COUNTY OF LOS ANGELES

Transportation Electrification Blueprint

Contents

Executive Summary

By reducing harmful concentrations of local air pollutants associated with the operation of petroleum-fueled vehicles, electric vehicles (EVs) can help alleviate health burdens—particularly in communities that have historically faced the brunt of these emissions. Strong regulatory and business focus on the environmental, health, and economic benefits of EVs has allowed California and the Los Angeles region to emerge as a leader in attracting investment and economic growth in the EV sector.

The Los Angeles region plays a vital role in global goods movement and international commerce, home to some of the world's busiest ports and airports. More than a dozen major freeways, as well as extensive rail networks, crisscross LA County and provide mobility for millions of drivers and billions of dollars' worth of goods across Southern California. Although Los Angeles' transportation system is one of the region's greatest assets, it also brings significant challenges. The region suffers from the poorest air quality in the nation, with emissions from petroleum-fueled vehicles contributing significantly to local air pollution. Los Angeles' notorious traffic congestion exacerbates these conditions, and low-income communities near ports, commercial trucking depots, and major roadways face acute health risks from tailpipe emissions.

Electrification alone cannot resolve regional transportation challenges, but it remains a key strategy in efforts to encourage smart growth of the EV sector that leads to equity for all County residents in accessing EV infrastructure and benefiting from clean air improvements.

The regional grid analysis provided in this Blueprint provides a glimpse into the rapid growth in EV technologies; the analysis emphasizes that proper consideration of load management must be prioritized to cost-effectively integrate this aggressive expansion in the existing grid. Workplace charging expansion is rapidly needed for California's 2030 Zero-Emission Vehicle (ZEV) targets, as EVs are likely to have a daily total state-of-charge deficit of more than four GWh. Residents of multi-unit dwellings without access to home charging will have even higher deficits, causing local grid capacity issues at their workplaces.

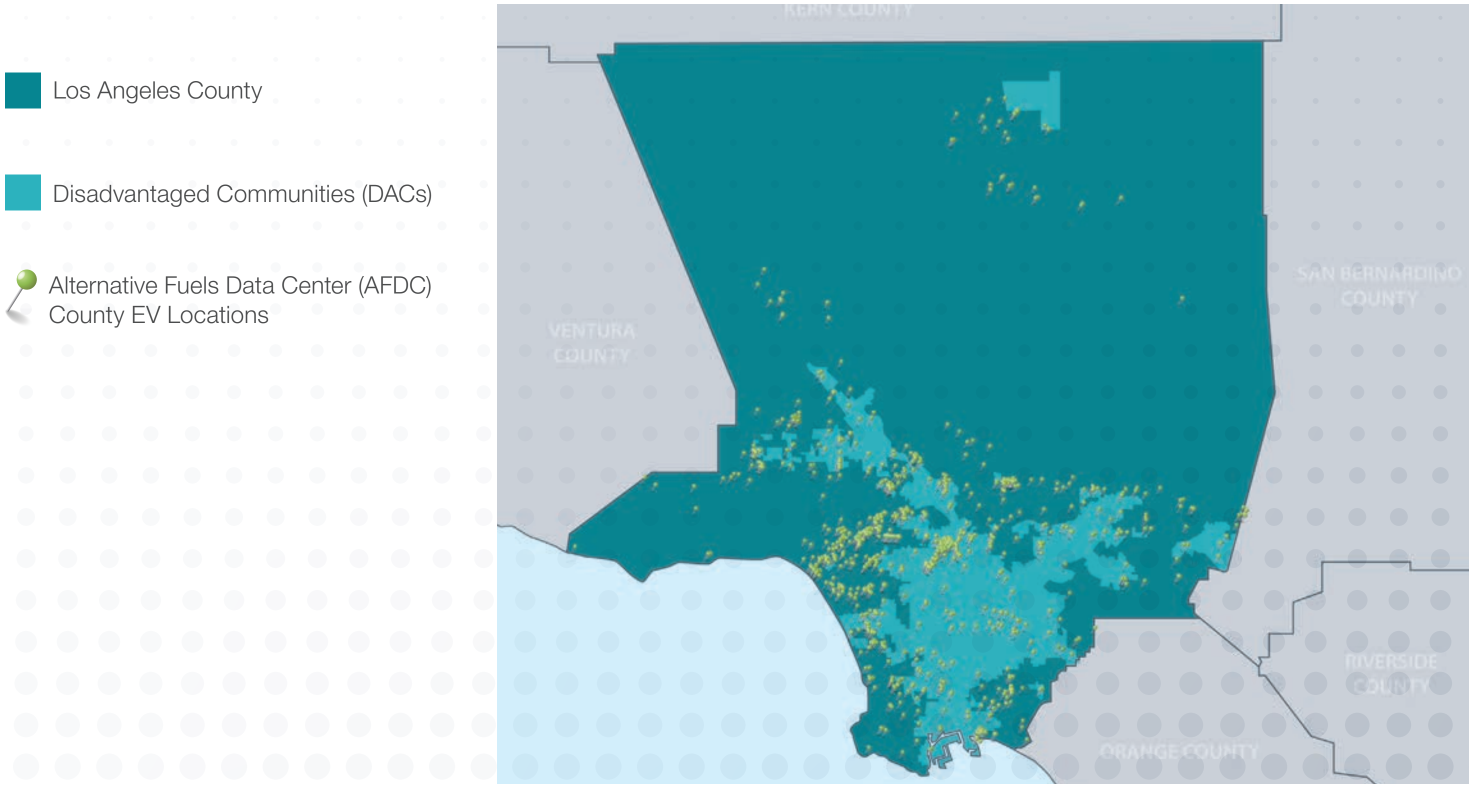
As an alternative to cars, ten local transit agencies together can reduce GHG emissions by 385–457 metric tons per day in 2025 and 694–739 metric tons per day in 2030 via bus fleet electrification, particularly through the deployment of smart charging for charging control and management. Drayage truck electrification could reduce Particulate Matter (PM2.5) and NO_x emissions by as much as 5.4 tons and 207.5 tons a year respectively by 2030 in certain adoption scenarios.

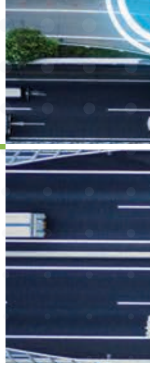
The County Blueprint concluded that EV charging may stress existing near- or over- capacity transformer banks, but bus and workplace EV load itself does not cause any significant substation degradation in the near term (2018–2025), based on initial demand estimates. This is primarily due to the timing of bus and workplace EV charging, which usually does not correlate with system peak load. However, increased EV charging can dramatically shape substation load profiles, including changing some areas from evening-peak to morning/midday-peak systems.

In summary, the analyses in this report conclude that EV technologies are maturing rapidly, and with proper consideration of load management, can be cost-effectively integrated onto the grid while also reducing harmful emissions. The overview of local planning requirements finds that, despite key policy and business model challenges for deploying EV charging infrastructure, the LA region is actively addressing many issues that hinder EV charging station growth. We present several existing market-based solutions to address barriers to EV adoption and offer three proposed Countywide solutions to scale regional electrification efforts: a regionwide, in-depth grid impact analysis, streamlined permitting requirements, and a municipal EV workplace charging program.

In addition, the County utilized a multi-pronged approach that leveraged multiple stakeholder public engagements through direct County efforts as well as efforts of our key partners. These stakeholder engagements served as a collaborative platform for obtaining feedback, recommendations, and increased local buy-in for transportation electrification.

This Blueprint serves as a foundation for local governments to strategically advance transportation electrification, providing an analysis of impacts to local electrical distribution systems, an overview of relevant policies and opportunities for charging infrastructure deployment, an EV Ready community plan, and an outline of Phase II requirements and potential near-term EV program opportunities.





SECTION 1: Introduction

The County of Los Angeles and its partners, University of California, Los Angeles (UCLA) Luskin Center for Innovation (UCLA Luskin), Kevala Analytics, Los Angeles Cleantech Incubator (LACI), and ICF—collectively known as the team—prepared the County of Los Angeles Electrification Transportation Electrification Blueprint (Blueprint) for the California Energy Commission (CEC).

1.1 Blueprint Context

The purpose of the Blueprint is to provide a regional outlook regarding the infrastructure planning considerations including potential associated grid impacts and recommendations on how to meet these potential challenges. A key component of the Blueprint is the "Grid Impact Model," which provides a single platform in which to conduct robust quantitative scenario analysis that reflects the complex interactions among various electric vehicle (EV) infrastructure inputs and existing grid capacity. In addition, the Blueprint details the necessary information and planning steps that would need to be considered and taken for implementation of a regional EV ready community.

The Blueprint supports multiple related efforts:

- The State's aggressive targets to meet five million zero-emission vehicles (ZEV) on the road by 2030, and the challenge that this large deployment would cause on the existing grid;
- California's legislative GHG goals and mandates;
- Current County and City of Los Angeles' aggressive sustainability plans that lead to bold actions to zero out Los Angeles' main sources of harmful emissions: buildings, transportation, and electricity; and,
- Local government agencies' current and future EV infrastructure planning.

Guiding Principles for the County of Los Angeles Transportation Electrification Blueprint

Reduce Regional Emissions

- Maximize greenhouse gas (GHG) emissions reductions that contribute to climate change
- Limit harmful air pollutant emissions—such as particulate matter and nitrogen oxides—to improve quality of life in our communities
- Leverage electric vehicles to further integrate renewable energy into the electricity system and reduce power sector emissions

Advance Equity

- Make the benefits of transportation electrification accessible to all communities
- Ensure that disadvantaged communities are represented in implementation of the Blueprint

Smart Growth for Electric Vehicles

- Use thoughtful analysis to develop a plan for growth in EV infrastructure
- Maximize public benefit by identifying critical infrastructure planning elements and associated grid impacts

1.2 Blueprint Scope

California's target of five million ZEV on the road by 2030 could increase the net annual electric load by 8–10 percent. However, the geographic and temporal distribution of the load increase could result in excess additional distribution and transmission system upgrades, avoidable rate increases driven by time-of-use patterns, and reversal of the environmental gains electric vehicles are intended to achieve. Where EV charging infrastructure is placed—and how and when EVs are charged—needs to be optimized in order to minimize net societal costs.

The Blueprint defines the challenges and opportunities for electrification, and then extrapolates the potential demand and grid impacts of three primary sectors to maximize the public benefits of transportation electrification and minimize the negative grid impacts. Two sample communities within the larger region of the County of Los Angeles were analyzed in the process of developing the Blueprint. In addition, the Blueprint includes identification of the analytic methodology and data needed for future planning activities.

The Blueprint period spans from 2020 to 2040 and focuses on current and potential drivers of EV infrastructure planning in the County of Los Angeles.

1.3 Blueprint Content

The Blueprint is sectioned to provide a holistic overview of the regional transportation electrification issues, detailed analysis of primary market sectors, preliminary considerations for regional EV infrastructure planning, the next steps for the region, and appendices to support this work. The sections provide the collected data and analysis to support the development of a comprehensive and replicable Blueprint that details the steps needed for a regional electrified transportation network and to transition the identified region to an EV ready community.

- **Section 2** provides an EV Ready community action plan broken down into transportation electrification challenges and opportunities with key steps and milestones for local government agencies.
- **Section 3** provides an in-depth needs assessment analysis that predicts demand for three primary market sectors (workplace charging, Transit Bus, and Drayage Truck electrification) and the grid impacts posed by these sectors based on the demand outputs.
- **Section 4** provides an overview of preliminary considerations for regional EV infrastructure planning, such as policies and ordinances as well as challenges and risks.
- **Section 5** provides an overview of what will be required in Phase II and next steps for regional EV infrastructure planning.
- **Appendices** provide additional supporting details on key topic areas.

> *"Five million zero-emission vehicles (ZEV) on the road by 2030."*

SECTION 2: Planning for EV Ready Communities

As a first step in the process of constructing a plan for increasing PEV readiness and charging infrastructure, a regional or local government must first identify the current level of available incentives as well as the local challenges and barriers they may face in the deployment of EV infrastructure. This section provides a high-level overview of available incentives and opportunities for implementing EV charging infrastructure. In addition, it outlines current local challenges as well as opportunities and regional efforts to support large-scale deployment of EV infrastructure.

2.1 State Incentives: Providing the Foundation

Drivers and fleets in California have many incentives to purchase plug-in electric vehicles (PEVs) and Electric Vehicle Service Equipment (EVSE), including rebates, grants, loans, and voucher programs. These incentives have helped break down the cost barriers that can impede the adoption of EV technologies. Table 2.1 lists some of the current California incentives and programs that support EVSE and PEVs.

California state agencies have also spearheaded a number of pilots targeting the Ports and disadvantaged communities (DACs) with the goal of reducing air pollution and bringing zero- and near-zero emission vehicles to these areas. The California Air Resources Board (CARB), through its contractor, the Center for Sustainability Energy (CSE), offers rebates for public fleets. Enhanced rebates of up to $7,000 to purchase or lease and deploy new PEVs are eligible for public fleets located in DACs. Fleets must report annual PEV usage data for at least 30 months after the vehicles are deployed so that CSE and CARB can track the vehicle usage and the percent of time the vehicles spent operating in DACs.

Senate Bill 350, enacted in 2015, provided the California Public Utilities Commission (CPUC) with the transformational authority to review, approve, and modify utility transportation electrification program proposals. Since the bill was enacted, the CPUC has approved approximately $1 billion in utility investments, which include charging infrastructure, customer education and outreach, rate designs, and other market acceleration pilots.

In addition, Assembly Bills 1082 and 1083, enacted in 2017, authorize investor-owned utilities (IOUs) in California to fund EVSE pilots at school facilities, educational institutions, state parks, and state beaches located in DACs. Guidance for IOUs on implementing these programs was released in January 2018.

These efforts help to ensure that the air quality benefits of PEVs reach all communities throughout California, regardless of socioeconomic status.

Table 2.1: California EV and EVSE Incentives

PROGRAM	
California Clean Vehicle Rebate Project (CVRP)	Rebates of ranging from $900 to $7,000 for public fleets, and up to $5,000 for others, are available for the purchase or lease of eligible all-electric, plug-in hybrid electric, and hydrogen fuel cell vehicles. Since the program's inception in 2010, more than 250,000 rebates have been issued—a majority for PEVs. Fleets—such as the County's—are eligible for a maximum of 30 rebates per calendar year.
California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)	HVIP offers point-of-purchase vouchers ranging from $2,000 to $300,000 for fleets to reduce the incremental cost of medium- and heavy-duty hybrid PEVs and ZEVs. Fleets in disadvantaged communities can receive additional funding.
California Alternative and Renewable Fuels and Vehicle Technology Program (ARFVTP)	Established in 2008, ARFVTP provides funding for various alternative fuel vehicle (AFV) projects, including, but not limited to, commercial AFV deployment pilots, AFV manufacturing, alternative fuel production, and alternative fuel outreach and education programs.
California Capital Access Program (CalCAP) Electric Vehicle Charging Station (EVCS) Financing Program	The goal of CalCAP is to alleviate range anxiety for PEV drivers by providing loans to small business owners and landlords to install EVSE for employee, tenant, and customer use. Rebates of 10%-15% of the enrolled loan account may also be available for program applicants.
California Property Assessed Clean Energy (PACE) Loss Reserve Program	California's PACE program assists residential property owners in funding energy improvement projects, including the installation of EVSE. Borrowed funds are repaid through a special assessment on the property.

2.2 Local Challenges and Opportunities for Transportation Electrification

While assessing regional efforts to deploy EVs and EV charging infrastructure, a series of policy, business model, and technological barriers came to light. These barriers are often heightened when considering low-income areas and DACs, which face additional barriers in accessing the benefits of transportation electrification. Fortunately, each challenge is addressed by a combination of state and local initiatives that lower barriers to EV adoption and lay the foundation for even more aggressive measures to accelerate electrification.

A one-size-fits-all approach to charging infrastructure planning and siting across the County of Los Angeles is not possible given the number of factors that must be considered. At a high level, a balance must be struck between publicly available charging options, residential options—including for the many residents of multi-unit dwellings in the County—and workplace charging. Further, there are decisions to be made as to what level of EV supply equipment is feasible at a given site and will best serve EV drivers in these locations. Layered into these considerations are other critical factors such as availability of power capacity at a given location, neighborhoods and zones in which demand is growing for EVSE, and how best to site EVSE in low-income areas and DACs.

Per assessment and stakeholder engagement processes led Blueprint partners, the leading regionals challenges and opportunities for transportation electrification are as follows:

1. Permitting and Interconnection Speed

Challenge

As explained in detail in Section 3.2, it is important for municipalities to develop efficient and low-cost permitting processes, and for utilities to streamline the interconnection process for EVSE. State legislation (AB 1236, Chiu, 2015) requires cities and counties to have adopted and implemented streamlined EVSE permitting processes. Jurisdictions with a population of 200,000 or more residents were required to have done so by September 30, 2016; cities and counties with a population of less than 200,000 residents were scheduled for the following year, September 30, 2017. Nevertheless, implementation of AB 1236 remains inconsistent across the County's 88 cities, as is the case throughout the State as a whole. There are examples of jurisdictions that are leading the way, including the City of Los Angeles and West Hollywood, the latter being notable for not only offering internal City resources that residents can utilize, but also providing a multitude of external resources and links for additional information on rebates, charging locations, etc.[1] Other cities, such as Azusa and Calabasas, have fulfilled the basic requirements of AB 1236, but much work remains in educating city planners and other officials who have not yet witnessed an increased demand for EV TE permitting in their cities as to the importance of getting ahead of this demand curve.

Connecting EV TE to the electricity grid is the domain of the utility for a given territory. The high degree of variability in the length of time that is required to complete the interconnection process

1 LACI, Electric Vehicle Charging Stations Streamlined Permitting, March 2019.

Figure 2.1: Electric vehicle charger in Los Angeles. *NREL Image 37527*

is often cited as a key barrier to the deployment of EVSE, both for charging stations intended for light-duty vehicles as well as infrastructure to be dedicated for medium- and heavy-duty PEVs. In spring 2019, LACI conducted a focus group discussion with companies in LA County that focus on the installation of EVSE to better understand common interconnection challenges and barriers, learning that the design phase between EVSE companies and a utility can often take upwards of a year, proving a significant challenge to planning and bringing an installment to reality. Similarly, in fall of 2018, LACI conducted a Request for Information together with CARB, the CEC and the Ports of Los Angeles and Long Beach on the state of zero emissions trucks, infrastructure and pilot projects for goods movement. One of the most often cited barriers from the RFI respondents to providing infrastructure to serve medium- and heavy-duty trucks is the unpredictable and lengthy timeline for the permitting and interconnection processes. In order to rapidly accelerate adoption of EVs throughout LA County it will be necessary to streamline these processes across the board.

Opportunity

Permitting and interconnection are important intermediate steps toward activating EVSE. The City of Los Angeles has developed effective EVSE permitting procedures that are also convenient for potential EVSE site hosts (Figure 2.1).

The Los Angeles Department of Building and Safety (LADBS) allows electricians installing EVSE to apply for a permit online after paying a low application fee. For standard EVSE installations that meet the LADBS requirements, the permit is approved and issued instantly online. More complex installations, such as upgrades required for DCFC, may take longer for LADBS review and approval. In addition, the Los Angeles Department of Public Works makes permit applications easily accessible online and reviews permits in a timely manner. Similarly, the City of West Hollywood includes permit applications for EVSE on its website. The City of Long Beach has an expedited permitting process as well. Applicants must complete the application and pay a small fee. The Long Beach Department of Development Services Building and Safety Bureau then determines whether the permit may be expedited based on the information in the application. Such permitting processes remove the barrier of difficult and lengthy permitting processes and help to support the increasing population of PEVs.

> *"A balance must be struck between public, residential and workplace charging."*

2. Lack of Simplicity and the Need for Consumer Education

Challenge

For many individuals, cities, fleet operators, as well potential host sites for EVSE such as property managers and businesses, deploying EVSE is a new experience, bringing with it numerous questions, including the differences between different types of charging equipment, the different business models of EVSE providers, costs, installation, maintenance, and applicable utility rates. Educating each of these potential customer segments will be key to accelerating the deployment of EVSE.

In the case of fleets, for instance, many early adopters have learned that electricity demand management is a highly challenging issue and that small human errors—such as turning on too many chargers simultaneously, scheduling charging incorrectly, or having faulty equipment—can have very expensive consequences. A report prepared for the Massachusetts Department of Energy Resources found that whether an electric school bus fleet used managed charging could make a significant economic difference. In the case of the pilot study, the e-fuel costs for the unmanaged fleet was $4.95 dollar-per-gallon-equivalent, whereas the managed charging solution dropped the price to $1.89 dollar-per-gallon-equivalent, compared to the diesel price of $3.25.[2]

One of LACI's portfolio companies, AMPLY Power, is innovating transportation electrification through a new business model that simplifies charging logistics for fleets and provides certainty on electric fueling costs by handling all aspects of EV charging operations and infrastructure, and only bills fleets for the number of electric miles driven. "As more companies and cities invest in electrification programs, we find taking the technical guesswork out of going electric is a critical step towards the mainstream adoption of electric fleet vehicles beyond the occasional pilot program," said Vic Shao, co-founder and CEO of AMPLY Power. "In response to the challenges fleet operators face in switching to electric, we handle everything to do with the infrastructure, from the finance and installation of charging hardware, to working with the utility to upgrade electrical service to depot buildings and ensuring the vehicles are charged at night and ready to work in the morning."

Similarly, innovative business models and education for each of these potential customer segments will be key to accelerating the deployment of EVSE. As the process is simplified, the need for intensive consumer education should reduce.

Opportunity

Many stakeholders, including State actors like the California Energy Commission and local players such as Southern California Edison, have developed accessible education and outreach materials for consumers and site hosts interested in EVs. This educational collateral is particularly effective when tied to the implementation of specific incentive programs such as CALeVIP or Charge Ready.

Reliable access to electricity as a transportation fuel is essential for ensuring EV drivers have a place to plug in, building confidence in EVs among prospective vehicle purchasers, and driving the transportation emissions reductions needed to achieve city and state goals. Because charging stations bridge the gap between the grid and EVs, their widespread deployment is crucial for setting LA on a path to a near zero-emissions transportation future by 2050. The following information on EV charging basics is readily available from several online sources and can be used to demystify the EV charging experience.

EV battery and charging station characteristics create a fueling dynamic that differs from internal combustion engine (ICE) vehicles. However, the diversity of charging options and charging locations allows for EVs to reasonably fit into drivers a balance must be struck between publicly available charging options, residential options—including

2 https://www.veic.org/documents/default-source/resources/reports/veic-ma-doer-electric-school-bus-pilot-project.pdf?sfvrsn=2

for the many residents of multi-unit dwellings in the County—and workplace charging.' day-to-day routine; in some cases, charging an EV may be even more convenient than fueling an ICE vehicle.

Three broad classes of charging stations are commercially available today for light-duty EV use: Level 1 (L1), Level 2 (L2), and Direct Current Fast Charging (DCFC) stations.

L1 stations are typically deployed at locations where vehicles are parked for long periods of time, such as homes, workplaces, and airports. A simple L1 cord-set can cost as low as $300 and is suitable for home use, but pedestal units that are more appropriate for parking lots can cost up to $1,500 per unit.[3] L1 stations are typically non-networked, meaning that they cannot send data to a network operator. L1 charging stations use a standard 120V outlet and provide about 1.1 kilowatts (kW) of power, refueling an EV at a rate of 2-5 miles per hour of charging.

L2 stations use a 208V/240V outlet and typically provide 3.3-6.6 kW of power, providing 10-20 miles of range per hour of charging. L2 stations are also deployed at locations where vehicles dwell for longer periods of time, including homes, workplaces, and other locations where vehicles may be parked overnight. These units may cost as low as $400 for basic, non-networked stations that may be appropriate for home use. However, for workplace and public networked L2 stations that require a pedestal, units can cost up to $6,000.[4]

Charging Stations

[3] https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf

[4] *Id.*

DCFC stations require 480V service; current stations provide power at 25 kW up to 350 kW, although most installed DCFC stations provide 50 kW of power.[5] These 50 kW plugs can add more than three miles of range per minute, while 350 kW connectors can add 20 miles per minute. DCFC stations are usually installed in public locations where cars may only be parked a short while or where electric shared mobility (e.g. car-sharing, ride-hailing, etc.) fleets can easily access them.[6] DCFC station costs are notably greater than L1 or L2 stations: 50 kW charging units cost roughly $50,000, and 150-350 kW units can be significantly more expensive.[7]

DCFC stations come with several special considerations: plug-in hybrid electric vehicles (PHEVs) rely on relatively small batteries and cannot refuel at DCFC stations. However, battery electric vehicles (BEVs) run solely on a battery and can accept charging at DCFC stations. In addition, while L1 and L2 charging equipment has adopted the uniform SAE J1772 standard that applies to virtually all EVs sold in the U.S., DCFC charging stations follow several different plug standards – meaning that EVs will only be able to charge at stations with compatible plugs. The majority of BEVs adopt the Combined Charging System (CCS) Combo standard, some adopt the CHAdeMO standard, and Tesla has its own proprietary standard. Many DCFC stations include both CCS Combo and CHAdeMO plugs. However, Tesla has its own Supercharger network that is accessible only to Tesla drivers.[8]

Installation costs for all three types of infrastructure vary widely and are dependent on charging station power levels and site-specific conditions. Installation cost drivers include, but are not limited to permitting, electricity metering, electrical supply conduit, trenching and boring to lay conduit, and upgrading electrical panels.

L1 installation costs are relatively modest, with wall-mounted units ranging from $300-$1,000 and pedestal-mounted units priced at $1,000-$3,000.[9] L2 installation costs vary widely: average costs hover around $3,000 per station but have been as high as $12,000.[10] DCFC installation costs also exhibit variability, with 50 kW stations averaging roughly $25,000 per installation but often surpassing $40,000 per installation in areas that require significant electrical upgrades.[11] Higher capacity DCFC station installations will likely drive costs upward.

5 Only BEVs can charge at DCFC stations.

6 These stations are also critical for enabling long distance EV travel on highway corridors.

7 It is important to note that these cost estimates listed for L1, L2, and DCFC stations do not include installation, operation, and maintenance costs, which can vary by site type and charging technology. http://www.caletc.com/wp-content/uploads/2019/01/Literature-Review_Final_December_2018.pdf

8 Tesla sells an adaptor that allows some of its vehicles to use DCFC stations with CHAdeMO plugs.

9 https://afdc.energy.gov/files/u/publication/WPCC_L1ChargingAtTheWorkplace_0716.pdf

10 https://afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf

11 *Id.*

Charging stations also incur operations and maintenance (O&M) costs that vary by charger type and location. Hardware replacements are common. In addition to per-kilowatt-hour electricity consumption costs, many utilities apply a demand charge based on instantaneous peak demand. Demand charges can incur costs of up to $2,000 per unit, per month and may pose a significant challenge to the economics of operating DCFC equipment while station utilization remains low. Simply put—it may be challenging for DCFC operators to earn a return in the short-term while EV penetration remains relatively low and operators face difficulties recovering station operation costs from EV charging revenues alone. Site hosts can attempt to avoid or minimize these costs by managing charging to occur during off-peak hours. On top of hardware component replacements and electricity costs (which may be passed on to EV drivers in some cases), networked stations also carry networking fees that can range from $100-$900 annually.[12] Routine maintenance is typically more crucial for DCFC stations, which have more components than L1 or L2 stations and are relied upon in key refueling situations (e.g. highway corridor charging).

Three broad categories of market segments are commonly used to describe where charging stations are deployed for light-duty vehicles: home, workplace, and public charging. Home charging was identified as a "virtual necessity" for the widespread adoption of EVs by the National Research Council of the National Academy of Sciences.[13] Currently, EV drivers do more than 80 percent of their charging at home and can take advantage of stable, relatively inexpensive refueling costs.[14] Drivers may be able to realize even greater fuel cost savings relative to gasoline by switching to time-of-use rates that encourage EV low-cost charging during off-peak times (e.g. overnight) when the grid has spare capacity.[15] Single-family residential EV charging station deployments

ADA Requirements

The Americans With Disabilities Act (ADA), which became law in July of 1990, includes accessible parking regulations that continue to evolve today. CALGreen building codes include requirements for handicap accessible EV charging for certain new multifamily and nonresidential buildings. These requirements were adopted into the 2016 CALGreen code and went into effect January 1, 2017. Accessibility requirements do not apply to fleet parking spaces or reserved parking spaces, but do apply to public or visitor parking spaces, employee parking spaces, and/or mixed-use spaces accessible to either visitors or employees.

The new CALGreen new construction standards require that the first space for public or employee parking be fully ADA-compliant. The first ADA compliant space must be 12 feet wide with a 5-foot pathway. It must be level and there must be a path of travel to an entrance adjacent to facilities.

Accommodation of ADA parking, particularly ADA parking for EVSE and Direct Current Fast Charge (DCFC), was not part of the design parameters for most existing County properties. Retrofitting workplace and visitor parking areas to install ADA-compliant EVSE has proven very challenging and, at times, prohibitively expensive.

Each facility is also required to provide a minimum number of parking spaces for occupancy. At times, when one or more spaces is modified to comply with ADA requirements, the site no longer provides the minimum number of parking spaces for occupancy. It has been possible to reconfigure the parking spaces at some larger sites to accommodate a limited number of required ADA spaces. At other sites, especially smaller sites, this has not been possible. If a site cannot provide the minimum number of parking spaces, one can appeal to the local Planning authority.

12 *Id.*

13 https://www.nap.edu/catalog/21725/overcoming-barriers-to-deployment-of-plug-in-electric-vehicles

14 https://www.energy.gov/eere/electricvehicles/charging-home

15 LA Department of Water and Power offers a time of use rate for residential customers: https://www.nap.edu/catalog/21725/overcoming-barriers-to-deployment-of-plug-in-electric-vehicles

typically do not require extensive upgrades or infrastructure enhancements, so they are generally the least expensive. Multi-unit dwelling (MUD) deployments are significantly more challenging for several reasons, including lack of governance structure between property managers and tenants for operating and maintaining charging stations, higher equipment and installation costs, parking specifications, and tenure of residents. To open the EV market to a broader, more diverse array of drivers, sustained efforts must be made to support the needs of MUD residents who drive EVs.

After the home, workplaces are where vehicles are parked for the longest period of the day. Workplaces provide critical refueling opportunities for EV drivers, particularly for PHEVs with smaller electric ranges. Workplace charging also provides opportunities for EVs to soak up excess solar generation on the electricity system and contribute to the grid flexibility and reliability needed to meet LA's clean energy goals. Charging stations deployed at workplace locations provide more consumer exposure to EVs and related infrastructure—growing consumer awareness of the technology. Many employers offer EV charging as an amenity or as part of a sustainability initiative. Deployment costs are more expensive than single-family units and depend on a number of site-specific factors, including permitting costs, metering costs, distance to electric service, panel upgrades, labor costs, and other conditions.

Finally, public charging encompasses all locations beyond homes and workplaces. Although public charging may not constitute a high percentage of drivers' charging profiles, a robust, accessible network of charging is needed to provide a safety net for drivers and to increase "range confidence" in EV technology. Public locations may include retail centers, grocery stores, restaurants, gas stations, rest stops, hospitals, municipal parking areas, airports, hotels, libraries, parks, and other locations with parking infrastructure. Creating a network of DCFC stations along highways and other thoroughfares outside of major urban cores will be essential for enabling practical, long-distance EV travel and encouraging more households to make EVs their primary vehicle. Urban DCFC stations may also be critical for drivers that do not have dedicated access to home EV charging—such as MUD residents—as well as for drivers of EVs used for shared mobility services (e.g. Uber, Lyft, etc.). Costs for deployment of public charging will depend on the same site-specific factors listed for workplace charging.

Many medium- and heavy-duty (MHD) EVs can use the same charging technologies as light-duty vehicles, such as the J1772 plug standard for L2 charging stations and CCS Combo standard for DCFC stations. Some vehicles, including buses, can take advantage of overhead charging applications that quickly recharge their batteries and are becoming more standardized (via the J3105 standard for overhead systems) as well as overhead catenary charging. Although there is great diversity of MHD vehicle types, the larger size of MHD EV batteries and duty cycles of these vehicles may require greater reliance on DCFC stations than light-duty vehicles. In addition, many MHD EVs have the benefit of charging at centralized depots where fleet operators can deploy large banks of charging stations. However, additional on-route fast charging infrastructure or catenary systems may be needed to support vehicle operation for some transit bus and long-haul trucking applications.

City of Pasadena official EV car promoting the Residential Electric Vehicle and Charger Incentive Program.
Photo editorial credit: Angel DiBilio / Shutterstock.com

3. Funding

Challenge

The cost of installing EVSE remains a barrier in many cases, including medium- and heavy-duty applications. While rebates for EVSE are available in some cases and are an important incentive, these rebates are often only applicable to the charging equipment and installation itself. Typically, that funding cannot be applied to necessary and potentially costly electrical capacity and meter upgrades that may be required prior to the EVSE installation.

Opportunity

Beyond the critical state incentives available for EVSE, various cities in Los Angeles County and the South Coast Air Quality Management District (SCAQMD) have provided financial incentives to consumers for purchasing PEVs and/or installing EVSE. For example, the City of Pasadena provides $250 to $500 to residents who purchase an EV and up to $600 for a Wi-Fi-enabled EVSE. The City of Long Beach will give a free Level 2 PEV charger to residents who own or lease a PEV. In addition, the SCAQMD and the Mobile Source Air Pollution Reduction Review Committee (MSRC) offer rebates toward the purchase of Level 2 EVSE for residents in SCAQMD's jurisdiction. The Antelope Valley Air Quality Management District provides an incentive for residents in its jurisdiction to purchase or lease a new EV or plug-in hybrid electric vehicle (PHEV). The focus of these municipalities on reducing air pollution from the transportation sector has been a major driver for these incentives.

Electric utilities serving the County, including the Los Angeles Department of Water & Power (LADWP) and Southern California Edison (SCE), have embraced the emergence of PEVs, offering special electricity rates for PEV charging as well as rebates for the purchase of PEVs and EVSE. The following Los Angeles County utilities offer PEV-specific incentives:

- LADWP: Charge Up L.A.!
- SCE: Residential and Business PEV Incentives
- Burbank Water & Power: PEV Incentives
- Pasadena Water & Power: PEV Incentives
- Glendale Water & Power: PEV Incentives
- Azusa Light & Water: PEV Incentives

SCE received approval from the California Public Utilities Commission (CPUC) for its Charge Ready Programs for both light-duty and commercial trucks and buses. As PEV sales increase, California utilities are fully engaged. Municipalities should work with their utilities to strategically plan EVSE installations.

4. Real Estate Availability and MUD Access

Challenge

The amount of EVSE infrastructure required will, at times, require tradeoffs concerning land use. With current EVSE solutions, for example, installing EVSE in a very small parking lot at a city park may require some encroachment on what had otherwise been designated as green space. A similar issue plays out at ports, where physical space is at a premium.

All players in the EV ecosystem are eager for business model solutions (as well as technology and policy solutions) that help address the challenge of charging in multifamily dwellings, especially apartment buildings. Many real estate managers, especially in DACs, are motivated to encourage their tenants to move toward EVs, but struggle with multi-tenant EV challenges (e.g., parking allocation, non-dedicated charging, sharing trenching costs, etc.). Installing EVSE in multifamily dwellings in DACs is especially difficult due to legacy infrastructure. Due to the age of both the building and area, these properties often require both internal switch gear upgrades and/or utility grid upgrades that are often cost prohibitive. This discourages both the property owner and independent installers from providing these services.

Opportunity

Although deployment of new infrastructure in areas as dense as Los Angeles County may prove to be challenging, updated building codes are improving site hosts' ability to plan for and deploy charging stations on their property. New building codes require that parking areas be pre-wired for EVSE or have EVSE installed. Codes can also prevent any restrictions to EVSE installation. California's existing Green Building Standards Code (CALGreen), requires that new projects valued at $200,000 or more dedicate a portion of parking spaces at residential and non-residential properties to be pre-wired for future EVSE installation. The number of spaces that must be pre-wired depends on the total number of parking spaces at the property (Table 1.2).

Table 2.2: CALGreen EVSE Pre-Wired Parking Requirements

TOTAL NUMBER OF PARKING SPACES	NUMBER OF REQUIRED EV CHARGING SPACES
0–9	0
10–25	1
26–50	2
51–75	4
76–100	5
101–150	7
151–200	10
201 and over	6 percent of total[16]

The CALGreen Code will facilitate building owner or tenant installation of EVSE in the future and support PEV drivers at the property.

Some municipalities in California have adopted more stringent requirements than CALGreen. The City of Los Angeles' amendments to CALGreen require that new single- and double- unit family dwellings with attached garages each have the capacity for EVSE installation. In addition, at least 5 percent of the parking spaces in multi-unit dwellings (MUDs), with a minimum of one, must be equipped for EVSE installation. New non-residential parking facilities are required to install pre-wiring for EVSE in at least 5 percent of their parking spaces, with a minimum of at least one parking space.

Although MUDs remain a challenging market segment for EVSE deployments, efforts to address the charging needs of MUDs are generating critical lessons for future initiatives. For example, Southern California Edison's (SCE) Charge Ready pilot has been deploying L2 stations since 2016

[16] Calculation for spaces shall be rounded up to the nearest whole number.

for MUD, workplace, and public locations. Of the 1,063 ports deployed in the program by the end of 2018, approximately 4 percent were located at MUDs.[17] From this experience, SCE has proposed a new program – Charge Ready 2 – currently under review at the California Public Utilities Commission. If approved, Charge Ready 2 would facilitate the deployment of 48,000 new ports across SCE's service area and leverage new approaches to address MUDs – including a targeted rebate program to support the deployment of 16,000 ports in new MUDs and the option for SCE to own and operate EVSE.[18]

> *"All players in the EV ecosystem are eager for business model solutions."*

Culver City based **Envoy Technologies** provides mobility as an amenity. They partner with apartment complexes, high rises, student housing, offices, hotels, and others to station several electric vehicles accessible exclusively to the residents, occupants and guests of those buildings. They have numerous locations in LA County, including in Culver City, Los Angeles and Santa Monica. From the WeWork facility in Culver City to the 888 Hilgard boutique-style hotel in Westwood to downtown Santa Monica apartments, Envoy is providing a community-based shared mobility platform.

In conjunction with the CEC, Envoy is also deploying electric vehicles at affordable housing developments throughout the San Francisco Bay area and in DACs in the Sacramento Metro Area. Envoy has also been selected by Electrify America to be the exclusive vendor partner for roundtrip car sharing.

PCS Energy, a Culver City-based company that provides a suite of services to multi-family housing including solar energy and EVSE systems, is targeting DACs with both demand control software and load sharing, which allows for some Level 2 chargers to be installed, but unfortunately not at the same rate as for those buildings built primarily after 1990. As an example, the property at 410 Hobart Blvd. in the City of Los Angeles, required demand control software in order to install the requested 9 EV chargers. Without the demand control software, they would have been limited to 2 EV chargers. This has been the case in over 70 percent of the buildings that PCS has encountered. As the demand for EV charging increases, load sharing will become more and more of a challenge without local grid upgrades from the utilities.

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[17] https://www.sce.com/sites/default/files/inline-files/SCE%20Quarterly%20Charge%20Ready%20Pilot%20Program%20Report%202018Q4_0.pdf

[18] https://www.edison.com/content/dam/eix/documents/innovation/electric-transportation/charge-ready-2-ev-charging-infrastructure-proposal.pdf

5. LDV Charger Visibility and Awareness

Challenge

Residents of Los Angeles County, no matter how they travel, frequently pass by highly visible gas stations. The same, however, isn't necessarily true of EVSE, even those that are part of public networks. Whether hidden on Level 2 of a parking garage or on the other side of a parking lot, would-be LDV/commuter EV drivers are often unaware of how much EVSE infrastructure already exists. Digital tools, such as Google Maps, are beginning to more prominently display EVSE locations and availability, but both physical and digital infrastructure for EVSE is lacking in visibility for existing infrastructure.

According to Greenlots, a company headquartered in Los Angeles that delivers new mobility infrastructure solutions, "Visibility of EV charging infrastructure is a critical educational and psychological tool for growing EV adoption. The more charging drivers see, the more comfortable they are with the idea of going electric. Based on local and regional goals for the deployment of transportation electrification, visibility and awareness of charging infrastructure is critically important to growing adoption of electric vehicles – both by individual drivers and fleets. Public-private partnerships may be a key pathway to increasing the deployment of highly visible charging."

Opportunity

Both the County and City of Los Angeles are leading the way to make transportation electrification a more visible part of the region's transportation fabric through the development of the County's Sustainability Plan and LA's Green New Deal. As more EVs are adopted per the goals in each plan and more EVSE deployed, consumer awareness and understanding of these technologies will improve—creating a feedback loop that encourages greater EV adoption.

> *"Visibility of EV charging infrastructure is a critical educational and psychological tool for growing EV adoption."*

6. Universal Payment and Interoperability

Challenge

Many site hosts and EV drivers lament the often-clunky payment mechanisms required at public EVSE. Some EVSE allow for non-subscribers use via one-time credit card payment, but a high number of EVSE networks have required an existing subscription to date. Efforts are underway to allow for mutual recognition across EVSE networks, but the EVSE experience may still be less-than-intuitive and opaque.

According to Greenlots, “Drivers expect EV charging to be as simple as the gas fueling experience. Peer to peer agreements between charging network providers are starting to enable easier driver roaming between networks, and upcoming ‘Plug and Charge’ capabilities promise a very simple driver experience. However, the industry has a ways to go in making EV charging accessible to credit card and point of sale payment methods”

Greenlots further explains, “While much attention is rightly focused on interoperability to support front end driver roaming, interoperability between EV charging hardware and software systems is a critical consideration for investment in and management of EV charging, especially at scale. Open protocols such as OCPP (Open Charge Point Protocol) are key to ensuring flexibility and scalability of systems. Further, open and interoperable communications between charging systems and the grid, as well as vehicles, are an important foundation for managing charging load and integrating it with the distribution system.”

Opportunity

Although payment options at publicly available EVSE may not provide the same experience as other fueling options, efforts are underway to standardize and simplify payment. Currently, CARB is considering the adoption of new regulation pursuant to the Electric Vehicle Charging Stations Open Access Act (Senate Bill 454). The Proposed

Electric car charging station in Hermosa Beach, CA.
Photo editorial credit: Thomas Trompeter / Shutterstock.com

Regulation Order would require that all publicly available EVSE be equipped with credit card readers in addition to mobile payment hardware and a toll free number to initiate charging sessions.[19] The regulation would apply to new DCFC EVSE installed July, 2020 or later, and new L2 EVSE installed July, 2023 or later. All existing public EVSE would need to comply within 5 years of the date of installation of the EVSE or by July 2020 (DCFC) or 2023 (L2)—whichever is later. The regulation would also require EVSE to display any related parking fees, nonmember fees for EVSE use, price to charge in terms of U.S. dollars per kWh, any potential price changes due to variable pricing schedules, and any other fees charged. If the regulation is adopted, it would ensure that EVSE provide more accessible payment options and clearer terms of service for EV drivers using public chargers in Los Angeles County.

[19] https://ww2.arb.ca.gov/sites/default/files/2019-03/evse-399-031119.pdf

"A fossil fuel-free LA County."

County of Los Angeles Sustainability Plan

The County of Los Angeles (the County) is currently developing its own regional sustainability plan, *OurCounty*, to outline what local government can do to improve environmental outcomes and better serve County residents. The plan is anchored by three pillars—equity, environment, and economy—which guide the development of 12 overarching goals, 37 long-range strategies to achieve those goals, and 148 discrete actions to support those strategies. The County's 12 goals are comprehensive and cover a broad spectrum of sustainability issues, including buildings, infrastructure, natural environments, local governance, food, energy, and transportation. The final draft of *OurCounty* is expected to be released this summer and will help inform the development of the County's Climate Action and Adaptation Plan.

