordable	Most time efficient	Access to most opportunities
3718 – Panorama City	Shared e-bike access	Shared e-bike access	Improved transit	4111 – Boyle Heights	Shared e-bike access	Shared e-bike access	Shared EV access
3731 – Panorama City	Shared e-bike access	Shared e-bike access	Improved transit	4114 – Boyle Heights	Shared e-bike access	Shared EV access	Shared EV access
3734 – North Hills	Shared e-bike access	Shared e-bike access	Improved transit	4115 – Boyle Heights	Shared EV access	Shared EV access	Shared EV access
3737 – Panorama City	Shared e-bike access	Shared e-bike access	Improved transit	4150 – Boyle Heights	Shared e-bike access	Shared EV access	Shared EV access
3864 – Reseda	Shared e-bike access	Shared e-bike access	Improved transit	4335 – East Hollywood	Shared EV access	Shared e-bike access	Shared EV access
3866 – Canoga Park	Shared EV access	Shared e-bike access	Shared EV access	4611 – Wilmington	Shared EV access	Shared e-bike access	Shared EV access
3872 – Winnetka	Shared e-bike access	Shared e-bike access	Improved transit	4612 – Wilmington	Shared EV access	Shared e-bike access	Shared EV access
3877 – Van Nuys	Shared EV access	Shared e-bike access	Shared EV access	4614 – San Pedro	Shared EV access	Shared e-bike access	Shared EV access
4067 – Boyle Heights	Shared EV access	Shared EV access	Shared EV access	4630 – Wilmington	Shared EV access	Shared e-bike access	Shared EV access
4105 – Boyle Heights	Shared e-bike access	Shared EV access	Shared EV access	*Calculated for low-vehicle ownership, low transit access, disadvantaged communities*			

Figure ES-4. Modeling results identifying neighborhood-specific multimodal strategies for affordability, time efficiency, and access to opportunities

Equity Strategies

Modeling, analysis, and community engagement identified the following strategies for achieving more equitable outcomes in the distribution of benefits and burdens in Los Angeles' transition to clean energy and electrified transportation. Strategies are organized by community guidance theme.

Tailor LADWP Incentives and Outreach to Meet Community Needs

- Increase the LADWP low-income used EV incentive from $2,500 to $4,000 and establish a purchase price cap of $25,000 for incentive eligibility.
- Shift from delayed rebates to a point-of-sale discount.
- Partner with community-based organizations to fund and staff networks of educators to target outreach to DACs, renters, and multifamily residents about incentives and low-barrier financing options (e.g., for those with low/no credit), and to co-design or refine those incentives with them.

Expand Accessible Electric Mobility Infrastructure

- Expand at- or near-home charging access for renters and multifamily residents to enable more equitable access to and use of EVs. Prioritize charging infrastructure development in DACs in charging deserts with a high prevalence of multifamily buildings, including Boyle Heights, South LA, San Pedro, Crenshaw, Canoga Park, Winnetka, and Sylmar. Acknowledging that installing charging infrastructure in all neighborhoods may be a long-term process. In the short term, Los Angeles could focus on programs and incentives that increase workplace charging or interstate fast charging, which may have lower barriers and may increase equitable access to charging (see Box 4 of Kneeland et al. [2020]).

- Develop EV-ready building codes and incentives to address EV charging infrastructure barriers (e.g., panel upgrades, service ratings, circuits) to make households EV ready.
- Provide vouchers or charging subscriptions for public EV charging infrastructure for low-income households, especially those without home charging access.

Expand E-Mobility Options

- Design a community-guided portfolio of electrified transportation options, including EV car share, e-bike, and e-scooter programs, that best serve the needs of each of the 19 neighborhoods identified as the most transportation disadvantaged and other priority areas identified by the City of Los Angeles and communities. Areas include the Boyle Heights, Wilmington, and Panorama City neighborhoods.
- Pair e-bike incentives with the expansion of safe and accessible bike infrastructure and safe charging options at home or away from home.

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1 Introduction

The LA100 Equity Strategies project seeks to inform an increase in equity in Los Angeles' transition to 100% clean energy. This chapter identifies:

- Strategies for increasing equity in new and used light-duty electric vehicle (EV) adoption and EV charging infrastructure distribution, focused on household used EV ownership and home charging access
- Affordable, energy efficient, and equitable multimodal electrified transportation options, specifically considering the non-vehicle-owning population. This research was guided by input from the community engagement process, and associated equity strategies are presented in alignment with that guidance.

1.1 EV and EV Charging Infrastructure Modeling and Analysis Approach

As depicted in Figure 1, for evaluating future scenarios of personally owned EVs and corresponding EV charging infrastructure, we leveraged three models: the Automotive Deployment Options Projection Tool (ADOPT) (NREL 2022a), the Electric Vehicle Infrastructure – Projection (EVI-Pro) (NREL 2022b) tool, and the Electric Vehicle Infrastructure for Equity (EVI-Equity) (NREL 2022c) model. ADOPT examined the impact of federal and state rebates on EV deployment, based on personal car market dynamics, technological advances, vehicle component costs, socioeconomics, and policy scenarios. EVI-Pro estimated charging demands for EVs, for which travel patterns, vehicle attributes, charging needs, and charging costs were considered. EVI-Equity assessed equitable distribution and affordability of used EVs, as well as access to EV charging infrastructure, and charging loads. EVI-Equity estimated household-level personal vehicle purchases, ownership, and utilization, as well as refueling preferences and behavior in the context of heterogeneous socioeconomic and demographic characteristics of individual households.

This analysis considered the latest EV rebates available from the federal, state, and city governments, as illustrated in Figure 2. We modeled two scenarios:

- **Business-as-Usual (BAU):** A $7,500 federal and $2,000–$7,500 state rebate for new battery electric vehicles (BEVs) ($1,000–6,500 for plug-in hybrid electric vehicles [PHEVs]) (Figure 2a) and a $4,000 federal and $1,500–$2,500 city rebate for used EVs (Figure 2b) were modeled based on income thresholds in the BAU scenario.
- **Equity:** To investigate the impact of increased rebates for used EVs for low-income consumers, an Equity scenario was evaluated in which the city rebate increases from $2,500 to $4,000 for households with annual incomes up to $40,000 (Figure 2c). The income threshold of $40,000 was determined based on LADWP requirements—only those participating in the Lifeline or EZ-SAVE low-income customer assistance programs are qualified to apply for the low-income rebate program (LADWP 2021a, 2021b).

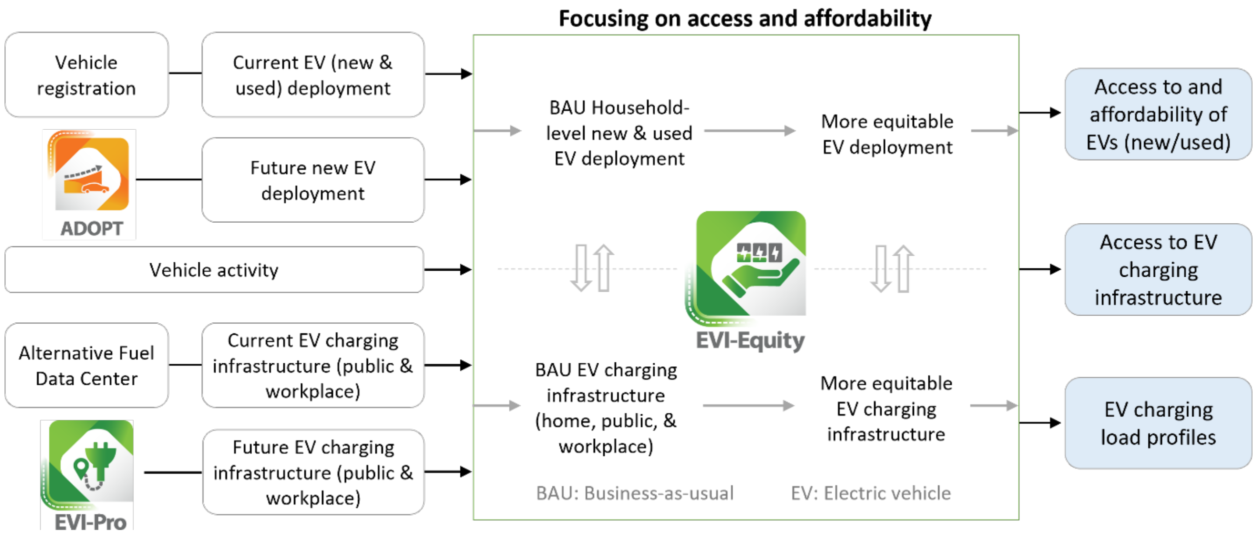

Figure 1. EV and EV charging infrastructure modeling workflow

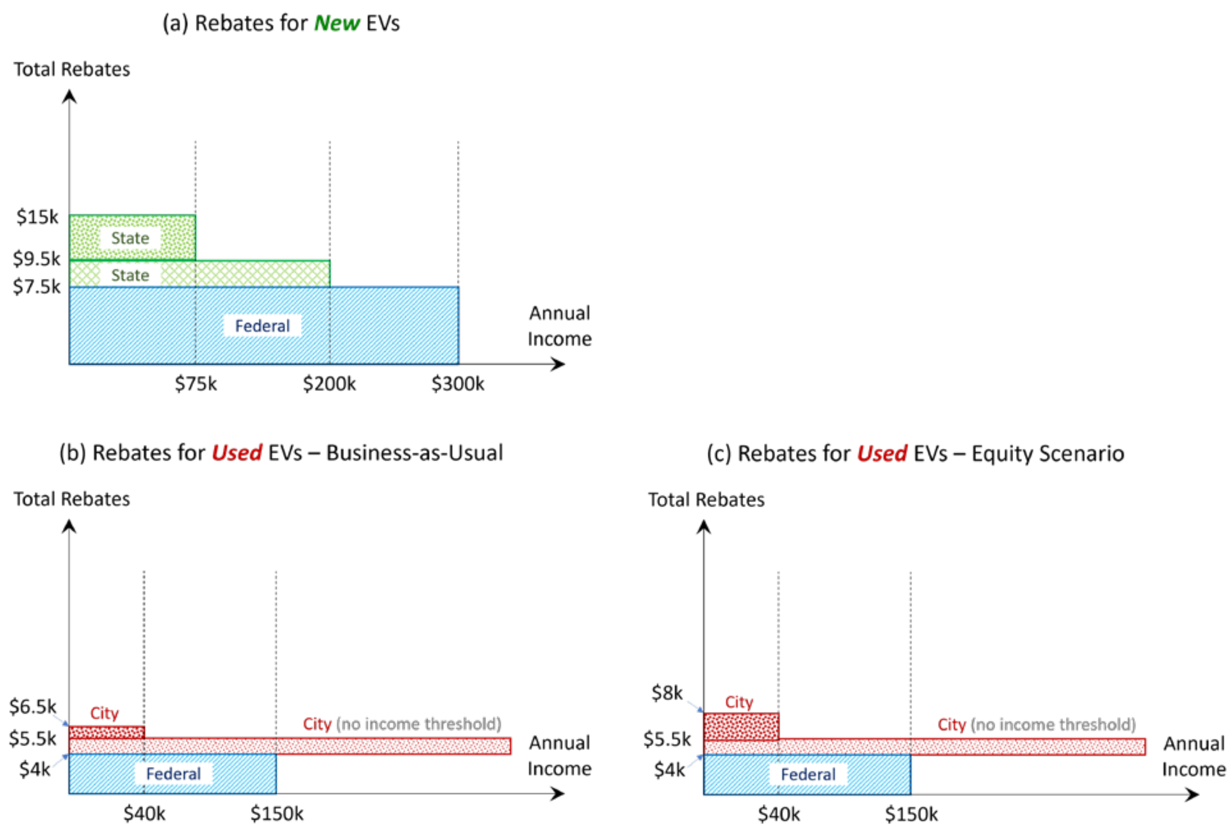

Figure 2. Considered scenarios for federal, state, and city rebates for (a) new EVs, and used EVs under (b) Business-as-Usual and (c) Equity scenarios

Key outputs include projected 2035 distributions of EVs by household income, purchase price, technology (PHEV versus BEV), used versus new vehicle status, and sociodemographic and economic characteristics, as well as the influence of purchase incentives on adoption. Affordability of EVs was characterized as expenditure-to-income ratio, including vehicle purchase and financing, fuel, and maintenance and repair costs. Access to EV charging infrastructure focused on the distribution of households who were predicted to own EVs but lack home charging capability. This can inform the city on the neighborhoods in which installing public EV charging infrastructure would best address the lack of access to home charging. Outputs also include EV charging infrastructure deployment by census tract, home charger access by tract, public EV charging infrastructure by tract, and associated EV charging load profiles. The results are modeled at the spatial resolution of census tracts and presented for BAU and Equity scenarios in Section 2.1 (page 6) for EVs and EV charging infrastructure.

1.2 Multimodal Modeling and Analysis Approach

This analysis investigates opportunities to provide multimodal electrified transportation services to disadvantaged community (DAC) households,[3] who are less likely to have access to privately owned electric vehicles (American Community Survey 2015–2019). Modeling evaluates reductions in transportation-related costs and travel time and increases in access to opportunities based on different modes (e-bike, improved public transit, and EV car share). We then use both model results and other resources to compare alternative multimodal equity strategies and understand their impacts on DACs. This comparison is intended to inform LADWP and City of Los Angeles decisions on options to improve access to electric mobility for residents who have higher levels of transportation disadvantage.

We built a behavioral model (details can be found in the appendix) that predicts how people choose among different travel modes (Figure 3). The model estimates mode choice based on the trips made in the study region from the National Household Travel Survey (NHTS) – California Add-On (U.S. DOT Federal Highway Administration 2017) data set. The model incorporates factors like the time and cost of using each mode. The underlying mode choice preference is used to predict the mode choice decisions of individuals when certain transportation services become lower in cost or new transportation services become available (e.g., an EV car sharing or e-bike sharing program). The multimodal modeling and analysis aim to answer the following questions:

- How much DAC daily travel can be supported by clean energy-powered transportation modes when they become available?
- How can providing alternative electrified travel modes, other than privately owned vehicles, help DACs reach more activity opportunities and reduce DAC transportation-related expenditures and time spent on transportation?
- What are the relative energy and emissions impacts from these mode options?

Travel demand forecast data from the California Department of Transportation (Caltrans) in the California Statewide Travel Demand Model (Caltrans 2022), as well as city mode shift targets,[4] are used to estimate the impacts in baseline and equity scenarios. The spatial resolution of the California Statewide Travel Demand Model is transportation analysis zones, which have similar boundaries to census tracts.

[3] Disadvantaged communities as defined by the California OEHHA (2022) Senate Bill 535.
[4] "Targets*," L.A.'s Green New Deal Sustainability Plan 2019, plan.lamayor.org/targets/targets_plan.html

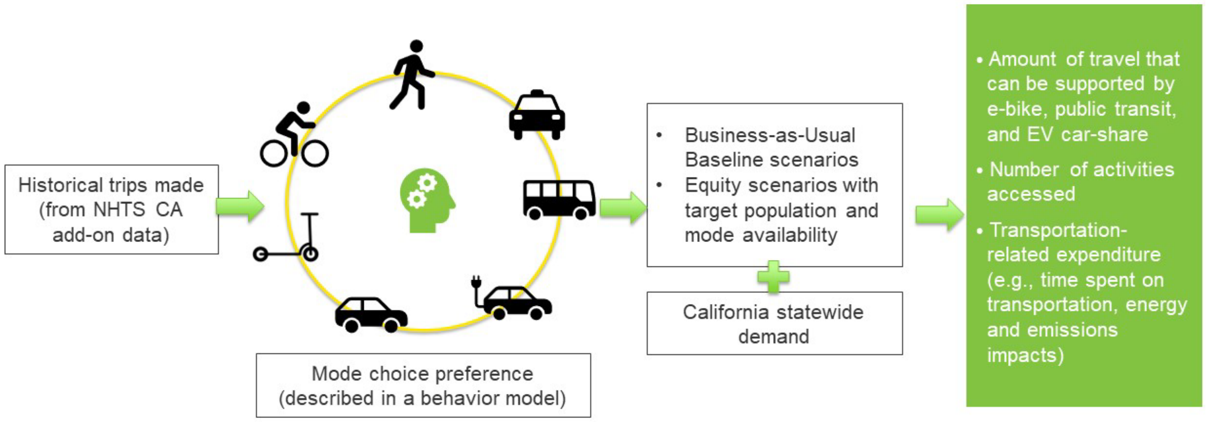

Figure 3. Multimodal transportation modeling workflow

The multimodal analysis began by first identifying areas of priority for transportation equity. Transportation disadvantaged priority DACs are where DACs meet the following three criteria (Figure 4):

- Transportation analysis zones in the top 40% for zero-vehicle households, or households that do not own a personal vehicle (Figure 4)—defined as 12% or more of households without vehicles—for Los Angeles based on American Community Survey data (2015–2019 5-year product).
- Transportation analysis zones in the top 40% for low-quality transit based on 2020 U.S. Environmental Protection Agency Smart Location Database data.
- Transportation analysis zones with 50% or more of their area in California Senate Bill (SB) 535-designated DAC census tracts.

These criteria are used because they indicate relative transportation disadvantage in a city that is widely considered to have an auto-centric transportation system. Areas that meet all three criteria have especially limited transportation options and services and represent transportation electrification equity-deserving communities requiring attention to meet residents' mobility needs.

To quantify the impact of potential multimodal transportation electrification strategies, a baseline scenario and three equity scenarios with different multimodal solutions were evaluated, including:

- **Baseline Scenario**: DAC residents without personal vehicles only have access to travel options that are currently available (i.e., transit with current service level, taxis, biking, and walking); DAC residents who have access to personal vehicles have one more travel option available (driving).
- **Equity Scenario 1:** DAC residents have access to a shared EV program.
- **Equity Scenario 2:** DAC residents have access to a shared micromobility (e-bike or e-scooter) program.

- **Equity Scenario 3:** DAC residents have access to improved transit services (i.e., adding transit service connecting DACs with frequently visited destinations if there is currently no transit service available, shorter access time or waiting time).

See the appendix for the detailed service level of each modeled travel option.

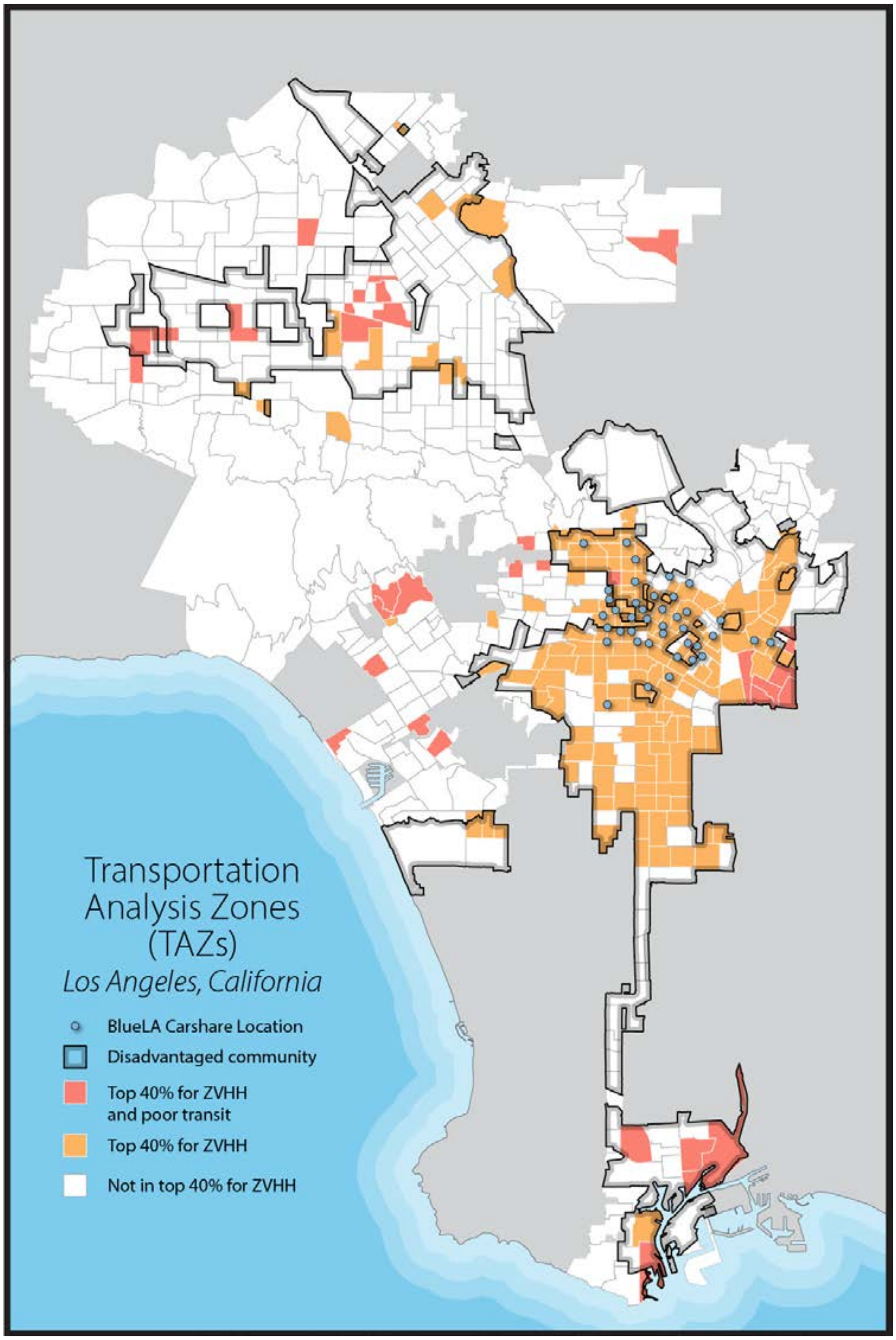

Figure 4. Metrics used to define transportation disadvantaged areas of Los Angeles for multimodal analysis, where ZVHH means zero-vehicle households

2 Modeling and Analysis Results

2.1 EV and EV Charging Infrastructure Access and Affordability

Access to EVs depends on the price of EVs and purchasing power of potential consumers, which, in turn, are influenced by socioeconomic factors. Analysis first evaluated longitudinal evolution of new and used EV stock and purchase price. Influx of new EVs was estimated by the ADOPT model, and the flow between new and used EVs in the personal car market was determined by the EVI-Equity model, which accounts for the average length of vehicle ownership after purchase (IHS Markit 2016), average vehicle age, scrappage rate (NHTSA 2006), and average age of used vehicles purchased (Papandrea 2022). Figure 5 shows the estimated stock of EVs through 2035 by technology (PHEV versus BEV) and vintage (or model year). By 2035, Los Angeles is expected to have about 1.6 million plug-in EVs, which include both BEVs and PHEVs. This estimate is based on California's zero-emission vehicle mandates (100% of new cars sold in the state to be zero-emission vehicles by 2035) as well as the LA100 study (NREL 2021; CARB 2022). In 2035, most EVs on the road in Los Angeles are expected to be BEVs, and about 50% of all EVs are expected to be 5 years old or younger. Around 90% of EVs on the road in 2035 are predicted to be 10 years old or younger, which is an indication of a still-growing and maturing EV market.

