POLE-MOUNTED ELECTRIC VEHICLE CHARGING:
PRELIMINARY GUIDANCE FOR A LOW-COST AND
MORE ACCESSIBLE PUBLIC CHARGING SOLUTION
FOR U.S. CITIES

EMMETT WERTHMANN AND VISHANT KOTHARI

EXECUTIVE SUMMARY

Highlights

- Public electric vehicle (EV) chargers located at the curbside can help serve drivers without access to a private charger; however, curbside installations often lack the necessary space or are prohibitively expensive. Chargers attached to utility poles and streetlights, or pole-mounted chargers (PMCs), present an emerging alternative to help address these barriers.

- PMCs can save between 55 and 70 percent on installation costs compared to ground-mounted chargers with no additional infrastructure on the curb. However, due to siting and electrical capacity limitations, not all poles can support PMCs.

- U.S. cities are better suited to retrofit utility poles versus streetlight poles due to voltage and capacity constraints of the existing infrastructure. The best type of pole for charging heavily depends on local context. Either way, electric utilities play a critical role in planning and scaling PMC deployments.

- Demand for and awareness of PMCs is growing, but to maximize PMC benefits, equitable access considerations must be built into the planning process while incorporating local community engagement.

- To meet electrification goals, Transportation Network Companies (TNCs), such as Uber and Lyft, need accessible public charging for drivers on their platform. Additionally, TNCs can be a data-sharing and financing partner.

Pole-Mounted Charging Context

In 2021, the U.S. government, with the support of automakers, set a goal for EVs to comprise half of all new vehicle sales by 2030 (Executive Office of the President 2021). To reach this goal and 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 (Hsu and Fingerman 2021; Huether 2021; Klock-McCook et al. 2021). 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 3,500 chargers on streetlight poles. 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 EV drivers often 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 has installed more than 430 chargers on streetlights. 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.

About This Paper

The purpose of this paper is to provide preliminary guidance for U.S. cities and utilities interested in deploying PMCs. Our research and analysis are informed by an extensive review of relevant literature and a series of interviews with more than 30 stakeholders, including city governments, electric utilities, charging equipment manufacturers, and potential end users of this infrastructure. 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 drew on the experiences of international cities, including Vancouver and London.

In this paper, we deliberately do not include detailed case studies on cities that have implemented PMC infrastructure. Instead, key insights from those cities are highlighted and accompanied by generalized and actionable guidance that can be applied to any city’s local context. This preliminary guidance is built on early learnings and recommendations from the small number of cities installing PMCs and is likely to be refined and improved over time.
Key Findings

Using insights gathered primarily from U.S. cities actively deploying PMC infrastructure, we found:

- PMCs provide an opportunity to install public charging infrastructure in locations previously considered too costly, and infeasible due to lack of curbside space.
- PMCs can help expand public charging networks, especially in residential areas, to support those who do not have access to private charging facilities. PMCs’ ability to improve the availability of public charging for all drivers hinges on the degree to which equitable access considerations are prioritized within the site selection process.
- Due to limitations on pole location and electrical capacity, not every pole in a city can support an EV charger. However, utility poles generally have greater electrical capacity than streetlights making them better positioned to support EV charging in more cases. This depends on a city’s local context.
- Drivers on TNC platforms present an obvious end user for PMCs. As a result, TNCs present a useful data partner for site selection and may be motivated to finance PMC infrastructure.
- Electric utilities often play a major role in PMC infrastructure ownership, installation, and operation. Utilities are also well-positioned to help finance PMC infrastructure, which presents an attractive business case due to lower installation costs.

Key Recommendations for U.S. Cities and Utilities

Building on the insights and observations gathered across cities with PMC programs, we have developed preliminary guidance for interested U.S. cities and utilities.

Key recommendations include:

- Ensuring technical feasibility of PMC installations can be complex as it uses existing infrastructure. It is recommended to start with a pilot project to establish buy-in and identify any barriers.
- If determined that a PMC project is viable, all relevant stakeholders should be identified and convened. The list of stakeholders can widely vary based on local context.
- These stakeholders will be essential in preparing a suitable plan for PMC deployment, such as generating installation cost estimates, establishing financing and business models, understanding the local permitting process, developing a payment system, and conducting community engagement.
- To help save both time and money, site visits should not be conducted until a short list of poles has been identified through a citywide analysis. This list should include a variety of information, including data related to location, electrical capacity, parking, equitable distribution, local community input, existing chargers, and EV adoption.
- Once chargers have been installed, their performance should be monitored to identify impact on EV adoption and plan for scaled deployment.

1. INTRODUCTION

Transportation electrification is accelerating in the United States. Bolstering this growth, ambitious electric vehicle (EV) adoption targets have been established across the country at the federal, state, and local levels. Most notably, the Biden administration intends for EVs to comprise 50 percent of new vehicle sales by 2030 (Executive Office of the President 2021). While this is a step in the right direction, without an equally ambitious effort to build the charging infrastructure to enable this growth, an insufficient charging network will remain a barrier to achieving these goals. According to the International Council on Clean Transportation, for EVs to comprise just 36 percent of new vehicle sales by 2030, 1.8 million public chargers will need to be deployed—40 times the volume of current U.S. deployments (Bauer et al. 2021; DOE 2021a).

In addition, to truly enable mass EV adoption, public charging access must be equitably distributed to support all drivers. Currently, low-income populations, communities of color, and those living in multiunit dwellings have the least access to charging (Huether 2021; Hsu and Fingerman 2021; Klock-McCook et al. 2021). Similarly, a focus must be placed on providing convenient and reliable public charging to vehicle owners who lack dedicated off-street parking or are unable to charge where they park. Goals for transportation electrification will only be reached if, among other incentives, a concerted effort is made to provide EV charging facilities to those who face the greatest barriers to adoption.
To help improve access, the installation of charging stations at the curbside is necessary, especially in areas where residents depend on on-street parking. Unfortunately, cities looking to improve the availability of curbside chargers are too often confronted by high installation costs and a lack of available space for installation on crowded curbsides. To navigate these challenges, a new approach has emerged in U.S. and European cities: using existing utility pole and streetlight infrastructure to install EV charging stations, or pole-mounted charging. Pole-mounted chargers (PMCs) are well-positioned to facilitate more cost-efficient and accessible public charging deployment due to several factors:

- Using existing infrastructure, PMCs lower installation costs and save valuable space on the curbside.
- PMCs can serve drivers who cannot charge their vehicles at home and enable more equitable charger distribution by focusing deployments in areas with the least access.
- Cities and utilities often own and operate utility poles and streetlights. Cities also manage the right-of-way (ROW) where poles are typically located.
- High utilization potential exists from ride-hailing vehicles and shared mobility.
- If necessary, PMCs can be relocated to different poles with relative ease, making them adaptable assets that can meet the ever-changing needs of a city.

Pole-mounted charging programs, which a handful of cities have begun to test and implement, are commonly accompanied by media attention highlighting PMCs as a simple solution for cities looking to expand public charging networks (Berman 2019; Carraggi 2021). Yet, few U.S. cities have managed to deploy this technology and only one, Los Angeles, has achieved scaled deployment (see Figure 1). Existing literature on PMCs is sparse and no comprehensive resource exists to help cities implement and scale this solution. This paper is designed specifically to address this gap and deliberately focuses on the U.S. context rather than a global one to provide the most relevant guidance for U.S. cities.

