


# Policies and innovative approaches for maximizing overnight charging in multi-unit dwellings

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The International Zero-Emission Vehicle Alliance is a network of leading national and sub-national governments demonstrating their deep commitment to accelerating the transition to zero-emission vehicles within their markets and globally. Its members include Austria, Baden-Württemberg, British Columbia, California, Canada, Chile, Connecticut, Costa Rica, Germany, Maryland, Massachusetts, the Netherlands, New Jersey, New York, New Zealand, Norway, Oregon, Québec, Rhode Island, the United Kingdom, Vermont, and Washington. The members collaborate through discussion of challenges, lessons learned, and opportunities; hosting events with governments and the private sector; and commissioning research on the most pressing issues in the ZEV transition.

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## Introduction and background

Inadequate access to charging infrastructure remains a key barrier to the adoption of electric vehicles (EVs) around the world.<sup>1</sup> Particularly in urban areas, many residents live in multi-unit dwellings (MUDs) in which the installation of a charger is contingent on such factors as private parking space availability, consent from other residents, and cost.<sup>2</sup> As demonstrated in a companion paper, increasing access to private overnight charging among MUD residents will become even more critical for reducing EV charging costs and enabling convenient and equitable access to charging as the number of apartment dwellers grows in coming years.<sup>3</sup>

This report presents policy and business model approaches for maximizing overnight charging at MUDs. Examples discussed below are mostly drawn from governments that are leading the electric vehicle transition, many of which are in International Zero Emission Vehicle Alliance (IZEVA) jurisdictions. The approaches can be classified into six broad categories: regulations, financial incentive programs, innovative business models, technology solutions for load management, education and awareness, and solutions for residents without access to home overnight charging. This paper also addresses community concerns related to EVs and charging, such as fire safety in enclosed garages and the impact of EV charging installation on housing affordability. Some of the approaches and policies described below are derived from stakeholder interviews presented in the appendix of this paper.

## Regulations

Charging installation in MUDs presents unique challenges compared with installation in single-family homes. A tenant or a unit owner will typically have to get approval from the building owner, manager, or homeowner association before altering a parking space and installing a charger. The unanimous consent of the other tenants is also often required for charger installation to move forward. Additionally, there is the question of who pays for the charger's acquisition, installation, and maintenance. Various regulations addressing permission, cost allocation, and ease of installation can help to promote charging buildout in MUDs.

## Right to plug

Right-to-plug (or right-to-charge) regulations aim to make it easier for unit renters or owners to install a charger in their parking space. While they differ from one jurisdiction to another, the regulations typically place responsibility on the tenant or unit owner for the costs associated with installing and using the charger. Many regulations also require the building owner, manager, or homeowner association to approve a charger installation request if it meets reasonable requirements (e.g., if it complies with safety standards and does not require significant alterations to the building).

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1 Logan Pierce and Peter Slowik, *Home Charging Access and Implications for Charging Infrastructure Costs in the United States* (Washington, DC: ICCT, 2023), <https://theicct.org/publication/home-charging-infrastructure-costs-mar23/>.

2 This report uses the term MUDs to refer to a range of urban dwellings, including apartment buildings, multi-unit residential buildings, or multi-family housing.

3 Marie Rajon Bernard, *A Technical Analysis of Private Overnight Charging Access in the International Zero Emission Vehicle Jurisdictions* (Washington, DC: ICCT, 2023), <https://theicct.org/publications/technical-analysis-of-private-overnight-charging-access-in-izeva-jurisdictions-dec23>.

**Table 1.** Summary of right-to-plug regulations in selected jurisdictions.

Jurisdiction	Applies to unit owners	Applies to unit renters	Denial period deadline for the MUD owner, manager, or homeowners association
Austria <sup>a</sup>	Yes	No	Yes: Non-consenting tenants must raise objections within two months of having been notified about the charger installation
California <sup>b</sup>	Yes	Yes	No
Colorado <sup>b</sup>	Yes	Yes	Yes: Non-consenting tenants must raise objections within 60 days from when the application was submitted
Connecticut <sup>b</sup>	Yes	Yes	Yes: Non-consenting tenants must raise objections within 60 days from when the application was submitted
British Columbia <sup>c</sup>	Yes	No	No
France <sup>d</sup>	Yes	Yes	Yes: Non-consenting tenants must raise objections within 6 months from when the application was submitted
Germany <sup>e</sup>	Yes	Yes	No
New Jersey <sup>b</sup>	Yes	No	Yes: Non-consenting tenants must raise objections within 60 days from when the application was submitted
New York <sup>b</sup>	Yes	No	Yes: Non-consenting tenants must raise objections within 60 days from when the application was submitted
Norway <sup>f</sup>	Yes	No	No
Oregon <sup>b</sup>	Yes	Yes	Yes: Non-consenting tenants must raise objections within 60 days from when the application was submitted
Virginia <sup>b</sup>	Yes	No	No
Hawaii <sup>b</sup>	Yes	No	No
Florida <sup>b</sup>	Yes	No	No
Washington <sup>b</sup>	Yes	No	Yes: Non-consenting tenants must raise objections within 60 days from when the application was submitted

<sup>a</sup> Parliament of Austria, “Residential property act – WEG amendment 2022,” <https://www.parlament.gv.at/gegenstand/XXVII/1/1174>.

