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Electric vehicle charging at multifamily homes in the United States: barriers, solutions, and selected equity considerations

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INTRODUCTION

The transition to electric vehicles (EVs) in the United States continues to accelerate. About 950,000 new battery electric and plug-in hybrid electric vehicles were sold in the United States in 2022, representing around 6.9% of new light-duty passenger vehicle sales, up from roughly 4.5% in 2021.[1] In August 2022, California became the first U.S. state to commit to 100% new light-duty zero-emission and plug-in hybrid electric vehicle sales by 2035, and several other states have followed suit.[2] The Biden Administration, along with automakers, committed to a 50% electric vehicle sales share for passenger vehicles by 2030.[3] These market and policy developments indicate that the electric vehicle market in the United States is poised to expand beyond the early market in the coming years to include much of the U.S. general population.

1 Calculation based on data from EV-Volumes, accessed December 19, 2023, https://www.ev-volumes.com.

2 California Air Resources Board, "Advanced Clean Cars II Regulations," accessed May 12, 2023, https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.

3 The White House, "Fact Sheet: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks," August 5, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/08/05/fact-sheet-president-biden-announces-steps-to-drive-american-leadership-forward-on-clean-cars-and-trucks/.

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Most early adopters of EVs live in single-family homes with a garage or driveway where an outlet is already available or a charger can be easily installed, allowing them to charge overnight more conveniently and typically at much lower cost than at public charging alternatives. As a result, the U.S. Department of Energy previously estimated that nearly 80% of all charging for EVs is done at home.[4] Meanwhile, around 31% of U.S. households live in multifamily homes (MFHs) such as condos, apartments, and duplexes,[5] where access to charging is less readily available, and around 75% of these households own at least one vehicle.[6] As the EV market moves beyond early adopters, access to equitably-priced home charging at MFHs must be addressed so that EV drivers living in MFHs are not reliant on more expensive, less convenient public charging options.

Addressing barriers to installing charging in MFHs would also help to support historically marginalized communities in the EV transition and avoid exacerbating existing inequities. A recent survey found that people of color, who were more likely than (non-Latino) White people to live in multifamily and rented homes, expressed comparable levels of interest in purchasing an EV, yet racial gaps in ownership persist.[7] This trend partly reflects legacies of discrimination: researchers have assessed that neighborhoods that were previously redlined—subject to discriminatory refusal of financial and other services based on race—have lower levels of EV adoption and rebate uptake, despite having worse present-day environmental quality and air pollution.[8] Policies to overcome impediments to charging access in MFHs are one critical tool to help enable EV adoption among marginalized communities and bridge racial gaps in EV uptake.

As of March 2024, there were no dedicated MFH charging programs at the federal level. Other federal infrastructure funds, such as those provided under the U.S. Federal Highway Administration's National Electric Vehicle Infrastructure Formula Program and the Charging and Fueling Infrastructure Discretionary Grant Program, primarily go towards expanding EV charging stations along state highways and interstates.[9]

Several state incentive programs related to MFH charging are available across the United States, however, mostly for existing MFHs to retrofit and install chargers. For example, California's Electric Vehicle Infrastructure Project (CALeVIP), initiated in 2017, has made available over $200 million in EV charging rebates for Level 2 and DC

4 "Charging at Home," U.S. Department of Energy, accessed March 11, 2024, https://web.archive.org/web/20210324171134/https:/www.energy.gov/eere/electricvehicles/charging-home.

5 Most studies refer to these as multi-unit dwellings (MUDs); we use multifamily home (MFH) to mirror the single-family home terminology.

6 Analysis of 2019 Census Bureau residence data in National Association of Home Builders, "Multifamily Homes: Types and Trends," accessed May 12, 2023, https://www.nahb.org/other/consumer-resources/types-of-home-construction/Multifamily; analysis of 2022 Census Bureau vehicle ownership data in National Multifamily Housing Council, "Household Characteristics," updated November 2023, https://www.nmhc.org/research-insight/quick-facts-figures/quick-facts-resident-demographics/household-characteristics/.

7 GreenLatinos, *Survey Says: Considerable Interest in Electric Vehicles Across Racial, Ethnic Demographics* (September 2022), https://www.greenlatinos.org/_files/ugd/a42c65_5fff34fba11748138063dbf9d8d80363.pdf.

8 Haley M. Lane, Rachel Morello-Frosch, Julian D. Marshall, and Joshua S. Apte, "Historical Redlining Is Associated with Present-Day Air Pollution Disparities in U.S. Cities," *Environmental Science & Technology Letters* 9, no. 4 (2022): 345-350, https://doi.org/10.1021/acs.estlett.1c01012; Eleanor M. Hennessy and Sita M. Syal, "Assessing Justice in California's Transition to Electric Vehicles," *iScience* 26, no. 7 (2023): 106856, https://doi.org/10.1016/j.isci.2023.106856.

9 "National Electric Vehicle Infrastructure Formula Program," Federal Highway Administration, accessed March 12, 2024, https://www.fhwa.dot.gov/bipartisan-infrastructure-law/nevi_formula_program.cfm; "Charging and Fueling Infrastructure Discretionary Grant Program," Federal Highway Administration, accessed March 12, 2024, https://www.fhwa.dot.gov/environment/cfi/.

fast charger installations, including in MFHs, throughout 36 counties.[10] In 2021, the California Energy Commission (CEC) launched its Reliable, Equitable, and Accessible Charging for Multi-family Housing (REACH) grant program, which made $8.5 million available for projects to enable charging access or promote greater EV adoption for MFH residents within disadvantaged or low-income communities.[11] In 2023, the CEC launched a successor, REACH 2.0, with up to $20 million in grant funding available for projects that "demonstrate replicable and scalable business and technology models for large-scale deployment" at MFHs.[12] Massachusetts provides rebates for property owners and managers of MFHs with more than five units to purchase and install Level 1 and Level 2 chargers under its MassEVIP Multi-Unit Dwelling and Educational Campus Charging program.[13]

Despite this growing number of incentive programs, property owners, property managers, and residents continue to face impediments in pursuing MFH charging options, with implications for equity in EV adoption and charging access. This paper examines impediments to home charging at multifamily homes in the United States, surveying possible solutions and best practices for addressing such barriers. To underscore the importance of expanding EV charging for closing demographic gaps in EV adoption, it also highlights selected equity implications for policymakers, regulators, and MFH owners, property managers, and residents to consider as they weigh MFH charging options. Informed by our review of the literature—from reports on government pilot charging programs to news articles describing stakeholders' experiences pursuing MFH chargers—and by expert interviews, we highlight barriers, solutions, and equity considerations in five areas: building codes, parking management, electrical issues, capital costs, and processes and stakeholder engagement. We close the paper with reflections and recommendations.

BARRIERS AND RECOMMENDATIONS FOR MULTIFAMILY HOME CHARGING

BUILDING CODES

Building codes set minimum standards for mechanical and electrical systems, energy efficiency, plumbing, and other components in buildings. In the United States, the International Codes family of model codes and standards, published by the International Code Council, have been adopted to varying degrees by all 50 states. The codes contain guidance for EV charging.[14] Some local authorities having

10 "About CALeVIP", CALeVIP, accessed May 12, 2023, https://calevip.org/about-calevip.

11 California Energy Commission (CEC), "GFO-21-603 – Reliable, Equitable, and Accessible Charging for multi-family Housing (REACH)," accessed May 12, 2023, https://web.archive.org/web/20230528064438/https://www.energy.ca.gov/solicitations/2021-11/gfo-21-603-reliable-equitable-and-accessible-charging-multi-family-housing.

12 CEC, "GFO-22-614 – Reliable, Equitable, and Accessible Charging for Multi-family Housing 2.0 (REACH 2.0)," accessed June 16, 2023, https://www.energy.ca.gov/solicitations/2023-04/gfo-22-614-reliable-equitable-and-accessible-charging-multi-family-housing-20?utm_medium=email&utm_source=govdelivery.

13 Massachusetts Department of Environmental Protection, "MassEVIP Multi-Unit Dwelling and Educational Campus (MUDC) Charging Program Requirements," accessed May 12, 2023, https://www.mass.gov/doc/massevip-multi-unit-dwelling-educational-campus-charging-requirements/download.

