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Planning for On-Street EV Charging Infrastructure

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Transitioning from petroleum-powered to electric vehicles (EVs) has the potential to create enormous reductions in greenhouse gas (GHG) emissions and air pollution. When EVs draw their electricity from clean sources, we will dramatically reduce our carbon footprints. Studies suggest that using an EV instead of an internal combustion engine (ICE) vehicle reduces carbon emissions by as much as 50 to 70 percent (Taub 2022). And if vehicle tailpipes stop pouring pollution—including carbon monoxide, nitrous oxide, and particulate matter—into the air of our towns and cities, we can save as many as 20,000 lives each year lost to cancer, asthma, and heart conditions (Choma et al. 2021).

The burdens of poor air quality generated by our cars are borne disproportionately by lower-income neighborhoods and communities of color (Harvard T.H. Chan School of Public Health 2022). As the outcry around air pollution has gathered strength over the last few decades, it is important to acknowledge the environmental justice (EJ) impacts of the transition to EVs. Providing publicly accessible EV charging infrastructure will be a key component of supporting an effective and equitable transition.

The majority of today's EV owners charge primarily in garages in single-family homes; 90 percent of EV owners have their own garage (Ricardo 2021). However, there is a significant number of people who currently have no option to charge EVs at their home or at their workplace. Many renters and homeowners are "garage orphans" who have no access to a garage or off-street parking lot due to housing that may be older, located in dense urban or peri-urban areas, and reliant on on-street parking. In addition, many commuters do not have access to off-street parking, or their employers may not offer EV charging stations in company parking lots. The presence of on-street charging infrastructure (Figure 1) provides important access for garage orphans and can reduce range anxiety for all EV drivers—quelling the fear of running out of battery power, which is a barrier to EV adoption and use (Wardlaw 2020).

Figure 1. On-street publicly accessible EV charging infrastructure expands access to those who don't have access to private charging facilities in garages or off-street parking spaces (FLO)

Given the increasing affordability of EVs and their air quality benefits, there is a growing equity issue associated with the provision of publicly accessible charging infrastructure. While there is a huge need to create EV charging infrastructure in new development (as addressed in "Preparing for the Electric Vehicle Surge," the October 2022 issue of APA's *Zoning Practice*), there is an complementary need for local governments to create publicly accessible on-street EV charging infrastructure.

This *PAS Memo* establishes a vision for equitable EV access through on-street, publicly accessible provision of charging infrastructure. It introduces planning principles that address where and how chargers should be located for equitable and effective access; identifies specific considerations for enabling the installation of chargers in those locations in ways that are compatible with dense urban environments; and drills down into specific actions that planners can take to enable and promote the equitable rollout of EV charging infrastructure.

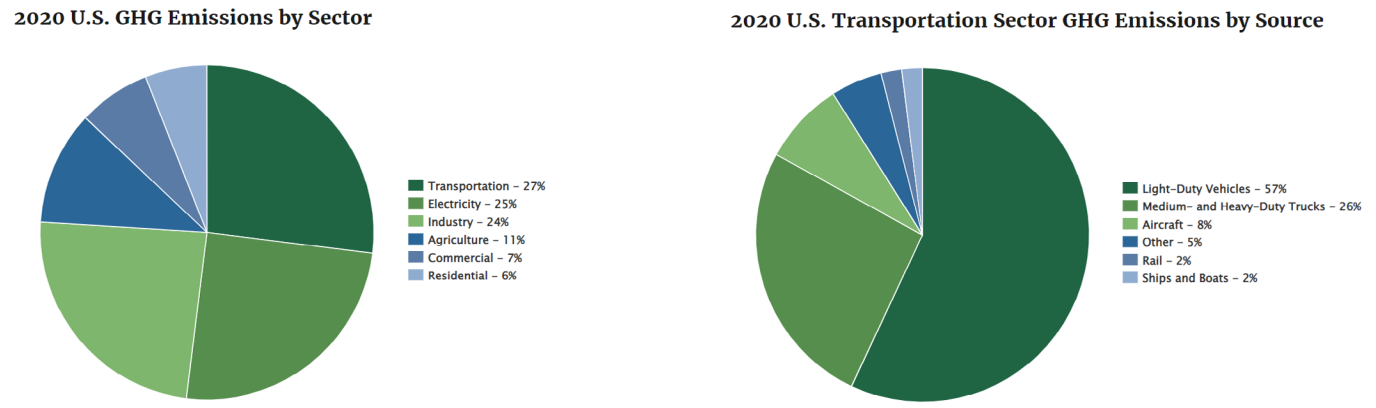

Figure 2. The transportation sector is the largest U.S. contributor to GHG emissions (left), and personal vehicles make up the largest share of transportation emissions (right) (U.S. EPA)

THE SHIFT TOWARD ELECTRIC VEHICLES

Rising temperatures and changes in climate due to GHG emissions have been global concerns for several decades. With further shifts in technology and developing infrastructure, a transition to EVs has emerged as one of the lowest-hanging fruits in the struggle to reduce emissions.

In 2020, 27 percent of total U.S. emissions came from the transportation sector, making it the country's largest contributor to GHG emissions. Personal vehicles produced 57 percent of these emissions, making them the largest contributors (Figure 2) (U.S. EPA 2022). Switching from fossil fuel- to electric-powered motor vehicles will be a critical component in the fight against climate change (Climate Central 2021). While some critics argue that focusing on the switch to EVs encourages driving instead of transit usage or nonmotorized transportation options, many urban, suburban, and rural residents live in transit deserts or have transportation needs for which car ownership is still a necessity—so in addition to promoting alternative modes of travel, transitioning from ICE vehicles to EVs will be vital in reducing emissions.