While pole-mounted charging is promising, it will only be a portion of a city’s public charging strategy. It should be noted that expanding public charging infrastructure can encourage private vehicle use and that EVs alone cannot achieve climate and sustainable mobility goals. Alongside

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**Figure 1 | Installed and Planned PMC Deployments in U.S. Cities in 2021**

- **Portland, OR**
  - 2 chargers installed in 2020

- **Lancaster, CA**
  - 5 chargers installed in 2017

- **Los Angeles, CA**
  - 431 streetlight chargers
  - 44 utility pole chargers

- **Melrose, MA**
  - 15 chargers installed in 2021

- **New York, NY**
  - Exploring pilot project

- **Charlotte, NC**
  - Planning 6 charger pilot

- **Kansas City, MO**
  - 30 chargers to be installed early 2022

Notes: Some cities have installed PMCs on utility poles, streetlights, or both. Several other U.S. cities, not depicted here, have pursued PMCs to some degree but have been unable to proceed due to various technical or political barriers.

Source: City of Lancaster 2017; authors’ stakeholder interviews (2021).
PMCs and other public charging, policymakers and planners should simultaneously prioritize multimodal, shared transportation to reduce private vehicle use, that will accelerate decarbonization and ensure equitable access.

2. METHODOLOGY
This research was informed by a series of qualitative data collection efforts, including a literature review, stakeholder mapping, and interviews. Through the literature review, it was clear a gap exists in evidence-based guidance to deploy PMCs. This process was accompanied by efforts to identify any completed, ongoing, or planned PMC projects in the United States and map the actors most relevant to those initiatives. Building on these efforts, five groups were identified as most relevant to this research:

1. Have installed: Cities or utilities that have installed and are operating PMCs; to understand the barriers and enablers encountered during the planning, installation, and operation process and identify lessons learned.

2. Plan to install: Cities or utilities currently engaged in the planning process to deploy PMCs; to understand their planning process thus far, plans for installation and operation, and identify barriers encountered or lessons learned.

3. Exploring viability: Cities or utilities that have previously explored or are currently exploring the viability of PMCs but have not yet engaged in the planning process; to understand what barriers or enabling factors have already been encountered.

4. Charging equipment manufacturers: They manufacture and/or operate PMCs; to understand the opportunity seen in PMCs, document any barriers encountered while implementing this type of infrastructure, and how the manufacturers can support deployment.

5. Transportation network companies (TNCs): Several ride-hailing platforms have made electrification commitments dependent on how quickly their drivers can transition to EVs. We spoke with TNCs to understand the opportunity seen in PMCs within their electrification strategy and how they could support deployment.

For each group, an interview questionnaire was designed to provide a standardized framework for discussion. The questionnaires used can be found in Appendix C.

Using this framework and the stakeholder mapping data, interviews were conducted with more than 30 different actors across 13 cities relevant to PMCs. Actors included city governments, electric utilities, charging equipment manufacturers, engineering contractors, TNCs, universities, and nonprofit 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. This data collection process was designed to identify learnings most relevant to U.S. cities.

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, operation, financing, 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 poles and/or streetlights played an integral role in planning and installation. In the most basic sense, pole owners can approve (or deny) the attachment and interconnection of EV chargers. 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 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 EV charger pilot in April 2021, most utility poles are jointly owned by National Grid (electric utility) and...
Verizon (communications company) (City of Melrose 2021). During the planning and installation process, Verizon required a percentage of the pole remain clear for workers to access their equipment, which necessitated a customized charger mounting solution.

- **Streetlight poles**: Cities that own their streetlights have greater decision-making power over infrastructure upgrades, including upgrading lighting fixtures to LEDs or attaching new equipment, such as an EV charger. 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 in part owned by the local utility, such as in Denver, Colorado, or owned almost entirely by the utility, such as Dominion Energy in Fairfax County, Virginia. In Charlotte, North Carolina, most poles are owned by Duke Energy, but within the utility itself multiple internal divisions individually manage poles depending on the type of infrastructure attached (i.e., streetlights or distribution wiring). PMC installations must receive approval from the appropriate division(s).

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

<table>
<thead>
<tr>
<th>POLE TYPE</th>
<th>CITY-OWNED</th>
<th>UTILITY-OWNED</th>
<th>THIRD PARTY (PRIVATE COMPANY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility poles</td>
<td>Not observed</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Streetlights</td>
<td>Yes</td>
<td>Yes</td>
<td>Not observed</td>
</tr>
</tbody>
</table>

**Table 1 | Observed Models for U.S. Pole Ownership**

- **Note**: Joint ownership models can exist depending on local context.
- **Source**: Authors’ stakeholder interviews (2021).

3.1.2 Charging equipment ownership

Another key stakeholder during the planning process is the charging station 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. We found utilities can be particularly well-suited to own PMCs because:

- Often, utilities already own and operate the pole; in such cases, it can be easier to coordinate the procurement, assessment, and installation.
- Utilities commonly own existing public charging infrastructure. Owning PMCs can be a natural extension of that role.
- Utilities have staff trained or contracted to maintain the pole and charging infrastructure. Not all cities have the staff or budget to fill this role.
- Utilities can charge for electricity, whereas due to regulation in some states, cities or third parties often cannot.

3.2 Load Management

Understanding the power demand from an EV charger 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 nonutility entities, and must account for existing loads on the circuit (Xue and Xia 2021). From a load management perspective, not every streetlight and utility pole within a city will be able to facilitate a charger. While not included in the ongoing PMC programs we spoke with, smart charging strategies could be implemented to help mitigate some of these constraints. 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. Level 1 is primarily installed in homes with private parking/garage access where a vehicle can top up on a regular basis. While PMCs are commonly installed in residential areas, they are public charging stations. Within this public setting, the higher power output of Level 2 charging (see Table 2) enables more charging sessions within a given period, improving utilization of the public infrastructure. Similarly, a 2021 study from UC Davis found EV owners who relied on Level 1 residential charging were 52 percent more likely to discontinue EV ownership and switch back to an internal combustion engine (ICE) vehicle, compared to EV owners with Level 2 residential charging (Hardman and Tal 2021).

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. If new power demand introduced by an EV charger will inhibit these core functions, upgrades to increase capacity will be needed. If those upgrades are not possible or too costly, PMC installation may not be viable. In the United States, utility poles and streetlights present two different installation settings. Utility poles usually have greater electrical capacity than streetlights often making them a better option for PMCs. However, the best pole for charging is dependent on local context.

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### Table 2 | Charging Equipment Specifications for Level 1 and Level 2

<table>
<thead>
<tr>
<th>CHARGER LEVEL</th>
<th>VOLTAGE (V)</th>
<th>POWER OUTPUT (KW)</th>
<th>AMPERAGE (A)</th>
<th>AVG. VEHICLE CHARGING RATE (MILES/HOUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>120</td>
<td>1.4–1.9</td>
<td>12–16</td>
<td>3.5–6.5</td>
</tr>
<tr>
<td>Level 2</td>
<td>208 or 240</td>
<td>3.3–19.2</td>
<td>16–80</td>
<td>14–60</td>
</tr>
</tbody>
</table>

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

Sources: CALeVIP 2021; DOE 2021b; Plug-in NC 2021.

**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 charger installations (see Table 2). Depending on the site-specific context, additional infrastructure, such as a step-down transformer or more fuses, may be required to support an EV charger (Figure 2).

