CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

City and County of San Francisco Multi-Unit Dwelling Electric Vehicle Charging Project

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Prepared by: City and County of San Francisco Center for Sustainable Energy

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-2014-603 to support new and existing planning efforts for plug-in electric vehicles and fuel cell electric vehicles. In response to PON-2014-603, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards April 15, 2015 and the agreement was executed as ARV-14-042 on January 16, 2015.

ABSTRACT

The objectives of the City and County of San Francisco Multi-Unit Dwelling Electric Vehicle Charging Project are to identify areas within the city that are highly suitable for electric vehicle charging station development; identify and develop technologies that will allow multi-unit dwellings garage, curbside, and lot charging solutions to be deployed; and develop a permitting process that will allow access to power and space for the deployment of curbside electric vehicle charging stations, and new multi-unit dwellings garage and surface lot charging technologies.

The project objectives were completed in a series of five reports as follows:

1. *Infrastructure Study*
2. *Demand Report*
3. *Electric Vehicle Charging Station Pathways Study*
4. *Deployment Carbon Dioxide Study*
5. *Technology Report*

This final report includes a summary of each report with some key results and conclusions. The full reports were provided to the City and County of San Francisco Center for Sustainable Energy but are not included in this report. In addition, a series of maps were generated using data collected for the study. The maps display by vehicle type (Battery Electric, Fuel Cell Electric, Internal Combustion, and Plug-in Hybrid Vehicles), and median income, owner-occupied housing, number of registrations, vehicles per capita, vehicles and single-family homes, and vehicles and public charging stations (where applicable).

Keywords: Multi-unit dwelling (MUD), City and County of San Francisco, electric Vehicle (EV), Homeowner Association (HOA), electric vehicle charging station (EVCS)

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EXECUTIVE SUMMARY

The objective of the City and County of San Francisco Multi-Unit Dwelling Electric Vehicle Charging Project is to analyze and determine which multi-unit dwelling sites should be prioritized for electric vehicle charging infrastructure and technical assistance.

Through assessing utility electrical capacity and building-level physical and electrical infrastructure, the analysis aims to identify both electrical and parking infrastructure barriers to electric vehicle charging deployment at multi-unit dwelling.

Results of the analysis, detailed in this infrastructure study, show that relying solely on public level 2 and direct current fast charging is not a long-term electric vehicle charging solution for multi-unit dwelling residents. It also was determined that although San Francisco's utility grid has available electrical capacity to meet forecasted electric vehicle charging demand, the building-level electrical capacity to meet the demand varies. Most multi-unit dwelling buildings have the electrical capacity to serve one or two 40-amp circuits for electric vehicle charging; however, significant building level electrical upgrades would be required if existing buildings were to be brought up to the standards in San Francisco's electric vehicle readiness ordinance, which requires all new construction and major renovations to have 10 percent of parking spaces fully wired for electric vehicle charging and 100 percent of parking spaces to be electric vehicle capable with a clear path to electrical infrastructure.

This report includes discussions on parking infrastructure, utility-scale and building-level electrical infrastructure, distribution of existing electric vehicle charging permits in San Francisco, electric vehicle charging infrastructure, accessibility requirements and conclusions regarding electric vehicle charging infrastructure barriers specific to San Francisco.

CHAPTER 1: Infrastructure Study

Introduction

The objective of the City and County of San Francisco Multi-Unit Dwelling Electric Vehicle Charging Project is to analyze and determine which MUD sites should be prioritized for electric vehicle charging infrastructure and technical assistance. Through assessing utility electrical capacity and building-level physical and electrical infrastructure, the analysis aims to identify both electrical and parking infrastructure barriers to electric vehicle charging deployment at multi-unit dwellings.

Results of the analysis, detailed in this Infrastructure Study, show that relying solely on public level 2 and direct current fast charging is not a long-term electric vehicle charging solution for MUD residents. It also was determined that although San Francisco's utility grid has available electrical capacity to meet forecasted electric vehicle charging demand, the building-level electrical capacity to meet the demand varies. Most MUD buildings have the electrical capacity to serve one or two 40-amp circuits for electric vehicle charging; however, significant building-level electrical upgrades would be required if existing buildings were to be brought up to the standards in San Francisco's electric vehicle Readiness Ordinance, which requires all new construction and major renovations to have 10 percent of parking spaces fully wired for electric vehicle charging and 100 percent of parking spaces to be electric vehicle capable with a clear path to electrical infrastructure.

