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Multi-Unit Dwelling Plug-in Electric Vehicle Charging Innovation Pilots in U.S. Metropolitan Areas

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Summary

Multi-unit dwellings (MUDs) make up approximately 34% of the U.S. housing inventory in major metropolitan areas,^[1] however, less than 5% of home charging^[2] occurs at MUDs.^[2] The U.S. Department of Energy funded a three-year market transformation project to develop a comprehensive view of the MUD and curbside residential charging market and identify and develop solutions to overcome the major barriers to widespread plug-in electric vehicle (PEV) charging deployment at MUDs. This paper includes results of a year-long, nationwide baseline evaluation of quantitative and qualitative MUD and curbside residential PEV charging data. The paper will summarize the current barriers, evaluate the utility of available tools to overcome barriers, highlight innovative technology solutions, and review tools that will be developed to bridge the gap. The paper will also summarize the design, demonstration, and expected findings from the innovative technology demonstration pilot program that will run from July 2020 through June 2021.

Keywords: smart charging, load management, Level 2, power management, electric vehicle (EV), electric vehicle supply equipment (EVSE), infrastructure, multi-unit dwellings (MUD)

1 Project Overview and Goals

The project will identify and address barriers to plug-in electric vehicle (PEV) charging for multi-unit dwelling (MUD) residents by engaging stakeholders across the country, demonstrating innovative technologies, and providing educational resources. MUDs include apartments, condominiums, duplex townhomes, and multilevel housing. PEVs includes both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), both of which require reliable access to charging. The Project Advisory Committee (PAC) consists of stakeholders that support this goal including 14 Clean Cities coalitions, the National Association of State Energy Officials, utilities, state/local government agencies, innovative PEV charging technology providers, and MUD developers. The project team and PAC are identifying barriers related to MUD and curbside residential charging and discuss innovative technologies that address these barriers. The project will collect and analyze charging session usage data from PEV charging stations (also referred to as electric vehicle supply equipment [EVSE]), from a range of MUD and residential curbside

EVSE currently in use. The data analysis results will: 1) characterize the baseline operation and business case, 2) identify opportunities to improve EVSE utilization, and 3) identify hardware, software, and system control options to reduce the capital and operations costs for both upgrading/expanding current installations and for planning new installations. This information will augment documented barriers and will be used to develop innovative technology solutions demonstrations that address the barriers. Project findings will be compiled in an easy-to-use toolkit that will be disseminated using established national, regional, state, and local channels.

2 PEV Charging at MUDs – Baseline Charging Data Evaluation Results

A baseline evaluation of PEV charging station use by MUD residents was done in Year 1 of the three-year project. The baseline evaluation included both quantitative (Sections 2.1) and qualitative (Section 2.2) data collection and analysis. The data collection and analysis goal is to characterize how MUD resident PEV charging is currently being done, and to identify opportunities to improve the process, capital costs, operating costs, etc. The evaluation results informed the design and deployment of the Year 2 innovative technology demonstration pilot program (Section 3) and the development of tools/resources for a MUD Charging Toolkit that will be developed to support widespread deployment of charging infrastructure at MUDs.

2.1 Quantitative Baseline Data Collection, Aggregation, & Analysis

2.1.1 Data Source Description

Several key data providers committed to provide MUD charging data to the project during the proposal. Additional project outreach was done to identify and secure additional data to augment the dataset. This effort was challenging because the locations of MUD charging stations are not always publicly-known by stakeholders (utilities, Clean Cities Coalitions, etc.) or included in online databases. MUDs with more basic non-networked stations do not collect the usage data the project requires so data came from networked/managed stations. Baseline charging session summary utilization data (EVSE identifier number, EVSE location, location type, charge level [e.g., Level 2 [L2] and direct current fast charge or DCFC], connection and charge start/end time, total energy provided [kilowatt-hours or kWhs], and EVSE maximum power output) were collected from both on-property MUD-sited EVSE and “MUD-Adjacent” EVSE located nearby MUD properties to provide a comprehensive view of residential charging in multiple regions. Several data providers did not provide the primary use type information. Data included: 1) eight data providers, 2) 512,175 charge sessions, 3) 1,474 charging stations, 4) 11 states and the District of Columbia, and 5) six charging networks. The data spans approximately six years (2014-early 2020). Data providers include EVSE charging network management companies, property owner/management companies, and state/local governments. Figure 1 summarizes the collected MUD charging sessions by anonymized data provider, anonymized charging network, state, and year.