- **Portland, Oregon:** In a utility pole PMC pilot run by Portland General Electric (PGE), poles with step-down transformers already installed, above or nearby, were prioritized. If PGE’s program is scaled further, additional transformers may be needed elsewhere to accommodate chargers on poles lacking an accessible transformer.

- **Melrose, Massachusetts:** In a few cases, National Grid had to install a larger transformer near the utility pole to accommodate chargers. Even with this additional infrastructure, National Grid estimates PMC installation costs to be between 55 and 70 percent less than ground-mounted chargers. Retrofitting streetlights was also considered, but the additional infrastructure required made it infeasible.
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. Streetlights of this design may accommodate a Level 2 charger, but only through extensive upgrades to the infrastructure. This could include installing a new underground conduit and a higher capacity electrical line back to a transformer, which can turn out to be cost prohibitive. To determine the viability of this option, the cost of these upgrades should be weighed against the cost of a ground-mounted installation. See Section 3.4 for more information on installation costs.

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 in the United States. Even with the 208/240 V line, infrastructure upgrades or modifications may be needed to support Level 2, depending on the existing capacity of the circuit and the location of the pole. Some examples include:

- Los Angeles’s streetlights operate on 120 V. However, the conduit, comprising two live wires (120 V each) and one neutral wire, can hold 240 V. As a result, the Bureau of Street Lighting brought in the existing second live wire to make it 240 V and added extra fuses for safety. Los Angeles has installed more than 430 streetlight chargers.

- Kansas City will begin installing streetlight chargers in the second half of 2021 and a portion of the city’s streetlights are fed at 208 V or 240 V. The project’s engineering team made it clear that even with this benefit, no charger installation would come without additional upgrades. In some cases, upgrades will involve pulling a 240 V line from the controller box or a nearby transformer to support Level 2 charging. Even so, Kansas City found the economic case for streetlight charging with these additional upgrades to be more favorable than a ground-mounted installation.

Streetlights and the role of LED conversions

Many of the cities we spoke with that are installing streetlight PMCs are doing so on LED converted streetlights. LED streetlight fixtures, which are 50 percent...
more efficient, last two to five times longer, and can save a city millions of dollars in electricity bills compared to their high-pressure sodium counterparts, reduce electrical load, and make room for new loads, such as a charging station (Gerdes 2013). LED streetlight conversions present an opportunity for PMCs to take advantage of this newly available electrical capacity.

In cases where even with LED fixtures accommodating PMCs is cost prohibitive, a streetlight’s preexisting 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 (Move PGH 2021). Hence, streetlight charging can also support multimodal sustainable transit options. For the hundreds of cities already supporting LED streetlight conversion programs (Northeast Group LLC 2020), this application may be a natural next step to explore.

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. The PMC site-selection process provides an opportunity to support a more equitably distributed charging network. 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. These considerations are divided into three categories based on geographic scale:

3.3.1 Citywide scale

- **Competition for poles:** Streetlights and utility poles are points of vertical real estate for several applications, most notably 5G sites, surveillance cameras, risers, fire alarm equipment, etc. (Kingson 2021). Due to this growing list of attachments, the available space and, more critically, the available electrical capacity for EV charging at a pole can be limited. In Los Angeles and London, United Kingdom, where 5G deployments are already underway, PMC initiatives have encountered competition with this infrastructure. In London, 5G modules have even been installed on streetlights already housing an EV charger without the operator’s knowledge, causing safety concerns. To address this challenge, in Charlotte, custom PMCs are being considered that can integrate other devices potentially in one package.

- **Existing public charging and urban planning strategy:** PMCs are a new tool that can be integrated with a city’s existing public EV charging strategy. While PMCs can enable public charging in locations previously deemed infeasible or too costly for installation, areas not suitable for PMCs should also be identified, where alternative approaches can be used to ensure equitable access throughout a city. In addition, PMC deployment can be coordinated with broader sustainable mobility efforts, ones that consider Avoid-Shift-Improve (ASI) framework principles (Bongardt et al. 2019). Compared to a ground-mounted installation, PMCs can be relocated to different locations with relative ease, making them assets adaptable to the changing needs at the curbside, such as the installation of a bike lane.

- **Enabling greater access to EV charging:** Greater availability of public charging infrastructure has been shown to increase EV uptake (Hall and Lutsey 2017), a relationship PMCs can help accelerate by improving charging access for residents that lack private charging facilities. In Santa Monica, California, for example, it is estimated that 77 percent of residents live in MUDs (City of Santa Monica 2021). Chargers sited near MUDs or low-income housing can provide go-to charging sites for many potential new EV users living nearby.

- Some cities, including Los Angeles, are trying a “utilization testing” model, where PMCs are deployed throughout the city in different neighborhoods. Over time, chargers will be added or even relocated to enable greater access throughout the city.

- Other cities, including Portland, are systematically increasing charger deployments neighborhood by neighborhood while emphasizing equitable access considerations.

- **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 infrastructure. TNCs can contribute data on charger placement and potentially finance PMCs to ensure the electrification needs of drivers, many of whom reside in MUDs, are met (Rajon Bernard and Hall 2021).
3.3.3 Curbside level

- **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 Bureau of Street Lighting was informed the curb was recently designated a no-parking zone and the charger had to be relocated. Los Angeles is also planning to work with parking enforcement to waive parking penalty fees from 10 p.m. to 6 a.m. at streetlight chargers to promote overnight charging.

- **On-street locations:** Several cities highlighted using poles located in the middle of a city block and on secondary streets as optimal for charging. This minimizes disruptions to traffic flow and provides the safest environment to charge. In Melrose, National Grid prioritized poles located closer to the street side of the sidewalk to avoid cords extending across a sidewalk, it also looked for poles located between parking spots to improve vehicle access.

- **Data connectivity:** A networked charger uses a data connection to collect usage metrics and help monitor the functionality of the charger remotely, among other uses. It is important to ensure there is sufficient Wi-Fi or cell coverage at the site to facilitate charger payment through mobile applications.

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. The key considerations relevant to the PMC installation process are described below.

3.4.1 Space management on the pole

The poles best suited for charger installation are those with minimal equipment already installed, such as risers, cable boxes, additional sensors, etc. The space available for PMCs can also be impacted by pole ownership and permitting requirements.

3.4.2 Permitting and accessibility

PMCs can help reduce the headache associated with permitting but are not completely immune to this challenge.

- **City permitting:** In some cities, mounting charging stations on a pole would require an encroachment permit or ROW permit which can be costly and time-consuming (City of San Diego 2021; City and County of Denver Department of Transportation & Infrastructure 2021).

- **Accessibly:** The Americans with Disabilities Act (ADA) dictates the space required for vehicle parking and clearance on a sidewalk. While federal ADA requirements do not address EV charging infrastructure or on-street parking, specific guidelines do exist in some states (DOE 2011). The absence of guidelines in many states adds another layer of complexity to ensure PMC installations comply with accessibility requirements.

- **Electrical code:** In the United States, the National Electrical Code (NEC) and National Electrical Safety Code (NESC) offer safety guidelines for electrical poles, which may be included in local regulations requiring compliance (National Fire Protection Association 2020; IEEE 2017). Ensuring compliance has been a complex process for some cities because neither code includes guidelines specific to EV charging infrastructure yet. National Grid developed an open standard for charger mounting, compliant with NEC and NESC, documented in Appendix B.