In August 2021, President Biden announced his goal to increase EV sale shares to 50 percent by 2030 (The White House 2021). In a step towards this 2030 goal, the federal Bipartisan Infrastructure Law, signed into law in November 2021, provides $7.5 billion to develop the country's EV charging infrastructure. This includes $5 billion available through the National Electric Vehicle Infrastructure Formula program to focus on adding public charging stations in underserved communities and on highways. The goal is to install 500,000 public chargers, which will make headway but not entirely meet the emerging demand (The White House 2022). Compounding these policies with the urgency of the continued and impending increase in global temperatures, the shift away from motor vehicle emissions is both necessary and supported.

Further supporting the fight against climate change, President Biden signed the Inflation Reduction Act in August 2022. The IRA provides federal tax credits for the purchase of EV charging infrastructure, with estimates of up to $1.7 billion to be claimed over a 10-year period (EV Connect 2022). Following on its heels, California's Air Resources Board passed a plan requiring all cars and light trucks being sold in the state to be EVs or hybrids by 2035 (NACS 2022), and four additional states have already joined California in this requirement (Tucker 2022).

With these proclamations, which will heavily influence the auto industry and other states, and the federal funding opportunities for EVs noted above, many saw the summer of 2022 as a potential turning point in the fight against climate change. But critics have also pointed out that a successful transition to EVs and a net-zero emissions future is dependent on the installation of EV charging infrastructure. Indeed, to power the federal target of 50 percent share of zero-emissions vehicle sales by 2030, global management consultants McKinsey & Company estimates the country will need to have installed 30 million chargers, 1.2 million of them as publicly accessible infrastructure (Kampshoff et al. 2022).

Providing more widespread EV charging infrastructure for passenger car users can be complicated, particularly when this involves retrofitting existing multifamily buildings and their garages, or, as noted above, addressing situations where homeowners and renters do not have access to garages and must park on-street. There are important equity issues associated with ensuring access to EV charging infrastructure, especially taking into account the improved air quality EVs can help provide in areas with high rates of asthma, heart disease, and other air pollution-related conditions. Widespread EV adoption will depend on the increased accessibility of EV charging locations, which will include off-street parking, in both residential and commercial lots, and on-street curbside parking.

There is a tremendous opportunity, and responsibility, for municipal planners to help improve access to EV charging infrastructure while centering equity in the process. While planners should continue to focus on supporting alternative modes of transportation, there are many places where there are few commuting options available beyond driving. In these areas, providing EV charging infrastructure is both an equity issue and critical to the fight against climate change.

A PRIMER ON EV CHARGING INFRASTRUCTURE

EV charging stations are typically divided into three categories—Level 1, 2, and 3—based on the speed at which they charge. These stations each have different voltage requirements, which consequently means that the infrastructural requirements vary, the impacts on the electrical grid are different, and the costs of installation diverge greatly.

Level 1 chargers use typical electric outlets (120V), which are usually located within garages and throughout houses. They typically take eight to 12 hours to fully charge a vehicle, and don't require special equipment or permitting.

Level 2 chargers are the most frequently marketed charging stations (Figure 3). They are typically freestanding or hanging, and they require a higher level of service (240V), which is what a clothes dryer usually requires. Level 2 chargers typically take four to eight hours to fully charge a vehicle. They usually require a dedicated circuit, and there is a need to confirm whether the existing electrical service can handle the extra electrical load and has the appropriate wiring.

Level 3 or **DC fast chargers** are freestanding stations. They can take around 30 minutes to charge a vehicle but require a very high level of service (480V). Almost all settings will require substantial upgrades, resulting in permitting requirements and significant costs. Level 3 chargers are not typically associated with installation in single-family homes or at the curb on a street; they are more typically found as installations at commercial sites, multifamily buildings, or along highways (Figure 4).

EV charging locations can broadly be divided into off-street locations and on-street locations. Off-street locations will include single-family homes (typically in garages), multifamily homes (typically in garages or parking lots), or commercial and institutional areas. On-street locations may be in a range of locations, such as residential streets, retail main streets, or other kinds of commercial and institutional areas.

In most contexts beyond single-family home ownership, EV owners are using charging stations that are part of a network owned by a private company, even if located in the public realm. Nearly all of these stations are Level 2. Use of these stations require registering with the network, and the fees are usually based on kWh usage, charging time, or percentage of battery charged. These networks and other available apps provide maps that label the locations of EV charging stations. With the exception of the Tesla charging network, any EV model is able to use any network.

As the number of EVs on the road increases, annual demands for electricity to charge them will grow as well. Increasing numbers of Level 3 chargers could theoretically create spikes in national grid electricity demand at peak times. Municipal planners may want to encourage Level 2 chargers in most contexts, such as on-street and in multifamily buildings, given both the current costs of Level 3 chargers and the adequacy of Level 2 chargers for overnight and top-up charging.

Figure 3. Level 2 chargers at Grand Canyon National Park (Grand Canyon National Park/Flickr (CC BY 2.0))

Figure 4. Solar-powered Level 3 fast charger at the Camp Roberts rest area along US 101 in California (Mavila97/Wikimedia (CC BY-SA 4.0))

Figure 5. Many homes in older, dense urban neighborhoods do not have access to garages or off-street parking spaces (Jim. henderson/Wikimedia (CC0 1.0))

AN EQUITABLE AND COMPREHENSIVE VISION FOR EV CHARGING

In many states, there have been significant efforts made to subsidize the costs of installing EV charging stations in single-family homes and to streamline the EV charging station permitting process. While these efforts are important to continue, it is critical to broaden efforts that include drivers who don't have access to their own garages or parking spaces. Approximately 37 percent of Americans live in housing that does not provide a parking space (U.S. DOE EERE 2017). Access to parking is even more challenging for low-income households. Research has found that less than 20 percent of households making $25,000 a year or less have access to a dedicated parking space that has an electrical outlet within 20 feet (Huether 2021).