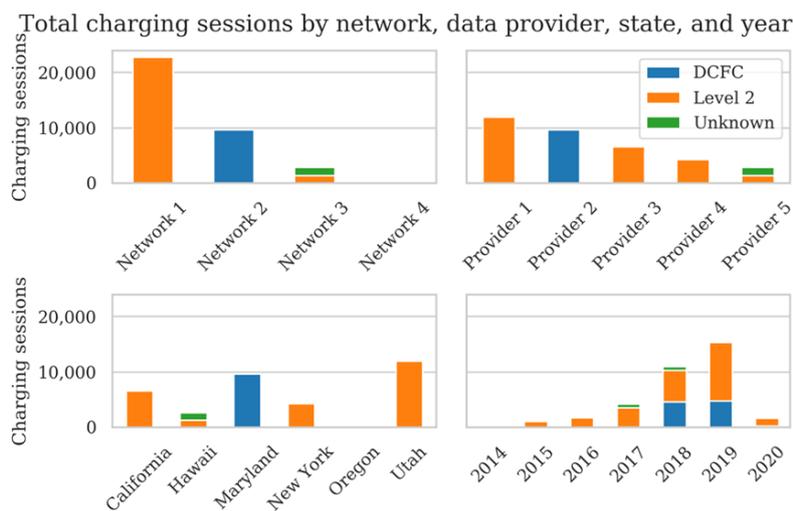


Figure 1: Charging sessions by anonymized network, anonymized data provider, state, and year

2.1.2 Analysis Methodology

2.1.2.1 Removal of Outliers

Filters to remove outlier data were chosen based on project experience and input from project partner Idaho National Laboratory staff, to exclude charging sessions with abnormal energy output and/or duration. Filters including maximum average power, maximum share of charging time, minimum plug-in duration, and minimum energy per charging session were applied to the data. Table 1 presents the outlier data filters that were used and the number of charging sessions they excluded. The result removed a total of 79,312 plug-in events (15.5% of the total) by the outlier filters.

Table 1: Charging session data excluded by data filters

Filter	Number of Charging Sessions Excluded	% of Total Charging Sessions Excluded
Average power > 500 kW	1,538	0.3%
Energy < 0.02 kWh	45,006	8.8%
Charging duration > Plug-in duration	34,772	6.8%
Plug-in duration < 3 minutes	42,961	8.4%
Charging duration < 0 seconds	67,012	13.1%
Total removed by filter**	79,312	15.5%

** *Note: Some charging sessions were screened out by multiple filters. The result was that 79,312 unique sessions were removed by the data filters.*

2.1.2.2 MUD Session and MUD Station Classification

Data providers were requested to provide only data from EVSE at MUDs. Not all data providers defined charging stations as being located at a MUD (“MUD-Located”) or not. Analysis determined that the dataset also included many charging stations that were not located on a MUD property; many were located nearby MUDs. These charging stations were likely not installed with the expectation of serving nearby MUD residents, but can be used this way (in addition to other customer types). Feedback from some data providers indicated some off-property EVSE are used by nearby MUD residents. These charging station locations include, but are not limited to: curbside parking spots, mixed-use properties, and shopping areas. Charging sessions from the cleaned dataset were categorized into two groups: 1) data provider indicated MUD-Located stations (~24,000 charging sessions) and 2) the potential “MUD-Supporting” stations. For MUD-Supporting stations, a 300-foot threshold (informed by a literature review) was used with the goal of only including off-MUD property located charging stations that were within a realistic and acceptable walking distance for most MUD residents to consider using regularly. Where possible, residential permit data with geographic coordinates was located to identify multifamily property locations. A Python script was developed to compare the location data of the MUD properties and charging stations to determine the shortest distance between each pair. The data were further reduced by including only repeat users. The data reduction resulted in charging session data from the final MUD-Supporting dataset that included 325 charging stations and ~2,700 charging sessions that were further analyzed.