3.4.3 Mounting EV chargers

Two types of PMC mounting configurations were found (Image 1):

- **Chargers at eye-level:** This equipment configuration is useful if there is already infrastructure mounted above, it also can offer greater visibility for drivers.

- **Elevated chargers:** Chargers are attached higher up the pole, typically with a retractable cord. This equipment offers several benefits, including helping reduce vandalism, resiliency in flood-prone areas, and keeping cords away from snowplows.
In both these cases, mounting chargers toward the sidewalk can help avoid damage from vehicles, where an elevated charger can also help limit obstruction to pedestrians.

Charging equipment manufacturers offer a range of products; some have equipment designed specifically for pole-mounted applications and others do not. In Los Angeles and Melrose, the equipment manufacturer was a key partner in developing a mounting solution for the city. Other collaborators can include the project’s engineering staff. For example, Kansas City used hardware developed by Black & MacDonald, Portland used its in-house PGE engineering team and equipment, and Charlotte developed its equipment at the University of North Carolina at Charlotte — EPIC. As PMCs scale, it is unclear if these custom mounting solutions will continue to be employed beyond the pilot phase.

### 3.4.4 Metering EV chargers

The kilowatt hours (kWh) distributed by a public EV charger need to be accounted for by a dedicated electrical meter. The meter, whether it is located within a charging station or mounted externally (Image 1), generally needs to be revenue-grade and utility-approved.

PMC installations commonly involve tapping into an existing unmetered electrical service. In several cities we spoke with, the city’s streetlights are unmetered, and the utility simply charges a fixed electricity rate based on the type of luminaire installed. Adding PMCs to the lighting circuit complicates this billing process and can require the installation of a dedicated electrical meter to differentiate the power consumed by a PMC from other loads.

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**Image 1** | **Eye-Level and Elevated PMC Mounting Configurations**

Notes: (Left) A PMC mounted at eye level in Portland, Oregon. This installation includes an external electrical meter mounted above the charger. (Right) An elevated PMC in Los Angeles, California. Note that this parking space has a parking meter.

Source: Flickr Emmett Werthmann/WRI.
Of the three charger equipment manufacturers we spoke with, each confirmed they had received on-charger utility-grade meter approval in certain jurisdictions, but this should be confirmed on a case-by-case basis as it comes with potentially significant IT and regulatory hurdles. For example, Ubitricity, which has 3,500 chargers mounted on London’s streetlights, was initially disapproved by ConEd for use in New York City’s pilot program due to metering issues. Additional meter-grade or submeter requirements can add to installation costs.

3.4.5 Installation costs

Installation costs consist of charger hardware, added materials and grid upgrades, 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$9,000 for a single unit (Agenbroad 2014). Most notably, National Grid saw a 55 percent reduction in installation costs and 30 percent reduction in overall costs. Most PMC programs interviewed found hardware cost for single Level 2 PMC to be between $1,500 and $6,000, comparable to a ground-mounted unit (Nelder and Rogers 2019). The greatest savings on cost (and time) were realized in avoided costs on construction and labor, fewer permitting fees, and timely communication with utilities. Factors that could increase PMC installation costs can include:

- **Upgrading costs:** Upgrading wiring and/or transformers to accommodate new load from EV charging stations.
- **Pole type:** Variations in the type of pole used for PMCs can impact installation costs. For example, in some cities, the electricity used by streetlights is purchased at a discounted rate. If this is the case, a dedicated electrical meter is necessary to measure the electricity consumed by a PMC, adding to installation costs. Additionally, PGE found installing chargers on streetlights in Portland can be up to three times more expensive than a utility pole installation.
- **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 already known a PMC cannot be attached to a pole because risers exist at that location, the time and money spent on a site survey can be avoided.

- **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) (Nelder and Rogers 2019).

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

3.5 Operation

3.5.1 Stakeholders involved

Several stakeholders can be involved in the operation of both utility poles and streetlights. Pole maintenance is commonly performed by the utility or the city. In some cases, such as Kansas City, streetlight maintenance is provided under contract by a third-party engineering company (see Table 3).

<table>
<thead>
<tr>
<th>TYPE OF POLE</th>
<th>CITY Operated</th>
<th>UTILITY Operated</th>
<th>THIRD PARTY (PRIVATE COMPANY) Operated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility poles</td>
<td>Not observed</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Streetlights</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Notes: Depending on the city, several types of actors can be involved in maintenance of poles. In some cases, multiple operators exist.

Source: Authors’ stakeholder interviews (2021).

3.5.2 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, especially for areas like networking costs for chargers, pole attachment rental fees, etc. Depending on the terms of the contract, the charging equipment manufacturer may be responsible for maintenance. 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. Equipment manufacturers noted maintenance costs were not always incorporated into funding for charger deployments, which becomes an issue for forecasting costs. From our research, solutions to reduce maintenance issues can include using retractable cables to prevent cord cutting and community education about the functionality and usability of the charger to prevent misuse.

3.5.3 End-user costs and payments

End-user costs and payments can directly influence the installation process and charger utilization. Several elements are involved:

**Payment for parking:** 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 (see Image 1). 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. Some cities have avoided placing chargers in paid parking locations and others have worked with the city’s parking department to coordinate. Montreal, Canada, which has deployed several curbside ground-mounted chargers, has developed an API linking charging and parking payments, providing a more seamless user interface.

**Pricing structure:** For Level 2 charging, the rate at which a vehicle battery receives energy depends on the charger’s maximum power output [between 3.3 kilowatts (kW) and 19.2 kW] and the maximum power an EV’s onboard inverter can accept. The latter varies from one vehicle to another, with more expensive and powerful EV models often accepting higher Level 2 charger outputs. As a result, charging fees based on charging time rather than a dollar per kWh basis is disadvantageous to some vehicles, making pricing an equity concern.

**Payment methods:** We observed three payment methods:

- **Credit cards:** While most users may have access to credit cards, having a credit card reader on the charger could be prone to vandalism. Some cities, like New York City, experienced challenges linking data from credit card swipes with the city’s accounting department systems.

- **Mobile application payments:** Most low-income individuals do have smartphones, but may not have robust data plans, so it is important to have low cellular data requirements for mobile applications.

- **Radio-frequency identification (RFID) system:** This easy-to-use, contactless payment system is growing in adoption and can be especially useful for vehicle fleets but is also prone to vandalism.

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 (Baker et al. 2019). Current PMC deployments in Los Angeles, Portland, and Melrose are funded entirely or in part by the Los Angeles Department of Water and Power, PGE, and National Grid, respectively.

As indicated in Tables 1 and 3, utilities often own and operate streetlights and utility poles. In several cities, the utility also already owns and operates public charging infrastructure. Additionally, utilities have an innate understanding of the existing electrical system, 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, if any, more streamlined and can help reduce program costs and avoid delays. In each city with a PMC program, an electric utility led the initiative or was a key project partner.

PMCs enable greater deployment volumes for the same cost compared to ground-mounted chargers. 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 commercial EV charging infrastructure, utility tariffs should be evaluated.
from a public good perspective to encourage equitable EV adoption and minimize unfair allocation of costs (St. John 2021; Knight et al. 2019).

3.6.2 Federal and state agencies

The federal government is increasingly interested in deploying public charging infrastructure, which offers more opportunities to demonstrate and scale solutions, such as PMCs (White House 2021). 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 Standard (LCFS) credits provide funding to increase public charging infrastructure in Los Angeles; as more states adopt similar programs, greater funding opportunities could open (California Air Resources Board 2021).