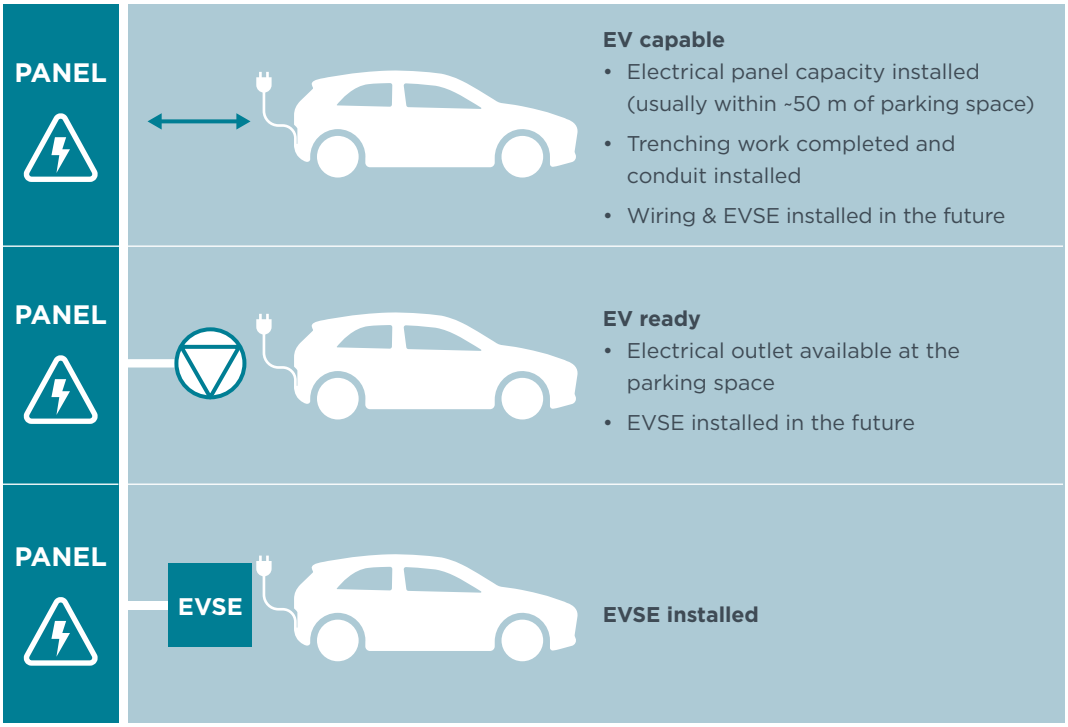
14 International Code Council, "The International Codes (I-Codes)," accessed May 12, 2023, https://www.iccsafe.org/products-and-services/i-codes/the-i-codes/; the I-Codes include the International Energy Conservation Code (IECC), which governs building energy efficiency, as well as other sets of regulations that establish minimum requirements to safeguard public health and safety, such as the International Building Code (IBC) and International Residential Code (IRC), which together have guidance for EV charging. See ICC, *Electric Vehicles and Building Codes: A Strategy for Greenhouse Gas Reductions* (2021), https://www.iccsafe.org/wp-content/uploads/21-20604_COMM_EV_Strategy_RPT_v5.pdf.

jurisdiction (AHJs) also have amended or enacted more stringent local building codes related to EV charging in MFHs.

That many building codes do not factor in EV ownership and the associated energy demands for EV charging is a key challenge for charging deployment at MFHs. This often results in insufficient electrical panel capacity to support EV charging and a lack of raceways, conduits, and circuitry to parking spaces, all of which are required for installing charging infrastructure. It is therefore essential that EV charging requirements be included in MFH building codes to future-proof for widespread EV adoption. In their absence, MFH residents may be more unlikely to switch to EVs, as relying on workplace and public charging to meet their needs is generally more costly, less secure, and less convenient for EV drivers.

EV charging parking space requirements mainly fall within three basic options: EV capable, EV ready, and electric vehicle supply equipment (EVSE) installed. Figure 1 illustrates these three options and briefly describes some of the defining characteristics of each. These EV charging requirements are typically defined as a percentage of total available parking spaces.[15]

Figure 1
Options for EV charging requirements in building codes



Source: Alexander Tankou, Kaylin Lee, Marie Rajon Bernard, Anh Bui, *Policies and innovative approaches for maximizing overnight charging in multi-unit dwellings* (ICCT/IZEVA: Washington, DC/London, UK, 2023), https://theicct.org/wp-content/uploads/2023/12/ID-34-%E2%80%93-Overnight-charging-policies-IZEVA-Report-A4-70129-fv.pdf.

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15 Matt Frommer, "Cracking the Code on EV-Ready Building Codes," *Southwest Energy Efficiency Project*, October 23, 2018, https://www.swenergy.org/cracking-the-code-on-ev-ready-building-codes.

EV-capable spaces have the electrical panel capacity (power and panel space) to support future Level 2 EV charging (208/240V service)—or, in some cases, Level 1 EV charging (120V service)—with a dedicated continuous raceway and conduit from the panel to the parking space. While EV-capable spaces require site power and panel space, they do not require a breaker, wire, or receptacle (i.e., outlet). EV-ready spaces include the same components, but also have a completed circuit that terminates in a receptacle. EVSE-installed spaces include fully installed charging stations that connect back to the panel, either directly or indirectly through an EV ready outlet.

A range of local and state governments have adopted EV charging building codes for MFHs (for a detailed list, see the appendix). While many of these codes do not provide for EV charging for 100% of units, let alone for every parking space, the cities of San Jose, San Francisco, Oakland, and Denver and the state of Illinois all have building codes that ensure that 100% of parking spaces are either EV capable, EV ready, or EVSE installed (see Table 1).

Table 1

U.S. jurisdictions with building codes that provide for EV charging capability at 100% of parking spaces in new MFH developments

Government	Effective year	Building code (all based on parking spaces)
San Jose, CA	2020	70% EV capable, 20% EV ready, 10% EVSE installed
San Francisco, CA	2018	90% EV capable, 10% EV ready, electric panel capacity sufficient to supply 20% of spaces
Oakland, CA	2017	90% EV capable, 10% EV ready, electric panel capacity sufficient to supply 20% of spaces
Denver, CO	2020	80% EV capable, 15% EV ready, 5% EVSE installed (10+ spaces)
Illinois	2023	100% EV capable

Notes: The effective year reflects the year of approval or most recent amendment of the building code for EV charging requirements at 100% of parking spaces. The first time an EV charging building code became effective in a jurisdiction might be earlier than the shown effective year.

Even these more comprehensive MFH EV building code provisions only require that most spaces be EV capable, however, which alone can often be insufficient to provide charging options for all residents. Moreover, several other barriers related to building codes and standards—including uneven distribution of parking spaces among residents, complicated electrical metering configuration, lack of signage, and limited accessible EV charging spaces for people with disabilities—currently go unaddressed in most U.S. building codes.

Building code recommendations

EV-ready requirements are the preferred option for MFHs because they avoid the higher costs of EVSE-installed requirements while still allowing any EV drivers at MFHs to charge at home at residential utility rates, similar to the experience of single-family homeowners with a garage. The additional cost to provide charging to all units at the time of construction is often marginal. A recent study in California found that the additional cost of making a 60-unit MFH 100% EV ready with low-power Level 2 (3.3 kW) was only 0.3% of total construction costs.[16] EV-ready parking provisions in

16 Sven Thesen & Associates, "A Comparison of Two Multi-Family Dwelling EV Charging Codes" (September 27, 2021), https://docs.google.com/document/d/1vtGgAIbJdEA5UfOgb_KD4ExYcyO6TfWEedhP59JrM5I/edit.

building codes also allow EV owners to purchase and manage an EVSE that best fits their needs, and the ability to take the EVSE with them when they move.

The EV Charging for All Coalition (EVCAC), which advocates for the inclusion of EV charging provisions in building codes, has identified four key principles for EV-ready building code design that can promote more inclusive and affordable charging (see Table 2).[17]

Table 2

Key principles for EV-ready building code design, according to EVCAC

Key principle	Explanation
Provide each household unit that has parking with at least one EV-ready space	Avoids uneven distribution of EV-ready parking spaces and amenity upcharges on residents who request charging access.
Require at least low-power Level 2 charging, or a 208/240V and 20-ampere branch circuit (equivalent to a 3.3 kW Level 2 charger), and an outlet, not necessarily EVSE	Helps minimize total costs while still expanding MFH charging access.
Wire the outlet or EVSE directly to the corresponding unit's panel or meter	Eliminates the burden on homeowners association (HOA) managers or property owners to maintain the charger or decide how to bill residents; also avoids the need to use third-party billing services, which usually charge a high premium.
Display EV-ready signage at each outlet	Helps inform residents that they can charge an EV at these spaces using just an outlet.

EV charging provisions in building codes can also apply to the repair or alteration of existing buildings. The San Francisco Green Building Code, for example, requires that during major alterations of existing buildings, as many parking spaces be made EV capable as permitted by the building's existing electrical capacity, and that any electrical service upgrades that are necessary as part of the alteration allow for 100% of parking to be made EV capable.[18] That said, safeguards should be in place to ensure that upgrades during major alterations do not displace existing residents, particularly those in underserved communities.