<sup>b</sup> U.S. Department of Energy (DOE), “Alternative Fuels Data Center: State Laws and Incentives,” accessed August 26, 2023, <https://afdc.energy.gov/laws/state>.

<sup>c</sup> Legislative Assembly of British Columbia, “Strata Property Amendment Act 2023,” 42nd Parliament, 4th Session, Bill 22 (2023), [https://www.leg.bc.ca/content/data%20-%20ldp/Pages/42nd4th/1st\\_read/PDF/gov22-1.pdf](https://www.leg.bc.ca/content/data%20-%20ldp/Pages/42nd4th/1st_read/PDF/gov22-1.pdf).

<sup>d</sup> Government of France, Ministry for Ecological Transition and Territorial Cohesion, “Développement des nouveaux équipements et réseaux recharges des véhicules électriques, stationnement vélos et très haut débit,” May 11, 2021, <https://www.ecologie.gouv.fr/developpement-des-nouveaux-equipements-et-reseaux-recharges-des-vehicules-electriques-stationnement>.

<sup>e</sup> NOW GmbH, “Easy charging at residential buildings,” accessed April 21, 2022, <https://www.now-gmbh.de/aktuelles/pressemitteilungen/neuer-leitfaden-einfach-laden-an-wohnbaeuden-veroeffentlicht/>.

<sup>f</sup> Government of Norway, Ministry of Local Government and Regional Development, “Amendments to the Housing Associations Act,” Prop. 144 L (2019-2020), <https://www.regjeringen.no/no/dokumenter/prop.-144-l-20192020/id2765793/?ch=8>.

As shown in Table 1, several jurisdictions have right-to-plug regulations as of 2023. While most right-to-plug regulations apply to unit owners, some jurisdictions—such as Germany and the U.S. states of California, Connecticut, Colorado, and Oregon—provide the same treatment to renters. From an

equity perspective, this is an important consideration, as lower-income residents will typically be renters rather than owners.<sup>4</sup>

Some right-to-plug regulations set a deadline for denial, after which the charger installation is considered approved. This is intended to ensure that the installation process will happen within a reasonable timeframe. In the United States, the deadline is typically 60 days after the charger application is submitted.

While right-to-plug regulations help streamline processes by making the approval of the charger installations easier, they potentially expose tenants to high costs related to the acquisition, installation, and maintenance of the chargers. As explained below, many jurisdictions offer incentives to amortize these costs.

### Cost allocation

Another important consideration for MUDs is the cost-effectiveness of electrifying all parking spaces at once, as opposed to incrementally. Norway's right-to-plug law, for instance, allows the full electrification of all parking spaces under the condition that interested tenants provide the board or homeowners association with a comprehensive plan that specifies cost allocations, fair pricing, and safety measures, among other elements.<sup>5</sup> Innovative business approaches, like that of Logivolt in France (discussed below), can also provide avenues for equitably electrifying all parking spaces in an MUD.

The question of how costs are allocated is also relevant when it comes to electricity billing. When installing charging infrastructure in MUDs, it is important to ensure that tenants who do not drive EVs are not subject to higher electricity bills. If the building is equipped with individual electricity consumption metering, the approach is straightforward: the meter records the additional electricity consumption by each EV, which is then reflected in the corresponding tenant's electricity bills. In cases where the MUD is equipped with a shared metering system, in which electricity consumption is measured across several units, a typical approach is to contract a private network service provider to monitor charging by each EV owner; this approach may incur payment processing and service fees.<sup>6</sup>

### Building codes

Building codes relating to EV charger installations are most often introduced at the municipality level and require that a certain percentage of available parking spaces be equipped with an electrical installation that enables EV charging. The most common installations required by building codes are EV-capable and EV-ready configurations.<sup>7</sup> Less common are codes that require the

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4 Sarah Crump and Jenny Schuetz, "US Rental Housing Markets are Diverse, Decentralized, and Financially Stressed," Brookings, April 20, 2021, <https://www.brookings.edu/articles/us-rental-housing-markets/>; Bernard, *A Technical Analysis of Private Overnight Charging Access*.