Robust and sustained stakeholder outreach was tightly integrated into plan development from the outset. The County's Chief Sustainability Office formally initiated the planning process in November 2017 with more than 100 community leaders in attendance. Since then, the County has held more than 150 meetings to collect feedback on key inputs to the plan from a diverse set of stakeholders, including: environmental groups, labor, community-based organizations (CBOs), local businesses, business associations, and other groups. In addition, each county Supervisorial District partnered with a dedicated CBO to facilitate workshops and ensure equity remained a central focus in the planning process.

OurCounty has one goal that directly implicates transportation electrification (TE): "a fossil fuel-free LA County."[20] This goal aims to achieve the County's commitment to the goals of the Paris Climate Agreement to reduce greenhouse gas (GHG) emissions while addressing local air pollution that often disproportionately impacts low-income and disadvantaged communities. One of the two strategies identified to achieve this goal is to "create a zero-emission transportation system."[21] Relevant targets are detailed in Table 2.3.

[20] https://ourcountyla.org/wp-content/uploads/2019/04/ourcounty_discussion_draft_.pdf

[21] *Id.*

Table 2.3: Zero-Emissions Targets

	2025	2035	2045
Countywide	• 60,000 new public EV charging stations (2018 baseline) • 30% of all new light-duty private vehicles are zero-emission vehicles	• 130,000 new public EV charging stations • 80% of all new light-duty private vehicles are zero-emission vehicles	• 100% of all new light-duty private vehicles are zero-emission vehicles
County Operations	• 5,000 EV charging stations at County facilities • 100% of new non-emergency light duty vehicle (LDV) purchases to be zero-emission vehicles	• 15,000 EV charging stations at County facilities • 100% medium-duty vehicle and emergency light-duty vehicle purchases to be zero-emission	• 100% of all vehicles in the County fleet to be zero-emission

The County also identifies five short- and medium-term actions to help meet the electrification targets established:

- Streamline permitting and construction of zero-emission vehicle infrastructure;
- Install EV chargers at County facilities and properties for public, employee and fleet use;
- Revise and regularly update the County's fleet policy to require zero-emission vehicles whenever possible;
- Convert Los Angeles Sheriff's Department (LASD) fleet to zero-emission by partnering with vehicle manufacturers to develop a zero-emission pursuit vehicle and transport bus; and,
- Partner with Los Angeles Fire Department (LAFD) and equipment manufacturers to pilot a zero-emission fire engine.[22]

Another County goal that indirectly implicates transportation electrification reads as follows: "a convenient, safe, clean, and affordable transportation system that enhances mobility and quality of life while reducing car dependency."[23] While this goal is focused primarily on reducing vehicle miles traveled and enhancing personal mobility options beyond single-occupancy vehicles, it includes several opportunities to advance electrification: increased use of battery electric transit buses and light-duty car-sharing service (e.g. BlueLA). Both transit and car-sharing will be critical tools for reducing single-occupancy vehicle use, and electrification will continue to make these options a cleaner, more sustainable choice for Angelenos' mobility needs.

[22] *Id.*

[23] *Id.*

City of Los Angeles Green New Deal

The Los Angeles Green New Deal (LAGND) represents a bold new vision to further integrate sustainability into city operations while growing the local economy in a manner that benefits all Los Angeles (LA) residents. The LAGND updates the Sustainable City pLAn from 2015, the City's first sustainability report focused on advancing environmental, economic, and equity goals.

The County of Los Angeles Chief Sustainability Office directly coordinated with the City Chief Sustainability Office to align key actions and targets between the two efforts. City of LA's new plan seeks to reduce or eliminate emissions from key sources, including transportation, buildings, electricity, and waste. New and updated targets from the report include:

- A commitment to 80% renewable energy supply by 2036
- New and majorly renovated equipment located in municipally owned buildings must be all-electric (as opposed to being powered by gas or other fossil fuel sources), with a commitment to emissions-free buildings by 2050
- The establishment of a Jobs Cabinet to convene local leaders to create 300,000 green jobs by 2035 and 400,000 by 2050.

Altogether, the LAGND is expected to reduce GHG emissions 50 percent below 1990 levels by 2025 and lead to carbon neutrality by 2050, avoiding an additional 200 million tons of GHG emissions by 2050 relative to the 2015 Sustainable City pLAn.

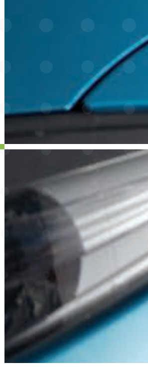
The LAGND identifies transportation electrification as a critical strategy for achieving the City's decarbonization targets and establishes ambitious goals for zero emission vehicle (ZEV) deployment in the region. The City has set notable targets to:

- Increase the share of ZEVs in the city 25 percent by 2025, 80 percent by 2035, and 100 percent by 2050
- Electrify 100 percent of LA Metro and Los Angeles Department of Transportation (LADOT) transit buses by 2030
- Reduce Port-related GHG emissions by 80 percent by 2050, which will involve electrification of port equipment and heavy-duty vehicles

These commitments depend on the deployment of a strategic, reliable, and accessible charging infrastructure network to support EV adoption. To that end, the City plans to encourage the installation of 10,000 publicly available EV chargers by 2022, scaling to 28,000 chargers by 2028.

The goals set forth in the plan are currently bolstered by several complementary City partner initiatives, including the Liberty Hill Foundation's emPOWER campaign. By working with a variety of community partners, the campaign connects residents in DACs to considerable financial resources to purchase new or used EVs—ensuring that all Angelenos have access to the clean air benefits that transportation electrification provides.

"Drivers expect EV charging to be as simple as the gas fueling experience."



SECTION 3:

Regional Needs Assessment and Grid Impact Analysis

The social benefits of plug-in electric vehicle (PEV) use are well known. As such, transportation electrification (TE) is seen as a key strategy for both greenhouse gas (GHG) and conventional air pollutant abatement. Deployment of charging infrastructure to fuel PEVs is a requisite for their widespread adoption. However, for investments in charging infrastructure to be effective, they should be made in locations where demand for vehicle charging is high. Furthermore, as electrification progresses, concentrated demand for electricity will have implications for local distribution grids.

Vehicle electrification has the potential to both provide benefits to and cause challenges for the electricity grid. On the upside, commuter PEVs plugged into workplace chargers during the day can be a reliable source of demand to absorb solar energy production, alleviating concerns of overproduction and curtailment as California relies on an ever-growing share of solar power. However, large numbers of PEVs charging on a single distribution circuit can cause strain on local grid infrastructure. Furthermore, because they both require more power and require faster charging, heavy-duty vehicle charging will yield heavy local loads, causing more strain on local grid assets.

Maximizing public benefits of transportation electrification, as well as managing grid impacts (both positive and negative) requires careful infrastructure planning that considers: 1) vehicle inventories, 2) travel patterns, duty cycles, and charging requirements 3) parcel-level land use, and, 4) distribution grid capacity and constraints.

The Blueprint Needs Assessment and Grid Impact Analysis provides a proof of concept for both developing spatially resolved forecasts of charging demand and assessing the opportunities and constraints presented by current distribution grid infrastructure given predicted demand. This analysis focused on Los Angeles County and incudes three future analysis years: 2025, 2030, and 2040. The Needs Assessment focused on three transportation sectors: light duty vehicles (LDVs), transit buses, and drayage trucking.

The Analysis predicts demand for charging at workplaces as well as for heavy-duty sectors facing immediate policy pressure to electrify transit buses and drayage trucks across the county. The Needs Assessment for each of the analyzed sub-sectors provides 1) estimated charging demand both spatially and temporally with estimates of the energy requirements to meet those demands, and 2) quantified public benefits in terms of reduced emissions or increased Electric Vehicle Mile Traveled (eVMT) associated with meeting those charging demands. All energy demand outputs are then used to evaluate grid capacity and impacts of local charging in two pilot areas within the Southern California Edison (SCE) service territory.

3.1 Workplace Charging Analysis

PEV adoption is rising and will continue to do so in the coming years. Worldwide sales increased by 42 percent from 2015 to 2016. The U.S. alone has seen an increase of 32 percent with California having the highest PEV penetration at 2 percent (Fitzgerald, 2017). Despite this development, infrastructure investments to support the growing electric vehicle fleet have lagged behind. With projected sticker prices for EVs in the U.S. projected to fall below those of internal combustion engines (ICEs) by 2025 (Fitzgerald, 2017), the availability and cost of charging is likely to play an increasing role in consumers' decision-making process and the successful adoption of PEVs.

Increasing the number of PEVs is a policy priority in California. In addition to purchase incentive programs and manufacturer mandates, California has set statewide goals for zero-emission vehicle (ZEV) adoption of 1.5 and 5 million in 2025 and 2030 respectively. While ZEVs can be built around other technology-fuel platforms, (primarily hydrogen fuel cell vehicles) the strong growth of PEV adoption compared to hydrogen fuel cell vehicles suggests that most of the ZEVs deployed in California will be plug-in hybrid electric vehicles (PHEVs) and battery-electric vehicles (BEVs).

The fueling patterns for PEVs differ substantially from those of traditional ICEs. Whereas ICEs can be fueled within minutes, charging a PEV may take several hours. For this reason, most charging (70 to 90 percent) currently occurs overnight at residential dwellings (ECOtality, 2012; California Energy Commission, 2011; Electric Vehicle Collaborative Center, 2013). However, workplace charging is the second most important charging option for most drivers (CALSTART, 2013). Charging at work requires few modifications to driving behavior and offers employees a convenient and potentially cheaper option to charge vehicles (Fitzgerald, 2017).

Workplace charging offers a number of important benefits that can improve PEV driver experience. Being able to obtain a charge at work can ameliorate range anxiety for drivers of BEVs whose vehicle ranges are limited to battery capacity. Also, commuters driving PHEVs, whose vehicles have limited all-electric range, can obtain range extending charges that enable them to use less gasoline on their return commutes.

As the PEV market grows and longer-range BEVs become the norm, workplace charging may increase in importance because it will be able to provide a consistent charging option for residents of multifamily housing who do not have access to home charging. Recent research suggests that as the amount of energy used by PEVs grows, it may become beneficial to have a large number of them plugged in during the day, allowing them to charge on cleaner daytime solar power, provide benefits to the electricity grid, and aid renewable integration (Fitzgerald 2017; Coignard 2019).

Workplace Charging and the Grid

With more PEV drivers on the road, it is also important to bear in mind the impact that this development will have on the grid. PEVs could increase annual consumer electricity demand by up to 40 percent (O'Connor 2017). Because employment is typically more spatially concentrated than residential areas and charging would happen during the day when demands for power are higher, growth in workplace charging could pose a relatively higher risk to increase peak demand on local distribution grids. Therefore, high growth in charging demand at workplaces could lead to the need for utility investment to build out new or shore up existing capacity on feeder lines and substations, actions that take considerable time and resources to complete.

However, as mentioned above, workplace charging also may offer benefits to the grid through vehicle-grid integration, where grid operators are able to modify vehicle charging rates as they are plugged in. When aggregated, PEVs can represent a substantial amount of dispatchable load. For example, if charging rates can be modified to shift load to mid-day, PEVs can absorb the oversupply of solar power that can cause renewable curtailments. Connected PEVs could also be used for more traditional demand response purposes. This not only allows utility companies to maximize the efficient use of solar energy but also decreases the cost of charging (Fitzgerald, 2017). However, it should be noted that these strategies will only be available if there is sufficient local grid capacity to support daytime charging at workplaces.

Objective

The objective of this analysis is to support Los Angeles County's efforts to plan for PEV adoption by using a spatially resolved model to predict PEV commute energy consumption and potential workplace charging load. This information can help guide planning efforts by offering a data-driven projection of which areas in the County will experience higher levels of charging demand, and thus deserve attention from the County's planning efforts. It also provides an early estimate of where high-energy demands from workplace charging may occur, which can then be used to evaluate whether existing grid capacity is sufficient to support that charging demand.

Consistent with a focus on near to medium-term PEV readiness planning, UCLA has modeled a baseline year in 2018 and two future years, 2025 and 2030. UCLA based PEV adoption in these two future years on California's ZEV adoption targets for those years, assuming for the purposes of planning that these targets will be met.

UCLA provided the results of its charging power demand analysis to research partner Kevala, who used the results as an input to evaluate potential workplace charging impacts on the grid.

Commuting Energy Demand

The first output of UCLA's model is a spatial dataset of one-way PEV commuter energy use, by commute destination for those currently commuting via single-occupancy vehicle. It is an estimate of the aggregated battery state-of-charge deficit of all commuting vehicles, caused by the loss of energy that they have incurred during their commutes. While the total state-of-charge deficit will also be influenced by the commuter's state-of-charge at the beginning of their journey, there is no way to reliably predict a vehicle's starting states-of-charge based on the locations from which they are commuting.

UCLA believes the energy use metric to be a good baseline estimate of the no-cost demand for workplace charging. In other words, it is the minimum amount of energy PEV commuters would choose to recover if doing so was entirely free.

Of course, there are costs to charging, either direct monetary costs where drivers have to pay for the energy they consume, or time and search costs that commuters must expend to seek out a charger and plug in. Whether drivers will elect to pay these costs will be dependent on how valuable recovering that energy is to them, which is in turn dependent on the costs of alternative charging, the residual state-of-charge of their vehicle and their individual tolerance for lower-states of charge. However, because it is impossible to accurately model differences in those driver-level charging behavioral characteristics at high-spatial resolution, the modeled metric provides a reasonable, if not perfect metric with which to gauge demand potential, particularly when comparing locations to each other for the purposes of PEV infrastructure planning.

UCLA conducted this analysis for the entirety of Los Angeles County, and can predict potential workplace charging demand at the level of a travel analysis zone (TAZ), a geographic unit used in travel demand modeling. In the short term, this charging demand potential metric can be compared to the existing charging capacity to identify the areas with the largest differences between potential demand and existing supply. Estimates for demand potential in the longer term in 2025 and 2030 are helpful to set a road map for private and public deployment of workplace charging in the County.[1]

Spatialized Workplace Charging Load

The second output from UCLA's modeling exercise is an estimate of the charging load that would occur if all PEV commuters replenished the energy used during their commutes when they arrive at work. This charging load represents what would occur if every vehicle had access to a charger and plugged in. While workplace charging penetration is not likely to support universal charging in most areas, this high-energy demand scenario provides a metric with which to apply a stress test for local distribution grid capacity against potential workplace charging loads.

Local distribution circuits only have so much capacity to deliver power; therefore, workplace charging might encounter constraints from the local grid, not because of high total energy demand directly, but due to peak power demand. More specifically, if peak power demand for workplace charging will occur simultaneously with high demand on the circuit from other electricity users, the expansion of workplace charging could require expensive distribution grid upgrades.

Estimating potential peak energy demand is only the first step in this process. To understand how charging demand might impact the grid, charging demand must be compared to spare circuit capacity on a temporally resolved basis. While UCLA has modeled potential workplace charging power demand across the County, the comparison of demand with capacity is outside of the scope of UCLA's model. For this reason, UCLA has collaborated with research partner, Kevala to provide this analysis for two pilot regions, Culver City and the adjacent cities of Pico Rivera and Montebello. In a following chapter in this report, Kevala details the analysis that they have conducted using the outputs from UCLA's analysis.

UCLA's model follows the four steps outlined in summary below. A detailed description of the methods UCLA used to estimate these numbers may be found in Appendix A.

1. Calculating Commute Destination Probabilities

Southern California Association of Government's (SCAG's) Transportation Demand Management (TDM) Plan analyzes travel patterns as trip counts from all origin TAZs to all destination TAZs. These trip counts can be thought of as probability distributions for trips leaving each origin. A destination that is the endpoint for more trips is a comparatively more probable destination than one that has fewer incoming trips. UCLA uses the destination trip distributions of origins to calculate the probability that any one commute starting in that place will terminate in each of the possible destinations.

1 It should be noted that the commute energy use metrics provided by UCLA are only measures of potential demand and do not convey any information about the socially optimal level of workplace charging supply. Therefore, this metric should not be used to define targets or goals for levels of infrastructure provision.

2. Simulating PEV Commutes

UCLA uses the origin-destination probabilities calculated in step one to simulate the commutes of PEVs traveling from each origin. The simulation is based on the concept of expected value, which is a predicted value calculated as the sum of possible values each multiplied by the probability of that outcome. For example, if one origin only supplied commuters to two destinations with an equal (50 percent) probability, and there are two PEVs in that origin, then the expected value of PEVs at each destination is one ([1 × 0.5] + [1 × 0.5] = 1). The result of the PEV commute simulation is a collection of expected value PEV trips from each origin to each possible destination.

3. Calculating Energy Use

To calculate energy use of commuting PEVs, UCLA multiplied the energy economy (in kWh/mile) of each commuting PEV by the distance of the shortest on-road route between the origin and destination. For example, a vehicle that that consumes 0.3 kWh of energy per mile will consume three kWh of energy over the course of a 10-mile commute. Energy use estimates are then multiplied by the expected value for that PEV in each destination to arrive at the expected value of energy consumption for that PEV, conditional on it driving to that destination.

4. Aggregating Results

Steps one through three result in a large collection of expected energy consumption values, one for each possible PEV-origin-destination grouping. On their own, these individual values of fractional potential trips are not meaningful outputs. However, the aggregate expected values of individual trip energy use from all origins, summed to a single destination is the expected value of energy use at that destination.

The output of the model is a set of expected energy use values for each of the 2,243 TAZs in Los Angeles County. Like most forecasting techniques, the commuting energy-use model smooths out random variation in commuting patterns. Furthermore, the model does not capture the possibility of differences between PEV owners and traditional vehicles in likely commute destinations.

Results

The charging demand estimation model provides two outputs at the TAZ level: 1) aggregate energy consumption, and 2) hourly charging power demand, otherwise known as a load shape. Insofar as commuting energy use is a predictor of demand for charging, the aggregate energy consumption output is a useful charging infrastructure planning metric because it identifies both the locations where the most PEVs could be charged and where those commuting PEVs have comparatively lower states-of-charge when they arrive at work. The load shape metric is useful from a grid infrastructure planning perspective because it represents a high-grid-stress scenario, where workplace charging is highly utilized.

Commuter Energy Demand

As the number of PEV commuters grows, the aggregate amount of energy used for PEV commutes grows accordingly. Countywide weekday energy consumption for one-way commutes grows more than eight-fold from 508 MWh in 2018 to 4,229 MWh in 2030.

Figure 3.1: Workday Commuter Energy Use Growth in LA County

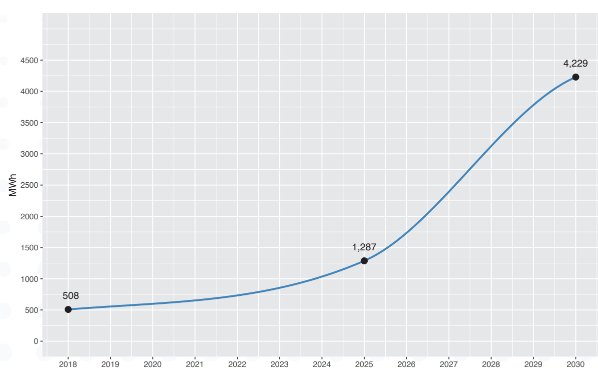


Table 3.1 lists the summary statistics of the commute energy use model. The distribution of commuter energy use by TAZ is heavily right skewed. That is, the distribution is characterized by a relative few high-energy-consumption zones and a large number of middle, and low-energy-consumption zones.

Table 3.1: Summary of Commuting Energy Use Model Outputs

	BY TAZ DAILY ENERGY USE (KWH)		
	2018	2025	2030
Mean	227	574	1,886
Median	135	346	1,137
Minimum	1	1	5
Maximum	5,111	12,660	41,373
n = 2243 TAZs			

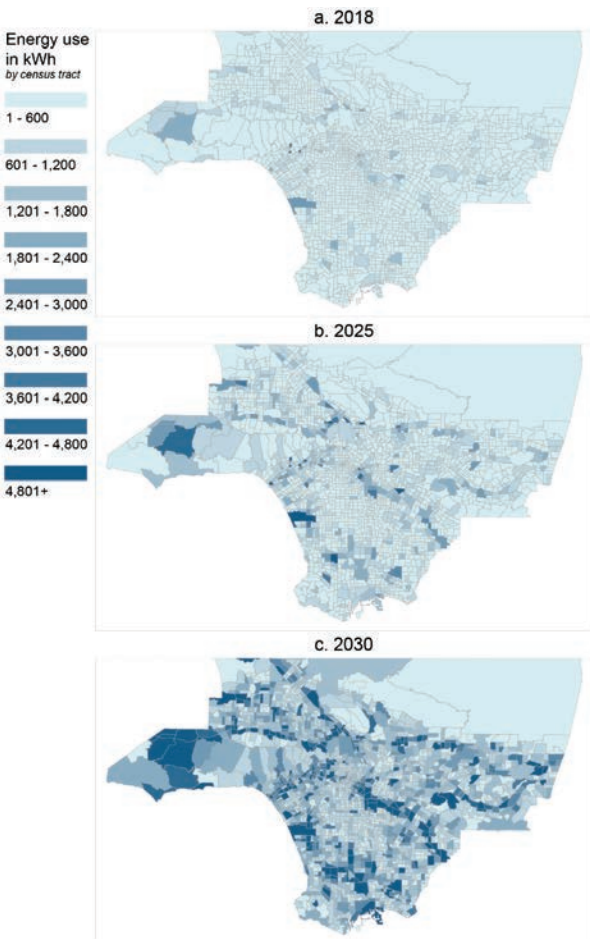
This result is unsurprising given the land-use patterns typical of within the County, which are characterized by a number of core employment-rich commercial areas surrounded by relatively spread out residential areas. There are a relative few higher-employment zones and a large number of low-employment residential zones. Moreover, geographic PEV adoption patterns are also concentrated, particularity in more affluent residential areas. Thus, the modeled energy-use outputs are primarily a function of the interaction between employment and relative proximity to PEV-dense areas, with one end of the distribution being residential areas with sparse PEVs and the other end being high-employment areas among concentrations of PEVs.

In addition to providing guidance on where demand for workplace charging might be highest, the energy consumption results also provide a starting point for understanding the potential for vehicle-grid integration (V1G) applications at workplaces. V1G relies on a pool of vehicles with uncharged battery capacity where rates of charging can be modulated to provide demand response when loads are high, energy storage during periods of renewable overproduction, and even ancillary grid services like frequency response. While it would potentially be advantageous in V1G applications for commuter PEVs to be incentivized to shift from overnight home charging to daytime charging, estimates of the energy expended during commutes can provide a baseline estimate of the minimum state of charge deficits at different workplaces.

"Vehicle electrification has the potential to both provide benefits to and cause challenges for the electricity grid."

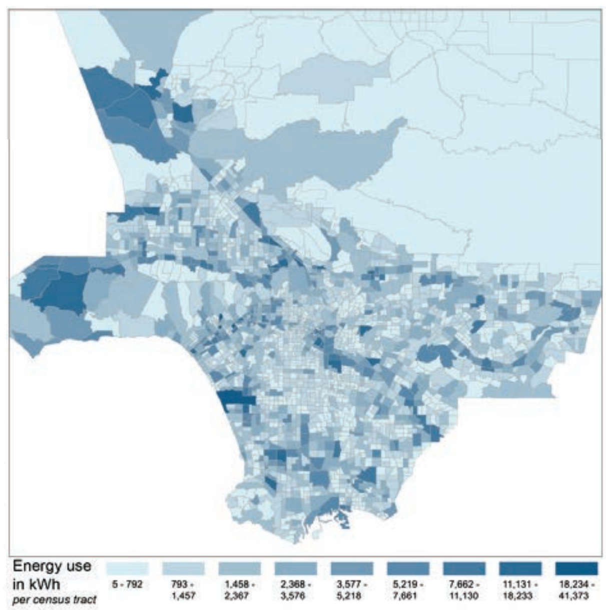
Figure 3.2 shows the mapped results of total charging demand per TAZ over the three scenarios in the heavily populated southern part of LA County. The charging demand bins are scaled to the base year scenario to show the increase in scope of high-energy-use TAZs over time. While only a few of the zones in the 2018 map are dark blue, indicating demand of over 4,800 kWh (or 4.8 MWh), by 2030 large portions of the map have moved into that category.

Figure 3.2: Commuting Energy Use in LA County



However, this progression of maps obscures variation in energy consumption on the high-end. A large portion of the growth is captured by increased intensity of charging demand in areas that had already demonstrated high relative charging demands in the base year. Figure 3.3 provides a more detailed look at commute energy consumption in 2030, where results have been grouped into like clusters using a Jenks natural breaks algorithm. This map shows more variation inside clusters of high energy use areas that are obscured by the low upper limit on the map in Figure 3.2.

Figure 3.3: 2030 Energy Use in California



A portion of the phenomenon of intensification seen in Figure 3.3 is simply being driven by the spatial concentration of high-employment areas. However, it should be noted that it may also be driven in part by the methods used to forecast the spatial distribution of PEVs.

To construct future-year scenarios, UCLA extrapolated adoption patterns far outside of the sample of available forecast data. The further out the projection goes, the greater the uncertainty. This is especially a concern in the case of PEV adoption because the market is still characterized by early adopters. Technological adoption often follows an "s-curve" characterized by slow early growth that accelerates as the technology gains widespread appeal and then slows again as the market reaches saturation. Because the historical trends used to allocate PEVs to individual census tracts are only representative of the first eight years of the market, the trends observed thus far are only in the early growth and early acceleration phases.

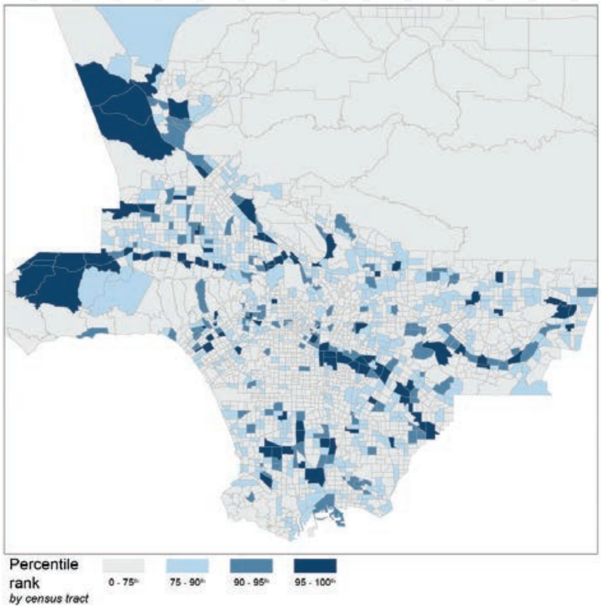
However, improvements in cost and performance may significantly impact the market in the 2020's. The implication being over the 12-year period between 2018 and 2030, in some Census tracts the market might slow, and in others accelerate, causing a more even geographic adoption trend. If that were to be the case, the actual distribution of charging demand in 2030 would be less concentrated than UCLA's model suggests. Furthermore, past trends for PEV adoption have largely been concentrated closer to LA County's core job centers. If mainstream adoption pushes out to areas on the County's periphery where commutes are longer, then commute energy consumption would also be higher than currently modeled.

Short-Term Planning: Energy Demand Capacity Gap

Aggregate energy demand is a useful metric for medium- and long-term planning. For short-term planning purposes, it is useful to also consider existing charging infrastructure when identifying early priorities for targeted outreach and investment. To that end, UCLA has compared charging demand against charging capacity at each TAZ in the base-year scenario.[2]

The results of that comparison are mapped in Figure 3.4. The top twenty-fifth percentile of TAZs are identified as high-potential locations, with the top fifth percentile being very-high potential.

Figure 3.4: Charging Capacity Gap—Percentile Rank LA County



The map of high potential locations shows similar patterns as the maps in Figure 3.4 with some exceptions for areas with high penetrations of charging stations. For example, the TAZs in downtown Santa Monica have high commuting energy use. However, because of Santa Monica's efforts to install charging stations, the gap between installed capacity and potential demand is relatively low.

[2] UCLA calculated charging capacity using Alternative and Renewable Fuels Data Center's (AFDC) Electric Vehicle Charging Station Locations data. (DOE 2019)

Table 3.2: Cities with More Than One TAZ Above 95th Percentile

CITY	PERCENTILE 95–100TH	90–95TH	75–90TH
Los Angeles	29	53	141
Unincorporated LA County	11	6	22
Burbank	7	0	3
Glendale	4	2	10
Industry	4	6	0
Santa Fe Springs	4	2	1
Torrance	4	4	6
Vernon	4	0	0
Carson	3	4	4
Commerce	3	2	1
Pomona	3	1	7
Agoura Hills	2	0	0
Pasadena	2	3	10
Santa Clarita	2	5	7
Santa Monica	2	3	3
Bell	1	0	0
Beverly Hills	1	1	2
Calabasas	1	0	1
Cerritos	1	2	2
Covina	1	0	4
Culver City	1	0	5
Downey	1	2	3
Gardena	1	0	8
Glendora	1	0	4
Hidden Hills	1	0	0
Irwindale	1	0	1
La Mirada	1	0	1
La Verne	1	0	1
Montebello	1	0	7
Monterey Park	1	0	5
Paramount	1	1	3
Pico Rivera	1	1	3
Westlake Village	1	0	0

It should be noted that the Alternative Fuels Data Center (AFDC) charging station data does not distinguish between workplace charging and non-workplace charging stations, so installed capacity is the sum of all public and private charging stations within a TAZ. The AFDC data is based on a number of different data sources including charging networks and self-reported, and therefore it is unclear how many non-network workplace chargers are included in the dataset.

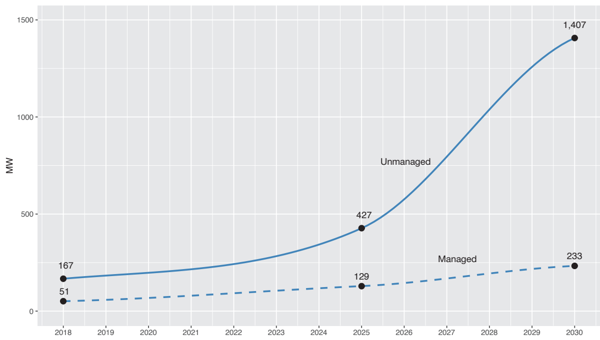
It is also unclear as to whether commuters have easy access to the existing chargers for workday charging. For example, the TAZ for Los Angeles International Airport generates significant charging demand from commuter PEVs and is in the top five locations for energy consumption but is ranked low on the charger capacity gap metric because it has large numbers of public charging stations. However, it is unclear whether workers can easily utilize those stations while they are at work.

Charging Power Demand

Because peak charging power demand is derived from commuter energy use, it closely tracks the results of that analysis both in relative magnitude and geographic distribution of results. Countywide, modeled peak power demand rises from 167 MW in 2018 to 1,407 MW in 2030.

For comparative purposes, UCLA modeled a scenario where the charging is perfectly managed to reduce peak loads to the minimum levels necessary while still delivering the required energy to charge. While managing charging that perfectly is not possible, software-driven energy management methods can approach that ideal. The managed load profile provides some context for how much peak demand could be reduced if charging was managed. However, current workplace charging is very rarely managed; users plug in when they arrive and start charging immediately. Because of this, the power demand profiles used in Kevala's subsequent analysis are for unmanaged charging.

Figure 3.5: Managed and Unmanaged Charging Peak Demand in LA County



While the values are obviously different, the distribution of peak load in Table 3.3 is very similar to the distribution of energy use shown in Table 3.1. The reasons for the right-skewed distribution are the same; land-use patterns in Los Angeles County are characterized by relatively few, concentrated employment areas and many dispersed residential areas.

Table 3.3 Summary of Peak Energy Demand in kW

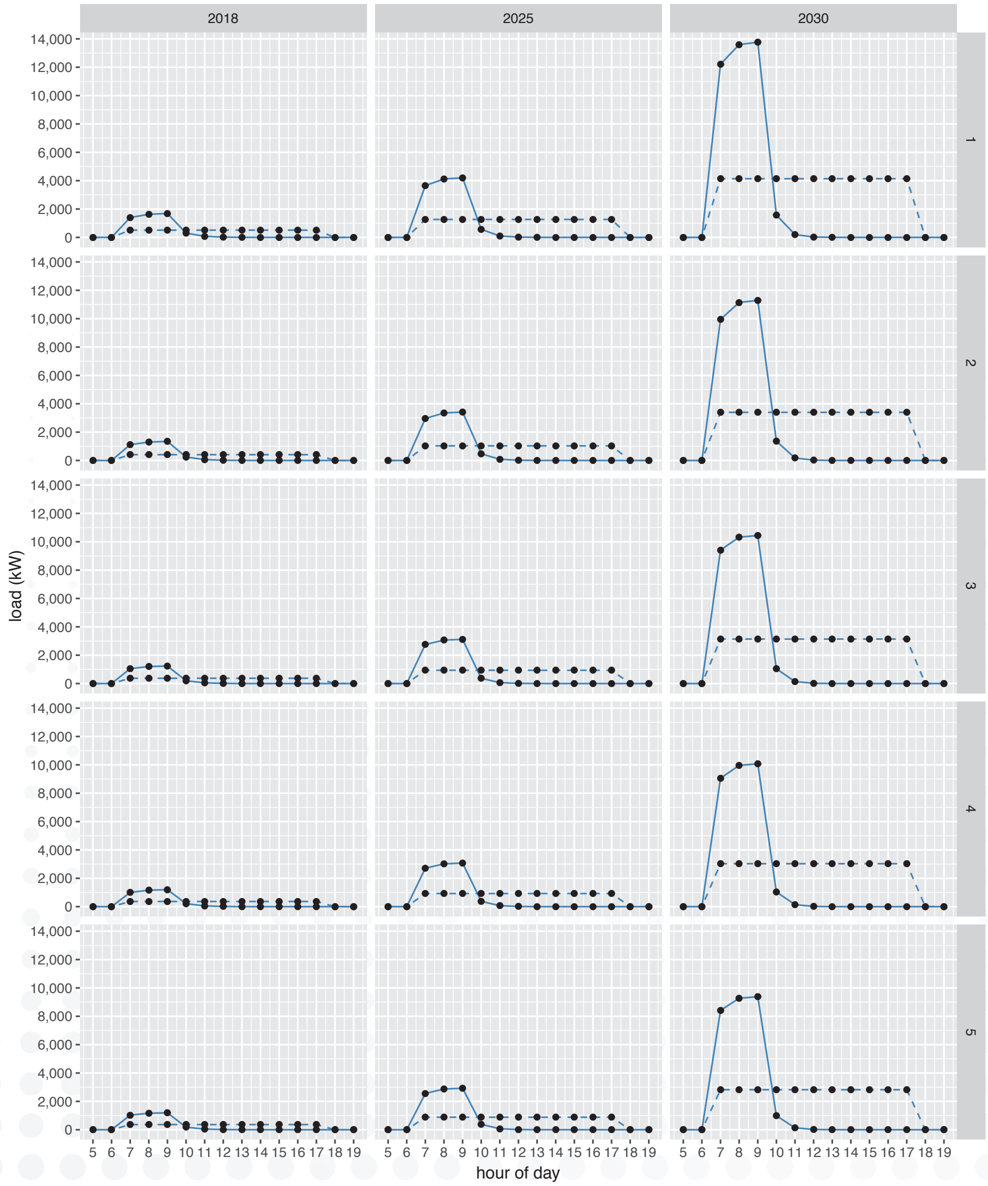
	2018		2025		2030	
	UNMANAGED	MANAGED	UNMANAGED	MANAGED	UNMANAGED	MANAGED
Mean	44.4	22.7	190.3	57.4	68	188.6
Median	74.6	13.5	114.6	34.5	39	113.7
Minimum	0.2	0.1	0.4	0.1	1.5	0.4
Maximum	1,683.9	511.0	4,199.7	1265.9	13,764.0	4,137.2

Figure 3.6 shows the load shape for the top five TAZs by peak load. As is evident from the graph, load shapes are generally consistent, even as peak demand is higher or lower in different years and between TAZs. This shape is consistent across all modeled TAZs.

Load spikes at 7:00 a.m., grows slightly until 9:00 a.m. and then drops off sharply between 10:00 and 11:00 a.m. This is caused by two factors. The first is simply due to the nature of workdays, which tend to begin between 7:00 and 10:00 a.m., meaning that commuters will be plugging in their vehicles predominantly during that timeframe. The second is that most commutes are relatively short, so the amount of energy each PEV must recover is relatively small. UCLA's model assumes that vehicles are charging using Level 2 chargers at either 3.3kW or 7kW, which are common charging rates for PHEVs and BEVs respectively. At those rates most vehicles charge in under one hour, while some may charge for two or three hours. This concentrates the entirety of the load in morning hours.

As mentioned before, the high-demand scenario that UCLA has modeled is based on the premise that every vehicle plugs in at their workplace.

Figure 3.6: Top Live LA County TAZs by Peak Load



For that to be possible in every workplace in the County, over a million workplace chargers would need to be installed by 2030. Such high adoption rate countywide is unlikely; however, there will likely be significant diversity in the numbers of chargers installed in different workplaces, and some workplaces may provide them in significant numbers.

It should be noted that employers might respond to high demand by enforcing limitations to charging time, as a rudimentary load management strategy and a way to increase charger capacity without additional investment. Some employers are already limiting charging time to a four-hour window to enable two vehicles to charge over the course of the day rather than one. In this scenario, there would be two distinct peaks in demand, one in the morning, as vehicles arrived at work, and another, possibly softer peak in the afternoon as vehicles are swapped.

Key Findings

As PEV adoption in Los Angeles County grows, so will the amount of energy used by commuting PEVs. If California meets its 2030 ZEV targets, PEVs arriving at workplaces in LA County are likely to have total state-of-charge deficits of more than four GWh on a daily basis. This growth could cause considerable demand for workplace charging in the coming decade. Understanding where this demand is likely to be geographically located is crucial to PEV readiness planning for light-duty vehicles. Furthermore, high demand for charging at workplaces may run into constraints on local grid capacity. Understanding where those constraints might occur is equally important to long-term planning.

Next Steps for Workplace Charging Analysis

While the modeling conducted thus far is a good first step in understanding how to plan for the future of workplace charging, there are a number of lines of inquiry that could serve to improve LA County's planning capacity.

In UCLA's analysis and other work, the forecasting of future PEV adoption is based on data and experience from the early stage of the market. However, as PEV ranges reach a point of price and functional range parity with gasoline cars, the market may shift quickly. This may impact the geography of PEV adoption as well as how drivers use workplace charging. Future work should be devoted to creating flexible PEV forecast methods that can accommodate differing assumptions about PEV adoption to simulate a broader set of adoption scenarios.

While the availability of workplace charging can impact any driver's choice to purchase a PEV, the impact is potentially the most significant for residents of multifamily housing, or those who otherwise do not own or control their residential parking spot. For those drivers, the availability of workplace charging is potentially the sole enabling condition for them to drive a PEV. This is especially important in LA County where almost half of all residents live in multifamily housing. In the next phase of the Blueprint, efforts should be devoted to understanding how workplace charging can be developed to better provide critical charging access to multifamily residents. This should include efforts at workplaces and be part of larger geographic plans.

Finally, recent research suggests that daytime charging for PEVs can enable significant grid benefits through vehicle grid integration strategies. There has been some effort to estimate the value of those strategies. However, if charging significant numbers of PEVs has local effects on the grid that require infrastructure upgrades, the value of those grid integration strategies might not exceed the costs of upgrading infrastructure. In the next stage of research efforts should be made to better understand the marginal value of additional daytime charging as it compares to the localized costs of expanding infrastructure to determine where and to what degree those strategies would prove beneficial in LA County.

3.2 Transit Electrification Grid Impact

Transit electrification offers a great opportunity to address local air quality in urban communities, especially disadvantaged communities (DACs), and to contribute to the statewide GHG emissions reduction. Air pollution disproportionally affects low-income and minority communities, as many of these populations live in close proximity to busy roads with major bus routes and freight activity (Chandler, Espino, & O'Dea, 2016). Zero-emission buses (ZEB) have no tailpipe emissions and research has shown that life-cycle GHG emissions are over 50-70 percent lower than those of diesel or compressed natural gas (CNG) buses (Chandler et al., 2016).

The State of California has adopted a variety of policies and incentive programs to spur the growth of the electric vehicle market in the medium/heavy-duty sector. The deployment of ZEBs has been supported through the Zero-Emission Truck and Bus Pilot Commercial Deployment Projects and the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). These projects aim to offset the high upfront costs of zero-emission medium-/heavy-duty vehicles and incentivize additional efforts on providing benefits for DACs. With these projects, costs associated with ZEBs have decreased over time and ZEB technologies are moving toward lifecycle cost parity with conventional bus technologies (Ambrose, Pappas, & Kendall, 2017; California Air Resources Board (CARB), 2018a). As of May 2018, 132 ZEBs (including 110 Battery-Electric Buses and 22 Fuel Cell Electric Buses) are in operation across California and additional 655 ZEBs are on order, awarded or planned (CARB, 2018b). More recently, CARB adopted the Innovative Clean Transit (ICT) regulation. The ICT regulation requires a gradual transition to ZEBs by 2040 for all transit agencies in California (Table 3.4). Starting in 2023, transit agencies are required to have an increasing fraction of new bus purchases to be zero emission, culminating in a requirement that all new buses be zero emission in 2029. Within Los Angeles County, four transit agencies including the Los Angeles County Metropolitan Transportation Authority (LA Metro), Foothill Transit, Los Angeles Department of Transportation (LADOT), and the Big Blue Bus have committed to a 100 percent electric fleet in operation by 2030. Given this policy commitment at the state and local level, transit buses will be on the leading edge of heavy-duty vehicle electrification.

Table 3.4. Schedule for ZEB Purchasing Requirements in the ICT Regulation

SCHEDULES (STARTING FROM)	REQUIRED SHARE OF ZEBS IN NEW BUS PURCHASES	APPLICABLE BUS TYPES	APPLICABILITY TO TRANSIT AGENCIES
January 1, 2023	25%	Regular buses	Large transit agencies[1]
January 1, 2026	25%	All buses[2]	Small transit agencies[3]
	50%	All buses	Large transit agencies
January 1, 2029	100%	All buses	All transit agencies

1 Large transit agencies in the South Coast refer to agencies with more than 65 buses in annual maximum service.

2 All buses include regular buses, articulated buses (i.e., 54-foot to 60-foot buses with two connected passenger compartments), double-deckers, and coaches or motor coaches.

3 Small transit agencies in the South Coast refer to agencies with 65 or less buses in annual maximum service.

Although BEBs and FCEBs are both considered ZEBs, BEBs are expected to be the primary technology to be widely adopted in the State (Ambrose et al., 2017). Besides the high initial purchasing costs, the requirement for new charging infrastructure remains another significant challenge for the wider adoption of BEBs. Depending on battery capacities and route lengths, some bus lines may be able to be served by buses on a single, slower charge, obtained off-duty at a bus yard. Others may require on-route fast charging to facilitate longer routes.

Charging associated costs for a transit agency may vary by the type of charging being deployed, the location of charging and the utility connections, and daily operations of the BEB fleet. Effective charging infrastructure planning is critical to maintaining and improving transit services with BEBs. On one hand, it helps transit agencies to minimize charging associated costs and eventually the lifecycle costs of BEBs. On the other hand, charging that occurs in bus yards has the potential to cause significant impacts on local grid infrastructure when large numbers of buses charge simultaneously. On-route charging will demand very high power for short intervals, which can stress the grid and limit where they may be installed. Understanding the growth and concentration of BEBs will prepare the utilities for potential load increases and grid upgrades in certain areas.

Based on historical bus retirement schedules and new requirements on ZEB purchase in the ICT regulation, we are able to model fleet turnover over time. With a review of current BEB technologies and charging solutions as well as a review of current transit operations in the County, we are able to identify the charging needs at the bus yard level and estimate load profiles for transit operations with BEBs. In the following sections, we will describe the data sources and methods used for the analysis and key findings.