Equity considerations

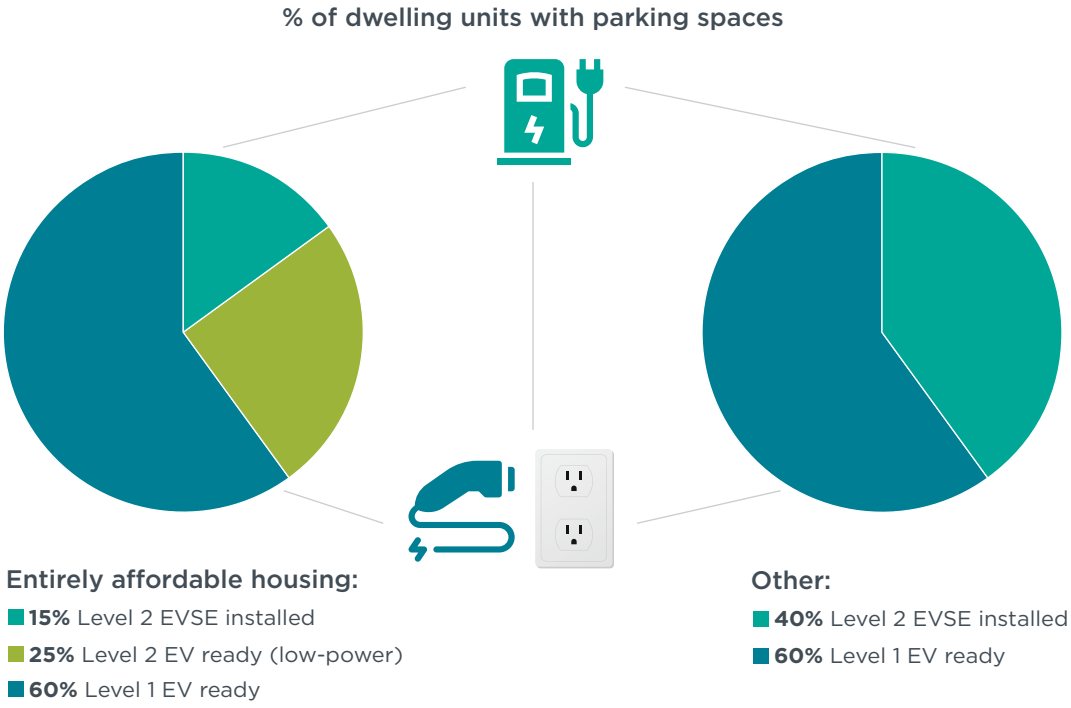
Building codes can also be designed to promote more equitable MFH charging access. In affordable housing units, for instance, codes can be designed to minimize the capital costs of EV charging for developers and avoid costs being passed down to residents. Having lower power requirements for EV-ready spaces at affordable MFHs is one way to limit costs. This reduces the electrical capacity needed to make MFH parking 100% EV ready, and can cut costs by more than 60% per parking

17 "Building Codes for Equitable, Ubiquitous EV Charging Infrastructure," EV Charging for All Coalition, accessed August 4, 2023, https://pluginamerica.org/policy/ev-charging-for-all/.

18 San Francisco Board of Supervisors, Requirements for Installation of Electric Vehicle Chargers, Green Building and Environment Codes, Ordinance 92-17, April 17, 2017, https://sfbos.org/sites/default/files/o0092-17.pdf.

space.[19] Figure 2 illustrates a potential MFH building code design proposed by Peninsula Clean Energy and Silicon Valley Clean Energy that includes Level 1 EV ready, low-power Level 2 EV ready, and Level 2 EVSE installed configurations. Permitting affordable MFHs to have 25% of spaces be low-power Level 2 EV ready, and 15% to have a Level 2 EVSE installed, instead of requiring 40% of spaces to have a Level 2 EVSE installed as suggested for other MFHs, reduces costs by requiring less hardware and reducing the amount of electrical capacity needed for lower-power charging. Several cities in California have adopted similar schemes. For example, the cities of Los Altos and Cupertino both require Level 2 EV-ready spaces for 10% of units and Level 1 EV-ready spaces for the remainder.[20] Understanding and tailoring building codes to meet the charging needs of residents in affordable housing can keep construction costs low while providing charging to as many residents as possible.

Figure 2
Model building code structure for new multifamily housing, including affordable housing



Source: Adopted from Peninsula Clean Energy and Silicon Valley Clean Energy, "2022 Reach Codes Initiatives: Advancing Safer, Healthier, and More Affordable Buildings and Vehicles," February 16, 2022, https://bayareareachcodes.org/wp-content/uploads/2022/02/2022-Reach-Code-Initiative-Feb-16.pdf.

Building codes should also account for EV charging by residents with disabilities, as governed by the Americans with Disabilities Act (ADA) for local- or state-owned residences and the Fair Housing Act (FHA) for privately-owned residences. While

19 Brendan McEwen, "Making Parking 'EV Ready': Requirements for New Construction & Incentives for Existing Buildings" (AES Engineering, February 2022), https://emc-mec.ca/wp-content/uploads/2023/05/EV-Ready-Parking-February-2022.pdf.

20 Silicon Valley Clean Energy, EV Reach Code Chart for Residential, February 17, 2021, https://www.svcleanenergy.org/wp-content/uploads/2020/02/EV-Reach-Code-Chart-Compared-to-CalGreen-Res-2.17.2021.pdf.

the ADA has accessible parking space requirements, as of March 2024, it does not have specific requirements for accessible EV charging stations or spaces. The U.S. Access Board, the federal agency that issues accessibility guidelines under the ADA, provides some guidance for EV charging related to space dimensions, mobility features, and placement, but it is not comprehensive. For example, there are no minimum requirements for the number of accessible charging stations that must be installed at MFHs.[21] AHJs at the state and local level can go further to require a certain number of accessible charging spaces in such buildings. California, for instance, includes provisions for the minimum number of accessible charging spaces for vans and ambulances in all newly constructed buildings and building alterations.[22] Incorporating such requirements and design elements into building codes would promote more equitable and inclusive EV charging access in MFHs.

PARKING MANAGEMENT

In new and existing buildings, parking configurations at MFHs can present challenges for charging access. Parking at MFHs is typically either assigned or shared. Assigned parking spaces make it possible to guarantee that residents will have access to installed EV charging infrastructure. However, the cost of charging at assigned spaces in a single lot can vary widely. In MFHs, the circuits in parking structures typically go to a shared house panel. The further an assigned parking space is from that panel, the more costly it is to install charging infrastructure. This makes it difficult to distribute charging access at equal cost to all MFH residents.

Meanwhile, for MFHs with shared parking spaces, EV charging access may be available only on a first-come, first-served basis, and drivers may not all be accommodated.[23] Among other factors, daily commute patterns may influence which residents have more regular access to charging. Even after fully charging, drivers may not always move their cars in a timely fashion to allow other residents to use the charger. Many incentive programs for MFHs require EV chargers to be located in shared spaces that are not reserved by residents.[24] While this requirement may help ensure that any residents can access charging, it is not fully equitable, because MFH residents may have to sacrifice reliable charging access to receive public subsidies, whereas single-family home residents can receive subsidies to install EV charging infrastructure that they alone will use. Unless there is charging access at each parking space or a minimum of one EV space per unit with parking, shared parking arrangements cannot guarantee the same level of convenience and reliability experienced by EV drivers with private dedicated charging.

21 U.S. Access Board, "Design Recommendations for Accessible Electric Vehicle Charging Stations" (updated July, 17, 2023), https://www.access-board.gov/tad/ev/#accessible-mobility-features-1; In the 2023 updated publication, the Access Board mentioned that in a future Notice of Proposed Rule Making, it will solicit comments from the public on the minimum number of accessible chargers that should be required at EV charging stations.

22 International Code Council, 2022 California Building Code, Title 24, Part 2 (Volumes 1 & 2) with Jan 2023 Errata, accessed January 18, 2024, https://codes.iccsafe.org/content/CABC2022P2/chapter-11b-accessibility-to-public-buildings-public-accommodations-commercial-buildings-and-public-housing.

23 "MURB and Workplace Charging," Plug In BC, accessed May 12, 2023, https://pluginbc.ca/charging/murb-and-workplace-charging/.

24 "Level 2 Multi-Unit Dwelling Program," North Carolina Department of Environmental Quality, accessed May 12, 2023, https://deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement/phase-2-volkswagen-settlement/level-2-infrastructure-program/level-2-multi-unit-dwelling-program; "MassEVIP Multi-Unit Dwelling and Educational Campus (MUDC) Charging Program Requirements," Massachusetts Department of Environmental Protection, accessed May 12, 2023 https://www.mass.gov/doc/massevip-multi-unit-dwelling-educational-campus-charging-requirements/download.

Parking management recommendations

For MFHs with assigned parking, an alternative to installing charging at parking spaces where costs might be prohibitive is to bring charging access to a parking space via mobile charging stations.[25] Mobile charging stations function like traditional EVSEs and can provide either AC or DC charging, but have wheels that allow them to be moved to wherever an EV is located.[26] The charging equipment for a mobile EVSE can be located near the house panel to keep installation costs low; once charged, the charger can serve any parking space. Mobile chargers would also be useful for shared parking arrangements, so that a charged EV would not need to be moved for another EV to receive a charge.