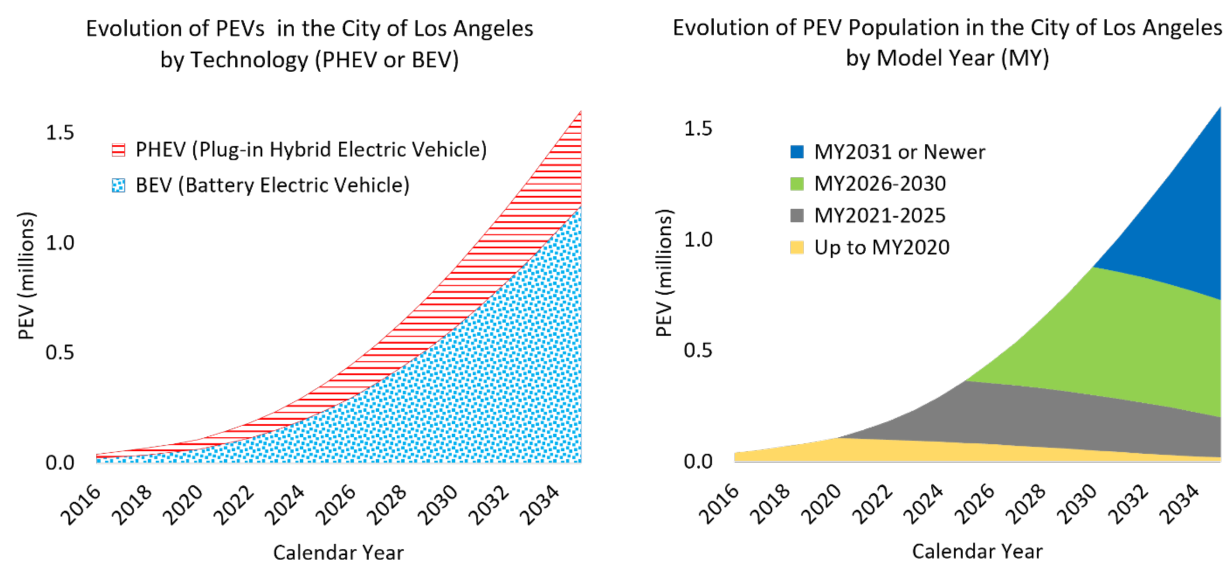

Figure 5. EV stock in Los Angeles by technology (PHEV versus BEV) and model year

Source: EVI-Equity
MY = model year)

In addition to EV stock, EV price (at the point of purchase—new or used) was also estimated by the EVI-Equity model. Figure 6 illustrates that EV prices decline over time, as lower-cost models are introduced in the new EV market and used EV prices depreciate over the vehicle lifetime, which improves the affordability of EVs. The overall cumulative sales-weighted average purchase price for EVs on the road in Los Angeles in 2035 is projected to be $35,000 (ranging from $32,000–$38,000) for new EVs and about $23,000 (ranging from $20,000–$25,000) for used EVs. The price in Figure 6 is the modeled market value consumers pay at the point of purchase for all new or used EVs in Los Angeles for each calendar year. For example, an EV in operation in calendar year 2035 may have been purchased as a used car in 2030 at $15,000 (without rebates), while another EV in operation in calendar year 2035 may be purchased in 2035 as a new car at $160,000 (without rebates). As such, the fleet-wide purchase price of EVs, for example, in 2035, includes all purchases made in 2035 or preceding years. The overall weighted purchase price for all EVs declines (Figure 6), because of the growth of lower-cost new EVs in the market and the depreciation of used EVs' market value over time. As Figure 6 suggests, the structure of the purchase price of EVs in Los Angeles through 2035 differs significantly between PHEVs and BEVs, as well as between new and used vehicles.

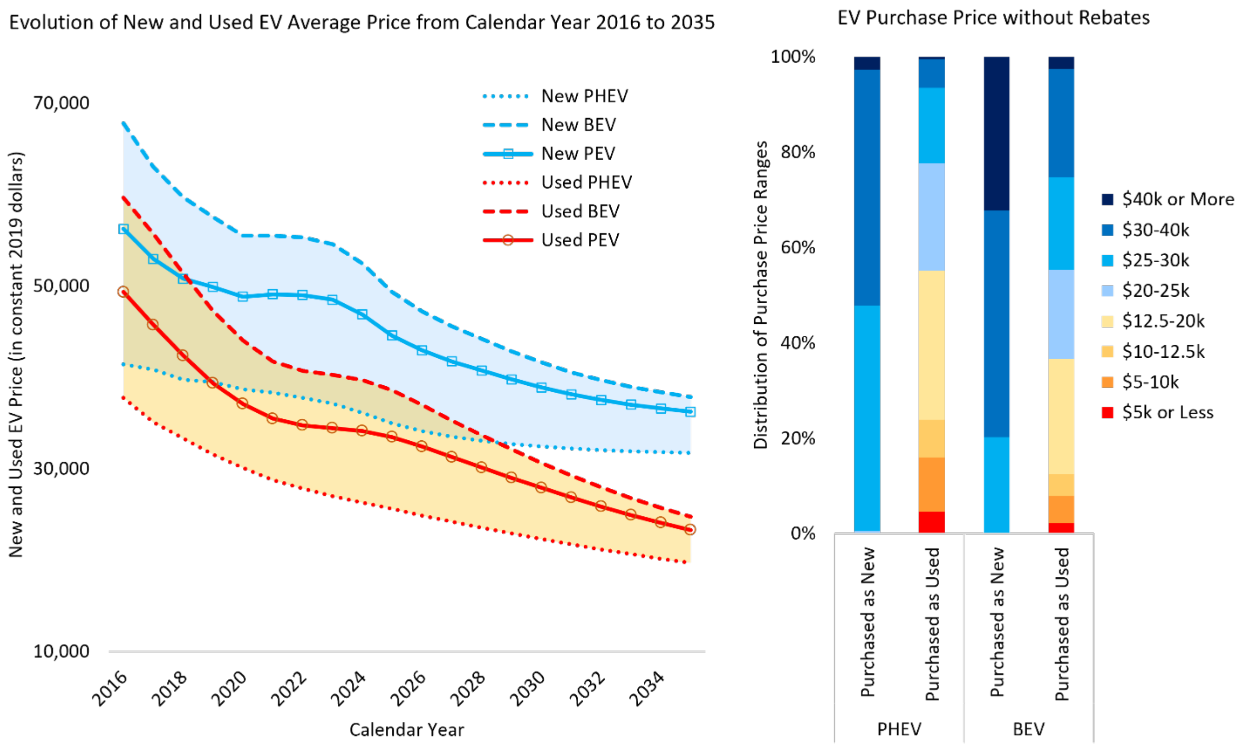

Figure 6. Projected purchase price for new and used EVs

EV = plug-in electric vehicles, including both BEVs and PHEVs; Source: EVI-Equity

The distribution of new and used EVs is expected to differ by income. The EVI-Equity model projects under these assumptions that about one-half of EV owners in Los Angeles in 2035 will be households making more than $75,000 per year, and one-half will be those making $75,000 or less (Figure 7). This is similar to the income breakdown of existing personal gasoline car owners. Partially because of the transitional nature of the EV market between now and 2035 and a significant influx of new vehicles, most EVs are expected to be purchased as new, but households making $75,000 or less a year are expected to purchase approximately equal shares of new and used EVs. In 2035, households making $75,000 or less are predicted to represent the majority of used EV purchasers. Therefore, improving access to EVs for those households may require two strategies: (1) introducing more affordable EV models in the new vehicle market; and (2) providing both financial and logistical support for the purchase of used EVs.

Access to home charging is expected to differ by housing type. Approximately 55% of EV owners in Los Angeles in 2035 that make more than $75,000 a year are estimated to reside in single-family homes. More than 50% of EV owners that make $75,000 or less in Los Angeles in 2035 are estimated to live in multifamily homes and be primarily renters. This is consistent with the nature of the housing stock in Los Angeles, which has a significant share of multifamily homes and has implications for access to home charging. Around 20% of EV owners in Los Angeles in 2035 are predicted to lack home charging access, of which about 80% are those living in multifamily homes. For EV owners who lack home charging access, policy changes and/or alternative charging options can support EV access and use, including building code modification, financial support for EV charging infrastructure installment in multifamily homes, and curbside or other public chargers in those neighborhoods.

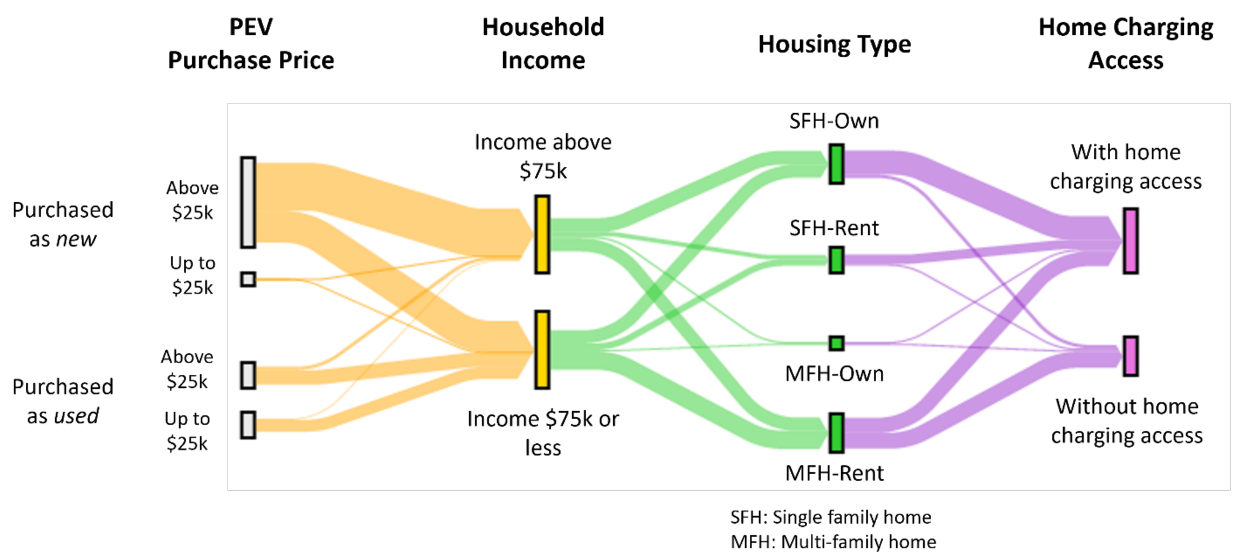

Figure 7. Breakdown of EV owners in Los Angeles in 2035 by household income, housing type, and access to home charging (based on BAU scenario), where plug-in EVs (PEVs) include both BEVs and PHEVs.

Source: EVI-Equity

To understand EV and EV charging infrastructure affordability, we assess the affordability of used EVs in terms of expenditure-to-income ratio using EVI-Equity, California-specific used EV market data, and heterogeneity in financing new versus used vehicles (e.g., interest rates for used vehicles are 40% higher than interest rates for new vehicles [Motor1.com 2023]), depending on the credit rating of potential EV consumers. Figure 8 shows an example for a household in Los Angeles making 20% less than the median income ($60,000 annual income), with two personal vehicles and a good credit score (700–800). Without an EV, this household has expenditures as illustrated in the far left of Figure 8, where transportation using personally owned vehicles makes up about 15% of total expenditures (relative to income). When adopting an EV, transportation makes up 12%–26% of total expenditures, depending on whether the adopted EV is new or used, whether rebates are available or not, whether they purchase a sub-premium (e.g., Tesla Model 3) or standard (e.g., Nissan Leaf) vehicle, and whether the household has home charging access or not.

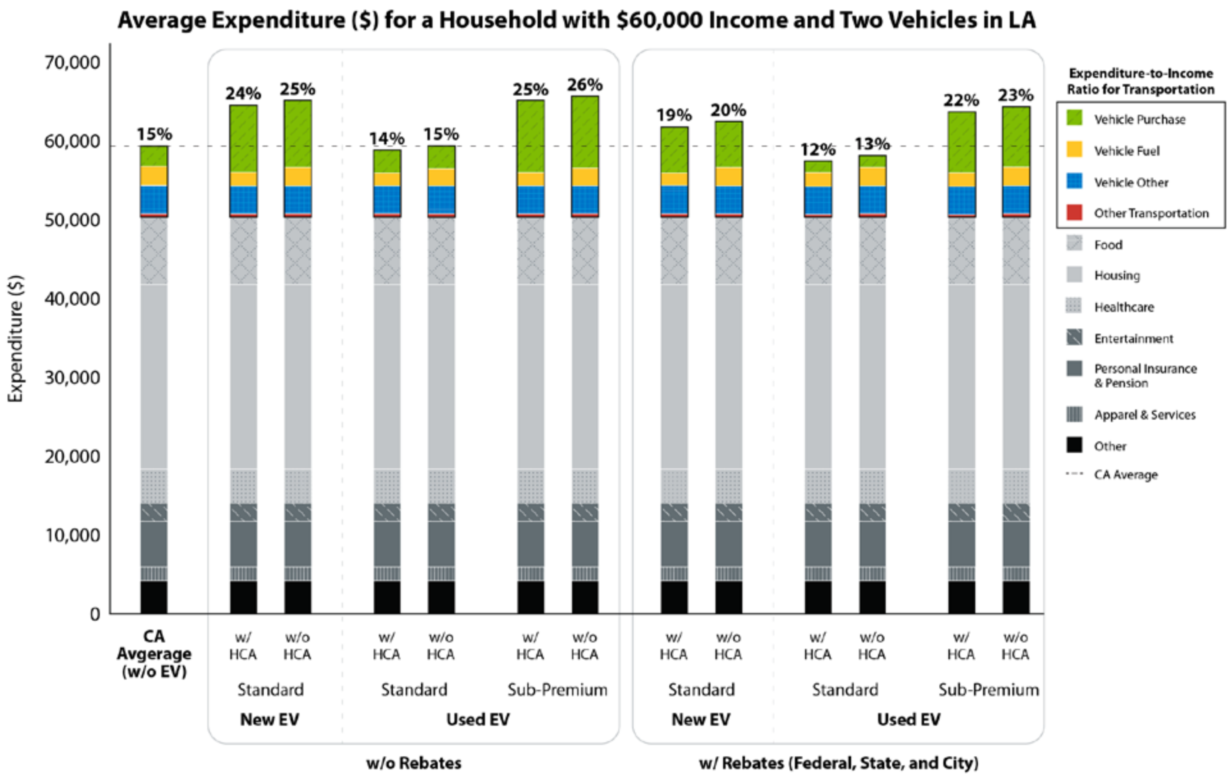

Figure 8. 2022 household expenditures related to EV and home charging access (based on today's market conditions)

Source: EVI-Equity
HCA = home charging access, CA = California

w/o = without, w/ = with

Results indicate that new vehicles (EVs or gasoline vehicles) in today's market are generally not affordable for households making $60,000 or less, as they increase household expenditures by about 10% relative to statewide average transportation expenditures without EVs. The availability of used EVs in the transition to electric vehicles can help mitigate this issue. For example, used EVs in the standard group (e.g., Nissan Leaf, Kia EV6) maintain a similar level of household expenditures or reduce expenditures, even without rebates in the case of the Nissan Leaf. Including all available federal and local rebates for used EVs (Figure 2), the results show a used Nissan Leaf could reduce overall household expenditures by 5% and decrease the transportation-related expenditure-to-income ratio from 15% to 12% for households with home charging access, and from 15% to 13% for households without home charging access. The analysis reveals the importance of standard model used EVs for improving access and affordability of EVs for lower-income households, which, in turn, highlights the need to increase support for standard EV model purchases and home charging for lower-income households.

Improving Access to and Affordability of EV and EV Charging Infrastructure

Introducing more affordable EVs in the new EV market will increase access to and affordability of EVs upstream. Improving access to and affordability of EVs for a broader group of consumers also requires tackling the problem downstream—the used EV market, as used EVs are relatively more affordable, and many low-income households rely on the used vehicle market for their personal car purchases. This is an area where the City of Los Angeles could play an important role. As depicted in Figure 2, LADWP currently provides $1,500 rebates for used EV purchases, and an additional $1,000 for low-income consumers with annual gross incomes of $40,000 (or less for two- or three-person households). Figure 9 illustrates the impact of LADWP increasing low-income rebates for used EVs from $2,500 to $4,000, reflecting federal rebate levels shown in Figure 2c.