Data Sources and Methods

This analysis used three primary data sources and multiple ancillary data sources with specific methods for data processing:

1) The National Transit Database (NTD)

Since 1974, the NTD has served as the primary source of information on the financial, operating and asset conditions of the U.S. transit systems. It aims to support multi-level planning efforts with a myriad of time-series data such as transit agency assets, performance measures of transit services, and funding sources. Each year, transit agencies that receive federal financial support are required to submit data to the NTD through an internet-based reporting platform. For this analysis, the NTD vehicles datasets for 2015-2017 were used to determine the average life cycle of buses at each transit agency.

2) The American Public Transit Association (APTA)

The APTA is an industry organization for public transportation. The APTA compiles a list of transit agencies and service providers by city, county, and state. We used the list for an initial screening of transit agencies that provide transit services within the County. The APTA also maintains a public transportation vehicle database with detailed fleet characteristics including mode, manufacturer, model, year built, fuel type, purchasing costs, etc. The analysis used the latest version of the database (the October 2018 release) to identify current fleet age distribution by fuel type and bus type for each transit agency.

"Transit electrification offers a great opportunity to address local air quality in urban communities."

3) The General Transit Feed Specification (GTFS) Static Datasets

GTFS is a standardized format that many transit agencies use to publish their transit schedules and associated geographic information such as bus stops, routes, and vehicle trips online. Application developers can use the GTFS datasets to visualize the information in an interoperable way. GTFS static datasets, when available, were used to estimate daily vehicle miles traveled (VMT). Transit operators usually define vehicle blocks as the assignment of one vehicle during a day which may include one or more trips depending on the service needs. When vehicle block information is not available in the GTFS static datasets, route-level average VMT was estimated as total miles traveled for a route divided by vehicles operated in maximum service (VOMS). VMT estimation was based on the most recent bus schedules to date (March/April 2019). Deadheading was not included in the analysis.

4) BEB Manufacturer Websites and Transit Agency Websites

For the review of BEB technologies and charging solutions, information was obtained directly from the websites of major BEB manufacturers and compiled a dataset with bus specifications by manufacturer and model (Appendix A1). A coefficient of 0.7[3] was applied to the OEM-claimed maximum range of BEBs in order to estimate the energy consumption rate (kWh/mile) in actual operating conditions. Additional information on operations and maintenance facilities from a number of planning documents and reports that are publicly available through the websites of transit agencies was also obtained.

5) The EMission FACtor (EMFAC) Model

The EMFAC estimates on-road mobile vehicle emissions of major criterial pollutants and GHGs at various scales of geographic concentration in California. State and local governments have used different versions of the EMFAC model for decision making on policies and programs to fulfill requirements under the Clean Air Act (CAA). GHG emission rates were obtained from the latest version of the model, i.e., EMFAC2017. The avoided tailpipe GHG emissions from transit electrification were estimated by multiplying projected electric VMT (eVMT) with average GHG emission rates (g CO_2e/mile) of natural-gas buses in LA County. Average GHG emission rates of natural-gas buses in 2025 and 2030 are estimated to be 2276 g CO_2e per mile and 2274 g CO_2e per mile, respectively.

In this analysis, we first developed a fleet turnover model for each transit agency. The fleet turnover model was based on the age distribution of current fleet (Appendix A2). For each agency, we assumed varying bus lifecycles (14 to 18 years), which are based on each agency's bus retirement behaviors in the past. We also assumed shorter lifecycles (12 to 14 years) for articulated buses given the higher level of wear and tear as a result of being operated on longer routes and with more passenger loads.

We developed three scenarios of fleet turnover: the reference scenario and two BEB adoption scenarios. In the reference scenario, retirement takes place at the end of assumed bus life cycles. The two BEB adoption scenarios are based on the fleet turnover schedules in the reference scenarios. For agencies without the target of 100 percent electric by 2030, we assume that agencies only meeting the minimum requirements (25-100 percent of new purchases) during early years and eventually catch up later in order to be 100 percent electric by 2040. This represents a slow BEB adoption in earlier years, which we note as the BEB-slow scenario. Whereas in the BEB-fast scenario, we assume that agencies act as early as possible and switch to BEBs only whenever retirement takes place. For agencies with the target of 100 percent electric by 2030 (i.e., LA Metro, Foothill Transit, LADOT, and Big Blue Bus), meeting the minimum requirements in the ICT regulation cannot help them achieve the goal and they have to act early as possible. For these four agencies, we assume 14-year life cycles for the BEB-slow scenario and

[3] Based on an interview with Roland Cordero, the Director of Maintenance and Vehicle Technology at Foothill Transit.

12-year life cycles for the BEB-fast scenario. A shorter life cycle results in faster retirement of non-electric buses and thus leads to a quicker turnover of BEB adoption.

The analysis on charging needs and grid impact is based on the number of electric buses in future years (i.e., outputs of the fleet turnover model), daily VMT (estimated from the GTFS datasets or agency reports), the BEB energy consumption rate in actual operating conditions, and specific charging strategies. For agencies with multiple bus yards, we assume electrification takes place yard by yard. At each yard, we assume electrification starts with buses with least daily assignment. For the load profiles, we designed two charging scenarios: (1) the unmanaged charging scenario, which we assume that charging for all BEBs starts at the same time; and (2) the managed charging scenario, which we assume charging is managed by a smart charging control system that queues the charging of BEBs in order to minimize the number of chargers needed and to reduce the peak load. For the managed charging scenario, we use a bin-packing[4] algorithm to estimate the maximum number of chargers needed within a fixed charging time period, which we assume to be from 9:00 p.m. to 6:00 a.m. the next day. When charging cannot be completed with a standard 80-kW charger within the time period, a fast charger (200-kW) is assumed to be added to ensure that charging for all buses can be finished before 6:00 a.m. Given that transit services peak during weekdays, daily charging needs and load profiles are estimated for weekdays to represent the peak load within a week.

Key Findings

The Current State of BEB Technologies and Charging Solutions

Although a growing number of conventional bus manufacturers have announced plans for new BEB production lines, there are currently four manufacturers that dominate the BEB market in the U.S.: Build Your Dream (BYD), Proterra, GreenPower, and New Flyer. Based on the specifications we obtained directly from these manufacturers, we estimated the range and average energy consumption rate in actual operating conditions by bus type and length (Table 2). Considering the actual operating conditions, BEBs can be operated for 38.5 to 298.2 miles after one full charge and energy consumption rate ranges from 1.89 to 3.80 kWh per mile traveled. Larger buses such as double-deckers and articulated buses have greater gross vehicle weight and more passenger capacities, and thus consume more energy when in operation. With a continuous monitoring and evaluation of Proterra buses purchased and operated by Foothill Transit, researchers at the National Renewable Energy Laboratory (NREL) found that: (1) 35-ft. BEBs consume 2.07 to 2.32 kWh per mile in 2016, 2.01 to 2.30 kWh per mile in 2017, and 1.99 to 2.25 kWh per mile in the first half of 2018; (2) 40-ft. BEBs consume 2.19 to 2.25 kWh per mile in 2017 and 2.08 to 2.21 kWh per mile in in the first half of 2018 (Eudy et al., 2016; Eudy and Jeffers, 2018a; Eudy and Jeffers, 2018b). The NREL analysis was based on actual operating data from two models made by one single manufacturer, and our estimation across a larger number of models and manufacturers are within reasonable range to the NREL results.

For the estimation of electricity demand and load profiles, we only distinguish between articulated buses and other buses. As shown in Table 3.5, average energy consumption rate for the first five types of buses range from 1.89 to 2.85 kWh per mile with a medium value of 2.36 kWh per mile. In addition, 40-foot buses are the most commonly operated by agencies in LA County. Thus, we assume energy consumption rates of 3.80 kWh per mile for articulated buses and 2.36 kWh per mile for all other buses.

4 Fitting objects of different sizes into bins of the same size.

Table 3.5: Estimated Energy Consumption Rate of BEBs in Actual Operating Conditions

BUS TYPE	LENGTH (FT.)	NUMBER OF AVAILABLE MODELS	AVERAGE ENERGY CONSUMPTION RATE* (KWH/MILE)
Bus	30	2	1.89 (0.1778)
	35	9	2.21 (0.1103)
	40	17	2.36 (0.0758)
	45	1	2.47
Double-decker	45	1	2.85
Articulated Bus	60	3	3.80 (0.3582)

* Standard errors in parenthesis.

Currently, there are three types of charging available for BEBs: plug-in charging, overhead charging (including roof-mounted pantographs and inverted pantographs), and inductive charging (Figure 3.7). The power level of these charging options varies from 50 to 500 kW. Plug-in charging is by far the most common and the cheapest option for BEB charging. For plug-in charging, BEBs are usually charged at night while they are parked at the bus yard. Thus, it reduces fuel costs when time-of-use electricity rates are in place. However, this type of charging may require BEBs to be equipped with batteries of a large size in order to satisfy the service needs on longer routes, which increases the initial capital investments on the purchase of long-range BEBs.

On-route charging such as pantographs and inductive charging offer the benefit of opportunity charging, which reduces the need for large battery packs and allows for extended range throughout the day. These two types of charging are significantly costlier than standard plug-in charging and often require additional processes such as permitting and right-of-way leases or purchases.

Given the uncertainty in cost reduction and project timing for on-route charging in the near and longer terms, we assume that standard plug-in charging (80 kW power level) at the bus yard is the primary charging solution for BEB operations in the County and fast plug-in charging (200 kW power level) is deployed when necessary for charging to complete within the assumed charging schedule (i.e., between 9:00 p.m. and 6:00 a.m. to avoid interfering regular services).

Figure 3.7: Available BEB Charging Solutions

eVMT and Tailpipe GHG Emissions Reduction

According to the American Public Transit Association (APTA), there are more than 100 regional and local transit agencies and services that operate within LA County. After the initial screening, we selected the 12 largest transit agencies in terms of fleet size. The 12 agencies maintain 26 bus yards in total across the County (Figure 3.8). Transit operations information at the Santa Clarita Transit and the Antelope Valley Transit Authority are not publicly available through either GTFS static datasets or agency reports, thus we did not include these two agencies in the grid impact analysis. Table 3.6 shows key operations information for each transit agency included in this analysis.

According to the definitions in the ICT regulation, there are six large transit agencies and four small transit agencies. The fleet size of these agencies ranges from 30 to more than 2,400. Our analysis on current BEB technologies indicates that a BEB can be operated for up to 298 miles after one full charge. Except for three vehicle blocks (i.e., daily assignment of a vehicle) at LA Metro, all other vehicle blocks at LA Metro and other transit agencies are below 298 miles. For most instances, existing available BEBs can support current daily operations with one full charge per day.

Figure 3.8: Bus Yards Maintained by Major Transit Agencies in LA County

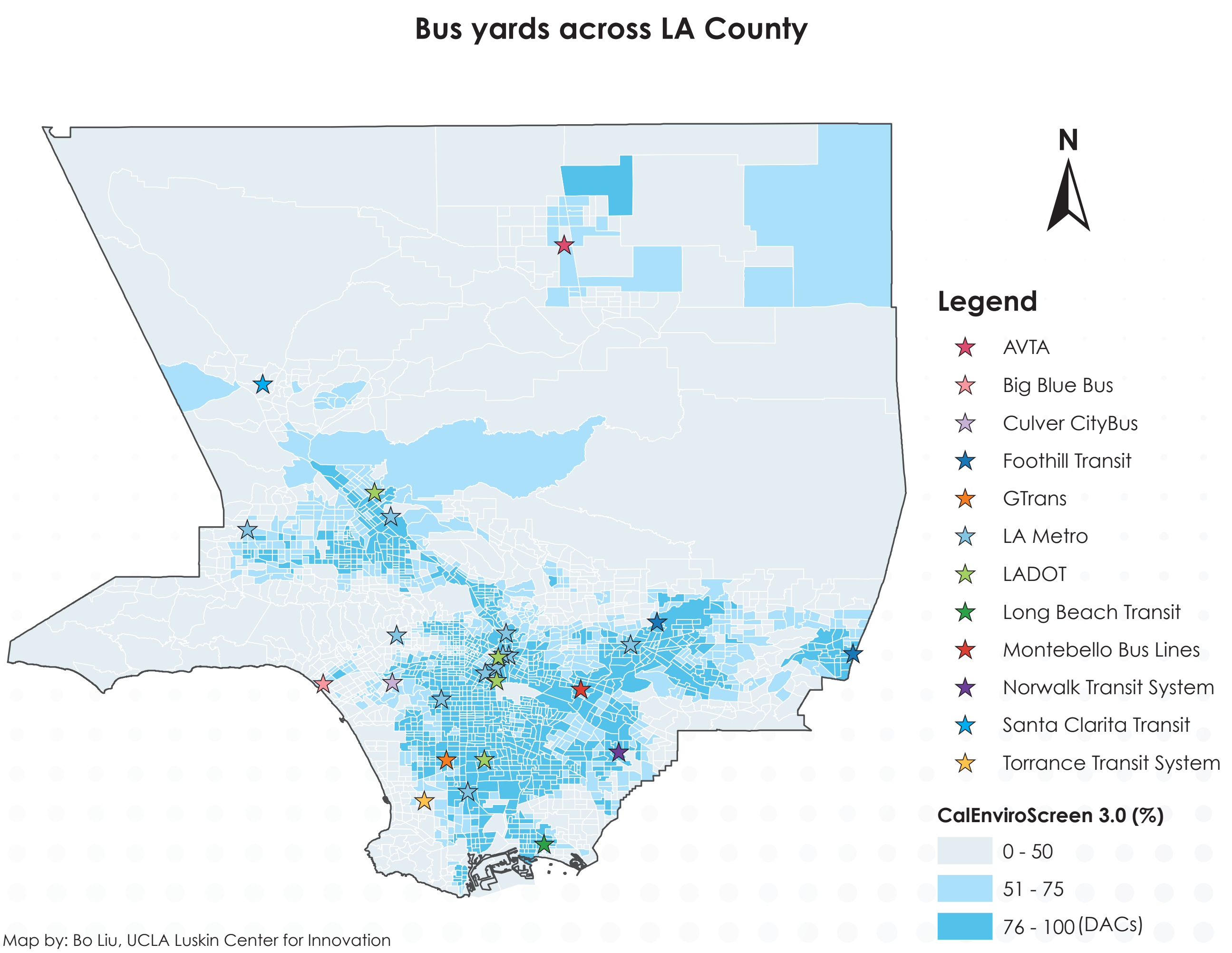


Table 3.6: Transit Agency Profiles

Transit Agency	Service Area (sq. miles)	Bus Fleet Size in 2018	Number of Bus Yards	Number of Bus Routes	Share of Weekday Vehicle Blocks Under 298 Miles	Target Year for 100% Electric Fleet*
LA Metro	1,419	2,311	11	143	99.7%	2030
Foothill Transit	327	373	2	39	100%	2030
LADOT	465	311	4	46	100%	2030
Long Beach Transit	98	263	1	40	100%	2040
Big Blue Bus	59	200	1	20	100%	2030
Montebello Bus Lines	151	66	1	8	100%	2040
Torrance Transit System	103	63	1	11	100%	2040
GTrans	40	56	1	5	100%	2040
Culver CityBus	33	54	1	8	100%	2040
Norwalk Transit System	37	30	1	6	100%	2040

*The 2040 target year is based on requirements in the ICT regulation.

Across the 10 transit agencies, 50 BEBs are currently in operation (Table 3.7). If agencies only meet the minimum requirements in the ICT regulation (i.e., the BEB-slow scenario), there would be 1,629 BEBs by 2025 and 3,315 BEBs by 2030. If agencies act as early as they can and only switch to BEBs in all future years (i.e., the BEB-fast scenario), we would see a faster growth—2,091 BEBs by 2025 and 3,558 BEBs by 2030. Among the ten agencies, vehicle assignment can be fixed or flexible. Depending on each agency's bus operations and schedules, a bus may be assigned to run multiple trips on the same route every day, and a bus could also be assigned for trips on different routes. At the route level, buses on average are operated for 4 to 284 miles daily on weekdays and 8 to 341 miles daily over the weekends.

As a result of transit electrification, total daily eVMT in LA County would increase to 169-201 thousand miles by 2025 and 305-325 thousand miles by 2030. The amount of eVMT would result in 385-739 metric tons of tailpipe GHG emissions reduction every day (Table 3.8). At the agency level, the share of eVMT in total daily VMT would increase to as high as 81 percent by 2025 and as high as 100 percent by 2030. With the goal of full electric by 2030, LA Metro along with Foothill Transit, LADOT, and Big Blue Bus would see a more rapid growth of BEBs in the fleets and greater eVMT and GHG emissions reduction in the near term.

Table 3.7: Projected Numbers of BEBs and BEB Shares in Bus Fleet by Agency

TRANSIT AGENCY	BUS TYPE	2018		BEB-SLOW SCENARIO 2025		BEB-SLOW SCENARIO 2030		BEB-SLOW SCENARIO 2040		BEB-FAST SCENARIO 2025		BEB-FAST SCENARIO 2030		BEB-FAST SCENARIO 2040	
		Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%
LA Metro	Bus	0	0	875	55	1921	100	1921	100	1025	74	1921	100	1921	100
	Articulated bus	0		390		390		390		390		390		390	
Foothill Transit	Bus	30	8	145	47	343	100	343	100	159	55	343	100	343	100
	Articulated bus	0		30		30		30		30		30		30	
LADOT	Bus	4	1	63	20	311	100	311	100	197	63	311	100	311	100
Long Beach Transit	Bus	10	4	22	8	43	19	249	100	95	36	135	56	249	100
	Articulated bus	0		0		7		13		0		13		13	
Big Blue Bus	Bus	0	0	67	44	172	100	172	100	67	44	172	100	172	100
	Articulated bus	0		21		28		28		21		28		28	
Montebello Bus Lines	Bus	0	0	10	15	17	26	66	100	39	59	54	82	66	100
Torrance Transit System	Bus	0	0	0	0	32	51	63	100	0	0	53	84	63	100
GTrans	Bus	6	11	6	11	6	11	56	100	51	91	51	91	56	100
Culver CityBus	Bus	0	0	0	0	11	20	54	100	6	11	32	59	54	100
Norwalk Transit System	Bus	0	0	0	0	4	13	30	100	11	37	25	83	30	100
Total		***50***		***1629***		***3315***		***3726***		***2091***		***3558***		***3726***	

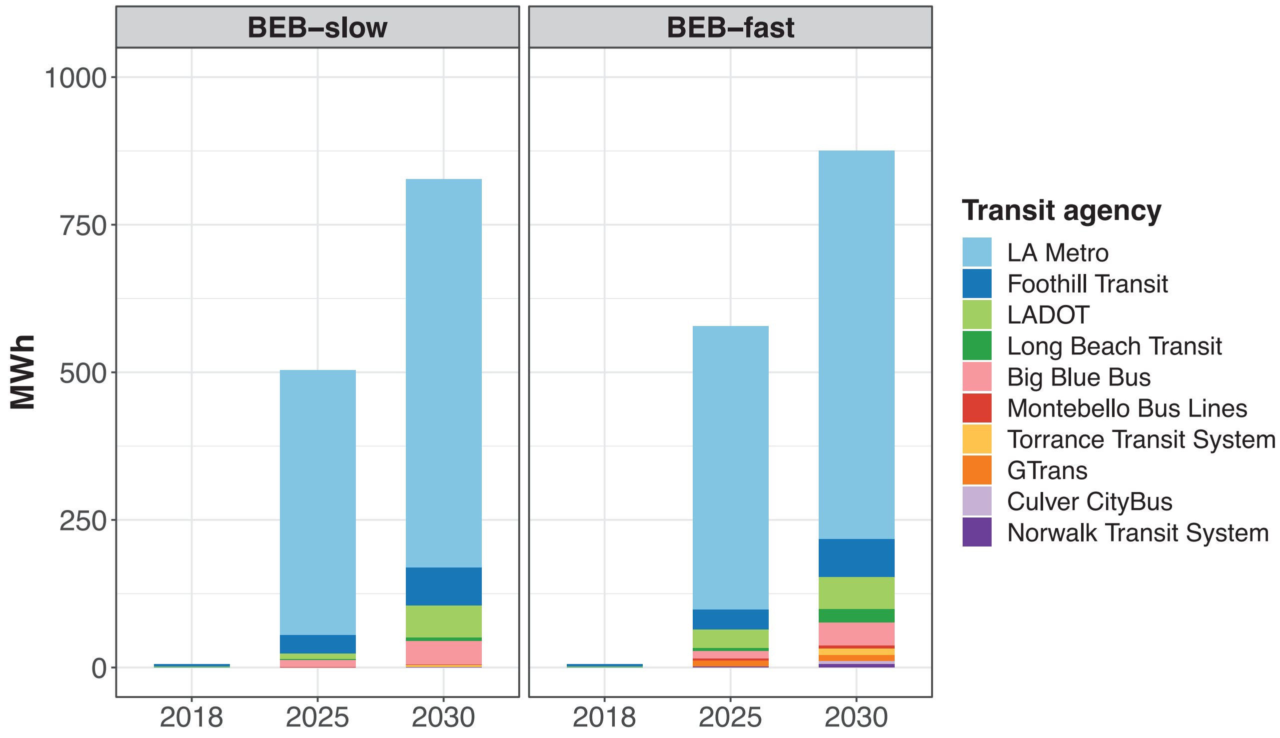
Table 3.8: Projected Weekday eVMT and Tailpipe GHG Emissions Reduction

TRANSIT AGENCY	BEB-SLOW SCENARIO						BEB-FAST SCENARIO					
	2025			2030			2025			2030		
	Daily eVMT (miles)	Share in total VMT (%)	Tailpipe GHG emissions reduction (Metric tons)	Daily eVMT (miles)	Share in total VMT (%)	Tailpipe GHG emissions reduction (Metric tons)	Daily eVMT (miles)	Share in total VMT (%)	Tailpipe GHG emissions reduction (Metric tons)	Daily eVMT (miles)	Share in total VMT (%)	Tailpipe GHG emissions reduction (Metric tons)
LA Metro	149153	63	339	237632	100	540	162389	68	370	237632	100	540
Foothill Transit	10844	43	25	25140	100	57	12133	48	28	25140	100	57
LADOT	3997	18	9	22632	100	51	13085	58	30	22632	100	51
Long Beach Transit	549	2	1	2036	9	5	2299	10	5	8189	35	19
Big Blue Bus	4400	29	10	15298	100	35	4400	29	10	15298	100	35
Montebello Bus Lines	372	14	0.8	633	24	1	1466	56	3	2081	79	5
Torrance Transit System	0	0	0	1148	16	3	0	0	0	4762	68	11
GTrans	23	0.4	0.1	23	0.4	0.1	4419	81	10	4419	81	10
Culver CityBus	0	0	0	339	6	1	144	3	0.3	2002	37	5
Norwalk Transit System	0	0	0	243	7	1	668	18	2	2625	72	6
Total	***169,338***		***385***	***305,124***		***694***	***200,994***		***457***	***324,780***		***739***

Electricity Demand and Grid impact Analysis

Currently four agencies (Foothill Transit, LADOT, Long Beach Transit, and GTrans) have BEBs in operation, which results in a daily electricity demand of 5 MWh. With the potential growth of BEBs under both adoption scenarios, the regional electricity demand for transit operations on a weekday would increase to 504-579 MWh in 2025 and to 827-876 MWh in 2030. Among the transit agencies, LA Metro would see the highest daily electricity demand with 449-480 MWh in 2025 and 658 MWh in 2030, followed by Foothill Transit with a daily electricity demand of 31-34 MWh in 2025 and 65 MWh in 2030.

Figure 3.9: Regional Weekday Electricity Demand for Transit Operations in LA County Under Both BEB Adoption Scenarios



We estimated the grid profiles for both the transit agency level and the yard level under two scenarios of BEB adoption and two scenarios of charging management. In the following sections, we describe the projected load profiles for each transit agency.

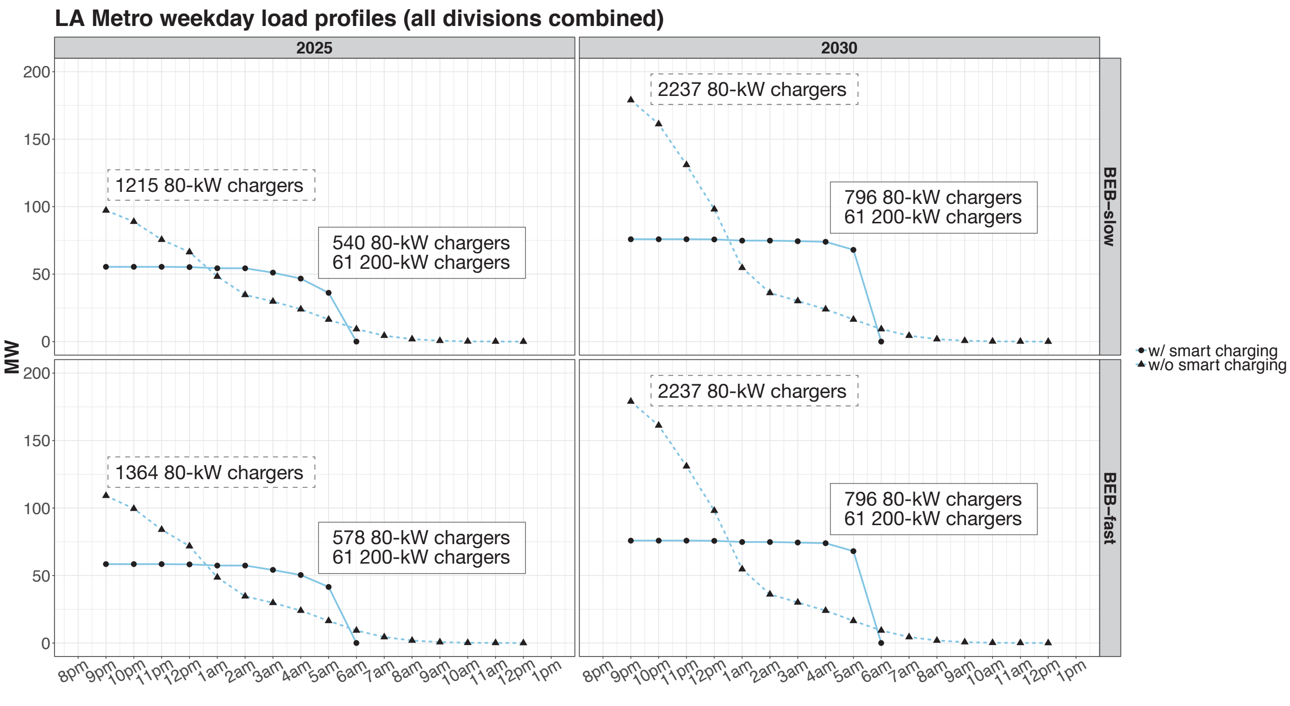
LA Metro Load Profiles

With unmanaged charging, total electrical load at LA Metro (all 11 bus yards combined) would peak at 97-109 MW in 2025 and 179 MW in 2030 (Figure 3.9). With managed charging, the peak load would be reduced to approximately half of that under the unmanaged charging scenario—55-58 MW in 2025 and 76 MW in 2030. The difference between the two scenarios of charging management is whether to deploy smart charging, which could potentially reduce costs in two ways.

First, it reduces the maximum number of chargers by queuing the charging of all buses instead of having them charged at the same time. Thus, it reduces capital investments on charging equipment. In addition, the use of smart charging reduces peak load and thus reduces electricity costs when demand charges are in place. As described in the methods section, we ran a bin-packing optimization to minimize the number of chargers needed for charging to complete within 9:00 p.m. to 6:00 a.m. to minimize interference with regular transit services. With unmanaged charging, LA Metro would need 2237 80-kW chargers when 100 percent electrification takes place and charging for some buses may last until noon, which goes beyond the 9:00 p.m. to 6:00 a.m. charging schedule. Whereas with the use of smart charging, only 796 80-kW chargers and 61 200-kW chargers are required and charging for all buses can be completed before 6:00 a.m.

At the bus yard level, our projections indicated that the peak load with unmanaged charging would be as high as 21 MW in both 2025 and 2030. However, the maximum peak load across yards may be reduced to 10 MW with the use of smart charging. Across all bus yards, smart charging may reduce the required number of chargers by 55-70 percent.

Figure 3.10: Projected Load Profiles Of LA Metro In 2025 And 2030 Under Two BEB Adoption Scenarios and Two Charging Management Scenarios

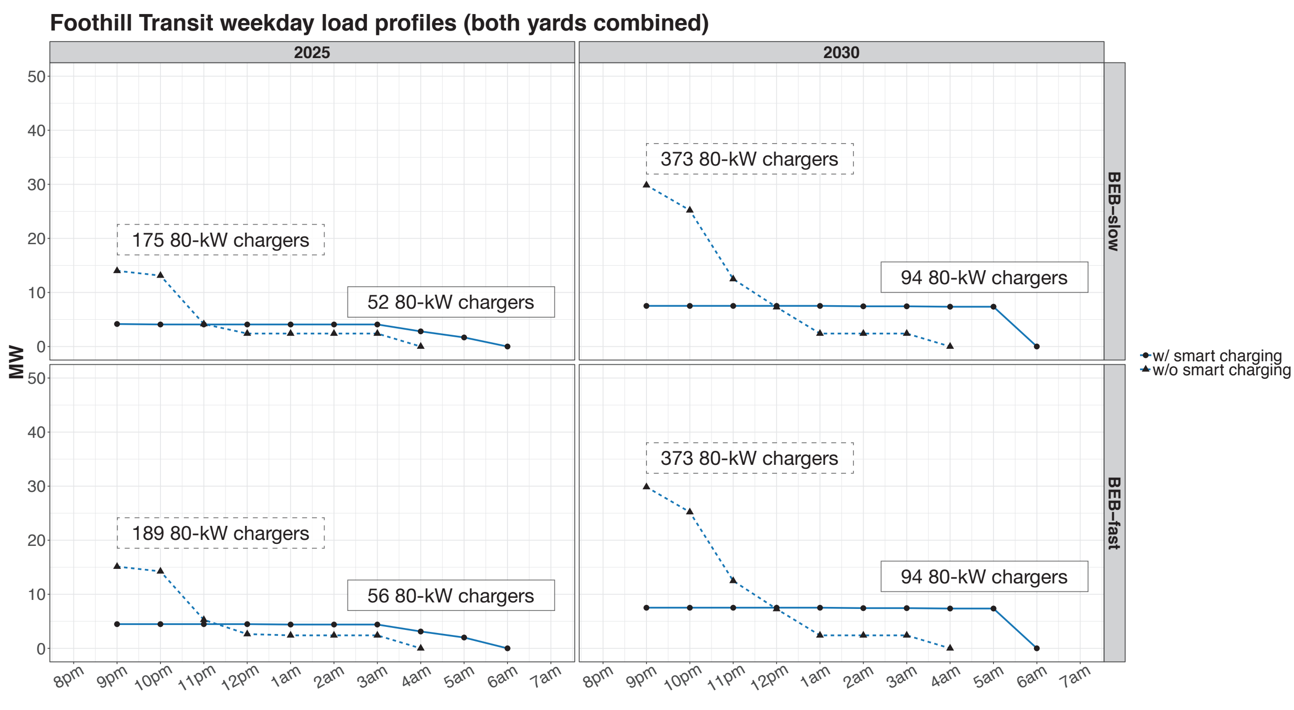


Foothill Transit Load Profiles

Although charging can be concluded by 4:00 a.m. with unmanaged charging, the total electrical load at Foothill Transit would peak at 14-15 MW in 2025 and 30 MW in 2030. Under this scenario of unmanaged charging, 373 chargers would be needed by 2030. With smart charging, the peak load would be reduced to 4 MW in 2025 and 8 MW in 2030, and only 94 chargers would be needed when the fleet is 100 percent electric.

Foothill Transit maintains two bus yards—the Pomona yard and the Arcadia yard. By 2030, the electrical load with unmanaged charging would peak at 13 MW and 17 MW, respectively (Appendix 3). Smart charging would reduce the peak load to 3MW at the Pomona yard and to 5 MW at the Arcadia yard. It also would reduce the number of chargers by 80 percent at the Pomona yard and by 71 percent at the Arcadia yard.

Figure 3.11. Projected Load Profiles of Foothill Transit in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios

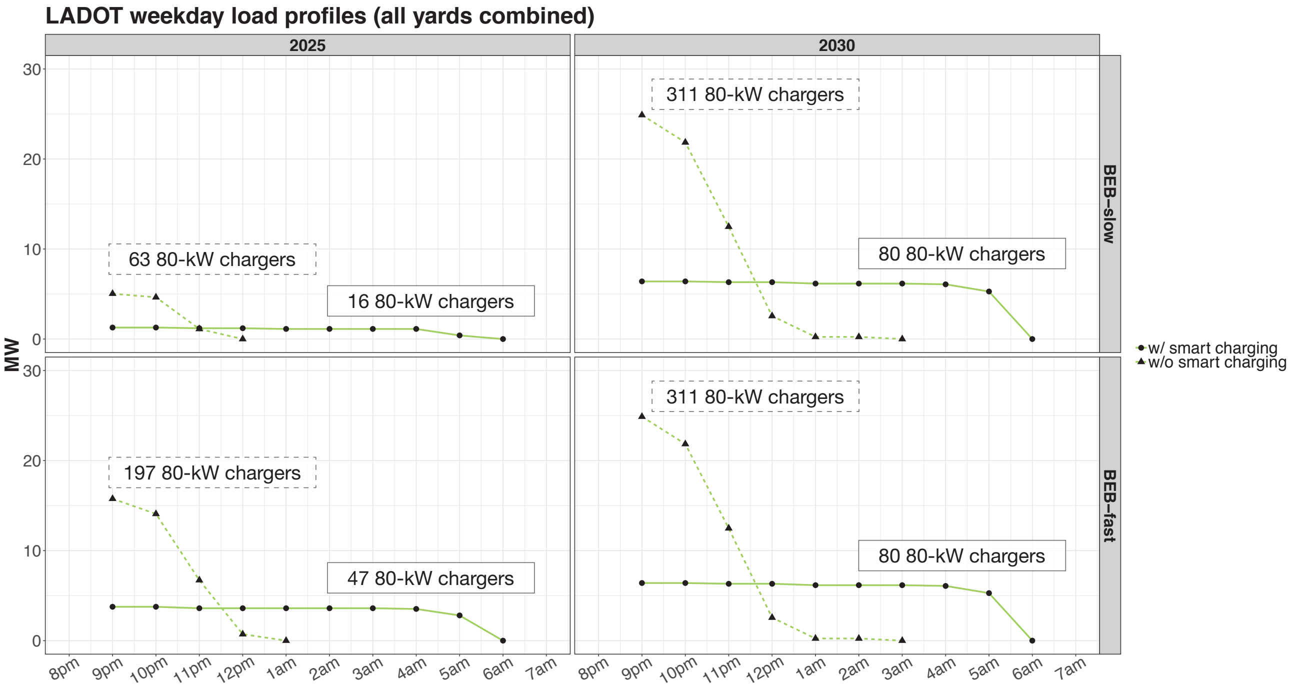


LADOT Load Profiles

When all four bus yards adopt unmanaged charging, aggregated electrical load at LADOT would peak at 5-16 MW in 2025 and 25 MW in 2030. When smart charging is adopted, the peak loads would be 1-4 MW in 2025 and 6 MW in 2030. The number of chargers needed for 2030 would be decreased from 311 under the unmanaged charging scenario to 80 under the smart charging scenario.

Across all four bus yards, the peak load at a single yard with unmanaged charging would increase to as high as 5 MW in 2025 and 7 MW in 2030. Smart charging could reduce the peak load to less than 2 MW at each yard. At all four yards, smart charging could cut down the need for chargers by approximately 75 percent.

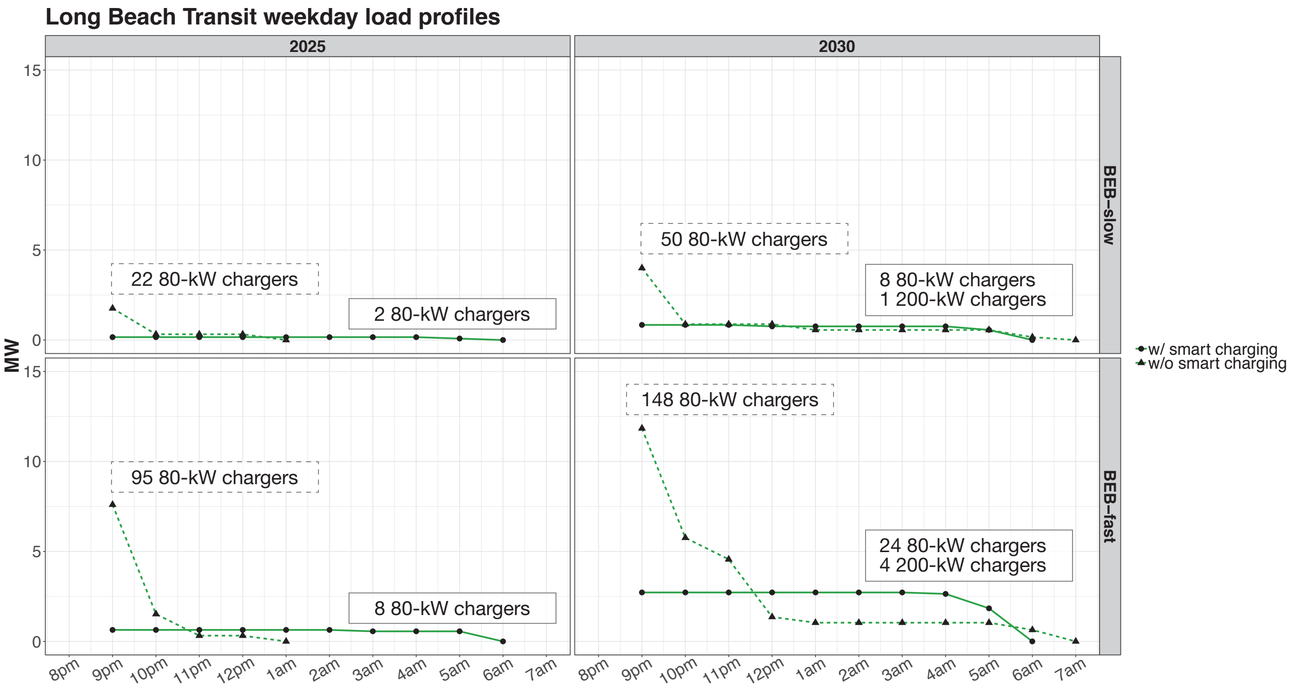
Figure 3.12 Projected Load Profiles of LADOT in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



Long Beach Transit Load Profiles

Without the use of smart charging, Long Beach Transit would encounter a peak load of 2-8 MW in 2025 and 4-12 MW in 2030 depending on the growth of BEBs in the fleet. Under this charging management scenario, charging for all buses would not be completed before 7:00 a.m. when charging starts at 9:00 p.m. of the previous day. With smart charging, peak loads would be greatly decreased—0.2-0.6MW in 2025 and 0.8-2.8 MW in 2030. By 2030, Long Beach Transit would need 24 80-kW chargers and 4 200-kW chargers for a fixed charging schedule between 9:00 p.m. and 6:00 a.m. of the next day.

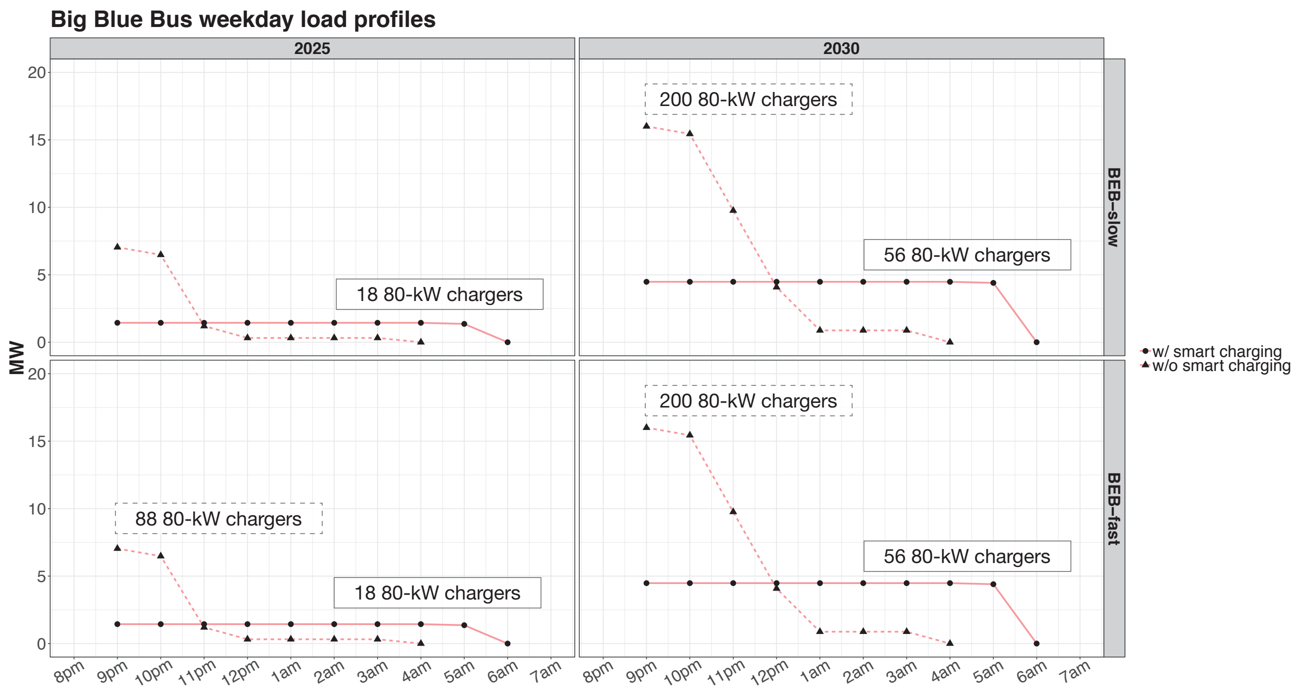
Figure 3.13 Projected Load Profiles of Long Beach Transit in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



Big Blue Bus Load Profiles

The peak load at Big Blue Bus would go up to 7 MW in 2025 and 16 MW in 2030 when smart charging is not in place. However, smart charging could potentially cut down the peak load to 1 MW in 2025 and 4 MW in 2030. When smart charging is in place, Big Blue Bus would only need 56 80-kW chargers, which is 28 percent of what would otherwise be needed under the unmanaged charging scenario (i.e., 200 chargers).

