Pole-Mounted EV Charging: Preliminary Guidance for US cities

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Summary

Public electric vehicle (EV) chargers located at the curbside can help serve drivers without access to a private charger; however, these installations typically lack the necessary space or are prohibitively expensive. Pole-mounted chargers (PMCs) are a solution growing in popularity, but there remains uncertainty regarding best practices and guidance for interested cities. This paper aims to help fill that gap through insights from the handful of U.S. cities already deploying PMCs and offer preliminary guidance for other cities.

PMCs can save between 30 and 70 percent on installation costs compared to ground-mounted chargers, among other benefits. Depending on local context, some cities are better suited to use utility poles versus streetlight poles due to capacity constraints. To maximize PMC benefits, equitable access considerations must be built into the planning process.

Keywords: EVSE (Electric Vehicle Supply Equipment); Charging; Infrastructure; Policy; Utility

1 Introduction

Enabling EV access to all is critical in achieving a decarbonized transport system. To enable EV access in all communities, convenient and affordable public charging is essential. This need is increasingly apparent for drivers who lack dedicated off-street parking and/or cannot install a private charger. Additionally, in the United States, the distribution of public charging currently does not adequately serve residents living in multiunit dwellings (MUDs), low-income neighborhoods, and communities of color [1–3]. Supporting vehicle electrification for these residents necessitates curbside charging installations (in concert with other sustainable mobility strategies).

In many cities, curbside ground-mounted charger deployments are hindered by several barriers. These include high installation costs due to invasive construction work, limited available space on crowded curbsides, and challenges installing near-home residential public charging. Pole-mounted charging, using existing utility pole or streetlight infrastructure to site EV chargers, has emerged as an innovative solution to help overcome many of these barriers in both the United States and Europe.

PMCs have experienced more widespread and rapid deployment in Europe than in the United States, the most notable case being London, United Kingdom, which has more than 5,000 chargers on streetlight poles [4]. The success of this strategy can be attributed to several factors specific to the European context, including the standard voltage fed to streetlights, which is 220 volts (V) (sufficient for Level 2 charging) and the fact that it is customary for EV drivers to carry their charging cord with them, requiring less equipment installed on a pole, thus lowering installation and maintenance costs.

So far, Los Angeles, California, is an exception within the United States, where the Bureau of Street Lighting (LABSL) has installed more than 430 chargers on streetlight poles (Figure 1). This can be primarily attributed to the fact that Los Angeles' streetlights are fed with a 240 V connection, something even nearby Santa Monica, California, does not have. One key advantage present within the U.S. context is the availability of electric utility poles, whereas in many European countries, utility poles are not a common feature because electrical lines are often located underground. As a result, in U.S cities there is a growing focus on using utility poles, rather than streetlight poles, for PMC deployments.

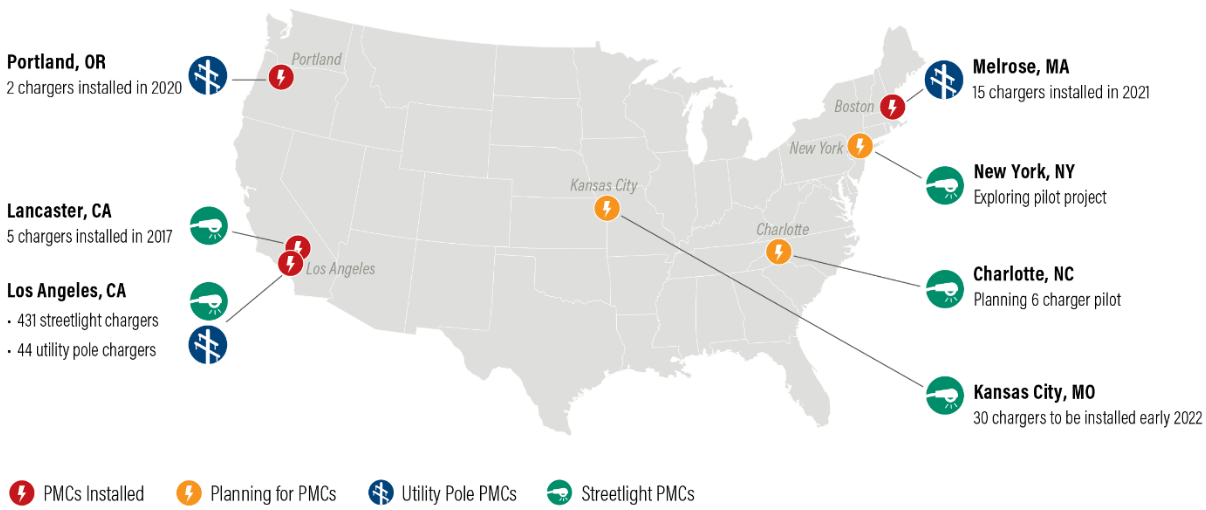

Figure 1: Installed and planned PMC deployments in the U.S. in 2021 [5]

1.1 Purpose of the Paper

The success of PMC deployments depends heavily on local context; hence this paper deliberately focuses on the United States to provide the most relevant guidance for U.S. cities. PMCs are a solution growing in popularity, but there remains uncertainty regarding best practices and guidance for others interested in applying it within their own context. We aim to help fill that gap through insights from the handful of cities that are already deploying pole-mounted charging and offer preliminary guidance on how other cities can develop a successful project. Despite our U.S. focus, we also draw experiences of international cities, including Vancouver and London.