This report includes discussions on parking infrastructure, utility-scale and building-level electrical infrastructure, distribution of existing electric vehicle charging permits in San Francisco, EV charging infrastructure, accessibility requirements and conclusions regarding electric vehicle charging infrastructure barriers specific to San Francisco.

Conclusions

The lack of EV charging for MUD residents continues to be a significant barrier for drivers to convert from gasoline-powered vehicles to EVs. Through this analysis, barriers for EV charging installations were found to be concentrated at the building and parking space-level and closely related to costs. However, citywide data is not available to characterize the extent of building level electrical barriers. Additionally, MUD building electrical configurations vary, making it difficult to determine, from a city-wide perspective, which sites have enough electrical capacity. Upgrades to electrical capacity are possible; however, they are costly, and many property owners may not want to make the investment. At properties governed by HOAs, residents may have trouble with general funding being spent on electrical upgrades that only benefit a few drivers.

CHAPTER 2: Demand Study

Introduction

Approximately two-thirds of San Francisco's households live in MUDs. In support of San Francisco's goal to electrify all private transportation over time, this study informs the prioritization of MUD sites for investment of funding, technical assistance resources and other efforts to make charging infrastructure available to all residents and businesses. It specifically characterizes advantages and obstacles associated with installation of EV charging equipment as related to building size and age. For this study, MUDs are defined as buildings with five or more units. Available parking spaces are calculated using the San Francisco County Transportation Authority's methodology for parking estimation, which uses the building construction year and the number of units. Construction year groups were defined based on milestone city ordinance implementation, such as rent control and parking requirements via San Francisco's planning code. Building sizes were grouped into very large (100 or more units), large (20 to 99 units), medium (10 to 19 units) and small (five to nine units).

Key findings:

The 5+ unit MUD sector is a very large part of San Francisco's housing and parking stock with approximately 179,000 units and 114,000 parking spaces.

Older MUDs are often smaller in scale and have only a few off-street parking spaces, if any. This is the dominant MUD type – approximately 86,000 units were built before 1940 and have fewer than 100 units – these present multiple, unique challenges.

Newer MUDs are often larger. Many are exempt from rent control and have ample off-street parking. These buildings provide the greatest opportunity for EV charging, but there are only about 250 such buildings.

Challenges differ per building type but residents and landlords in MUDs face significant obstacles in almost all existing MUD developments:

- Shared and often fully utilized electrical supply, sometimes with deferred maintenance
- Distributed ownership and control over common spaces and investments
- Limitations on ability to profit from improvements, especially in rent-controlled buildings
- Prohibitive costs of taking an incremental 1:1 approach to installing charging, versus larger, more economically efficient installations.

Conclusions

Larger, newer buildings are likely to be the most feasible locations for installing EV charging equipment. They are more likely to have on-site management to assist with installation and operation of charging equipment, as well as electrical capacity to support charging multiple vehicles at once.

Smaller, older buildings present more numerous and complex challenges. They are more likely to be subject to rent control or administrative steps related to HOA administration. Older buildings also are more likely to have smaller parking lots, which decreases operational flexibility and increases opportunity costs associated with assigning EV-only parking spaces, particularly at buildings where there is high tenant turnover.

Other factors affecting the feasibility of installing charging equipment include unit tenure and parking allocation; factors which may or may not be related to construction year or building size. Strategies and solutions for overcoming various obstacles to installation will be explored in the deployment and technologies reports.

CHAPTER 3: EVCS Deployment Pathways Report

Introduction

With the goal to achieve widespread transportation electrification, residents of the City of San Francisco's MUDs will need convenient access to EV charging. Previous reports have identified more than 11,300 parking spaces at MUDs capable of hosting EVCS. When coupled with the appropriate application of technologies and electrified in a cost-effective manner, these spaces create the opportunities for great contributions to San Francisco's greenhouse gas reduction goals. As with many innovations, substantial barriers toward widespread development of EV infrastructure at MUDs remain. This report identifies pathways to increasing the deployment of EVCS in three primary areas: Electrical & parking requirements, permitting processes, and property owner/manager processes.

Electrical & Parking Requirements

Level 2 EVCS require a substantial amount of electrical capacity relative to other loads commonly seen in MUDs, and many properties do not have the electrical capacity to support large scale Level 2 EVCS deployments. To find the best charging solution, electrical capacity must be determined. Load balancing or demand management systems can help maximize existing electrical capacity, although new or upgraded service might still be needed in many cases.