Many older urban and suburban neighborhoods with single-family and multifamily housing have few transit options and were built without garages, driveways, or parking lots (Figure 5). Their residents still rely on cars for commuting, and if they want to own an EV, they are dependent on on-street charging or workplace charging. There are also homeowners who rent parking spaces in commercial garages without EV chargers, and these parking-space renters have little leverage to have EV charging installed. Finally, there are many renters who have limited or no ability to access EV charging in their rental homes. From an equity perspective, it is important to ensure that these populations also have access to the infrastructure needed to support EV ownership.

Publicly accessible EV charging infrastructure is also key to overcoming one of the most common barriers to EV adoption: range anxiety. Individuals are discouraged from purchasing or using EVs because they fear running out of electricity on the road. The lack of EV infrastructure in the United States as a whole, alongside EV costs, is often cited as the most significant impediment to EV adoption (Satterfield and Shefter 2022). And industry research suggests that "charge anxiety"—worries that public EV charging infrastructure is not widespread, accessible, or reliable to support EV use—may be overtaking range anxiety as a barrier to EV adoption (Volkswagen Financial Services 2022). The installation of public EV infrastructure, and careful consideration of where it is sited, represents an important opportunity to help drivers overcome range and charge anxiety.

The transition to EVs requires an equitable and comprehensive vision for EV charging networks. This must include publicly accessible charging infrastructure to support potential EV owners who are not able to install their own charging stations. This vision requires investment, analytical planning approaches, and engagement to target "charging deserts" in ways that will underpin healthier communities. It will require meeting three objectives:

- Promoting off-street EV charging for multifamily residential uses
- Promoting off-street EV charging for commercial, office, and institutional uses
- Planning for and implementing an equitable, effective on-street EV charging network

This *PAS Memo* focuses primarily on how planners can achieve this third objective.

PLANNING TO SUPPORT AN EQUITABLE VISION FOR ON-STREET CHARGING

There is a temptation to site on-street charging infrastructure where there is already evidence of EV ownership. However, this approach precludes the potential of using public charging infrastructure to seed new areas of EV usage.

Recent surveys have shown that the availability of public EV charging is an important factor in decisions for EV purchases (U.S. DOT 2022). This creates a danger that our cities will become increasingly segregated by EV and ICE vehicle usage—with the corresponding differences in air pollution levels—if some areas have little access to charging infrastructure.

The following three-part planning approach frames ways of creating an equitable and feasible vision for planning on-street charging infrastructure. It offers important big-picture siting considerations, highlights data-driven analysis of potential locations to meet community goals, and emphasizes the importance of community input and public engagement throughout the process. The siting of on-street public charging must include historically marginalized areas so that the air quality benefits of EVs can be gained in places that have suffered the most from previous negligent siting of infrastructure. A strategic vision for on-street charging infrastructure can focus on equity and environmental justice while targeting deployment in ways that will attract multiple user groups and raise the profile of EV usage. This approach draws from *Curb Enthusiasm*, a guide for the deployment of on-street charging infrastructure in New York City authored by WXY Studio and Barretto Bay Strategies.

Consider Big-Picture Siting Principles

When a local government is preparing to make investments in publicly accessible EV charging infrastructure, it's vital that such efforts are carefully planned. This will help ensure an equitable and effective charging network that meets community goals and maximizes support of the transition to EVs. Planners can consider the following principles to inform their community's charging station siting strategies.

Plan for maximum inclusivity and broad distribution. There are an increasing number of studies showing that Black- and Hispanic-majority neighborhoods have lower access to charging infrastructure (see, for example, Hsu and Fingerman 2021; Khan et al. 2022). It is important to deploy on-street charging in underserved areas and EJ communities with little access to off-street charging so that owning an EV can be as convenient as owning a non-EV for all members of a community.

Any planning framework for on-street charging infrastructure should begin with a demographic analysis to understand how both the current distribution of on-street charging infrastructure and the availability of EV charging infrastructure in parking lots and garages relates to low-income and EJ communities. This analysis can be done by overlaying census data with maps showing EV charging locations, such as the U.S. DOE Alternative Fuels Data Center's Alternative Fueling Station Locator map (Figure 6) (U.S. DOE EERE AFDC 2022). The resulting map helps to specifically target low-income communities that are in "EV charging deserts" (often defined as areas beyond a 10-minute walk to an EV charger). This can be complemented with additional analysis of existing building typologies to understand where there are multifamily and single-family buildings without access to parking lots and garages (Barsamian 2022).