2 Methodology

This research was informed by a series of qualitative data collection efforts, including a literature review, stakeholder mapping, and interviews. Building on these efforts, five groups were identified as most relevant to this research including cities or utilities that 1) have installed PMCs, 2) plan to install PMCs, 3) are exploring viability of PMCs, as well as 4) electric vehicle supply equipment (EVSE) manufacturers who have deployed PMCs, and 5) transportation network companies (TNCs).

Using this framework and the stakeholder mapping data, interviews were conducted with more than 30 different actors across 13 cities. Actors included city governments, electric utilities, EVSE manufacturers, engineering contractors, TNCs, universities, and non-profit organizations. A qualitative, rather than quantitative, data collection approach was used for this research as only a handful of U.S. cities have implemented PMC projects.

3 Observations from Current PMC Programs

This section details observations made from our research across seven key areas: infrastructure ownership, load management, site selection, physical installation, operations and maintenance cost, financing charging infrastructure, and community engagement. When necessary, key differences are highlighted between utility poles and streetlights.

3.1 Infrastructure Ownership

3.1.1 Pole ownership

Pole ownership varies by city. In each U.S. city with an ongoing PMC program where we conducted interviews, the owner of utility and/or streetlight poles played an integral role in planning and installation. In the most basic sense, pole owners can approve (or deny) the attachment and interconnection of EVSE. This section focuses on the ownership of the poles themselves and not of the land poles are installed on because PMCs are most commonly in the public right of way (ROW), avoiding the need for legal approval from private landowners.

- **Utility poles:** This infrastructure tends to be owned by electric utilities. In some cases, utility poles are partially or fully owned by telephone and cable service providers who also run wires on this infrastructure. In Melrose, Massachusetts, which launched a utility pole PMC pilot in April 2021, most utility poles are jointly owned by National Grid (electric utility) and Verizon (communications company).
- **Streetlight poles:** Cities that own their streetlights have greater decision-making power over infrastructure modifications, including attaching new equipment, such as EVSE. However, even within city agencies, a range of owners have been observed—the Department of Transportation in New York City, the Bureau of Street Lighting in Los Angeles, etc. In some instances, streetlights are owned in part or entirely by the local utility. In Charlotte, North Carolina, most poles are owned by Duke Energy. Within the utility itself multiple internal divisions individually manage poles depending on the type of infrastructure attached (i.e., streetlights or distribution wiring); therefore, a PMC installation must receive approval from the appropriate division(s).

Pole ownership models in the United States based on our research are shown in Table 1. Joint ownership models can add to the complexity of the planning and installation process due to varying needs and requirements.

Table 1: Observed Models for U.S. Pole Ownership *[5]*

Pole Type	City-Owned	Utility-Owned	Third Party (private company)
Utility poles	Not observed	Yes	Yes
Streetlight poles	Yes	Yes	Not observed

3.1.2 EVSE ownership

Another key stakeholder during the planning process is the EVSE owner, who plays an active role in equipment operation once infrastructure is installed. This entity may or may not be the same as the owner(s) of the pole itself. Separate ownership of the pole and charger can increase the complexity of PMC operations. We found utilities can be particularly well-suited to own PMCs because they often already play a role in pole ownership and operation, own other public EVSE, and already have staff trained on hand to maintain the infrastructure.

3.2 Load Management

Understanding the power demand from EVSE relative to the existing electrical capacity available at a utility or streetlight pole is crucial. Quantifying this relationship can be a complicated process, especially for non-utility entities, and must account for existing loads on the circuit [6]. From a load management perspective, not every streetlight and utility pole within a city will be able to facilitate a charger. Two key factors are linked to determining the viability of PMCs: charging level and existing electrical capacity.

3.2.1 Charging level

Due to the limited capacity available at street poles, only Level 1 and Level 2 charging are feasible for PMC installations. As depicted in Table 2, Level 1 charging is supported by a 120-volt (V) connection (comparable to a U.S. household outlet). Level 2 charging, with greater power output, requires a 208 V or 240 V connection (240 V is standard for a U.S. household electric dryer outlet). We found all U.S. PMC programs to be implementing Level 2 rather than Level 1 charging.