Allowing residents to charge at other residents' assigned parking spaces can also be an effective way to increase charging access at MFHs and help to facilitate turnover so that residents can access chargers when they need to. Under this scheme, EV drivers who lack dedicated EV charging spaces can, for a fee, reserve the space of another resident who does have an assigned charging space when that charger is not in use. Reservation fees can help recoup the upfront costs of charger installation borne by the property manager and/or resident assigned to the space. In MFHs with shared EV chargers, meanwhile, reservations could help ensure charging access for EV drivers who would otherwise have to hope that a charger will be available when they need it.

The ability to reserve chargers is not commonly offered by charging providers. EVgo introduced a reservation feature for public DC fast chargers in 2021, but has not made the service widely available.[27] ChargePoint allows EV drivers to join a queue for a charger through a waitlist system, but does not offer reservation services.[28] Some community charging-station management systems, like EVMatch, OpConnect, and AmpUp, do enable reservations, however, while other general parking apps, such as Parkade, can also allow reservations and hourly fees to be charged for EV parking spaces.[29]

Some community charging-station management systems also offer other services and tools, like variable pricing and idle fees, which can be used to increase turnover for shared MFH chargers. For instance, the recent Vehicle Charging Innovations at Multi-Unit Dwellings project funded by the U.S. Department of Energy highlighted a case in which a multifamily home in Hawaii implemented a $25 idle fee for shared chargers and found that no residents were billed for this fee during the

25 Whitaker Jamieson, Geoff Gibson, Kevin Wood, and Russell Owens, *Technological Barriers to Electric Vehicle Charging at Multi-Unit Dwellings in the U.S.* (Forth Mobility, June 11, 2022), https://forthmobility.org/storage/app/media/Reports/MUD%20EVS%20Paper.pdf.

26 "Mobi® EV Charger," FreeWire Technologies, accessed May 12, 2023, https://freewiretech.com/products/mobi-ev/; "DC Mobile EV Charging Stations", EVESCO, accessed May 12, 2023, https://www.power-sonic.com/mobile-ev-charging-stations/.

27 Stephen Edelstein, "Do EV fast-charging reservations make sense? EVgo thinks so," *Green Car Reports*, June 2, 2021, https://www.greencarreports.com/news/1132440_do-ev-fast-charging-reservations-make-sense-evgo-thinks-so and Landing page for EVgo charger reservations, EVgo, accessed May 12, 2023, https://www.evgo.com/reservations/.

28 "Waitlist," ChargePoint, accessed May 12, 2023, https://www.chargepoint.com/products/waitlist.

29 Taraneh Arhamsadr, "EVmatch: The EV Charging Solutions for Apartments and Condos," *EVmatch*, April 19, 2022, https://blog.evmatch.com/evmatch-the-ev-charging-solution/; "EV Charging At Work", OpConnect, accessed May 12, 2023, https://www.opconnect.com/press/ev-charging-at-work/; AmpUp product description page for station owners, AmpUp, accessed July 20, 2023, https://ampup.io/station-owners/; Evan Goldin, "Should EV chargers be put in assigned or communal parking spots?," *Parkade*, October 6, 2020, https://parkade.com/post/should-ev-chargers-be-put-in-assigned-or-communal-parking-spots.

demonstration period, illustrating that economic incentives can be an effective solution to facilitate turnover.[30]

Equity considerations

Shared charging spaces must comply with ADA requirements, while assigned spaces do not.[31] In MFHs with assigned parking, property managers may have less economic incentive to provide charging at accessible spaces reserved for residents with disabilities, thereby preventing other residents from using the spot and limiting the revenue that the charger could otherwise generate. This lack of incentive risks further excluding an already marginalized group of drivers from charging access. Fair housing laws can ensure that residents with disabilities are not discriminated against if the HOA or property owner chooses not to provide charging at accessible spaces. In such cases, MFH residents in some states can invoke right-to-charge laws, which allow residents to install their own chargers without interference from the HOA or property owner so long as they follow minimum electrical safety requirements. However, this typically means that the resident would have to pay for the costs of hardware, installation, and maintenance, which can be prohibitively expensive for many residents. More details on right-to-charge laws can be found in the Processes and Stakeholder Engagement section.

ELECTRICAL ISSUES

The primary electrical obstacles to MFH charging are limited existing electrical capacity and a lack of circuits serving the parking spaces. MFHs built prior to the 1980s—about 43% of MFHs in the United States, according to the one analysis—often require significant refurbishment to support the electrical needs of EV charging.[32] For these buildings, it can be prohibitively expensive to install charging, which could require upgrades to the nearest panel, installation of new panels, or even electrical service upgrades. Such renovations can also entail significant delays, for instance in the event of transformer upgrades. Moreover, the likelihood of needing these upgrades is greater at MFHs than at single-family homes because of the sheer volume of demand on the electrical system.

Electrical recommendations

Given electrical capacity constraints in many buildings, and the potential cost of service upgrades, MFHs should use the existing electrical capacity as efficiently as possible. One solution is to perform load management across multiple chargers via an EV energy management system (EVEMS), also known as an automated load management system.[33] An EVEMS monitors a group of EV chargers to provide adaptive load management and keep electrical output under the electrical capacity

30 Jamieson, Gibson, Wood, and Owens, *Technological Barriers to Electric Vehicle Charging at Multi-Unit Dwellings in the U.S.*

31 U.S. Access Board, "Design Recommendations for Accessible Electric Vehicle Charging Stations" (updated July, 21, 2022), https://www.access-board.gov/tad/ev/#accessible-mobility-features-1.

32 National Multifamily Housing Council, "Characteristics of Apartment Stock [tabulations of 2022 American Community Survey microdata on when apartments were built]," updated November 2023, https://www.nmhc.org/research-insight/quick-facts-figures/quick-facts-apartment-stock/characteristics-of-apartment-stock/; Larry Rillera and Samantha Houston, "Electric Vehicle Charging in Communities" (ET Community, November 2022), https://etcommunity.org/assets/files/03-StrikeForceEquityWorkgroupReport-ElectricVehicleCharginginCommunities.pdf; Sherry Lee Bryan and Mahlon Aldridge, "Innovation in Electric Vehicle Charging for Multi-Unit Dwellings" (Ecology Action, November 4, 2020), https://efiling.energy.ca.gov/GetDocument.aspx?tn=235942&DocumentContentId=68936.

33 Jamieson, Gibson, Wood, and Owens, *Technological Barriers to Electric Vehicle Charging at Multi-Unit Dwellings in the U.S.*

threshold of the circuit or another designated set point in cases where limiting demand charges is important. When only one EV is charging, it can draw the full allowable power from the circuit; as more EVs plug in, the power management system adjusts the power output of all the chargers to ensure that all EVs are able to charge simultaneously while not exceeding the capacity of the circuit. EVEMSs can provide either static load management, which provides a fixed amount of power across multiple chargers, or dynamic load management, which balances the charging needs of each vehicle.[34] A Peninsula Clean Energy study found that a 1.65 kW charger with EVEMS—lower than the 3.3 kW low-power Level 2 charger requirement in California's statewide green building code, CALGreen—would satisfy 94% of commute needs in three California counties by providing around 60–70 miles of range each night.[35]

A related solution is a shared electrical circuit, which uses hardware to connect a group of chargers to a single circuit and manages the electrical output to those chargers via metering and circuit controls. Shared electrical circuits are also compatible with non-networked chargers (i.e., chargers not connected to the internet), making them particularly useful for affordable MFHs where installing non-networked chargers or outlets may be necessary to keep costs low.

Directly wiring EV charging infrastructure to an MFH unit's panel can be another way to take advantage of available electrical capacity and reduce the need for electrical service upgrades. An MFH unit's panel is likely to have more manageable or excess electrical capacity than an MFH house panel, allowing for faster charging while load managing; in some cases, there may be enough capacity to have a dedicated circuit for an EV charger without the need for load management at all. While direct wiring could lead to increased installation costs because of the distance from the unit panel to the parking structure, there are solutions that can bypass the panel and connect directly to a unit's meter while still balancing electrical loads with in-unit appliances.[36] Direct wiring also allows MFH residents to take advantage of less-expensive residential EV time-of-use (TOU) electric rates that might otherwise not be available for chargers connected to a house panel. TOU rates vary depending on the time of day and are lowest when the grid has less demand to incentivize customers to use electricity during those periods. Grid demand is typically lowest overnight, which coincides with when EVs are most often charged at home. As such, access to TOU rates is a major contributing factor to the affordability of EVs, and the lack thereof for MFH residents significantly hampers equitable access to low-cost charging.[37]

As EV adoption and charging demand at MFHs increase, it is likely that service upgrades will become more necessary. Regulators can help to ensure that such upgrades do not disincentivize EV charging deployment through performance-based regulation for electrification that prioritizes increasing charging access at MFHs. With

34 Vanessa Wang, "What is EV Load Shedding or Load Management?" *WattLogic*, January 3, 2023, https://wattlogic.com/blog/ev-load-shedding/.