2.1.3 Charging Session Data Analysis Results

The MUD-Located data are the most concrete data, so the analysis presented here focuses on this data. This data subset included a total of 23,925 charging sessions at 223 charging station ports. The data were analyzed to quantify the charging station utilization. The increasing trend of average weekly charging sessions per station is shown in Figure 2. The apparent 2020 decrease is solely due to partial year reporting. Figure 3 shows trends in total charge sessions and total energy usage over time (partial 2020 data). There is an increase in both the number of charging sessions and the amount of total electricity provided by MUD PEV charging stations every year. The increased growth rate starting in 2017 matches expectations from increased PEV model availability and adoption. There is a positive correlation

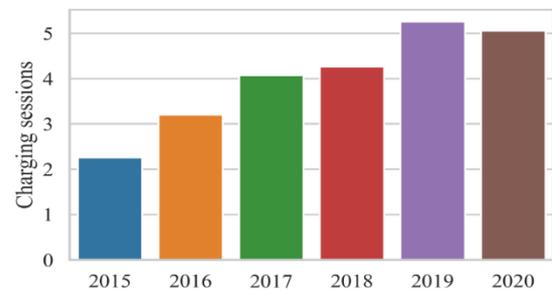


Figure 2: Average weekly charging sessions per charging station type

between the energy provided and the number of charging sessions over time (as time passed, more annual charging sessions provided more total energy). There is a clear and consistent relationship between the number of charging sessions and the amount of energy provided, with an average of approximately 18.4 kWh per charge (~2.8 hours on a 6.6 kW L2 EVSE).

The expectation was that MUD charging sessions would frequently last for many hours, likely overnight. The violin plots in Figure 4 show probability density functions for: 1) plug-in duration and 2) charging duration. The typical MUD-Located AC Level 2 charging session lasted an average of 12.2 hours and had an average charge duration of 3.6 hours, shorter than initially expected. The longer plug-in durations meet expectation for overnight charging sessions. The difference also highlights that energy is not being provided to the PEVs for those entire time connected to the EVSE. The long period of time when charge is not being provided to the vehicle highlights the opportunity to increase charging station, or electric infrastructure utilization with software and hardware smart charging station technologies.

The violin plots in Figure 5 provide a similar view on the charging sessions but focus on the energy provided. The plots illustrate the variation between the energy provided per charging session and the charging session length. The plots show two probability density functions: 1) for charging sessions connection time equaled the charging time (orange), and 2) for charge sessions where the connection times were longer than the charging time (blue). The data profiles, averages, and interquartile range (i.e., 25%-75%), for both subsets are similar. The fact that the plots have similar profiles and summary parameters confirms the conclusion that energy is not being provided for the entire plug-in sessions on long sessions.

Figure 6 shows the combined *weekday* (top) and *weekend* (bottom) connection time data with low (green), average (blue), and high (orange) bands shown. As expected for residential charging, the average weekday usage is low during the day and starts to increase as early as 3 PM and continuing through 11 PM. Usage remains high and nearly constant as expected overnight. The largest connections decrease occurs from 6 AM – 9 AM as residents leave for the morning commute to work.

As expected for *weekend* residential charging, the usage is low during the day and starts to increase as early as 3 PM and continuing through 11 PM. Usage remains high and nearly constant as expected overnight. The average *weekend* trends are similar to the *weekday* trends, but are more muted and gradual. This is logical because it captures people’s personal trips that happen on their schedule, not a set workday/commuting schedule. The somewhat lower amount of connections on the weekend could be from a variety of factors including: less driving than workday commuting, charging at other locations, or weekend trips.

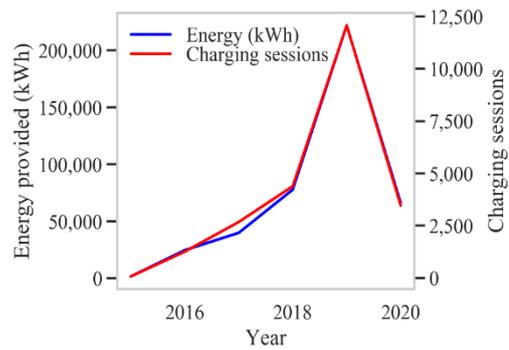


Figure 3: Historical trend of number of sessions and energy provided

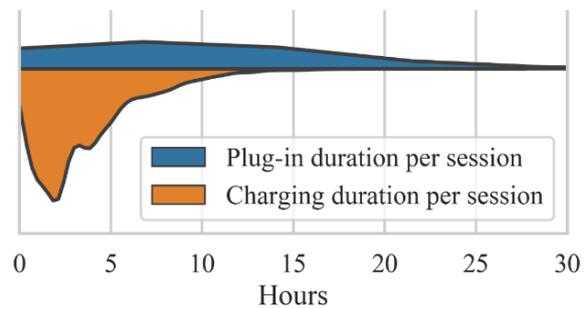


Figure 4: Distribution and comparison of charge session time for charge sessions equal to (orange) and longer than (blue) the plug-in time