Table 2: U.S. EVSE Specifications for Level 1 and Level 2 *[7–9]*

Charger Level	Voltage (V)	Power Output (kW)	Amperage (A)	Charging Rate (miles/hour)
Level 1	120	1.4–1.9	12–16	3.5–6.5
Level 2	208 or 240	3.3–19.2	16–80	14–60

Note: Level 1 and Level 2 charging are most relevant to PMC installations due to the limited voltage available at poles. Direct current fast charging is not included in this table as it is beyond the scope of this research. Exact EVSE specifications should be collected from the manufacturer.

3.2.2 Pole electrical capacity

Ensuring the reliability of a pole's primary functions (such as a streetlight) is always the first operational priority. In U.S. cities, utility poles and streetlights present two different installation settings. Utility poles usually have greater electrical capacity than streetlight poles often making them a better option for PMCs within the United States. However, the best pole for charging is dependent on local context. Comparatively, in European cities, streetlight poles are best positioned for PMCs due to more substantial electrical capacity. In addition, electric distribution lines often run underground, so utility poles are not a common feature.

3.2.2.1 Utility pole capacity

Utility poles commonly support several types of wires carrying varying levels of voltage. This set of wires typically includes a secondary distribution wire with a voltage of 208 V or 240 V, making utility poles strong candidates for Level 2 EVSE installations (see Table 2). In a utility pole PMC pilot run by Portland General Electric (PGE), poles with step-down transformers already installed at that location were prioritized (see Figure 2). If PGE's program is scaled further, additional transformers may be needed elsewhere to accommodate chargers on poles lacking an accessible transformer. Comparatively, in Melrose, Massachusetts, National Grid in some cases had to install a larger transformer near the utility pole to accommodate chargers. Even with this additional infrastructure, National Grid estimates PMC installation costs are between 50 and 70 percent less than ground-mounted chargers.

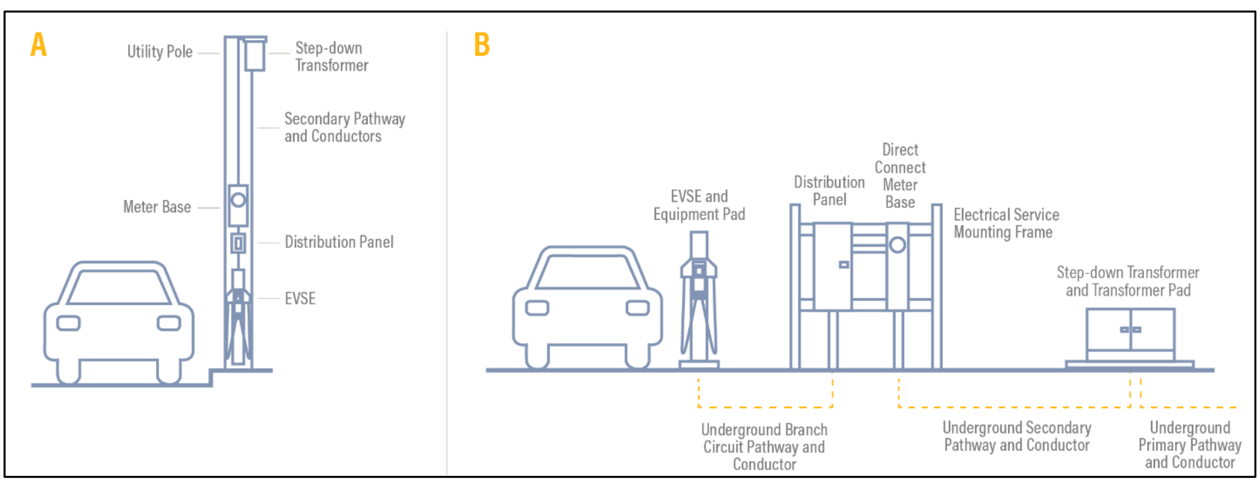

Figure 2: Comparative Infrastructure Requirements of a pole-mounted and ground-mounted charger (adapted from *[10]*). A) depicts the infrastructure setup for a utility PMC, B) details the infrastructure necessary for a ground-mounted charger.

3.2.2.2 Streetlight capacity

We found streetlights in the United States to most commonly be fed with a 120 V connection, which is often all a streetlight requires and aligns with Level 1 charging. A handful of cities, including Los Angeles, California, and Kansas City, Missouri, have some or all their streetlights wired up to a 208/240 V connection, which can more easily accommodate Level 2 charging. This points to how unstandardized the capacity fed to streetlighting is within the United States. Within the European context, it is standard for streetlights to be fed with 220 V making this infrastructure comparatively better positioned for PMCs. Cities in the Czech Republic, France, Germany, Ireland, and United Kingdom are already taking advantage of this, the most notable being London with over 5,000 units installed [4,11].