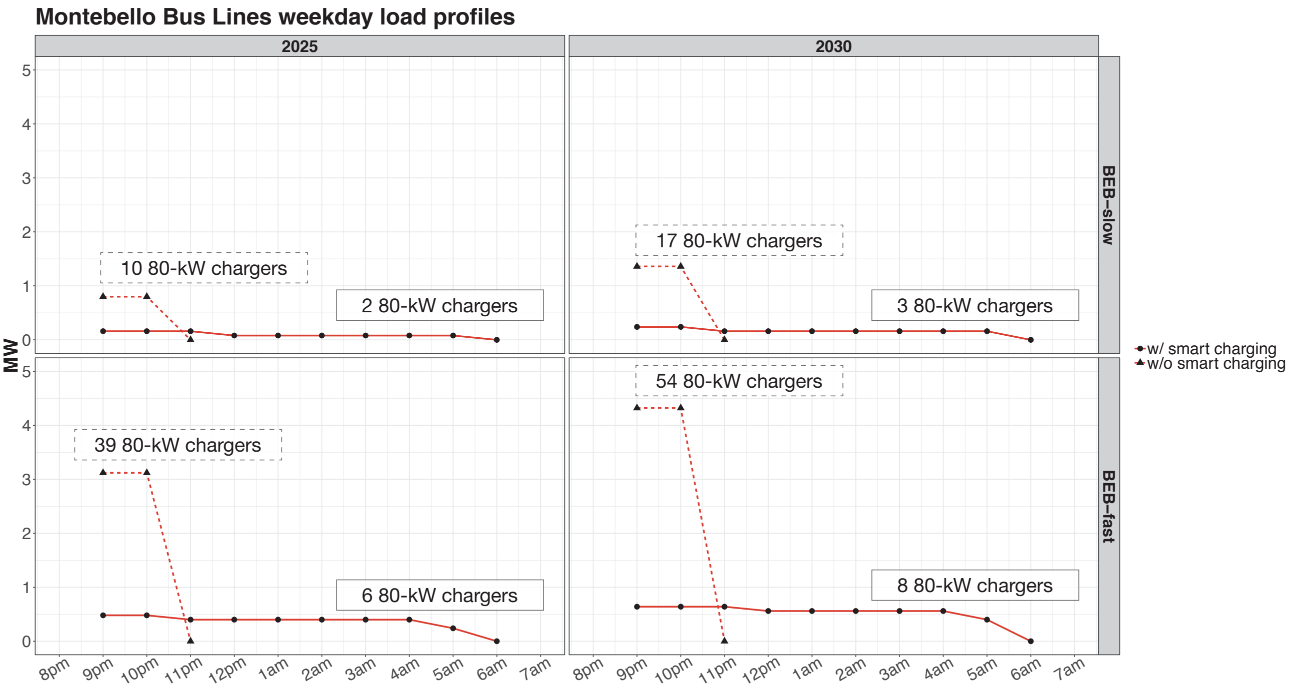
Figure 3.14 Projected Load Profiles of Big Blue Bus in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



Montebello Bus Lines Load Profiles

With the aid of smart charging, electrical loads at Montebello Bus Lines would peak at 0.2 MW in 2025 and 0.5 MW in 2030, which are only a fraction of the peak loads under the unmanaged charging scenario, i.e., 0.8-3 MW in 2025 and 1-4 MW in 2030. By 2030, Montebello Bus Lines would need 54 chargers without smart charging in place or eight chargers along with smart charging.

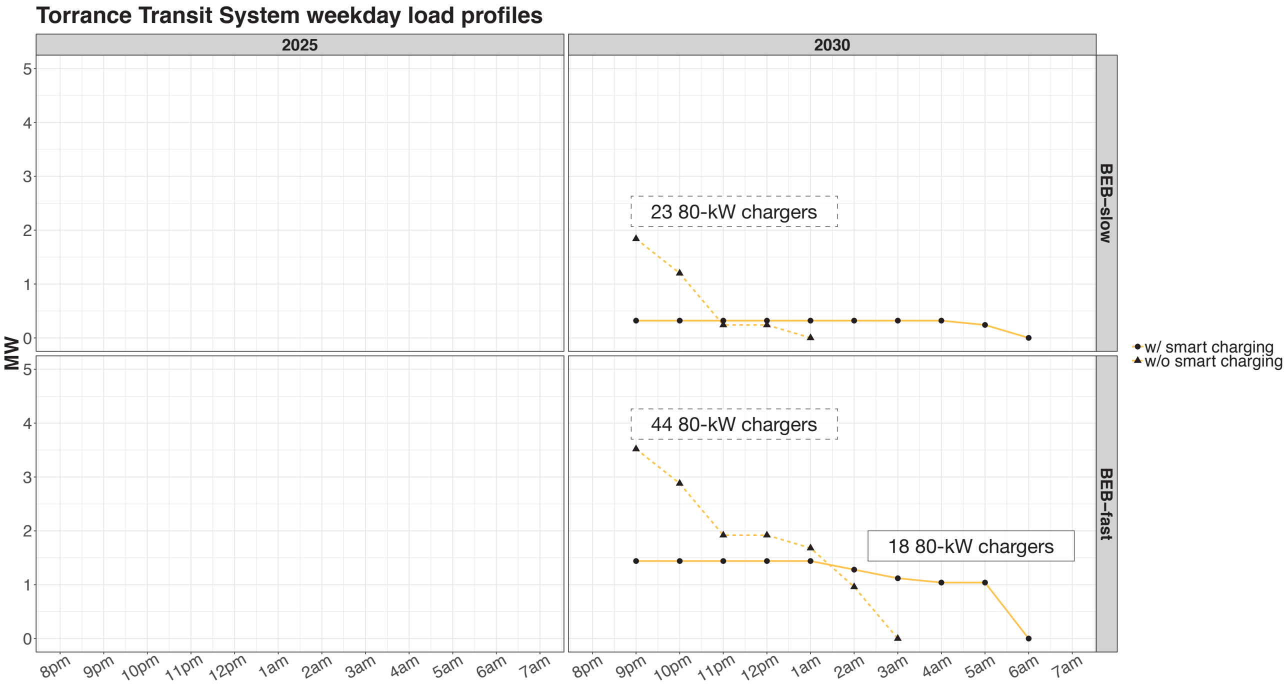
Figure 3.15. Projected Load Profiles of Montebello Bus Lines in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



Torrance Transit System Load Profiles

Under both BEB adoption scenarios, Torrance Transit System would not have BEBs in the fleet before 2026. By 2030, the agency would encounter a peak load of 2-4 MW under the unmanaged charging scenario or a peak load of 0.3-1.4 MW with the use of smart charging. Smart charging could also lessen the need for chargers by 59-83 percent depending on the BEB adoption scenarios.

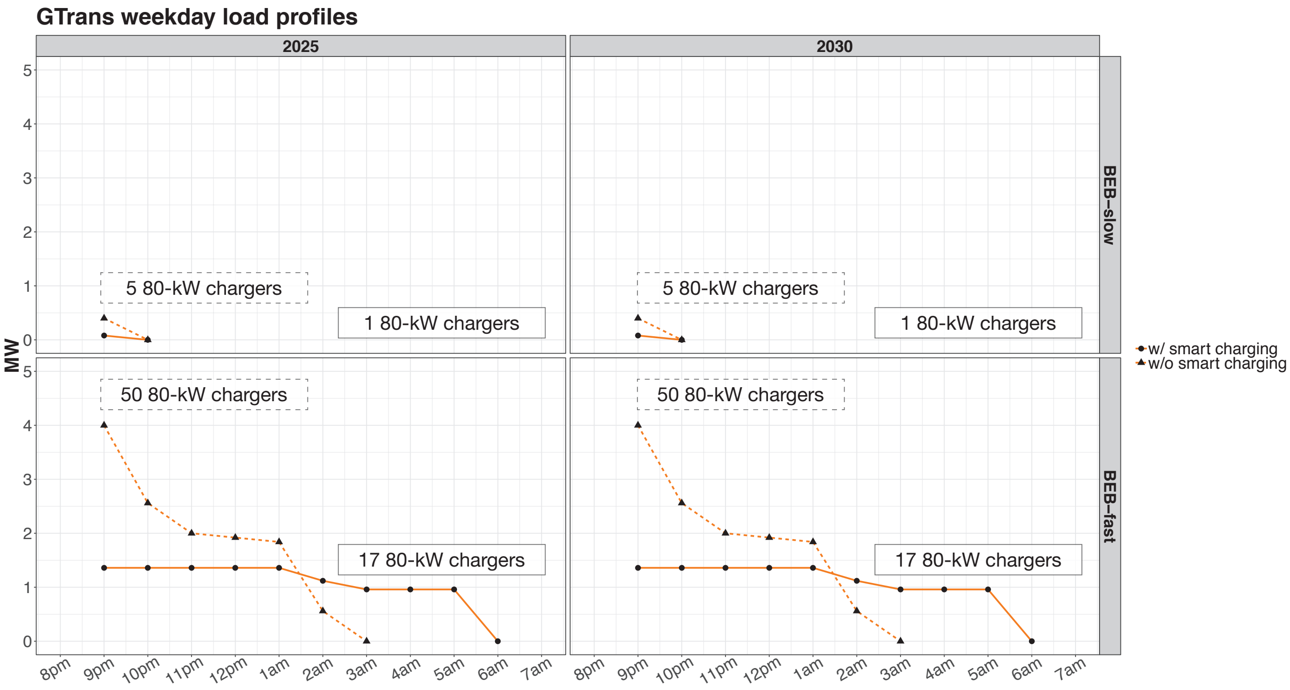
Figure 3.16 Projected Load Profiles of Torrance Transit System in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



GTrans Load Profiles

With unmanaged charging, electrical load at GTrans would peak at 0.4-4 MW in both 2025 and 2030. Deploying smart charging would reduce the peak load to 0.1-1.4 MW. Depending on the specific BEB adoption scenario, one or 17 chargers may be needed by 2030 when smart charging is in place. Otherwise, five to 50 chargers would be needed.

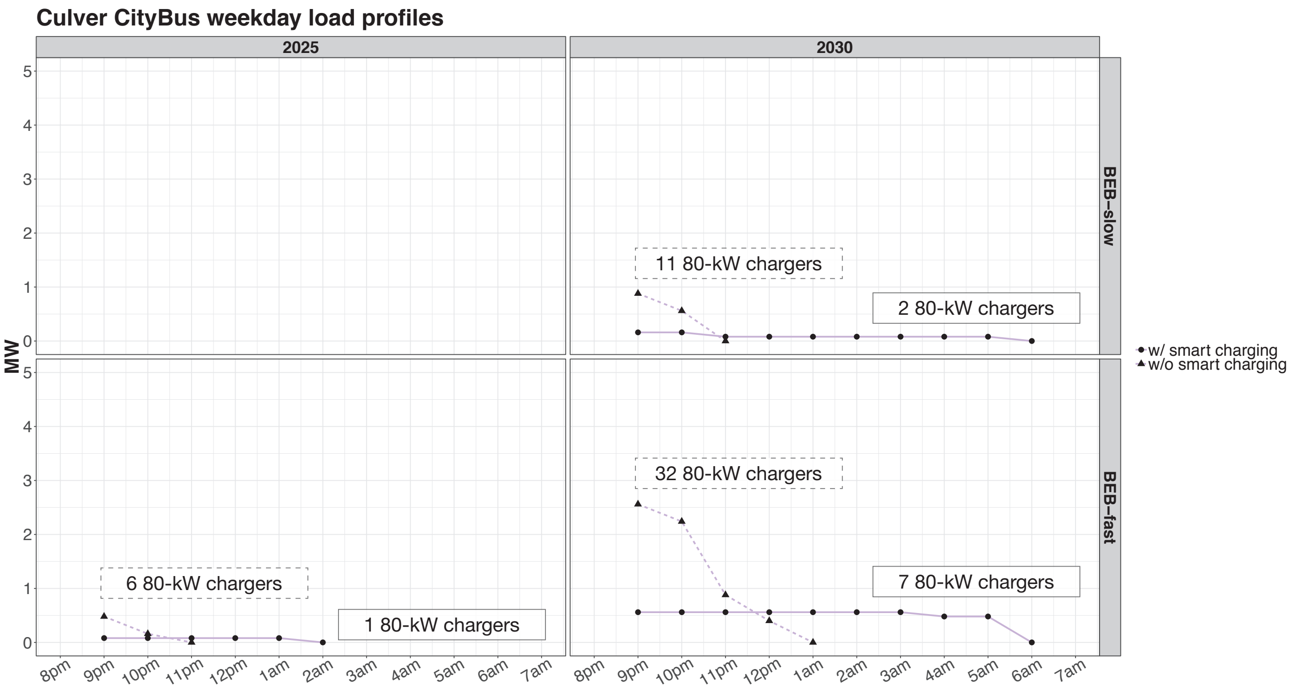
Figure 3.17 Projected Load Profiles of GTrans in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



Culver CityBus Load Profiles

Without the use of smart charging, Culver CityBus would require a peak load of 0-0.5 MW and 0-6 chargers in 2025, as well as a peak load of 0.9-2.6 MW and 11-32 chargers in 2030. With smart charging, the peak load in 2030 would be decreased to 0.2-0.6 MW and only 2-7 chargers would be needed.

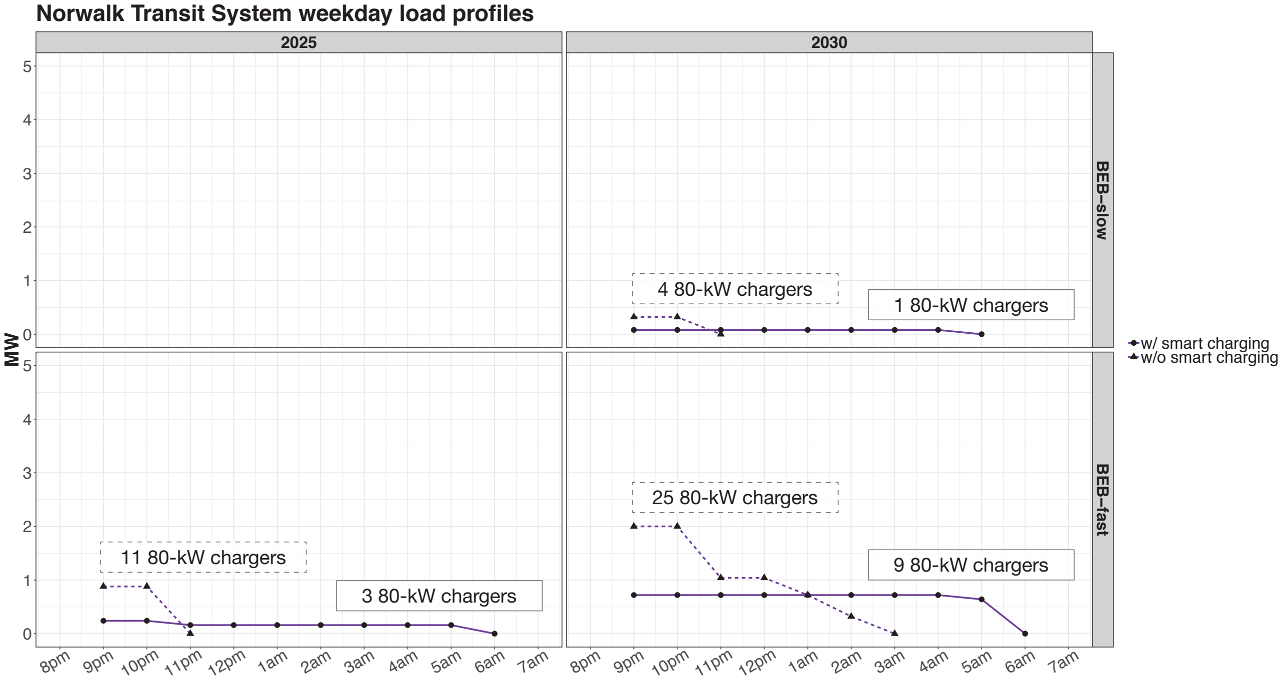
Figure 3.18 Projected Load Profiles of Culver CityBus in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



Norwalk Transit System Load Profiles

The peak load at Norwalk Transit System would increase up to 0.9 MW in 2025 with unmanaged charging and 0.2 MW with smart charging. By 2030, the electrical load would peak at 0.3-2 MW with unmanaged charging and 0.1-0.7 MW with smart charging. The number of chargers needed would decrease by 64-75 percent when smart charging is in place.

Figure 3.19 Projected Load Profiles of Norwalk Transit System in 2025 and 2030 under two BEB Adoption Scenarios and Two Charging Management Scenarios



Implications for Transit Electrification in LA County

Transit electrification reduces tailpipe emissions. With the potential growth of BEBs in the bus fleets, the ten transit agencies together can reduce GHG emissions by 385-457 metric tons per day in 2025 and 694-739 metric tons per day in 2030. This analysis has demonstrated the technical feasibility of transit electrification at major transit agencies in LA County given the scale of current transit services and the current state of BEB technologies and charging solutions. This analysis also indicated the potential grid impacts of deploying standard plug-in charging at bus yards with or without smart charging—a flattened load versus a maximum load.

As illustrated in our results, smart charging would be a critical element in the planning of transit electrification at the facility level. First, it reduces the maximum number of chargers by queuing the charging of all buses instead of having them charged at the same time. Thus, it reduces capital investments on charging equipment's. In addition, the use of smart charging reduces peak load and thus reduces electricity costs when demand charges are in place. We recommend transit agencies to consider the deployment of smart charging for charging control and management.

This analysis is a first step toward a broader study considering cost dynamics associated with BEB technologies, charging solutions, and the corresponding installation, configuration, and potential grid upgrades. The ultimate grid impact is determined by a number of factors: the actual siting of charging equipment (at-depot versus on-route), the connectivity of charging (conductive versus inductive), the speed of charging (standard versus fast charging), the type of BEB technologies (long-range versus short-range), and connection to the utility grid. With certain objectives such as minimizing total costs and minimizing interference with current transit services, the optimal sets of bus and charging combination can be identified for the cost-effective planning of transit electrification.

Metro Local bus in Los Angeles, CA.
Photo editorial credit: 3DMart / Shutterstock.com

3.3 Drayage Trucks Analysis

Drayage trucks transport containerized cargo to or from ports or other intermodal facilities like railyards. Every day a fleet of thousands of heavy-duty class-8 trucks haul freight to and from the ports of Long Beach and Los Angeles. Together, the two ports' [referred to collectively as the San Pedro Bay Ports (SPBP)] container volume throughput is greater than any other port in North America (Ports, 2017). Most of that container volume is transported to and from the SPBP using diesel heavy duty trucks. This concentration of truck activity near the ports and along regional freight corridors connected to the ports causes significant local pollution burdens on nearby communities and contributes to the degradation of regional air-quality in the South Coast Air Basin.

Diesel trucks emit oxides of nitrogen (NOx) and particulate matter (PM) pollution which cause adverse health effects in exposed populations. Health risks from diesel pollutants include asthma, cancer and premature death. (US EPA, 2016). While pollution from drayage trucks impacts the health of people across Los Angeles and the larger region, much of the harm is concentrated on residents in designated disadvantaged communities (DAC) near the port and along freight corridors. Sensitive populations, which include children, seniors and the chronically ill, are particularly vulnerable to the adverse effects of diesel pollution. In addition to causing significant conventional pollution, diesel trucks also emit large quantities of greenhouse gases (GHG).

To remedy the air-quality impacts of drayage truck traffic near the SPBP and across the region, the Mayors of Los Angeles and Long Beach issued a joint memorandum setting a goal to convert the drayage fleet to zero-emission (ZE) vehicles by 2035 (Garcetti and Garcia, 2017). This goal has since been adopted into Los Angeles' Green New Deal. In response, SPBP has proposed a Clean Truck Program to incentivize adoption of ZE trucks starting in 2020 (Ports, 2017). The plan includes a fee assessed on diesel trucks entering the Port, meant to incentivize the adoption of zero and near-zero emission vehicles in the near term while prioritizing only ZE trucks by 2035.

As the name implies, ZE trucks emit no tailpipe pollution, meaning that their use can eliminate the local air pollution impacts of drayage freight movement. While at the moment, the electrical energy used to fuel ZE trucks does emit both air pollution and GHG, the amount that they pollute is considerably less on a mile-per-mile basis as compared to diesel vehicles. Furthermore, as the electricity grid becomes cleaner, so do ZE trucks.

ZE truck development is mostly centered on two fuel-technology platforms, battery-electric and hydrogen fuel cell. A number of studies have identified drayage service as a good early market for Battery-electric trucks. Drayage service is usually limited to in-region goods movement and typically characterized by shorter range duty-cycles dominated by low-speed urban driving, making it an ideal use-case for battery-electric trucks (BET) (Gao et al. 2018; Kelly et al. 2016; CARB 2015). While both battery electric and hydrogen fuel cell vehicles trucks have been successfully demonstrated, BETs have progressed further toward commercial availability (Couch et al. 2018). BETs are therefore likely to make up most if not all of the early ZE drayage fleet. Of the nearly 40 industry responses to the Request for Information (RFI) on Zero Emissions Trucks, Infrastructure and Pilots that LACI issued in Fall 2018 with CARB, the CEC, and the SPBP, three times as many of the responses were focused on BET versus fuel cell vehicles.

Implications of Drayage Trucking

While the advantages of using battery electric trucks over diesel alternatives are many, it is important to consider that BETs can consume significant quantities of electricity. For example, the currently available BYD 8TT class-8 truck has a 435-kWh battery,[5] and the recently announced Freightliner eCascadia will have a 550-kWh battery.[6] BET battery capacity will only grow in the future as per-kWh battery costs fall. To put those numbers in perspective, the Energy Information Agency estimates that the average American household consumes 867 kWh per month (EIA 2015). A BET might use half that amount in a single day.

Recovering that amount of energy requires significant amounts of power, particularly if a truck must be recharged over a short period of time. A truck that operates for only one shift per day, might be able to charge at a relatively slow rate. However, because SPBP terminals are open for two shifts, trucks are often shared between two drivers, operating 18-20 hours a day. Those trucks may have as little as four hours to recover the energy required to run for two consecutive shifts, requiring significant amounts of power.

The high amount of power required to recharge drayage trucks may pose problems for the local distribution grid including feeder circuits and substations, particularly where a large number of charging trucks are geographically clustered. While most charging will happen at night when the trucks are idle and demands on the grid from other users are low, large numbers of charging trucks may cause enough demand to overwhelm feeder or substation capacity.

Objective

UCLA's analysis informs Los Angeles County's EV planning by projecting the energy and electrical load caused by charging battery-electric drayage trucks across potential adoption scenarios. To the extent possible given available data, UCLA attributes that load to a geographic location. This will allow LA County to plan for the impacts that drayage fleet to ZE trucks may have on local energy demand and identify where there may be grid limitations that might hinder electrification progress. In addition, UCLA will quantify the tailpipe-emissions reduction benefits associated with the use of battery electric trucks.

UCLA has conducted this analysis for 2025 and 2030. Because there were no BET drayage trucks in service in 2018, an analysis of the base year is moot. Given the uncertainty in BET adoption trends UCLA has modeled three different scenarios for each year based on low, high and central estimates of adoption rates made by SPBP in their Clean Truck Program planning.

The first output from UCLA's analysis is an estimate of the energy use and power demand caused by charging drayage BETs in Los Angeles County. For a subset of that energy use and power demand where UCLA has accurate spatial data, UCLA will provide a geographic dataset of localized energy and power demand. Power demand is represented by temporal load shapes caused by high-power vehicle charging.

To understand how it might impact the grid, Drayage BET charging demand must be compared to spare circuit capacity on a temporally resolved basis. UCLA has estimated drayage charging loads at drayage yard locations; however, analyzing the interaction of drayage charging loads with grid capacity is beyond UCLA's scope. For this reason, UCLA has collaborated with research partner, Kevala to provide this analysis for two pilot regions, Culver City and the adjacent cities of Pico Rivera and Montebello. In a following chapter in this report, Kevala details the analysis that they have conducted using the outputs from UCLA's analysis.

5 BYD 8TT specification sheet. https://en.byd.com/wp-content/uploads/2018/07/8tt_redesign6-23-18.pdf

6 Freightliner eCascadia specification sheet. https://media.daimler.com/marsMediaSite/en/instance/print/Vehicle-Data-Sheet-Freightliner-eCascadia.xhtml

The second output from UCLA's analysis is an estimate of the reduction in tailpipe emissions of NOx and PM 2.5 (particulate matter smaller than 2.5 micrometers in diameter), and the well-to-wheel GHG emissions reductions associated with the replacement of diesel trucks with BET alternatives.

It should be noted that due to a relative paucity of data and significant uncertainty in the adoption patterns of BETs for drayage service, the geographic charging demand outputs of this exercise are speculative. They are useful to build a general understanding of how drayage trucking might impact the grid. However, this study should not be used to inform specific planning activities. Further data collection and study will be necessary to plan for BET adoption in the drayage sector.

Energy Use Estimate Inputs

Understanding how much energy drayage BETs will consume and how much recharging power they will demand requires an understanding of a) the energy economy (energy consumed per distance traveled) of BETs, b) drayage truck duty cycle characteristics, and c) how many drayage BETs will be brought into service.

Battery-Electric Truck Energy Economy

As of 2018, there was one commercially available BET on the market and five precommercial BETs models in pilot demonstrations at the ports. Both established market players and startups are targeting commercial deployment of their first BETs in the very early part of the 2020's. However, information on the fuel economy of those trucks is limited because manufacturers rarely advertise energy consumption specifications.

To date, only one study has evaluated BET energy consumption performance on standard vehicle test cycles. Researchers at the Center for Environmental Research and Technology at the University of California, Riverside measured the energy consumption of a TransPower BET on a dynamometer that simulates various driving scenarios, such as highway cruising and urban driving. During testing, energy consumption rates varied from 2 to 2.4 kWh per mile (Johnson et al. 2015) It should be noted that these consumption metrics neither included the effects of auxiliary loads nor energy lost during battery charging.

Drayage Duty Cycle Characteristics

Estimating drayage truck energy use is complicated by significant variation in daily trip lengths. Drayage trucks do not follow defined routes; they are dispatched to transport cargo to and from the ports on a load-by-load basis. The same truck might travel half as many miles one shift as it does the next. Furthermore, there is also variation between drayage operators, with some reporting significantly longer average mileage than others. In addition to variation in shift miles, the number of shifts trucks are used for varies, with some operating for one shift and others for two.

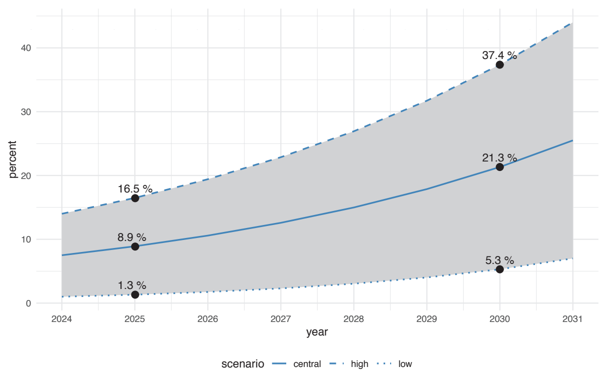
Drayage operations at the SPBP are understudied. To date, the best data on drayage driving is gathered from surveys. In support of their Clean Truck Program planning process, SPBP recently commissioned a study on drayage truck feasibility which included surveys of drayage operators. The survey asked operators about average shift travel distances for the trucks in their fleets. Responses ranged from 12 miles to 300 miles, with a weighted average of 160 miles and a mode of 100 miles per shift (Couch et al., 2018). The same study found that approximately 60 percent of trucks are used for two shifts a day.

Drayage BET Adoption

Given uncertainty in the BET truck market, the adoption of BETs in drayage service is difficult to predict. While there is a policy goal to have all drayage trucks be ZE by 2035, there are no interim policy targets and no binding procurement requirements to inform estimates of adoption.

SBPB staff have projected potential ZE truck adoption as a range of percentages of the overall drayage fleet in both 2024 and 2031. Given the uncertainties involved, SPBP staff estimates cover a wide range of potential BET penetration rates. In 2024, SPBP staff estimate that between 1 and 14 percent of the fleet's trucks will be ZE. By 2031, they predict adoption between 7 and 44 percent penetration of ZE trucks. (Ports 2017) Figure 3.20 shows the interpolated adoption curves for a high, low and central ZE adoption scenario at the ports.

Figure 3.20: Interpolated Adoption Curve for ZE trucks at the Ports



Estimating Energy Use and Power Demand

UCLA's analysis of drayage BET power use is outlined in the steps below:

1. Attribute BET Adoption to Drayage Firms

The firms with drayage trucks registered to pick up loads at the SPBP are diverse both in the number of trucks they have registered, and in the frequency with which their trucks call at the ports. Attributing BET adoption to individual drayage companies (and more specifically to the truck yards they will charge at) is complicated by uncertainty in which companies might elect to adopt BETs. There are no firm-level adoption requirements nor is there reliable data on individual firms' propensity to adopt new technology with which to predict firm-level adoption.

In the absence of other available data, UCLA uses port trip volume as a proxy for propensity to adopt BETs. UCLA believes this to be a reasonable proxy for two reasons: 1) firms that do more business at the ports are more likely to be influenced by port policy levers, and 2) larger (higher volume) firms are more likely to have the technical and financial capacity to support the adoption of BETs. Over time, as BETs reduce in price and the market matures, smaller firms will be more likely to purchase BETs.

UCLA operationalizes this proxy by a) limiting adoption to larger firms (defined as the top decile) for the 2025 scenario year while relaxing that limit (to the upper two quartiles) for the 2035 scenario year, and b) distributing BETs within those limited firms in proportion to port trip volume. While this is an obvious abstraction from real-world adoption patterns, such abstraction is a necessary to forecast adoption patterns under conditions of uncertainty and data paucity.

2. Estimate BET Energy Use

Estimated energy use for trucks was measured by multiplying miles traveled by an average BET energy economy rate. UCLA used the central value (2.2 kWh per mile) of energy use from dynamometer testing conducted by Johnson et al. (2015). Because that testing did not include auxiliary loads or charging inefficiencies, UCLA scaled the energy use metric by an additional 10 percent to provide a buffer for those impacts on energy economy.

Because drayage trucks do not serve defined routes, it is impossible to predict precise energy needs like can be done in analyses of route-based operations common in transit or delivery operations. In the absence of refined operational data, UCLA applied the modal average shift length estimate of 100 miles found by Couch et al. (2018). UCLA used the modal shift length estimate for two reasons: a) the most common response is likely a better central estimate of shift lengths than an average of averages, and b) battery electric trucks will be range-limited and are likely to be used for lower mileage shifts in the near term. Drawing from Couch et al. 2018 findings, UCLA's calculations assume that 60 percent of trucks are used for two shifts and 40 percent are used for a single shift. For two-shift trucks, UCLA doubles the single shift mileage estimate.

3. Estimate BET Power Demand

UCLA based estimates of power demand on truck energy consumption and the amount of time available to recharge. For trucks that drive a single shift, UCLA assumed that charging would be confined to the hours between 9:00 p.m. (when TOU rates switch to off-peak) and 6:00 a.m. (when trucks leave yards in the morning to queue at port terminals). For trucks that work two shifts, UCLA assumed that charging would start at 2:00 a.m. (after the port terminals close) and also conclude at 6:00 a.m. UCLA assumes that all single-shift trucks work the day-time shift.

UCLA's baseline charging assumptions are that chargers will be sized to recover charge deficits in the time allotted, and that charging equipment will be differentiated between single-shift and two-shift trucks. Due to lack of data on the distribution of drayage shift mileage outside of the distinction between single-shift and two-shift trucks, the output of this estimation exercise will best resemble scenario where charging is managed to reduce peaks.

Estimating GHG and Pollutant Emission Reductions

UCLA estimated GHG reductions by comparing electricity GHG emissions factors to counterfactual diesel emissions that would occur if BETs do not replace diesel trucks. To account for full well-to-wheel emissions, UCLA used the carbon intensity pathways developed by CARB for use in the Low Carbon Fuel Standard, to compare the two fuels. (CARB 2019) Because charging will happen overnight, UCLA used an average of the 9:00 p.m.—6:00 a.m. carbon intensity values estimated by CARB. It should be noted that while the electricity grid will become cleaner over the study period, diesel fuels are unlikely to become considerably cleaner in the same time frame.

Because BETs have zero tailpipe emissions, direct air pollutant emission reductions are simply the sum of avoided diesel truck emissions. It should be noted that BETs cause indirect air pollution by relying on electricity derived from combustion sources. However, emissions from electricity production are both significantly less than diesel tailpipe emissions and occur further from population centers, limiting the harms they cause. UCLA used per-mile drayage truck specific emissions factors obtained from CARB's Emissions Factor 2017 to estimate diesel emissions reductions (CARB 2017).

Table 3.9: Per-mile Emissions Factors in Grams Per Mile

	DIESEL	BATTERY ELECTRIC
PM 2.5*	0.38	-
NO_x*	1.51	-
GHG	2286.21	701.40

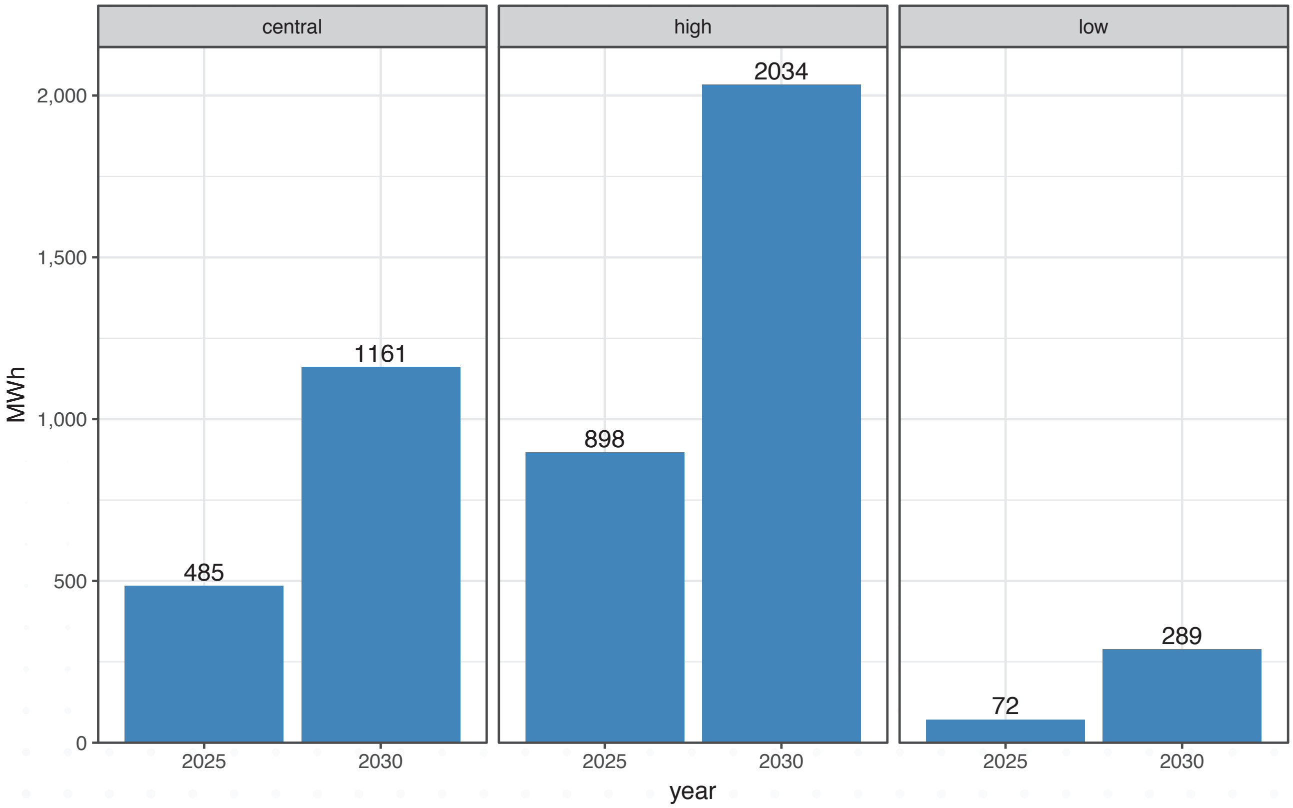
*Tailpipe emissions only

Results

The combined and summary statistics presented here are for all drayage firms serving the ports. Because the location data obtained by UCLA is incomplete, precisely filtering only County locations is not possible. Geolocated energy and load data, where available, is limited to drayage yards reliably located in LA County.

Given the high energy consumption of BETs on a per-mile basis, drayage energy use could be quite significant, particularly in the central and high adoption scenarios. In the central scenario, weekday energy use increases from 485 MWh in 2025 to 1,161 in 2030. In the high scenario energy use by drayage BETs surpasses two GWh by 2030.

Figure 3.21: Total Weekday Energy Consumption Per Scenario (in MWh)



The distribution of drayage companies by size is right skewed, with some larger firms and a high number of small to medium sized firms. In 2025 UCLA assumes that adoption is limited to the upper decile (top 71) of drayage firms. This assumption condenses the distribution of energy demand estimates as early truck adoption is confined to fewer, larger firms. When UCLA relaxes this requirement in 2030, the distribution spreads out, with smaller firms with fewer trucks pulling down the mean and minimum firm energy use values.

Table 3.10: Summary Statistics of Drayage Yard Daily Energy Demand in kWh

	CENTRAL		HIGH		LOW	
	2025	2030	2025	2030	2025	2030
Minimum	3,270	768	6,055	1,347	485	191
Median	5,276	1,799	9,769	3,153	782	447
Mean	6,827	3,243	12,642	5,681	1,012	806
Maximum	19,478	26,175	36,068	45,846	2,888	6,505
n	71	358	71	358	71	358

This pattern is repeated in peak power demand statistics, which are derived from energy demand. It should be noted that the distribution of load in the data is driven by UCLA's choices in how to attribute truck adoption from fleet wide estimates to per-company BET uptake. This distribution is therefore only accurate insofar as fleet size is a good proxy for BET adoption.

Table 3.11: Summary Statistics of Drayage Yard Daily Peak Power Demand in kW

	CENTRAL		HIGH		LOW	
	2025	2030	2025	2030	2025	2030
Minimum	704	165	1,304	289	104	41
Median	1,135	387	2,103	678	168	96
Mean	1,469	698	2,721	1,223	218	173
Maximum	4,193	5,635	7,765	9,869	621	1,400
n	71	358	71	358	71	358

Because data on drayage truck shift mileage distribution is unavailable, UCLA could only estimate energy and power use as a summation of "average" shifts, which is a relatively close approximation of the load that would occur if charging was well managed to avoid high peak loads (and attendant demand charges).

Figure 3.22 shows the estimated load shape for the largest drayage yard (by port trip volume). The shape of the curve is defined by the assumption that some trucks will drive two shifts and some only one. The single-shift trucks plug in between 9:00 p.m. and 6:00 a.m. Because they have only driven one shift, they have less energy to recover and more time to recover it in, meaning that their charging power demand is relatively low. Two-shift trucks drive further distances (on average) during their shifts but have less time to recover energy while idle. This leads to the large peak in energy demand seen between the hours of 2:00 a.m. and 6:00 a.m. Because it is based on average operational characteristics this basic shape is repeated across all truck yards.

In reality some trucks will drive shorter distances, and some will drive longer distances over the course of an average day, meaning that there will be variations in the amount of energy each truck needs to recover. In an unmanaged charging scenario, that would lead to higher peaks at the beginning of charging (at 9:00 p.m. and 2:00 a.m.) and a declining load over time.

Figure 3.22: Weekday Load Shape Between 7:00 p.m. and 7:00 a.m. for Largest Drayage Company

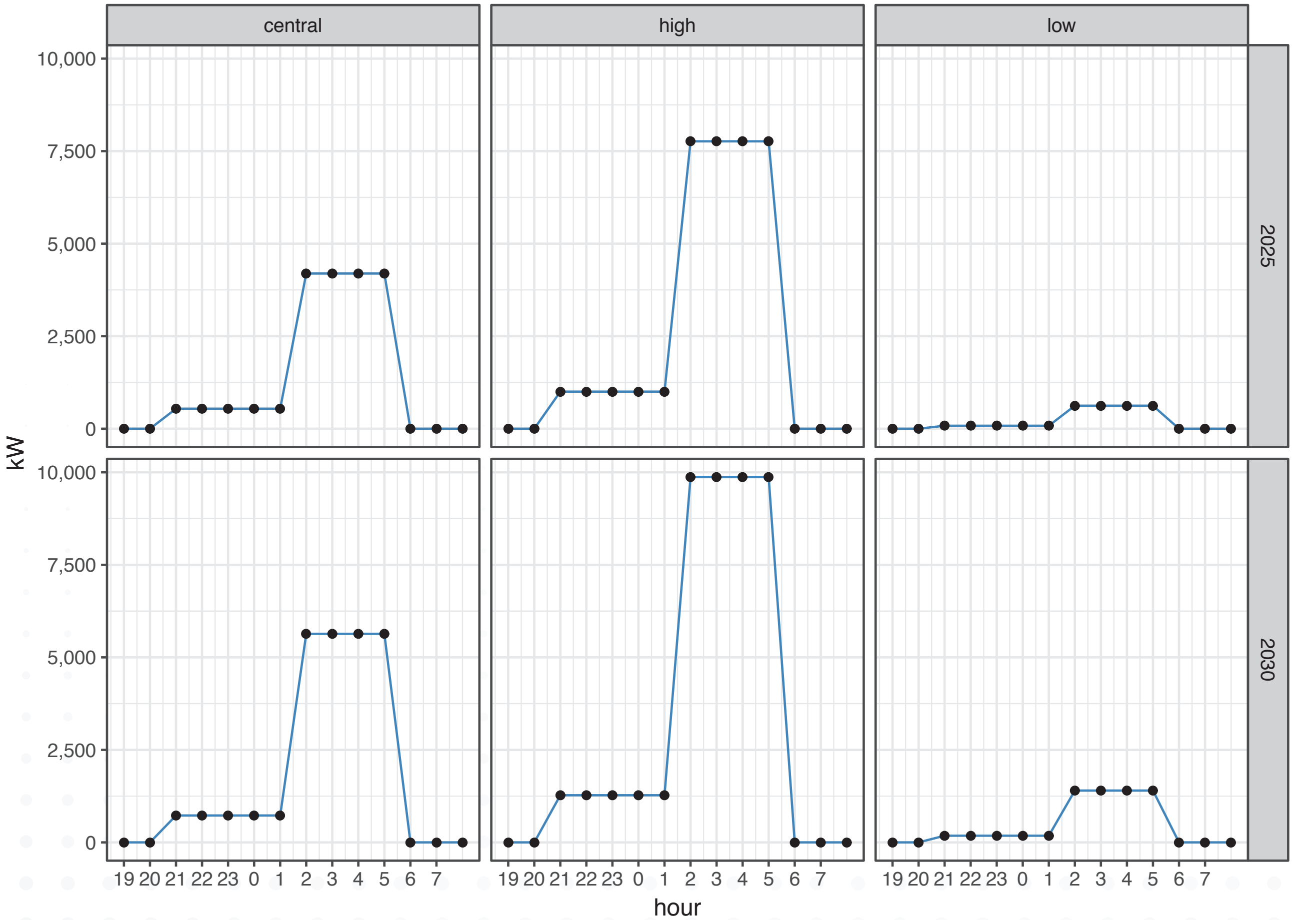
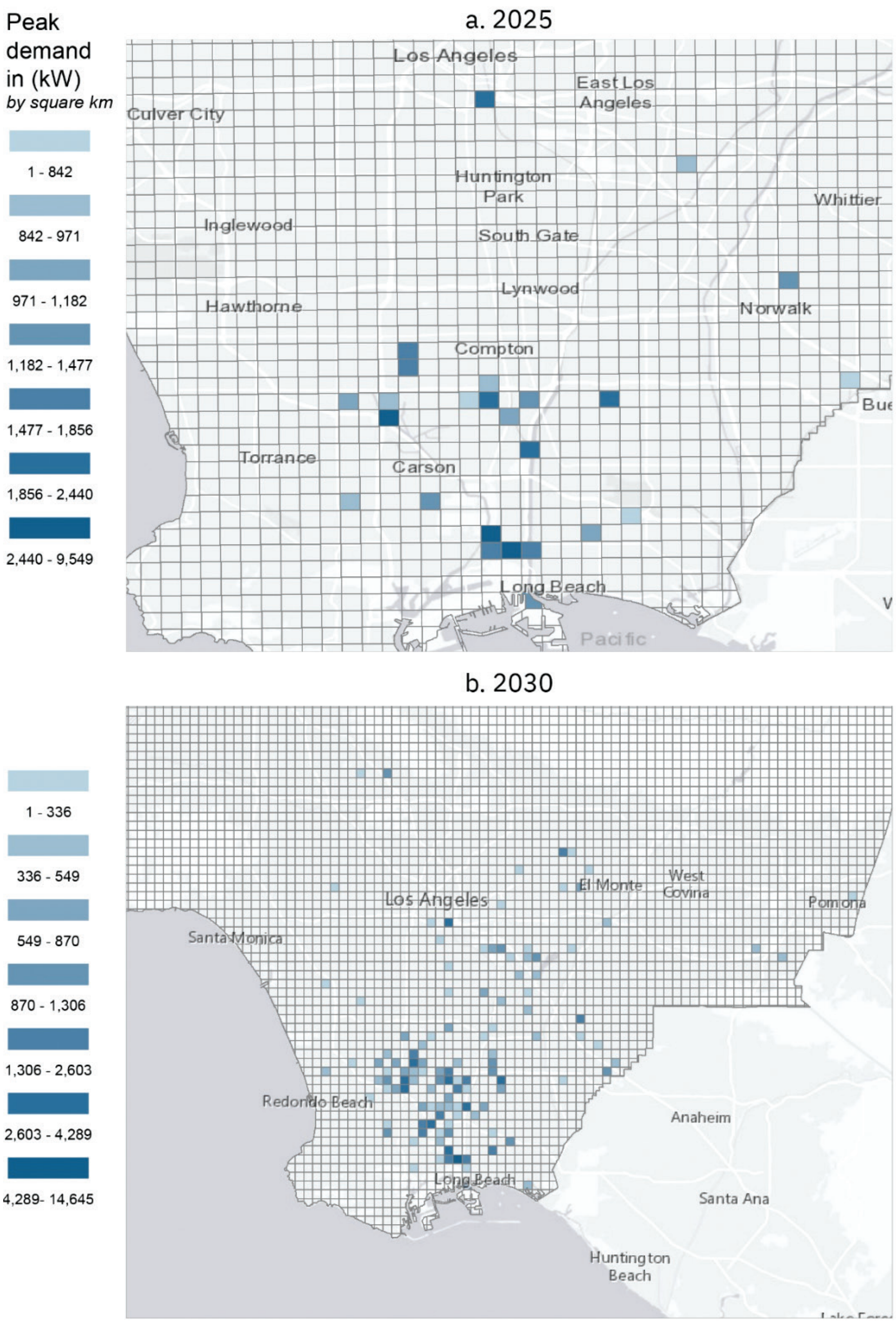


Figure 3.23 shows a map of peak load aggregated into square kilometer grids. Due to limitations in location data quality, the 2025 map only displays data from 34 drayage yards and the 2030 map is limited to 167 locations.