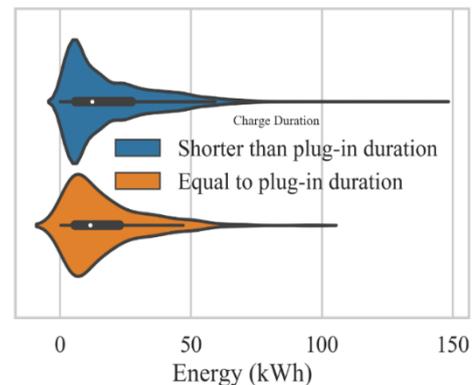


Figure 5: Distribution and comparison of charging energy by connection time

2.2 Qualitative Baseline Data Aggregation & Analysis

Decision-making for MUDs requires consensus, authorization, and action by numerous stakeholders (e.g., tenants, asset owners, property managers, homeowner association board members, and technology providers). The project’s qualitative analysis includes identifying the decision-making process for MUDs, identifying the key barriers to charging, and an evaluation of tools/resources available to help MUD stakeholders select, install, and operate charging infrastructure.

2.2.1 MUD Decision-Making Process

MUD buildings in the U.S. are a wide group consisting of multiple building types, ranging from apartments and condominiums to duplex townhomes and multilevel housing. Two key categories of MUD building types are created for the purpose of this paper. Type 1 MUD buildings have a single owner and decision-maker, whereas Type 2 MUD buildings have a collective decision-making process. Interviews stated the decision process is straightforward for Type 1 MUD buildings. The process mostly involves the building owner or manager receiving requests from the residents to initiate the process, followed by a consultations with a vendor or installer and receiving one or more bids. Once the building owner accepts the installation cost bid, the installation can start. On the flip side, the decision-making process is much more complicated for Type 2 MUD buildings. For example, a condominium will have covenants or declarations which dictate rules for the building, and bylaws which outline the management structure. For most circumstances, the bylaws prescribe that most of decisions will be conducted through a group, like a board of directors, for a homeowner association (HOA). The board members are generally recommended by the homeowners and elected by a voting process that grants the elected delegates the power to decide on issues for the building on behalf of the homeowners. HOA boards do not have the power to make all decisions. For example, an amendment to declare common areas (e.g., parking) to install charging often requires a two-thirds majority vote to approve. The decision is made by a democratic voting process among all homeowners. In one example, a Seattle high-rise condo building resident with assigned parking took nearly 10 years to convince the HOA to provide a communal charging station, and later a program for limited common area charging [3]. The HOA members’ education and engagement outlined the complicated processes to get charging through the HOA. While HOAs and buildings differ, the article captured the considerably more complicated stakeholder engagement and decision-making process for Type 2 MUDs.

2.2.2 Identification of Key Barriers

To ensure the project’s final deliverable toolkit will feature resources that address the barriers faced by existing MUDs, this chapter focuses on identifying key barriers to providing charging stations in MUDs. The barriers are derived from a mixture of literature review and project outreach and engagement efforts, which include stakeholder survey responses and interviews.

2.2.2.1 Education and Awareness Barriers

There is a major knowledge gap between those working in the electric vehicle industry and the consumers and key players who make decisions for MUDs. Deficiencies of knowledge about both the vehicles and the charging infrastructure created a significant barrier to the implementation of charging infrastructure. As one of the most documented and mentioned barriers in both the literature and our outreach effort, the lack of PEV education and awareness is one of the most important and easiest barriers to overcome.