3.6.3 Transportation Network Companies (TNCs)

TNCs can play a transformative role in funding PMC infrastructure, to increase Level 2 charging station 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 (Klock-McCook et al. 2021). 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 an important part of understanding local needs, barriers, and who will utilize PMC infrastructure and is crucial to the ongoing process. Our research identified four areas where cities and utilities engaged the local community in planning for PMC deployment:

- **Understanding local needs:** In Kansas City, Melrose, and Portland, community engagement provided an opportunity for residents to voice concerns and discuss solutions during the planning process. Concerns regarding PMCs included siting chargers outside of homes or storefronts, ensuring equitable distribution, and safety concerns (see below). This process can be facilitated through community boards and town halls, public meetings, and coordination with local grassroots organizations.

- **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.

- **Site selection input:** Community members can be an invaluable source of information on where charging infrastructure 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 (Francis 2021).

- **Building awareness:** Several cities have used PMC programs to develop awareness of EV benefits, the infrastructure, and foster a sense of community ownership. This can include door-to-door engagement and/or dissemination of informational resources. In some cases, this was done to address occurrences of vandalism.

4. PRELIMINARY GUIDANCE ON PLANNING FOR PMCs

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:

- **Step 1:** Viability assessment for a PMC program
- **Step 2:** Planning for PMC deployment
- **Step 3:** Siting and installing PMCs
- **Step 4:** Operating a PMC program

### 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 (see Sections 3.1 and 3.5)

For both utility poles and streetlight poles, a range of ownership and operation models exist (Table 1 and Table 3). 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 (see Section 3.2)

It is recommended to determine to what extent PMCs are technically feasible in the city before proceeding further. The questions in Table 4 are intended to help identify and uncover barriers present within a city’s local context that could inhibit PMC feasibility. If streetlights and/or utility 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>
<thead>
<tr>
<th>UTILITY POLE</th>
<th>STREETLIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 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?</td>
<td>• Are streetlights wired with a subsurface or overhead connection? If there is a subsurface electrical connection, is the existing electrical conduit large enough to facilitate EV charging?</td>
</tr>
<tr>
<td>• Are existing charger equipment models compatible for attachment to the city’s network of pole infrastructure? (Section 3.4)</td>
<td>• Are there any structural or aesthetic issues with attaching an EV charger to the pole?</td>
</tr>
<tr>
<td>• What types of infrastructure modifications or upgrades are necessary to facilitate Level 1 charging? To facilitate Level 2 charging? (Section 3.2)</td>
<td>• Have any streetlights been converted to LED? (Section 3.2)</td>
</tr>
<tr>
<td>• Do utility poles need to be accessible for maintenance personnel? Could this inhibit charger installation? (Section 3.1)</td>
<td>• Is streetlight power dependent on photocells or timers?</td>
</tr>
</tbody>
</table>

Source: Authors’ stakeholder interviews (2021); Puentes 2019.
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:

- Owner(s) of pole infrastructure
- Operator(s) and maintenance provider of pole infrastructure
- Electricity service provider, including staff well-versed in the local electric utility regulatory environment, NEC and NESC standards, and utility staff who interface with the city and local community
- Power distribution engineers (usually from the utility) familiar with local pole infrastructure, who can help inform site selection and charger mounting
- City departments responsible for management of the ROW, parking payment, parking enforcement, and deployment of competing infrastructure, such as 5G small cell sites
- Local community organizations to provide feedback during the planning process, support outreach to residents and an equity-first approach
- Charging equipment manufacturers who can be a key partner for helping share knowledge from other deployments and workshop solutions
- Relevant data collection and analysis partners, such as TNCs, universities, and NGOs
- Potential infrastructure financing partners

Assess charging infrastructure equipment options. During the site selection process, the charging equipment used will have implications on site-specific criteria for installation. For this reason, it is advised that the charger type and configuration are identified prior to confirming installation sites. It is possible to incorporate multiple types of charging equipment and mounting strategies into a pilot.

- **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 a vehicle charging port can be from the charger (Section 3.4). It is also important to confirm if the electrical meter installed in the charger is approved by the local utility (Section 3.4). If the city or utility already utilizes a specific Charging Network Operator (CNO), this should also be noted to help streamline monitoring across the city’s charging network (Section 3.5).

- **Charger attachment mechanism:** Working with the charging equipment manufacturer and/or the project’s engineering staff, determine how chargers will be attached to poles (Section 3.4).

- **Charging level:** Determine if Level 1 or Level 2 charging is most suitable in the city considering the available capacity at poles and the infrastructure most appropriate to effectively serve current and future demand (Section 3.2).

- **Charger connectivity:** It is recommended networked chargers be installed so usage metrics can help evaluate performance and plan for future installations based on demand.

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

Generate installation cost estimates. Building on 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. A list of budget considerations can be found in Appendix A.

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, consulting with relevant city officials and the electric utility can help identify necessary permits and other approvals required.
to proceed with PMC installations. Understanding this can help foresee impacts on charger site selection or other hurdles moving forward.

**Establish charging payment scheme.** This will largely depend on infrastructure ownership arrangements, utility rates, and the local utility regulatory environment. 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 with limited budgets should consider taking advantage of federal and state funding opportunities. A compressive list can be found on Alternative Fuels Data Center’s “Federal and State Laws and Incentives” web page (DOE 2021c). Utilities and TNCs 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. As Los Angeles’s Bureau of Street Lighting put it, “a broken charger is worse than no charger.”

**Conduct ongoing, consistent, and broad community engagement.** Informing community members about PMC initiatives is a necessary part of the planning process (see Section 3.7). Community groups to engage with can include community boards, faith-based organizations, property management companies, civic/historic preservation organizations that may have issues with chargers in certain designated areas, 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. Recommended data points to consider in this analysis are listed below. 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. It should be noted that the approach taken for site selection and the data inputs used will directly impact the ability of PMCs to foster a more accessible and equitable charging network within a city.

**Primary data**

- Location of utility poles and/or streetlights. This provides potential points of attachment for chargers in the city. Using the other data below, the best situated poles will be narrowed down.
- Location and type of existing on-street parking zones to determine where pole locations align with parking zones, including parking time limits, public versus residential, and metered versus unmetered parking.
- Status of the local distribution grid. This includes the location of distribution transformers or other necessary infrastructure and the existing capacity available to install the charging equipment identified in Step 1.
- Streetlights with LED fixtures to determine where excess available capacity may exist.

**Equitable deployment data**

- Neighborhoods and MUDs that lack dedicated off-street parking.
- Residences with dedicated off-street parking but unable to install an EV charger. Some residents have a private parking spot, but the property owner is unable or unwilling to install a charger.
- Existing public charging stations to identify both “charging deserts” and areas with sufficient public charging to determine how PMCs best fit into the existing network (Ulrich 2020).
- Existing EV drivers to identify areas with preexisting charging demand and areas facing barriers to EV uptake.
- Median household incomes throughout the city to understand where underserved communities reside.
- Local community input provided on optimal or preferred charger locations, informed by Step 2.
- Other equity-centric data sources, such as the Mapping Inequality database (Nelson et al. 2021), the Greenlink Equity Map (Greenlink Equity Map 2020), or the Opportunity Atlas (Opportunity Insights 2020).
Secondary data

- Charging log data from existing public chargers to determine charging hot spots and where an increased density of charging is needed
- Anonymized driver residence data provided by TNC platforms to inform where placing chargers can enable electrification for ride-hailing and delivery drivers
- ASI planning framework for sustainable mobility: Cities should consider this framework for mobility planning and deploying accessible public charging infrastructure at specific locations or hubs should be prioritized (Bongardt et al. 2019).
- Points of interest such as workplaces, shopping/retail centers, public transit, public parks, etc.