Streetlights and the role of LED conversions:

Many cities installing streetlight PMCs are doing so on LED converted streetlights. Compared to their high-pressure sodium counterparts, LED streetlight fixtures are 50 percent more efficient, reduce electrical load, and can make room for new loads, such as a charging station [12]. LED streetlight conversions present an opportunity for PMCs to take advantage of this newly available electrical capacity.

In cases where PMC installations are not feasible even with LED retrofits, a streetlight's pre-existing electrical connection could be used to supply electricity to micro-mobility charging docks. This solution has been implemented in Pittsburgh, Pennsylvania, as part of a citywide mobility hubs pilot [13]. Hence, streetlight poles can also support multimodal sustainable transit options.

3.3 Site Selection

A well-designed site identification process for PMCs can save both time and money by efficiently narrowing down the poles best situated for charger installation. Without a deliberate effort to deploy PMCs in areas where drivers face the greatest barriers to adoption, improvements to EV access for all will be limited. We identified several issues encountered by cities installing PMC infrastructure. Cities engaging with PMC planning and operation highlighted the following considerations for identifying potential installation sites:

- **Competition for poles:** Streetlight and utility poles are points of vertical real estate for several applications, most notably 5G sites. As a result, the available space and, more critically, the available electrical capacity for EV charging at a pole can be limited.
- **Existing public charging and urban planning strategy:** PMC deployment can be coordinated with broader sustainable mobility efforts, ones that consider Avoid-Shift-Improve (ASI) framework principles [14]. PMCs can be relocated to different locations with relative ease, making them adaptable to changing curbside needs, such as shifting parking regimes or a planned bike lane installation.
- **Enabling greater access to EV charging:** Greater availability of public charging infrastructure has been shown to increase EV uptake [15], a relationship PMCs can help accelerate by improving charging access for residents that lack private charging facilities. Chargers sited near MUDs or low-income housing can provide go-to charging sites for potentially new EV users living nearby.
- **TNC partnerships:** Collaborating with TNCs to achieve electrification goals can be mutually beneficial. Although platforms like Uber and Lyft have programs to encourage electrification, many drivers are constrained by limited access to charging. TNCs can contribute data on charger placement to ensure the electrification needs of drivers, many of whom reside in MUDs, are met [16].
- **Parking enforcement:** Awareness of how on-street parking is permitted and any planned modifications, such as bike lane installations or shifting parking zones, is crucial. In Los Angeles, following the installation of a new streetlight charger, the LABSL was informed the curb was recently designated a no-

parking zone and the charger had to be relocated, a relatively low-cost operation compared to the relocation of a ground-mounted EVSE.

- **On-street locations:** Several cities highlighted using poles located in the middle of a city block and on secondary streets as most optimal for charging. This minimizes disruptions to traffic flow and provides the safest environment to charge.

3.4 Physical Installation

PMCs present a unique installation scenario because they build on existing infrastructure. While this strategy reduces installation costs, challenges specific to PMCs can arise due to competition for electrical load and space on a pole, determining charger mounting and metering, and local permits. While the key considerations relevant to the PMC installation process are extensive, we have chosen to highlight installation cost and mounting here.

3.4.1 Installation costs

Installation costs consist of make-ready materials and grid upgrades, associated labor, site surveying, and permitting. We found cities and utilities have experienced net savings from PMC infrastructure compared to ground-mounted charging, which can run as high as US$10,000 for a single charger installation. [10,17,18]. Most notably, LABSL can install a streetlight PMC for $2,750 or less. From the utility pole perspective, National Grid experienced a 55 percent reduction in installation costs, a figure that prior to COVID supply chain constraints was quoted closer to 70 percent, and a 30 percent reduction in overall costs. In Portland, PGE experienced a 34 percent reduction to installation costs. Data sourced directly from cities and utilities can be seen in Table 3 and excludes the cost of the charger itself.

Most PMC programs we interviewed found hardware cost for single Level 2 PMC to be between $1,500-$6,000. The greatest savings on cost (and time) were realized in avoided costs on materials, construction and labor, and fewer permitting fees. Factors that could increase PMC installation costs can include:

- **Upgrading costs:** Upgrading wiring and/or transformers to accommodate new load from EVSE.
- **Metering requirements:** Depending on the utility, an EVSE's onboard metering hardware may or may not be accepted to monitor electricity consumption. For streetlights, this can be particularly challenging if electricity is purchased at a bulk discount rate, where adding a new type of load would complicate billing. Metering hardware and the labor to install it can add to project costs.
- **Site surveying:** The more detailed the process of elimination is to identify the best poles for PMCs, the more time and cost-efficient the site surveying process will be. For example, if it is known a PMC cannot be attached to a pole because risers (an electrical connection running the length of a pole) exist at that location, the time and money spent on a site survey can be avoided. The number of on-site visits can also be limited by using free accessible tools like Google Street View.
- **Installation personnel & efficiency:** PMC installations conducted by a third-party contractor may be more costly than utilizing an in-house team.
- **Communication with utilities:** Utilities are a key collaborator on PMC projects and communication with them is crucial. Poor communication with utilities can increase costs due to delays during the site selection process (e.g., understanding available capacity) [18].