35 Peninsula Clean Energy, "Commute & Multifamily EV Charging Level Needs Analysis: Level 1 or Power-Managed Level 2 Charging at 1.65 kW Meets the Daily Needs of 94+% of Drivers," n.d., https://www.peninsulacleanenergy.com/wp-content/uploads/2021/09/Determining-the-Appropriate-Level-of-Power-Sharing-for-EV-Charging-in-Multifamily-Properties-1.pdf.

36 DCC product offering page, RVE, accessed August 6, 2023, https://dccelectric.com; Michelle Lewis, "Siemens' new home EV charger adapter ends need for electrical panel upgrades," *Electrek*, July 27, 2022, https://electrek.co/2022/07/27/siemens-home-ev-charger-adapter/.

37 Maxwell Woody et al., "Electric and gasoline vehicle total cost of ownership across US cities," *Journal of Industrial Ecology* 00 (2024): 1-22.

a performance-based approach, a utility will base its grid management and investment decisions on financial incentives it can receive for meeting or making progress toward societal goals.[38] For example, if removing barriers to installing EV charging at MFHs is a societal objective, utility regulators could provide financial incentives for utilities that assess where expected MFH charging loads will be in the long-term and invest in utility-side make-ready grid infrastructure (e.g., transformers and service lines) to support widespread EVSE deployment at those locations in the future.

If given the authority to do so, utilities can include these EV charging infrastructure investments in their rate base, which would otherwise make EV charging projects at MFHs cost-prohibitive for property managers and residents alike. While MFH customers typically would represent a minority of a utility's customer base, there is reason to believe these investments could bring savings to ratepayers. A 2022 analysis of the top three utility service territories in the United States for EV penetration found that EVs brought in more in revenue than associated costs, driving electricity rates down for all ratepayers.[39] Utilities, as such, have an economic incentive to make these investments whereas MFH stakeholders often do not.

Equity considerations

EV drivers living in MFHs should not bear a disproportionate share of costs associated with service upgrades for EV charging. Traditionally, utilities have supported service upgrades as requests, on a first-come, first-served basis. As a result, a customer may have to pay some or all of the upgrade costs associated with increased service capacity at the location if their requested upgrade would mean that a feeder reaches service capacity.[40] MFH residents are particularly vulnerable given the greater likelihood of needing panel and service upgrades, and the lower incomes on average among MFH residents. Some utilities have developed programs to support EV drivers facing these costs, as shown in the next section, but most utilities across the United States are not yet doing so. This further highlights the need for performance-based regulation to guarantee that MFH residents can afford the cost of charging and are not priced out of their homes.

CAPITAL COSTS

The cost to purchase and install an EV charger at an MFH poses a critical barrier to charging access. The average cost of purchasing and installing a Level 2 charger in an MFH is about $4,100 per charger, compared with $1,400 in a single-family home, although costs of charger deployment in MFHs can be significantly reduced if chargers are installed during construction.[41] Moreover, on average, people living in MFHs have lower incomes and less disposable income to put towards installing a charger than people in other housing arrangements, particularly those in single-

38 Jesse Hitchcock, Meryl Compton, Bill Leblanc, and Steven Day, "Performance-based regulatory strategies to accelerate beneficial electrification" (E Source, March 30, 2022), https://www.esource.com/report/430211hlay/performance-based-regulatory-strategies-accelerate-beneficial-electrification.

39 Tyler Fitch, Jason Frost, and Melissa Whited, "Electric Vehicles Are Driving Electric Rates Down," (Synapse Energy Economics, Incorporated, 2022), https://www.nrdc.org/sites/default/files/media-uploads/ev_impacts_december_2022_0.pdf.

40 Michael Hartnack and Jesse Hitchcock, "Transportation electrification and EVs: Who pays for grid upgrades?" *Utility Dive*, January 11, 2023, https://www.utilitydive.com/news/transportation-electrification-and-evs-who-pays-for-grid-upgrades/639420/.

41 Michael Nicholas, *Estimating electric vehicle charging infrastructure costs across major U.S. metropolitan areas*, (Washington, DC: ICCT, 2019), https://theicct.org/wp-content/uploads/2021/06/ICCT_EV_Charging_Cost_20190813.pdf.

family homes: 30% of apartment households make more than $75,000 annually, compared to 50% of all households.[42]

Costs can vary widely across jurisdictions, depending on the specific site characteristics, parking layout, and charger functionality (i.e., networked or non-networked) required. In a residential charging rebate program in Columbus, Ohio, that supported 48 MFH chargers, the total cost—including equipment purchase, signage, installation, and educational materials—was close to $6,700 per Level 2 charger.[43] Pacific Gas & Electric (PG&E) in California estimates the cost to install a charger at an MFH or workplace ranges from $1,150 to $6,850.[44]

The installation costs for chargers at MFHs can become increasingly expensive when additional trenching is required to reach a parking space. As noted above, costs generally increase with greater distance between the electrical service panel and the location of the parking space. In addition, trenching through asphalt and concrete, which are common in MFH parking lots and garages, is more costly than through greenspace, such as a yard. Without adequate financial incentives, charger deployment may be too costly for property managers, HOAs, or residents.

Capital cost recommendations

As noted above, installing EV charging infrastructure during new construction is the most effective way to reduce the costs of charger deployment, and could be addressed in building codes. Requiring EV charging infrastructure to be installed during major alterations, meanwhile, may require financial incentives to help offset costs so that existing residents are neither priced out of their homes nor unable to afford the charging that is installed.

The expansion of federal, state, local, and utility incentives for both new and existing buildings will be crucial to overcome MFH charging cost barriers for all stakeholders. Although there are many early incentive programs to help deploy charging at MFHs, they are yet to be widespread across the United States and vary in the amount of financial support they provide. Financial incentives that cover at least 50% to 75% of the costs to install chargers in existing buildings would go further in encouraging 100% EV-ready retrofits, whereas incentives worth less than this value are more likely to lead to incremental deployment and, therefore, increased total costs.[45]

Allowing incentive stacking, or combining multiple incentives together, is another way to help mitigate the costs of MFH charging infrastructure and encourage widespread charger rollout. In parts of Pennsylvania, the Drive PA Forward state-level EV charger installation rebate can be combined with incentives from the electric utility, Duquesne Light Company. Similarly, MassEVIP funding in Massachusetts can be

42 National Multifamily Housing Council, "Characteristics of Apartment Stock [tabulations of 2022 American Community Survey microdata on household income by housing type]," updated November 2023, https://www.nmhc.org/research-insight/quick-facts-figures/quick-facts-resident-demographics/household-incomes/.

43 Atlas Public Policy, "Smart Columbus kickstarts EV charging deployments at multi-unit dwellings" (2018), https://d2rfd3nxvhnf29.cloudfront.net/legacy/uploadedfiles/playbook-assets/electric-vehicle-charging/mud-case-study-final.pdf.

44 Pacific Gas and Electric Company, "EV Charge Network Program Guide," (n.d.), https://web.archive.org/web/20221108153654/https://www.pge.com/pge_global/common/pdfs/solar-and-vehicles/your-options/clean-vehicles/charging-stations/program-participants/EV-Charge-Network-Program-Guide.pdf.

45 Brendan McEwen, "Making Parking 'EV Ready': Requirements for New Construction & Incentives for Existing Buildings" (AES Engineering, February 2022), https://emc-mec.ca/wp-content/uploads/2023/05/EV-Ready-Parking-February-2022.pdf.

combined with other funding sources, such as incentives from utilities like Eversource and National Grid.[46]

Leveraging partnerships among government, industry, and non-profit stakeholders is another way to provide financial support for MFH charging projects. For example, the GM Climate Equity Fund partners with Montgomery County Green Bank in Maryland to help fully cover the costs associated with EV charger installations at affordable MFH properties through loans and grants, with funds that can be paired with existing utility rebates.[47] Similarly, the non-profit Grid Alternatives established the Energy Resilience Fund that attracts investors who are climate-conscious and focuses on providing flexible financing to a range of marginalized communities, including affordable MFHs, for clean energy projects.[48]

Funding programs should consider the financial limitations of some MFH stakeholders. For example, rebate programs will be ineffectual if a resident or property manager is unable to fund the upfront costs of installing EV charging infrastructure. Government or utility rebate programs can consider coordinating with lenders to guarantee low or 0% interest rates for those seeking to install chargers, so that MFH stakeholders who take out loans to finance the installation are not faced with greater costs in the event of interest rate increases. Also, while external funding can make installing EV charging infrastructure at MFHs more economically feasible, it does not necessarily benefit residents by ensuring the costs to utilize chargers are affordable. Designers of incentives programs could stipulate that recipients who install EV chargers at MFHs must keep electricity rates or charging fees no higher than those associated with the regular operation or maintenance of EVSEs to ensure that charging costs to residents are as affordable as possible.