Conduct site visits. Once a list of pole sites has been narrowed down, those locations should be visited in person and inspected alongside the power distribution engineering team and other relevant community stakeholders to confirm if the pole is well-suited for charger installation. It is advised that residents are informed of and, where necessary, included in upcoming site visits. The series of questions in Table 5 is intended to help identify and uncover site-specific barriers that may be encountered. In some cases, data points associated with these questions could also help inform the pole identification process above.

Table 5 | Identification of On-Site PMC Installation Barriers

<table>
<thead>
<tr>
<th>UTILITY POLE</th>
<th>STREETLIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>- What is the least expensive installation pathway, one using the greatest portion of existing infrastructure?</td>
<td>- Pole aesthetics—some streetlights may not be able to accommodate PMCs due to historic preservation ordinances.</td>
</tr>
<tr>
<td>• If new wiring is needed, can existing underground conduit be reused without digging up sidewalks? Does overhead wiring exist that can be repurposed?</td>
<td></td>
</tr>
<tr>
<td>• If necessary, can an existing nearby transformer be used rather than a new unit?</td>
<td></td>
</tr>
<tr>
<td>• At a minimum, can the pole be used to avoid concrete base construction and limit permitting needs? Can PMCs be coordinated with a pole-replacement program?</td>
<td></td>
</tr>
<tr>
<td>- Where is the pole located in relation to the road and sidewalk?</td>
<td></td>
</tr>
<tr>
<td>• Charger placement on a pole should avoid obstruction of the sidewalk and limit risk of being struck by vehicles from the road.</td>
<td></td>
</tr>
<tr>
<td>• Mounting a charger higher or lower and varying its orientation on the pole can help accommodate these constraints.</td>
<td></td>
</tr>
<tr>
<td>- Once installed, will the charger cord reach EV ports located on the front, back, and sides of an EV, sometimes away from the curb?</td>
<td></td>
</tr>
<tr>
<td>- Is there sufficient cellular coverage at the site? Networked chargers commonly require a cellular or wireless signal to operate.</td>
<td></td>
</tr>
<tr>
<td>- Is there other infrastructure that may conflict with a charger installation, such as bike lanes or 5G small cell sites?</td>
<td></td>
</tr>
<tr>
<td>- How do NEC and NESC standards impact the installation site? (Consult the utility.)</td>
<td></td>
</tr>
<tr>
<td>- Can charging equipment be installed to prevent non-maintenance personnel from accessing or climbing the poles?</td>
<td></td>
</tr>
<tr>
<td>- Identify poles structurally sound enough to support a mounted charger.</td>
<td></td>
</tr>
<tr>
<td>- Select “clean poles” or those without preexisting risers, cable boxes, or other equipment. The electric utility can help inform this.</td>
<td></td>
</tr>
<tr>
<td>- Does the utility have plans to move any power lines underground? If so, how might this impact the long-term viability of PMC installations on those poles?</td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors’ stakeholder interviews (2021); Puentes 2019.
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 charging equipment. Once final sites have been identified and the charging equipment is procured, install the charging equipment with support from the project’s technical and operational staff and the charging 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 and promote EV use. Some cities have instituted fines and penalties for parked ICE vehicles and EVs parking longer than permitted to ensure the spot is open for those who need to charge (Washington State Legislature 2021; Illinois General Assembly 2021).

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.

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 poles and streetlights 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. In collaboration with end users, including local communities and TNC drivers, PMCs can also spur greater EV adoption. 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.

While some planning considerations are common to both utility poles and streetlights, such as charging level, charger equipment ownership, and community engagement, there are key differences, including available electrical capacity, pole ownership, and installation. We have attempted to simplify these 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 increases.

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.
APPENDIX A. PMC BUDGET CONSIDERATIONS

This table details a range of costs that can be associated with PMC planning and installation and is intended to help inform budget development for a PMC program.

<table>
<thead>
<tr>
<th>COST TYPE</th>
<th></th>
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<tbody>
<tr>
<td><strong>Materials</strong></td>
<td></td>
</tr>
<tr>
<td>Charging station hardware</td>
<td></td>
</tr>
<tr>
<td>Step-down transformer (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Meter equipment (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Primary conductor</td>
<td></td>
</tr>
<tr>
<td>Secondary conductor (if applicable)</td>
<td></td>
</tr>
<tr>
<td>EV signage and paint</td>
<td></td>
</tr>
<tr>
<td>Distribution panel (if applicable)</td>
<td></td>
</tr>
<tr>
<td>Charging station mounting hardware</td>
<td></td>
</tr>
<tr>
<td><strong>Labor and Design Fees</strong></td>
<td></td>
</tr>
<tr>
<td>Civil/electrical engineering and design costs</td>
<td></td>
</tr>
<tr>
<td>Mounting hardware engineering and design costs</td>
<td></td>
</tr>
<tr>
<td>Mounting EV charger to pole</td>
<td></td>
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<tr>
<td>Charger interconnection</td>
<td></td>
</tr>
<tr>
<td>LED streetlight conversion (if necessary)</td>
<td></td>
</tr>
<tr>
<td>Structural assessment of pole (if necessary)</td>
<td></td>
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<tr>
<td>Site surveying fees</td>
<td></td>
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<tr>
<td><strong>Other</strong></td>
<td></td>
</tr>
<tr>
<td>Permits</td>
<td></td>
</tr>
<tr>
<td>ROW fees</td>
<td></td>
</tr>
<tr>
<td>Franchise fees (if applicable)</td>
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</tbody>
</table>
APPENDIX B. NATIONAL GRID DISTRIBUTION WOOD POLE-MOUNTED EV CHARGING STATION CONSTRUCTION STANDARD

NOTE:
1. All new or replacement electric vehicle charging stations to be metered. Installations should be avoided on poles with other equipment. Poles shall be accessible by bucket and the proposed installation shall be field reviewed and approved by the company and any joint pole owners prior to work.
2. Customer shall furnish, install, own and maintain all material and equipment shown above except as noted.
3. Locate meter socket away from vehicular traffic flow and refer to ESB #750 for details and installation notes. Meter socket shall be installed in true vertical position on approved support. See Pg. 17-107 for approved support details.
4. Service equipment amp rating to be determined by installer per NEC requirements.
5. All conductors in non-metallic conduit attached to pole in accordance with NEC requirements.
6. Proximity reader and signage shall be mounted flush to pole to avoid making the pole readily climbable.

DISTRIBUTION WOOD POLE MOUNTED ELECTRIC VEHICLE CHARGING STATION – SINGLE CHARGER

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<th>ISSUE</th>
<th>PAGE NUMBER</th>
<th>OVERHEAD CONSTRUCTION STANDARD</th>
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<td>7/21</td>
<td>17-201</td>
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NOTE:
1. All new or replacement electric vehicle charging stations to be metered. Installations should be avoided on poles with other equipment. Poles shall be accessible by bucket and the proposed installation shall be field reviewed and approved by the company and any joint pole owners prior to work.
2. Customer shall furnish, install, own and maintain all material and equipment shown above except as noted.
3. Locate meter socket away from vehicular traffic flow and refer to ESB #250 for details and installation notes. Meter socket shall be installed in true vertical position on approved support. See pg. 17-107 for approved support detail.
4. Service equipment amp rating to be determined by installer per NEC requirements.
5. All conductors in non-metallic rigid conduit attach to pole in accordance with NEC requirements.
6. Proximity reader and signage shall be mounted flush to pole to avoid making the pole readily climbable.