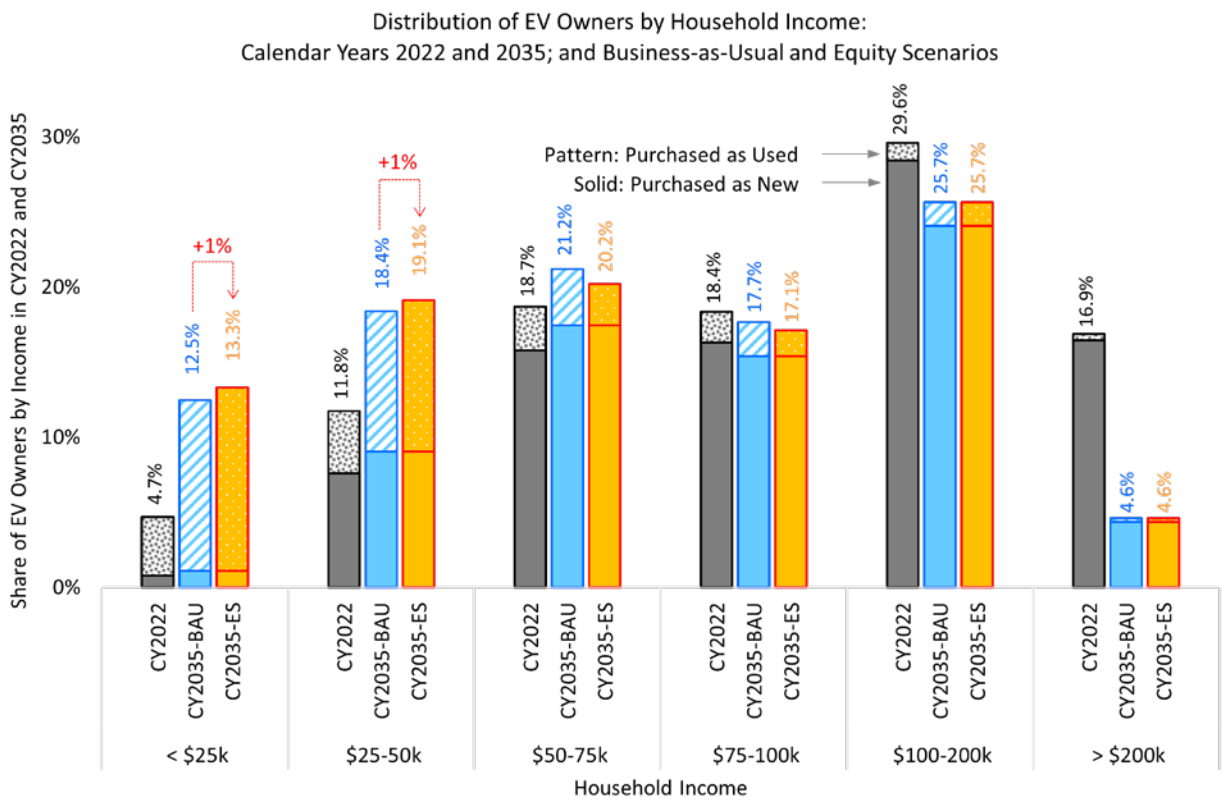

Figure 9. Share of predicted EV owners in Los Angeles in 2035 by household income and EV market (purchased as new versus used) in Business-as-Usual and Equity scenarios

Source: EVI-Equity
CY = calendar year, BAU = Business-as-Usual, ES = Equity scenario

Increasing used EV rebates for low-income households by 60% from the current $2,500 to $4,000 could result in a 2% increase in used EV adoption among low-income households in Los Angeles, as shown in Figure 9, or approximately 50,000 vehicles by 2035. When evaluating the impact of changes in EV rebates, EVI-Equity assumes increasing rebates by a certain amount will increase purchasing power by that amount, and thus, consumers will behave as if their income had increased by the same amount. The 60% increment from $2,500 to $4,000 represents a little less than 4% of an annual income of $40,000. The distribution of EVs across income groups will largely remain the same, regardless of the predicted 2% migration.

EVI-Equity estimates that the change in *used* EV rebates would not affect *new* EV deployment patterns (Figure 10), and high-income groups would not change their EV purchase behavior because of the change in used EV rebates targeted toward low-income households. The new and used vehicle markets could interact (for example, automakers adjusting their strategies due to the used vehicle market dynamics), but that is not considered in this analysis. Also, the migration of used EV share from the $50,000–$100,000 groups in Figure 9 to the lower-income groups is an artifact of the assumption that the citywide EV population will remain the same, regardless of revamped rebates for used EVs. This analysis did not consider potential competition for used EVs between different socioeconomic groups within the city or areas beyond the city, which may lead to an increase in the demand and thus price of used EVs. Another artifact of the assumption that the total EV population will remain the same in 2035 could be a masking of potential increased total EV adoption as a result of low-income incentives.

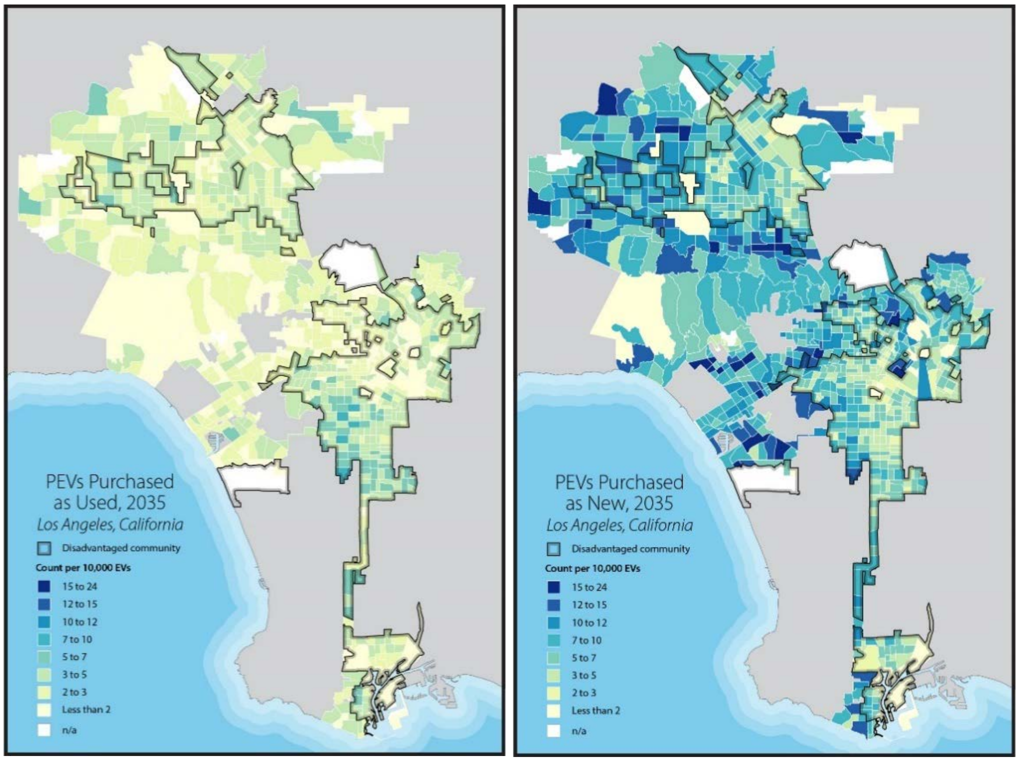

Figure 10. Projected spatial distribution of EVs in Los Angeles, calendar year 2035, purchased as new versus used. PEVs include both BEVs and PHEVs.

Source: EVI-Equity

The data are normalized to show EV adoption distribution using the following equation: (modeled adopted EV count per tract) / (total modeled EV count in LA [1.6 million]) x 10,000

Figure 11 shows the impact new versus used EVs could have on expenditure-to-income ratio for households in Los Angeles that make $75,000 or less per year. Household expenditure estimation in EVI-Equity is based on a consumer expenditure survey (BLS 2020), local fuel prices (gasoline and electricity), future evolution of fuel prices (EIA 2023), and maintenance and repair cost differentials between gasoline vehicles versus EVs (Burnham et al. 2021). In the left section of Figure 11 (Vehicle Purchase and Financing), we see that on average, households in Los Angeles adopting used EVs could save about 3% of their household expenditures (a reduction from 7% to 4% for vehicle purchase and financing), scaled by income, compared to adopting new EVs. Buying new EVs is predicted to increase the expenditure share for most households that make $75,000 or less a year. While the levelized cost of driving new EVs, without rebates, is predicted to be lower than the levelized cost of driving new gasoline cars by

2035 for general consumers of new vehicles, lower-income households do not typically drive new vehicles. For this population, a new EV would increase expenditures, as shown in Figure 11.

EVs decrease fuel cost burden in all scenarios, whether with home charging access or not, as shown in the middle section of Figure 11. EVs decrease maintenance and repair burden by 35%, which is equivalent to a 0.5% decrease in household expenditure-to-income ratio compared to households with gasoline cars, as shown in the right section of Figure 11. Regarding fuel cost, compared to households with home charging access, not having home charging access could lead to a 1% increase in household expenditures, scaled by income, due to higher costs of public charging. This is equivalent to about $300 a year. To reduce the cost burden for those households who drive EVs while having no home charging access to the level for those with home charging access, about $300 per year of financial support would be needed. This could help alleviate the financial burden associated with the lack of home charging access and thus having to use public chargers that tend to be more expensive.

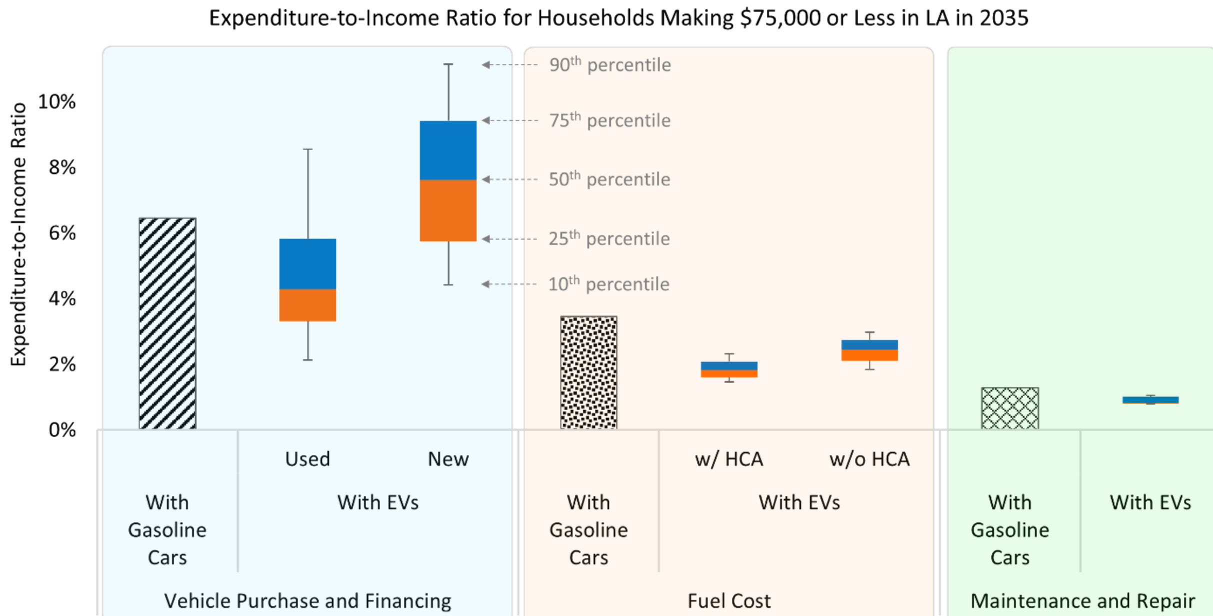

Figure 11. Expenditure-to-income ratio for households with an income of $75,000 or less that adopted EVs in Los Angeles by 2035

HCA = home charging access

Households who drive EVs while having no home charging access are sometimes referred to as "home charger orphans." In addition to offsetting higher costs of public charging, addressing the lack of home charging access may also require installing chargers in the neighborhoods where home charger orphan households are located. Figure 12 shows the projected concentration of home charger orphans across the city in 2035, which can inform where neighborhood chargers can compensate for the lack of home charging access and enable increased low-income EV adoption and affordability. Neighborhoods including Downtown, Mid-Wilshire, West LA, Hollywood, and North Hollywood are projected to have high EV adoption potential with low home charging access. Overall, census tracts not designated as DACs by SB 535 are projected to have 99,000 EV home charger orphans with an average of 9.6% and median of 7.8% of EVs per census tract, whereas tracts designated as DACs by SB 535 are projected to have 320,000 EV home charger orphans with an average of 10.2% and a median of 9.1% of EVs per census tract.

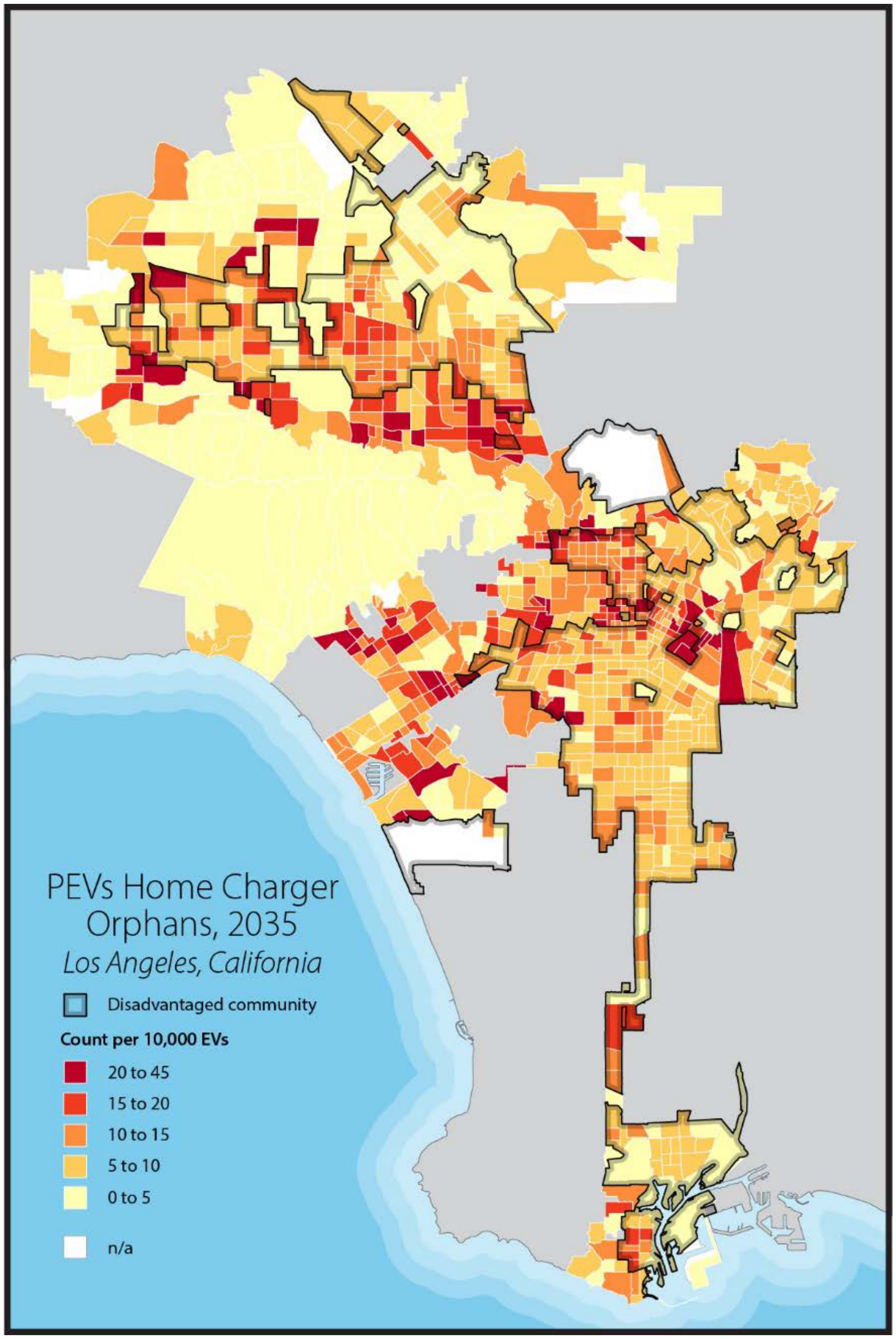

Figure 12. Projected spatial distribution of EV adopters without home charging access requiring neighborhood charging options or installation of home chargers (2035), where PEVs include both BEVs and PHEVs

Source: EVI-Equity

The data are normalized to show EV adoption distribution using the following equation: (modeled adopted EV count per tract) / (total modeled EV count in LA [1.6 million]) x 10,000

2.2 Reducing Transportation Energy Burdens Via Multimodal Solutions

Recognizing many LA households do not currently own a vehicle and are not likely to adopt a new or used EV in the next 10 years, we next examined non-personally owned electric mobility options to increase equity in transportation electrification.

2.2.1 Mode Choice Modeling and Metrics

We modeled the extent to which providing multimodal electric travel options, including shared EVs, shared micromobility, or improved transit services, can reduce transportation-related energy burdens for DAC residents. We modeled Baseline and Equity scenarios to identify the impact of gaining additional travel modal options on: (1) travel time, (2) travel cost, and (3) the number of opportunities that can be accessed. The modeling results are presented as the comparison between the Baseline scenario (i.e., BAU scenario) and Equity scenarios where new transportation services became available. The results are shown for the 19 transportation analysis zones that meet all three criteria for transportation disadvantage (i.e., high rates of zero-vehicle households, poor quality transit, and SB 535 DAC). Table 1 shows aggregated results.

Table 1. Usage of New Services and Impacts of Multimodal Solutions on Travel Time, Travel Cost, and Opportunities Reached

Strategy	Percentage of Trips Using New Services (%)		Reduction in Travel Time		Reduction in Travel Cost		Increase in Opportunity Reached	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Shared EV Access	6.8%	3.9%	3.2%	4.2%	7.4%	11.5%	1.8%	3.5%
Shared E-Bikes	16.9%	3.1%	-0.4%	4.2%	6.6%	8.6%	0.41%	0.88%
Improved Transit	10.0%	4.6%	11.7%	7.9%	18.5%	22.1%	3%	4.7%

The mode choice behavioral model evaluates the cost and time needed to use each travel option in daily travel and estimates the likelihood people would use different travel options. The percentage of DAC travel demand that utilizes newly added travel options is 3.5% to 26% (Figure 13). This percentage varies across DACs, and also by mode. In most cases, the shared micromobility program attracts the most DAC demand, followed by improved transit. The shared EV program ranks first in two DACs (4614 and 4067).

The newly added travel options can reduce DAC daily travel expenditures in most cases. Transit service with a fixed fare provides, on average, the greatest reduction in DAC residents' travel expenditures. However, the newly added travel options do not always help DAC residents reduce costs. Depending on the locations and travel demand patterns of a neighborhood, they can bring zero reduction, or even an increase in travel-related expenditures, while decreasing travel time and providing access to more destinations. This also indicates that, for some portion of DAC residents' demand, new travel modes that cost a little more than existing options but save time are also useful.

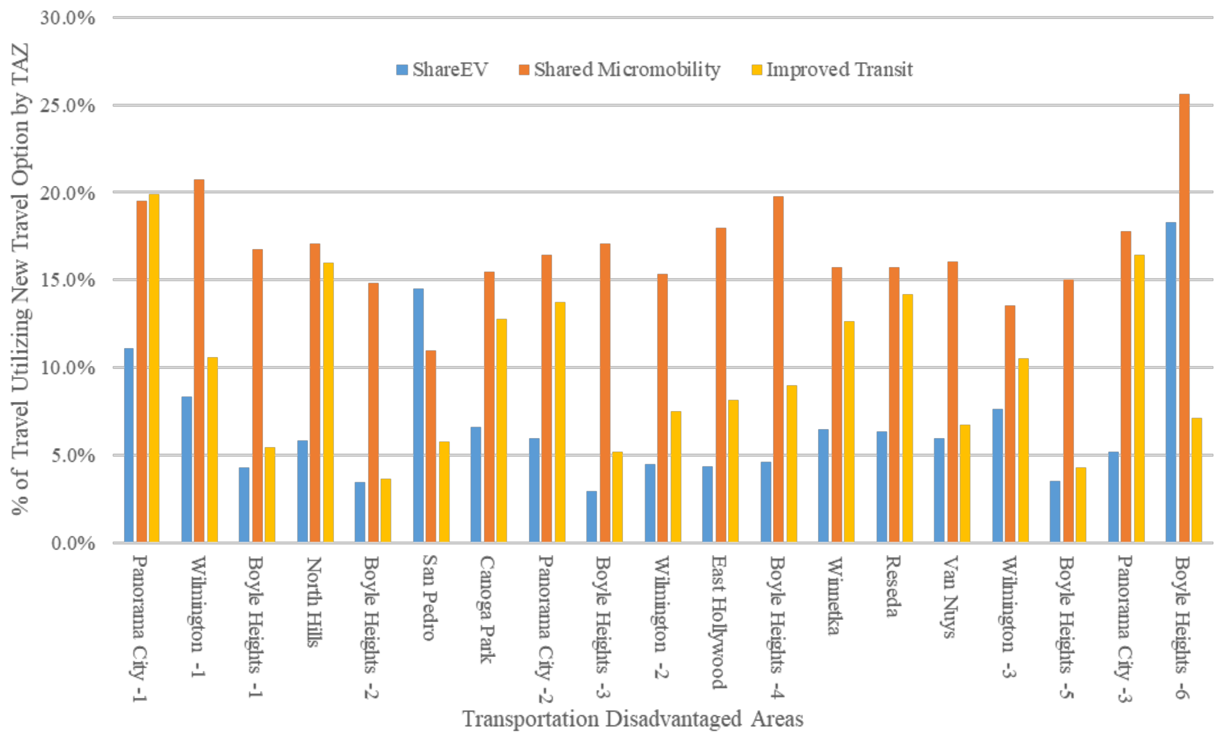

Figure 13. Percentages of DAC residents' travel using newly added travel options

Similarly, providing new travel options to DACs could help reduce the time they need to spend on transportation (Table 1). On average, improved transit reduces travel time the most (12% on average, with the highest savings reaching 30%). Shared micromobility service is the most attractive option for DACs based on consideration of cost, travel time, and accessible opportunities, although it saves the least amount of travel time due to its slower speed.