Distinct from incentives and rebate programs are third-party ownership models for EV chargers at MFHs. Under this model, a charging provider or a utility pays for the installation, operation, and maintenance of an EV charger, and may share some amount of the revenue generated from its use with the property owner. PG&E's EV Charge Network program offers this arrangement to MFHs and workplaces.[49] Demand response agreements, which reduce or shift electricity demand during peak demand periods, are typically done in conjunction with these utility EVSE ownership programs. Demand response either takes the form of incentives that pay consumers to use less energy at certain times or price signals like TOU rates whereby electricity rates are increased during peak periods and lowered during off-peak periods to encourage consumers to use electricity when the grid has more capacity, thereby allowing residents to charge their EVs more cheaply.[50] Private charging providers that

46 Duquesne Light Company, "Community Charging Program Guide," (n.d.), https://www.duquesnelight.com/docs/default-source/default-document-library/community_programguide_final.pdf?sfvrsn=185ca942_0; "MassEVIP Multi-Unit Dwelling and Educational Campus (MUDC) Charging Program Requirements," Massachusetts Department of Environmental Protection, accessed May 12, 2023 https://www.mass.gov/doc/massevip-multi-unit-dwelling-educational-campus-charging-requirements/download.

47 "The Montgomery County Green Bank Uses a General Motors Grant to Build Equitable Access to EV Charging," Montgomery County Green Bank, accessed May 12, 2023, https://mcgreenbank.org/the-montgomery-county-green-bank-uses-a-general-motors-grant-to-build-equitable-access-to-ev-charging/.

48 "Flexible Financing to Fit Your Community's Needs," Energy Resilience Fund, accessed May 12, 2023, https://www.energyresiliencefund.org/financing.

49 Pacific Gas and Electric Company, "EV Charge Network Program Guide," (n.d.), https://web.archive.org/web/20221108153654/https://www.pge.com/pge_global/common/pdfs/solar-and-vehicles/your-options/clean-vehicles/charging-stations/program-participants/EV-Charge-Network-Program-Guide.pdf.

50 Michael Schoek, "Multi-unit housing EV chargers participate in demand response program," *pv magazine USA*, February 7, 2023, https://pv-magazine-usa.com/2023/02/07/multi-unit-housing-ev-chargers-participate-in-demand-response-program/.

are looking to quickly recover their investment from charger use will likely have less flexibility to offer cheap electricity rates than utilities with a regulated rate structure. As such, they may not be a viable option for non-luxury MFHs, where keeping charging prices affordable is a crucial consideration.

Similarly, third-party deployments of charging hubs located outside but near MFHs, with the intention of serving both MFH residents and the broader public, can be a solution for MFHs for which the cost to install chargers on-site are prohibitive. Unlike chargers at MFHs, where electrical capacity is often limited, these off-site charging hubs can feature DC fast chargers in addition to Level 2 chargers to allow for faster charging speeds and greater throughput, usually at higher prices.[51] However, because MFH residents and owners would not own the off-site property, it is unlikely they would be able to influence the installation of such DC charging hubs. Utilities can help entice private investment in charging hubs near MFHs through tolling agreements, whereby a charging provider pays the upfront capital costs for installing a charging hub while the utility assumes the responsibility of rate setting, paying for the electricity delivered, and paying a recurring fee to the charging provider to help recover capital expenditures. A tolling agreement between East Bay Community Energy, Calibrant Energy, and EV Realty is currently under development to serve MFHs in California's Alameda County.[52] Such a collaborative arrangement could also help to keep usage fees more reasonable for residents, as utility rates would not fluctuate based on utilization in the same way private charging fees might.

Equity considerations

Incentives can be structured to equitably distribute funding. This can include ensuring EVSE incentive programs are needs-based and scaled up to 100% of costs for affordable MFHs with the lowest-income residents and with the highest environmental justice screening scores, such as federally recognized tribal lands.[53] For family-owned MFH properties such as duplexes, triplexes, and townhouses that may have fewer resources to apply for incentives, having a separate pool of funding is critical. In addition, the first-come, first-served structure of incentives can leave behind the properties that are slower to apply. The development of additional criteria that recognize these distinctions would be the first step in creating a fairer application process.

MFH eligibility for existing incentive programs currently varies. Incentives are often designed based on the definition of an MFH that has a minimum number of units or parking spaces. For example, rebates from the utility Silicon Valley Clean Energy only apply to MFH properties with at least four units. Likewise, Southern California Edison's Charge Ready Turn-Key Installation program for disadvantaged communities

51 Jamieson, Gibson, Wood, and Owens, *Technological Barriers to Electric Vehicle Charging at Multi-Unit Dwellings in the U.S.*

52 Jeff St. John, "Renters need EV charging at home. These companies aim to provide it," *Canary Media*, January 24, 2023, https://www.canarymedia.com/articles/ev-charging/renters-need-ev-charging-at-home-these-companies-aim-to-provide-it.

53 Larry Rillera and Samantha Houston, "Electric Vehicle Charging in Communities" (ET Community, November 2022), https://www.etcommunity.org/wp-content/uploads/2024/03/EV-ChargingEquityWorkgroupReport.pdf.

requires a minimum of four Level 2 chargers.[54] These schemes might exclude smaller, often family-owned MFH properties.

Moreover, affordable MFH properties in lower-income neighborhoods can be entirely excluded from some incentive programs that operate on a first-come, first-served basis, as these properties may have little, if any, EV adoption. The types of MFHs that should receive prioritized or additional funding and support can be defined explicitly to ensure funding gets where it is most needed. For example, Southern California Edison's Turn-Key installation program provides MFH customers extra funds if they are in the top quartile score of Disadvantaged Community census tracts, created by the California Communities Environmental Health Screen Tool (CalEnviroScreen 3.0). The score is based on several economic, health, and environmental criteria.[55] The criteria for extra funding eligibility can balance these factors to ensure that MFH communities most in need are not ignored. For example, a program could avoid a scenario where MFHs tailored for higher-income residents, but burdened by pollution, are approved for extra funding at the expense of MFHs in comparatively less polluted areas that serve lower-income residents. Equity-focused programs should be simplified and streamlined where possible.[56]

Pre-financing arrangements for EV charging infrastructure that spare residents from facing increased costs until they have an EV can be a way to assuage some of the capital cost concerns. In France, for example, charging investment firm Logivolt offers 100% financing for a charging provider to install EV charging infrastructure and levies a connection fee to each resident when they decide to have their charger connected for use; once 30% of spaces are connected, ownership of infrastructure is transferred to the property.[57] Similarly, a pre-financing decree from France's energy regulatory body requires grid operators to pay for the upfront costs of EV charging infrastructure at MFHs, with residents paying once they connect their parking space. For equity purposes, the decree sets a maximum connection fee so that older MFHs with the most costly retrofits are not faced with exponentially higher costs than newer buildings.[58]

Because of the scale and scope of MFH charging deployments, soft costs, such as those associated with permitting, planning, and financing of MFH construction projects, can become significant. Simplifying and streamlining codes and permitting, facilitating easement processes, and providing informational materials for MFH

54 "Charge Ready Program Offer Comparison," Southern California Edison, accessed May 12, 2023, https://www.sce.com/sites/default/files/2022-07/CR%20Program%20Comparison%20Fact%20Sheet_WCAG.pdf; "Attract More Residents to Your Property by Adding EV Chargers," Silicon Valley Clean Energy, accessed May 12, 2023, https://svcleanenergy.org/multifamily-charging/.

55 Southern California Edison, "Quick Reference Guide for Charging Infrastructure and Rebate and Turn-Key installation," (n.d.), https://www.sce.com/sites/default/files/custom-files/PDF_Files/Quick_Reference_Guide_No_CSR_Final_11.16.2023.pdf.

56 Peter Slowik, *Expanding zero-emission mobility equity and access* (Washington, DC: ICCT/IZEVA, 2019), https://zevalliance.org/wp-content/uploads/2019/12/ZEV_access_workshop_report-_fv.pdf.

57 "Vous êtes résident, conseil syndical ou syndic de copropriété" [You are a resident, union council or co-ownership trustee], Logivolt, accessed August 23, 2023, https://logivolt.fr/offre-recharge-copropriete/.

58 Délibération de la CRE du 22 juin 2023 portant avis sur le projet de décret relatif à l'instruction des demandes d'intervention financière de l'Etat pour une prise en charge partielle des coûts associés à la conversion des usages de gaz pétrole liquéfié, Commission De Régulation de L'énergie [CRE deliberation of June 22, 2023 providing an opinion on the draft decree relating to the examination of requests for financial intervention from the State for partial coverage of the costs associated with the conversion of uses of liquefied petroleum gas, Commission Energy Regulation]. Deliberation No. 2023-170, June 22, 2023, https://www.cre.fr/documents/Deliberations/Avis/projet-de-decret-relatif-a-l-instruction-des-demandes-d-intervention-financiere-de-l-etat-pour-une-prise-en-charge-partielle-des-couts-associes-a-l.

stakeholders could help to bring costs down.[59] For instance, allowing all the administrative filing and application approvals for permitting to be done online can expedite EV infrastructure installation, making it easier and more affordable to builders, property owners, and residents.