DISTRIBUTION WOOD POLE MOUNTED ELECTRIC VEHICLE CHARGING STATION – DUAL CHARGER

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<td>PAGE NUMBER</td>
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<tr>
<td>17-202</td>
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APPENDIX C. INTERVIEW QUESTIONNAIRES

To help guide the interviews, questionnaires were developed for each group. The authors have deleted questions that repeat for brevity.

Cities/Utilities That Have Installed PMCs

KEY QUESTIONS

City EV Charging Context

6. Does the city have an EV road map?

7. In what locations is public EV charger installation prioritized in the city? What type of public charging infrastructure is currently installed? How many public chargers are Level 2 versus Level 3?

8. Has the city been able to incorporate renewable energy into public EV charging? If so, to what extent?

9. What entity/entities operate/maintain the public charging infrastructure in your city? What role does the city play in supporting charger operation and maintenance?

10. Does the city have plans to support electrification of rideshare/delivery fleets? If so, how is the city supporting this?

11. During the process of EV charger deployment is there any data the city has needed that it has found difficult to access or obtain? If so, what were those data and why were they difficult to access or obtain?

City Pole Context

1. What entity/entities own and/or maintain the pole-mounted infrastructure in the city?

2. What is the utility supplying electricity to streetlights and/or utility poles in the city?

3. What is the voltage of the electrical connection to streetlights and/or utility poles in the city?

4. How are the city’s streetlights metered?

5. Has the city converted any of its streetlights to LEDs (percentage or count)? What challenges has the city encountered when switching to LEDs? Have pole-mounted LED conversions been performed with pole-mounted charging in mind?

6. Is the city currently using poles to accommodate other types of (non-EV charging) infrastructure that also require an electrical connection (i.e., telecommunications)? If so, how are you prioritizing?

City PMC Context

1. What entity/entities own and/or maintain PMCs in the city?

2. Who is the manufacturer(s) of the pole-mounted charging equipment installed in the city?

3. How do PMCs fit into the city’s greater public charging plan (location, charger level, etc.)? What are your goals as you continue to scale pole-mounted charging infrastructure?

4. What was the city’s process used to determine the charging equipment that would be used? Was pole-mounted charging first presented as an option from a manufacturer or an idea that came from the city government internally?

5. What do you see as the greatest benefits of pole-mounted charging for your city? What do you see as the greatest detriment?

Pole-Mounted Charging Project Planning

1. Who was consulted early on within the city (city entities) to help inform the project planning? Who was consulted externally (non-city entities)? Please list the stakeholders that were involved during the pole-mounted charging planning process.

2. When determining where to place PMCs, what factors were taken into consideration (on-street/off-street, residential/commercial, etc.)? What tools/methods has the city used to inform this decision-making process?

3. Has the city considered the impacts that pole-mounted charging will have on promoting/disenchanting private vehicle ownership in cities? If so, how is this consideration being incorporated into the planning process?

4. How are the needs of lower-income people and other vulnerable groups considered when planning EV charging?

5. During the PMC planning process, what are the data sets that are necessary for decision-making? Has that data been difficult to access or obtain? If so, what were those data and why were they difficult to access or obtain?

6. Are there any stakeholders that were not originally involved in the project planning but are now involved in supporting pole-mounted charging infrastructure? If so, why were they brought on to support the initiative?

7. Is the electrification of for-hire vehicles/delivery fleets a factor being incorporated into the pole-mounted charging planning process? If so, how is this being done?

Pole-Mounted Charging Installation

1. What changes, if any, were made to pole-mounted infrastructure to accommodate EV chargers (e.g., timer/photocell removal, capacity upgrades)?

2. What has the city found to be the greatest challenges during the PMC installation process?

3. In your opinion, what makes one PMC model superior to another?

4. What features help make a charger easier to install?

5. What features make a charger easier to operate and maintain?

6. What features provide a better user experience?

PMC Implementation and Operation

1. Has it been necessary for the city to bring on additional maintenance crew capacity for PMCs? If so, what was the cost associated with this and how was it funded?
2. Has the city encountered issues with having enough capacity at street poles due to competition with other electrical loads? If so, how were those issues identified? Has the city been able to incorporate renewable energy into pole-mounted charging?

3. How is electricity consumption from a street pole’s lighting load and EV load differentiated? Has the city encountered any issues with metering?

4. What type of data are collected on charger operation?

5. Has pole-mounted charging allowed the city to install chargers in a wider range of areas than conventional Level 2 charger installations? What types of areas has the city been able to install charging where it previously was not feasible?

6. Have rideshare/delivery services been able to take advantage of the installed pole-mounted charging infrastructure? Have considerations for rideshare vehicles impacted the placement of chargers?

7. Has the city encountered issues with non-EV drivers displeased with a decreasing number of on-street parking spaces available to them? Has the city encountered challenges addressing that on-street EV charging may be seen as an advantage of availability to parking for those that can afford an EV over those who cannot?

Cost/Funding/Payment

1. Are there any grants, subsidies, or other financial incentives the city is receiving from the city or national government to support EV deployment? What funding mechanisms were/are used to help fund PMC CAPEX and installation?

2. Has the city found CAPEX or installation costs to be greater or lesser than conventional Level 2 chargers? By how much?

3. As the city has continued to install PMCs, are there specific factors it has identified that can increase or decrease the cost of installation? If so, please describe those.

4. What payment method(s) do EV owners use to pay for charging sessions (credit card, QR code, mobile app, etc.)? Has the city encountered any benefits or challenges with the payment method(s) EV owners use to pay for charging sessions?

5. In the case of the city, what is the CAPEX for a single PMC?

6. In the case of the city, what is the cost of installation for a single PMC?

Policy Environment

1. What policies are in place that have made pole-mounted charging more or less difficult to implement? Please explain why.

2. Has the city run into issues with zoning/permits hindering the deployment of pole-mounted charging? Does this differ from the city’s experience installing non-pole-mounted charging units? If so, please explain.

Cities/Utilities Planning to Install PMCs

KEY QUESTIONS

PMC Implementation and Operation

1. How will electricity consumption from a street pole’s existing load and EV load be differentiated? Has the city encountered any issues with metering?

2. If the city will be responsible for PMC maintenance, describe how it will facilitate and support this effort. Will it be necessary for the city to bring on additional maintenance crew capacity for PMCs? If so, what will be the cost associated with this and how will it be funded?

3. Has the city encountered issues with limitations on grid capacity from charging loads? If so, how were those issues identified?

4. Will pole-mounted charging allow the city to install chargers in a wider range of areas than conventional Level 2 chargers? What types of areas will charging be able to expand to?

Policy Environment

1. What policies are in place that have made pole-mounted charging more or less difficult to implement? Please explain why.

2. Has the city run into issues with zoning/permits hindering the deployment of pole-mounted charging? Does this differ from the city’s experience installing non-pole-mounted charging units? If so, please explain.