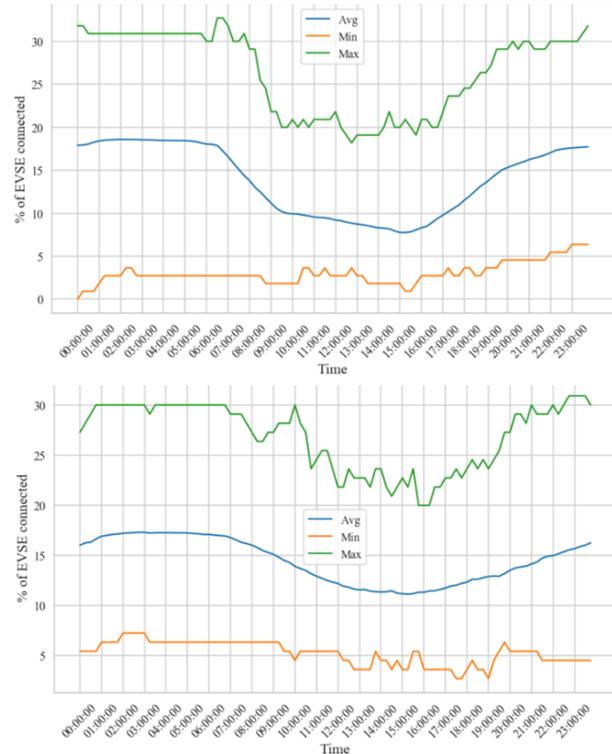


Figure 6: Weekday and weekend charging trends

2.2.2.1.1 Awareness Barriers among Building Owners, Managers, and HOAs

The lack of awareness among MUD building owners and managers has a highly negative impact on the provision of charging infrastructure due to their position as key decision-makers. Their decision-making process is often dominated by common misconceptions and misinformation about charging such as limited demand, prohibitively high costs, and the lack of a business case. As pointed out by a 2015 study for Silicon Valley, property managers do not understand how to evaluate factors for deploying EVSE, and they lack business strategy and have limited authority [4]. Without proper education, the building owners could oppose charging infrastructure out of unfamiliarity with the subject and a lack of awareness to residents’ demands. HOAs for condominiums, under most circumstances, have the right to reject requests from the residents or homeowners for installing charging stations or electrical outlet for a resident supplied charging station. The lack of awareness and understanding of PEV and charging blocks homeowners from installing charging stations and may prompt HOA directors to dismiss the idea quickly without proper evaluation.

2.2.2.1.2 Awareness Barrier by Consumers and Residents

MUD residents’ level of awareness about the available EV makes and models that can meet their needs will dictate their demand for charging; hence educating consumers with proper EV knowledge will be beneficial to improve adoption and encourage stronger self-advocacy from the residents. As for PEV charging, MUD residents most likely don’t understand the complexities of installing a charging station in the building, and many non-PEV drivers may reject the provision of charging infrastructure due to extra costs. This may leave the PEV advocate to either live somewhere else with charging or having to give up PEV as a viable option entirely. MUD residents should be properly informed on the costs and benefits of EV charging stations and be equipped with basic information about charging infrastructure and installation. To advocate for such an amenity for the building calls for specific resources to educate all residents and gaining their support in getting charging stations at their buildings.

2.2.2.2 Financial Barriers

As an emerging technology, PEVs and EVSE continue to undergo rapid changes. As shown in Figure 7, which is an estimates of costs for EVSE installation [5], the potential costs related to EVSE installation at MUDs have multiple levels, and due to different building layout and structures, the total cost estimates vary greatly. The financial cost of

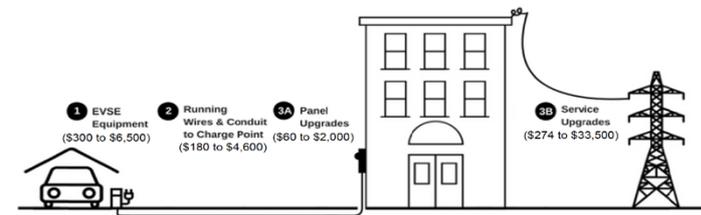


Image Source: Noun Project; car by Tracy Tam; electric equipment by Prosymbols; building by Nicholas Menghini; pylon by Arthur Shlain.

Figure 7: Summary of component costs for EVSE installations

charging stations is one of the most widely recognized and well-documented barriers that have been repeatedly brought up in the project’s survey and outreach interview efforts. This section will explore the range of costs associated with EV charging in MUDs, including those related to EVSE installation, operation and maintenance, and cost-sharing between parties.

2.2.2.2.1 Installation Costs

The capital to install EVSE and the ability to recover these investments are significant barriers for providing charging in MUDs. EVSE installation costs typically include permitting, inspections, engineering, electrical work, construction, and labor [6]. Unlike a single-family home with a more straightforward cost structure, installing charging stations at MUDs can vary greatly. The first installation cost category is connecting the parking spaces to the existing electrical panel.

This cost increases as the distance between the electrical service panel and the parking space increases, resulting in one of the highest costs associated with EVSE installations. Excavation, trenching or boring through parking garage walls and floors significantly increase the total installation cost [7]. Table 2 is from

Table 1: MUD installation cost factors

Cost Category	Average % of Installation Costs	% Range
Materials	33%	28-40
Labor	46%	41-56
Tools, Permits, and Fees	7%	3-10
Others	13%	12-20

a report that assessed MUD barriers in Los Angeles County’s South Bay region [8] shows the high cost of installation is mostly a factor of high labor costs related to construction activities. If the existing electrical panel does not have sufficient space or electrical capacity to accommodate the EVSE intended to be installed, additional cost to upgrade the panel will be needed. The total implementation cost as a significant barrier has been well-documented in numerous reports and studies for cities ranging from EV-ready areas including Los Angeles, the San Francisco Bay Area, and in Midwest cities such as Columbus, Ohio.