Target areas with a high proportion of commuters travelling significant mileage. Understanding that the prior analysis will identify many potential options for locating on-street charging infrastructure, another layer of analysis

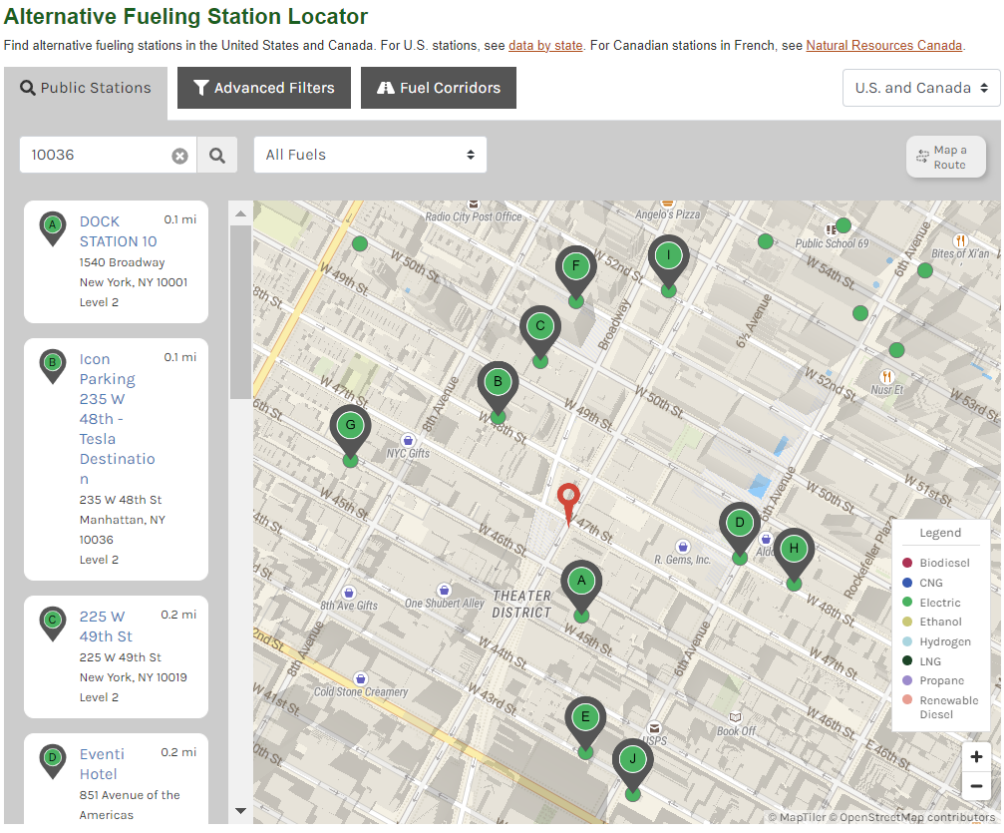

Figure 6. The U.S. DOE Alternative Fuels Data Center's Alternative Fueling Station Locator map shows locations of EV charging stations across the United States (U.S. Department of Energy)

should consider an area's number of incoming car commuters. This additional information highlights where there may be a broader base of potential users for the on-street charging stations.

A major goal of publicly accessible charging infrastructure should be to replace ICE vehicle usage with EV usage. The most effective approach will be to target ICE drivers who cannot easily shift modes of travel and who are driving a considerable number of miles each week, as well as EV owners who may not currently be using their EVs for their daily commutes.

For optimal EV charging station siting, planners should examine where there is a combination of a lack of public transportation infrastructure, a high rate of incoming and outgoing commuters, and the presence of large workforce attractors, such as hospitals and universities. There are significant advantages to engaging with large institutions, including the potential to reach out to large numbers of employees at once and to encourage these large employers to incentivize a shift to EV use.

In addition, there will be an increasing desire to target rideshare (e.g., Lyft and Uber) drivers as these companies move to meet targets—or state and municipal requirements—to make their fleets all-electric by 2030 (Lyft 2020; Uber n.d.). Because many low-income neighborhoods are transit deserts, there is often a heavy reliance on rideshare, and rideshare drivers will be increasingly in need of public charging opportunities as they convert to EVs (Huether 2021).

Support multiple user groups by considering land-use adjacencies. To maximize the impacts of investments, it is important that EV charging stations can serve many different uses. By identifying and supporting multiple user groups, planners can optimize the use of new on-street EV charging stations—which will be occupying former parking spaces—while minimizing underusage. On a most basic level, this considers the potential for 24-hour usage and encourages the placement of EV infrastructure in locations that will serve residential uses, commercial uses, and visitor destinations.

This requires careful consideration of charging station sites, with an eye toward sites adjacent to both residential areas and commercial destinations. One example, drawing on the previous principle, might be the siting of EV charging stations on streets near hospitals or medical institutions to which nurses and doctors may be commuting from surrounding areas. Planners could work with parking authorities to adjust on-street parking regulations to support daytime parking and charging for medical staff while allowing residents to park and charge overnight.

Identify parking conditions that optimize Level 2 charger use. In residential areas, there may be neighborhood resistance to the conversion of on-street parking spaces that are usually occupied by ICE vehicles into designated EV charging spaces. In addition, parking regulations in residential areas often don't require car owners to move their vehicles very often, if at all. A more compatible approach for EV charging station siting is to target on-street parking areas adjacent to other neighborhood uses, such as main streets with retail, where typical parking regulations require people to move their cars at a greater frequency than residential areas.

Figure 7. Municipalities can support EV adoption and use through providing EV infrastructure, such as this on-street charging station at the Hillsboro Civic Center in Hillsboro, Oregon (Visitor7/Wikimedia (CC BY-SA 3.0))

Time-limited parking zones support favorable charging turnover, and this will help to ensure that the charging infrastructure is well used. Planners should review parking regulations to ensure users are provided enough time to receive a good charge (e.g., at least two hours) from a Level 2 charging station. At the same time, it is important that the parking regulations don't allow EVs to remain at the parking space for so long that turnover at the charging station is reduced, limiting access for others to charge.

Identify key destinations as potential target locations. The points above have highlighted the importance of analyzing uses that generate significant incoming car commuters, such as universities and hospitals. Other destinations that draw large numbers of visitors are also well suited to targeting EV drivers. Places such as baseball stadiums, zoos, and parks draw vehicles, and creating on-street parking spaces with EV charging infrastructure near the entrances to these kinds of destinations provides a strong incentive for EV or potential EV drivers.