PROCESSES AND STAKEHOLDER ENGAGEMENT

The process of getting EV infrastructure approved, installed, and operating within an MFH can be another significant barrier to charger deployment. These steps include procuring information on EV infrastructure for MFHs, understanding the steps involved, and coordinating among the large numbers of stakeholders, including property managers and owners, developers, utilities, electricians, building or service contractors, city permitting officials, and HOAs. Insufficient technical knowledge and uncertainty around utilization can deter residents and property managers alike from seeking to install a charger. In addition, the complex approval process of building code updates and local AHJ changes can present significant obstacles. Jurisdictions that wish to adopt EV building codes may base their process and code requirements on existing protocols and yet need careful consideration of the local infrastructure landscape and stakeholders involved. Each project is unique, with its own set of questions and challenges, and there is no one-size-fits-all solution.

EV charging deployment also faces the challenge of split incentives, in which all parties, including building owners, property managers, and residents, have an incentive to let others bear the costs of installation. Property managers may be unwilling to invest due to uncertainty related to the added value to the property and by a desire to maximize profit by keeping costs low. Beyond capital cost constraints, residents might fear being unable to recoup their investment if they move or cannot afford the parking space in the future. Property managers and HOAs, for their part, might prioritize other projects that are deemed more urgent or less capital intensive. Residents without EVs, meanwhile, may fear that installing EV charging infrastructure may cause their rent to increase.

Process and stakeholder engagement recommendations

At existing MFHs, decisionmakers need to be well-equipped with the information and resources to develop a charging strategy specific to their property and needs. The Vehicle Charging Innovations at Multi-Unit Dwellings project funded by the U.S. Department of Energy produced an online MFH charging toolkit with guides tailored to residents, HOAs, and apartment building managers on how to craft an EV charging plan.[60] This includes how to assess potential charging demand, how to contact utilities and contractors, and how to identify incentives that they may qualify for. Each stakeholder has different responsibilities if they are initiating the process of getting EV chargers at their MFH.

Government incentives for consultations to evaluate an MFH property and develop a plan to install EV charging can help address knowledge deficits. Property managers and owners and HOAs looking to install charging infrastructure in existing buildings should determine the MFH's electrical capacity and any potential costs to upgrade it.

59 Chih-Wei Hsu, Peter Slowik, and Nic Lutsey, *City charging infrastructure needs to reach electric vehicle goals: The case of Seattle* (Washington, DC: ICCT, 2021), https://theicct.org/wp-content/uploads/2021/06/Seattle-charging-infra-jan2021.pdf.

60 Vehicle Charging Innovations at Multi-Unit Dwellings, landing page, accessed May 12, 2023, https://vci-mud.org.

Once these costs are understood, HOAs and property managers can begin to survey residents on their need for, or interest in, charging to then estimate revenue from chargers and the expected return-on-investment. For example, the British Columbia Clean BC EV-Ready Rebate program, launched in 2021, offers rebates for existing MFHs to create EV-Ready Plans that assess the electrical needs and costs to fully retrofit with EV chargers.[61] Similarly, the Netherlands offers subsidies for consultant reports that assess an MFH and recommend the best option for future-proofed EV charging installations on the property.[62]

City, utility, and other stakeholder engagement with residents, particularly those without EVs, is important to educate them on the benefits of charging and work in consultation with them to determine where and how charging is deployed to best serve their needs.[63] This is particularly important when chargers are built before any residents own an EV to mitigate the risk that chargers are perceived as serving future rather than the current residents.[64] Pre-financing arrangements for EV charging infrastructure that spare residents from facing increased costs until they have an EV can be a way to assuage some of these concerns.

The expansion of right-to-charge laws to more states would empower residents to seek their own EV charging solutions and serve as a clear indication to property managers about the increasing demand for EV charging. Right-to-charge laws provide residents the right to install charging for their use, with limited mechanisms for management to prevent such installations.[65] According to research published in December 2023, right-to-charge laws typically apply to owner-occupied units, as is the case in New Jersey, New York, Virginia, Hawaii, Florida, and Washington. For a few other states, namely California, Colorado, Connecticut, and Oregon, right-to-charge laws also cover rented units.[66] The laws, however, do not require the HOA or property manager to cover the costs of charging or to install charging as an amenity. Especially for existing MFHs, the visibility of the laws and residents' ability to pursue home charging might influence an HOA or property managers' decision to prioritize charger installations to attract more residents.

Other recommendations include AHJs' requiring any EV charging-related issues be discussed annually or more at MFH building assemblies or meetings, implementing fines against entities in charge of delivering connections if the process takes more than the contracted time, and instituting requirements that charging permits be approved by default by the AHJs within a certain time period if there is no substantial evidence of any specific adverse impacts to public health or safety. In collaboration with research and industry organizations, AHJs could additionally allocate resources to research and provide incentives for portable chargers where EV charging space

61 "EV charging rebates for apartment and condo buildings," BC Hydro, accessed May 12, 2023, https://electricvehicles.bchydro.com/incentives/charger-rebates/apartment.

62 "Oplaadpuntenadvies voor VvE's" [Charging point advice for HOAs] VvE laden, accessed August 15, 2023, https://vveladen.nl/subsidie/.

63 Slowik, *Expanding zero-emission mobility equity and access.*

64 Slowik, *Expanding zero-emission mobility equity and access.*

65 "Right To Charge Laws," NESCAUM, accessed May 12, 2023, https://www.nescaum.org/documents/ev-right-to-charge.pdf/#:~:text=%E2%80%9CRight%20to%20charge%E2%80%9D%20laws%20provide,responsibility%20for%20all%20associated%20costs.

66 Alexander Tankou, Kaylin Lee, Marie Rajon Bernard, and Anh Bui, *Policies and innovative approaches for maximizing overnight charging in multi-unit dwellings* (Washington, DC: ICCT/IZEVA, 2023) https://theicct.org/wp-content/uploads/2023/12/ID-34-%E2%80%93-Overnight-charging-policies-IZEVA-Report-A4-70129-fv.pdf.

is limited. These initiatives can help accelerate the process of approving and implementing retrofits and charger installations.[67]

Equity considerations

The implementation of simplified permitting processes and right-to-charge laws would make charging installation more convenient, cost-effective, and straightforward for builders, property owners, and residents. This is of particular importance for charging installations at MFHs in low-income communities, which may have greater need for service upgrades and therefore require more comprehensive approval processes. Tailoring approaches to local demands, needs, and resource constraints will be essential to drive EV adoption and charging infrastructure deployment in MFHs. Through the outreach services noted above, MFH residents should be consulted on how EVs can benefit their daily lives, rather than solely how EV charging infrastructure can be deployed in their building.[68]

CONCLUDING REFLECTIONS

This paper summarizes the unique challenges to EV charging deployment that multifamily homes face and details technology and policy recommendations to address these challenges. Table 3 summarizes the five barriers discussed, as well as the key issues, key recommendations, and equity considerations for each barrier.

67 Tankou, Lee, Rajon Bernard, and Bui, *Policies and innovative approaches for maximizing overnight charging in multi-unit dwellings.*

68 Slowik *Expanding zero-emission mobility equity and access.*

Table 3

Summary of key issues, key recommendations, and equity considerations discussed

Barriers	Key issues	Key recommendations	Equity considerations
Building codes	• Most existing building codes in the United States do not guarantee charging for all residents. • Existing building codes do not ensure multifamily homes are built with sufficient electrical capacity to support EV charging.	• AHJs can adopt comprehensive EV-ready building codes for new constructions and major alterations. • Codes would ideally allow for one Level 2 EV-ready outlet per MFH unit with parking, wired directly to unit panel, and capacity for at least 20A, 208/240V charging.	• Because of more limited capacity and cost considerations for affordable multifamily homes, building codes could allow for low-power Level 2 or load managed charging at these properties. • Given the lack of federal requirements, AHJs could stipulate a minimum number of accessible charging spaces in their building codes.
Parking management	• Unequal access to charging when chargers are installed in shared spaces. • Chargers are often underutilized when installed in assigned spaces and can vary widely in installation costs.	• Property managers could allow residents to reserve shared and one another's chargers; this both guarantees access and increases charger use, helping to recoup costs faster. • MFH properties could purchase mobile chargers to minimize installation costs and allow for EVs to be charged at any parking space. • MFH properties could implement price signals, like idle fees, to increase charger throughput.	• There is less economic incentive for property managers to install chargers in assigned, accessible spaces reserved for residents with disabilities, as they cannot be shared with other residents; residents can invoke right-to-charge laws to ensure they are not discriminated against, and can install their own charging.
Electrical issues	• Many existing MFHs have limited excess electrical capacity for EV charging. • MFHs are more likely to trigger costly utility service upgrades due to limited capacity.	• MFH properties could load manage across multiple chargers using shared circuits or EVEMS/load management systems. • MFH properties could directly wire charging infrastructure to unit panels to potentially avoid service upgrades and allow residents to access less expensive TOU rates.	• Because MFH service upgrades are more commonplace and cost-prohibitive for property owners and residents alike, utility regulators could permit utilities to perform make-ready service upgrades and rate base MFH charging infrastructure investments; performance-based regulation that incentivizes grid investment for future MFH loads could be a way to accomplish this.
Capital costs	• The capital costs to install EV charging infrastructure are higher than at single-family homes. • Costs are significantly higher when chargers are installed incrementally.	• Legislators could create incentive programs that ideally would fund 50% to 75% of capital costs to encourage full-scale retrofits with stipulations for minimizing charging costs and against displacement of residents. • Non-profit, private sector, and public sector organizations could collaborate to offer alternative financing mechanisms to support charging deployment at MFHs. • Property managers can consider third-party ownership of chargers by utility companies. • Utilities could partner with private charging companies to deploy off-site charging hubs near MFHs to support residents and the public.	• Legislators could create incentive programs that would ideally provide up to 100% funding for low-income housing locations because of their unique challenges in acquiring capital. • Because first-come, first-served incentive structures can exclude smaller, family-owned MFHs that may not have the resources to apply for competitive funding or MFHs with low-income residents that have virtually no EV adoption, legislators could design incentive programs that prioritize these properties and set aside funds for their use. • To ensure the costs of charging installations are shared equitably, legislators could create pre-financing programs that levy costs on residents only when they connect a charger.
Processes and stakeholder engagement	• HOA/property managers have split incentives compared to residents. • MFH stakeholders lack technical knowledge about installing EV charging and the related approval processes.	• Legislators can pass right-to-charge laws. • Property managers can gauge resident's interest and consult contractors/utilities to assess charging demand and capacity. • Legislators can provide incentives to fund expert consultations for EV charger deployment.	• Because affordable MFHs are more likely to require service upgrades and thus a more comprehensive permitting process, regulators could streamline permitting processes to reduce costs and approval time.