Missing data points make it difficult to draw strong conclusions from the maps in Figure 3.23. However, it does appear that most of the larger firms (those that UCLA assumes will adopt BETs first) are strongly clustered near the Port. When the adoption threshold for firm size is relaxed in 2030, the geographic distribution of energy use and load spreads out significantly.

Figure 3.23: Map of Central Scenario Peak Demand in Central and South LA County *(in square kilometer grids)*



Key Findings

Drayage operations causes concentrated harm on communities near the SPBP and along freight corridors leading to and from the Ports. ZE BETs in drayage service have the potential to significantly alleviate those harms. For example, by 2030 in the SPBP central ZE adoption scenario, the use of BETs could reduce PM 2.5 and NO_x emissions by as much as 5.4 tons and 207.5 tons a year respectively. However, the use of BETs will also require significant amounts of energy and power. In the same scenario year, BETs could consume as much as 1.1 GWh of electricity each weekday. Recovering this power could cause significant stress on the grid, particularly where truck yards with many trucks each are clustered and rely on the same local infrastructure.

Emissions Reductions from BET Drayage Truck Use

If BET adoption occurs relatively quickly (as in the central and high scenario) it will cause significant pollutant emissions reductions in 2025 and 2030. While the amount of emissions reductions in not large as a fraction of total emissions in Southern California, because they are largely concentrated in a narrow geographic region, the benefits will be significant. It is outside of the scope of UCLA's analysis to estimate changes in exposure; however, UCLA expects most of the air pollution reductions shown in Table 3.12 would occur near the ports and along freight corridors. This will reduce exposure in disadvantaged communities (DACs) where residents have historically faced high pollution burdens. Because drayage trucks do not operate exclusively in LA County, some of the emissions reductions shown in the table will occur in neighboring counties.

While the primary purpose of electrifying the drayage fleet is to reduce local air pollution, the GHG impacts are also relatively significant, particularly when considering that drayage is a small fraction of the overall freight industry in Southern California. By 2030 in the central adoption scenario, BET use could reduce GHG emissions by the equivalent of removing almost 50,000 cars from the road.

Future Analytic Considerations

While the present analysis offers a good early approximation of the potential impacts of drayage truck electrification, relative data paucity limits the precision of the study and thus its usefulness to specifically inform planning efforts. Future study in the second round of the EV Ready Communities Blueprint should include efforts to better understand drayage truck operations and firm-level propensity to adopt BETs. Moreover, detailed planning will require a higher quality inventory of drayage yard locations.

In addition, while drayage trucks are specifically facing policy pressure to electrify, they represent only a small fraction of the medium and heavy-duty goods movement fleet in Los Angeles County. As the economics of BETs improve, regional operators such as distribution and parcel delivery fleets will increasingly adopt BETs. Like drayage trucks, the energy requirements for those vehicles will be large. Future study should investigate when, how and where those fleets might charge, to understand the infrastructure constraints that could limit BET adoption among the wider freight sector in the medium to long term.

Table 3.12: Annual Emissions Reductions Associated with Each Scenario

	CENTRAL		HIGH		LOW	
	2025	2030	2025	2030	2025	2030
PM 2.5 *(short tons)*	2.2	5.4	4.1	9.4	0.3	1.3
NO_x *(short tons)*	86.6	207.4	160.3	363.2	12.8	51.5
GHG *(metric tons)*	82,533	197,709	152,827	346,283	12,239	49,135

3.4 Grid Capacity Evaluation and Impacts of Local Charging

As LA County considers options surrounding the future of transportation and developing EV infrastructure, it needs to develop a good understanding of both the changing electricity grid as it evolves to accommodate a high percentage of renewables penetration, as well as of the underlying data and assumptions about adoption levels and consumption patterns.

One such example is the need to account for the growth in EVs and to make assumptions about the rate and locations of adoption, charging patterns, and supporting policies such as timed charging. At the extremes, a large number of EVs charging could either exacerbate reliability issues for the peak hours of electrical demand during the day or potentially increase the ability for the grid to support more renewable generation or higher penetration vehicle electrification without significant impacts to the grid.

Several tools that can provide insight into the capacity of the grid to accommodate additional EVs and the relative value of EV charging based on its location on the grid. This report explores two of these tools and conducts preliminary analysis in the Pico Rivera/Montebello and Culver City regions. The first tool, hosting capacity analysis, identifies MW limits at the feeder level based on the estimated distributed energy resources (DER) load shape, the type of violation that occurred, and the estimated cost of upgrades. The second tool is a component of locational value analysis, which identifies the beneficial value that DERs can have on the electric grid by providing grid services. The locational value of DERs is a much-debated topic and many of the proposed values are not yet realized via utility programs or policies or are in nascent stages of implementation[7]. Kevala's analysis identifies two potential avoided cost values: avoided distribution capacity value, and avoided energy value.

Finally, this report identifies the impacts of charging across two the present year (2018) and future year (2025), holding other variables (e.g., load and distributed generation) constant. This analysis is not the same as load forecasting, but rather isolates the impact of EVs on the grid.

The grid capacity analysis was performed with available public and proprietary data, and models by UCLA and Kevala, and reflects the team's best analysis of grid capacity with the singular focus on identifying potential bottlenecks to growth of EV infrastructure. Southern California Edison has extensive internal analysis and planning capability to identify grid constraints and to plan for as well as meet future load growth; this work is not meant to be a replacement for that work that utilities need to perform, but is rather an alternative tool to help public policy decision makers estimate when and where issues may arise.

About the Study Area

The grid impact analysis focused on two initial study regions, Culver City, and Pico Rivera/Montebello. These two cities represent a small piece of the diversity of Los Angeles County across all metrics, including EV adoption and impacts. Culver City is a part of West LA, while Pico Rivera and Montebello are both considered southeast Gateway Cities.

Culver City

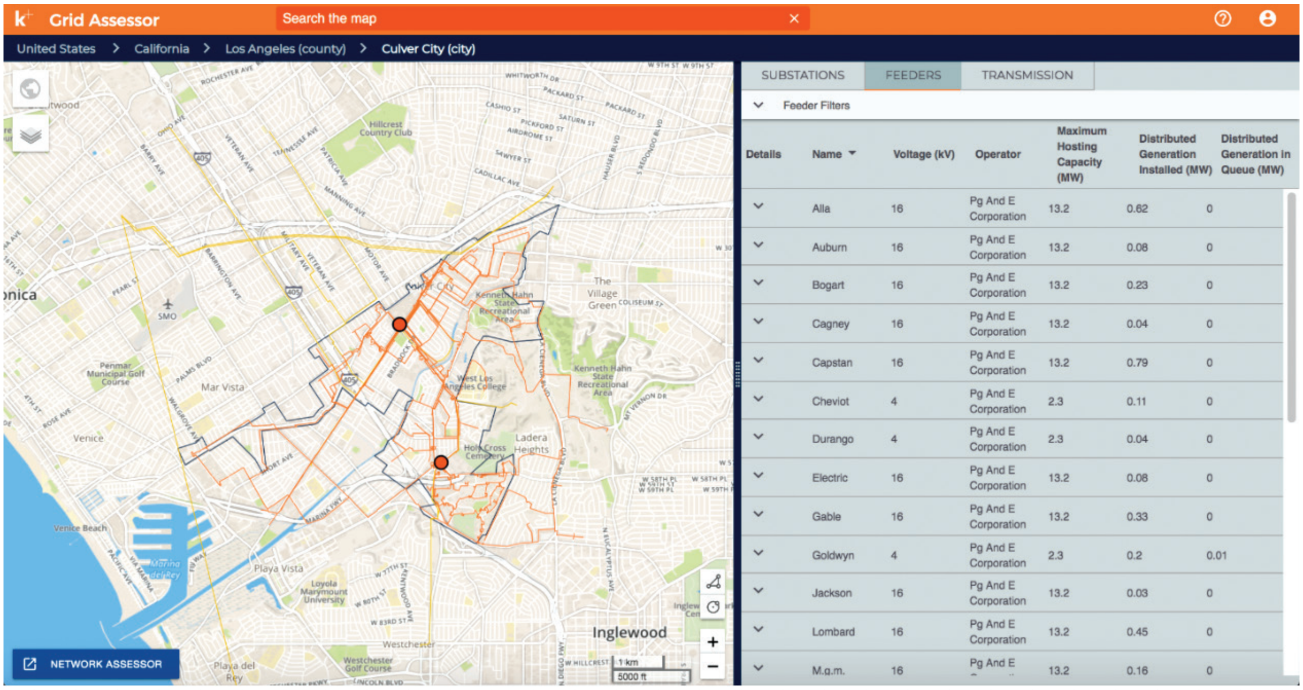
Culver City encompasses 5.14 square miles, with a population of 39,400 residents and a median household income of $86,997. White residents make up 46.8 percent of the population, 24.3 percent are Hispanic or Latino, and 15.7 percent are Asian. The majority of residents in Culver City (77.5 percent) commuted to work in individual vehicles, single passenger, with an average commute time of 24.6 minutes. This commute time is lower than the average LA County commute time (29.2 minutes). Only 6.6 percent of residents carpooled, and only 3.2 percent of residents took public transit as a method of commuting. Two or more vehicles are owned by 72.2 percent of households (48.1 percent of households own two vehicles).

[7] See: California's work on LNBA and New York's Reforming the Energy Vision LMP+D work.

One bus transit yard currently exists in Culver City, located at 1285 Jefferson Boulevard, and connects to the Marlene feeder. Currently, EV adoption is at 1,482 vehicles.

The following distribution infrastructure information (feeders and substations) is identified in Culver City within the Network Assessor platform:

Figure 3.24: Culver City Distribution Infrastructure within Network Assessor Platform (orange dots are substations; orange lines are three phase distribution circuits)



Details	Name	Voltage (kV)	Operator	Maximum Hosting Capacity (MW)	Distributed Generation Installed (MW)	Distributed Generation in Queue (MW)
	Alla	16	Pg And E Corporation	13.2	0.62	0
	Auburn	16	Pg And E Corporation	13.2	0.08	0
	Bogart	16	Pg And E Corporation	13.2	0.23	0
	Cagney	16	Pg And E Corporation	13.2	0.04	0
	Capstan	16	Pg And E Corporation	13.2	0.79	0
	Cheviot	4	Pg And E Corporation	2.3	0.11	0
	Durango	4	Pg And E Corporation	2.3	0.04	0
	Electric	16	Pg And E Corporation	13.2	0.08	0
	Gable	16	Pg And E Corporation	13.2	0.33	0
	Goldwyn	4	Pg And E Corporation	2.3	0.2	0.01
	Jackson	16	Pg And E Corporation	13.2	0.03	0
	Lombard	16	Pg And E Corporation	13.2	0.45	0
	M.g.m.	16	Pg And E	13.2	0.16	0

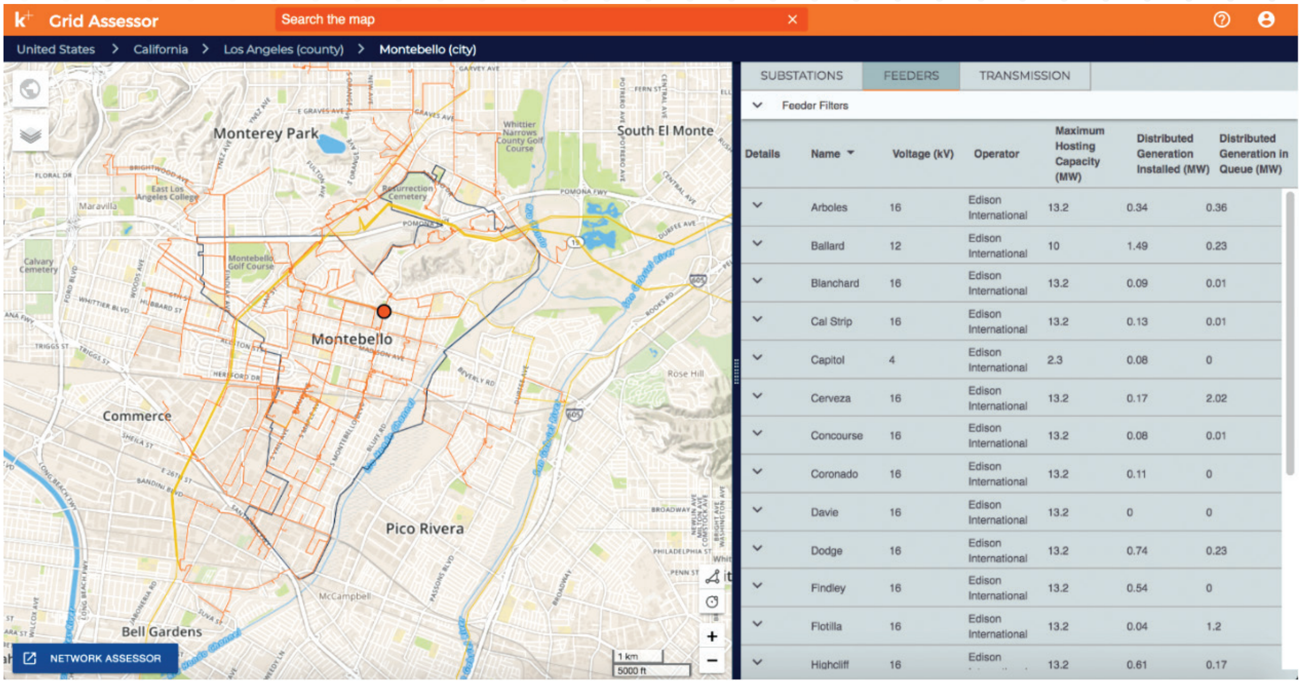
Pico Rivera/Montebello

Pico Rivera and Montebello together encompasses 127,218 residents across 8.88 and 8.37 square miles respectively, with an average median household income of $55,949. Hispanic or Latino residents make up 83.5 percent of the population, 6.64 percent are White, and 7.89% are Asian. The majority of residents in the Pico Rivera/Montebello region (79.5 percent) commuted to work in individual vehicles, single passenger, with an average commute time of 31.4 minutes. This is higher than the average LA County commute time. More residents in the Pico Rivera/Montebello region carpooled (10.3 percent) or used public transit (4.51 percent) as a method of commuting than residents in Culver City. Two or more vehicles are owned by 82.1% of households (36 percent of households own two vehicles).

One bus transit yard currently exists in the area, located at 400 S Taylor Avenue, and connects to the Concourse feeder. Currently, EV adoption is at 1,253 total vehicles, which is smaller than the adoption rate in Culver City. Further, the Pico Rivera/Montebello region is more industrial than Culver City - warehouses comprise 2,522,657 square feet of space in Pico Rivera/Montebello, compared to only 137,963 square feet in Culver City. Finally, a significant majority of residents in Pico Rivera/Montebello (79 percent) reside in a DAC.

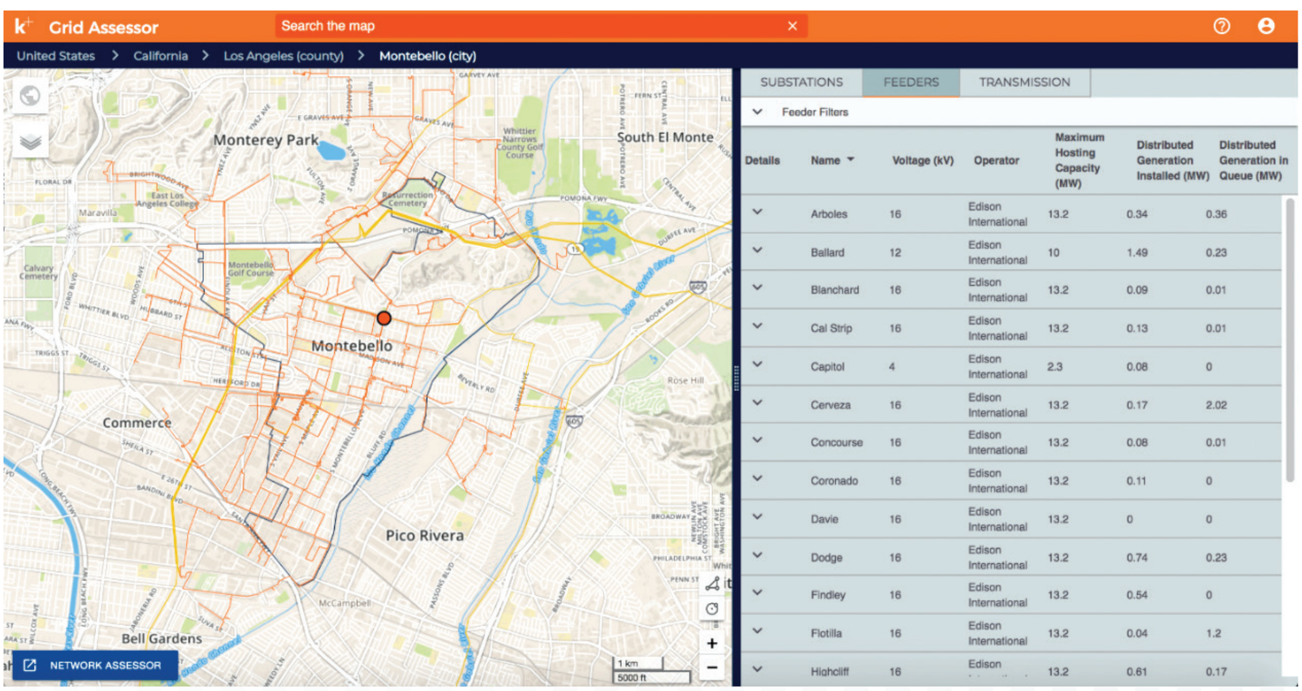
The following distribution infrastructure information (feeders and substations) is identified in Montebello within the Network Assessor platform:

Figure 3.25: Montebello Distribution Infrastructure within Network Assessor Platform (orange dots are substations; orange lines are three phase distribution circuits)



The following distribution infrastructure information (feeders and substations) is identified in Pico Rivera within the Network Assessor platform:

Figure 3.26: Pico Rivera Distribution Infrastructure within Network Assessor Platform (orange dots are substations; orange lines are three phase distribution circuits)



Introduction of Distribution Grid Constraints

Reliable electricity service is frequently defined by adherence to parameters such as the frequency of the alternating current (AC) system, voltage at the customer premise, adherence to thermal limits of the system, and circuit protection equipment protocols and constraints. Distribution grid constraints are operational limitations of the distribution system, caused by excessive load or generation, and resulting in adverse impacts to reliability, safety, thermal limitations, or power quality. These violations can lead to necessary upgrades of distribution infrastructure to resolve the identified problem. Every upgrade has a different cost in dollars based on the type of upgrade required to mitigate the violated criteria. For this analysis, Kevala used its hosting capacity methodology to identify the MW limit requiring a distribution grid upgrade, and an estimated cost range, based on average utility infrastructure equipment costs based on NREL's Distribution Grid Integration Cost Database[8].

This analysis is bound to distribution infrastructure using Kevala's Network Assessor Platform, which integrates load, local generation, and the built infrastructure into one dynamic data analytics platform.

Load

Meeting customer demand for electricity has been the primary purpose of distribution infrastructure since the inception of the electric grid. Individual customer demand for electricity is aggregated on distribution infrastructure and supplied via a combination of bulk power system generation and distributed generation resources. As aggregated demand for electricity on a circuit changes over time, circuit protection and power quality equipment is used to ensure reliable electrical service to all interconnected customers.

Kevala's analysis of load includes its own modeled load at the parcel level and modeled EV load based on UCLA's analysis.

Local Generation

As technology has evolved, the amount and variety of generation devices being interconnected (both behind or in front of the customer meter) to the electric grid via the distribution network has increased. While local generation can be viewed as a mechanism for meeting distribution circuit-specific demand for electricity, the infrastructure utilized to deliver electricity from remote locations present difficulties in integrating large amounts of local generation. Kevala's hosting capacity methodology analyzes the balance of load and local generation in light of these probable historical infrastructure limits.

Kevala uses information about installed distributed generation (DG) systems, nameplate capacity, and actual production to develop 8,760 generation shapes at the aggregated feeder level.

Infrastructure Limits

Historically, utilities have designed their systems to maximize reliability for a broad spectrum of load conditions via switching and power quality equipment. This equipment is generally designed for a variety of conditions:

- To ensure that power is kept within the distribution infrastructure's thermal limits;
- To operate within safe ranges so that voltage and power quality are not violated; and,
- To provide circuit protection for operating conditions such as harmonics while ensuring special circuit protection schemes are maintained.

As the amount of distributed generation increases on a given circuit, utilities may incur expenses associated with balancing these aspects of the distribution circuit while maintaining power quality. Kevala's hosting capacity methodology recognizes that historical distribution circuit designs are likely to incur integration costs in a predictable manner utilizing probabilistic assessments of the combination of load, generation, and circuit topography.

[8] https://www.nrel.gov/solar/distribution-grid-integration-unit-cost-database.html

These three inputs allow Kevala to develop 8,760 hourly annual load shapes and identify whether EV load exceeds common distribution infrastructure limits.

About Hosting Capacity

At a high level, hosting capacity analysis determines the level of distributed energy resources (DERs) that can be integrated on a circuit without violating thermal, power quality, safety, protection, or operational limits and avoid triggering time consuming and costly infrastructure upgrades. Hosting capacity analysis is a useful tool for utilities undergoing grid modernization and who are engaging in the proactive distribution planning efforts needed to meet the increased adoption of DERs. The results of a hosting capacity analysis provide a quantitative appraisal of current and future projected grid limitations for a given set of assumptions.

There are many methodologies for conducting hosting capacity analysis that produce results at varying levels of granularity. In general, the application of any method of hosting capacity analysis is considered more robust than previous standards for interconnection studies which have commonly relied on engineering "rules of thumb." While some hosting capacity methodologies provide single data points at which interconnection studies are triggered or at which a specified level of interconnection expenses are likely to be incurred, Kevala's hosting capacity methodology is designed to provide multiple values related to interconnection costs based on DER penetration.

Hosting capacity can additionally be thought of in two ways, "generation" hosting capacity, and "load" hosting capacity (also known as load carrying capacity). Generation hosting capacity tests how much additional DG can be interconnected on the grid, considering existing load, generation, and infrastructure limits. This hosting capacity tests for multiple limits, including negligible interconnection costs, and larger thermal limit considerations. Load hosting capacity tests how much additional load can be added to individual feeders before requiring upgrades at the feeder and substation level. This report considers EV charging as additional load, however, for future EV use cases (e.g., enabling V2G programs), conducting additional generation hosting capacity analysis may be appropriate.

Methodology

For this report the following limitations are considered:

Aggregated load at the circuit level exceeds feeder load limits: tests whether additional EV load exceeds feeder capacity, resulting in a wires upgrade - in this case, line reconductoring. EV load shapes are added into modeled feeder-level load shapes to obtain a net load shape.

Aggregated load at the substation level exceeds transformer bank: tests whether additional EV load across multiple feeders within the study area exceed MVA ratings at the substation transformer bank, which would result in upgrading transformer banks, building a new transformer bank, or expanding substation capacity. EV load shapes are added into modeled feeder-level load shapes across multiple feeders.

This report does not include analysis on upgrades at the single-phase level. The analysis could be refined over time with the provision of utility data on installed equipment at the single-phase, such as transformers.

For the purposes of the analysis, the following inputs were used across 2018 and 2025 scenarios:

EV charging load shapes: Kevala identified EV charging load shapes based on Assessor's Parcel Numbers (APN), assigned the shape to the likely feeder serving that parcel, and developed a feeder-level aggregated EV load shape.

DG Photovoltaic (PV) installed: Kevala's modeled load shape considers the impact of distributed PV at the feeder level, based on utility-reported PV installed, and Kevala's own methodology to develop PV generation shapes based on installed project characteristics. This study avoids DER forecasting and does not presume an increase in PV adoption between 2018 and 2025, though it is likely that installed projects will increase over time.

Feeder-level load: Kevala's modeled load produces hourly results based on parcel-level load, aggregated up to the feeder level. Information about specific parcel characteristics and other local factors (e.g., weather) are used to develop parcel-specific load shapes. These shapes are bound by distribution feeders.

Load growth: Kevala's analysis considers a 1.5 percent annual load growth.

Distribution infrastructure: Kevala's map of distribution feeders and substations are used to bound the load analysis to utility infrastructure. The same dataset is used for the 2018 and 2025 analysis; that is, Kevala does not assume any additional system changes, such as line reconfiguration or upgrades to feeder kV, between 2018 and 2025. Kevala assumes current equal distribution of load across substation banks; however, associating which feeders are connected to which substation banks is not publicly available data.

Estimated cost: Kevala uses a public database on distribution grid integration unit costs published by NREL to estimate upgrade costs for feeders and substation transformer banks based on size and rating. The 2019 Unit-Cost Database includes estimated costs for the Southern California Edison (SCE) territory. This could be further refined with the provision of utility-specific cost data.

As this analysis focuses on the impact of additional load at the feeder level, the likely costs of other distribution infrastructure, such as transformers, capacitors, or voltage regulators, was generally not quantified.

Southern California-specific unit cost estimates used for this analysis are as follows[9]:

WIRES UPGRADE	ESTIMATED COST
Reconductoring – underground	$80/ft.
Reconductoring – urban	$180/ft.
Reconductoring – rural	$130/ft.
New wood pole line	$150/ft.
230/115 kV	$7,464,000/unit
230/66 kV	$6,850,000/unit
New distribution transformer (3-phase)	$57,600/unit (480 V/750 kVA rating)
Voltage regulator	$180,000/unit (12 kV)
Capacitor bank	$32,200/unit (16 kV/1200 kVar)
Switch – SCADA	$56,000/unit (12 kV)
Recloser	$131,000/unit
DERMS system	$100,000 – $2,000,000/unit (average $1,000,000)
Upgrading from single phase to three-phase	$10 per linear foot

9 Kevala assumes the unit cost of equipment stays the same between 2019 and 2025 and does not apply inflation.

Avoided Cost Analysis: Overview

The value of distribution-level utility avoided costs is a growing area of interest in the United States and elsewhere. States including California (Distributed Resource Planning proceeding, Integrated Demand-side Energy Resource proceeding), New York (Reforming the Energy Vision dockets), and others are developing methodologies to enable resources including PEVs to capture value from the electric grid by providing services that lower utilities' costs. Research institutions including the New York State Energy Research and Development Authority (NYSERDA), the National Renewable Energy Laboratory (NREL), and the Department of Energy (DOE) are actively researching the full spectrum of potential costs and the potential for a broad spectrum of DER to capture this value.

The ability to capture this value remains subject to many regulatory proceedings and, quite probably, utility procurement processes. California has so far identified these values in the Locational Net Benefits Analysis (LNBA) development as part of the CPUC's Distributed Resources Plan (DRP) Proceeding. LNBA work to date identified that DERs can provide both transmission-level and distribution-level benefits, as well as non-energy benefits (e.g., improved land use, non-GHG emissions, etc.). Transmission-level benefits are considered system-level benefits and included benefits such as avoided transmission capacity and congestion costs, while distribution-level benefits are considered more localized benefits and include benefits such as avoided distribution capacity and improved reliability/resiliency. In addition, system-level benefits can have locational components, including avoided capacity and avoided energy benefits.

Kevala identifies two component parts that should be considered in a full locational value analysis: 1) avoided distribution capacity value analysis and 2) avoided energy cost analysis. Both of these analyses are identified at the substation-level.

Avoided Distribution Capacity Value

Avoided distribution capacity value is the practice of assigning an expanding distribution capacity infrastructure to meet peak load on the circuit. DERs can provided avoided distribution capacity services to utilities by modifying their behavior (e.g., charge versus discharge behavior) to avoid adding load when distribution infrastructure is stressed. For LA County, this can be beneficial in understanding how to modify when vehicles charge to avoid these capacity event-hours.

Currently, there is no established market for distribution capacity value, but Kevala expects that this value will become more important in future years as the number of EVs charging on the distribution grid increases. In the short term, EVs provide services to the grid by leveling out demand via specific charging behavior, which can reduce fluctuation and load spikes during the day (similar to how a battery storage system would operate). Over the long-term, high EV penetration rates and uncoordinated charging/discharging behavior could cause the load to become spikier, requiring more active management. Kevala calculates avoided distribution capacity costs at the substation level using the same load shapes, generation shapes, and infrastructure constraints identified in the hosting capacity analysis. Kevala's method identifies the top 1% of peak load and assigns a dollar value to each of those event-hours, based on the total cost of infrastructure, spread over 10 years

(aligned with the average utility distribution planning horizon). The resulting value is a $/MW per hour value that estimates the value DERs can provide to utility distribution planners if they are able to avoid adding load to the system at that hour.

For this analysis, Kevala took the estimated EV load shapes and assigned them to the feeder level to assume load growth. The resulting analysis identifies how distribution capacity event-hours change over time and frequency, with the increased proliferation of EVs.

Avoided Energy Value

Avoided energy value represents the avoided cost of generating and distributing energy at any hour of the year, to better align supply and demand of the system. Kevala calculates avoided energy prices by identifying LMP nodes and day-ahead market prices, and associates LMP nodes to likely electric infrastructure at the substation level. For this analysis, avoided energy values are held constant between 2018 and 2025, as Kevala did not predict how load on the larger system would change future energy prices.

Findings

Kevala conducted analysis on the impact of EV load from bus charging and workplace charging in Pico Rivera/Montebello and Culver City across two sample years, 2018 and 2025. The impacts of each type of EV is first analyzed, then the combined impact on distribution grid is studied in aggregate for the 2025 scenario.

Bus Analysis

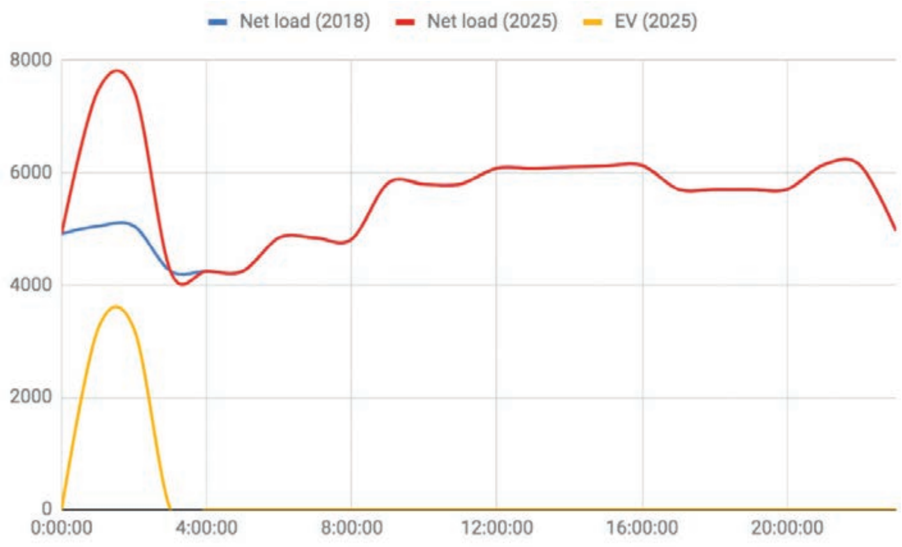
The bus charging analysis analyzes grid impacts based on two sample years (2018 and 2025) and two example scenarios:

- Scenario 1: This scenario only meets the minimum requirements of the Innovative Clean Transit regulation in early years, with a target to reach 100 percent battery electric buses (BEBs) by 2040.
- Scenario 2: This scenario models switching to BEBs as early as possible, as older buses are retired.

Culver CityBus Analysis: Culver CityBus is not expected to adopt any new electric buses under Scenario 1. Scenario 2 projects that Culver City will adopt 10 new electric buses, charging at nighttime between 1:00 a.m.–2:30 a.m. Monday–Friday (total daily load of 820 kWh, 800 kW peak demand) using DC Level 2 chargers. This adoption is predicted by replacement of buses entering retirement. Bus charging connects at the Marlene feeder, a 16-kV feeder running near the east side of Culver City, which is connected to the Culver substation.

Montebello Bus Lines Analysis: This analysis studies both Scenario 1 and Scenario 2 adoption impacts. Scenario 1 assumes that Montebello Bus Lines will adopt 10 new electric buses using DC Level 2 chargers., charging between 1:00 a.m.–2:30 a.m. Monday–Friday (total daily load of 1,000 kWh, 800 kW peak demand), and 1:00 a.m.–2:45 a.m. on Saturday -Sunday (total daily load of 1,080 kWh, 800 kW peak demand). Scenario 2 assumes that Montebello Bus Lines will adopt 39 new electric buses using DC Level 2 chargers, charging between 1:00 a.m.–2:15 a.m. Monday–Friday (total daily load of 3,900 kWh, 3120 kW peak demand), and 1:00 a.m.–2:30 a.m. on Saturday and Sunday (total daily load of 3,580 kWh, 2800 kW peak demand). Bus charging connects at the Concourse feeder, at 16 kV feeder running through the middle of the city of Montebello, connected to the Vail substation.

Figure 3.27: Example of 24-hour Load and Impact of bus Charging in Montebello (Scenario 2, 2025)



Overall Analysis

Analysis shows that EV bus charging on its own will not require reconductoring or other major upgrades to the entire three-phase distribution feeder to solely meet load demand requirements, for either Culver City or Montebello. This is because all of the bus charging occurs at night, when load is low. However, the instantaneous demand of DC fast chargers[10] will require infrastructure upgrades at the charging site to meet ramping requirements, which are currently concentrated in a 1.25 to 1.5-hour window. For example, the utility may require the bus depot to connect chargers directly to three-phase lines. Further, fast charging can have a significant impact on power quality, affecting voltage deviations, phase imbalance, line current harmonics, and more[11]. This will likely require current and voltage control equipment, plus potentially more frequent replacement of existing infrastructure due to higher "wear-and-tear."[12] These impacts are in addition to upgrades required to provide service to the estimated number of bus chargers, including upgrading the transformer, AC/DC converter, and other costs.

Two recommendations to manage EV load integration in 2025 are 1) integration of onsite battery storage systems and 2) managed charging behavior.

First, onsite battery storage systems can be installed to meet a portion of EV charging electric demand locally. There are multiple benefits to installing onsite storage. Storage systems can be charged at times of lowest-cost energy, which may not necessarily coincide with expected bus charging times. Storage could, for example, charge during midday periods when excess solar generation causes low or even negative prices. Consumption of this stored energy can be shifted to meet subsequent EV charging loads by providing energy or ramping services. Storage can support the grid in meeting peak demand, while limiting the distribution system reliability and line losses. Storage can also help bus authorities manage their demand charges, lowering the cost of charging a significant number of vehicles. Finally, integrating storage with intelligent communications software can potentially serve future use cases for batteries, creating new economic price arbitrage opportunities or additional service opportunities (e.g., ancillary services).

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[10] The EV adoption scenarios for 2018 and 2025 presume the adoption of DC Level 2 fast chargers, which usually carry a rating of 200/450 V, 200 A, and a power rating of up to 90 kW.

[11] https://www.sciencedirect.com/science/article/pii/S2215098617315057

[12] These impacts can be better qualified through a power flow analysis study, which is not in the scope of this study.

Next, managed charging can reduce strain on the distribution grid while improving utilization efficiency. Montebello Bus Lines in particular should also determine whether staggered, managed charging of vehicles is appropriate without impacting reliability of bus service, to meet 2025 Scenario 2 goals. Managed charging via controls at the charger would smooth out the load requirements over multiple hours so not all buses are charging at once. This example is shown in Figure 3.28, which represents how nighttime bus charging in Montebello could spread out charging across its estimated 39 bus fleet . As noted by UCLA, managed charging could reduce peak demand significantly, limiting the impact of a fast-adoption scenario (Scenario 2).

Managed charging is not only beneficial to prevent system overloading, but it may also reduce the cost of charging via the utility bill, by reducing demand charges. It should be noted that the expected managed charging behavior can change the expected size and duration of any additional battery storage system installations.

Workplace Charging Analysis

Kevala evaluated the grid impact of workplace EV charging in 2018 and 2025 using its hosting capacity methodology. The results of this analysis can be used to facilitate blueprint studies determining where EV chargers could potentially be better integrated, and which feeders could be targeted for upgrade needs or NWA.

First, Kevala studied the three-phase feeder-level load impact of workplace charging to understand where EV charging occurs, how EV charging impacts load on the circuit, and whether increased EV load will require major grid upgrades to accommodate load (and if yes, what the likely cost may be). To conduct this study, Kevala first identified feeders, kV, and estimated remaining MW capacity on the feeder by using utility planning rules-of-thumb principles and 8760 modeled demand (load) profiles at the feeder level. Known information about installed DG and extrapolated generation data from installed PV projects in the local region was used to develop an 8760 PV generation profile, aggregated to the feeder and net against demand to create modeled net load. Next, Kevala aggregated parcel-level EV charge data to the feeder level and evaluated the impact of additional load to the feeder peak load limit and load capacity utilization. In this analysis, modeled load and PV generation are held constant between the 2018 and 2025 scenarios, to isolate the specific impact of EVs.

Table 3.13 shows each feeder's limit, remaining capacity in 2018 and 2025 after factoring in EV workplace charging load and increase in load factor utilization.

Figure 3.28: Example of Managed Bus Charging in Montebello

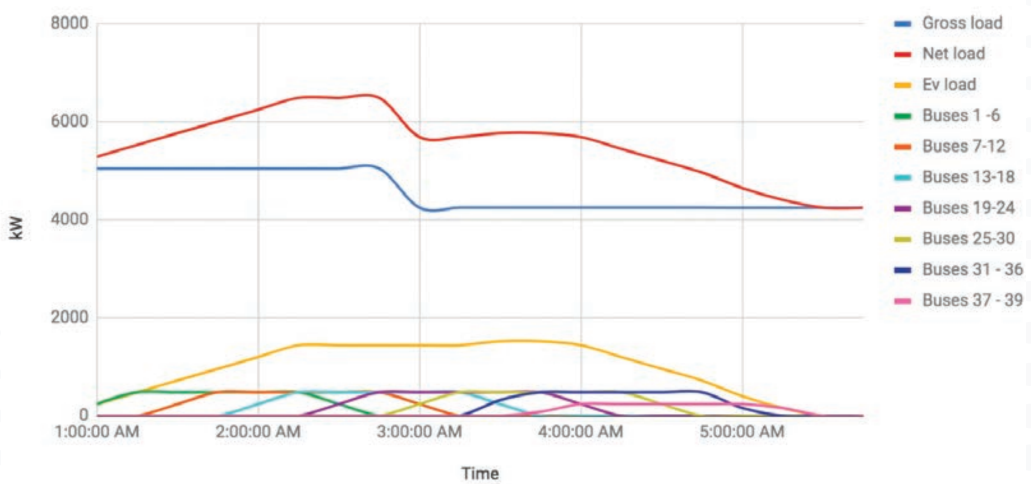


Table 3.13: Feeder-Level Impact of Workplace EV Charging

Substation	Feeder	Max EV load (2018) (kW)	Feeder Level Limit (2018) Remaining Capacity (MW)	Max EV Load (2025) (kW)	2025 Total EV (kWh)	Increase in Load Capacity Utilization (2018–2025) (kWh)	Remaining Capacity (MW) (2025)
Culver	Alla	13.4	9.43	21.02	19,876.59	7,163.86	9.43
Mesa	Arboles	15.24	1.98	22.85	21,608.76	123,192.40	1.98
Narrows	Aston	10.04	1.95	14.80	13,999.48	4,464.44	1.95
Culver	Auburn	41.8	5.90	60.89	58,973.75	19,277.17	5.90
Narrows	Ballard	18.7	1.09	28.42	26,878.49	9,125.23	1.09
Bartolo	Bexley	0.89	0.01	1.38	1,303.24	458.28	0.01
Movie	Bogart	115.95	3.94	186.59	176,544.48	66,357.85	3.40
Narrows	Bronco	8.02	2.83	12.21	11,543.93	3,932.41	2.83
Narrows	Cadillac	0.005	1.56	0.01	6.89	2.21	1.56
Movie	Cagney	27.27	7.49	44.40	42,007.86	16,095.42	7.49
Laguna Bell	Cal Strip	18.48	5.30	27.62	26,124.15	8,570.50	5.30
Newmark	Capitol	15.86	0.01	23.99	22,688.62	7,622.69	0.01
Culver	Capstan	0.054	4.76	0.08	77.38	25.67	4.76
Mesa	Cerveza	18.45	0.92	27.66	26,157.08	8,640.83	0.92
Culver	Cheviot	4.94	9.97	7.62	7,206.36	2,522.57	9.97
Gallatin	Church	2.21	1.32	3.23	3,049.08	952.71	1.32
Vail	Concourse	39.39	3.08	59.04	55,844.75	18,420.96	3.08
Mesa	Coronado	1.82	7.51	2.75	2,598.38	874.71	7.51
Narrows	Corvette	0.063	2.79	0.09	87.10	27.13	2.79
Vail	Davie	16.4	4.47	24.51	23,183.76	7,606.63	4.47
Passons	Decosta	0.49	1.74	0.70	665.50	200.45	1.74
Gallatin	Deuce	94.64	3.29	144.43	136,571.44	46,711.19	3.29
Laguna Bell	Dodge	27.79	4.39	41.54	39,286.32	12,888.59	4.39
Culver	Durango	50.16	0.18	74.15	70,154.74	22,495.67	0.18
Bartolo	Durfee	0.09	0.07	0.76	720.22	234.70	0.07
Culver	Electric	0.007	11.26	0.07	68.49	23.55	11.26
Narrows	Escamilla	0.089	0.02	0.13	124.06	39.88	0.02
Vail	Findley	0.3	0.64	0.44	420.33	139.24	0.64
Vail	Flotilla	3.65	1.53	5.51	5,206.27	1,740.16	1.53
Movie	Gable	33.29	5.56	55.27	52,290.00	20,659.70	5.56
Gallatin	Gaspar	8.897	1.89	13.09	12,661.35	4,216.36	1.89
Culver	Goldwyn	11.56	0.01	17.37	16,415.68	5,447.82	0.01

Substation	Feeder	Max EV load (2018) (kW)	Feeder Level Limit (2018) Remaining Capacity (MW)	Max EV Load (2025) (kW)	2025 Total EV (kWh)	Increase in Load Capacity Utilization (2018–2025) (kWh)	Remaining Capacity (MW) (2025)
Culver	Jackson	7.02	10.01	10.45	9,887.31	3,214.05	10.01
Narrows	Julep	3	0.87	4.52	4,275.24	1,431.34	0.87
Mesa	Lomas	0.8	1.26	5.86	1,191.00	430.83	1.26
Movie	Lombard	13.37	8.46	21.60	20,428.78	7,725.11	8.46
Vail	Malden	44.88	0.63	67.33	63,679.61	21,057.27	0.63
Culver	Mar Vista	28.29	6.57	43.86	41,462.58	14,607.25	6.57
Culver	Marlene	14.43	6.37	21.05	19,900.09	6,205.79	6.37
Rivera	Maxine	1.03	0.01	1.53	1,441.04	457.83	0.01
Culver	Mesmer	13.42	0.01	19.74	18,656.42	5,917.96	0.01
Culver	MGM	592.26	11.26	864.64	818,284.04	255,321.73	10.99
Passons	Millergrove	20.59	1.84	31.07	29,382.43	9,832.49	1.84
Culver	Overland	8.03	0.27	12.35	11,672.66	4,048.56	0.27
Culver	Pancake	2.02	0.65	2.96	2,798.44	878.26	0.65
Culver	Pathe	2.62	8.66	3.83	3,616.82	1,133.93	8.66
Rush	Peck	15.86	2.96	23.99	22,688.62	7,622.69	2.96
Gallatin	Perkins	3.43	2.75	5.02	4,747.60	1,492.18	2.75
Culver	Rimpau	8.81	0.01	12.60	12,229.96	3,861.23	0.01
Culver	Runway	14.91	9.99	21.91	20,718.15	6,554.90	9.99
Bartolo	Sanka	3	0.01	4.55	4,299.98	1,450.25	0.01
Rivera	Serapis	1.03	0.01	1.53	1,441.03	457.82	0.01
Culver	Servo	43.23	0.33	64.67	61,151.67	20,104.86	0.33
Gallatin	Stamper	59.569	1.74	90.89	85,941.51	29,382.15	1.74
Culver	Stevens	6.77	0.31	10.09	9,539.71	3,113.09	0.31
Gallatin	Stoakes	0.89	1.66	1.34	1,267.60	422.79	1.66
Rivera	Sunglow	0.87	0.01	1.27	1,198.20	369.09	0.01
Rivera	Topeka	1.93	0.04	2.80	2,644.15	811.14	0.04
Narrows	Torpedo	2.96	2.53	4.44	4,193.40	1,386.83	2.53
Vail	Tube	22.51	1.72	33.65	31,829.47	10,442.26	1.72
Rivera	Unity	0.08	0.01	0.11	108.19	33.80	0.01
Passons	Vicki	34.22	0.13	52.00	49,167.22	16,677.89	0.13
Culver	Wesley	2.76	0.34	4.03	3,809.50	1,181.88	0.34
Vail	Yates	40.16	8.67	60.02	56,768.91	18,619.14	8.67

This analysis suggests that reconductoring of circuits, due to exceeding load carrying capacity limits, is not expected during the 2018–2025 time period for the pilot cities. In aggregate, workplace charging will likely add 2.4 MW of load between 7:00 a.m.–9:00 a.m. It is likely that there would be a greater impact on single phase than three-phase conductors due to simultaneous load increases between 7:00 a.m. and 9 a.m. (e.g., transformer upgrades), which may be analyzed in future studies.