The new travel options modeled here can also help DAC residents access more destinations (e.g., restaurants, medical service, education), given that further distances can be traveled with faster travel modes in the same amount of time. As shown in Table 1, on average, improved transit services result in the greatest increase in accessible opportunities. Shared micromobility brings the least increase (0.41% on average). Different communities can benefit at different levels when provided with new travel options, which leads to a relatively high standard deviation of changes in increased opportunities. Figure 14 shows neighborhood-specific multimodal strategies for affordability, time efficiency, and access to opportunities. Detailed results can be found in the appendix section A.1.

Shared e-bike access | Shared EV access | Improved transit

Transportation Analysis Zone ID & Neighborhood	Most affordable	Most time efficient	Access to most opportunities	Transportation Analysis Zone ID & Neighborhood	Most affordable	Most time efficient	Access to most opportunities
3718 – Panorama City	Shared e-bike access	Shared e-bike access	Improved transit	4111 – Boyle Heights	Shared e-bike access	Shared e-bike access	Shared EV access
3731 – Panorama City	Shared e-bike access	Shared e-bike access	Improved transit	4114 – Boyle Heights	Shared e-bike access	Shared EV access	Shared EV access
3734 – North Hills	Shared e-bike access	Shared e-bike access	Improved transit	4115 – Boyle Heights	Shared EV access	Shared EV access	Shared EV access
3737 – Panorama City	Shared e-bike access	Shared e-bike access	Improved transit	4150 – Boyle Heights	Shared e-bike access	Shared EV access	Shared EV access
3864 – Reseda	Shared e-bike access	Shared e-bike access	Improved transit	4335 – East Hollywood	Shared EV access	Shared e-bike access	Shared EV access
3866 – Canoga Park	Shared EV access	Shared e-bike access	Shared EV access	4611 – Wilmington	Shared EV access	Shared e-bike access	Shared EV access
3872 – Winnetka	Shared e-bike access	Shared e-bike access	Improved transit	4612 – Wilmington	Shared EV access	Shared e-bike access	Shared EV access
3877 – Van Nuys	Shared EV access	Shared e-bike access	Shared EV access	4614 – San Pedro	Shared EV access	Shared e-bike access	Shared EV access
4067 – Boyle Heights	Shared EV access	Shared EV access	Shared EV access	4630 – Wilmington	Shared EV access	Shared e-bike access	Shared EV access
4105 – Boyle Heights	Shared e-bike access	Shared EV access	Shared EV access	*Calculated for low-vehicle ownership, low transit access, disadvantaged communities*			

Figure 14. Modeling results identifying neighborhood-specific multimodal strategies for affordability, time efficiency, and access to opportunities

These modes should be given strong consideration when developing community-guided portfolios of e-mobility options.

2.2.2 Multimodal Solutions

Modeling and analysis results indicate providing optimized multimodal solutions to DACs reduces travel time and costs and improves access to DAC residents' destinations. Implementation of multimodal solutions requires associated infrastructure investments, such as bike lanes to increase safety, covered bus stops with lighting, and well-lit, accessible sidewalks to access shared micromobility options such as e-bikes and e-scooters. Such infrastructure planning and development requires collaboration across multiple city agencies.

Priority Areas for Multimodal Strategies

The map shown in Figure 4 highlights areas of the city where at least 12% of the households do not own personal vehicles, as well as existing locations of BlueLA EV car sharing vehicles. Expanding access to BlueLA and other EV car share programs can be informed by the relative rates of vehicle ownership, as shown in Figure A-7 (appendix); for example, the top quintile where more than 18% of households are zero-vehicle households. Some areas with low vehicle ownership that do not currently have BlueLA vehicles include the Watts, Wilmington, and Boyle Heights neighborhoods.

Forthcoming e-bike incentives from the California Air Resources Board of $1,000 for regular e-bikes, and up to $1,750 for cargo or adaptive e-bikes, will be limited to households with incomes at or below 300% of the federal poverty level (FPL). Households at less than 225% of the FPL are eligible for an extra $250. The total budget is about $10 million, with an estimated 7,000 incentives provided. The expectation is that there will be far more demand for e-bike incentives than what this initial round of funding can provide, similar to what has been seen in other locations, such as Denver, Colorado,[5] where the January 2023 rebates were claimed within 20 minutes.[6] Initial insights from the Denver e-bike rebate program, where 67% of funds went to income-qualified residents and 30% of recipients surveyed were new bike riders, estimate about 1 lb carbon dioxide equivalent (CO_2e) saved per year per dollar invested.[7]

Figure 15 shows the census block groups in Los Angeles where the median household income is at or below 300% FPL and therefore most households would be eligible for the California Air Resources Board e-bike incentive. This amounts to 49% of the city's census block groups, shown in red and yellow on the map. Out of these areas, fewer than one-half of the census block groups are within 1,000 feet of existing bike infrastructure (based on census block group centroid). Therefore, light green areas on the map are where more than half of households are eligible for the e-bike incentive but most do not have nearby access to bike infrastructure. In addition, some existing Metro Bike stations are not within 1,000 feet of existing bike infrastructure. Without access to safe and convenient routes for riding bicycles, the full potential benefit of prospective mode shift described in Section 2.2.3 (Table 2) will be unrealized. This is especially noticeable in the Hollywood and East Hollywood neighborhoods. Note that demand for other existing e-bike incentives far exceeds supply. For example, Denver's rebates have consistently been claimed within minutes each time a new round is available[8].

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[5] "Electric Bikes (E-Bikes)," City and County of Denver, denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Climate-Action-Sustainability-Resiliency/Sustainable-Transportation/Electric-Bikes-E-Bikes-Rebates

[6] "Denver's Latest Round of Electric Bike Rebates Were GONE in 20 minutes," Micah Toll, electrek, February 8 2023, electrek.co/2023/02/08/denvers-electric-bike-rebates-gone-in-20-minutes/.

[7] "8 New Insights From Denver's EBike Incentive Program ," Nelle R. Pierson, Ride Report, March 7, 2023, www.ridereport.com/blog/ebike-inventive-programs.

[8] "The Latest Round of e-Bike Rebates Ran Out Fast Again," Rebecca Tauber, *Denverite*, January 31, 2023, https://denverite.com/2023/01/31/the-latest-round-of-e-bike-rebates-ran-out-fast-again/.

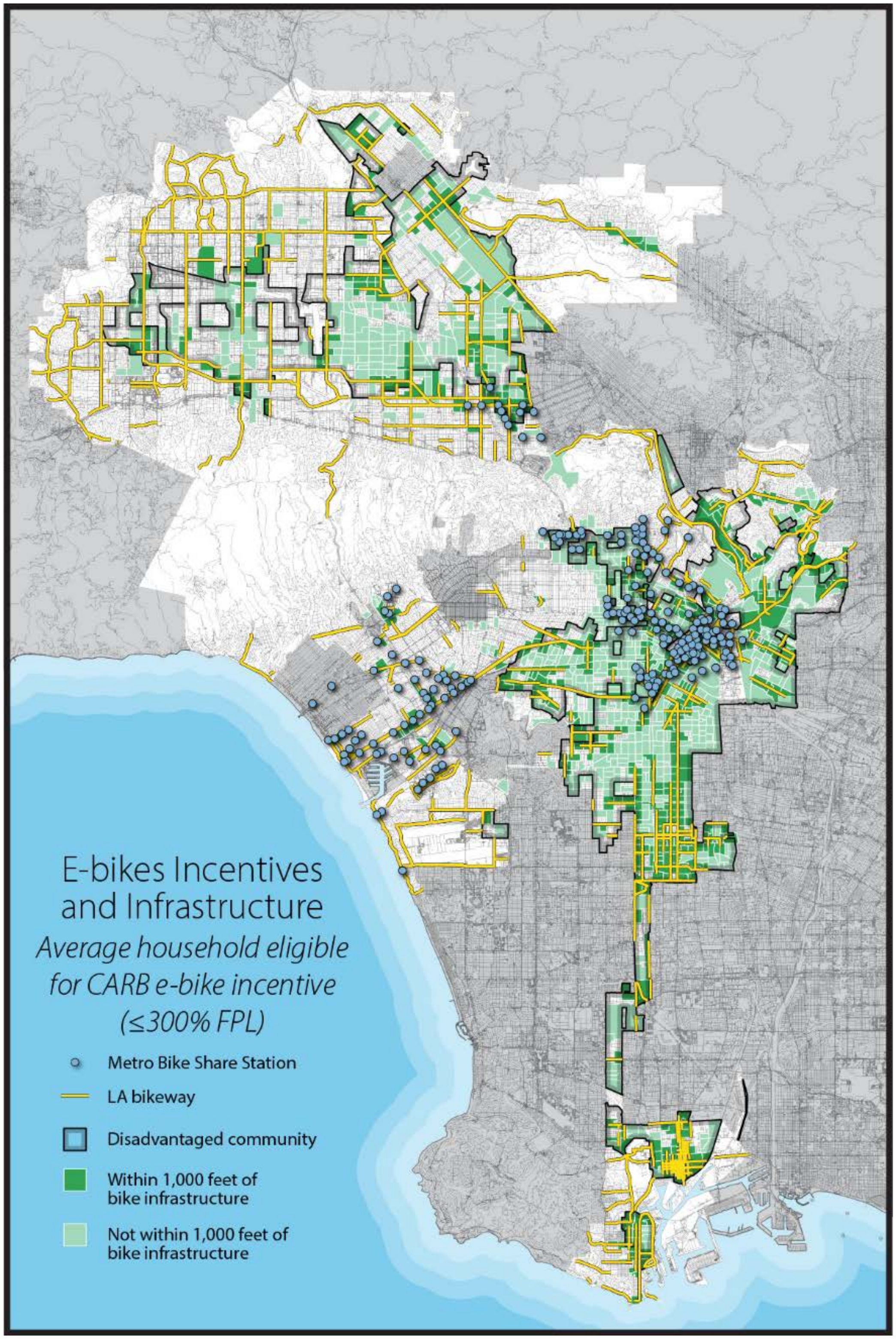

Figure 15. Existing bike infrastructure (bike paths and lanes) relative to areas of the city where the most households will be eligible for the forthcoming California Air Resources Board e-bike incentive (income less than 300% FPL)

Map uses American Community Survey 2015–2019 household income and 2019 FPL

2.2.3 The Case for Incentivizing Multimodal Transportation Electrification

In tandem with other literature and evidence, modeling results demonstrate at least four ways that investments in expanding access to multimodal transportation electrification can address transportation equity and make measurable progress on city goals. The primary metrics discussed above in the context of transportation equity are cost savings and the number of opportunities accessible by different modes. The primary metrics discussed below in terms of city goals are vehicle miles traveled (VMT) reduction and reduction in CO_2e emissions.

The March 2023 report on Denver's e-bike incentive program provides detailed insights on program design, implementation, and evaluation metrics. See the sidebar[9] for highlights of the program's success.

This analysis includes all trips originating in Los Angeles for an average weekday that are less than 35 miles one-way, with total miles traveled of 59,000,000. Thirty-five miles was used as the one-way trip distance threshold, as it encompasses approximately 99% of daily trips originating inside the city limits. That total is used as the denominator for the VMT reduction analysis that follows. Approximately 60% of those daily trips were modeled and evaluated in the mode shift baseline and equity scenario analysis, and the mode shift potential of the remaining trips was estimated through a linear regression using trip distance and a per mile mode shift conversion factor derived from the modeled trips. More detailed methods and results can be found in the appendix section A.1 Multimodal Solutions.

Denver's E-Bike Program

- 67% of funding and 49% of vouchers went to income-qualified residents.
- Operational emissions: e-bikes emit 3% of the CO_2e emissions as EVs and 1% of internal combustion engine vehicles.
- Per dollar spent, 0.94 lb of CO_2e was avoided, for a per-year total of 2,040 metric tons

Surveyed participants

- Ride an average of 26 miles per week, replacing about 7 vehicle trips.
- Use their gas vehicles less often (71% of respondents).
- Are new bike riders (29%).
- Use their e-bikes nearly 50% more than others if they are income-qualified residents.

Implications for LA

LA100 Equity Strategies modeling results suggest broad e-bike access could result in:

- Up to 4.7% reduction in total VMT/year
- Up to 316,000 tons reduced in CO_2e/year.
- Up to 187 GWh/year reduction in electricity demand compared to EV trips

Table 2 is split into three sections showing metrics on VMT, CO_2e emissions, and electricity demand for existing baseline trips, the modeled modes, and the combined impact of the two. CO_2e and electricity estimates for transit were not included due to high variability in potential emissions and electricity impact based on vehicle type, occupancy, and variable lifecycle emissions.

The first section of the table shows metrics from the perspective of avoided VMT, CO_{2e}, and GWh given the baseline rates of walking/bike and existing transit service use compared to if

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[9] Information on Denver's e-bike rebate program is from the March 2023 report *Denver's 2022 Ebike Incentive Program: Results and Recommendations* (City and County of Denver et al. 2023).

these same trips were done driving alone. In other words, these avoided impacts indicate the significance of preserving existing walk/bike/transit trips, in addition to the value of shifting existing vehicle trips to other modes. The middle section of the table uses modeling results to show metrics for trips that are taken by providing expanded access to shared e-bikes and improved transit service. These two modes are used to estimate reduction potential for the metrics of interest when the new modes are used compared to these trips being taken in light-duty EVs driving alone. The bottom section considers the impact of both trip types together (existing non-auto modes plus potential future trips shifted to the e-bike mode).

Table 2. Vehicle Miles, Emissions, and Energy Impacts of Existing and Modeled Walk/Bike and Transit Trips, in Comparison to Driving Alone

Table figures estimate 99% of trips in Los Angles that were included in the mode choice modeling and the results are for an average weekday. Results are rounded.

Metrics for Existing (Baseline) Non-Driving Modes		
Daily Impacts (relative to light-duty vehicles)	**Baseline Walk/Bike Trips**	**Baseline Transit Trips**
Private light-duty VMT avoided	2,000,000	6,600,000
CO_2e avoided by existing modes (tons) (compared to light-duty EV)	280[c]	N/A
CO_2e avoided by existing modes (tons) (compared to ICEV)	440[c]	N/A
MWh avoided by existing modes (compared to light-duty EV)	580[a]	N/A
Metrics for Future, New, Non-Driving Modes (modeled)		
Daily Impacts (relative to light-duty vehicles)	**Trips Switched to Shared E-Bike**	**Trips Switched to Improved Transit**
VMT reduced (miles) (compared to baseline driving VMT)	2,800,000	12,000,000
VMT reduced (%)	4.7%	20%
CO_2e reduced (tons) (compared to light-duty EV)	200[a]	N/A
CO_2e reduced (tons) (compared to ICEV)	1,300[b]	N/A
MWh reduced (compared to light-duty EV)	780[a]	N/A

Metrics for Existing (Baseline) Non-Driving Modes	
Daily and Annual Metrics for Both New E-Bike Mode and Existing Non-Driving Modes	
Total Daily VMT avoided (by existing modes) and reduced (by e-bike mode)	11,400,000 miles/day
Total Daily MWh avoided (by existing walk/bike modes) and reduced (by e-bike mode) (compared to LD EV)	1,400 MWh/day
Total annual VMT avoided (by existing modes) and reduced (by new e-bike mode) [weekdays only, 48 weeks per year]	2,700,000,000 miles/year (weekdays)
Total annual MWh avoided (by existing walk/bike modes) and reduced (by e-bike mode) (compared to LD EV) [weekdays only, 48 weeks per year]	330,000 MWh/year (weekdays)

[a] Lent and Lutzker, 2019

[b] Metro Bike Share CO_{2e} estimate: https://bikeshare.metro.net/about/data/

[c] MIT Energy Initiative, 2019

2.2.4 Energy Demand Impacts

The multimodal analysis provides information on how future mode shifts may impact peak electricity demand. To investigate peak demand impacts, we used the hourly data from sub-meters that received a rebate from LADWP for time-of-use metering for EV charging infrastructure. While only 36 addresses had 2019–2022 hourly data, several patterns emerged. The following observations and conclusions were drawn from the data of the 36 locations; however, this small sample size means the conclusions may not be representative. Hourly data was used to enable consideration of shifting designated low and high peak periods. Charging during LADWP's high peak hours (1 p.m.–5 p.m.) for these sub-meters is largely concentrated in the downtown area, while overnight charging hours occur more in the periphery. This geographic distinction is largely associated with commercial customers located downtown and residential customers in the periphery (shown in Figure 16, as red dots and yellow dots, respectively).

We analyzed residential and commercial customer charging across 4 years (2019–2022) for patterns in charging during high peak, low peak (10 a.m.–1 p.m. and 5 p.m.–8 p.m.), overnight (8 p.m.–6 a.m.), and other (6 a.m.–10 a.m.) hours (Figure 16 and Figure A-9). Nearly 20% of total EV charging analyzed takes place during low or high peak periods, except in 2021. Residential sub-meters charge overnight more than 70% of the time, while commercial customers charge overnight around 40% of the time. Apartments had the lowest peak charging of the commercial or multifamily chargers analyzed, indicating increased at-home or near-home EV charging infrastructure for multifamily residents and renters will likely not increase peak demand, at least while EV ownership remains relatively low among these residents. For the eight locations that host BlueLA EV car sharing vehicles (Figure A-10 in the appendix), approximately 50% of charging in 2021 and 2022 occurred overnight, and about 22% of charging occurring during peak hours. Note that for this data set, all charging was reported during the end hour of the charging event.

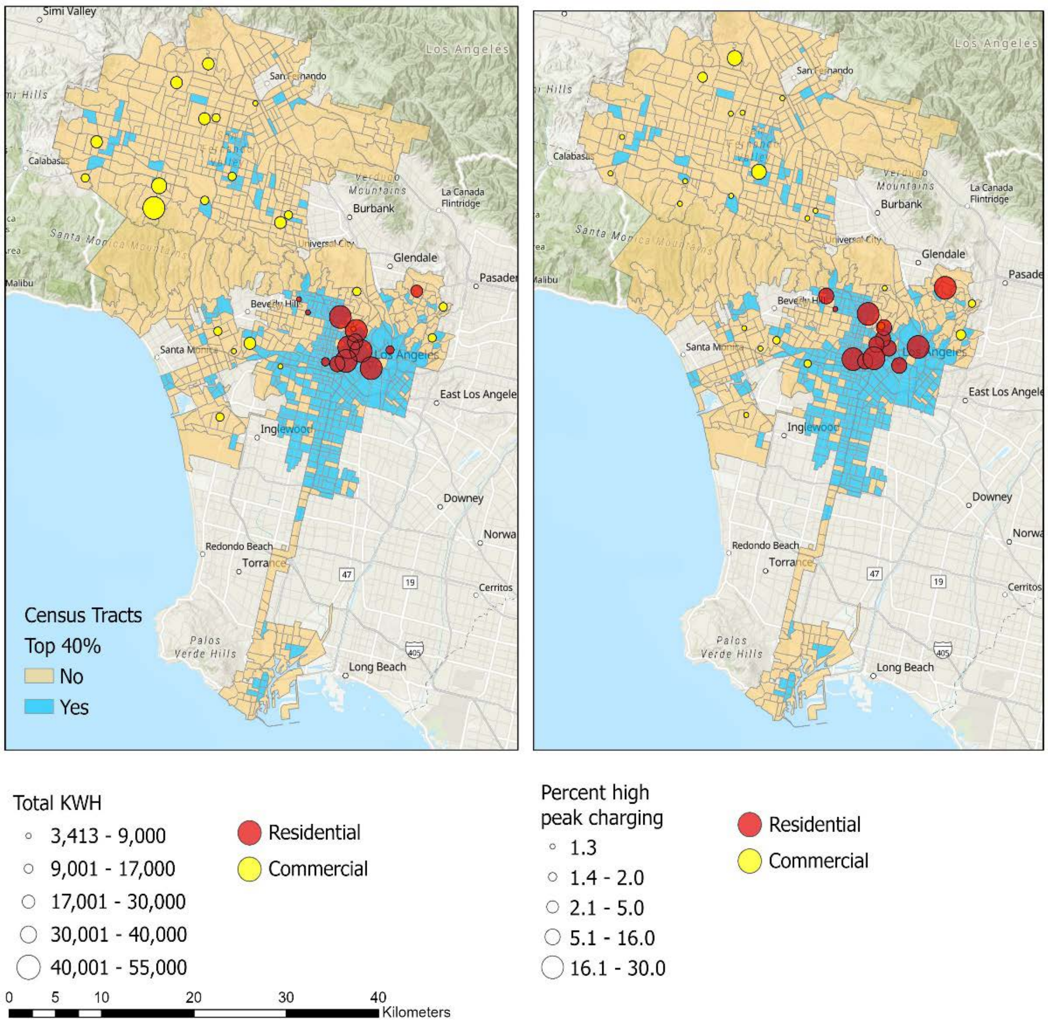

Figure 16. Time-of-use EV charging infrastructure sub-meter analysis (2019–2022)

In both maps, commercial meters are in red and residential meters in yellow, and both show whether each tract is in the top 40% of zero-vehicle households. The map on the left shows total kWh used at each sub-meter and the map on the right shows the percentage of kWh at each sub-meter used during the LADWP peak (1 p.m.–5 p.m.).