Parking configurations can have a major effect on the cost of installation of EVCS. Some parking layouts may require complicated electrical wiring runs to reach the desired parking spaces, especially when deeded parking limits flexibility. Compounding these issues are requirements for Americans with Disability Act accessible parking, which when required can necessitate costly parking reconfiguration or loss of a space. Creativity in managing both electricity and parking issues can support increased EVCS deployment.

Permitting Processes

The City of San Francisco Department of Building Inspection currently has an efficient process for electrical permits; however, some challenges still exist to successfully permitting EVCS deployment. For instance, despite that the current permit process for EVCS is the same as any other electrical load permit, potential applicants may be unsure of the requirements. EVCS provisions are included in both the state energy code as well as San Francisco's EV Readiness Ordinance for new construction and major renovations. Additional guidance could help applicants navigate the process.

Property Owner/Manager Processes

The process of EV charging installation is still relatively new to the greater public, and many property owners/managers lack current and relevant knowledge needed to successfully deploy EVCS at their buildings/properties. Technical assistance programs can guide the property through the process of developing an EVCS project, or alternately more guidance may be needed for property managers to act. Possessing the most accurate information can lead to quicker, more cost-effective installations.

Conclusions

There are multiple pathways to increased deployment of EVCS at MUDs, all of which can be implemented as resources allow. Electrical and parking issues at existing buildings will always be a barrier, but creative solutions can be found. The permitting process itself is not a major source of delays, but a lack of understanding of the process by applicants can make it seem like a barrier. There may also be opportunities for the city to leverage the permitting process to encourage more installations in conjunction with other projects. Finally, property owners need help to navigate the process of installing charging stations, either through direct onsite technical assistance or through additional guidance to help them find the best solutions for their properties.

CHAPTER 4: EVCS Deployment Cost-Benefit Analysis

Introduction

The objective of the City and County of San Francisco Multi-Unit Dwelling Electric Vehicle Charging Project is to analyze and determine which MUD sites should be prioritized for EV charging infrastructure and to provide technical assistance. Through assessing carbon dioxide equivalent (CO_2e) reduction potential and costs associated with EVCS installation in all MUD parking spaces (MUD buildings of 5 units or larger), this analysis seeks to determine the CO_2e reduction cost-benefit of EVCS installation.

Results of the analysis show that EVCS installations in larger MUDs yield a lower average cost per metric ton of CO_2e reduced. The reason for this is that larger MUDs have a lower associated average cost of EVCS installation, and assuming constant values for miles traveled per parking space, which translates to CO_2e reduction potential, they have a lower average cost per CO_2e reduced. This metric can be used to determine the value of investments in EVCS deployment in terms of dollars spent per CO_2e reduced.

It is important to note that if all MUD parking spaces are electrified, their associated vehicles are converted from gasoline-powered vehicles to EVs, and the city moves to 100 percent renewable energy, this would have the potential to reduce an estimated 221,864 metric tons of CO_2e annually. For perspective, this would account for 12 percent of total CO_2e emissions from passenger vehicles in the city. Therefore, this EVCS deployment scenario would substantially help the city achieve its greenhouse gas reduction goals.

Conclusions

Utilization of EVCS is important to consider when finding the best cost benefit. Simply put, the investment should be made in places where the infrastructure is most likely to be used, and where the units are likely to be used the most. Even if EVCS are installed, not every resident will purchase an EV, and those who own PHEVs will not conduct all their driving on electric drive. Furthermore, EVCS may not be used directly after installation (i.e., there may be a time gap between installation and utilization when stations are being placed). If this time gap is extensive, it will have an impact on the CO_2e cost-benefit of that installation because the EVCS installation will have been paid for but is not actually providing CO_2e reductions.

Another important strategy to identify is how to lower the cost of installation to improve the overall cost/benefit score of EV charging. Lower costs can be accomplished by identifying individual MUDs that have the highest capacity to install EV charging, and efforts should be made to install charging infrastructure during new construction, major retrofits, or in conjunction with other projects. Furthermore, as EV technology improves, particularly in terms of miles/kilowatt-hour efficiency, the cost/benefit score of EVCS installation will improve as well.