Planning for on-street charging stations near such destinations creates an excellent opportunity to incentivize EV driving by creating preferential parking spaces in places where on-street parking is in high demand. Moreover, these high-profile on-street charging spaces can showcase the local government's support of EV vehicles and provide further encouragement for EV drivers (Figure 7).

Develop Data-Driven Scenarios to Inform Potential On-Street Charging Locations

Since there are limitations to how many charging stations can be provided due to cost considerations, it is important to set out a clear rationale to inform charging locations. Municipal efforts to provide new or improved infrastructure, whether a

school or a bike lane, generally require intensive studies that provide justification for the infrastructure spending. It is important to put similar effort towards identifying and justifying potential publicly available charging station locations to support public engagement and community outreach processes as well as officials' decision-making processes.

To establish scenarios for public-access EV charging infrastructure, planners should analyze and overlay factors, including those suggested by the principles above, that are important drivers for equitable access and for the promotion of EV adoption and use. These include the following:

- **Current EV charging locations**, including publicly owned and publicly accessible parking spaces. This can be used to create an "EV charging desert" map showing areas further than a 10-minute walk from a station.
- **Demographic analysis.** This Census data-based analysis should map areas based on income, race, and any other population factors that might be relevant for a particular community.
- **Environmental justice issues.** Depending on available data, this can add air pollution concerns, brownfields, presence of power plants, or high asthma rates to the analysis.
- **Building typology.** Census data offers basic building type information, and many municipalities will have additional information that can help to map areas of garage orphans with no access to personal garages or off-street parking spaces for private charger installation.
- **Public transportation.** This analysis could be used to highlight areas of high and low existing transit areas, so that on-street charging stations aren't targeted towards areas where they may compete with transit to induce greater amounts of driving and car ownership.
- **Commuting patterns.** Planners can use Census information on predominant travel modes and the number and percentage of incoming and outgoing commuters to identify potential target locations that will support increased EV use among these drivers.
- **Major employers.** An analysis of an area's large employers may suggest opportunities to encourage large institutions to install charging stations in institutional lots and garages, or to collaborate on communications with large groups of employees regarding EV incentives and new charging station locations.
- **Destinations.** This adds information on major visitor destinations, including a review of the visitors being generated by the destination and the parking opportunities adjacent to these destinations, to the analysis.
- **On-street parking regulations.** Many municipalities have a range of time-specific parking regulations that can range from 30 minutes to unlimited time. As noted, it can be useful to match on-street charging locations with parking regulations that allows for a good amount of charging time while also enforcing some turnover.
- **Historical districts.** There is often additional sensitivity to the siting of charging stations in historical districts.
- **Current EV ownership and charging station use.** While this article has downplayed the importance of basing new charging station location distribution based on current EV ownership, it is useful to understand where within the community current EV owners live (typically found through state car registrations) and also, if the information can be obtained, where the most heavily used charging stations are.

Once planners have collected these different layers of data, by integrating layers and conducting spatial analysis in GIS they can create scenarios that emphasize different options and allow the public and officials to weigh these different approaches. For example, planners could generate scenarios for charging station deployment that emphasize the following:

- **High levels of environmental justice concern.** This scenario would prioritize data focused on EV charging deserts, demographics, and EJ issues to identify charging station locations that would best expand access to underserved communities and where EVs' air quality benefits would have the highest impact. Public transportation data could also be incorporated to further refine locations where cars are the main mobility option.
- **High levels of demand.** This scenario would concentrate on the data layers of building typologies, commuting patterns, major employers, destinations, and EV ownership to identify areas of potential highest demand for new publicly available charging infrastructure. This scenario emphasizes supporting garage orphans and other EV owners who rely heavily on on-street parking and do not have access to private means of charging their vehicles.
- **High turnover zones.** This scenario would overlay time-limited parking regulations associated with retail main streets and high-visibility destinations that can be used by nearby residents when the destinations are not active. These areas host different populations at different hours of the day and maintain metered and time-limited parking, which are conducive to supporting charging station turnover. Not only will deploying charging infrastructure in areas of high visibility serve the charging needs of garage orphans along with all EV users, but local businesses may participate in siting efforts to generate attention for themselves as well.

Planners can use this data-driven scenario planning approach to explore outcomes emphasizing different community goals, desired outcomes, or potential strategies. The results can then inform community outreach and engagement efforts, as well as officials' decision-making and deployment.

Provide Information and Gather Local Input, Publicly Test Options, and Share Results

Public engagement is a critical component in all planning processes. It enables planners to help residents shape their desired outcomes for their communities, and it can be key feedback for

decision makers to see community support for local spending on public infrastructure investments. It is especially important to engage the broader public on the provision of infrastructure that impacts public health, including EV charging infrastructure. Just as with other engagement efforts, planners should be sure to undertake the following elements of community outreach when planning for a publicly accessible EV charging network.

Information sharing and gathering. Planners can begin an EV charging infrastructure planning process with this stage of outreach. The community must be made aware that the local government is planning an upcoming investment in on-street EV charging infrastructure, and this is an important opportunity to share information and dispel myths about this equipment. Typical engagement methods for this stage of outreach may include informational websites with options to submit feedback, surveys, and local meetings.