Based on our research and examples of MFH charging programs primarily throughout North America, we draw the following conclusions:

Building codes and financial incentives could ideally be designed to encourage charging access for all multifamily home residents, either through comprehensive retrofits of existing buildings or new construction. Costs to install chargers at MFHs are three to five times higher than at single-family homes, and are even higher when chargers are installed incrementally rather than all at once. Building codes could be designed to maximize charging access and minimize future costs by requiring that at least one parking space per MFH unit is EV ready for new construction and by having major alterations to existing buildings trigger requirements for comprehensive EV-ready retrofits, while avoiding displacement of residents. This requirement can help enhance equity for MFH residents by guaranteeing they have reliable and convenient access to home charging like single-family home residents. Meanwhile, financial incentives for MFHs would ideally cover most of the costs to install chargers to encourage MFH property managers to commit to full-scale retrofits rather than retrofitting repeatedly at individual parking spaces as EV adoption and charging demand increase over time. Third-party ownership of charging infrastructure by utilities could also eliminate costs for MFH property managers while keeping charging costs reasonable for residents. These tools enhance equity for MFH residents by ensuring they can install charging at home at reasonable costs.

Authorities having jurisdiction and MFH communities could implement mechanisms to incentivize charger throughput and ensure all residents have charging access when chargers are shared. When shared chargers are operated on a first-come, first-served basis, many residents can be left without reliable charging access. At the state level, expanding right-to-charge laws would enable residents to pursue their own EV charging solutions and serve as a signal to property managers of increasing demand for EV charging. At MFHs, idle fees that penalize residents who park at an EV charger while not charging could be effective in freeing up charger space. Allowing residents to reserve chargers could also expand charging access when not all drivers have allocated charging spaces. These tools enhance equity by allowing MFH residents to more reliably access home charging.

Efficient use of electrical capacity through load management can keep charging installation costs low; where service upgrades are needed, utilities could help bridge the gap. Given limited electrical capacity, MFHs could implement low-power Level 2 charging, load management via power-management systems, or share electrical circuits to avoid triggering costly panel or service upgrades. Shared charging at around 1.65 kW can meet the driving needs of nearly 94% of drivers in some California counties. Connecting directly to a housing unit's meter can also allow for load management with in-unit appliances while allowing residents to take advantage of TOU rates that make charging more affordable. Access to TOU rates allow for equitable access to low-cost charging. As EV adoption accelerates and service upgrades become increasingly necessary, installing EV charging infrastructure at MFHs could become cost prohibitive. Regulators could empower utilities to offset the costs of service upgrades to MFHs by including these grid investments in their rate base.

Multifamily home stakeholders may need technical education and support to proceed with EV charging infrastructure installations. The process to install charging, which includes assessing a building's electrical capacity and demand, securing the proper permits, and identifying applicable incentives, is complex to navigate for residents and property owners alike. Streamlining and simplifying these processes could make charging installations more straightforward and accessible for MFH properties. This could also support equity for residents of affordable MFHs, in which approval processes may require more steps and thus be more costly. Additionally, government incentives that cover the cost of a consultant to assess an MFH property, draft a plan for installing charging infrastructure, and provide guidance throughout the project can address these knowledge deficits and accelerate charging deployment at MFHs. Local government, utility, and other stakeholders could also engage residents to educate them on the benefits of charging and the process for connecting their own chargers. Ensuring that all strategies are pursued in consultation with, and driven by, community members could increase the EV adoption rate and charging infrastructure deployment in MFHs.

APPENDIX

Table A1

Electric vehicle building codes for multifamily homes in selected states, counties, and cities in the United States

Government	Effective year	Building code (all based on parking spaces)
Illinois	2023	100% EV capable
California	2023	New construction: 10% EV capable, 25% low-power Level 2 EV ready, and 5% high power Level 2 installed (20+ units for high power Level 2); Existing construction: 10% EV capable for new parking or altered spaces
Massachusetts	2023	20% EV ready
Oregon	2022	20% EV capable
Rhode Island	2022	25% EV ready
Vermont	2020	4% EV capable (MFHs w/ 100+ parking spaces)
Washington	2023	10% EV capable, 25% EV ready, 10% EVSE installed
Washington, DC	2022	20% EV ready
Larimer County, CO	2022	30% EV capable, 15% EV ready, 5% EVSE installed (10+ spaces)
Summit County, CO	2020	34% EV capable, 10% EV ready, 5% EVSE installed (10+ spaces)
Scottsdale, AZ	2022	4% EVSE installed, 20% EV capable
Los Altos, CA	2020	Market rate housing: 75% EV-ready Level 1, 25% EV-ready Level 2 (20+ spaces), 100% EV-ready Level 2 (<20 spaces); Affordable housing: 90% EV-ready Level 1, 10% EV-ready Level 2
Mountain View, CA	2019	85% EV ready, 15% EVSE installed, 1 DCFC for every 100 spaces
Oakland, CA	2017	90% EV capable, 10% EV ready, 20% panel capacity
Palo Alto, CA	2017	1 EV-ready space per unit, 20% EV capable for guest parking with 5% EVSE installed
San Francisco, CA	2018	New and major alterations: 90% EV capable, 10% EV ready, 20% panel capacity
San Jose, CA	2020	70% EV capable, 20% EV ready, 10% EVSE installed
Avon, CO	2020	15% EV capable, 10% EV ready, 5% EVSE installed with minimum one-dual port (7+ spaces)
Breckenridge, CO	2020	20% EV capable, 2 EVSE installed (26+ spaces)
Boulder, CO	2020	40% EV capable, 10% EV ready, 5% EVSE installed (25+ spaces)
Denver, CO	2020	80% EV capable, 15% EV ready, 5% EVSE installed (10+ spaces)
Dillon, CO	2020	34% EV capable, 10% EV ready, 5% EVSE installed (10+ spaces)
Durango, CO	2021	15% EV ready, 1 per 15 spaces EVSE installed (16+ spaces)
Fort Collins, CO	2022	New market rate housing: 40% EV capable, 20% EV ready, 10% EVSE installed New affordable housing: 20% EV capable, 15% EV ready, 1 EVSE installed; Existing: 1 EVSE installed under 50% building area alteration
Frisco, CO	2020	20% EV capable, 2 EVSE installed (26+ spaces)
Lakewood, CO	2019	18% EV capable, 20% EV ready, 2% EVSE installed (10+ spaces)
Louisville, CO	2021	15% EV capable, 10% EV ready, 10% EVSE installed
Orlando, FL	2022	20% EV capable (all). 2% EVSE installed (50+ spaces)
Atlanta, GA	2017	20% EV capable
Honolulu, HI	2020	25% EV ready (8+ spaces)
Chicago, IL	2020	20% EV ready (5+ spaces)
St. Louis, MO	2022	5% EV ready (increases to 10% in 2025), 2% EVSE installed (50+ spaces)
New York, NY	2013	20% EV capable
Seattle, WA	2019	100% EV ready < 7 spaces, minimum 6 for 7-25 spaces, 20% 25+ spaces
Madison, WI	2021	New or existing with 50% addition or significant reconstruction: 10% EV ready and 2% EVSE installed (increases by 10% and 2% respectively, every 5 years starting 2026)

Notes: The effective year reflects the year of approval or most recent amendment of the building code for the EV charging requirements shown. The first time an EV charging building code became effective in a jurisdiction might be earlier than the shown effective date.

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