2.2.2.2.2 Operation and Maintenance Costs

In addition to the initial hefty cost of EVSE installation, the upkeep and operation of EVSE can constitute a set of cost barriers for MUD buildings. Operation and maintenance costs include but are not limited to electrical utility costs, including energy and demand charges, EVSE network subscription fees, management time, billing and transaction costs, and hardware maintenance and repairs.

Some MUD buildings may decide to install EV charging stations for communal use by all residents, which may also be used by the public in some cases. In these circumstances, it is typical for buildings to commit to a long-term contract with an EVSE service provider that handles all aspects related to EV charging station operation, maintenance, and customer billing with a certain reoccurring costs.

2.2.2.2.3 Perceived Lack of Resident Demand and Business Case

Another significant financial barrier is the business case for charging stations as an investment is deemed unknown. Many building owners do not invest in EVSE due to unknown costs, lack of perceived demand, complex installation process, and unclear business model [6]. The typical “chicken-and-egg” problem for an emerging technology is in full play when buildings are deciding on such an investment. Are residents already driving PEVs but utilizing charging elsewhere? Will more PEVs be purchased if charging exists in their building? Building owners may not hear from residents interested in charging or actively canvassing residents’ interest levels, which leads to a vacuum of information and an impression of a lack of demand for charging.

The project’s interviews revealed that building owners are less willing to accept the risk of installing charging stations when little demand exists because there are other more urgent items of building maintenance and upkeep competing for the same resources. For those building owners looking at EVSE as a revenue source and a way to maintain competitiveness in the market, the return on investment is largely perceived as uncertain.

2.2.2.3 Electrical Preparedness Barriers

For existing MUDs, the building’s physical infrastructure, especially its electrical preparedness, can turn out to be a difficult to overcome or expensive cost barrier. Considering that most buildings today were built before EV charging infrastructure was future possibility that buildings should be prepared for, most are simply not designed to accommodate PEV charging.

2.2.2.3.1 Electrical Capacity

In addition to the aforementioned installation costs for bringing power from the panel to the parking spaces, there are potentially significant costs for additional transformer or service capacity upgrades. The total capacity and baseload of each building varies, so the the ability of the building’s electrical system to accommodate the additional load from EV charging also varies depending on the surplus capacity. Typically, utilities will work with building owners to determine if upgrades are required by reviewing the annual peak load or, alternatively, building owner can conduct a 30-day load study with qualified electrical engineers.

From our project interviews with stakeholders, we learned that some building owners found it difficult and expensive to determine available capacity without conducting a costly load study. One interviewee received an astonishing \$100,000 quote for a load study to determine available electrical capacity. However, drawing from the project survey and comments of the Project Advisory Committee and key stakeholders, the barrier of existing electrical infrastructure requiring upgrades before charging stations can be installed is ranked on the lower end of the spectrum, indicating a lower level of concern.

2.2.2.3.2 Metering

Some older and smaller rental buildings are bulk metered, which means that the electric utility only has one master meter for the entire building, and the electricity costs are distributed among all residents based on the total electricity consumption. This configuration can create equity challenges when the building is paying for the energy of the stations while most stakeholders indicated that PEV owners should pay for themselves.

MUD buildings that are direct metered by each unit still pose unique challenges. Even though each unit has its own meter and is charged for electricity based on the unit's consumption, the unit's meters may not be close to the parking areas. Adding additional utility meters can be prohibitively expensive.

According to project interviews, stakeholders noted that the situation could be even more expensive due to limited switchgear space, which requires upgrades, and the need for revenue-grade submeters to be compliant for direct meter regulations of local electric utilities.

2.2.2.4 Building Physical and Design Barriers

A building's physical design can present both opportunities and barriers to EVSE installation as most existing buildings were not designed with EVSE in mind.

2.2.2.4.1 Parking Arrangement and Operation

A building's parking arrangement will be a major determining factor for the location of charging stations. The interviewed stakeholders identified the supply of parking and different parking arrangements present barriers to EVSE implementation.