Cities/Utilities Exploring the Viability of PMCs

KEY QUESTIONS

Funding/Cost

1. What funding mechanisms have been used in the past to help fund charger CAPEX and installation?

Data

1. Does the city have access to a map of streetlights and/or utility poles in your city?

2. Does the city have access to load data on electricity consumption by streetlights?

3. Does the city have access to capacity data for the infrastructure that services streetlights and/or utility poles operating in your city?

4. Does the city have EV penetration data disaggregated by neighborhood and income level? A map of existing EV charging infrastructure overlaid with spatial distribution of income and key destinations (employment centers, schools/universities, health facilities)?
Charging Equipment Manufacturers (CEMs)

KEY QUESTIONS

Charging Type Context
1. Is pole-mounted charging a business opportunity the CEM is actively working to develop?
2. How does the CEM see pole-mounted charging fitting into preexisting public charging networks?
3. What charging level does the CEM offer for pole-mounted charging applications?
4. In your opinion, what types of EV users will find pole-mounted charging to be most useful?
5. What are the key selling points of a PMC compared to a comparable conventional (non-pole-mounted) EV charger?
6. In your opinion, what makes one PMC model superior to another?
7. What features help make a charger easier to install? To operate and maintain?
8. What features provide a better user experience?

Charging Deployment
1. In what cities is the CEM prioritizing charging station deployment currently? For what reasons have these cities been chosen to focus your efforts in?
2. Several U.S. cities, including Charlotte, Kansas City, Los Angeles, and New York City, have installed or are planning to install pole-mounted charging. In what locations is the CEM deploying pole-mounted charging infrastructure?
3. Are there barriers the CEM has encountered when working on projects installing conventional (non-pole-mounted) charging infrastructure that you could foresee being a barrier to pole-mounted charging? If so, what are they and how can these barriers be avoided?
4. When reaching out to potential installers of pole-mounted charging infrastructure, have people been receptive to the concept? Have cities been receptive to the concept of pole-mounted charging? Have cities expressed disinterest? For what reasons?
5. Have rideshare and last-mile delivery companies expressed an interest in pole-mounted charging installations? Do you see pole-mounted charging as an opportunity to support electrification of those fleets?
6. Within the pole-mounted charging space, has the CEM experienced a lot of competition from other charging equipment manufacturers?
7. How are the needs of lower-income people and other vulnerable groups considered when expanding the CEM’s network? Do you think pole-mounted charging can help increase access?

Pole-Mounted Charging Installation and Planning
1. What role does the CEM play in the charger planning and installation process? During the planning and installation process, what entities does the charging equipment manufacturer work most closely with?
2. What types of challenges has the CEM encountered during the installation process? Based on your experience, what can be done to help overcome these challenges?
3. Has the CEM considered partnering with other private sector entities that have an interest in also using existing street poles to expand their infrastructure, such as telecommunications (Wi-Fi/5G) networks? Why or why not?
4. What type of data does the CEM need from a city or utility to support the installation of pole-mounted charging? Has the CEM encountered any issues obtaining certain types of data necessary to support pole-mounted charging projects?

Charger Operation
1. What types of data is the CEM able to provide cities on charger utilization/operation?
2. What type of support is the CEM able to provide on charger maintenance and stocking parts?

Financing
1. Cities often have limited budgets. What financing mechanisms can the CEM provide to a city with limited financial resources to help them purchase and install pole-mounted charging?
2. What types of entities do you see as the most willing and able to purchase charging stations (cities, electric utilities, private companies, etc.)?

Transportation Network Companies (TNCs)

KEY QUESTIONS

Electrification Strategy
1. Does the TNC have an EV plan or road map?
2. What percentage of the TNC’s fleet is comprised of EVs currently?
3. To meet the TNC’s electrification targets, how are you planning to support the development of charging infrastructure? Beyond charging infrastructure, what can be done to accelerate TNC electrification?
4. In your experience, what have been the greatest barriers to increasing access to charging for TNC drivers?
5. What types of charging solutions/strategies do you view as the best way forward to support electrification of rideshare and delivery fleets? What level(s) of charging is most useful for TNC drivers? What types of locations are most useful for TNC drivers to charge at?
6. For a driver on the TNC platform, are there certain characteristics you have identified that make the switch to an EV easier for one driver on your platform over another? Garage access, specific driving habits, or other characteristics?
7. In terms of the cities the TNC operates in, are there certain city characteristics you have identified that make it easier to electrify the vehicles on your platform in one city over another?
8. Do you know what percentage of TNC drivers operate on multiple TNC platforms? Would you consider collaborating with other TNCs to determine the most effective place to site charging infrastructure?

9. In which cities is the TNC prioritizing your vehicle electrification efforts currently? For what reason have these cities been chosen to focus your efforts in?

10. How are the needs of lower-income people and other vulnerable groups who drive on the TNC’s platform considered when planning the TNC’s electrification efforts?

Pole-Mounted Charging

1. Does the TNC see pole-mounted charging as an opportunity to support electrification of vehicles used by drivers operating on your platform?

2. TNC drivers can have variable schedules. Do you think this could impact the viability of relying on Level 2 overnight pole-mounted charging?

3. What do you foresee being the greatest barriers to pole-mounted charging being a viable part of a TNC driver’s charging strategy?

4. TNC’s electrification plan mentions efforts to influence policy at the federal, state, and local levels, partner with utilities and other third parties to expand charging infrastructure, among other action items. How can the TNC incorporate pole-mounted charging deployment into these proposed initiatives?

5. Several U.S. cities have installed or are planning to install pole-mounted charging. Is the TNC currently focusing its electrification efforts in any of these cities?

Data

1. What types of data does the TNC collect that you envision would be useful for cities planning for EV infrastructure, such as pole-mounted charging?

2. Is it possible to identify the areas where TNC drivers reside and where installing overnight charging would be most useful?

3. Can the TNC share this data with cities? If so, what does that process look like?

Financing

1. Cities have limited budgets to support EV infrastructure deployment. What is the TNC doing or planning to do to help finance the purchase, installation, and operation of electrification efforts?

2. Does the TNC intend to support drivers on your platform to purchase EV charging infrastructure?

3. Is the TNC planning to help finance pole-mounted charging infrastructure to assist the electrification of TNC vehicles?

4. Beyond financial support, are there other actions that the TNC has identified that can be used to help increase access to charging for drivers?

GLOSSARY

ASI – Avoid-Shift-Improve framework

CNO – Charging Network Operator. It is a company that provides the charging network infrastructure, managing the back-end technologies as well as the connection between the chargers to deliver reliable and consistent EV charging.

Ground-mounted charger – an in-ground EV charging station mounted on a concrete pedestal.

MUD – multiunit dwelling

Off-street parking – an area that is available for vehicles parked in locations other than the street; i.e., private garages, parking lots, and others.

PMC – pole-mounted charger. It is an EV charging station mounted on a pole with an existing power line.

ROW – right-of-way. It is the legal right, established by usage or grant, to pass along a specific route through grounds or property belonging to another. In the case of PMCs, it is used in the context of the curbside.

TNC – Transportation Network Companies. They enable ride-sharing by providing a platform for drivers and riders.
REFERENCES


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ABOUT THE AUTHORS

Emmett Werthmann is a research analyst in the Electric Mobility team at WRI.

Contact: emmett.werthmann@wri.org

Vishant Kothari is a manager in the Electric Mobility team at WRI.

Contact: vishant.kothari@wri.org

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World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

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Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth’s resources at rates that are not sustainable, endangering economies and people’s lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

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