Base map source: Esri

3 Equity Strategies Discussion

Modeling, analysis, and community engagement identified the following strategies for achieving more equitable outcomes in the distribution of benefits and burdens in the LA transition to clean energy and electrified transportation. Strategies are organized by community guidance theme.

Tailor LADWP Incentives and Outreach to Meet Community Needs

- **Increase the LADWP low-income used EV incentive from $2,500 to $4,000 and establish a purchase price cap of $25,000 for incentive eligibility. Consider making low-speed EVs eligible for the rebate.** Vehicle adoption modeling indicates by 2035 in a Business-as-Usual case, the majority of predicted used EV consumers are households that make less than $75,000 per year. Increasing used EV rebates for low-income households by 60% from the current $2,500 to $4,000 could result in a 2% increase in used EV adoption among low-income households in Los Angeles by 2035, an increase of approximately 50,000 vehicles. Used, standard EV model purchase and use results in an estimated 2% reduction in total household expenditures. Modeling indicates high-income groups would not change their EV purchase behavior because of this modeled change in used EV rebates. Low-speed electric vehicles are available at a much lower price point (~$10,000[10]). Any consideration of removal of the existing 8 year model limit for used EV incentives should account for community concerns about the remaining useful life of batteries in older EVs and associated potential risks to low-income consumers.
- **Shift from delayed rebates to a point-of-sale discount.** This approach, consistent with the Inflation Reduction Act, allows car buyers to transfer the credit to dealers at the point of sale to directly reduce the purchase price (U.S. Department of the Treasury 2022).
- **Offer an incentive to test-drive EVs or ride e-bikes to low- and moderate-income households and households in communities that received disproportionately fewer LADWP EV incentives.** Pair this with education about the technology. For example, for e-bikes: educate consumers on how to ride, how to get a helmet, how and where to charge, how to keep bike safe from theft, and available adaptive e-bike options. Partner with e-mobility or advocacy groups to do this outreach, test rides, etc. Technology exposure can lead to increased interest and confidence in adoption. Set an incentive amount per participant (e.g., the Orlando, Florida utility offers a $50 gift card for electric car test drives and survey completion[11]).
- **Partner for used EV battery testing or certification.** Battery life can be an equity issue for used EV consumers. The city could develop a partnership with vehicle dealerships to test used EV batteries and replace them if needed, to prevent purchase of vehicles with low

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[10] "Low-Cost Tiny Electric Cars Like These Could Be the Next Big Thing," Micah Toll, electrek, January 23, 2023, https://electrek.co/2023/01/23/low-cost-tiny-electric-cars-lsv-nev/

[11] "Electric Vehicles & Charging," Orlando Utilities Commission, https://www.ouc.com/residential/save-energy-water-money/electric-vehicles

battery life. The city could also partner on a certified used EV program and service technician training programs.

- **Partner with community-based organizations to fund and staff networks of educators to target outreach to DACs, renters, and multifamily residents about incentives and low-barrier financing options (e.g., for those with low/no credit), and to co-design or refine those incentives with them.** Community-based organizations will be most effective if they can work across LADWP and city agencies including transportation, mobility, and parking; housing; planning and community development; and public works.
- **Conduct e-bike outreach and education paired with test rides and drives.** Provide detailed information on incentives, safe bike routes, where public charging is available, how to charge, how to secure the bike, and how to avoid battery fires.
- **Consider electrification incentives for taxi and ride-hailing services**. While large ride-hailing platforms (i.e., Lyft and Uber) are on a state-mandated timeline to electrify, incentives could encourage others to electrify.
- Create an incentive for use of EV technician training or infrastructure training participants in DAC neighborhoods.
- **Partner with other agencies on their statewide e-bike rebate data collection.** The California Air Resources Board has an e-bike rebate program. The implementer, Pedal Ahead, is partnering with the University of California, Davis to study and understand the effectiveness of the e-bike rebate program. The University of California, Davis will be using an NREL tool, OpenPath, to track energy and behavior impacts of the incentives. LADWP and the City of Los Angeles can partner to learn more about the impacts of e-bikes or provide incentives for participation. That information can be used to inform the rollout of local incentives. Out of a population of 10,000 (estimated range of statewide incentives), a sample size of about 400 across demographic groups would be considered representative.

Expand Accessible Electric Mobility Infrastructure

- **Expand at- or near-home charging access for renters and multifamily residents to enable more equitable access to and use of EVs. Include 120V outlets at all charging stations. Include a list of co-benefits that might be included with the installation. Prioritize charging infrastructure development in DACs in charging deserts with a high prevalence of multifamily buildings, including Boyle Heights, South LA, San Pedro, Crenshaw, Canoga Park, Winnetka, and Sylmar.** About 45% of LA households that make less than $75,000 a year and are predicted to be used EV consumers live in rented properties and/or multifamily homes. About 50% of those predicted EV consumers living in multifamily buildings will not have access to power outlets near where their vehicles park. Additionally, current public charging availability is found to be lower in predominantly Hispanic communities compared to predominantly non-Hispanic communities. The high potential for used EV adoption among less-than-median-income households may be at risk if home or near-home charging is not available. Making charging available to renters and multifamily residents will require overcoming barriers to home charging (lack of dedicated off-street parking for multifamily dwellings, upfront cost of home charging, and lack of actionable information for property owners) as well as to public charging (unclear payback for installing and maintaining public chargers, cost of using public chargers, unclear price structures, and need for cash payment options). LADWP can build on its existing efforts in neighborhoods like Crenshaw, where LADWP installed chargers at its Crenshaw Customer Service Center, available to motorists at no cost (LADWP 2019). LADWP utility poles in public rights-of-way in existing on-street parking areas can also be used to offer low-cost, scalable, and equitable access to overnight charging. *LADWP can leverage EV infrastructure investments to benefit multiple modes by include 120V outlets at each charging station. Offering other co-benefits, such as sidewalk improvements, crosswalk enhancements, benches, or other amenities can increase the number of residents who benefit from the infrastructure.* These plugs can serve low-speed electric vehicles, e-bikes, etc. This program will require partnership between the local government and LADWP to own, operate, and maintain Level 2 chargers (with 120V outlets) in dedicated on-street EV-charging-only spaces, using an approved tariff designed to be comparable to the cost of home charging.

- **Provide vouchers or charging subscriptions for public EV charging infrastructure for low-income households, especially those without home charging access.** While modeling finds adopting EVs decreases fuel cost burdens, not having home charging access can lead to a 1% increase in fuel cost burden compared to homes with charging access, equivalent to about $300 a year. That incrementally higher cost of public charging means that access to home charging (or access to public charging for a similar cost to home charging) is likely to influence used EV adoption, as lower-income households are especially sensitive to price differences.
- **Develop charging installation and infrastructure upgrade incentives for locations that are "near-home" for households without home charging access.** Acknowledging that installing charging infrastructure in all neighborhoods may be a long-term process, in the short term, the City of Los Angeles could focus on programs and incentives that increase workplace charging or interstate fast charging, which may have lower barriers and may increase equitable access to charging (see Box 4 of Kneeland et al. [2020]).
- **Create a program for EV readiness audits by trusted partners in designated neighborhoods.** Use the promotora model with trusted partners to help households identify underlying barriers to home charging access (e.g., new panel, higher service rating, running new circuit) and inform residents of federal funds to cover costs.
- **Develop EV-ready building codes and incentives to address EV charging infrastructure barriers (e.g., panel upgrades, service ratings, circuits) to make households EV-ready.** This strategy could be paired with workforce training for electricians to make electrical upgrades and monitor, operate, and maintain charging infrastructure. One such example is the Electric Vehicle Infrastructure Training Program.[12]
- **Incentivize employers to provide secure e-bike parking and charging.** Enabling employees to safely store and charge e-bikes at work can encourage more individuals to

[12] https://evitp.org/

commute by bicycle or other small electric mobility options. Employers who provide the amenity could receive an incentive from the city or utility.

Expand E-Mobility Options

- **Design a community-guided portfolio of electrified transportation options, including EV car share, e-bike, and e-scooter programs, that best serve the needs of each of the 19 neighborhoods identified as the most transportation disadvantaged and other priority areas identified by the city and communities, including the Boyle Heights, Wilmington, and Panorama City neighborhoods.** Recognizing that in LA disadvantaged communities, 16% of households do not have vehicles (compared to 11% citywide) and cannot be expected to purchase EVs in the near term, equitable transportation electrification requires extending the distribution of benefits to these households as well. Modeling shows the benefits of travel time and cost savings differ across e-bike, improved transit, and EV car share modes depending on the neighborhood. Shared e-bikes provided the highest travel time and cost savings for Panorama City, North Hills, Reseda, Winnetka, and in some parts of Boyle Heights. EV car share provided the most affordable, time efficient, and increased access to destinations in other parts of Boyle Heights and the most affordable and opportunity access in Canoga Park, East Hollywood, Wilmington, and San Pedro. Improved transit service mostly could help increase the opportunity access for Panorama City, Winnetka, and North Hills. Adding electrified multimodal electric travel options could cover up to 26% of travel demand in some of these communities. Ultimately, providing transportation choices for residents allows individuals and families to pick the best mode for different trip types or purposes. The Los Angeles Department of Transportation's implementation of a Universal Basic Mobility Pilot in South LA[13] since 2022, in partnership with LADWP and others, is an excellent example of providing such choices.
- **Expand community-guided multimodal shared programs to transportation disadvantaged communities citywide.** While homeowners can invest in home chargers, renters must rely on building owners, employers, or public chargers. As a result, EV ownership is low among renters. In Los Angeles, many low-income residents have had to relocate to less central areas of the city where housing is more affordable, yet vehicle ownership is often necessary due to a lack of convenient, safe, and efficient alternatives, such as rapid transit and dedicated bicycle infrastructure. Expanding multimodal opportunities citywide will help address this gap. Equitable access to and use of such programs will require enabling payment options for residents who rely on cash and do not own smartphones.
- **Establish a personally owned e-bike incentive.** In the United States, approximately 100 million bicycles are privately owned, far surpassing shared micromobility vehicles (232,000 in total, including e-bikes). Additionally, e-bikes are currently outselling electric cars (2022 sales were estimated at 800,000 electric cars and 1 million e-bikes). Therefore,

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[13] "LADOT Launches Universal Basic Mobility Pilot," City of Los Angeles Department of Transportation, April 26, 2022, https://ladot.lacity.org/dotnews/ladot-launches-universal-basic-mobility-pilot; https://ladot.lacity.org/ubm#about

incentives for personally owned e-bikes are likely to be important for cost and time savings, increased access to destinations, and wider adoption by multimodal users. LADWP incentives should be stackable with federal, state, and other local incentives. Successful implementation will require secure storage with charging near transit locations.

- **Pair e-bike incentives with the expansion of safe and accessible bike infrastructure and safe charging options at home or away from home.** When e-bikes are an option, they are the top choice for many of these communities. However, many of these same communities lack bike infrastructure, such as protected bike lanes, to make this mode choice a safe one. Community engagement also highlighted the critical nature of safety, including street lighting, shaded transit stops, and safe pedestrian access, in making e-bikes, e-scooters, and EV car sharing accessible. Creation of dedicated infrastructure for safe travel by different modes is an essential element of a multimodal system. While not considered in all elements of the multimodal modeling work, this topic was highlighted during the community engagement. For example, one community member shared their experience: "I used to ride my bike until I was run off the road. So it's not a safe mode of transportation in LA. The roads from my house [in East LA] to my work areas are beat up and they don't fix them. So there's no real reliable bicycle lanes, so I stopped."
- **Consider vehicle incentives for low-speed EVs or neighborhood EVs.** Low-speed and/or neighborhood EVs are energy efficient and much lower in cost.
- **Consider discounted or free charging for taxi and ride-hailing vehicles in DAC neighborhoods**. A large portion of taxi or ride-hailing drivers come from DACs. Providing discounted or free charging for taxi and ride-hailing vehicles can both reduce operational costs for these drivers and help facilitate fleet electrification. Discounted and free charging can also attract more taxis and ride-hailing vehicles to serve DACs.

Strategies and Associated Metrics

For strategies that were quantified in this analysis, Table 3 summarizes the expected benefit and cost, the timeline for implementation (short or long term), the party responsible for implementing the strategy, and metrics for measuring the success of the strategy.

Table 3. Equity Strategy Options: Benefit, Cost, Timeline, Responsible Party, and Metric for Evaluation

Equity Strategy	Benefit/Impact	Cost	Timeline	Responsible Party	Metric
Community Guidance Theme: Tailor Incentives					
Increase the LADWP low-income used EV incentive from $2,500 to $4,000 and establish a purchase price cap of $25,000 for incentive eligibility. Establish e-bike and electric low-speed vehicle rebates.	Increasing low-income used EV rebates could result in 50,000 more vehicles adopted among low-income households by 2035. Low-speed EVs are available at a much lower price point.	$6.2 million/yr. May be offset by $25,000 purchase price cap	2024–2035	LADWP	Incentive uptake of 4,200 low-income households per year for 12 years
Shift from delayed rebates to a point-of-sale discount	A point-of-purchase price discount will shift some administrative burden off the customer and lower credit and loan qualification barriers.	Neutral	2024–2035	LADWP and local car dealerships	Number of participating dealerships in the city. Incentive uptake of 4,200 low-income households per year for 12 years
Offer an incentive to test-drive EVs or test-ride e-bikes to low- and moderate-income households and households in communities that received disproportionately fewer LADWP EV incentives	Technology exposure can lead to increased interest and confidence in adoption.	$50 per participant	2024–2026	LADWP	Number of ride and drive event participants from DACs and/or identifying as LMI.
Partner for used EV battery testing or certification	Prevent purchase of vehicles with low battery life	Unknown	2024–2028	City, vehicle dealerships, EV maintenance providers	Number of used EVs tested and/or certified

Equity Strategy	Benefit/Impact	Cost	Timeline	Responsible Party	Metric
Community Guidance Theme: Expand Infrastructure Access					
Expand at- and near-home charging access for renters and multifamily residents to enable more equitable access to and use of EVs. Include 120V outlets at all stations for use by smaller EVs.	Apply the LADWP $5,000 Level 2 charging station in DACs rebate and other incentives to achieve 50,000 chargers by 2035 to meet charging needs of the projected 340,000 home charger orphans in DACs. Support Level 1 charging (120V outlet) access at workplaces and public locations, specifically for PHEVs, low-speed EVs, e-bikes, and other smaller electric mobility.	$22 million/yr through 2035 $260 million total	2024–2035	LADWP, private sector, property managers, EV car share programs	50,000 chargers by 2035, 4,200 chargers/year in predicted low-income EV adopter areas with low charging access. Two charging ports/location. Rebates calculated by: 70% Level 2 in DACs: 20% Level 2 non-DAC: 10% direct current fast charger (DCFC)
Provide vouchers or charging subscriptions for public EV charging infrastructure for low-income households, especially those without home charging access	Public charging costs approximately $300/year more than home charging in Los Angeles. Consider LADWP's desired locations and times for L2 and DCFC charging demand and adjust incentives accordingly.	$1.7 million/yr through 2035	2024–2035	LADWP, private sector, property managers, EV car share programs	Provide each low-income used EV incentive recipient with $300/year EV charging infrastructure voucher

Equity Strategy	Benefit/Impact	Cost	Timeline	Responsible Party	Metric
Community Guidance Theme: Expand Mobility Options					
Partner to establish community-guided EV car share, e-bike, and e-scooter shared programs that best serve the 19 neighborhoods identified as the most transportation disadvantaged	Grants for program establishment and e-bike and e-scooter purchase. Support with EV charging infrastructure rebates of $5,000 for Level 2 in DACs.	See universal basic mobility pilot in South LA (LADOT) costs[14]	2024–2026	LADOT, LADWP, (rebates), private sector (mobility as a service)	Apply the DAC EV charging infrastructure rebate for each installed charger for the program
Expand community-guided multimodal shared programs to transportation disadvantaged communities citywide	Grants for program establishment and e-bike and e-scooter purchase. Support with EV charging infrastructure rebates of $5,000 for Level 2 carshare chargers in DACs.	See universal basic mobility pilot in South LA (LADOT) costs	2026–2030	LADOT, LADWP, (rebates), private sector (mobility as a service)	Apply the DAC EV charging infrastructure rebate for each installed charger for the program
Establish a personally owned e-bike incentive program	Stackable with CA state incentive and prospective federal incentive.	CARB $13 million 2023 budget will fund 4,000–7,000 rebates. Denver provided 4,734 rebates in 2022 with $4.7 million.	2024– 2035	LADWP	Number of participants; VMT reduction brought by personally owned e-bikes and associated emission reduction, travel time reduction and cost saving

[14] "Universal Basic Mobility (UBM): South Los Angeles," https://ladot.lacity.org/ubm#about.

Equity Strategy	Benefit/Impact	Cost	Timeline	Responsible Party	Metric
Pair e-bike incentives with the expansion of safe and accessible bike infrastructure and charging options	Collaborate on charging and protected bike infrastructure planning, provide financial support for program development. Support electrification of high-volume or other strategic docking stations for shared or personal e-bikes through rebates to provide seamless recharging. Include 120V outlets at all light-duty EV charging stations, for use by smaller electric vehicles or mobility devices (e.g., low-speed vehicles and e-bikes).	Universal e-bike charging station equipment is available for $1,500 and up.[a] Chicago's Divvy bikeshare stations are being electrified but cost info is not public.	2024–2035	LADWP, LADOT, CBOs	E-bike incentive recipients within 1,000 ft of bike lanes. Opportunities include collaboration on Bipartisan Infrastructure Law Safe Streets for All (SS4A)[b] funded bike lane and charging infrastructure planning and investment

[a] Example: "Saris Infrastructure Releases Public e-Bike Charger Station," Bicycle Retailer and Industry News, June 9, 2022, https://www.bicycleretailer.com/new-products/2022/06/09/saris-infrastructure-releases-public-e-bike-charger-station

[b] "Safe Streets and Roads for All (SS4A) Grant Program," U.S. Department of Transportation, https://www.transportation.gov/grants/SS4A.

Equity strategies and the analysis of baseline equity, community guidance, and modeling results that informs them are outlined by community guidance theme in Figure 17, Figure 18, and Figure 19.

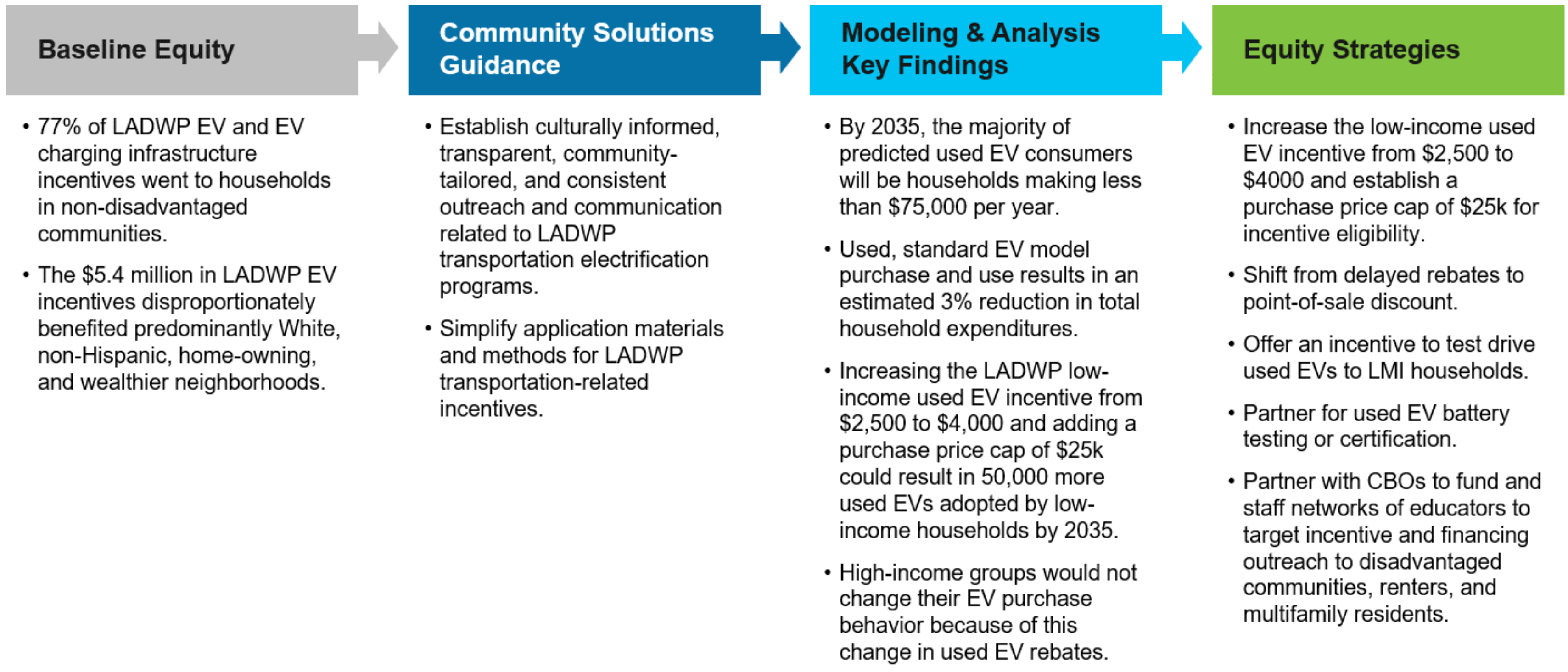

Figure 17. Equity strategies for LADWP electric vehicle incentives and outreach

Equity strategies that redress distributional inequity in LADWP incentives and increase equity in vehicle electrification can include strategies to shift the used EV rebate to support affordability for lower-income customers. A price cap, informed by the EV market analysis shown in Figure 6 and/or excluding premium EV models from eligible vehicles can shift incentives toward lower-income customers. Converting from a rebate to an incentive at the purchase point managed by dealerships can further reduce cost barriers. Partnering with trusted community organizations to establish funded and staffed resource centers and educators in DACs can provide targeted technical assistance. Evaluation metrics include continued tracking of rebates by DAC and sociodemographic metrics and setting a goal and timeline for percentage of incentives provided to DACs.