To understand the true avoided cost of installation from a PMC, the costs that would be associated with installing ground-mounted chargers should be included as part of a complete cost comparison.

Table 3: Level 2 EVSE Installation Costs for PMC vs Ground-mounted (US$/port) [10]

Cost Category	LABSL Streetlight Pole	PGE Ground-Mounted	PGE Utility Pole	National Grid ground-mounted (avg.)	National Grid Utility Pole (avg.)[5]

Utility Labor and Materials[1]	$0[4]	$500 - $1,000	$500 - $1,000	$2,000	$594
Make-ready Labor, Materials and EVSE Installation[2]	$750-$1,250	$4,100 - $10,500	$500 - $1,000	$6,000	$2,647
Engineering, Design, Permits, and Fees[3]	$1,000-$1,500	$150 - $300	$1,210 - $2,000	N/A	$599
Total (US$/port)	$1,750-$2,750	$2,050-$11,800	$2,210-$4,000	$8,000	$3,840[6]

Note: 1) Primary and secondary conductor, metering equipment, fusekits, grounding rods, and transformer (if applicable). 2) Does not include EVSE cost. Includes primary pathway (if applicable), secondary pathway, meter base, distribution panel, and branch circuit pathway and conductor, and associated labor. Mounting of EVSE to utility pole and/or connection to make-ready infrastructure. 3) Civil / electrical engineering and design costs (if applicable), permits, and right-of-way / franchise fees (if applicable). 4) LABSL's PMCs installations do not require new utility materials or labor as of 2022. 5) National Grid installed both single and dual-charger PMCs, which can impact the $/port. 6) National Grid also had one-time fixed costs incurred by agreements and surety bonds totalling $1,300. These fixed costs are not included in the total $/port figure.

3.4.2 Mounting EVSE

Two types of PMC mounting configurations were observed in the United States: eye-level and elevated mounting. The former is useful if there is already infrastructure mounted above and can offer greater visibility for drivers. Elevated chargers are attached higher up the pole, typically with a retractable cord. This approach offers several benefits, including resiliency in flood-prone areas, helping reduce vandalism, and keeping cords away from snowploughs. In both these cases, mounting chargers toward the sidewalk can help avoid damage from vehicles, whereas an elevated charger can also help limit obstruction to pedestrians. In addition, PMC mounting can be completed in a matter of hour or days, compared to the weeks or months associated with ground-mounted units.

Several European cities have installed PMCs with the EVSE hardware contained within the streetlight pole housing. This is possible because it is customary for EV drivers carry their cord with them, preventing the need for cords to be managed and supported on the pole. This helps lower the cost of both the EVSE and ongoing charger maintenance. This is a solution New York City explored but encountered regulatory roadblocks regarding metering from the local utility, ConEdison,

3.5 Operations and maintenance costs

Most PMC deployments are in the pilot stage and available information about maintenance and ongoing operational costs is limited. However, these costs can be significant. Cities and utilities—often responsible for operations and maintenance—should plan accordingly when establishing project funding sources, especially for areas like networking costs for chargers, pole attachment rental fees, etc. In Los Angeles, 60 percent of charger failure was found to be due to vandalism, such as cord cutting or power theft from the lighting circuit.

End-user costs and payments can directly influence charger utilization. This can include:

- **Payment for parking and charging:** In some cities, multiple departments or agencies have oversight and rules related to curbside parking space, which can make implementation challenging to coordinate. Additional complexity comes from a lack of alignment between the pricing structures for an existing parking zone and the charging station and their respective fee collection systems. If the two payment systems are kept separate, EV drivers must manage two payments, which could deter PMC use. Parking fees are a source of city revenue and free parking for EVs in those spots can reduce that revenue.
- **Pricing structure:** Charging fees based on charging time is disadvantageous to vehicles that cannot be charged quickly, making pricing an equity concern for those that own vehicles with a slower on-board AC/DC converter. Having a dollar per kWh metric to base the pricing structure is more equitable.

3.6 Financing Charging Infrastructure

Due to lower installation costs, for the same price, more PMCs can be deployed than ground-mounted curbside units. The potentially high demand for PMCs combined with lower up-front costs presents a high-impact economic case for several funding streams.

3.6.1 Utilities

The average utility stands to create $3 billion to $10 billion of new value from the rise of EVs [19]. Current PMC deployments in Los Angeles, Portland, and Melrose are funded entirely or in part by the Los Angeles Department of Water and Power, Portland General Electric, and National Grid, respectively.

Utilities often own and operate streetlights and utility poles. In several cities, the utility also already owns and operates public EVSE. Additionally, utilities have an innate understanding of the existing capacity suitable for EV charging loads, regulatory barriers, safety considerations, and often have in-house technical expertise regarding charger interconnection. This makes coordination for deployment, program administration, procurement, and infrastructure upgrades, more streamlined and can help reduce costs and avoid delays.