For buildings with parking garages that are not assigned to a certain unit of the building, the limited parking spaces provided may result in a substantial barrier to station siting. Due to the lack of available parking spaces, it becomes a challenge to reassign parking spaces dedicated for PEV charging. Even if the charging station will be for communal use, it can be difficult to locate and may be an unpopular change to the residents.

For MUD buildings with deeded parking, the building's design could create prohibitive costs if the assigned stall of the PEV driver is far from the electrical panel. As mentioned, the necessary excavation, trenching, or boring through the parking garage to connect the EVSE to the electrical panel could be cost prohibitive.

Stakeholders interviewed also noted that problems may arise from EVSE being utilized by outside visitors and unauthorized vehicles such as internal combustion-engine cars. This calls for educating the residents and operation personnel and creating a guideline of proper parking policy for EVSE operation and enforcement.

2.2.2.4.2 Internet Connectivity

For many MUD buildings looking to provide charging as an amenity for communal use, it is important to consider the EVSE's network capabilities. Networked EVSE enables access control and billing services for the site host, while also collecting data and providing analysis for station utilization.

In order to ensure data collection and charging station operation, it is important to provide stable internet connectivity. According to interviewed stakeholders, many have experienced the barrier of no connectivity in the parking area, especially in an underground garage that may not permit strong cellular signal essential for network functionality. This barrier results in the need to run ethernet wiring or install multiple WiFi routers/repeaters that increase the overall charging station installation cost.

2.2.2.5 Other Barriers

2.2.2.5.1 Condo-Specific Barriers

In condos, the barrier to EVSE installation lies in common area management, which is dictated by the covenants of HOAs, including the processes required to amend anything. The need for amendment may be triggered when individual condominium owners desire to run electrical wiring from an electrical room to their parking space. The terms and conditions can impact a condo HOA's ability to implement modifications and make investments that would enable any or all owners to install EVSE.

An HOA's bylaws for an amendment typically requires formal notice periods, approval votes of a two-thirds majority of unit owners, and legal amendments to the covenants. These steps create delay, risk of

nonapproval, and add cost. This process will require dedicated EV advocates to educate the association members about the costs and benefits of charging infrastructure and to build a coalition of a two-thirds majority vote to approve any amendments.

2.2.2.6 Rental Property-Specific Barriers

It is particularly challenging for renters to negotiate to get charging and to convince building owners to install or pay for a charging stations. Typically, other renters have low to no motivation to investment in EV charging, and the building owners do not yet see charging as an amenity by which to increase property value and attract tenants. Furthermore, renters are unlikely to invest in immobile equipment in a building they may move away from in the future. So no one has a strong enough motivation to invest in rental properties for EVSE.

2.2.3 Key Barriers Identified Through Project Stakeholder Engagement

Table 3 summarizes the key identified MUD charging barriers that were identified through a survey to the Project Advisory Committee members and project participants, which included housing authorities, charging equipment contractors, EVSE providers, MUD owners / managers, utilities, parking service companies and government agencies. As indicated in interviews of key stakeholders, **HOA-related barriers** have been ranked the highest, followed by **Education barriers**, **Parking limitation**, and both **Installation** and **ongoing costs**. It is worth noting that the **electrical-related barrier** received a significant 12 counts as well. The identified barriers were derived from the open-ended question: “What are the most significant barriers to installing and/or operating MUD charging stations?” in the survey that was sent out.

Table 3: Summary of Identified Key Barriers

Barrier name	Count	Descriptions and Examples
Information and education	16	-Chicken-and-egg problem for PEV adoption and EVSE need -Need proper information for building owners, managers, and HOA on features and benefits
HOA related	18	-Common area management -Association approval difficulties and homeowner buy-in -A few stalls far from electrical panel will be extremely costly
Parking limitation	15	-Dedded parking and limited parking spaces -Parking garage or spaces far from electrical panel, increasing costs
Parking operation	9	-Drivers do not unplug when done charging -Outside free-riders problem
Capital constraints	10	-Not enough funding and/or may need grants or incentives
Electrical related	12	-Older building may not have enough electrical capacity and require costly upgrades -Distance of electrical panel from garage increases installation costs -Potential need to conduct expensive load study
Cost of installation	16	-Installation cost of running electrical circuit and conduit for EVSE -Installation cost for electrical panel or service upgrade
O&M ongoing cost	16	-Power management and network subscription fees
Network signal	4	-Weak cellular signal in garages -Expensive to run internet cables and install Wi-Fi router or cellular repeaters