Baseline Equity

- Mostly non-Hispanic communities have more charging stations than mostly Hispanic communities.

Community Solutions Guidance

- Ensure EV charging stations are located to meet daily household routines.
- Co-design and implement low-income community infrastructure for transportation electrification without adding environmental and socioeconomic burdens.
- Build inclusive charging infrastructure for charging personal EVs, shared EVs, e-bikes, and other electric options (e.g., electric public transit, low-speed EVs).

Modeling & Analysis Key Findings

- By 2035, ~50% of potential LMI used EV consumers will be renters or live in multifamily buildings.
- 40% of households living in multifamily homes lack access to charging at or near their homes.
- Home charging is more affordable than public charging and can make the difference between used EVs increasing or decreasing expenditures for median income households.
- Commercial customers are 4-6× more likely to charge during peak hours than residential customers. Apartments had the lowest peak charging of commercial/multi-family chargers analyzed.

Equity Strategies

- Expand at- or near-home charging access for renters and multifamily residents to enable more equitable access to and use of EVs.
- Develop public, near-home charging in disadvantaged communities in charging deserts including Boyle Heights, South LA, San Pedro, Crenshaw, Canoga Park, Winnetka, and Sylmar.
- Develop publicly accessible EVSE at LADWP and other city facilities.
- Provide vouchers or charging subscriptions for low-income households relying on public EVSE.

Figure 18. Equity strategies for charging infrastructure

A focus on expanding access to affordable at-home or near-home charging for renters and multifamily residents can expand EV adoption. Evaluation and goal setting metrics include the number of DAC households receiving charging incentives and proportion of EV charging infrastructure incentives going to DAC versus non-DAC communities.

Baseline Equity

- 16% of households in disadvantaged census tracts (SB 535) in Los Angeles do not own vehicles, compared to 12% of households citywide.
- Even with LADWP, state, and federal incentives, used EVs may still be unaffordable for low-income households.

Community Solutions Guidance

- Co-develop affordable electric transportation options with local communities to improve access and reduce pollution.
- Expand shared EV, e-bike, and e-scooter programs.
- Increase street safety (e.g., street lighting, shaded transit stops, protecting bikers) to enable safe access to multimodal electric transportation.

Modeling & Analysis Key Findings

- Behavior modeling shows EV car sharing can provide affordable access to EVs, substantially reduce transportation time, and increase access to opportunities in areas with very low car ownership rates.
- Widespread access to e-bikes could reduce vehicle miles traveled by 6.8%, saving 294,200 tons of CO_2e and avoiding 185.8 GWh of electricity demand.
- Fewer than 50% of households eligible for California Air Resources Board e-bike incentives are within 1,000 feet of existing bike infrastructure.

Equity Strategies

- Design community-guided, shared EV, e-bike, and e-scooter programs that best serve the 19 disadvantaged communities, including Boyle Heights, Wilmington, and Panorama City, with poor transit and low vehicle ownership.
- Establish a personally-owned e-bike incentive program.
- Pair e-bike incentives with expansion of safe and accessible bike infrastructure and charging options targeted to transportation disadvantaged neighborhoods.

Figure 19. Equity strategies for multimodal transportation electrification

Transportation electrification equity requires consideration of households without personally owned vehicles. Goal setting and evaluation metrics for expanding multimodal electrified transportation options for transportation disadvantaged neighborhoods include number of car share EVs in DACs, number of low-income e-bike incentives distributed, and number of public e-bike sharing and charging locations in DACs, with specific goals for transportation disadvantaged communities.

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Appendix. Transportation Modeling and Analysis: Supplementary Methodology and Results

A.1 Detailed Methods and Additional Results

Baseline Equity Analysis

The baseline equity analysis presented in the Chapter 10: Household Transportation Electrification Executive Summary included a breakdown of statistical significance of incentive investments by program type (Figure A-1, Figure A-2, and Table A-1). These show that distribution of residential chargers and used vehicle spending amounts are similar, both by number of households (Figure A-1) and by dollars spent (Figure A-2).

Number of Households: *p values*

EV Incentives by Product and Rebate Type

Program(s)	Non-DAC/DAC	Mostly White/ Mostly Non-White	Mostly Non-Hispanic/Mostly Hispanic	Mostly Owners/Renters	Above/Below Median Income*
Commercial New Charger	≤ 0.001	0.170	≤ 0.001	0.024	0.011
Commercial New Sub-Meter	0.546	1.000	≤ 0.001	0.979	0.222
Direct Current Fast Charger	0.167	0.351	0.347	-	-
Residential New Charger	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001
Residential New Sub-Meter	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001
Residential Used Vehicle	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001

NOTE: Medium and heavy duty (MDHD) EV Incentives could not be analyzed due to an insufficient population size of 6 data points.
**Median income: $73,100 annual salary (2019)*

Are these *p values* significant?
Yes, benefitting populations in **blue**.
Yes, benefitting populations in **gold**.

Programs with a **statistically significant difference** in the **number of benefits received by communities** characterized according to the socio-demographic metrics are marked in **blue** or **gold**. Unmarked boxes indicate no statistically significant difference.

Link to Methodology

Figure A-1. Number of LADWP EV related incentives by program, in areas of the city with various indicators of advantage versus disadvantage

Total Dollars Spent: *p values*

EV Incentives by Product and Rebate Type

Program(s)	Non-DAC/DAC	Mostly White/ Mostly Non-White	Mostly Non-Hispanic/Mostly Hispanic	Mostly Owners/Renters	Above/Below Median Income*
Commercial New Charger	≤ 0.001	0.709	≤ 0.001	0.016	0.024
Direct Current Fast Charger	0.432	0.157	0.282	-	-
Residential New Charger	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001
Residential New Sub-Meter	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001
Residential Used Vehicle	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001	≤ 0.001

NOTE: Medium and heavy duty (MDHD) and commercial new sub-meter EV incentives could not be analyzed due to an insufficient data.

**Median income: $73,100 annual salary (2019)*

Are these *p values* significant?
Yes, benefitting populations in **blue**.
Yes, benefitting populations in **gold**.

Programs with a **statistically significant difference** in the **incentive dollars received in communities** characterized according to the socio-demographic metrics are marked in **blue** or **gold**. Unmarked boxes indicate no statistically significant difference.

Link to Methodology

Figure A-2. Dollar value of LADWP EV related incentives by program, in areas of the city with various indicators of advantage versus disadvantage

Table A-1. Characteristics of EV related LADWP incentives (2013-2021)

Program Name	Used in This Analysis?	Years	Number of Unique Locations	Total Number of Records	Total Dollars	Customer Sector	Description	Notes
Electric Vehicle Incentives	X	2013-2021	6,910	987	$63,647,945	Commercial	Commercial New Charger	Rebate
	X			339	*no data*	Commercial	Commercial New Sub-Meter	Rebate
				6	$430,000	Commercial	MDHD	Insufficient population size of 6 data points.
	X			14	$1,800,000	Commercial	DCFC	Rebate
	X			5,678	$3,017,576	Residential	Residential New Charger	Rebate
	X			374	$92,500	Residential	Residential New Sub-Meter	Rebate
	X			1,967	$2,251,350	Residential	Residential Used Vehicle	Rebate

Evolution of Levelized Cost of Driving for EVs

In addition to household expenditure analysis, this study also evaluated levelized cost of driving for EVs in comparison with conventional internal combustion engine vehicles (ICEVs). For levelized cost of driving ($/mile) estimation, this analysis considered the manufacturer's suggested retail price by model year and costs associated with financing, tax and fees, fuel, insurance, maintenance, and repair. The manufacturer's suggested retail price was estimated by ADOPT (NREL 2022a). Historical motor gasoline price was assumed to be between $3.5/gallon and $5.5/gallon (Los Angeles Almanac 2022; AAA 2023), of which future price evolution was based on EIA projections (EIA 2023). Electricity fuel price for home charging was assumed to be between $0.19/kWh and $0.31/kWh (LADWP 2023; NREL 2022b), of which future evolution was based on EIA projections (EIA 2023). Charging costs paid by EV drivers in public charging stations were assumed to be between $0.27/kWh and $0.49/kWh (NREL 2022b). Vehicular energy efficiency (miles/gallon for gasoline cars, and kWh/mile for electric vehicles) was based on NREL's Transportation Decarbonization Analysis project (NREL 2023). A discount rate for 15 years of vehicle lifetime was assumed to be 5% (Lee et al. 2013). Other cost parameters related to financing, tax and fees, insurance, maintenance, and repair are based on (Burnham et al. 2021).

EV adoption in Los Angeles will be dominated by BEVs rather than PHEVs. For that reason, levelized cost of driving analysis here is focused on BEV versus ICEV. In this study, levelized cost of driving includes vehicle purchase (without rebates), maintenance, repair, insurance, financing, taxes and fees, and fuel costs over the vehicle lifetime of 15 years. Also, note that levelized cost of driving values in this analysis are based on sales-weighted aggregation of all new light-duty vehicles for each model year. As shown in Figure A-4, the levelized cost of driving of BEVs is currently higher, compared to ICEVs. However, BEV is expected to achieve levelized cost of driving parity with ICEVs in around 2025. For model year 2035 new BEVs, LCOD is estimated to be 8%–12% lower in comparison with ICEV counterparts, depending on whether home charging access is available or not.

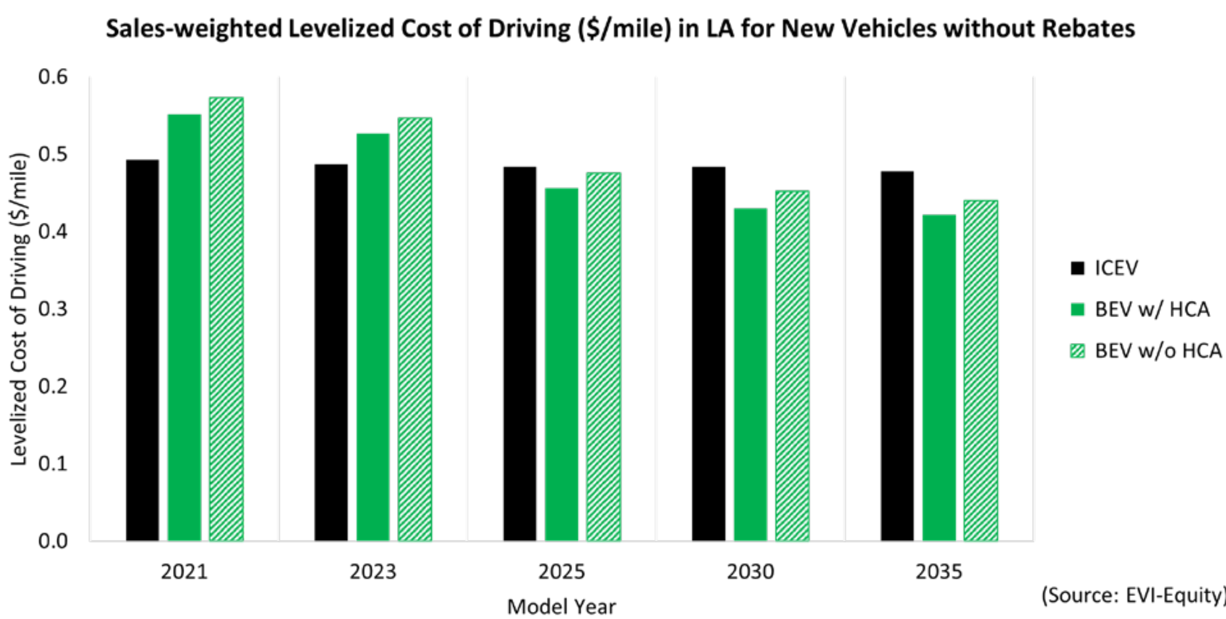

Figure A-4. Levelized cost of driving for different vehicle technologies and model years

EVs and Home Charging Access in DACs versus Non-DACs

Table A-2 shows varying concentrations of EVs and home chargers between DACs and non-DACs. As the table shows, EV owners in Los Angeles would be more or less evenly distributed between DACs and non-DACs by 2035, but EV owners in DACs tend to have lower income than those in non-DACs and to rely more on used EVs (see Figure 9, page 10). Also, note that the number of "home charger orphans"—those without home charging access (HCA)—in DACs is

26% greater than that in non-DACs. This implies that relatively more support (e.g., measures to compensate the lack of home charging access) may be necessary for EV owners in DACs.

Table A-2. Number of Households (in thousands) in Los Angeles That Own EVs

Annual Income	Non-DAC				DAC			
	Single-Family Home		Multifamily Housing		Single-Family Home		Multifamily Housing	
	w/ HCA	w/o HCA	w/ HCA	w/o HCA	w/ HCA	w/o HCA	w/ HCA	w/o HCA
< $25,000	22	8.0	5.9	9.7	42	17	14	22
$25,000–$50,000	31	7.4	14	25	53	14	26	46
$50,000–$75,000	34	3.6	23	25	44	5.0	30	33
$75,000–$100,000	36	2.3	25	18	33	2.3	24	17
$100,000–$150,000	52	3.7	29	22	35	2.7	21	16
$150,000–$200,000	32	2.1	14	10	14	1.0	6.9	5.1
> $200,000	38	2.9	3.5	3.2	6.9	0.5	1.0	0.9
Total	**245**	**30**	**114**	**114**	**229**	**42**	**124**	**139**
	275		**227**		**271**		**262**	
	503				**533**			

Charging Load Profiles for Personally Owned EVs

Most of the EV/ EV charging infrastructure analysis in this study was conducted using NREL's EVI-Equity, ADOPT, and EVI-Pro tools, as described in the main text. Some new features were created and/or updated specifically for this study, including predicted charging load profiles associated with personal car EVs on a census tract level in the City of Los Angeles by 2035, as well as underlying distribution of home and public (including workplace) EV charging infrastructure.

EV charging load profiles, previously generated in the LA100 study (NREL 2021), were based on an older version of EVI-Pro that has been updated over the past few years (CEC 2021). This study utilized one of the more recent versions of EVI-Pro (CEC 2021) for charging load profiles for personally owned EVs, documented in the Assembly Bill 2127 Staff Report (CEC 2021). Different versions of EVI-Pro, used in the LA100 study versus this analysis, lead to different shape and structure of charging load profiles.

For this analysis, EVI-Pro's simulated charging events for generic EVs, including PHEVs and BEVs, for Los Angeles County were utilized, distinguishing vehicle technology (PHEV versus BEV), home charging access (with versus without), and vehicle type (small car, large car, sport car, small SUV, large SUV, van, and pickup truck). As noted in the main text, this study assumes Los Angeles will have about 1.6 million EVs (PHEVs and BEVs) by 2035. To break down EVs to different vehicle types (e.g., small car, large car) adopted in EVI-Pro, this study employed projected distribution of vehicle types in the CARB's zero-emission vehicle mandates (CARB 2022).

The generic charging events from EVI-Pro contained the type of destination, including home, workplace, or public; type of EV charging infrastructure, such as Level 1 (L1), Level 2 (L2), and DC fast charger (DCFC); day of the week—weekday or weekend; and charging load in kW with the timestamp for the start and end of charging event. To assign charging events and loads to different locations across the city, this study assumed that home charging events will occur in home census tracts to which EVs are likely to be registered to, which is determined by the EVI-Equity model, as discussed in the main text. For all the other charging events related to workplace and public locations, this analysis treated them as charging loads in commercial sites or facilities for simplicity. In other words, EV charging load profiles in this analysis are categorized as home or commercial.

While home charging loads are assigned to home census tracts for EV owners in Los Angeles, commercial charging loads are distributed according to the projected concentration of public EV charging infrastructure across the city. For this, two assumptions were made. First, the concentration of commercial EV charging infrastructure across the city will be mostly proportional to the land area share of commercial sites between different census tracts, for which LA-specific land use data were leveraged (City of Los Angeles 2022). Second, census tracts that currently have high concentration of public EV charging infrastructure will continue to have significant level of concentration of EV charging infrastructure in 2035. In other words, a census tract that has that has one of the highest concentrations of public EV charging infrastructure today is assumed to be not likely to have the least share of public EV charging infrastructure in 2035.

As such, for each census tract, this analysis aggregated the generic charging events for home and commercial locations (not on a site, but census tract level) for weekday and weekend; PHEVs and BEVs; different vehicle types; and with and without home charging access, which were all used to identify target/candidate samples among the original set of generic charging events. Among the identified candidates that qualify for corresponding criteria, including day of the week, EV technology, location type, vehicle type, and home charging access, a sample was drawn randomly to constitute a load profile for each EV in each census tract.

The aggregated charging load profiles are shown in Figure A-5. The overall shapes or patterns of load profiles may appear to deviate from the statewide load profiles documented in the CEC Staff Report (CEC 2021), as this study is based on a simulation specific to Los Angeles County that has different characteristics of EV fleet, housing types, and so on from those for the entire state of California.

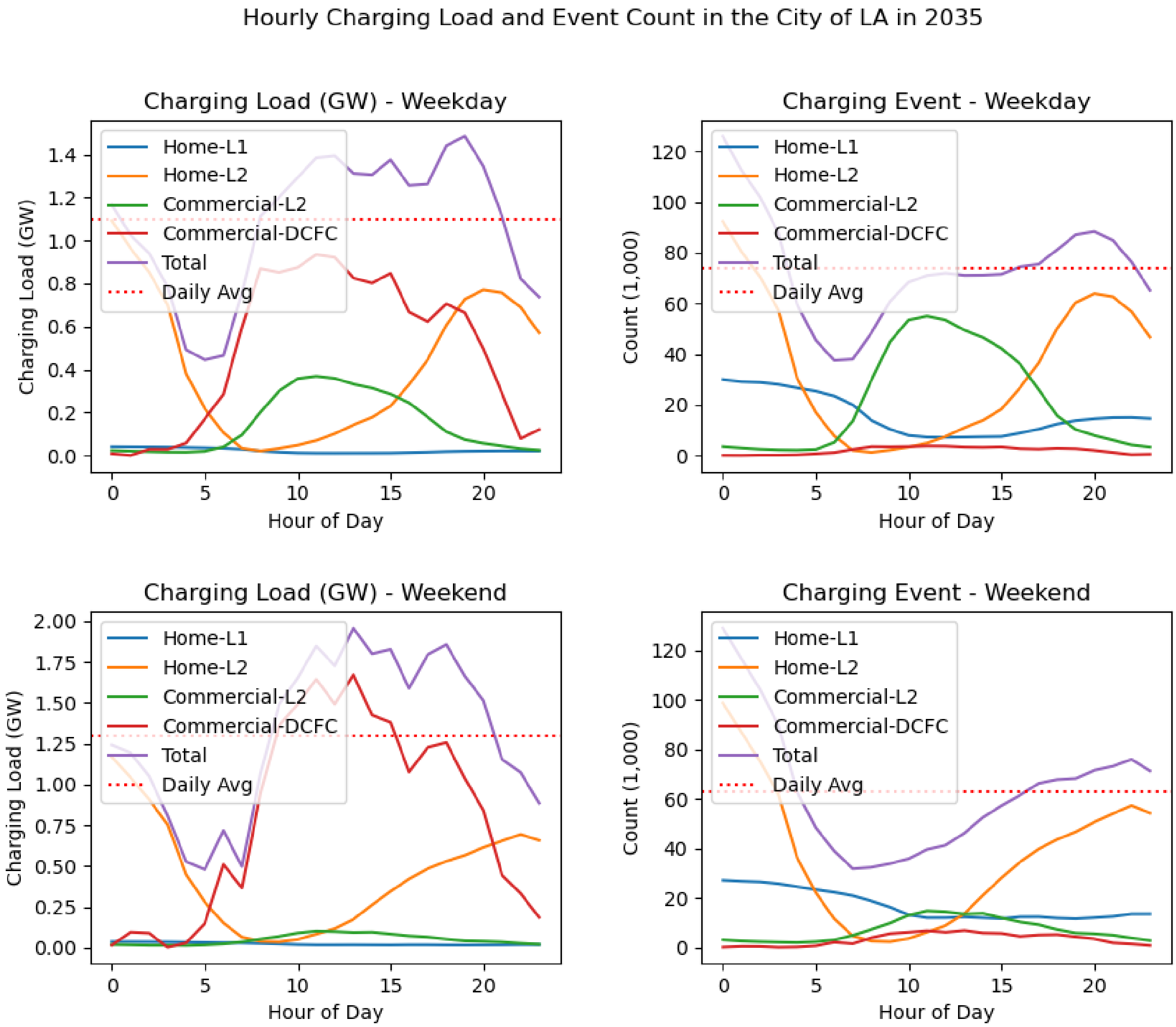

Figure A-5. Hourly EV charging load profiles in Los Angeles in 2035: Business-as-Usual scenario

The load profiles (Figure A-5) show that home charging is estimated to be the dominant form of refueling for EVs during nighttime and commercial during daytime. The relative significance of home or overnight charging during nighttime is more pronounced during weekdays in comparison with weekends. The load profiles also reveal the impact of different charger types: L1, L2, and DCFC. Regarding charge event count, L1 home charging has a significant share, but the overall impact on load profiles is negligible, as L1 (1 kW) is generally much less powerful than L2 (7–19 kW) (US DOT 2022). The same applies to the relative magnitude of DCFC in charge event count versus charging load. DCFC (50–350 kW) appears to be very small in the charge event count chart, but its aggregated impact on load profiles is very significant. Between weekday and weekend, the frequency and load impact of commercial L2 charging activity decreases during the weekend, in part because workplace charging diminishes significantly on the weekend. On the other hand, DCFC has the opposite pattern between weekday (smaller) versus weekend (greater) in terms of charge event count and overall charging load.