Electricity demand from charging can lead to increased revenue for the utility, depending on utility tariffs and charger utilization. As with any other form of public EV charging infrastructure, utility tariffs should be evaluated from a public good perspective to encourage equitable EV adoption and minimize unfair allocation of costs [20,21].

3.6.2 Federal and State Agencies

The United States federal government is increasingly interested in deploying public charging infrastructure, which offers more opportunities to demonstrate and scale solutions, such as PMCs. Most notably the Infrastructure Investment and Jobs Act allocated $7.5 billion for EV charging infrastructure [22,23]. Several cities deploying PMCs have capitalized on direct and indirect funding avenues. U.S. Department of Energy grants currently support PMC pilot programs in Kansas City and Charlotte; grants focusing on equitable deployment of charging infrastructure can be leveraged by more cities.

State initiatives like Low Carbon Fuels Standards credits, which can compensate EVSE owners for carbon offsets from vehicle charging, can help fund PMCs, something Los Angeles has taken advantage of; as more states adopt similar programs, greater funding opportunities could open [24].

3.6.3 Transportation Network Companies (TNCs)

TNCs can play a transformative role in funding PMC infrastructure, to increase Level 2 EVSE access for drivers. Insufficient charging is often cited as a significant hurdle to achieving a 100 percent electric TNC platform as drivers on these platforms often reside in MUDs [3]. PMCs offer an attractive and mutually beneficial means to achieve common electrification goals for cities, utilities, and TNCs. Engaging with TNCs can also help identify locations of aggregated demand for charger use, informing charger siting, and maximizing utilization.

We posit that public-private partnerships to finance PMCs on streetlights can offer an interesting solution, wherein the savings from LEDs over time can be used to pay back the investment for chargers. However, this requires additional quantitative research.

3.7 Community Engagement

Engaging with the community is crucial to understanding local needs, barriers, and who will utilize PMC infrastructure and is crucial to the ongoing process. Our research identified three areas where cities and utilities engaged the local community in planning for PMC deployment:

- **Understanding local needs and site selection:** Community members can be an invaluable source of information on where EVSE should be located. Kansas City found those with incomes of $25,000 or less were more likely to prefer chargers located near grocery or pharmacy locations, while higher-income groups preferred chargers at workplace or retail centers [25].
- **Addressing safety concerns:** The key purpose of streetlights and utility poles is to ensure community safety and service. With the introduction of new equipment like PMCs, it is important to understand and address any community concerns around functionality of the existing infrastructure.
- **Building awareness:** In Melrose, Kansas City, and Portland, community engagement provided an opportunity for residents to voice concerns and discuss solutions during the planning process. PMC programs can also be used to develop awareness of EV benefits, the infrastructure, and foster community ownership. This can include door-to-door engagement and/or dissemination of informational resources.

4 Preliminary Guidance on Planning and Implementing a PMC Program

Building on the considerations detailed above, this section is intended to offer actionable steps for a city or utility interested in deploying PMCs in the United States. This preliminary guidance is built on early learnings and recommendations from the small handful of cities installing PMCs and is likely to be refined and improved over time as the number and scale of deployments increase.

Based on insights from U.S. cities currently deploying PMCs, we recommend cities begin by testing these chargers with a small-scale pilot, even in the most progressive and EV-forward cities. Every municipality is home to a unique set of local policies, regulations, and relationships that may not be accounted for in the preliminary guidance below. A pilot project provides the opportunity to uncover any foreseeable barriers, build relationships with relevant stakeholders, and lay the foundation for future expansion. This guidance is broken into four steps depicted in Figure 3.

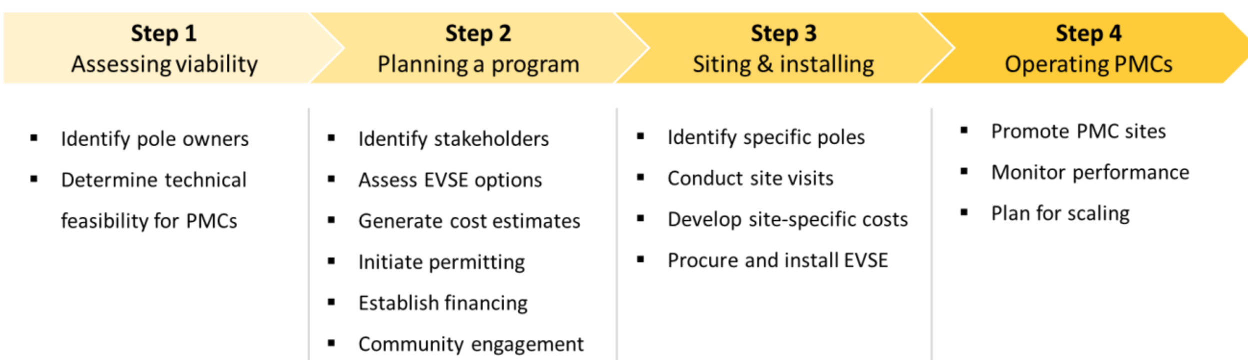

Figure 3: An overview of the steps cities and utilities interested in installing PMCs should take.