CHAPTER 5: EVCS Technology Review and Specification Report

Introduction

The objective of the City and County of San Francisco Multi-Unit Dwelling Electric Vehicle Charging Project is to analyze and prioritize MUD sites for EV charging infrastructure and provide technical assistance. This Technology Review and Specification Report identifies specific barriers to infrastructure deployment and respective solutions to meet them.
EVCS installation in MUDs can be stalled by a range of technology-related reasons. Examples of barriers include unavailable electrical capacity in buildings and costly demand charges, as well as a lack of coordination between property owners and tenants necessary to implement new technology solutions.

Enabling EVCS installations in MUDs requires more than a single technology or program fix. This report details how a mix of technologies, including load balancing solutions and demand management/response systems coupled with an understanding of other building loads can reduce costs of installation and allow more EV drivers to charge with a fixed number of EVCS. Other considerations were made to inform potential charging hosts of common issues regarding charging capacity, cost repayment schemes, and operational considerations. This report may be used by MUD property owners, residents, stakeholders in the EV industry, local governments, technology providers, and others to enable and increase the ease of EVCS installations in MUDs.

Smart charging technologies such as load sharing EVCS and whole building energy management systems offer benefits to both MUD residents and property owners. These include greater cost- effectiveness and the ability to serve a greater number of EVs. The SF Department of Building Inspection is well equipped to permit these new charging systems; however, a lack of knowledge and training among property owners and EVCS installers prevents wider adoption.

For both property owners and EVCS installers, a lack of awareness means missed opportunities. Inexperienced installers, for example, often recommend unnecessary and expensive service panel upgrades and dedicated circuits to each parking spot as the only way to implement EV charging. Property owners are not well positioned to research or ask installers about load management alternatives. Most have never heard the term before, know how much potential capacity their building has, or understand what charging station usage they might expect to see.

Without an understanding of building electrical capacity and expected charging station usage, neither installers nor property owners can identify cost effective solutions. Utility demand management and demand response programs are effective at ensuring that charging is well-integrated with the grid, but do not directly address building level capacity issues. Property owner and EVCS installer trainings paired with individualized technical assistance may prove an effective solution.

Conclusions

The upfront cost of charging is still a major barrier for MUDs, but project planning can help minimize installation costs in combination with grants and other types of incentives. Ultimately, property managers and HOAs must find innovative solutions to covering the costs of EVCS installations between the current EV drivers who directly benefit, while planning for growth as other residents buy EVs or new EV-owning residents are attracted to the property.

GLOSSARY

CARBON DIOXIDE EQUIVALENT (CO_2e)—A metric used to compare emissions of various greenhouse gases. It is the mass of carbon dioxide that would produce the same estimated radiative forcing as a given mass of another greenhouse gas. Carbon dioxide equivalents are computed by multiplying the mass of the gas emitted by its global warming potential.

ELECTRIC VEHICLE (EV)—A broad category that includes all vehicles that are fully powered by electricity or an electric motor.

ELECTRIC VEHICLE CHARGING STATION (EVCS)—An electric vehicle charging station, also called EV charging station, electric recharging point, charging point, charge point, electronic charging station (ECS), and electric vehicle supply equipment (EVSE), is an element in an infrastructure that supplies electric energy for the recharging of plug-in electric vehicles—including electric cars, neighborhood electric vehicles and plug-in hybrids.[1]

HOMEOWNER ASSOCIATION (HOA)—California Homeowners Associations was developed to provide contact information to assist real estate professionals, attorneys, title companies, mortgage brokers, banks, homeowners etc., so they can easily contact a representative or property manager for a given HOA. Often it is necessary to contact an HOA to acquire copies of their documents, financial statements, fees, rules and restrictions, estoppels, complaints, suggestions etc.

MULTI-UNIT DWELLING (MUDS)—is a classification of housing where multiple separate housing units for residential inhabitants are contained within one building or several buildings within one complex. Units can be next to each other (side-by-side units) or stacked on top of each other (top and bottom units). A common form is an apartment building. Many intentional communities incorporate multifamily residences, such as in cohousing projects.[2]

PLUG-IN HYBRID ELECTRIC VEHICLE (PHEV)—PHEVs are powered by an internal combustion engine and an electric motor that uses energy stored in a battery. The vehicle can be plugged in to an electric power source to charge the battery. Some can travel nearly 100 miles on electricity alone, and all can operate solely on gasoline (similar to a conventional hybrid)

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[1] Electric vehicle charging station https://en.wikipedia.org/wiki/Charging_station

[2] Multi-Unit Dwelling Definition https://en.wikipedia.org/wiki/Multi-family_residential