Note that these simulated load profiles are for a typical day of the year, without accounting for potential seasonal or longitudinal variation of travel pattern, energy price, and so on. Also note that the load profiles are scaled to be consistent with the LA100 study in terms of the total electrical energy drawn from the grid per day for charging. The focus of this analysis is the distribution (or redistribution) of EVs and EV charging infrastructure, while maintaining the high-level consistency with the preceding LA100 study, especially for the size of the EV fleet in Los Angeles and corresponding overall load profiles.

For a more rigorous analysis incorporating travel pattern into EV charging simulation, the study considered the travel pattern across and beyond Los Angeles that is estimated in the CSTDM (California Statewide Travel Demand Model) (Caltrans 2022). However, due to the level of detail that the study had for CSTDM's modeled travel pattern in and around Los Angeles, it was not feasible to allocate the generic simulated charging events from EVI-Pro to different areas of the city corresponding to the travel volume or pattern in the CSTDM. For example, a vehicle may travel from downtown to the northwest side of the city in the morning and return to the downtown in the evening, but chaining trips for individual vehicles as such was not possible, as it was not supported by the resolution of the data that the study had access for CSTDM. Even if the study had detailed vehicle activity data, for example, telematics, simulating those trips through EVI-Pro was out of the scope of this study.

For similar reasons, the study did not make spatial or temporal connections between where individual EV owners/drivers live and where they charge their EVs outside their homes (e.g., workplace, grocery store). Although a significant portion of the vehicle activity is related to intra-city travel, the CSTDM indicated that there is considerable vehicle movement between the city and the neighboring areas, for instance, between Los Angeles and Riverside, Irvine, or San Bernardino. This implies that charging activity, mostly influenced by travel pattern or vehicle activity, in Los Angeles may require region-wide travel plus charging simulation, but that was not feasible within the scope of timeline of this study. This also has an important implication for the question of who is benefiting from EV charging infrastructure in commercial locations within the city boundary. Given the significant travel activity between the city and neighboring areas, it is very possible that many EV owners/drivers using EV charging infrastructure in commercial locations within the city boundary may be from another city or area, or vice versa. That is why the study focused on home charging access that is presented in the main text, rather than public/private EV charging infrastructure in commercial locations.

With regards to vehicle activity beyond the city boundary and corresponding charging demands as well as load profiles in commercial locations in Los Angeles, the study assumed that the vacuum created by outbound travel volume (e.g., from Los Angeles to Irvine) will be filled with similar level of inbound activity (e.g., from neighboring areas to LA), resulting in mostly similar level of charging demands in the city. In other words, having 1.6 million EVs in Los Angeles in 2035 does not necessarily mean that all EV charging infrastructure in the city will exclusively serve those 1.6 million EVs registered in the city. Assuming that the net gain or loss of vehicle activity across the city boundary is close to zero, and that the EV adoption level in neighboring cities/areas is similar to that in Los Angeles, the study estimates that the load profiles shown in Figure A-5 would be citywide EV charging loads in 2035.

From the perspective of Business-as-Usual versus Equity Scenario, the overall load profiles are very similar (Figure A-6), mostly due to the assumptions discussed earlier, for example, respecting or inheriting the overall citywide energy consumed for EV charging that was estimated in the LA100 study (NREL 2021). Also, even if the distribution of EV charging infrastructure within the city boundary is adjusted, that would not necessarily show up in the overall load profiles. Nevertheless, the inner structure of load profiles across the city is different between the two scenarios, as Equity scenario assumes that there will be relatively higher concentration of public EV charging infrastructure, compared to Business-as-Usual scenario, in the neighborhoods where home charger orphans live—presented in the main text.

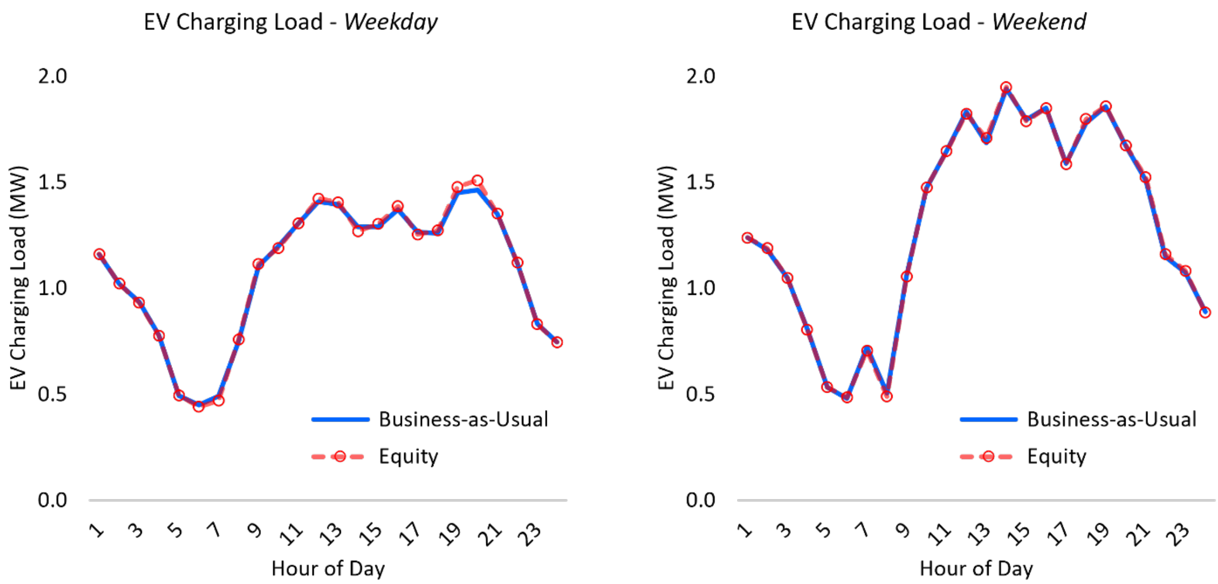

Figure A-6. Citywide hourly EV charging load profiles: Business-as-Usual versus Equity scenarios

Multimodal Solutions

Methods Background

The multimodal work used three factors to identify "transportation disadvantage." The proportion of zero-vehicle households by transportation analysis zone are shown in Figure A-7. While only 19 of these transportation analysis zones (TAZs) were in the top 40% for zero-vehicle households, poor quality transit, and also designated DACs, this map shows all areas of the city where travel by modes other than personally owned automobiles should be prioritized and improved to meet the needs of households that don't own cars.

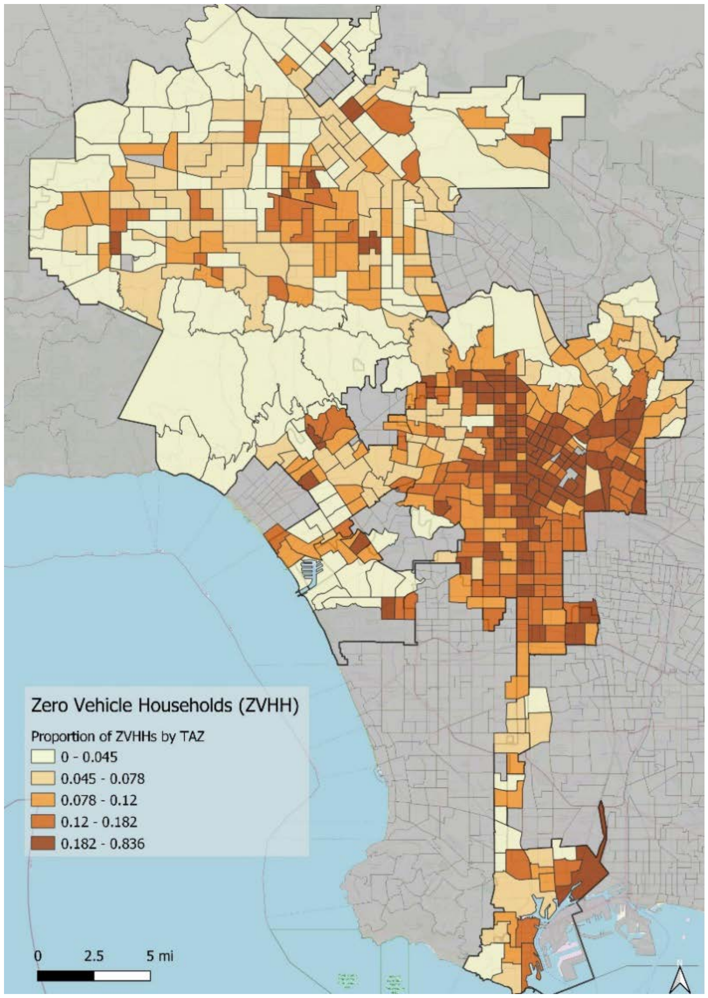

Figure A-7. Proportion of zero-vehicle ownership households by TAZ, Los Angeles (American Community Survey 2015–2019).

The top 40% of census tracts with zero-vehicle ownership households (> 12.0%) were flagged as priority tracts for multimodal equity analyses.

TAZ = transportation analysis zone.

Detailed Scenario Settings

In the Base scenario, for DAC residents who do not have access to privately owned cars, they only have access to walking, biking, transit, and taxi/transportation network companies. The rest of DAC residents who have their own vehicles have an additional travel option (i.e., driving). The level of service for these modes is either obtained from observed data or assumed with a reference from a similar existing service, as follows:

- **Driving:** The Google Maps API was used to query the needed travel time between DACs and their destinations. An average driving cost of $0.66/mile is used in the analysis, which covers the gas, insurance, and maintenance.
- **Transit:** The Google Maps API was used to query the availability of transit as well as the travel time, access time (i.e., the walking time needed to reach a transit station), and egress

time (i.e., the walking time needed to reach the final destination from a transit station). If the Google Maps API returned transit fare information, it was adopted; if not, $1.75 per trip ride was used to represent the transit fare.

- Taxi/transportation network companies have the same travel time as driving privately owned vehicles. The cost is calculated as distance × $1.00/mile + time × $0.50/minute.
- The cost of nonmotorized travel modes (i.e., walking and biking) is 0, and their travel time is queried from the Google Maps API.

In Equity scenario 1, where shared EV programs are provided to DACs, all residents in the Base scenario (including those with access to private cars and those without) have shared EV as an additional available travel option to choose from. The travel time of using shared EV programs is the same as driving personal vehicles, but shared EV programs require users to pick up and drop off the vehicles at stations; therefore, 5 minutes of access and egress time (total of 10 minutes) was added to the total travel time that a shared EV program requires. The rate used in this study adopts parameters similar to an existing EV-sharing program in the LA region (i.e., BlueLA) which uses $0.15 per minute plus tax as a community rate.[15] Features of other alternative travel modes (e.g., transit and taxis) are the same as the Base scenario.

In Equity scenario 2, where shared micromobility programs are provided to DACs, all residents in the Base scenario (including both those with access to private cars and those without) have shared micromobility as an additional available travel option to choose from. The travel time of using shared micromobility is calculated from the biking option. E-bikes/e-scooters are typically 1.3 times faster than using a traditional bike in urban areas, so the travel time needed to use shared micromobility is calculated proportionally. Additionally, depending on whether the shared micromobility service is docked or dockless, users need to either walk to a station or to the nearest vehicles. Therefore, an average of two minutes of time to access a micromobility vehicle was added to the total travel time of using shared micromobility. The rate of this newly added travel option in the study adopts a rate similar to existing EV-sharing program in the LA region (i.e., MetroBike) with $1.75 per 30 minutes and a minimum fare of $1.75.[16] Features of other alternative travel modes (e.g., transit and taxis) are the same as the Base scenario.

In Equity scenario 3, where transit services are improved, all residents in the Base scenario (including both those with access to private cars and those without) have access to better transit services in terms of: (1) adding transit services with a minimum speed of 20 mph if no existing transit service connects DACs and their destinations; (2) reducing the transit travel time to be 20% faster than the current transit service, which can be achieved by implementing dedicated bus lanes; and (3) reducing access time to be the lower value between the current level or 5 minutes, which can be achieved by on-demand bus services. The cost of transit remains the same as in the Base scenario. Features of other alternative travel modes (e.g., transit and taxis) are the same as the Base scenario.

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[15] blinkmobility.com/rental-rates

[16] https://bikeshare.metro.net/signup/#/

Mode Choice Model

The mode choice model was used to capture LA residents' mode choice preference, or which mode to choose when facing multiple available travel mode options. The mode choice model was estimated based on the trips made in the Southern California region from the National Household Travel Survey (NHTS): California Add-On (U.S. DOT Federal Highway Administration 2017) data set. The data set includes 51,263 trips made by individuals, with driving, walking, transit, bike, and taxi making up more than 99% of travel modes (Figure A-8).

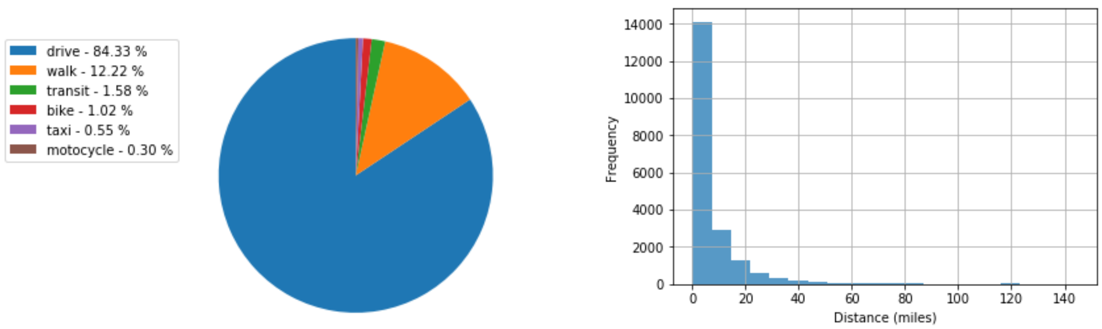


Figure A-8. Observed mode share in Southern California region (left) and travel distance histogram (right) (2017)

Source: 2017 National Household Travel Survey California Add-On, U.S. DOT Federal Highway Administration

A multinomial logit model was used to describe the mode choice preference. The utility of choosing each travel option is shown in Equations 1 through 6, and Equation 7 shows the probability of choosing a certain travel option.

$$V_{transit} = ASC_{transit} + \beta_{time} ivtt_{transit} + \beta_{cost} cost_{transit} + \beta_{egr} egr_{time} + \beta_{acc} acc_{time} \quad (1)$$

$$V_{drive} = ASC_{drive} + \beta_{time} ivtt_{drive} + \beta_{cost} cost_{drive} \quad (2)$$

$$V_{walk} = ASC_{walk} + \beta_{time} ivtt_{walk} \quad (3)$$

$$V_{bike} = ASC_{bike} + \beta_{time} ivtt_{bike} \quad (4)$$

$$V_{taxi} = ASC_{taxi} + \beta_{time} ivtt_{taxi} + \beta_{cost} cost_{taxi} \quad (5)$$

$$ASC_{drive} = 0 \quad (6)$$

$$P_i = \frac{\exp(V_i)}{\sum_{j=1}^{J} \exp(V_j)} \quad (7)$$

The data used to estimate the mode choice model were queried from the Google Maps API, in the same way as described in the scenario settings. A multinomial logit was estimated from the collected data with existing travel modes (i.e., driving, walking, transit, biking, and taxi). Motorcycle trips were removed from the data set as their mode share was too small. The R package Apollo was used to estimate the model, and the generated mode choice model is shown in Table A-3. The model has a good representation with an adjusted Rho-square of 0.73. The signs and magnitudes of estimated coefficients are also behaviorally reasonable.

Table A-3. Estimated Mode Choice Model

Variable	Estimates	Standard Error	T Value
ASC_taxi	-3.9	0.14	-27.64
ASC_transit	-1.2	0.11	-11.27
ASC_bike	-3.0	0.06	-54.01
ASC_walk	0.27	0.04	6.68
ASC_car	0	—	—
Travel time	-0.08	0.002	-43.46
Travel cost	-0.12	0.01	-11.22
Access time	-0.07	0.007	-9.83
Egress time	-0.05	0.007	-6.45

LL (start) = -25297.2

LL (final) = -6813.44

Adjusted Rho-Square = 0.7303

AIC = 13642.87

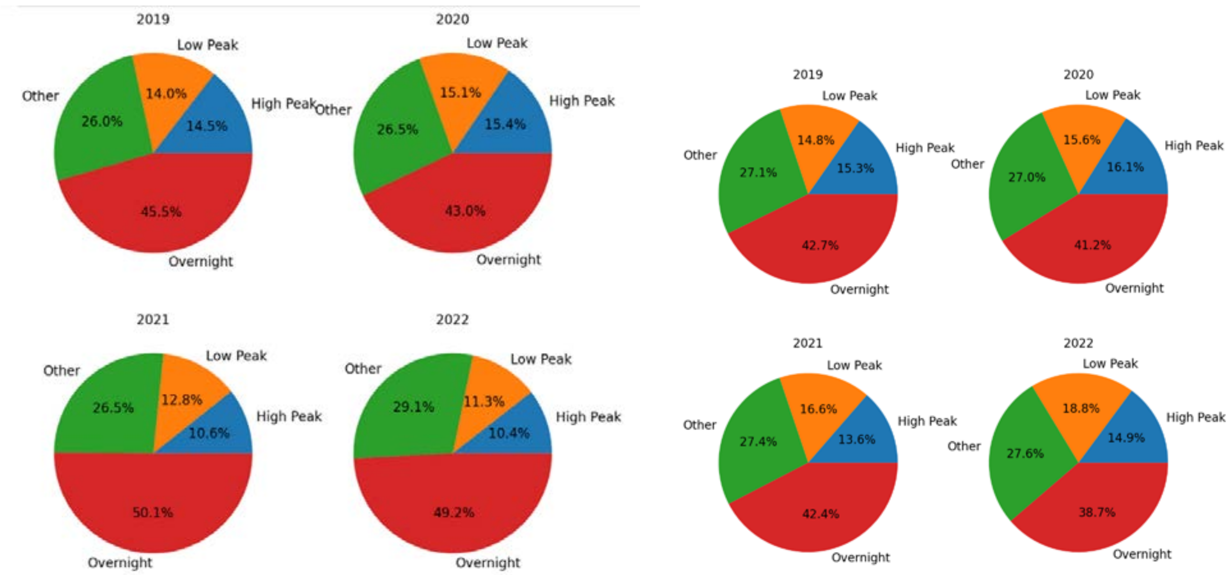
BIC = 13705.01

An incremental logit model for newly added travel modes (i.e., e-bikes and shared EVs) in the Equity scenarios uses the relative preference between existing modes and newly added modes from other studies, where such preferences are observed from real-world data. We used the relative mode choice preference among travel modes in the literature for the Equity scenario analysis.