4.1 Step 1: Viability Assessment for a PMC Program

Not every city is well-suited to PMC installations. Before proceeding with a pilot, the owners and operators of the poles and charging infrastructure should be identified and consulted to explore all viable options, seek approval, and determine technical feasibility.

Identify pole owners and operators: For both utility poles and streetlight poles, a range of ownership and operation models exist (Table 1). In case of a joint ownership or operation model of pole infrastructure, it is important to involve all parties. In the case of differing ownership between the pole and charger, it is useful to identify the approval process from the pole owner.

Determine the technical feasibility of poles to support EV charging: The questions in Table 3 are intended to help identify and uncover barriers present within a city's local context that could inhibit PMC feasibility. If utility and/or streetlight poles are identified as possible options, proceed to Step 2. If neither type of infrastructure is identified as a suitable location for EV charging, we would suggest pursuing other charging strategies.

Table 3: Identifying Technical and Installation Barriers to PMCs *[5,26]*

<table>
<tr><th>Utility Pole</th><th>Streetlight Pole</th></tr>
<tr><td colspan="2">Do any regulations, policies, or guidelines exist that would prevent objects, such as electrical meters or chargers, from being mounted on poles or certain pole types?
Are existing EVSE models compatible for attachment to the city's network of pole infrastructure?
What types of infrastructure modifications or upgrades are necessary to facilitate Level 1 charging? To facilitate Level 2 charging?</td></tr>
<tr><td>Do utility poles need to be accessible for maintenance personnel? Could this inhibit charger installation?</td><td>Is the existing electrical conduit large enough to facilitate EV charging?
Are there any structural or aesthetic issues with attaching an EV charger to certain poles?
Have any streetlights been converted to LED?
Is streetlight power dependent on photocells or timers?</td></tr>
</table>

4.2 Step 2: Planning for PMC Deployment

Once PMCs have been established as technically feasible, several steps are necessary to facilitate a successful and efficient planning process. The following steps are based on best practices observed in cities with PMCs, but the most logical approach may vary by city depending on the partners involved, city-specific procedures, or specific funding mechanism(s) supporting a project.

Identify relevant stakeholders: Building on engagement with the owner(s) and operators in Step 1, other stakeholders most relevant to inform a PMC pilot program should be identified. Each city that has successfully installed PMCs has assembled the right entities and decision-makers to do so. Several distinct roles have been identified as critical to the success of a project including owners and operators of pole infrastructure, electricity service provider, power distribution engineers, city departments responsible for ROW, parking payment/enforcement, local community organizations, EVSE manufacturers, relevant data collection and analysis partners, and potential financing partners.

Assess EVSE options: The EVSE used will have implications on site-specific installation criteria. For this reason, it is advised that the charger identified prior to confirming installation sites. It is possible to incorporate multiple types of EVSE and mounting strategies into a deployment.

- **Charging station model:** Determine if chargers will be mounted at eye level or elevated. Some models can accommodate both configurations and others cannot. Similarly, a charger's cord length will impact the maximum distance to a vehicle's charging port. Additionally, confirm if the electrical meter within the EVSE is approved by the local utility.
- **Charger attachment mechanism:** Working with the EVSE manufacturer and/or the project's engineering staff, determine how chargers will be attached to poles.
- **Charger connectivity:** It is recommended networked chargers are installed so usage metrics can help evaluate performance and plan for future installations based on demand. Determine if the city or utility already utilizes a specific charging network, this can help integrate PMCs across a city's network.

Taking these criteria into account, the city or utility should consult with EVSE vendors to determine the charging station(s) best suited for PMCs.

Generate installation cost estimates: Using insights from the viability assessment in Step 1, it is advised that installation cost estimates be developed regarding the average PMC unit and ensure that cost savings compared to a ground-mounted unit are analyzed. This information should be factored into the project budget and will help estimate the number of units it is financially feasible to install.

Understand and initiate permitting process: Permits for an infrastructure project such as an EV charger installation (especially in the ROW), can differ by state and city. During the planning process, consult with relevant city and electric utility staff to identify any necessary permits required for PMC installations, including National Electric Code (NEC) and National Electric Safety Code (NESC) standards. Understanding this can help foresee impacts on site selection or other EVSE installation hurdles moving forward.

Establish charging payment scheme: It is recommended the pricing structure be on a dollar per kWh basis because this approach is most equitable. If chargers will be installed at metered parking locations, coordination with the city's parking payment/enforcement department will be necessary.