Questions that often emerge early in the conversation may relate to the safety of charging stations (e.g., can they cause an electric shock? The answer is no) or their potential impact on local electrical grids (e.g., will they create a power outage in my home? The answer is no). It is important to prepare materials that cover these concerns as well as the benefits of on-street charging, which include broader carbon reduction benefits, local improvements to air and noise pollution, and benefits to Main Street businesses through drawing EV owners to their shops. Additional information to share includes the importance of EV charging access to garage orphans for more equitable and inclusive EV ownership; data on current EV ownership and expected growth in the market; visuals that show how the EV charging stations will look on the street; and information on how the charging stations will be operated, priced, and maintained.

And it is vital that planners gather local input. In some cases, residents and business owners will see the benefits of on-street charging infrastructure, but there are other cases in which local stakeholders will see any change to current parking conditions as a significant disruption. It is important to surface any such concerns early in the planning process.

Options testing. Planners should create opportunities to get direct feedback on potential locations for on-street charging stations. By providing an overview of data-driven scenarios as described above, planners can show community members and officials that suggested locations were selected based on clear drivers and careful analysis. Methods for receiving feedback on options can include interactive web-based maps and surveys as well as local meetings.

Testing options allows residents and commercial business owners to voice concerns, allowing planners to identify potential challenges that will need to be addressed for successful implementation. For example, one concern may be that on-street designated spaces for EVs won't get used frequently, which would mean a loss of parking for residents or shoppers without EVs. Other issues raised may include the appearance of charging stations on the sidewalk, or safety concerns such as charging cables creating tripping hazards or needing to enter the street right-of-way to plug in the vehicle.

Results sharing. Sharing the final decisions about charging station locations is an important part of building public support for these sites, which can improve both chances of success and the volume of use. These results can be shared online as well as through local meetings and directly on-site. When New York City deployed on-street charging stations, the local utility set up a small tent on the sidewalks to provide demonstrations and information.

Soliciting information from a broad array of people includes residents, elected leaders, community boards, nonprofits and community-based organizations, business owners and business improvement districts, and workplaces. As is the case throughout the process, it is vital to identify potential conflicts and concerns so they may be addressed.

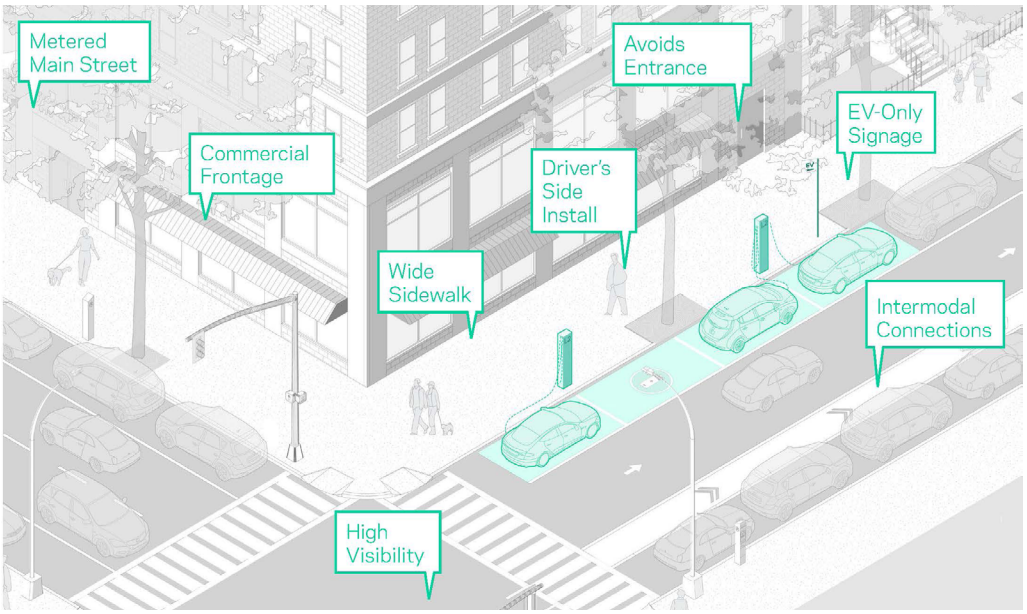

Figure 8. Many considerations figure into the optimal placement of on-street EV charging stations (NYSERDA and NYDOT 2018)

SITE-SPECIFIC DEPLOYMENT STRATEGIES

Once planners complete their higher-level assessments of what an equitable and inclusive on-street charging infrastructure network should look like, their next area of focus can be a more detailed understanding of the specific locations within neighborhoods and on streets where EV infrastructure should best be sited.

Charging stations have physical and operational considerations that make them compatible with certain street typologies and not others. Because the installation context for charging stations can contribute greatly to the station's use, matching charging infrastructure to the right streets is critical.

Site deployment should broadly work to reinforce a sense of place, promote accessibility, and support street life. Site characteristics that factor into successful deployment strategies include street type, parking regulations and space types, and sidewalk characteristics.

Street Type

Many on-street charging stations will employ two ports per station, and it's best to assume that one dual port charging station will require 40 feet (at 20 feet per space) on a street with parallel parking. Several factors play into identifying the optimal streets for a curbside pilot deployment that maximizes use and minimizes disruption (Figure 8, p. 8).

Local residential streets may be one-way or two-way, with parallel parking often on both sides of the street. As most EV charging ports are on the driver's side, for one-way streets with parking on both sides of the street, it is ideal to install charging stations on the left (driver's) side so that drivers won't need to enter the street to plug in their vehicle.

As noted above, streets in neighborhood commercial or business districts are potentially viable sites for on-street EV charging infrastructure (Figure 9) because on-street parking is often time limited with high turnover rates. These streets also provide high visibility and can create a symbiosis between retailers and EV car owners.