In Phase 2, Kevala's cost analysis study will explore if the substation transformer bank is near capacity. If it is found that the answer is no, then estimated costs will be composed of the reconfiguration of circuits to accommodate new load, if there is available capacity on nearby feeders. If the answer is found to be yes, then estimated cost will reflect the addition of a new substation transformer bank, assuming there is room at the substation for growth.

For example, to accommodate additional load at the Topeka/Unity feeders, the utility would likely reconfigure existing feeders, as there is capacity on neighboring feeders and at the substation transformer bank. It also may propose a new 4 kV line, depending on other growth factors in the area, or upgrades to existing feeders, depending on the age of existing installed equipment. At the Durango feeder, the utility would likely consider reconductoring the existing line to ensure it can accommodate continued growth as it approaches its carrying capacity limit over the next ten years.

The minor impact to load carrying capacity is likely due to the estimated timing of workplace charging, which is modeled to occur primarily between 7:00 a.m. and 9:00 a.m. on weekdays, when SCE's distribution system is not normally constrained. Load carrying capacity is designed to accommodate the highest peak demand on each circuit. Even though the MGM feeder adds 818,284 kWh of load between now and 2025, this load is not simultaneous with system peak, and does not require upgrades to the circuit to accommodate the additional load.

This study hopes to identify an initial path forward to analyzing grid impacts of EV charging and should not be taken as comprehensive recommendations on where the grid should or should not be upgraded. It should be emphasized that the lack of additional impacted feeders is due primarily to the timing of the estimated workplace charging load. Shifting that estimated load by just a few hours can significantly impact the carrying capacity of the feeders.

Finally, multiple variables can impact when peak load occurs, and change our understanding of whether the timing of EV charging impacts the load carrying capacity at the feeder. Future analysis on EV charging and grid impacts should consider the following:

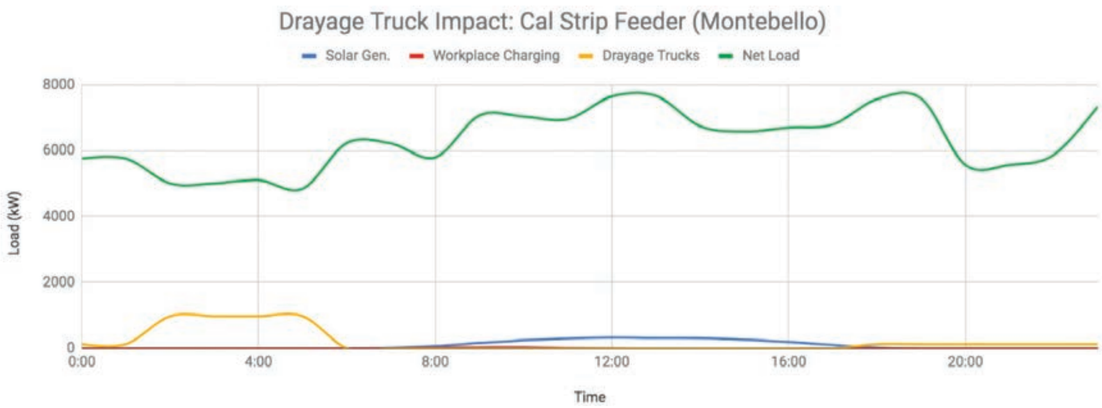
- PV adoption forecasts and solar plus storage forecasts
- Load growth forecasts, including percent change and changes to the load shape due to changing consumption patterns, adoption of new rate structures (e.g., time of use rates)
- Other DER adoption forecasts, including residential EV charging.

Drayage Truck Impacts

UCLA and Kevala identified a likely drayage yard in Montebello at 1400 Date St, Montebello, CA 90640, where drayage trucks are expected to charge for 11 hours per day – 970 kW/h between 2:00 a.m.–5:00 a.m., and 125.24 kW/h between 6:00 p.m.–2:00 a.m. This drayage yard is expected to charge at the Cal Strip feeder, connected to Laguna Bell substation.

The feeder is expected to retain 5.3 MW of capacity, even considering daytime workplace charging and 11 hours of drayage truck charging. This is due to both time of charging and expected load. For instance, drayage load is expected to impact evening peak on the feeder and at the substation level, but the total expected load is 125.24 kW per hour, well under the feeder's load carrying capacity. Upgrades at the drayage yard will likely be needed to accommodate potential ramping requirements. Trucks are expected to increase their charging load between 2:00 a.m.–5:00 a.m., when the grid is not stressed. This is illustrated in Figure 3.29, using modeled 2018 gross feeder load.

Figure 3.29: Example Impact of Drayage Truck Demand on Feeder Load



It is important to note that the potential impact in Montebello is not indicative of larger grid impact in LA County. First, the county expects that more significant drayage truck charging will occur in other cities by 2025, including Carson, Compton, Gardena, and Long Beach. For example, drayage charging in Long Beach expects to total 18.2 MW in 2025 at 3:00 a.m. For the city of Long Beach, it will be crucial to understand the specific charging patterns and likely feeders that EV chargers are expected to interconnect.

The feeder-level impact on peak load is also expected to be more significant for other cities, particularly as drayage trucks are expected to begin charging during the evening peak (6:00 p.m.). Additional study should also be done to determine whether overnight bus charging and overnight drayage truck charging coincide on the same feeders or substations, given the similar expected times of overnight charging. Finally, this study should include likely impacts of residential overnight charging.

As a next step, the same hourly time series analysis is needed for all cities in the LA County region to evaluate coincident impact of multiple types of EV charging to the distribution grid.

Substation Impacts and Distribution Capacity Value Analysis

Substation-Level Impacts

Kevala studied the aggregate impact of EV charging (workplace charging, drayage charging, and bus charging) at the substation-level, to determine whether increased EV load across multiple feeders would require upgrades to the substation, such as upgrading or installing a new transformer. This analysis used publicly available substation transformer ratings and MVA capacity values but did not use transformer age or headroom capacity. The analysis also did not have access to information regarding transformer-feeder configuration, and instead dispersed feeder load evenly across substation transformers.

This analysis assumed that PV and load growth (absent EVs) would be held constant between 2018–2025, to isolate the impact of EV charging load. Kevala additionally assumed a conservative power factor of 0.9 and studied transformer headroom capacity in an 85 to 120 percent utilization range. This assumes that substation upgrades likely show up in a utility's 10-year distribution planning process as it approaches 85 to 90 percent capacity. While transformers can accommodate temporary loading over their rated capacity, it has a significant impact on the expected life of the equipment. This range of analysis allows Kevala to provide a best guess estimate on likely upgrades, without knowing current age and remaining lifetime expectancy of installed transformers.

Table 3.14: Substation-Level Impacts

Substation	Associated Feeders with EV Load	City	Transformers	Estimated 2018 Peak Loading (MW)	Estimated EV Aggregate Peak (2025)	% Load Utilization Factor Increase (2018–2025)	Estimated Impact
Bartolo	Bexley, Durfee, Sanka	Pico Rivera	3 12/4 kV transformers	6	0.01 MW	>0.00%	N/A[13]
Culver	Alla, Auburn, Capstan, Cheviot, Durango, Electric Goldwyn, Jackson, Mar Vista, Marlene, Mesmer, MGM, Overland, Pancake, Pathe, Rimpau, Runway, Servo, Stevens, Wesley	Culver City	2 115/12 kV transformers; 56 MVA	45.69	1.53 MW	3.63%	~86% of transformer bank capacity
Gallatin	Church, Deuce, Gaspar, Perkins, Stamper, Stoakes	Pico Rivera	2 66/12 kV transformers 45 MVA	43.61	0.26 MW	2.4%	~102% of transformer bank capacity
Laguna Bell	Cal Strip, Dodge	Montebello	2 66/16 kV transformers; 56 MVA	55.22	0.97 MW	0.53%	~104% of transformer bank capacity
Mesa	Arboles, Cerveza, Coronado, Lomas	Montebello	3 69/12 kV transformers, 2 66/16 kV transformers, 75 MVA	54	0.05 MW	0.02%	~76% of transformer bank capacity
Movie	Bogart, Cagney, Gable, Lombard	Culver City	2 66/16 kV transformers, 45 MVA	29.4	0.31 MW	0.08%	~69% of transformer bank capacity
Narrows	Aston, Ballard, Bronco, Cadillac, Corvette, Escamilla, Julep, Tornado	Pico Rivera	4 66/23 kV transformers; 90 MVA	81.8	0.011 MW	>0.00%	~96% of transformer bank capacity
Newmark	Capitol		6 66/4 kV transformers, 2 66/16 kV transformers, 28 MVA	13.2	0.02	0.02%	~50% of transformer bank capacity
Passons	Decosta, Millergrove	Pico Rivera	66/12 kV transformers	44.8	0.03	0.01%	N/A[14]

13 Kevala did not find publicly available information about transformer MVA for this substation.

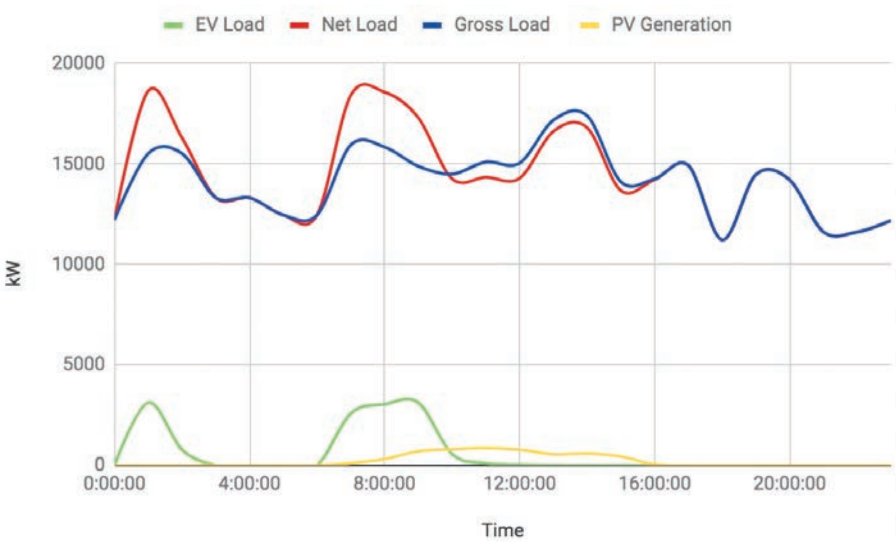
14 Kevala did not find publicly available information about transformer MVA for this substation.

Substation	Associated Feeders with EV Load	City	Transformers	Estimated 2018 Peak Loading (MW)	Estimated EV Aggregate Peak (2025)	% Load Utilization Factor Increase (2018–2025)	Estimated Impact
Rivera	Maxine, Regina, Serapis, Sunglow, Topeka, Unity,	Pico Rivera	2 12/4 kV transformers; 21 MVA	11.8	0.01 MW	>0.00%	~59% of transformer bank capacity
Rush	Peck	Montebello	4 66/16 kV transformers, 101 MVA	97.7	0.02 MW	>0.00%	~102% of transformer bank capacity
Vail	Concourse, Davie, Findley, Flotilla, Malden, Tube, Yates	Montebello	4 66/16 kV transformers; 106 MVA	103.91	0.25 MW	0.24%	~103% of transformer bank capacity

Takeaways from the substation-level analysis show that EV charging (both workplace and bus charging) increase load utilization at the substation. EV workplace charging itself does not greatly impact substation upgrade requirements, due to the timing that the load appears on the system (7:00 a.m.–9:00 a.m.). Kevala expects that some substations are already at or over capacity at the individual transformer bank. For these nearly overloaded transformers, expected EV charging load may exacerbate existing transmission capacity constraints, depending on the charging coincidence with peak. While this overloading can be mitigated without transformer replacement, it is still costly and may only prove to be a temporary fix.

Notably, EV charging has the ability to change the load profile at the substation level for areas expecting increased EV load. One such example is at Culver substation, where both bus charging EV and workplace charging could be significant enough to change the Culver substation from a primarily evening-peaking system to a morning-peaking system.

Figure 3.30: Sample Daily Load at Culver Substation (January 2025)



Distribution Capacity Value Analysis

Understanding when distribution capacity value occurs and the associated cost can help LA County understand specific locations where it might be more or less valuable to shift or limit charging, to avoid impacts to distribution infrastructure. Kevala's distribution capacity analysis is conducted at the substation level. The following time blocks are used to characterize occurrence of DCV hours:

- **Morning**: 6:00 a.m. – 10:00 a.m.
- **Midday**: 11:00 a.m. – 4:00 p.m.
- **Evening**: 5:00 p.m. – 12:00 p.m.
- **Overnight**: 1:00 a.m. – 5:00 a.m.

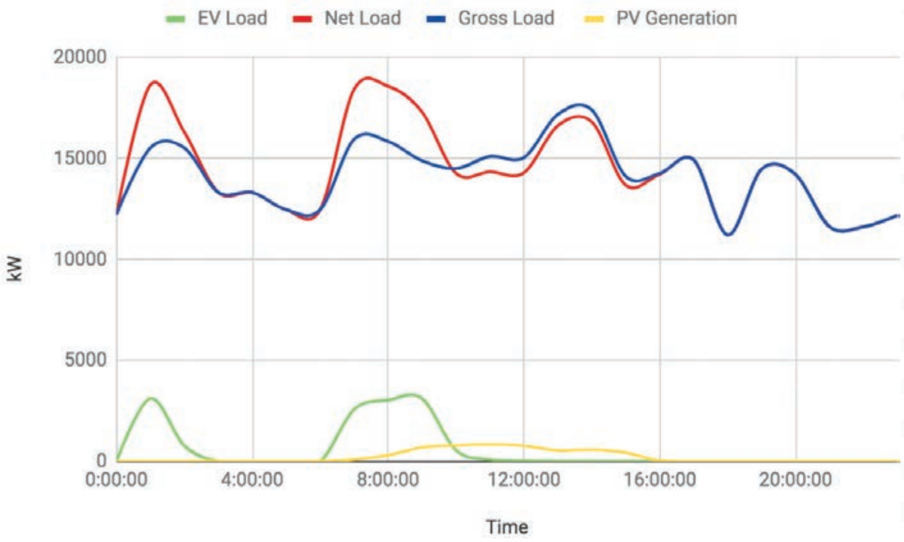
Substation	Associated Feeders with EV Load	City	Transformers	DCV ($/MW-hour)	Current Substation Characterization – DCV Hours	Substation Characterization – Impact of EVs (2025)
Bartolo	Bexley, Durfee, Sanka	Pico Rivera	3 12/4 kV transformers	N/A[15]	Primarily midday peaking (87%), followed by evening peak (13%)	No significant change
Culver	Alla, Auburn, Capstan, Cheviot, Durango, Electric Goldwyn, Jackson, Mar Vista, Marlene, Mesmer, MGM, Overland, Pancake, Pathe, Rimpau, Runway, Servo, Stevens, Wesley	Culver City	2 115/12 kV transformers; 56 MVA	$2,465.12	Primarily evening peaking (67%), followed by midday (18%), morning (8%), and overnight (7%)	Primarily morning peaking (59%), followed by evening (27%), overnight (11%), and midday (5%)
Gallatin	Church, Deuce, Gaspar, Perkins, Stamper, Stoakes	Pico Rivera	2 66/12 kV transformers 45 MVA	$2,209.30	Primarily evening peaking (49%), followed by midday (46%) and morning (5%)	Primarily morning peaking (52%), followed by midday (34%) and evening (16%)
Laguna Bell	Cal Strip, Dodge	Montebello	2 66/16 kV transformers; 56 MVA	$2,465.12	Primarily midday peaking (62%), followed by evening (38%)	No significant change
Mesa	Arboles, Cerveza, Coronado, Lomas	Montebello	3 69/12 kV transformers, 2 66/16 kV transformers, 75 MVA	$1,651.16	Primarily midday peaking (77%) followed by evening (24%)	No significant change
Movie	Bogart, Cagney, Gable, Lombard	Culver City	2 66/16 MVA transformers, 45 MVA	$2,209.31	Primarily midday peaking (88%) followed by evening (12%)	No significant change
Narrows	Aston, Ballard, Bronco, Cadillac, Corvette, Escamilla, Julep, Tornado	Pico Rivera	4 66/23 kV transformers; 90 MVA	$3,255.81	Primarily evening peaking (63%), followed by midday (22%), morning (8%), and overnight (7%)	No significant change

15 Kevala did not find publicly available information about transformer MVA for this substation.

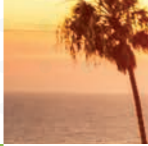
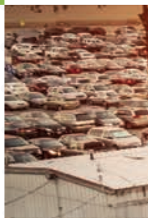
Substation	Associated Feeders with EV Load	City	Transformers	DCV ($/MW-hour)	Current Substation Characterization – DCV Hours	Substation Characterization – Impact of EVs (2025)
Newmark	Capitol		8 66/4 kV transformers, 15 MVA	$1,511.62	Primarily midday peaking (81%), followed by evening (19%)	No significant change
Passons	Decosta, Millergrove		66/12 kV transformers	N/A[16]	Primarily midday peaking (81%), followed by evening (19%)	No significant change
Rivera	Maxine, Regina, Serapis, Sunglow, Topeka, Unity,	Pico Rivera	2 12/4 kV transformers; 21 MVA	$1,651.16	Primarily midday peaking (73%), followed by evening (23%) and morning (5%)	No significant change
Rush	Peck	Montebello	4 66/16 kV transformers, 101 MVA	$3,511.63	Primarily midday peaking (82%), followed by evening (16%)	No significant change
Vail	Concourse, Davie, Findley, Flotilla, Malden, Tube, Yates		4 66/16 kV transformers; 106 MVA	$3,627.90	Primarily midday peaking (86%), followed by evening (14%)	No significant change

Absent other load forecast impacts, EV load is expected to significantly change load shape and peak load for the Culver and Gallatin substations between 2018 and 2025. These substations would change from primarily evening-peaking systems to morning-peaking systems. Overnight-peaks also become more frequent than midday-peaks at the Culver Substation, due to significant overnight bus charging.

Figure 3.31: Distribution Capacity Value Hour Occurrence–Culver Substation (2025)



[16] Kevala did not find publicly available information about transformer MVA for this substation.

SECTION 4: EV Ready Community Action Plan

Los Angeles County has a robust suite of direct state, federal, and utility incentives to take advantage of when deploying the EV charging infrastructure needed to meet regional needs. However, a limited number of other financial resources exist to offset the capital and operational costs associated with EV charging stations. These resources include funding from the Volkswagen Settlement, Electrify America, Low Carbon Fuel Standard (LCFS) credits, California Environmental Quality Act (CEQA) mitigation credits, and ChargeBack planning.

4.1 Market Based Solutions for Regional Implementation

Volkswagen Settlement

Appendix D of the Volkswagen Settlement allocated settlement funding to states proportional to the number of non-compliant diesel Volkswagen vehicles sold in each state to reduce excess mobile source nitrogen oxide (NOx) emissions caused by their operation. California was allocated $423 million; in May 2018, the California Air Resources Board (CARB) released its Beneficiary Mitigation Plan (BMP) which outlines how the State plans to spend the funding.

Over the 10-year life of the plan, California is expected to reduce NOx emissions by 10,000 tons through the deployment of clean vehicle technologies and replacement of aging diesel vehicles. Rather than focusing purely on cost-effective NO_x emissions reductions, California is broadly taking the Volkswagen Settlement as an opportunity to accelerate the commercial deployment of zero-emissions vehicle technologies and focus on improving economies of scale for these technologies.[1]

CARB takes a balanced approach in allocating BMP funding across the spectrum of Eligible Mitigation Actions and in many cases, specifies that at least half of investments must be made in areas that benefit disadvantaged communities (DACs).[2] The majority ($290 million) of funding is dedicated to incentivizing zero-emission buses (ZEBs), class 8 trucks, and port vehicles and equipment. However, the BMP specifies that funding can be used toward the purchase of associated charging equipment of these heavy-duty and off-road EVs, providing another significant stream of funding for zero-emission vehicles (ZEVs) that are deployed in LA County.[3]

The BMP also allocates $10 million (2 percent of total funding) toward the deployment of light-duty ZEV infrastructure, which includes both charging stations for EVs and hydrogen fueling stations for fuel cell electric vehicles.[4] For charging stations, the

1 https://ww2.arb.ca.gov/resources/documents/californias-beneficiary-mitigation-plan

2 *Id.*

3 https://ww2.arb.ca.gov/sites/default/files/2018-07/bmp_june2018.pdf

4 CARB has a goal to split the funding evenly between charging stations and hydrogen fueling stations.

BMP may cover up to 100 percent of the cost of publicly accessible charging stations at government owned property, up to 80 percent of the cost to deploy publicly accessible stations at privately owned properties, and up to 60 percent for non-public charging at workplaces and multi-unit dwellings (MUDs). At least 35 percent of charging infrastructure deployed is expected to benefit DACs.

Electrify America

Electrify America (EA) is a subsidiary of Volkswagen Group of America and was established in conjunction with the settlement outlined above to develop a National Zero Emission Vehicle Investment Plan and invest $800 million is required to be spent in California between 2017 and 2027, and EA is the entity tasked with implementing the Zero Emission Vehicle Investment Plan.

Cycle 1

EA has divided its investment plan into four 30-month cycles—each with a planned investment target of $200 million in California.[5] The first cycle began in 2017 and ends in 2019, and includes four primary investment categories: highway DCFC stations (~$75 million), community L2 and DCFC stations (~$45 million), a Green City initiative for the city of Sacramento (~$44 million), and a public education and awareness campaign (~$20 million).

In its final Cycle 1 investment plan, EA anticipated having approximately 50 highway sites operational by mid-2019 across California and leveraging approximately five interoperable 150+ kW DCFC chargers for many highway-based locations. EA expects that I-5 will receive the greatest number of DCFC highway sites, followed by US-101, I-10, I-15, and I-80. Roughly 25 percent of stations will be located in DACs identified by CalEnviroScreen.

For community-based sites, EA selected five California metropolitan areas to focus its initial investment: Los Angeles, San Francisco, San Diego, San Jose, and Sacramento. EA's community-based network will include multi-unit dwellings (MUD), workplace, commercial locations, community fast-charging depots, and municipal parking areas. EA anticipates activating a cumulative 350 community-based stations by mid-2019. According to DOE's Alternative Fuels Data Center, there are 14 operational EA stations in California—four located in the greater LA region.[6]

Finally, EA has initiated a multi-media, brand neutral EV awareness campaign to encourage California drivers to go electric. The primary messages in the consumer-focused campaign intend to convey how EVs already meet the needs of many drivers today, and as more advanced and accessible charging options become available, barriers to adoption will continue to decline. EA launched the campaign on a wide variety of media, including TV, digital radio, social media, websites, and other media partnerships.

5 https://elam-cms-assets.s3.amazonaws.com/inline-files/California%20ZEV%20Investment%20Plan%20Cycle%201.pdf

6 https://afdc.energy.gov/stations/#/find/nearest

Cycle 2

EA's Cycle 2 Investment Plan for California was submitted to CARB on October 3, 2018 and was approved on December 13, 2018.[7] EA's plan largely builds off of the foundational investments planned in Cycle 1 but includes several shifts and areas for new engagement.[8]

Approximately $95-$115 million will be spent to expand EA's community-based charging network, including expanding the network in the five original metro areas identified in Cycle 1. Community DCFC investments will continue to be targeted at retail and MUD locations; however, EA will also deploy stations designed specifically to serve shared mobility use cases, such as car share, taxis, and transportation network companies. The greater LA region should expect to see 14–18 new community stations from this investment cycle. EA will also develop a number of residential home charging resources and solutions ($8–$12 million) aimed at lowering barriers to residential L2 charging deployments, make investments to support bus and shuttle charging ($4–$6 million), deploy L2 chargers in rural areas outside of the prioritized metro regions ($2 million), and pilot charging stations specifically designed for autonomous vehicle charging ($2–$4 million). EA is scaling back its highway DCFC investment to $25-$30 million, aiming to deploy four chargers per site and moving toward a greater emphasis on regional highway routes and reinforcing Cycle 1 interstate investments. Most sites will serve light-duty vehicles, but a select few may be targeted for medium- and heavy-duty EVs. In all, EA expects Cycle 2 will yield up to 3,460 new sites with up to 3,300 of those sites being residential locations.

Building off of Cycle 1, Cycle 2 calls for $17 million for consumer education and outreach activities to build EV awareness and increase EV adoption. EA will employ a combination of traditional media advertising, digital engagement, and live EV events to encourage more consumers to research and become familiar with EVs. The company will also develop targeted marketing ($10 million) to increase utilization and awareness of its existing charging stations, including signage.

Finally, pursuant to CARB guidance, EA aims to invest 35 percent of the total Cycle 2 budget in or targeted for low-income and disadvantaged communities. In sum, Electrify America's investment plans play an important role in overcoming infrastructure and awareness-related barriers to EV adoption in the LA region. Continued engagement with Electrify America will be critical to ensuring that future investments meet County needs and that lessons learned from innovative pilots can be modified and scaled to meet regional goals.

Low Carbon Fuel Standard (LCFS)

The Low Carbon Fuel Standard (LCFS) Program is another potential funding mechanism that can offset the operational costs associated with EV charging. The LCFS, administered by CARB, is a market-based mechanism that lowers the carbon intensity (CI) of transportation fuels in California with a goal of reducing the CI of the transportation fuel pool by at least 20 percent by 2030. Transportation fuels with a CI below the declining CI standard, like electricity, generate credits that can be sold to regulated parties that need to obtain credits to comply with the standard. Electric Vehicle Service Providers (EVSPs), fleet operators, battery switch station owners, site hosts for EV charging stations, transit agencies, and utilities can all opt into the LCFS and sell credits that are generated when EVs charge at their stations.[9] CARB estimates that with an LCFS credit price of $150/metric ton, LCFS credit revenues could be equivalent to approximately 12 cents per kWh of charging.[10] While the LCFS may be an attractive option for charging station operators seeking to monetize the value of EV charging, operators will likely need to aggregate credits in order to sell quantities that are sufficient for larger transactions that take place in

7 https://media.electrifyamerica.com/en-us/releases/42

8 https://elam-cms-assets.s3.amazonaws.com/inline-files/Cycle%202%20California%20ZEV%20Investment%20Plan.pdf

9 https://www.arb.ca.gov/fuels/lcfs/guidance/regguidance_16-04.pdf

10 The current price of an LCFS credit is around $183/ton. https://www.arb.ca.gov/fuels/lcfs/credit/lrtweeklycreditreports.htm visited May 17, 2019

the secondary market for LCFS credits. More detail on LCFS and its interaction with EV charging station economics is covered in the Chargeback Analysis section of this report.

California Environmental Quality Act (CEQA)

EV charging stations could also be used as a GHG mitigation measure on a project-by-project basis for developer compliance under CEQA.[11] In cases where developments need to demonstrate greater emissions reductions to comply with CEQA regulations, EV charging stations (and incentives) may be deployed off-site. For example, the Newhall Ranch development in LA County established three mitigation measures related to EV charging stations, including 20 off-site EV charging stations that could count toward the emissions reductions requirements for the development and be located at retail locations, workplaces, recreational centers, schools, or other public facilities.[12] Although this approach is project-specific and dependent on other emission mitigation efforts, development emissions reductions required under CEQA may create new funding streams for EV charging stations from developers needing to demonstrate sufficient emissions mitigation.

ChargeBack Analysis

The County identified the cost of installing and operating the charging ports between 2020 and 2030 (with a total of 10,000 charge ports deployed by 2030). The costs are captured in Appendix B, the full ChargeBack Plan—capital expenditures, electricity costs (at a rate of $0.135/kWh and utilized at 6,000 kWh per port per year), O&M costs, and LCFS credit revenues (at $130/ton). In addition, ICF included a ChargeBack rate, which is the rate charged to users of the Level 2 equipment. In the reference case below, we show the revenue from a ChargeBack rate of $0.30/kWh.

There are a variety of steps the County and partners can take to offset charging program costs to yield a revenue neutral program by 2030. For instance:

- If looking solely to capital expenditures on installation and hardware, the costs would need to be decreased by about 40 percent over the course of implementing the program, which is a reduction from $9,000 per charge port to about $3,600 per charge port or $7,200 per Level 2 EVSE. This is an aggressive cost reduction that will be difficult to achieve. However, other opportunities are more likely. For instance:
  - A $1,000 decrease in the cost of the EVSE alone would yield about $6.9 million in savings.
  - An incentive of $5,000 per EVSE, either from a utility program or state-administered program that was available through 2025 would yield savings of $12.3 million.
- For every $0.01/kWh that electricity costs are reduced from the default rate of $0.135/kWh, presumably through some managed charging or price signal (e.g., via TOU rate), then electricity costs will decrease by $3.45 million.
- Similarly, for every 1,000 kWh of increased station utilization, the program will generate an additional $15.3 million in revenue.
- For every $10/ton increase in LCFS credit prices, the program would generate an additional $2.7 million in revenue. At today's credit prices of between $180 and $190/ton, that would yield an additional $14.7 million of revenue over what is shown in Table 4.1
- If the ChargeBack rate is increased to $0.31/kWh, then the program would generate an additional $3-4 million in revenue (depending on the utilization of the equipment).

11 https://www.sccgov.org/sites/dnz/Documents/Task-3D-EV-Charging-Stations-as-GHG-Mitigation-Mechanism-under-CEQA_White-Paper.pdf

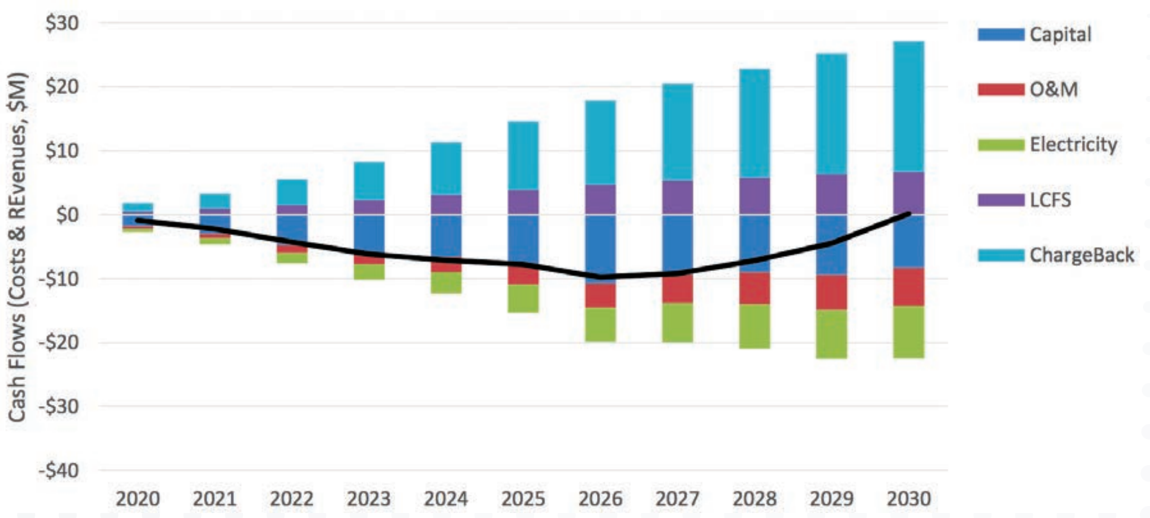
12 *Id.*

The table below illustrates the sensitivity to the assumptions outlined above, and shows that when these modest changes are implemented, the program is revenue neutral by 2030.

Table 4.1. Cash Flow Sensitivity to Different Cost Parameters

COST / REVENUE PARAMETER	DESCRIPTION OF CHANGE	PROGRAM IMPACT
Net Program Cash Flow Without Cost Reduction Strategies		-$38.6 million
Lower EVSE Price	Decrease EVSE cost by $1,000 through bulk installations	$6.9 million
Incentive	$5,000 incentive per EVSE through 2025	$12.3 million
Electricity Rate	Decrease rate by $0.01/kWh via managed charging	$3.5 million
Charge Port Utilization	Assume a utilization rate of 6,600kWh	$10.1 million
Higher LCFS Credit Price	Increase LCFS credit price by $10/ton to $140/ton	$2.7 million
Increased ChargeBack Rate	Increase ChargeBack Rate to $.31/kWh	$3.3 million
Total Change in Cash Flow		**+$38.8 million**
Net Program Cash Flow by 2030		**+$.2 million**

Figure 4.1 Modified Costs of Deploying and Operating 10,000 Charge Ports in Los Angeles County



In this modified version, the program shows a slightly positive net cash flow by 2030 of about $0.2 million, and by 2027, the program is generating net revenue on a year-over-year basis with about 7,500 charge ports deployed.

4.2 EV Ready Community Outreach Strategy

As previously discussed, substantial charging infrastructure investments coupled with key legislation will contribute to growing EV adoption and penetration not only throughout the state but regionally. Facilitating this needed growth in EV adoption and infrastructure investments will require significant buy-in and broad-based public engagement strategies that provide meaningful opportunities for stakeholder and public involvement. Early and sustained public involvement can provide cost savings, time savings, and broader outreach to all stakeholders. In addition, public engagement allows for better, more durable achievement of project goals and more effective use community assets.

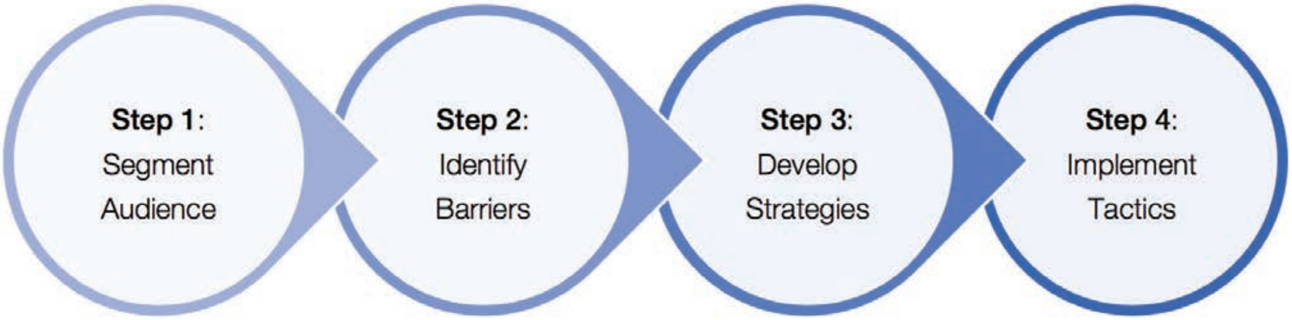
Public engagement produces clear and more valuable input for decision-making. In addition to providing information to citizens, local governments can obtain valuable input. Access to information and electronic communications allow citizens to more effectively share their views and affect decisions. New technologies for resident engagement, including social media and other digital applications, are expanding opportunities to reach and gain feedback from new audiences.

In implementing an EV Ready Community, a local government must have an outreach plan that provides a comprehensive communications strategy that reaches multiple public audiences coupled with key stakeholder engagement so that key partnerships can support outreach efforts and play an important role of increasing awareness on PEV adoption and the benefits to the community and surrounding public.

The following sub-sections provides a step-by-step guide in formulating a strategic outreach plan for an EV Ready Community deployment. Following this subsection, an overview of current ongoing regional stakeholder engagement efforts and opportunities within the County of Los Angeles is also provided.

Outreach Strategy

To ensure an EV Ready community outreach plan is fully integrated, and in line with the communities' goals and objectives, the Community could utilize the following process:



Step 1. Segment Audience

Audience segmentation will enable a community to focus on groups that can be realistically reached with available resources and will allow a community to motivate distinct groups to adopt certain strategies based on their needs and values.

These segments include but are not limited to:

- Consumers (EV Buyers)
- Charging Station Site Hosts (Property Owners)
- Charging Station Site Hosts (Employers)
- Transit Riders
- Local Governments (Fleet Owners)
- Trade Associations

Step 2. Identifying Barriers

Once the audience has been segmented, identification of common concerns and misperceptions must be identified for each segment. This will allow for common messages to be developed that can be utilized to reach each sub-segment. These messages will be supported with customized themes addressing issues unique to each group.

Table 4.2 provides some common concerns and misperceptions currently associated with a sub-set example of possible segmented groups within a region.

"Los Angeles County has a robust suite of direct state, federal, and utility incentives to take advantage of."

Table 4.2. Common Concerns and Misperceptions to TE Implementation

AUDIENCE SEGMENT	BARRIERS
Consumers	• Lack of awareness of EVs and their capabilities: Many consumers have not experienced what it is like to drive an EV. In addition, they have misperceptions regarding the safety, performance and range of an EV. • Financial barriers: Many consumers find EVs to expensive. They also have concerns around installation of charging infrastructure in their homes and the may also be unaware of the incentives available to do so. They may also be unaware of the incentives to buy or lease an EV.
Charging Station Site Hosts (Employers)	• Charging infrastructure costs: Costs primarily composed of hardware, permitting and installation. • Ongoing operation and maintenance costs: Changes to commercial electricity rates, demand charges, charging network fees, fixes to EVSE components and the need for new parts due to breakdown or vandalism. • Physical and organizational considerations: Employers of all sizes need to plan for workplace charging at each site. Parking spots need to be close to available electric services. In addition, safety consideration needs to be addressed (e.g., lighting, pedestrian hazards, etc.) and accessibility regulations (i.e. ADA requirements)
Charging Station Site Hosts (Property Owners)	• Charging infrastructure costs: Costs primarily comprised of hardware, permitting and installation. Unaware of available state and federals grants to defray deployment costs. • Financial split incentive: Charging stations are not necessarily profitable and thus present an expense. Property owners similar to businesses typically must meet a rate of return on any large property expense.

Step 3. Develop Strategies

Once barriers have been identified targeted messages must be developed that aim to change the mindsets of the audience segments by addressing their specific issues and concerns. These strategic messages. Outreach strategies should assuage fears by providing information that overcome misperceptions and increase awareness of what will be available. An EV Ready Community primary message should convey that EV infrastructure is coming and describe the benefits EV infrastructure will provide to the community.

Table 4.3 provides a list of identified strategies that can be utilized by a regional community in preparation for EV readiness. For reference, only a subset of segments has been identified as an example.

Table 4.3. EV Ready Community Message Strategies by Segment

	BARRIER	STRATEGY
Consumers	Lack of awareness of PEVs and their capabilities	• Targeted messages that are conveyed through channels where they live, work and play. • A central hub website.
	Financial barriers	• EV Ready community website that details all information regarding available EV discounts.
Employers	Charging infrastructure costs	• Funding is available; provide information on subsidies • Connect site hosts with financing offers
	Ongoing operation and maintenance costs	• Provide information on the associated long-term benefits
	Physical and organizational considerations	• Provide information on available solutions and preparation for planning ahead
Property Owners	Charging infrastructure costs	• Funding is available; provide information on subsidies
	Financial split incentive	• Provide information on the benefits of the new amenity • Provide information on being a brand differentiator

Step 4. Implement Tactics

Last and most importantly, an EV Ready Community outreach strategy must include campaign tactics with specific actions to carry out strategy and goals. Table 4.4 outlines the tactics that will help carry the EV Ready Communities' messaging strategies to the targeted audience groups.

Table 4.4. EV Ready Community Tactics

TACTIC	
1. Develop a suite of marketing collateral	• Create compelling and engaging suite of collateral tailored to each audience focused on gaps and needs that are easily adapted to social media. • To be utilized across website, email, social media and in-person encounters. • Collateral includes but not limited to: – Fact Sheets – Ads – Infographic – Poster – Social Media Plan – Campaign Image library specific to the EV Ready Community
2. Develop a branded, community-facing, central hub website	• Develop a resource hub (behind a login) containing marketing materials and templates. This will help maintain brand consistency while being able to customize the pieces to meet local needs. • Draft content to provide information that caters both the consumer group and the charging station hosts. Focus on listing information resources that will facilitate decision-making. • Add interactive elements (video testimonials, etc).
3. Conduct a campaign launch	• Utilize press releases with specific local and regional print and radio media outlets.
4. Conduct a targeted paid media campaign	• Traditional and digital advertising • Paid Search (Google Keyword Search) and Paid Social (Facebook ads).
5. Utilize social media to drive awareness	• Utilize the communities' social media pages to drive awareness, grow and engage audiences.
6. Promote at events and conferences	• Consumer events, employer events
7. Engage employers and property owners	• Leverage lunch and learn opportunities at local chambers of commerce.
8. Conduct email marketing	• Develop a series of email campaigns that will inform and drive web traffic to the EV Ready Community website.