Determine project funding source(s): Cities and utilities with limited budgets should consider taking advantage of federal and state funding opportunities [27]. TNCs or other private sector partners can also play an important role in helping to finance PMCs. It is also important to ensure sufficient funding is available for charger maintenance and ongoing operations.

Conduct ongoing, consistent, and broad community engagement: Community groups to engage with can include community boards, faith-based organizations, property management companies, civic/historic preservation organizations, school boards/staff, recreational and park staff, and others whose property is adjacent to where the equipment will be located. This is a step that should be incorporated throughout the planning and installation process.

4.3 Step 3: Siting and Installing PMCs

After programmatic planning, the following steps are intended to inform PMC siting and installation. This section highlights the importance of incorporating equity data to ensure PMC deployment meets accessibility goals.

Identify specific poles for PMCs: Performing a spatial mapping analysis to identify a short list of poles can help save time and cost by limiting the number of site visits required. Examples of data points to consider in this analysis are listed in Table 5. The primary data are those most critical to identify which poles are best situated for charging. Equitable deployment data help identify areas where PMCs can support those with the greatest barriers to charger access. The secondary data can help narrow down locations based on a range of other attributes.

Table 5: PMC Site Selection Data Examples *[5,14,28]*

Primary Data	Equitable Deployment Data	Secondary Data
• Utility and/or streetlight pole location	• Existing public EVSE to identify "charging deserts"	• Anonymized TNC driver residence data
• On-street parking zone location & type	• Neighborhoods and MUDs without off-street parking	• ASI planning efforts
• Location & capacity of distribution transformers	• Median household incomes across the city	• High utilization points like retail, public parks, etc.

Conduct site visits: Once a list of pole sites has been narrowed down, those locations should be inspected alongside the power distribution engineering team and other relevant community stakeholders to confirm if the pole is well-suited for charger installation. Some cities have used Google Street View to virtually assess potential installation sites before visiting in-person. On-site considerations can include identifying the least expensive installation pathway, where a pole is located relative to the road and sidewalk, and "clean poles" without conflicting infrastructure such as risers, cable boxes, 5G nodes, or other equipment [5].

Develop site-specific cost estimates: Due to a range of situational factors, installation costs can vary from one site to the next. For example, at some sites a distribution transformer will have available capacity, while at others a new transformer will need to be added.

Install EVSE: Once final sites have been identified and the EVSE is procured, install the EVSE with support from the project's technical and operational staff and the equipment vendor.

4.4 Step 4: Operating a PMC Program

Once installed, several actions can be taken to optimize PMC operation, encourage greater EV adoption, and expand a PMC network. Key steps can include:

EV signage and parking enforcement: PMC parking spots should be marked with EV signage and road paint to keep the spot open, promote EV use, and highlight charger location.

Monitor performance: One benefit of PMCs is the equipment can be relocated to different poles relatively easily, which can help accommodate changing priorities at the curbside, including ASI planning. Performance monitoring and data collection can inform future deployment and help make the case for additional investments. Following PMC installations in Melrose, multiple residents living in MUDs informed the city they were able to adopt an EV with the new public charging infrastructure.

Plan for scaled deployment: Pilot or demonstration projects are helpful to prove technical feasibility, but often lack a clear plan to scale. Identifying success metrics and pre-planning a phased approach will encourage sustained investments toward scaled PMC deployment.

5 Conclusion

Accelerating transportation electrification in the United States means establishing charging networks where all drivers have access to convenient and reliable charging. PMCs, using existing utility and streetlight poles to deploy EV chargers, present a strategy to site chargers in locations typically considered infeasible for ground-mounted units. Additionally, PMCs can support those that lack access to private charging infrastructure. However, if improperly planned and deployed, retrofitting poles may cause adverse impacts on the local distribution grid, lighting, and safety issues, or lead to inequitable deployment and underutilized infrastructure.

While PMCs may seem like an ideal means to expand curbside charging in every city, it is a strategy significantly impacted by local context. In addition, the low volume of current U.S. deployments means the ability to solidify replicable best practices for PMCs is limited. More pilots and scaled installations will help identify broader factors for success and encourage participation by more diverse funding partners.

We have attempted to simplify several complex considerations by developing a stepwise approach for cities and utilities to assess the viability, planning, installation, and operation of a PMC program. This information is likely to be refined and improved over time as the number of U.S. deployments increase.

Moving forward, several opportunities exist for future research and analysis. As a greater number of U.S. and global cities incorporate PMCs into their charging network, those experiences should be compared with existing schemes and against the information presented in this paper. Additionally, future research should focus on using a quantitative approach to identifying U.S. cities (and those in other countries) best suited for PMCs, identifying regulatory barriers, and developing suitable business models.

Pole-mounted charging offers a cost-effective and creative approach to developing more equitable public charging networks. While it may not be for all cities, it is a climate-positive solution that should not be overlooked.

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