2.2.4 Overview of Existing Resources and Next Steps

The literature review conducted on the barriers also revealed many existing resources. Hence, it is also important to take a holistic look at the existing resources available addressing these barriers. Additionally, the project will execute a demonstration of innovative technologies identified that could address some of the barriers. Existing resources for EV charging infrastructure facilitation have been developed by various parties around the nation, including the Department of Energy’s Alternative Fuel Data Center, state agencies, nonprofit organizations and charging infrastructure and network providers. Many of the resources are already well developed to address the barriers identified by this report. A next step for the project is to create a toolkit that captures the high-quality resources identified during the research and provide a user-friendly platform to organize information and present it to stakeholders.

In terms of resources and the toolkit, the initial design of the toolkit has been determined to be an interactive roadmap of charging installation in MUDs. This roadmap will become a front-end for organizing the existing resources along with some new resources that will be finalized after the demonstration phase is completed.

3 Innovative PEV Charging Technology Demonstrations

3.1 Innovative PEV Charging Technology Demonstrations – Program Design

The quantitative and qualitative baseline evaluation results guide the innovative charging technologies demonstrations development planning. Innovative technology solutions will be demonstrated to determine their impact on improving EVSE operations, capital costs, operating costs, etc. Technology demonstrations are expected to be deployed in multiple regions (targets include Southern California, Mid-Atlantic, Pacific Northwest, Midwest, and Mountain) to demonstrate the performance and value of innovative technology solutions against the baseline operations conditions. The demonstration pilot program will run from July 2020 through June 2021.

Technologies Description – The innovative technologies to be demonstrated are summarized in Table 4. Some technology providers have new product offerings that are now available that are being considered to be included in the demonstration phase. The identified systems range in complexity from relatively simple to very complicated and have a range of costs. All of the technology solutions provide a lower average cost per charging port than commonly used conventional high-feature charging networks provide.

Table 4: Innovative Technologies for Demonstration

Company	Innovative Solution
<u>Liberty Plugins</u>	Multiplexed EVSE charging to maximize utility capacity utilization and load management
<u>CyberSwitching</u>	Multiplexed rotational charging control for EVSE to maximize utility capacity utilization and load management
<u>Electric Vehicle Institute</u>	1) Off-property turnkey management, smart management of L2 EVSE on property and L2/DCFC off property MUD-adjacent 2) <u>Converted gas station to EV charging station</u>
<u>PowerFlex</u>	Adaptive load management
<u>OpConnect</u>	Turnkey management, smart management of L2 EVSE (with and without battery energy storage) on property and off property MUD-adjacent
<u>Freewire Technologies</u>	Mobile battery-powered dual-port L2 EVSE
<u>ampUp</u>	Software control added functionality to nonnetworked stations (e.g., scheduling/reservations, billing, data collection, analytics overstay notifications, and adjacent session user communication)
<u>Xeal Charge</u>	Software control added functionality to nonnetworked stations (e.g., scheduling/reservations, billing, data collection, analytics overstay notifications, and adjacent session user communication)
<u>EVmatch</u>	Software control added functionality to nonnetworked stations (e.g., scheduling/reservations, billing, data collection, analytics overstay notifications, and adjacent session user communication)

Category of Technologies – The functionality of each system is different, however, several key functions are common to multiple technologies, including:

- Power management to maximize electric supply use and minimize demand charges
- Software control that adds functionality (access control, billing, data collection, power management) to non-networked, sometimes referred to as “dumb”, EVSE
- Reservations/scheduling
- Mobile EVSE, address energy and parking barriers
- Some technologies are focused on long-dwell parking/charging connections while others are focused on more effectively using EVSE at shared parking spots.

3.1.1 Technology and Site Host Match-up

The site-host/technology pairings target sites that have barriers/issues that the technology can solve. For example, a facility with high demand charges is a good candidate for demonstrating a system that manages power consumption to minimize demand charges. As another example, a power capacity-constrained facility could use a system that manages multiple EVSE on a single supply to more effectively use the available capacity and increase the number of charging ports without requiring an electrical capacity upgrade.

3.2 Program Outputs

The team will share preliminary data from the baseline evaluation and describe the set of toolkits being developed during the project to support PEV charging stations at MUDs (e.g., technology selection tool, fact sheets, online calculators). On completion in 2022, the project’s demonstrations and resources will be compiled in an easy-to-use toolkit that will help to advance the MUD charging market. It will be disseminated using established national, regional, state, and local channels.

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