Historic EV Charging Data

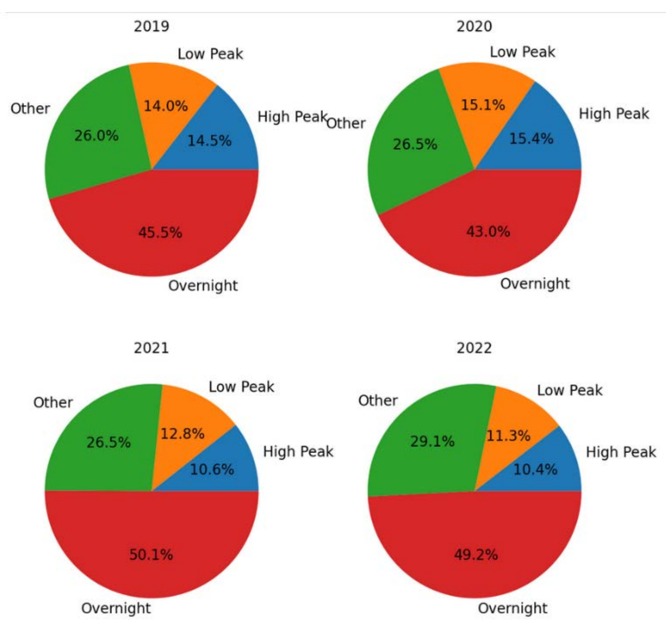
To better understand charging behavior and the extent to which it may impact peak electricity demand as vehicle electrification increases, NREL conducted analysis on LADWP-provided data on charging patterns at 35 charging stations. Stations analyzed included residential, commercial, and BlueLA EV car share. Findings include:

- Residential charging occurs more consistently overnight and at non-peak times when electricity rates are generally lower:
  - About 40% of sampled commercial charging consistently occurred overnight, versus >70% of residential.
  - Residential charging occurred during peak times an average of 26% of the time compared to commercial at 31% of the time.
  - Apartments had the lowest peak charging times of commercial chargers analyzed (22% versus 78%).
- BlueLA car share sites used approximately 50% overnight charging and 26% peak demand charging times.



Residential (n=22) Commercial (n=13)

Figure A-9. Charging times by peak period and year for LADWP customers who received an EV charging infrastructure rebate for installation of a time-of-use sub-meter, for residential customers (left) and commercial customers (right)



EV Car Share Sites (n=8)

Figure A-10. Charging times by peak period and year for time-of-use sub-meters for EV charging at commercial customer sites that host BlueLA EV car sharing vehicles

Multimodal

This section shows the detailed modeling results, including the impacts of the multimodal strategies on travel time, travel cost, and opportunities reached across neighborhoods.

Newly added travel options can reduce DACs' expenditure on daily travel in most cases. As shown in Figure A-11, transit service with a fixed fare, on average, reduces DAC residents' expenditure on travel the most. Newly added travel options do not always help DAC residents save costs. Depending on the location and travel demand patterns of a neighborhood, travel options can bring zero reductions, or even an increase in travel-related expenditures.

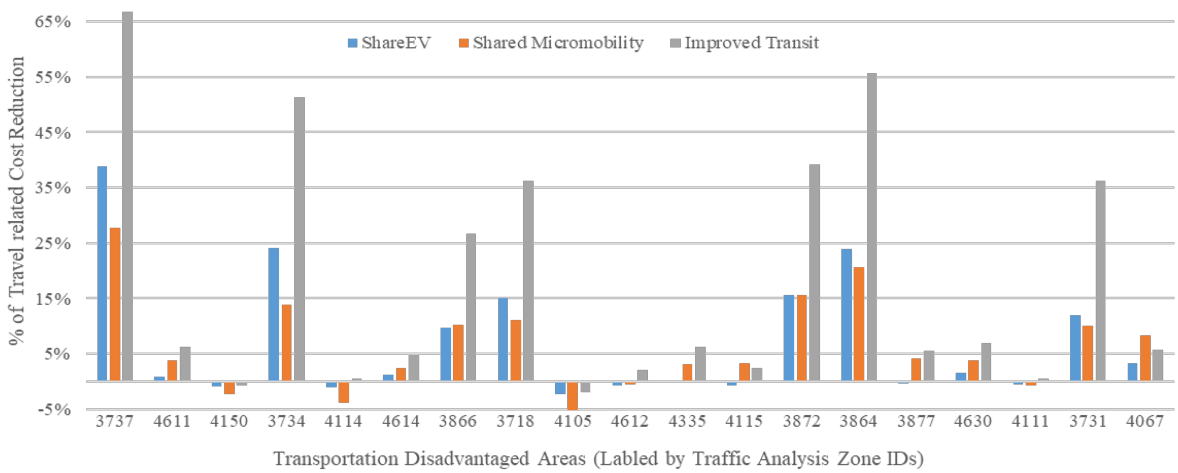


Figure A-11. Percentages of travel cost reduction from newly added travel options (where positive values are cost reductions and negative values are cost increases)

Providing new travel options to DACs can help reduce time spent on transportation. As shown in Figure A-12, on average, improved transit reduces travel time the most, with the highest time saving reaching 30%.

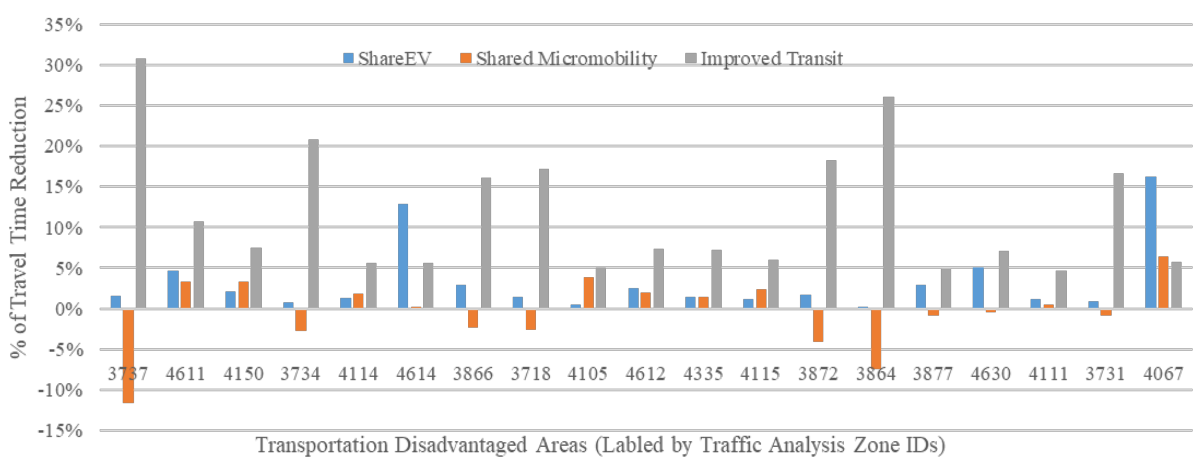


Figure A-12. Percentage of travel time reduction from newly added travel options relative to the baseline (where positive values are a reduction in travel time and negative values are an increase in travel time)

Newly provided travel options can help DAC residents reach more destinations. As shown in Figure A-13, improved transit on average has the highest increase in destinations that can be reached, ranging between 0.33% and 20%.

Figure A-13. Percentage of change in accessible opportunities relative to the baseline

Assumptions in Multimodal Modeling

- 2017 NHTS data-based mode choice model preference still applies to future year scenarios.
- The Google Maps API-queried traffic conditions represent the average conditions in the analyzed scenarios.
- In the Equity scenarios, the provided multimodal services (e.g., shared EV program and shared e-bikes) are sufficient to DAC residents (i.e., service is always available when a DAC resident needs to access the service). Modeling the exact number of vehicles needed and the specific locations of service (i.e., shared EV or e-bike station) is out of the scope of this analysis.
- From CSTDM data, each traffic analysis zone could have up to 7,000 destinations per day. We only take the destinations with more than 30 trips per day for analysis. This resulted in 60% of total demand included in final modeling.
- The analysis does not consider the variation of demand and traffic conditions within a day.
- The travel demand data, the number of trips traveling between origins and destinations by sociodemographic category or DAC metric, is not available. Therefore, we disaggregated the travel demand by the proportion that is transportation disadvantaged to identify the travel demand of the targeted DAC population. For example, if 80% of the population in a census tract do not own vehicles (i.e., are zero-vehicle households), then we estimated that 80% of the travel demand originating from the subject census tract is generated by those zero-vehicle households (which in our analysis are considered transportation disadvantaged).

- The added new services are not expected to change the traffic conditions (e.g., creating more congestion). Although this study did not estimate the exact number of vehicles needed for shared EV programs or buses needed to achieve the improved transit service, based on existing studies of the relationship between number of vehicles and speed in the traffic flow fundamental diagram, the typical number of vehicles deployed through similar new services is not expected to significantly affect traffic conditions. Additionally, the new services are only expected to be implemented in a limited area, and the usage of those services would be spread across different times of day.

Modeling Mode Shift Implications

The multimodal modeling work described above covered about 60% of trips in the 2020 CSTDM dataset that originate within the city of LA, down selecting for origin-destination pairs that account for 70% of trips and then data cleaning that whittled that down to 59.3% of all trips. Using just those results for approximately 60% of trips, the metrics presented in the Denver E-Bike sidebar were estimated, including:

- Up to 6.8% reduction in total VMT/year
- Up to 294,000 tons reduced in CO_2e/year.
- Up to 186 GWh/year reduction in electricity demand compared to EV trips

To better estimate the implications of mode shift to e-bikes for vehicle miles traveled (VMT), carbon dioxide equivalent emissions, and electricity demand, the mode shift potential of all trips less than or equal to 35 miles (99.1% of trips in the dataset) needed to be modeled. To do this, a simple linear regression was generated from the modeled trips (Figure A-14), using trip distance and the VMT reduced by e-bike trips per total miles traveled (TMT). This VMT reduction metric was generated by dividing the modeled shift of VMT to e-bikes by the TMT, including transit, driving, biking, and walking.

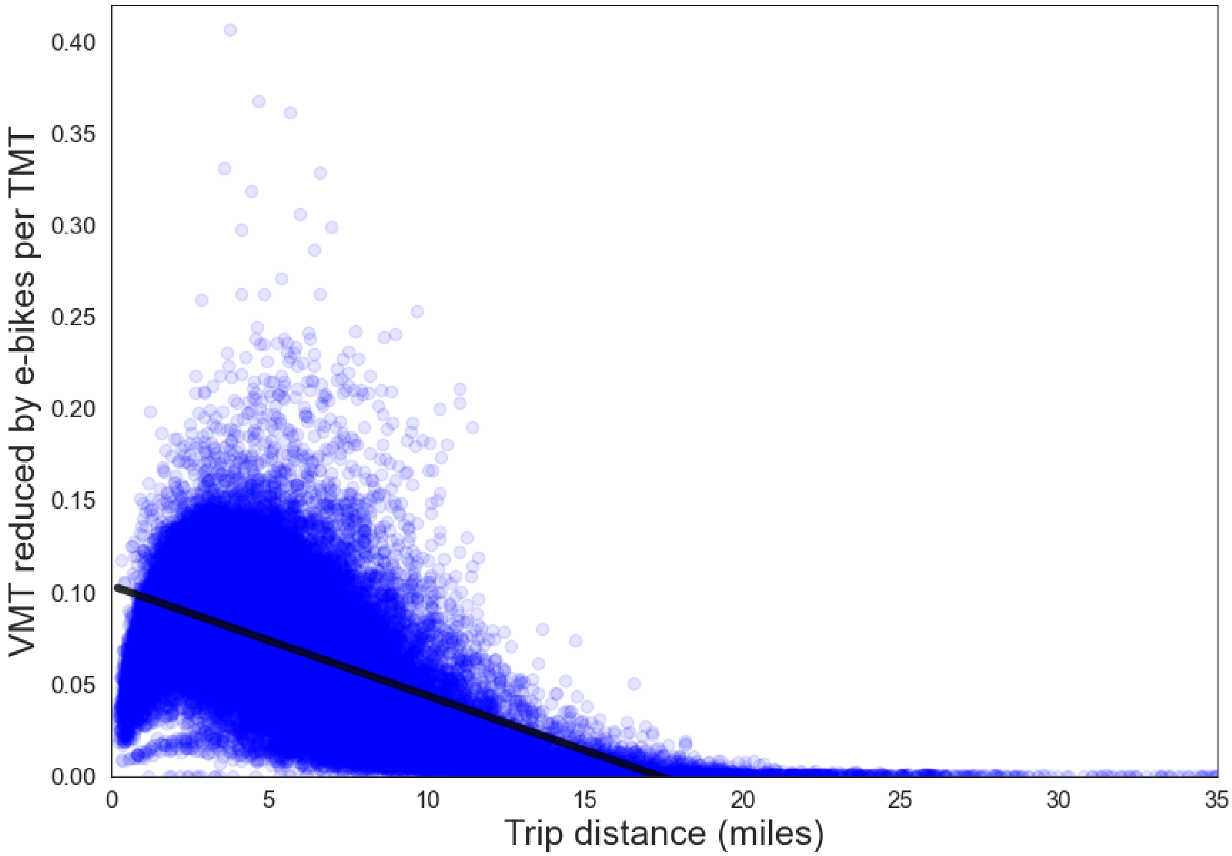


Figure A-14. Regression of trips whose mode shift potential was modeled, to estimate mode shift potential of unmodeled trips.

Filling in the mode shift potential of these disproportionately longer trips shifted the e-bike impact metrics to the ones shown in the callout box:

- Up to 4.7% reduction in total VMT/year
- Up to 316,000 tons reduced in CO_2e/year.
- Up to 187 GWh/year reduction in electricity demand compared to EV trips

A.2 Data Sources and Assumptions

NREL used multiple data sets relevant to EV rebates, residential EV charging infrastructure rebates, public charging stations usage, and commercial EV charging infrastructure rebates, as described in Table A-4.

Table A-4. Summary of Transportation Modeling Data Sources

Data	Source	Description	Resolution	Vintage
Existing EV ownership	Experian (proprietary and licensed to NREL)	Vehicle registration data, including EVs	Zip code	2021 (Q4)
Existing EV charging infrastructure	Alternative Fuels Data Center Station Locator	Location of public and private EV charging stations, both current and planned	Point location	Current
Historical energy price	Bureau of Labor Statistics	Electricity and gas prices	Metropolitan level	2016–2021
California Statewide Travel Demand Model	Caltrans	Travel demand data in California (historical and projection)	State level	2015, 2020, 2030, 2040
Building type data	NREL LA ResStock model	Building type information	City level	2017
Mode shift and VMT reduction targets	City of Los Angeles, Los Angeles County, Metro	Mode shift or VMT reduction targets or projections based on: LA Metro Traffic Reduction Study, Mobility Plan 2035, Transportation Demand Management Ordinance and Guidelines, Metro Strategic Plan (Vision 2028), California Environmental Quality Act Vehicle Miles Traveled (VMT) reduction requirements, Sustainable City pLAn, and the LA Green New Deal Targets and Annual Reports	Variable	Variable
National Household Travel Survey - California Add-On	NREL Transportation Secure Data Center	Historical travel demand data in California	Point location	2017
Vehicle consumer choice and stock	NREL Automotive Deployment Options Projection Tool (ADOPT)	ADOPT is a vehicle consumer choice and stock model.	ZIP code	Variable
EV charging infrastructure	NREL Electric Vehicle Infrastructure Projection Tool (EVI-Pro)	EVI-Pro estimates how much charging infrastructure is needed to meet given charging demand in a given area.	State level	Variable

Data	Source	Description	Resolution	Vintage
EV penetration	NREL Electric Vehicle Infrastructure for Equity Model (EVI-Equity)	EVI-Equity evaluates questions related to equitable EV charging and EV ownership.	2021	
LADWP EV and EV charging infrastructure data	LADWP	Load profiles for EV charging for customers who have received EV charging infrastructure rebate for time-of-use sub-meter (residential and commercial) Load profiles for EV charging infrastructure owned by LADWP or other city agencies Vehicle information provided in applications for EV charging infrastructure rebates (used vehicle only).	Variable	Variable; typically one year
Disadvantaged communities (DACs)	California Senate Bill 535	DACs are identified as tracts designated disadvantaged by California Senate Bill 535.	Census tract	2021
Zero-vehicle households	American Community Survey	Vehicles available by housing unit	Census tract	2015–2019
Transit quality	U.S. Environmental Protection Agency Smart Location Database	Field D5de: Proportional Accessibility of Regional Destinations (expressed as a ratio of total metropolitan statistical area accessibility)	Census tract	2020

Modeling and Analysis Limitations

EV/ EV charging infrastructure modeling and analysis do not account for dynamic relationships (potential feed-back loops) between EV adoption and EV charging infrastructure deployment or the overall cost of public EV charging infrastructure stations (e.g., real estate, equipment, maintenance). EV adoption can possibly induce EV charging infrastructure deployment, or vice versa. However, in this task, citywide EV adoption is inherited from (or set by) the previous round of modeling for the initial LA100 study (Cochran and Denholm 2021), and the focus is on the distribution of EVs across the city to achieve a certain level of equitable access to EVs. Based on the distribution of EVs as such, the distribution of EV charging infrastructure is determined for different levels of equitable access. Similar to the LA100 study, this task is mostly scenario-based analysis, but with a particular focus on equity. In addition, this task does not incorporate the overall cost of charging stations when determining the location or distribution of EV charging infrastructure. The cost or economics of charging stations may affect the decision around location, but this task is more interested in equity, rather than accurate or precise siting analysis of charging stations.

In addition to the assumptions listed in Section A.2, multimodal modeling analysis has one more data assumption. The CSTDM demand matrix, predicted by Caltrans for all scenarios, is adopted to represent the travel demand of DACs. The CSTDM travel demand data are generated through a transportation planning process that comprehensively considers population, demographic characteristics, land use, road network characteristics, transit service, and other important influencing factors. Therefore, data represent the demand pattern in the planned scenarios. The travel demand associated with DACs describes the number of trips originating from or arriving at DACs. However, it is likely that a subset includes trips that are not made by DAC residents, as the data set may contain the through traffic or the traffic that comes from other areas to DACs for activities but includes travel by individuals who do not reside in DACs. However, to improve the transportation services to DACs and life quality of DAC residents, the enhancement of the general access to/from DAC regions will improve DAC residents' overall access to opportunities.

A.3 Additional Output Metrics Added and Capabilities Enabled

EV/ EV Charging Infrastructure: Higher Resolution, More Dimensions

Compared to the LA100 study (Cochran and Denholm 2021), the more integrated and bottom-up approaches (using ADOPT, EVI-Pro, and EVI-Equity) for LA100 Equity Strategies enable us to characterize EV adoption as well as EV charging infrastructure deployment by location (census block group or tract), household income, race, ethnicity, and other metrics. In addition, we can now show the impact of various incentives (federal, state, and local) on equitable EV adoption and examine scenarios or strategies that could help achieve more equitable EV adoption. Similarly, one of the new output metrics is the degree of affordability for owning EVs, accounting for household income and expenditures, EV capital cost, and charging cost. For various equitable EV charging infrastructure distribution configurations, we can investigate who is benefiting from that EV charging infrastructure, which was not addressed in the original LA100 study.

Multimodal Transportation: Beyond Privately Owned Vehicles

Additional output metrics about travel modes other than privately owned vehicles are included, such as transportation energy-related expenditures of using non-driving modes, peoples' usage of non-driving modes, and the potential electricity demand of providing multimodal transportation services to DACs.

Multimodal transportation-related output metrics provide a broader picture of the transportation mobility status of DACs. Improving transportation services to currently disadvantaged communities requires collaborative efforts from multiple city agencies in addition to LADWP. The City and County of Los Angeles also have goals and pathways identified for achieving more equitable transportation services. Adding multimodal transportation-related output metrics could not only help LADWP better align its efforts with other city agencies but will provide a picture of the electricity impact of these efforts.

Enabling Equity Strategy Analysis

These synergistic modeling pathways address two primary concerns expressed by Steering Committee members: namely, the barrier of EV affordability and the relevance of multiple modes of transportation to the target DAC or overburdened and underserved populations. The focus on multimodal transportation is relevant for multiple reasons, including both the reality that EVs are financially inaccessible, even for many households that own personal vehicles, and that many households in Los Angeles cannot or choose not to own a personal vehicle.

The modeling framework described here provide equity strategies for EV and EV charging infrastructure access and expand the s transportation conversation to include all households, not just those that own vehicles. The metrics provided (as summarized in Table 3) will enable evaluation of policies and practices and prioritization of investments with respect to transportation equity impacts.

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