4.3 Stakeholder Engagement

A central goal shared by all EV readiness plans is to foster an engaged network dedicated to supporting PEV adoption and charging station deployment by building lasting relationships among a diverse set of partners. These partners can include:

- State and local policymakers and staff
- Regional planners and municipal planning organizations (MPOs)
- Utility companies
- Developers and business owners
- Charging station providers
- Automobile dealers and manufacturers
- Vehicle fleet or operations managers

To deliver a plan with maximum buy-in, it is necessary to get wide representation as early as possible in the process and encourage strong participation. Wide representation ensuring participation from multiple levels of stakeholders. Stakeholder engagement strategies that could be pursued include at the minimum:

1. Identifying initial partners
2. Establishing working groups to gather information and analyze community needs
3. Building community awareness and participation through public events

Once relationships have been established and stakeholder engagement strategies have been implemented, fostering these relationships should begin so that they can strengthen the collaborative platform for implementing their recommendations, increase local buy-in, and result in partnerships on new grants and initiatives to promote PEVs.

County of Los Angeles Stakeholder Engagement

The County recognizes this value and has engaged in several stakeholder partnerships. For this Blueprint, the County utilized a multi-pronged approach that leveraged multiple stakeholder public engagements through County efforts and several key partnerships. Through the County Sustainability Plan development efforts, the County's Chief Sustainability Office held more than 150 meetings, 11 half to full day workshops, and a city summit to collect feedback on key inputs including EV deployment throughout the region from a diverse set of stakeholders, including: environmental groups, labor, community-based organizations (CBOs), local businesses, business associations, and others. In addition, through the Blueprint development process, the County engaged various local government stakeholder meetings that contributed directly to this document. The LACI Transportation Electrification Partnership held more than 20 stakeholder working group and leadership advisory meetings. This key partnership has resulted in highlighting participating stakeholders' priorities in transportation electrification as it relates to job creation and the 710 corridor electrification, providing further awareness to community stakeholders who participated on the County's objectives.

Figure 4.2. Transportation Electrification Partners Release the Zero Emissions 2028 Roadmap

The County and Luskin Center team have also been actively engaged with the Mayor's Office and CALSTART in LA Region Electric Bus Working Group Meetings. These meetings have brought together almost a dozen regional bus services including METRO, LADOT, Foothill Transit, the Big Blue Bus, AVTA, Long Beach, UCLA, and others. The Team has provided significant input to the State's Department of General Services' Procurement Group as they developed specifications for the Statewide solicitation for Zero Emission Buses. As a direct result of this effort, local agencies, the UCs, and State Universities will be able to order these vehicles directly through the State's contract. The County and the Luskin Center were also active participants in SCE's Charge Ready pilot programs for Charge Ready Transport and Charge Ready Transit.

LACI Transportation Electrification Partnership

Existing efforts within any region should be leveraged whenever possible to further transportation electrification efforts. Over the course of the past year, LACI, in conjunction with the County, has been convening a regional public private Transportation Electrification stakeholder engagement partnership, bringing together local government officials, utilities, state regulators, and industry leaders to accelerate progress toward transportation electrification and zero-emissions goods movement in the Greater LA region, including the County of Los Angeles.

This stakeholder engagement partnership is governed by a Leadership Group composed of senior executives and leaders from LACI, Los Angeles Mayor Eric Garcetti's Office, the County of Los Angeles, CARB, LA Metro, LADWP, and SCE. This team is complemented by a growing Advisory Group that includes additional public sector agencies (South Coast Air Quality Management District, Clean Power Alliance), labor unions (International Brotherhood of Electrical Workers, National Electrical Contractors Association), and a number of leading industry partners (Audi, BMW Group, BYD, Greenlots, Itron Idea Labs, Nissan North America, PCS Energy, Proterra, and Tesla).

Since September 2018, the Transportation Electrification Partnership has been working diligently to identify policy, funding, technology, infrastructure, and behavioral solutions that will be needed to achieve the goals set forth in the Roadmap. LACI has established four working groups within the stakeholder engagement partnership, each of which typically meets every other week to drive progress. Following are some of the issues and actions that the working group's stakeholders are focused on as relates specifically to EVSE deployment.

Technical Working Group

LACI is conducting sophisticated greenhouse gas modeling to refine the vehicle and EVSE ranges identified in Roadmap 1.0 to achieve the stakeholder engagement partnership established 25 percent GHG emissions reduction goal by 2028. For this work, LACI is adapting a GHG policy tool for cities called Climate Action for Urban Sustainability (CURB), which was developed by AECOM for C40 and the World Bank. Importantly, the City of Los Angeles used CURB in the development of Mayor Garcetti's recently released Green New Deal plan.

- This working group provides critical input to the modeling to ensure alignment with relevant commitments and policies made by the partners.
- In addition to narrowing the vehicle and EVSE ranges called for in the Roadmap, this group is also providing input to spatial analysis to outline where in LA County EVSE demand is likely to occur, segmenting for public, home and workplace charging, as well as charger level.

People Movement Working Group

This group is focusing on questions related to the EVSE needed to support the Roadmap's people movement goals. In particular, they are working to solve problems related to the length of time that it can take to install EVSE (as outlined in Section 1.2) through the following actions:

- LACI is partnering with the Southern California Association of Governments to present

- information and tools on expediting EVSE to city managers and planners throughout the greater LA metropolitan area.
- LACI has conducted a focus group discussion with EVSE companies that have experience with LADWP's interconnection process, to identify ways that the utility might expedite this process.
- Working to standardize permitting and interconnection processes.

Goods Movement Working Group

This group is focusing on two areas that connect to EVSE deployment:

- LACI partnered with CARB, the CEC, and the Ports of Los Angeles and Long Beach to issue a Request for Information on the state of Zero-Emissions Trucks, Infrastructure, and Pilot Projects for goods movement in Southern California. The RFI was designed to elicit responses to provide insights into the current and future state of zero-emission truck technology and related infrastructure needs to inform the development of future pilots and demonstrations by the partners. Nearly 40 companies provided information to the RFI, many of which provided information on the opportunities and barriers for EVSE for medium- and heavy-duty vehicles as well as a number of compelling pilot project concepts.

  As a result, the RFI partners are jointly recommending a holistic approach for future pilots. As fleets plan to transition their operations, many fleets that use hub-and-spoke distribution methods will need to coordinate their medium-duty solutions with their heavy-duty solutions based on site needs and operational challenges. This pilot framework would establish heavy-duty drayage routes supported by medium-duty distribution hubs serving as both cargo transfer points and charging stations. Additional charging options would be established at third-party logistics yards, truck stops and/or via mobile charging solutions. LACI is now working with the partners to identify sources of funding for pilots of this nature.
- This group is also developing a feasibility assessment for the creation of a last-mile zero-emissions cargo zone, in which all parcels must be delivered by zero emissions solutions, such as electric trucks and e-cargo bikes. The assessment will include the preconditions and principles of such a zone to operational requirements, barriers, cost/benefit analysis, EVSE needs and potential pilot locations.

Energy-Transportation Nexus Working Group

- This group is focused on Vehicle to Grid (V2G) issues, in the context of some of the broader changes happening in energy and transport such as autonomous vehicles and blockchain technology. LADWP and SCE are both in the early stages of determining how to implement V2G technology to track EV charging behavior and utilization and use vehicle to grid integration as a load management tool. This group is working to address these questions.

In the spirit of moving from commitment to action, the Transportation Electrification stakeholder engagement partnership is serving as a platform for pilots linked to issues raised by the working groups. For example, on May 2, 2019, Mayor Garcetti helped announce a new mobility pilot program for clean air, reducing GHG emissions and bringing the benefits of the green economy to disadvantaged communities. The Zero Emissions Mobility and Community Pilot Project Fund will dedicate at least $300,000 for proposed solutions—along with technical assistance from LACI and members of the Transportation Electrification stakeholder engagement partnership—in three disadvantaged communities in the City and County of Los Angeles. Lessons from these projects will be shared and used to inform new projects and policy recommendations.

This stakeholder engagement will culminate in the publication of Roadmap 2.0 in Fall 2019, with key milestones for future years along the way to the 2028 targets. This Roadmap will also identify solutions needed to advance towards the milestones and targets. This is just one successful example of how stakeholder engagement is successfully leading to more implementation of EV TE infrastructure.

4.4 TE Implementation for Low-Income and Disadvantaged Communities

Legislation and Policy Drivers

The passage of SB 1275 (De León) in 2014 established the Charge Ahead California Initiative, declaring, "It is the goal of the State to increase access for disadvantaged, low-income, and moderate-income communities and consumers to zero-emission and near-zero-emission vehicles and to increase the placement of quality, lower greenhouse gases, and promote overall benefits for those communities and consumers."

This legislation was sponsored by a coalition of environmental and environmental justice organizations (Coalition for Clean Air, Communities for a Better Environment, Environment California, The Greenlining Institute, and the Natural Resources Defense Council), who came together to ensure that *all* Californians, especially lower-income households most impacted by air pollution, benefit from zero tailpipe emissions.[13] This pioneering legislation first established equity as a priority specifically for the state's transportation electrification efforts, and directed CARB to undertake a variety of related measures including:

- Establishing an income cap for eligibility to rebates from the California Vehicle Rebate Project (CVRP) in order to ensure that limited state funding incentives car purchases that would not otherwise have occurred.
- Creating a suite of equity pilot programs to:
  - Establish innovative electric car sharing programs for low-income communities (this program resulted in the successful BlueLA carsharing program in the City of Los Angeles).
  - Provide incentives for trading in older, highly polluting vehicles for new or used EVs and receive up to $9,500 in incentives for low- and moderate-income drivers in disadvantaged communities (DACs), and create a "mobility option" as an alternative to car ownership by offering vouchers for transit and electric car sharing instead of car replacement vouchers.
  - Increase consumer access to financing options to purchase EVs.[14]

Since then, a number of pioneering state, regional, local, and utility programs have been adopted to further advance California's transportation electrification equity goals. Notably SB 350 (De León 2015), otherwise known as the Clean Energy and Pollution Reduction Act, has led to hundreds of millions in utility-led EVSE investment with significant carve-outs for DACs and investments in heavy-duty electrification to reduce emissions in DACs. In January 2018, "the CPUC approved the first transportation electrification applications under SB 350 from the three large investor-owned utilities," funding $42 million in projects.[15] Shortly thereafter, in May 2018, the CPUC made headlines for its approval of $738 million in additional transportation electrification projects. This legislation also required CARB to complete and publish a study on the Barriers to Clean Transportation Access for Low-Income Residents.[16]

Senate Bill 1275 and SB 350, both authored by Senator Kevin De León, built on the passage of SB 535 in 2012, which directs 25 percent of the Greenhouse Gas Reduction Fund revenues to projects that benefit DACs and at least 10 percent to projects located in DACs, including transportation funding.

13 https://environmentcalifornia.org/programs/cae/charge-ahead-california

14 https://www.nrdc.org/experts/max-baumhefner/charge-ahead-california-initiative-passes-overwhelmingly

15 https://www.cpuc.ca.gov/sb350te/

16 https://www.arb.ca.gov/msprog/transoptions/sb350_final_guidance_document_022118.pdf?_ga=2.69329557.422569696.1560556996-1728616254.1535473653

The CEC's CALeVIP program has also been instrumental in driving the prioritization on equity for transportation electrification projects, setting aside 25 percent of project funds for DACs in LA County.

Despite these critical policy drivers, significant barriers remain, particularly in regard to the lack of accessible charging infrastructure for low-income areas and DACs.

Common Barriers

Grid Alternatives, which has been selected by CARB as the statewide administrator of the One-Stop-Shop Pilot Project to provide streamlined access to CARB's ecosystem of low-carbon transportation equity incentive programs, shared insights into some of the largest barriers facing EVSE access in low-income areas and DACs.[17] These barriers include:

- The high percentage of low-income Californians who live in multifamily housing complicates residential access to electricity outlets for L1 charging as well as the installation of L2 or L3 charging equipment.
- The multifamily affordable housing sector faces significant financial and logistical barriers, making it difficult to dedicate the resources necessary to navigate the new EVSE landscape.
- The lack of coordination among programs serving the multifamily sector across different agencies.
- The lack of technical assistance and community outreach built with and designed for individual communities.
- Even with EVSE installation at individual multifamily housing complexes, it is necessary to establish additional site locations that are not restricted to the residents of one specific complex and are places that are convenient to the daily lives of the community members. It is not sufficient to site EVSE in locations that may be in a DAC, but do not offer significant access to low-income community members, such as corporate campuses.

Strategies for Addressing TE Implementation for LI and DACs

To establish a transportation system that benefits all people, a regional or local community must embrace an equitable deployment of investments and policy interventions to prioritize the mobility needs of low-income and disadvantaged community members. This type of reform must center social equity and community power as primary values in all transportation planning and decision-making. Addressing the needs of these specific vulnerable communities with clean, sustainable mobility options provides innumerable societal benefits, including positive health impacts, increased quality of life, and greater employment and education opportunities. When these communities of prosper, this benefits the entire regional economy.

Local governments must utilize a framework that specifically elevates values and address structural inequities through an adaptable, customizable process for community, advocates, and transportation decision-makers. Some elements of this framework should include:

- A community needs assessment: identifying most pressing unmet mobility needs of particular underserved communities
- Educate the community on mobility equity: educating the community on the basic principles of mobility equity and transportation burdens and benefits
- Transpiration planning tools: Ensure that planning tools promote the most equitable and environmentally sustainable transportation modes and address community-identified needs

[17] Letter from Grid Alternatives and the California Housing Partnership Corporation to the California Energy Commission regarding Energy Commission Docket 17-EVI-01, October 12, 2018. Supplemented with direct conversation between LACI and Grid Alternatives, May 9, 2019.

- Ensure proper representation in regional transportation planning: A regional community should identify ways to incorporate more underserved representatives within the decision-making of long-range transportation plans

Streetlight Electrification

Another potential strategy explored for low-cost EV charging within DACs is electrification of streetlights. The County of Los Angeles' Department of Public Works administers approximately 60,000 streetlights through its County's Lighting Maintenance District. The streetlights are attached to utility poles within the unincorporated areas of the County. The streetlights are currently owned and maintained by SCE.

The County's monthly SCE charge is a flat rate energy charge for electrical service and a facility charge for the "pole rental" for the ongoing maintenance of streetlights and the distribution system. The flat rate energy charge is based upon an assumed 11.5-hour illumination period (dusk to dawn). The streetlights are daisy chained and unmetered. Most streetlights are currently controlled by a photocell installed on each individual streetlight. In some instances, a single photocell installed in a service cabinet controls an entire circuit of streetlights.

Over the next five years Public Works will purchase approximately 40,000 (66 percent) of these streetlights from SCE and will become responsible for their maintenance and operation. Upon transfer of ownership, Public Works will begin replacing the High-Pressure Sodium Vapor (HPSV) street light fixtures with LED fixtures. Power savings will vary depending upon the existing street light system. A typical HPSV street light's power consumption is between 100W and 250W. Average available savings due to the replacement HPSV with LED fixtures will be within 50W to 125W range per fixture. A typical Level 2 EVSE plug uses 7200 W or 7.2 kW. The capacity savings from every 58 ~ 144 streetlights could power one Level 2 EVSE. As these 40,000 streetlights are converted to LEDs, as many as 666 curbside Level 2 EVSE could theoretically be installed throughout the County's unincorporated area to take advantage of what will become surplus light fixture capacity.

However, there are several assumptions to consider. One assumption is that it would be permissible and practical to park adjacent to the streetlights. Many streetlights serve less developed and/or rural County roads such as Las Virgenes Road in Calabasas, Gorman, or roads in the Antelope Valley. There would be limited opportunity for charging in along these roads. Street lighting in more urban unincorporated areas could reasonably facilitate curbside parking and charging. Therefore, based on the quantity of streetlight fixtures in areas with parking access, a more realistic estimate of potential Level 2 EVSE that could be deployed would be approximately 200 to 300.

The streetlights are 120/240V. The Level 2 EVSE is 220 V 208-240VAC. Nonlinear loads, such as EVSE, may introduce power quality issues within distribution circuits. This could have detrimental effects on system components. SCE would need to evaluate and possibly redesign their transformers, relays, feeders, and other equipment to accommodate the additional load from curbside EVSE.

The EVSE would need to be on a separate drop or circuit with the correct voltage from the streetlights circuit if they were to be "hot" and available throughout the day when streetlight fixtures are not illuminated. To protect the street light operations, EVSE should be on a separate circuit if they were hit or vandalized. Unless they were made available to EV drivers free of charge, each EVSE would also need to be separately metered to comply with State regulations for public EV charging.

SECTION 5:
Next Steps

For investments in charging infrastructure to be effective, they need to be in locations where demand for vehicle charging is high. As electrification progresses, concentrated demand for electricity will have implications for local distribution grids. The analysis provided in this Blueprint was preliminary and limited. Maximizing public benefits of transportation electrification, as well as managing grid impacts (both positive and negative), requires careful infrastructure planning accompanied by an in-depth grid impact analysis.

5.1 Recommendations for Further Study

Communities looking to become EV Charge Ready will need to identify:

- Vehicle usage and driving patterns to optimize the type and placement of charging infrastructure to support all levels of mobility (commercial, residential, and transit).
- Optimal locations for electric vehicle charging infrastructure deployment.
- Analytical tools, software applications, and data needed to improve future planning activities.

Although this preliminary analysis included in this Blueprint did provide a glimpse of what is to be anticipated, it is only a limited case study. However, even this limited case study did reveal valuable information regarding spatially resolved forecasts of charging demand and assessing the opportunities and constraints presented by current distribution grid infrastructure given predicted demand. This information and grid impact tool could be valuable to any local government or government agency looking to implement an EV Ready Community.

An expansion of the analyses provided in this Blueprint to additional municipalities and communities would be a key input to any EV Ready Community plan. This expanded analysis would include a revisit of the grid impact analysis for specific regions experiencing longer commutes, more EV adoption, and increased workplace charging in lieu of residential charging, leading to a second EV charge "peak" in the afternoon (caused by lack of available chargers). The County suggests the expanded analysis to include at minimum an additional 30 cities. This could be piloted by the County of Los Angeles utilizing Phase II funding and would support ongoing long-term EV infrastructure planning.

5.2 Streamlining Regional Ordinances and Permitting Processes for TE Implementation

Local governments have a critical role to play in the development of public and private charging infrastructure due to their authority over zoning, parking, and signage; building codes; and permitting and inspection processes. Local ordinances and procedures can present barriers to charging station development, which can be avoided by amending codes and streamlining processes. In addition, local ordinances and procedures also present opportunities to proactively support charging station installation.

As a very fragmented region, the County of Los Angeles poses as a great opportunity to pilot a regional streamlining of ordinances and permitting processes. Common regional zoning and development guidelines would reduce confusion, increase efficiency, and harmonize regional efforts for PEV readiness.

The County's Office of Sustainability, in conjunction with the City of Los Angeles Mayor's Office, the City of Long Beach, and their respective Building and Safety Departments, have met several times to craft harmonized requirements for EVSE in new construction that would go well beyond the current Green Building Code. These requirements include a minimum number of EVSE to be installed on "Day One" as well as provisions for significant future expansion—blanks for panels, pads for transformers, and raceways for future cabling. As these sites are built out, the need for managed charging will be essential and required.

Through this collaboration, the County and the cities of Los Angeles and Long Beach will create a template and new minimum requirement for other cities throughout the County, and hopefully, the region.

The City of Los Angeles' Building and Safety has implemented concierge service for DCFC installations and at scale Level 2 deployments. One senior staff person is assigned to expedite the review and approval of each project.

Through Phase II funding, a regional task force could be piloted and could assist in developing a new regional streamlined ordinance and permitting process that allows for expedited EV charging installations. The task force would include all local stakeholders working together to develop and implement a permitting process for residential and commercial TE infrastructure. The result could be a much more efficient and lower cost TE permitting processes for the entire County of Los Angeles.

This approach is neither foreign nor untested. A similar pilot of regional streamlining of permitting processes regarding solar implementation has been utilized frequently both at the local and state level to great success.

Spurred by a recent state law, hundreds of California communities have streamlined their permit process for small residential solar systems over the past few years, some bringing it down to a single day. Some cities have also fast-tracked inspections to within a few days of permit approvals. As a result, the state's biggest cities are now processing and signing off on hundreds of these solar projects each month.

5.3 Charging Access for Low-Income and DAC: Strategic Partnership TE Pilot Program

State lawmakers encourage Californians to consider zero-emission vehicles such as plug-in hybrid electric and electric vehicles (PHEV and EV). However, moving to an PHEV or EV can be especially difficult for low-income families and residents who reside in underserved disadvantaged communities (DACs). Providing access to charging sites is one barrier to providing access throughout these communities. Another and more prevalent barrier to low-income and disadvantaged communities is access to EVs due to cost and financial barriers. Partnership pilots have proven successful in overcoming these specific barriers within the City of Los Angeles. One specific example is BlueLA,[1] a partnership between Blue Solutions, a division of the Bollore group of France, and the Los Angeles Department of Transportation.

Unfortunately, this partnership is currently limited with only 100 EVs available for member use[2] and 200 EV chargers (that support the available BlueLA fleet) within the central part of Los Angeles. The County believes a similar partnership with a "car- or ride-sharing" partner could be expanded and offered regionally thus expanding EV access to a wider range of to low-income and disadvantaged communities.

The County hopes to propose in Phase II a similar partnership with a "car- or ride-sharing" organization to provide access to EVs for low-income and DAC residents. This partnership program would include the County providing EV chargers at key public facilities within low-income and DAC areas thus allowing both access to PEVs and charging infrastructure. In addition, the County will seek to incorporate additional partnerships such as the LA Metro thus allowing additional sites to be paired alongside public transportation.

1 BlueLA is a 100% electric car sharing service and part of the City of Los Angeles' mobility strategy. The BlueLA service is available to anyone over 18 years of age with a valid driver's license. Members have access to a network of shared electric vehicles 24-hours a day, 7 days a week, at self-service locations throughout central Los Angeles.

2 Car sharing membership is short-term car rental meant for trips around the city, providing the freedom of vehicle use without the costs and hassle of owning a personal vehicle. BlueLA is a membership-based subscription service in Los Angeles, offering access to a network of shared electric vehicles 24 hours a day, 7 days a week, at self-service locations throughout the central city.

5.4 Capital for Large-Scale EV: Chargeback Revolving Revenue TE Public Agency Program

The biggest barrier to local and regional governments in large-scale deployment of EV infrastructure is the high-up front costs and the access to capital to fund the large-scale deployment. However, as discussed in the Blueprint's market based-solutions, there are possible solutions that could help facilitate local and regional governments' large-scale strategic deployment over the long -term.

As identified in the preliminary analysis contained in this Blueprint, EV charging may stress existing near- or over- capacity transformer banks, but bus and workplace EV load itself will not cause any significant substation degradation in the near term (2018–2025). However, in the mid-to-long term (2025–2030), the growth in workplace EV load and consumer PEV demand is likely to increase by 2.5x thus causing a considerable impact on the regional and local distribution grid. Local and regional governments will be key partners to the state for ensuring that EV TE infrastructure planning is strategically deployed and is available to be accessed by all community members and stakeholders.

However, local and regional governments need the resources to strategically deploy large scale infrastructure in time to meet PEV adoption demand and to properly plan for where EV infrastructure.

The County looks to propose additional funding in Phase II to seed a program that would utilize a chargeback plan to recoup revenues on initial project installations that would then in-turn fund new EV charging installations at various public agency facilities around the region. Utilizing revenues from a chargeback plan from the initial project charging station installations would essentially become a revolving fund which would allow public agencies access to capital and allow for large-scale deployment of EV installations over time.

5.5 Conclusion

Over the past decade, the County has deepened previous electric vehicle research and analyzed entirely new facets of increasing electric vehicle adoption. It has made progress on the issues the County faces, but the road to widespread adoption is still long. In order to have the County fulfill its potential as an EV market leader it must continue to make progress on increasing infrastructure, improving vehicle economics, and furthering education. These are policies that the County has committed to at both the local and regional level.

The County has developed concrete plans for electrifying portions of its fleet and identifying key pilot programs in which it can participate in to fund additional charging site (currently the County has 368 EV charging stations on County facilities. In addition, and as mentioned previously, the County has set aggressive goals to increase the number of chargers and charger ready locations by approximately 10,000 spots over the next 10 years. Finally, the County has also mapped potential fast charge locations and identified the local barriers to making such chargers cost-effective.

Incorporating EVs into car share remains a goal, both to green those fleets and for the value exposure to EVs would have for County communities. The County has the potential for many pilot projects in the next coming years and plans to utilize its local strengths and the key findings and information contained within this Blueprint to engage and other regions and cities within its served territory to help shape future necessary EV charging infrastructure. The County hopes to be part of a continued collaboration with other cities and state regulatory groups, such as the CEC, that seek to increase electric vehicle adoption.

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APPENDIX A:

Needs Assessment and Grid Impact Analysis Supporting Materials

Appendix A1. Bus specifications from major BEB manufacturers

OEM	Model	Subcategory	Length (ft.)	Max. range (mile)	Battery size (kWh)	Charging Power level (kW)
BYD	k7m		30	135	196	80/200
	k9s		35	230	350	
	k9mc		40	255	500	
	k11		60	230	652	
Proterra	E2	DUOPOWER	35	302	440	60/125/500
	E2	PRODRIVE	35	251	440	
	E2	DUOPOWER	40	305	440	
	E2+	DUOPOWER	40	367	550	
	E2 max	DUOPOWER	40	426	660	
	E2	PRODRIVE	40	251	440	
	E2+	PRODRIVE	40	303	550	
	E2 max	PRODRIVE	40	350	660	
	FC	DUOPOWER	35	67	94	
	FC+	DUOPOWER	35	86	126	
	XR	PRODRIVE	35	163	220	
	XR+	PRODRIVE	35	235	330	
	FC	DUOPOWER	40	68	94	
	FC+	DUOPOWER	40	87	126	
	FC	PRODRIVE	40	55	94	
	FC+	PRODRIVE	40	72	126	
	XR	DUOPOWER	40	164	220	
	XR+	DUOPOWER	40	238	330	
	XR	PRODRIVE	40	136	220	
	XR+	PRODRIVE	40	193	330	
GreenPower	EV250		30	175	210	50/100/200
	EV300		35	175	260	
	EV350		40	185	320	
	EV400		45	185	320	
	EV450		60	185	400	
	EV550		45	240	478	
New Flyer	Xcelsior		35	192	400	126
	Xcelsior		40	260	545	
	Xcelsior		60	275	818	

Appendix A2. Bus fleet age distribution in 2018

Transit agency	Bus type	Fleet age distribution 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17+	Subtotal
LA Metro	Bus	0	0	0	350	546	0	150	0	90	91	259	0	0	60	94	4	0	277	1921
	Articulated bus	0	0	0	0	0	0	0	0	0	0	0	0	96	95	199	0	0	0	390
Foothill Transit	Bus	0	44	32	30	106	0	0	14	14	30	0	0	10	0	63	0	0	0	343
	Articulated bus	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	30
LADOT	Bus	0	4	29	54	0	31	129	5	0	24	0	5	19	0	0	0	11	0	311
Long Beach Transit	Bus	40	10	0	8	0	31	33	0	0	25	0	15	0	48	0	0	37	2	249
	Articulated bus	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
Big Blue Bus	Bus	7	20	5	15	13	45	0	0	24	0	0	0	10	0	33	0	0	0	172
	Articulated bus	0	0	0	7	0	0	0	0	21	0	0	0	0	0	0	0	0	0	28
Montebello Bus Lines	Bus	5	0	7	0	0	8	4	3	16	8	15	0	0	0	0	0	0	0	66
Torrance Transit System	Bus	0	0	0	24	0	0	9	20	10	0	0	0	0	0	0	0	0	0	63
GTrans – City of Gardena	Bus	0	0	0	1	0	0	0	0	18	21	0	0	0	16	0	0	0	0	56
Culver CityBus	Bus	0	0	18	0	6	0	16	4	0	6	0	0	0	0	0	0	0	4	54
Norwalk Transit System	Bus	1	2	0	0	0	12	2	0	3	6	0	0	1	1	0	0	2	0	30

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
LA Metro	10/48	56	56	56	56	56	71	77
LA Metro	102	100	100	100	100	100	107	107
LA Metro	105	68	68	68	68	68	109	115
LA Metro	106	91	91	91	91	91	0	0
LA Metro	108	68	68	68	68	68	122	122
LA Metro	110	86	86	86	86	86	127	118
LA Metro	111	68	68	68	68	68	90	124
LA Metro	115	85	85	85	85	85	123	112
LA Metro	117	76	76	76	76	76	87	91
LA Metro	120	93	93	93	93	93	214	214
LA Metro	125	74	74	74	74	74	124	117
LA Metro	126	40	40	40	40	40	0	0
LA Metro	127	76	76	76	76	76	0	0
LA Metro	128	99	99	99	99	99	0	0
LA Metro	130	94	94	94	94	94	181	181
LA Metro	14/37	48	48	48	48	48	80	90
LA Metro	150/240	97	97	97	97	97	135	178
LA Metro	152	58	58	58	58	58	178	206
LA Metro	154	78	78	78	78	78	0	0
LA Metro	155	46	46	46	46	46	84	130
LA Metro	158	69	69	69	69	69	188	114
LA Metro	16	46	46	46	46	46	74	63
LA Metro	161	63	63	63	63	63	206	160
LA Metro	162	59	59	59	59	59	128	136
LA Metro	164	56	56	56	56	56	88	146
LA Metro	165	51	51	51	51	51	99	151
LA Metro	166	50	50	50	50	50	177	144
LA Metro	167	155	155	155	155	155	238	238
LA Metro	169	104	104	104	104	104	0	0
LA Metro	175	31	31	31	31	31	0	0
LA Metro	176	166	166	166	166	166	0	0
LA Metro	177	59	59	59	59	59	0	0
LA Metro	18	65	65	65	65	65	80	100
LA Metro	180/181	82	82	82	82	82	119	120
LA Metro	183	69	69	69	69	69	162	150

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
LA Metro	2	56	56	56	56	56	108	96
LA Metro	20	53	53	53	53	53	105	73
LA Metro	200	38	38	38	38	38	82	77
LA Metro	201	124	124	124	124	124	137	137
LA Metro	202	43	43	43	43	43	0	0
LA Metro	204	72	72	72	72	72	86	93
LA Metro	205	160	160	160	160	160	225	267
LA Metro	206	72	72	72	72	72	129	148
LA Metro	207	78	78	78	78	78	111	124
LA Metro	209	167	167	167	167	167	0	0
LA Metro	210	120	120	120	120	120	153	138
LA Metro	211/215	37	37	37	37	37	0	0
LA Metro	212	61	61	61	61	61	93	113
LA Metro	217	72	72	72	72	72	67	59
LA Metro	218	87	87	87	87	87	111	136
LA Metro	222	90	90	90	90	90	104	156
LA Metro	224	57	57	57	57	57	173	162
LA Metro	230	51	51	51	51	51	74	104
LA Metro	232	92	92	92	92	92	185	190
LA Metro	233	111	111	111	111	111	106	130
LA Metro	234	61	61	61	61	61	143	207
LA Metro	236	50	50	50	50	50	191	191
LA Metro	237/656	133	133	133	133	133	137	137
LA Metro	239	71	71	71	71	71	0	0
LA Metro	242/243	95	95	95	95	95	177	0
LA Metro	245	38	38	38	38	38	63	23
LA Metro	246	73	73	73	73	73	99	109
LA Metro	251	89	89	89	89	89	115	113
LA Metro	252	92	92	92	92	92	158	157
LA Metro	254	93	93	93	93	93	152	0
LA Metro	256	186	186	186	186	186	176	159
LA Metro	258	179	179	179	179	179	0	0
LA Metro	260	111	111	111	111	111	161	159
LA Metro	265	147	147	147	147	147	141	141
LA Metro	266	101	101	101	101	101	188	192

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
LA Metro	264/267	131	131	131	131	131	100	150
LA Metro	268	63	63	63	63	63	67	74
LA Metro	28	65	65	65	65	65	116	118
LA Metro	30	54	54	54	54	54	67	69
LA Metro	33	50	50	50	50	50	69	84
LA Metro	344	67	67	67	67	67	162	122
LA Metro	35/38	73	73	73	73	73	134	96
LA Metro	4	72	72	72	72	72	94	97
LA Metro	40	86	86	86	86	86	135	136
LA Metro	442	22	22	22	22	22	0	0
LA Metro	45	57	57	57	57	57	91	97
LA Metro	460	107	107	107	107	107	157	174
LA Metro	487	57	57	57	57	57	116	119
LA Metro	501	119	119	119	119	119	341	341
LA Metro	51/52	53	53	53	53	53	88	125
LA Metro	53	46	46	46	46	46	110	144
LA Metro	534	73	73	73	73	73	93	109
LA Metro	55	38	38	38	38	38	75	101
LA Metro	550	119	119	119	119	119	126	189
LA Metro	577	165	165	165	165	165	0	0
LA Metro	60	50	50	50	50	50	113	106
LA Metro	601	110	110	110	110	110	103	103
LA Metro	602	32	32	32	32	32	49	45
LA Metro	603	66	66	66	66	66	111	111
LA Metro	605	63	63	63	63	63	117	117
LA Metro	607	45	45	45	45	45	0	0
LA Metro	611	111	111	111	111	111	165	165
LA Metro	612	84	84	84	84	84	196	196
LA Metro	62	59	59	59	59	59	114	182
LA Metro	625	62	62	62	62	62	0	0
LA Metro	66	47	47	47	47	47	84	125
LA Metro	665	89	89	89	89	89	143	123
LA Metro	68	67	67	67	67	67	95	116
LA Metro	685	140	140	140	140	140	0	0
LA Metro	686/687	112	112	112	112	112	89	89

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
LA Metro	70	75	75	75	75	75	86	78
LA Metro	704	81	81	81	81	81	121	123
LA Metro	705	53	53	53	53	53	0	0
LA Metro	71	65	65	65	65	65	86	129
LA Metro	710	89	89	89	89	89	144	0
LA Metro	720	68	68	68	68	68	132	170
LA Metro	728	50	50	50	50	50	0	0
LA Metro	733	84	84	84	84	84	153	165
LA Metro	734	167	167	167	167	167	0	0
LA Metro	740	95	95	95	95	95	108	0
LA Metro	744	172	172	172	172	172	147	147
LA Metro	745	60	60	60	60	60	92	126
LA Metro	750	111	111	111	111	111	0	0
LA Metro	751	98	98	98	98	98	0	0
LA Metro	754	58	58	58	58	58	113	99
LA Metro	757	76	76	76	76	76	0	0
LA Metro	76	66	66	66	66	66	75	91
LA Metro	760	73	73	73	73	73	94	0
LA Metro	762	140	140	140	140	140	0	0
LA Metro	770	114	114	114	114	114	124	0
LA Metro	78/79	66	66	66	66	66	111	101
LA Metro	780	83	83	83	83	83	0	0
LA Metro	788	47	47	47	47	47	0	0
LA Metro	794	114	114	114	114	114	0	0
LA Metro	81	66	66	66	66	66	103	149
LA Metro	83	61	61	61	61	61	119	120
LA Metro	860	76	76	76	76	76	127	127
LA Metro	861	57	57	57	57	57	0	0
LA Metro	862	60	60	60	60	62	0	100
LA Metro	90/91	0	0	0	0	0	92	0
LA Metro	901	66	66	66	66	66	109	113
LA Metro	910/950	131	131	131	131	131	217	217
LA Metro	92	117	117	117	117	117	247	247
LA Metro	94	101	101	101	101	101	80	104
LA Metro	96	84	84	84	84	84	124	137

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
Foothill Transit	178	129	129	129	129	129	185	143
Foothill Transit	185	105	105	105	105	105	92	92
Foothill Transit	187	110	110	110	110	110	133	133
Foothill Transit	188	108	108	108	108	108	146	146
Foothill Transit	190	124	124	124	124	124	159	159
Foothill Transit	194	65	65	65	65	65	63	127
Foothill Transit	195	101	101	101	101	101	136	150
Foothill Transit	197	108	108	108	108	108	94	94
Foothill Transit	269	79	79	79	79	79	102	102
Foothill Transit	270	103	103	103	103	103	103	103
Foothill Transit	272	93	93	93	93	93	65	65
Foothill Transit	274	55	55	55	55	55	79	79
Foothill Transit	280	78	78	78	78	78	180	180
Foothill Transit	281	102	102	102	102	102	107	107
Foothill Transit	282	109	109	109	109	109	102	102
Foothill Transit	284	115	115	115	115	115	138	138
Foothill Transit	285	108	108	108	108	108	177	177
Foothill Transit	286	110	110	110	110	110	90	90
Foothill Transit	289	158	158	158	158	158	121	121
Foothill Transit	291	95	95	95	95	95	88	88
Foothill Transit	292	105	105	105	105	105	81	81
Foothill Transit	480	40	40	40	40	40	0	0
Foothill Transit	482	126	126	126	126	126	138	138
Foothill Transit	486	127	127	127	127	127	189	189
Foothill Transit	488	112	112	112	112	112	141	141
Foothill Transit	492	76	76	76	76	76	94	94
Foothill Transit	493	93	93	93	93	93	122	122
Foothill Transit	495	38	38	38	38	38	0	0
Foothill Transit	497	39	39	39	39	39	0	0
Foothill Transit	498	52	52	52	52	52	0	0
Foothill Transit	499	30	30	30	30	30	0	0
Foothill Transit	690	37	37	37	37	37	0	0
Foothill Transit	699	16	16	16	16	16	0	0
Foothill Transit	Silver Streak	48	48	48	48	48	0	0
Foothill Transit	851	146	146	146	146	146	199	199

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
Foothill Transit	853	25	25	25	25	25	0	0
Foothill Transit	854	11	11	11	11	11	0	0
Foothill Transit	860	9	9	9	9	9	0	0
Foothill Transit	861	95	95	95	95	95	0	0
LADOT	DASH Downtown B	112	112	112	112	112	90	0
LADOT	DASH Downtown E	80	80	80	80	80	0	0
LADOT	DASH Downtown F	77	77	77	77	77	86	31
LADOT	DASH Downtown D	81	81	81	81	81	8	44
LADOT	DASH Downtown A	88	87	87	87	87	0	0
LADOT	Larchmont Shuttle	77	77	77	77	77	0	0
LADOT	DASH Wilmington	22	22	22	22	22	0	0
LADOT	DASH San Pedro	76	76	76	76	76	77	77
LADOT	DASH Chesterfield Square	104	104	104	104	104	77	51
LADOT	DASH Vermont Main	73	73	73	73	73	110	110
LADOT	DASH Crenshaw	119	119	119	119	119	91	0
LADOT	DASH King-East	52	52	52	52	52	43	0
LADOT	DASH Leimert/ Slauson	87	87	87	87	87	83	0
LADOT	DASH Midtown	123	123	123	123	123	98	0
LADOT	DASH Southeast	118	118	118	118	118	96	0
LADOT	DASH Pueblo Del Rio	108	108	108	108	108	112	112
LADOT	DASH Watts	130	130	130	130	130	98	0
LADOT	DASH Pico Union/ Echo Park	116	116	116	116	116	172	0
LADOT	DASH El Sereno/ City Terrace	98	98	98	98	98	136	136
LADOT	DASH Boyle Heights/East LA	124	124	124	124	124	143	176
LADOT	DASH Van Nuys/ Studio City	65	65	65	65	65	56	0
LADOT	DASH Panorama City/Van Nuys	137	137	137	137	137	113	0
LADOT	DASH Northridge	86	86	86	86	86	89	89
LADOT	DASH Beachwood Canyon	190	190	190	190	190	99	0
LADOT	DASH Hollywood	196	196	196	196	196	161	0
LADOT	DASH Hollywood/ Wilshire	31	31	31	31	31	25	0

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
LADOT	DASH Highland Park/Eagle Rock	113	113	113	113	113	0	0
LADOT	DASH Fairfax	112	112	112	112	112	84	0
LADOT	DASH Los Feliz	104	104	104	104	104	87	0
LADOT	DASH Lincoln Heights/Chinatown	68	68	68	68	68	0	0
LADOT	DASH Wilshire Center/Koreatown	107	107	107	107	107	81	0
LADOT	Commuter Express 142	78	78	78	78	78	60	60
LADOT	Commuter Express 409	262	262	262	262	262	231	231
LADOT	Commuter Express 419	62	62	62	62	62	0	0
LADOT	Commuter Express 431	25	24	24	24	24	0	0
LADOT	Commuter Express 534	41	41	41	41	41	0	0
LADOT	Commuter Express 573	27	27	27	27	27	0	0
LADOT	Commuter Express 574	58	58	58	58	58	0	0
LADOT	Commuter Express Union Station/ Bunker Hill	69	69	69	69	69	0	0
LADOT	Commuter Express 422	16	16	16	16	16	0	0
LADOT	Commuter Express 437	133	133	133	133	133	0	0
LADOT	Commuter Express 448	38	38	38	38	38	0	0
LADOT	Commuter Express 549	62	62	62	62	62	0	0
LADOT	Commuter Express 438	87	87	87	87	87	0	0
LADOT	Commuter Express 423	79	79	79	79	79	0	0
LADOT	DASH Observatory	92	92	92	92	92	0	0
Big Blue Bus	1	57	57	57	57	57	68	68
Big Blue Bus	2	115	115	115	115	115	121	120
Big Blue Bus	3	96	96	96	96	96	100	89
Big Blue Bus	5	160	160	160	160	160	178	197
Big Blue Bus	7	76	76	76	76	76	0	0
Big Blue Bus	8	155	155	155	155	155	204	188
Big Blue Bus	9	103	103	103	103	103	129	146

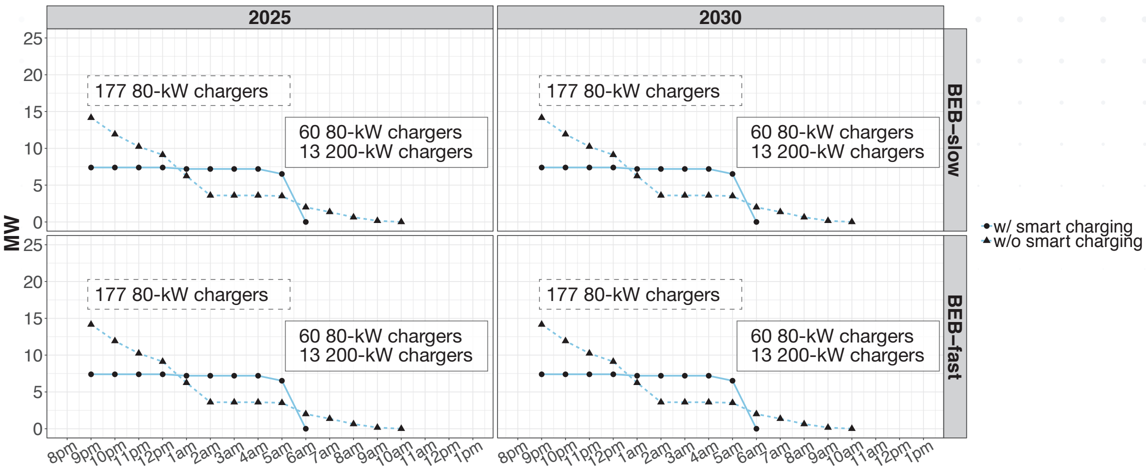
Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
Big Blue Bus	R10	56	56	56	56	56	130	112
Big Blue Bus	R12	36	36	36	36	36	0	0
Big Blue Bus	14	70	70	70	70	70	190	181
Big Blue Bus	15	213	213	213	213	213	219	154
Big Blue Bus	16	114	114	114	114	114	0	0
Big Blue Bus	17	106	106	106	106	106	0	0
Big Blue Bus	18	119	119	119	119	119	151	151
Big Blue Bus	R3	115	115	115	115	115	119	110
Big Blue Bus	R7	49	49	49	49	49	0	0
Big Blue Bus	41	128	128	128	128	128	0	0
Big Blue Bus	42	116	116	116	116	116	117	117
Big Blue Bus	43	116	116	116	116	116	0	0
Big Blue Bus	44	89	89	89	89	89	0	0
Montebello Bus Lines	10	47	47	47	47	47	0	0
Montebello Bus Lines	20	76	76	76	76	76	231	217
Montebello Bus Lines	30	137	137	137	137	137	104	0
Montebello Bus Lines	40	208	208	208	208	208	195	0
Montebello Bus Lines	50	117	117	117	117	117	180	182
Montebello Bus Lines	60	36	36	36	36	36	128	0
Montebello Bus Lines	70	155	155	155	155	155	120	0
Montebello Bus Lines	90	82	82	82	82	82	0	0
Torrance Transit System	1	61	61	61	61	61	105	0
Torrance Transit System	10	128	128	128	128	128	173	178
Torrance Transit System	2	91	91	91	91	91	47	0
Torrance Transit System	3	34	34	34	34	34	0	0
Torrance Transit System	4X	151	151	151	151	151	0	0
Torrance Transit System	5	83	83	83	83	83	0	0
Torrance Transit System	6	67	67	67	67	67	140	140