Figure 9. On-street charging in neighborhood commercial districts can serve shoppers during the day and nearby residents at night (Raphael Laude)

There are many examples of retailers and EV charging networks creating partnerships to attract environmentally concerned shoppers. For example, the Volta charging network has struck an agreement with Walgreens to install 1,000 charging stations at 500 locations (PYMNTS 2022), and Kroger's has already installed more than 350 chargers at grocery stores in 10 states, with plans to add them at stores in six additional states (Silberstein 2022). Public on-street charging stations offer an avenue for Main Street retail to compete with large-format stores that have their own parking lots.

To mitigate concerns that on-street EV charging station spaces on main commercial streets won't have the same turnover as typical on-street parking spaces and result in less retail traffic as a result, one solution is to install on-street charging infrastructure nearby, on streets that are not metered and are perpendicular to the main streets, close to the intersection with the main street. This provides additional opportunities for the EV infrastructure to be used by both residents and shoppers visiting the area. It is also important to install on-street charging locations close to corners so that people with disabilities can access a curb ramp to get to the charging station (White 2022).

Another opportunity for siting EV chargers is in spaces close to highway exits on high-traffic collector streets. For best visibility and consistency, it can be useful to site the on-street charging stations in the first legal parking spaces after a street intersection. Charging spots should not be located in curbside bus lanes or along protected bike lanes to ensure that charging cables do not interfere with the safe operation of transit or bicycles.

Parking Regulations and Space Types

Parking regulations vary widely by municipality, with some cities allowing for residential parking permits (with or without a fee) on residential streets and other places simply allowing anyone to park on-street at any time. On commercial streets, metering is typical, with the length of time regulated based on uses (e.g., retail shopping tends to enforce quick turnover with one- or two-hour windows).

Providing EV charging in residential areas often raises concerns, pitting non-EV owners who bemoan the loss of space for their gas-powered vehicles against EV owners who may have no other options but to charge on-street. But providing dedicated charging and parking spaces for EVs sends a message of support for EV adoption, and municipalities can also further incentivize potential EV owners by waiving residential parking permit fees for EVs.

As noted previously, siting strategies can target car commuters in areas with little public transit by placing EV chargers in restricted-use parking zones, such as dedicated on-street parking for teachers or medical staff around schools or hospitals. These uses tend to generate high levels of car commuting and have longer periods of time (six to eight hours) associated with their parking regulations. Providing premium on-street parking spaces with no or reduced charge for the electricity

Figure 10. Head-in angled parking spots are good locations for EV charging infrastructure, as with these stations installed in front of San Francisco's City Hall as part of the city's Green Vehicle Showcase in 2009 (Felixkramer/Flickr (CC BY-SA 2.0))

and parking is an impactful incentive. Siting EV charging in short-metered retail zones can also be popular with drivers who want top-off charging.

Head-in angled parking should be considered as strong opportunity sites for EV charging, as it allows drivers to plug in without having to enter the right-of-way (Figure 10). Bollards should be installed to protect these charging stations.

Finally, it is critical that municipalities address enforcement. Cities and states have implemented penalties such as fines and the authority to tow cars occupying EV parking. In Arizona, nonelectric vehicles are not allowed to stop, stand, or park in EV designated parking areas, with violators subject to fines (ARS §28-876), while in California, unauthorized vehicles not connected for electric charging purposes will be towed at the owner's expense (California Vehicle Code §22511).

Sidewalk Characteristics

Like parking regulations, the physical characteristics of sidewalks vary considerably among municipalities, with some suburban locations lacking sidewalks altogether. The width of sidewalks, the amount of sidewalk furniture (e.g., benches), the size of tree pits, the frequency of curb cuts, and proximity to building entryways are all factors in the site design and placement of EV charging stations.

Basic considerations should prioritize wide and uncluttered sidewalks. EV charging site selection should avoid sidewalks where fire hydrants, bike parking fixtures, benches, streetlamps, and signposts are installed at high densities. Streets should have minimal curb cuts, as many curb cuts can make it difficult to site charging stations.

Some municipalities have created EV charging station design guidance. New York City's establishes a five-foot minimum walking path clearance from stations as per ADA standards, with eight feet of preferred clearance per New York City's Street Design Manual. Units should not be installed on very high-traffic pedestrian corridors, given the potential impact to safe circulation.

IMPLEMENTATION OF EV INFRASTRUCTURE INSTALLATION

There are a range of implementation challenges to installing public EV charging stations. These include the need for consultation with agencies that may have jurisdictions that overlap with on-street charging stations; the need for public engagement; and basic procurement practices.

The siting of EV charging stations on public streets needs to be cleared with multiple responsible entities. In many municipalities, primary responsibility is with the department of transportation or public works department. But there are frequently other entities that need to be consulted, including departments responsible for curbside sewers and downspouts (e.g., departments of environmental protection), fire departments responsible for hydrants and pipes beneath the roadbed, parks departments often responsible for street trees, and landmarks or historic district commissions if an area is historically significant.

There are still relatively few examples of municipalities with widespread deployment of on-street charging stations, and the approach to implementing on-street charging is varied. In some municipalities, private companies are working in partnership with utilities and the municipality. In New York, the local utility, Con Edison, issued an RFP to companies in 2017 interested in managing 100 on-street charging locations. Con Edison selected FLO, a North American charging network operator, to manage the network under contract with Con Edison (Figure 11) (FLO 2021). Charging costs $2.50 per hour during the day (7 a.m. to 7 p.m.) and $1.00 per hour overnight. This makes the daytime charge roughly equivalent to the cost of fueling up at a gas station, while overnight charging can be more than 60 percent cheaper. Otherwise, the parking is free of charge. After some delays created by the COVID-19 pandemic, the 100th curbside charging location was installed in the fall of 2022 (FLO 2022).

