

Challenges to Electric Vehicle Adoption

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Due to a variety of historic, systemic, and economic factors, low-income and minority communities are often adversely impacted by transportation emissions from roads, highways, and airports. Clean transportation and electrification of the transportation network powered by a clean grid can help improve environmental and health outcomes among all Americans, and low-income and minority communities in particular. Despite investments intended to build a national electric vehicle (EV) charging network, more research, policy, and technological innovation are needed to support both the mass market and equitable adoption of EVs, particularly among low-to-moderate income households and minority communities.

Studies have consistently found that limited charging infrastructure is one of the primary barriers to EV adoption (Kumar & Alok, 2020) (Winjobi & Kelly, 2021). These studies indicate that policy should encourage a multi-faceted approach to reducing barriers to EV ownership, such as expanding charging opportunities at home, workplaces, public venues, and along transportation corridors (Huang & Kockelman, 2020) (Hardman, et al., 2018) (Hsu, Slowik, & Lutsey, 2021) (Lee, Chakraborty, Hardman, & Tal, 2020). Emerging research also suggests that there are disparities in EV adoption and charging access by low-income and minority households (Canepa, Hardman, & Tal, 2019) (Hsu & Fingerman, Public electric vehicle charger access disparities across race and income in California, 2021) (Fakhrmoosavi, et al., 2021). One study examining the adoption of plug-in electric vehicles (PEVs) in California disadvantaged communities found that the new and used PEV sales account for only 5.7% and 8.7% of total sales, respectively (Canepa, Hardman, & Tal, 2019). The study also found that households adopting PEVs in disadvantaged communities tend to be households that are more likely to own a home with comparatively higher income and greater levels of educational attainment than the general population of their neighborhoods.

Research across the U.S. has also found that EV owners tend to be more affluent, more White, have higher levels of educational attainment, and live in owner-occupied single-family homes (MacArthur, Harpool, & Schepke, 2018) (Carley, Krause, Lane, & Graham, 2013) (Center for Sustainable Energy, n.d.) (Farkas, Shin, & Nickkar, 2018). A study by Hsu and Fingerman (2021) found that Black and Hispanic census blocks are significantly less likely to have access to any public charger in their immediate neighborhoods. The California Air Resources Board's Clean Vehicle Rebate Project (CVRP) provides rebates to California consumers for the purchase or lease of light-duty plug-in hybrid, all-battery, and fuel-cell electric vehicles. A survey of the program's administrator found that 79 percent of respondents had an annual household income greater than \$100,000, and 38 percent had annual household incomes exceeding \$200,000 (Johnson, Williams, Hsu, & Anderson, 2017).

Four common challenges to expanding electric vehicle adoption among vulnerable populations include:

Cost: The inability to afford an EV can be a notable barrier to adoption. Although the cost of EVs is starting to fall, EVs are generally more expensive than legacy internal combustion engine vehicles. Additionally, retrofitting a residence for home-based charging can be expensive. Emerging research modeling EV charging demand suggests that PEV drivers substitute home-based charging with workplace charging when either workplace charging is free or when electricity rates are higher at home (Chakraborty, Bunch, Leea, & Tal, 2019). Tax credits and other incentive programs are needed to reduce the cost of EV purchases, home-based charging retrofits, and charging utility rates for low-income households. Additionally, low-interest and reduced down payment lending programs (similar to the Federal Housing Administration backed-loans for home purchases) could be another policy to expand access to credit for low-income households to purchase EVs.

Home-based Charging: Home-based charging can represent another challenge to EV adoption among vulnerable populations. OEMs and policymakers often implicitly assume that EV households will charge their vehicles at home. However, home ownership is often lower among low-income and minority households. Traut et al. (2013) found that while 79% of have some type of dedicated parking where EV charging could be installed, many urban residents and non-homeowners have large barriers to EV charging and vehicle adoption (Traut, Cherng, Hendrickson, & Michalek, 2013). Many renters may not have access to charging at their rental units, and almost certainly lack reliable on-street charging. Policies and incentives are needed to encourage the addition of EV chargers in rental units (Elkind, 2017). Some studies suggest that home-based charging (inclusive of multi-family dwellings) could be expanded through policy strategies such as requiring EV charging as part of new construction and financial incentives for multi-family property owners to retrofit existing housing complexes for EV charging (Lopez-Behar, Tran, Froese, Mayaud, & Herrera, 2019) (Wollschlaeger, 2020). Other studies question the scalability and efficacy of home-based charging as a policy strategy, and encourage the development of a charging network for users unable to access overnight home-based charging (Ge, Simeone, Duvall, & Wood, 2021). Others have proposed the use of peer-to-peer (P2P) shared charging infrastructure as a strategy to overcome limited home-based charging. With P2P charging, a marketplace (i.e., online provider) could facilitate the sharing of EV chargers between a property owner and an EV driver for a fee (Plenter, et al., 2018). In cases where residents lack access to off-street charging, local governments should encourage workplace charging, charging at public facilities, and expand access to on-street charging. The expansion of on-street charging may also be coupled with a permit program that allows EV owners to have an assigned on-street parking space. Additionally, limited home-based charging infrastructure can also be overcome by encourage fast charging infrastructure at centralized locations. Because if a driver doesn't have home-based charging, they are dependent on public charging and must have access to dependable charging in the absence of ubiquitous public and fast charging infrastructure (Pardo-Bosch, Pujadas, Morton, & Cervera, 2021).

Vehicle Range and Affordable Housing: Vehicle range, job access, and affordable housing represent another notable challenge. The spatial mismatch between jobs and affordable housing has led to a growing number of super commuters. In order to expand the adoption of EVs among low-to-moderate income households, policymakers must expand access to affordable

housing near jobs (to reduce commute distance) or OEMs must improve the range of EVs (Lee, Chakraborty, Hardman, & Tal, 2020). Both will likely be required. If this doesn't occur, super commuters with the longest distance commutes and greatest environmental impact will be the last to purchase EVs. A study by Verclas (2018) suggests that policies that encourage the adoption of EVs in conjunction with solar may be an effective strategy to help expand affordable EV charging to low- and moderate-income households (Verclas, 2018). Studies have also found that increases in vehicle range will likely need to be accompanied by corresponding increases in DC fast-charging infrastructure (Ucer, et al., 2019).

Rural Charging: Longer distance trips and very limited charging infrastructure represents a notable challenge to expanding EV adoption in rural communities (Niels, et al., 2019). Both policy and investments are needed to expand access to EV charging in low-density built environments and intermittently along key corridors between metropolitan areas. Although research is limited, emerging evidence suggests that policy should also emphasize well-lit and safe waiting areas along rural routes to improve perceived and actual charging safety in less frequently traveled locations.

Identifying and understanding the unique challenges confronted by low-to-moderate income households and rural communities is the first step to expanding equitable adoption of EVs for all. Policies that expand the number and diversity of charging options coupled with building codes conducive to EVs; streamlined permitting and prioritized zoning for charging; and preferential EV parking have the potential to encourage public-private collaboration and private-sector investment (Hsu, et al., 2020). To encourage broad and equitable EV adoption, multi-faceted policy strategies are needed by the public and private sectors to overcome key challenges through policy, incentive programs, new and retrofitted charging infrastructure, affordable housing, and vehicle range enhancements.

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