Agency	Route	Mon. VMT (miles)	Tue. VMT (miles)	Wed. VMT (miles)	Thu. VMT (miles)	Fri. VMT (miles)	Sat. VMT (miles)	Sun. VMT (miles)
Torrance Transit System	7	111	111	116	111	116	205	205
Torrance Transit System	8	154	154	154	154	154	135	135
Torrance Transit System	9	91	91	91	91	91	121	121
Torrance Transit System	R3	128	128	128	128	128	0	0
GTrans – City of Gardena	5	140	140	140	140	137	166	162
GTrans – City of Gardena	4	122	122	122	122	118	142	0
GTrans – City of Gardena	3	4	4	4	4	4	0	0
GTrans – City of Gardena	2	115	115	115	115	115	147	127
GTrans – City of Gardena	1X	74	74	74	74	74	0	0
Culver CityBus	1	158	158	158	158	158	0	0
Culver CityBus	2	180	180	180	180	180	130	130
Culver CityBus	3	116	116	116	116	116	79	79
Culver CityBus	4	284	284	284	284	284	0	0
Culver CityBus	5	146	146	146	146	146	154	154
Culver CityBus	6	171	171	171	171	171	0	0
Culver CityBus	6R	61	61	61	61	61	163	0
Culver CityBus	7	56	56	56	56	56	71	77
Norwalk Transit System	1	100	100	100	100	100	107	107
Norwalk Transit System	2	68	68	68	68	68	109	115
Norwalk Transit System	3	91	91	91	91	91	0	0
Norwalk Transit System	4	68	68	68	68	68	122	122
Norwalk Transit System	5	86	86	86	86	86	127	118
Norwalk Transit System	7	68	68	68	68	68	90	124

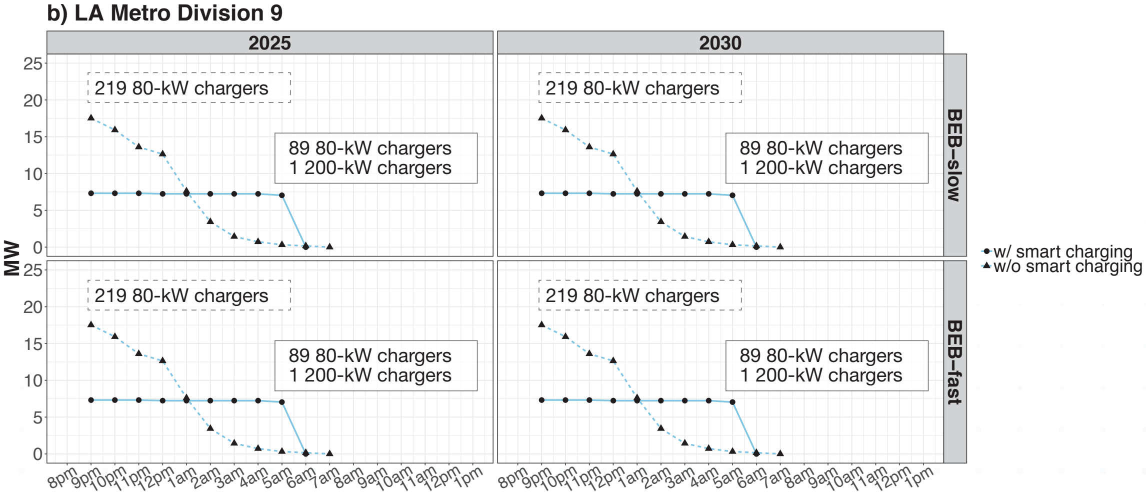
Appendix A3. Projected load profiles at the facility level

1. LA Metro

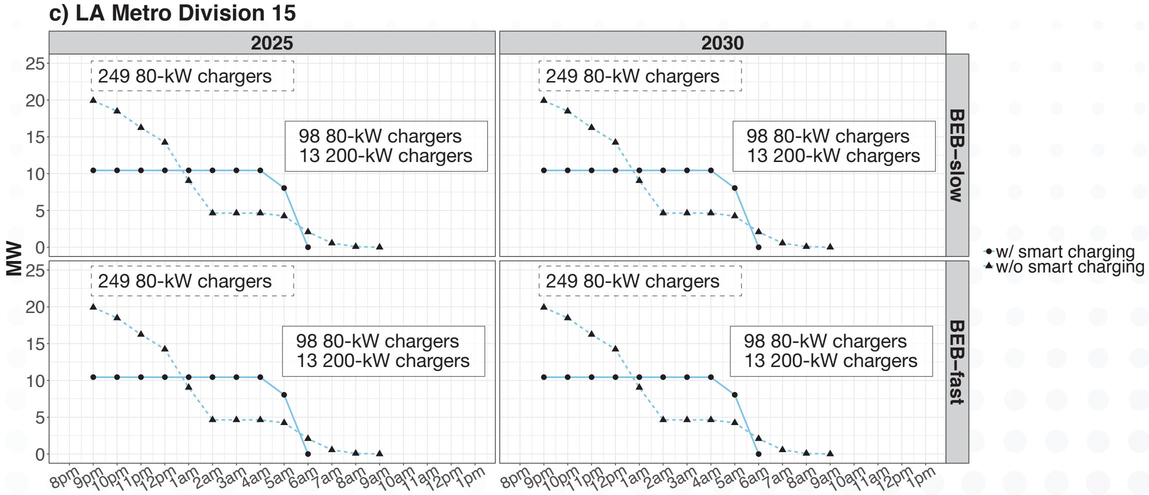
a) LA Metro Division 8



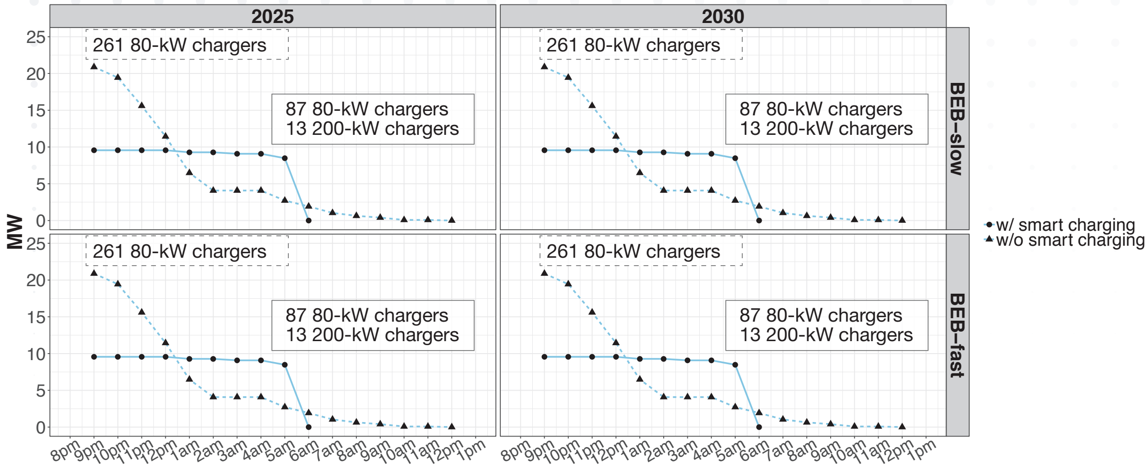
b) LA Metro Division 9



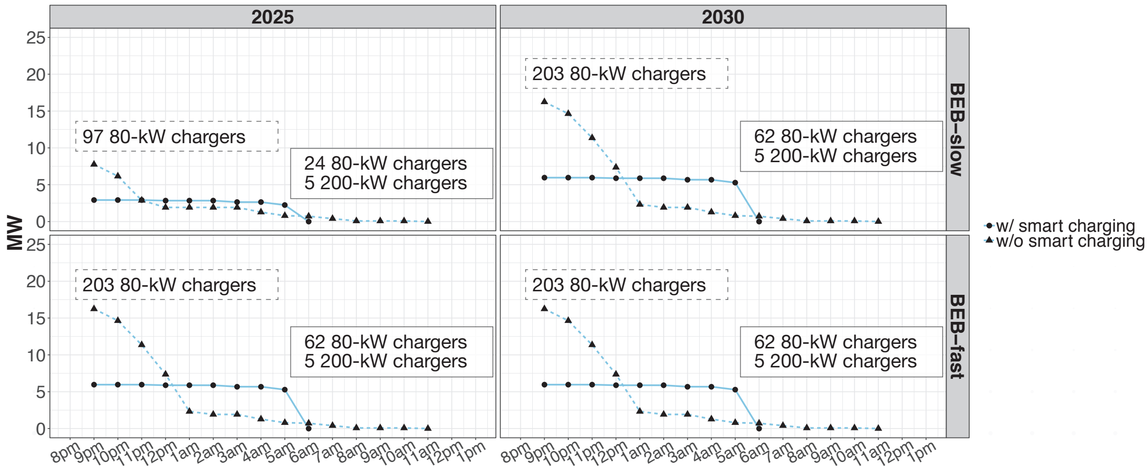
c) LA Metro Division 15



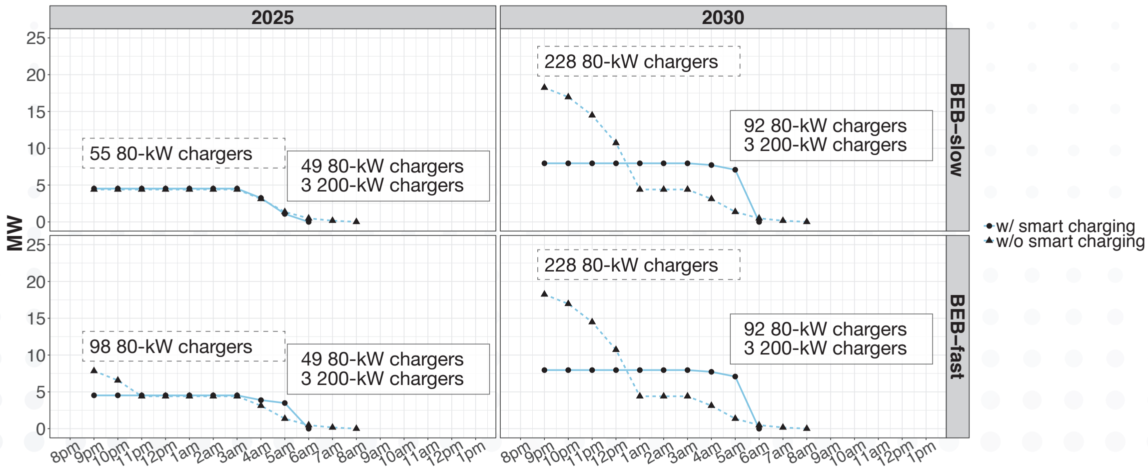
d) LA Metro Division 18



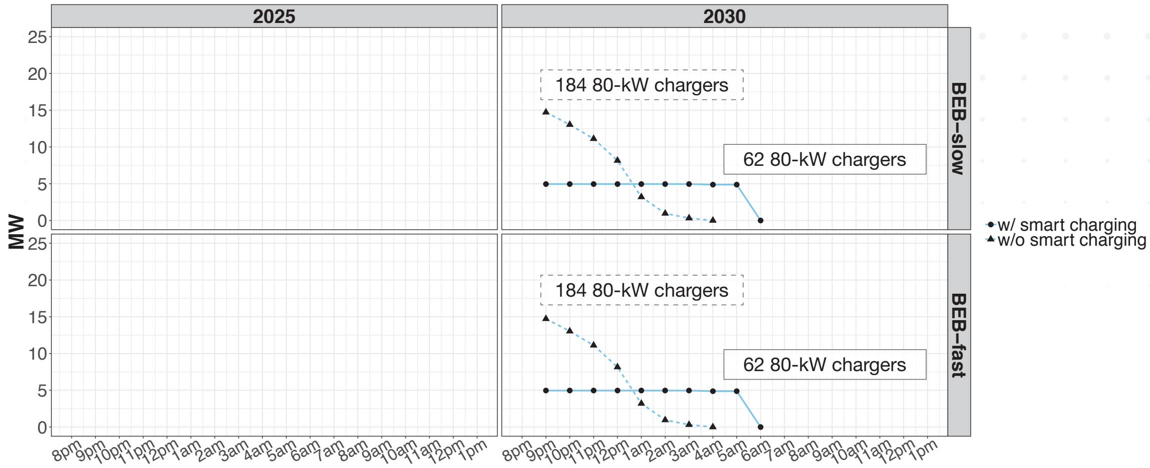
e) LA Metro Division 7



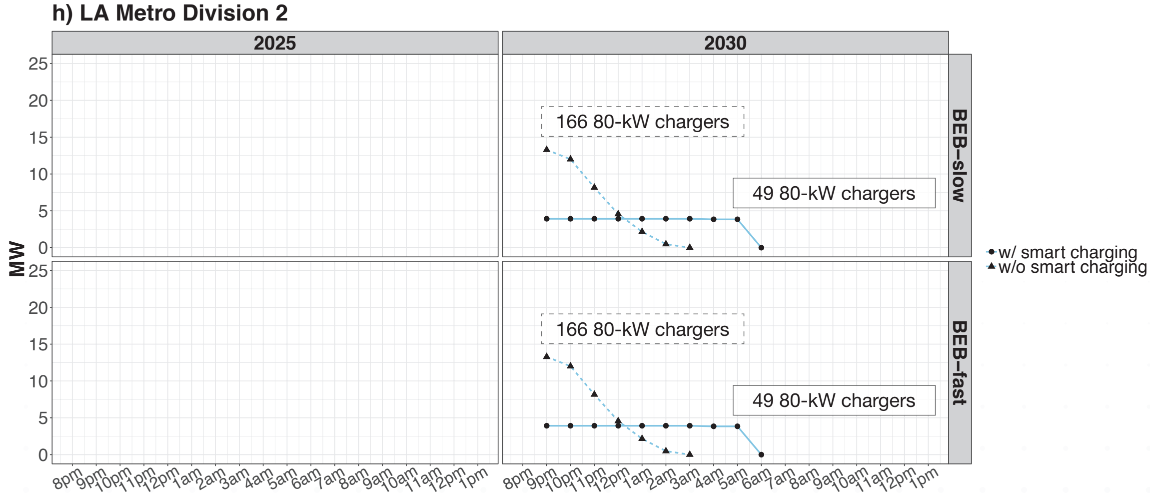
f) LA Metro Division 5



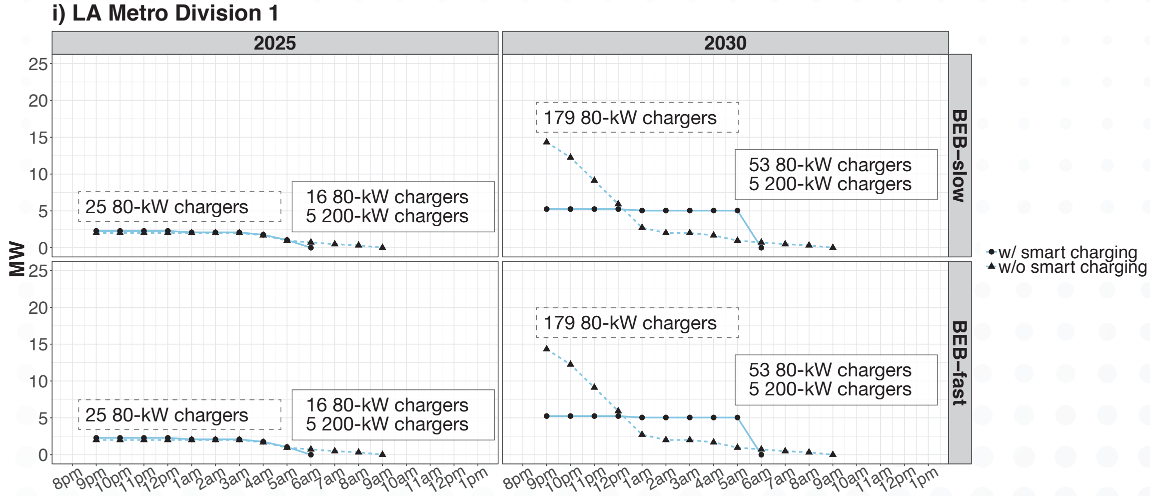
g) LA Metro Division 3



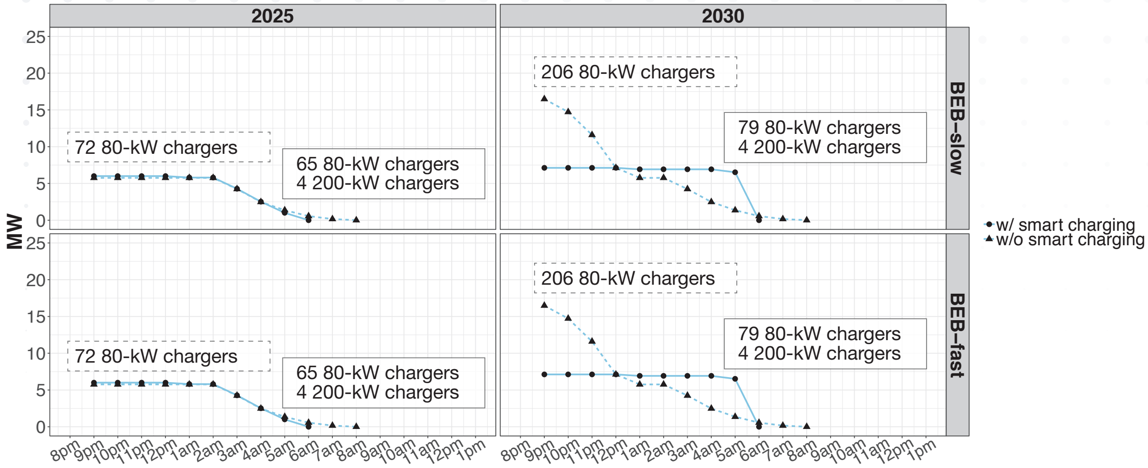
h) LA Metro Division 2



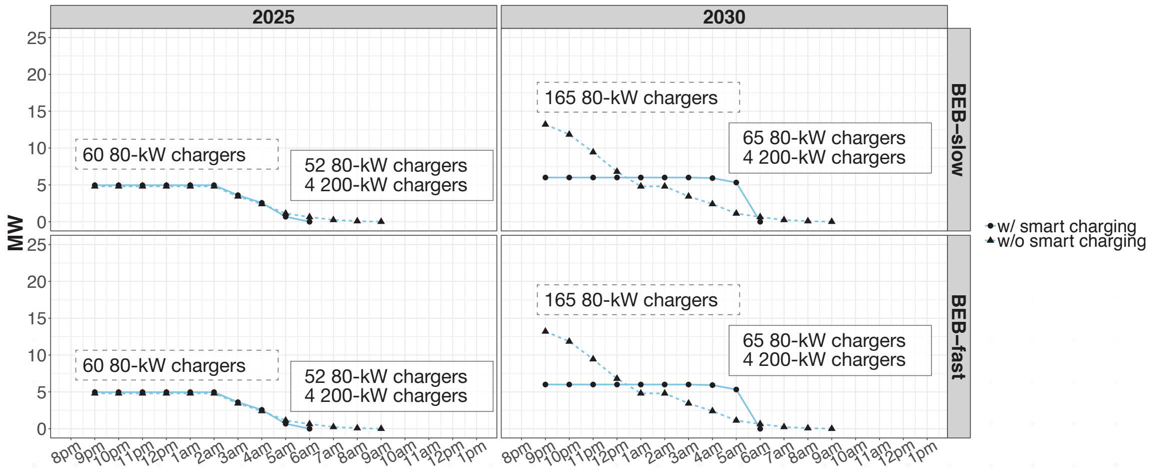
i) LA Metro Division 1



j) LA Metro Division 13

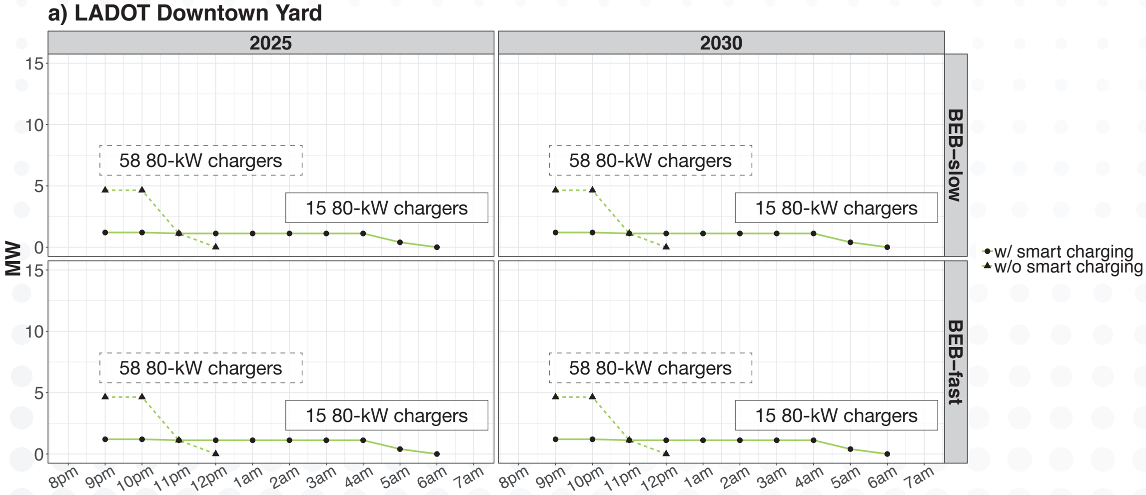


k) LA Metro Division 10

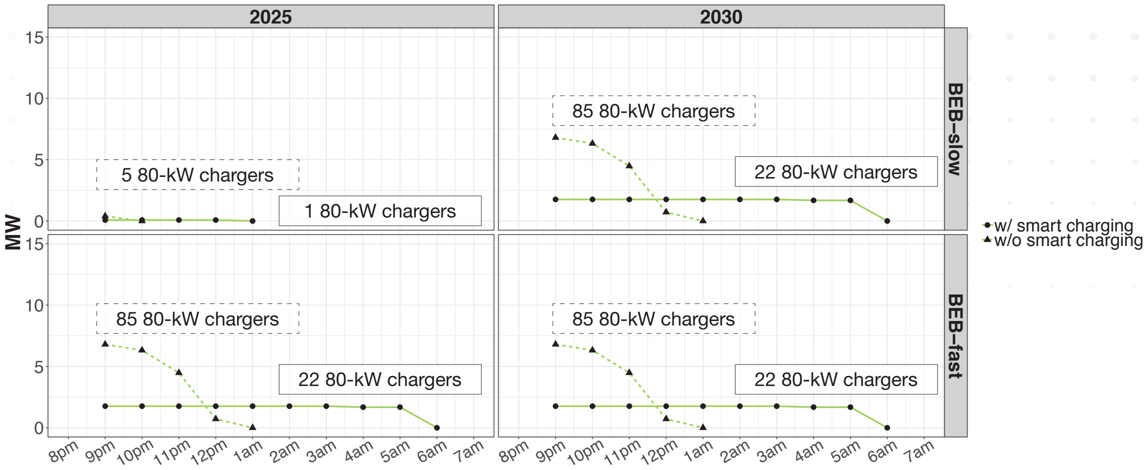


3. LADOT

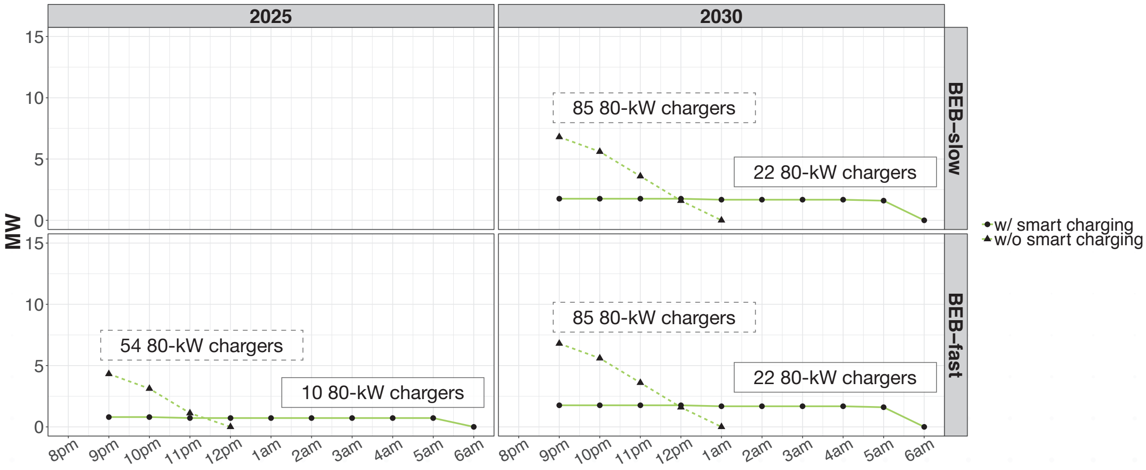
a) LADOT Downtown Yard



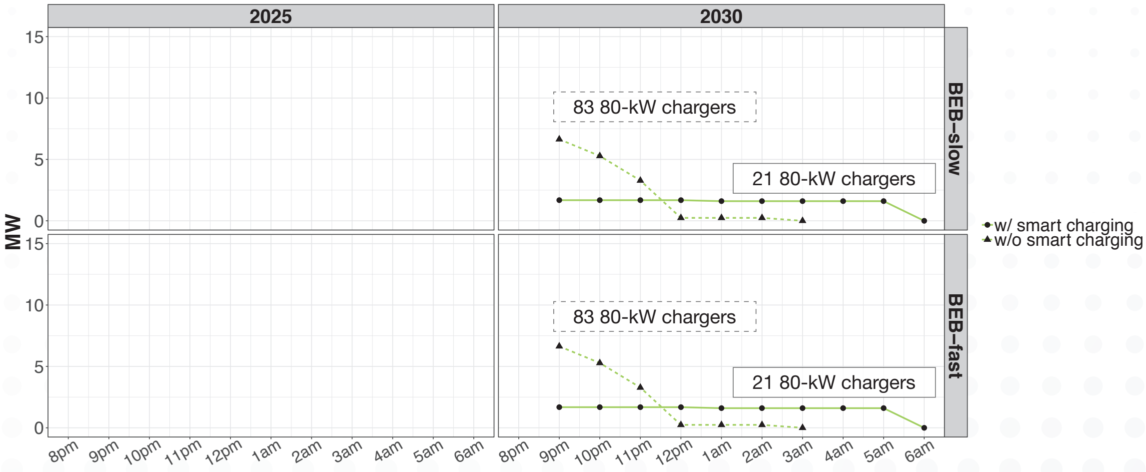
b) LADOT Washington Yard



c) LADOT Sylmar Yard



d) LADOT Compton Yard



APPENDIX B:
Chargeback Plan, Draft Report

Introduction

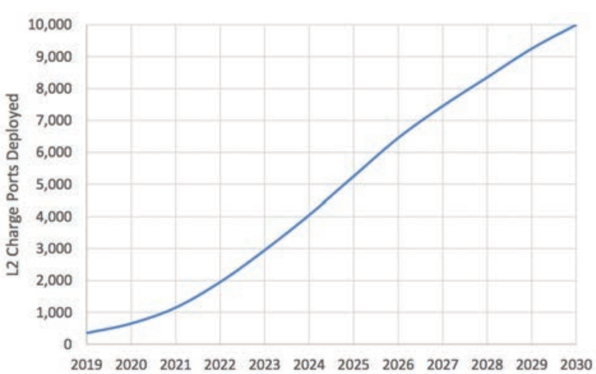
ICF developed this Chargeback Plan—an analytical exercise to estimate the costs of deploying electric vehicle (EV) charging infrastructure around Los Angeles County to support EV adoption by County employees, the County's light-duty vehicle fleet, and the general public. The Charge Back Plan is based on a spreadsheet model that ICF developed in coordination with the County to estimate the level of investment required to achieve deployment targets (i.e., annual costs), and to understand the fees that the County would need to collect from users to offset the investments required to deploy that infrastructure (i.e., breakeven charge). The modeling considered two major expenditures associated with Level 2 (L2) electric vehicle supply equipment (EVSE): 1) capital expenditures associated with the hardware and installation of the equipment and 2) the operation and maintenance (O&M) expenditures, including electricity, networking fees, and general EVSE maintenance. We also considered the value of credits generated via the use of electricity as part of the Low Carbon Fuel Standard (LCFS) program. Lastly, the analysis considered the potential revenue that would be generated from charging users a fee, on a dollar per kilowatt-hour ($/kWh) basis, for using the equipment—this is referred to as the ChargeBack rate. The net cost or financial impact of the program is the sum of the expenditures (capital and O&M) after considering any revenue from LCFS credits and the ChargeBack rate. The following sections describe the model inputs and summarize our findings.

Modeling Inputs

Total EV Charging Infrastructure Deployment

ICF modeled the deployment of 10,000 charging ports by 2030 (see Figure 1 below); we assumed that the County would have 350 charge ports deployed at the end of 2019.

Figure 1. Level 2 Charging Ports Deployed in Los Angeles County



Capital Expenditures

The modeling includes the costs of the EV charging infrastructure—including the hardware (referred to as electric vehicle supply equipment or EVSE) and the corresponding installation costs. These costs were estimated based on existing deployments managed by the County, and costs from other deployments, referenced as appropriate. Table 1 includes the breakdown of costs on a per L2 EVSE basis.

Table 1. Installation and Hardware Costs Assumed for L2 EVSE

EXPENDITURE	L2 EVSE
Installation	**$13,500**
Site Preparation	$470
Demolition	$1,900
Trenching/Concrete	$3,980
Electrical	$3,180
Concrete/Paving	$2,780
Signage/Striping/Bollards	$1,190
Hardware/EVSE Dual-port, networked	**$4,500**
Total per Level 2 EVSE	**$18,000**
Total per Charge port	**$9,000**

The Level 2 EVSE installation costs were estimated based on ICF research of existing installations, including a report from the DOE,[1] review of installation costs of County-supported efforts,[2] and similar efforts in other jurisdictions.[3] The costs included in this report, for $9,000 per Charge port, fall in the middle of this cost range.

Operations and Maintenance Expenditures

The analysis includes the costs of operating and maintain the EVSE, including electricity costs, networking costs, and maintenance costs. These costs are summarized in Table 2 below.

Table 2. Assumed Operations and Maintenance Expenditures for L2 Charge Ports

COST PARAMETER	EST COST
Electricity ($/kWh)	
Default	$0.135
High	$0.200
Managed	$0.093
Operations & Maintenance	
Networking ($/month)	$50
Maintenance ($/month)	$25

Electricity Costs

ICF used three different rates for electricity: a default value of $0.135 per kWh, a high value of $0.200/kWh and a low or managed rate of $0.093/kWh. The default rate and the high rate are based on ICF's review of selected rates from Southern California Edison (SCE) and Los Angeles Department of Water and Power (LADWP) that County facilities are currently paying. The managed rate is based on ICF's analysis of taking advantage of a proposed demand response (DR) program with a rate structure similar to what SCE has proposed for its Charge Ready program participants. This

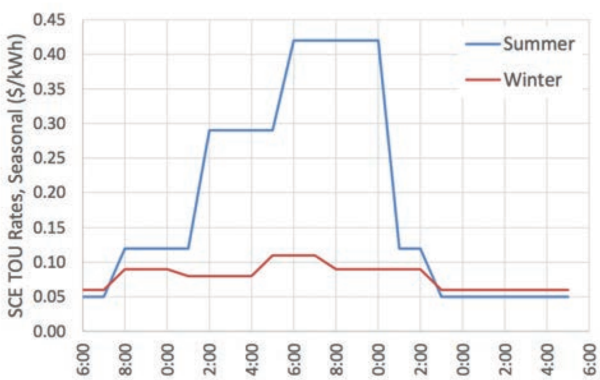
1 Costs Associated with Non-Residential Electric Vehicle Supply Equipment, Department of Energy, November 2015. Accessed online via https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf.

2 Consider for instance that the County recently accepted funds from AQMD's Mobile Source Resources Committee with an estimate of $10,000 per charge port.

3 For instance, NYSERDA reports that the average Level 2 EVSE installation ranged from $1,554 to $25,785 with an average cost of $7,435 per station. See Roy, B et al, New York State EV Charging Station Deployment, EVS29 Symposium, June 2016. Accessed online via http://www.mdpi.com/2032-6653/8/4/877/pdf.

rate is meant to help quantify the impact of taking advantage of Time-of-Use (TOU) rates on electricity costs. TOU rates can vary considerably by season, with the price of charging on peak in excess of $0.40 per kWh in some cases—Figure 2 below illustrates these differences with a sample TOU rate from an SCE filing. Today, most of the County's existing EVSE are not on separate meters, and any charging is simply added to the existing load of the building to which it is connected. In order to participate in attractive demand response events and realize the benefits quantified by using the lower managed rate of less than $0.10/kWh, charging infrastructure site hosts (including the County) would need to meter equipment separately.

Figure 2. Illustrative TOU Rate for Summer and Winter



To estimate the total electricity costs for each charge port, ICF assumed a utilization of 6,000 kWh per port based on a review of electricity consumption at existing Level 2 charging equipment in the County. The model developed for the analysis can be varied to decrease or increase the annual utilization to 2,000 kWh or 10,000 kWh, respectively.

Other O&M Costs

ICF also assumed a monthly networking cost of $75 per EVSE or $900 per EVSE per year.

[4] This value is taken from the LCFS Reporting Tool.

Low Carbon Fuel Standard Revenues

Electricity is an eligible fuel under California's LCFS, and the County earns LCFS credits for every kWh of electricity delivered to vehicles in its fleet, or via charging stations that it owns. The model calculated the number of credits generated annually based on the estimated electricity dispensed at charging stations (see previous sub-section); these credits are subsequently monetized based on an assumption of low, medium, or high pricing at values of $80/ton, $130/ton, and $180/ton, respectively.

ICF used a carbon intensity (CI) value of 81.49 g/MJ for electricity using the California grid average.[4] This value will likely decrease over time as California deploys more renewables to achieve the targets of the Renewable Portfolio Standard (RPS). Furthermore, as part of the California Air Resources Board's (CARB) recently approved amendments to the LCFS program, EV charging station owners/ operators are able to reduce their carbon intensity below the California grid average using "low CI" electricity pathways.

Other Modeling Inputs/ Assumptions

For the sake of simplicity, ICF assumed no demand charges in this analysis; we note that SCE has proposed waiving demand charges on some of its pilot rates through at least 2025.

Review of Findings

Total Cost of Ownership of Level 2 EVSE

ICF analyzed the cost of installing and operating Level 2 EVSE equipment (assuming a dual-port EVSE) over a 20-year lifetime and report it here on a net present value (NPV) basis using a 5% discount rate. The table below summarizes the key expenditures incurred over the 20-year assumed life, including replacing the hardware every seven years (replaced twice over the assumed lifetime of the equipment). ICF estimates that there a net cost of $40,200 (on a NPV basis) of owning and operating a dual-port Level 2 EVSE over a 20-year lifetime, assuming that each port delivers 6,000 kWh of electricity at a rate of $0.135/kWh, and that the LCFS credits generate a value of $130 per metric ton.

Table 3. Estimated Lifecycle Cost of Owning Dual Port Level 2 EVSE

COST PARAMETER	EMPLOYEE OR PUBLIC
Capital, Dual-Port EVSE	$23,500
O&M	$11,800
Electricity (6,000 kWh/y/port)	$21,200
LCFS Credit Revenues	$16,300
Net	**$40,200**

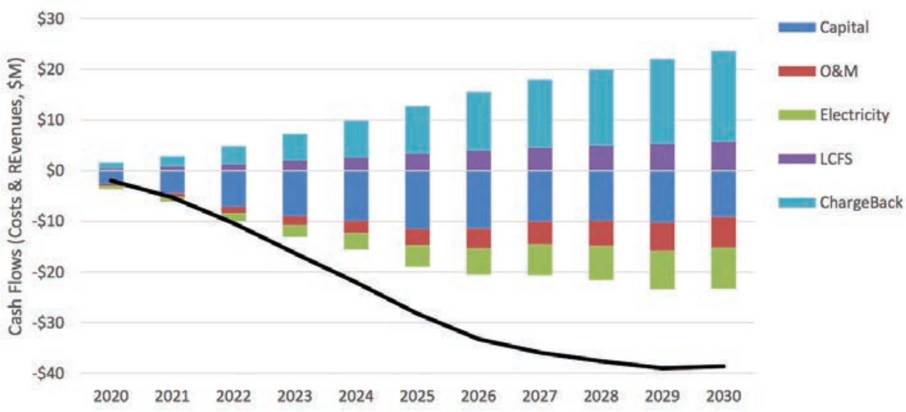
There are several ways which these lifecycle costs can be reduced:

- ICF employed a conservative estimate of $4,500 per dual-port Level 2 EVSE. There is potential for cost reductions as EV charging infrastructure becomes more ubiquitous; if we assume a hardware cost of just $3,000, then the total cost of ownership over the 20-year lifetime would decrease by more than $3,000 on an NPV basis.
- Consider for instance that some incentive programs, including state-run programs like the California Electric Vehicle Infrastructure Project (CALeVIP) and utility incentives like SCE's Charge Ready or LADWP's Charge Up LA! Program offer as much as $5,000 per charge port. These types of incentives can have a significant impact on the total cost of ownership for site hosts.
- LCFS credit prices have traded near or higher than $180/ton for more than six months. A higher credit price of $180/ton over just the first five years of ownership would increase the revenue by more than $2,000 on an NPV basis.

ChargeBack Analysis

The figure below shows the cost of installing and operating the charging ports between 2020 and 2030 (with a total of 10,000 charge ports deployed by 2030). In addition to the costs laid out previously—capital expenditures, electricity costs (at a rate of $0.135/kWh and utilized at 6,000 kWh per port per year), O&M costs, and LCFS credit revenues (at $130/ton). ICF also included a ChargeBack rate, which is the rate charged to users of the Level 2 equipment. In the reference case below, we show the revenue from a ChargeBack rate of $0.30/kWh. The black line shows the net cumulative costs (in $2019 real dollars) associated with deploying, owning, and operating the network of EV charge ports.

Figure 3. Costs of Deploying and Operating 10,000 Charge Ports in Los Angeles County, Reference



As shown in the figure above, the total revenue from LCFS credits at $130/ton and a ChargeBack rate of $0.30 per kWh is insufficient to offset the costs of installing and operating the 10,000 charge ports. The program generates net positive revenue in 2030 of about $0.4 million. By 2030, the program is at a net loss of $38.6 million.

There are a variety of ways that costs can be offset to yield a revenue neutral program by 2030. For instance:

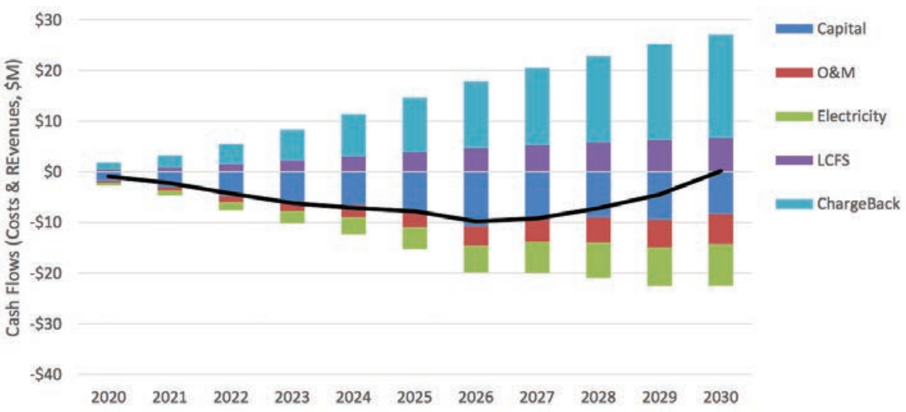
- If looking solely to capital expenditures on installation and hardware, the costs would need to be decreased by about 40% over the course of implementing the program, which is a reduction from $9,000 per charge port to about $3,600 per charge port or $7,200 per Level 2 EVSE. This is an aggressive cost reduction that will be difficult to achieve. However, other opportunities are more likely. For instance:
  - A $1,000 decrease in the cost of the EVSE alone would yield about $6.9 million in savings.
  - An incentive of $5,000 per EVSE, either from a utility program or state-administered program that was available through 2025 would yield savings of $12.3 million.
- For every $0.01/kWh that electricity costs are reduced from the default rate of $0.135/kWh, presumably through some managed charging or price signal (e.g., via TOU rate), then electricity costs will decrease by $3.45 million.
- Similarly, for every 1,000 kWh of increased station utilization, the program will generate an additional $15.3 million in revenue.
- For every $10/ton increase in LCFS credit prices, the program would generate an additional $2.7 million in revenue. At today's credit prices of between $180 and $190/ton, that would yield an additional $14.7 million of revenue over what is shown in Figure 3.
- If the ChargeBack rate is increased by $0.01/kWh, then the program would generate an additional $3-4 million in revenue (depending on the utilization of the equipment).

Table 4 illustrates the sensitivity to the assumptions outlined above, and shows that when these modest changes are implemented, the program is revenue neutral by 2030. And the figure that follows shows the revised cash flow using the assumptions listed in Table 4.

Table 4. Cash Flow Sensitivity to Different Cost Parameters

COST / REVENUE PARAMETER	DESCRIPTION OF CHANGE	PROGRAM IMPACT
Net Program Cash Flow		-$38.6 million
Lower EVSE Price	Decrease EVSE cost by $1,000	$6.9 million
Incentive	$5,000 incentive per EVSE through 2025	$12.3 million
Electricity Rate	Decrease rate by $0.01/kWh (managed charging)	$3.5 million
Charge Port Utilization	Increase utilization by 10% from Reference	$10.1 million
Higher LCFS Credit Price	Increase LCFS credit price by $10/ton	$2.7 million
Increased ChargeBack Rate	Increase ChargeBack Rate by $0.01/kWh	$3.3 million
Total Change in Cash Flow		**+$38.8 million**

Figure 4. Costs of Deploying and Operating 10,000 Charge Ports in Los Angeles County, Modifications



In this modified version, the program shows a slightly positive net cash flow by 2030 of about $0.2 million, and by 2027, the program is generating net revenue on a year-over-year basis with about 7,500 charge ports deployed.

COUNTY OF LOS ANGELES

Transportation Electrification Blueprint