In some cities, municipal agencies are purchasing, installing, and operating charging stations (Kingston 2023). In Los

Figure 11. New York City worked with local utility Con Edison and national charging operator FLO to create 100 on-street charging stations in the city (FLO)

Figure 12. Cities such as Seattle are beginning to install EV charging stations attached to utility poles (Stephen Barnes/iStock/Getty Images Plus)

Angeles, the Bureau of Street Lighting has been attaching charging stations to street lamps (LA DPW BSL n.d.). Seattle will soon be rolling out charging stations attached to utility poles (Figure 12) targeted at residents without off-street EV charging options; the city opened a request process for single-family or multifamily residential properties without garages or off-street parking options in 2022 and plans to start installing chargers in 2023 (Seattle City Light 2023).

Finally, planners should be aware of emerging technology, policy, and private-market innovations that could expedite or improve the deployment of EV charging options in their communities. Startups such as SparkCharge are exploring mobile delivery options for charging stations, while in London, Shell Oil has converted one of its gas stations into a public EV charging hub (Jones 2022). As the public sector and private companies seek to keep up with charging demands, there will be other opportunities for publicly accessible charging sites that complement on-street charging.

ACTION STEPS FOR PLANNERS

If your municipality has committed to providing publicly accessible on-street EV charging infrastructure, it is important to carefully plan deployment to ensure that the resulting charging network supports equitable and inclusive adoption of EVs for all residents. As increased federal funding resources enable more local governments to create or expand their publicly accessible EV charging networks, clear siting strategies will be needed to guide these efforts. Planners can use the information provided in this article and the following questions to help guide local planning processes accordingly.

What are the goals of our strategy? This *Memo* has set out some clear factors that consider equity and access for EJ communities and garage orphans, as well as different planning scenarios that prioritize various approaches. Strategic goals may also be informed by local opportunities, such as working in conjunction with large employers or major destinations that can partner on incentivizing EV driving.

Your plan is a first step toward building interest, excitement, and a sustainability identity for your municipality. It is important to write a scope for the work, whether the work is going to be conducted internally or with an external consultant.

Who should develop the strategy? Decide if your municipality has the capacity and expertise to develop a plan for on-street charging stations. If not, there are many consultants who can help support the technical and engagement aspects of the work. Local governments can procure a consulting firm in many ways, including advertising through procurement sites or using existing contracts with firms. There are a number of EV advocacy organizations operating at the state level (such as Empire Clean Cities in New York State) that can provide support. This work can typically be completed in four to eight months, depending on community engagement plans.

What kinds of data analysis should we conduct, and what kind of data do we have? Planners should review the list of data types provided above to determine what is easily accessible. The data-driven analysis for scenario explorations discussed earlier in the article is a good starting point for planning the analysis.

Who should we engage? For an effort like this, it is hugely beneficial to speak with interested stakeholders early and often. Large employers, business improvement districts, major destinations, and community board members are all potentially critical partners. In some cases, it may make sense to use a steering group to guide the effort.

How do we start to find sites for charging stations? Start at 10,000 feet up. Don't start talking about specific locations until you've set clear goals for your strategy. Make sure you are using data transparently to understand which neighborhoods you should focus on.

Once you've established the neighborhoods, begin to establish the street types that you want to focus on. Where are the locations that have adjacent land uses so you can maximize turnover between garage orphan residents and incoming commuters? Use parking regulations or key destinations as one way of considering street locations.

From there, start selecting sites. You will need to do precise site surveys. What are the conditions on the ground, in terms of proximity to street furniture and sidewalk widths?

How do we get feedback on our siting strategy? Creating a webtool with interactive mapping and survey questions is a great way to crowdsource feedback from people. The author has had projects that have generated hundreds of thousands of views—people really care when new infrastructure is being planned! Community members can provide a substantial amount of valuable information on siting opportunities, in terms of places that are most convenient or problematic.

How do we finalize the sites? You should plan to identify more potentially workable sites than you actually require. There will be problems with sites as you start to do your final vetting, whether local opposition or physical design and construction challenges.

What's the best way to announce the final locations? Lean on your steering committee or most interested stake-

holders to amplify your plans. While it is great to have a project website that links to the municipal website, make sure that your key stakeholders are able to post information as well. Keep people up to date on how implementation is going, and be sure to celebrate the installations and the first use of the charging stations.

CONCLUSION

The transition from fossil fuel-burning cars to EVs will be largely driven by the private market, as individual car owners make decisions to replace their ICEs with EVs. However, the public sector has a vital role to play in helping to create the charging infrastructure that will be needed to power this next generation of automobiles. In addition to adopting ordinances that support (if not require) the provision of charging options in the garages and off-street parking spaces of new private development, local governments must also consider how to expand EV charging access to residents who don't have their own garages or parking spaces, as well as how to retrofit existing residential and commercial neighborhoods with charging infrastructure.

One way to support EV ownership by these garage orphans—as well as to expand charging options for commuters whose places of employment don't make EV charging stations available to employees, consumers shopping at businesses that don't have off-street parking lots, and rideshare drivers using EVs—is to provide publicly accessible on-street EV charging infrastructure. Recent federal funding programs are dramatically increasing local opportunities to do so. Planners can use the guidance provided by this *PAS Memo* to help their communities plan a charging network that supports equitable and inclusive EV ownership and use and maximizes the carbon emission and air pollution reduction benefits that will result from the transition to EVs.

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