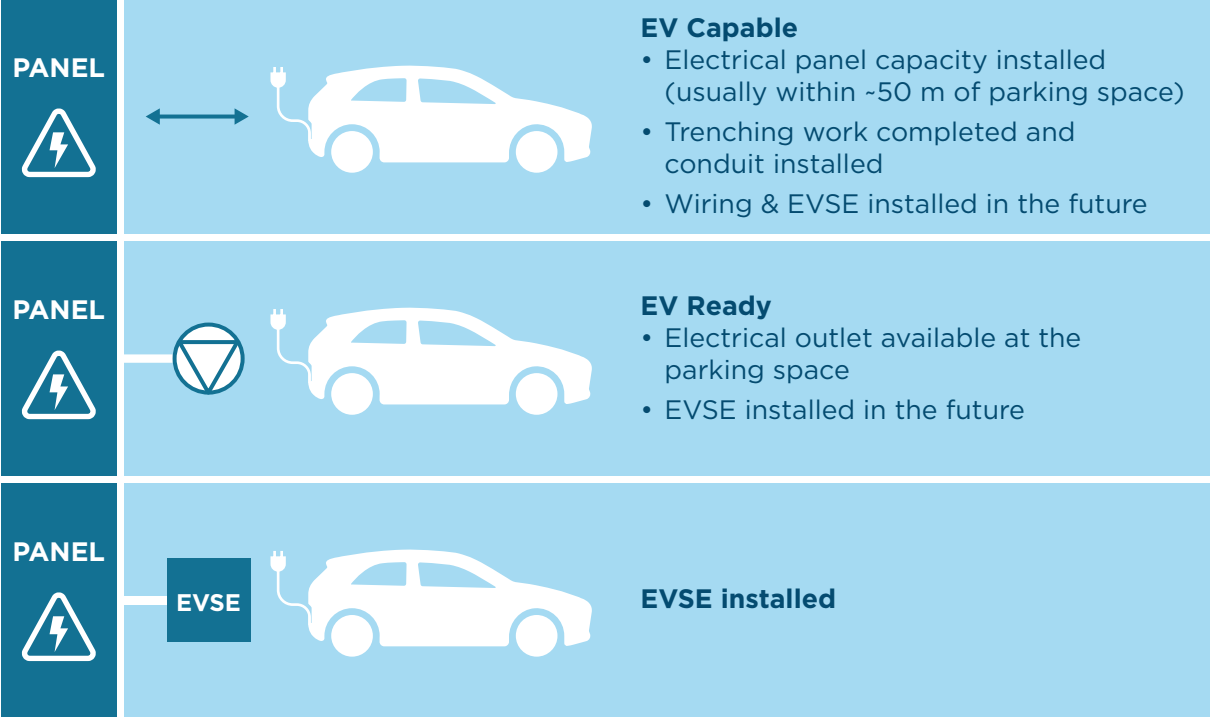
5 Government of Norway, Ministry of Local Government and Regional Development, "Amendments to the Housing Associations Act."

6 Center for Sustainable Energy (CSE) and the San Diego Association of Governments (SANDAG), *Multi-Unit Dwelling Electric Vehicle Charging* (n.d.), [https://sites.energycenter.org/sites/default/files/docs/nav/transportation/plug-in\\_sd/Plug-In\\_SD-EV\\_Charging\\_for\\_Multi-Unit\\_Dwellings.pdf](https://sites.energycenter.org/sites/default/files/docs/nav/transportation/plug-in_sd/Plug-In_SD-EV_Charging_for_Multi-Unit_Dwellings.pdf).

7 Dale Hall et al., *Electric Vehicle Capitals: Cities Aim for All Electric Mobility* (Washington, DC: ICCT, 2020), <https://theicct.org/publication/electric-vehicle-capitals-cities-aim-for-all-electric-mobility/>.

installation of electric vehicle supply equipment (EVSE) configurations, in which both the electrical system and charger are required to be installed.<sup>8</sup>

**Figure 1.** EV charging electrical configurations.



Source: Brendan McEwen and Devon Miller, *EV Ready MURB, Workplace & Fleet Parking: Incentive Program and Policy Interventions to Support Future Access to EV Charging* (prepared for BC Hydro by AES Engineering and ORIGIN, April 2020), privately shared with the authors.

Requiring the coverage of all available parking spaces could be particularly advantageous when considering a long-term scenario in which most tenants eventually drive an EV. In France, for example, building codes for new residential developments require that 100% of parking spots be EV-capable and that the electrical panel be dimensioned to be able to provide power to at least 20% of parking spots simultaneously, with a power per charging point of 7.4kVA. The building code does not require electrical circuits, so as not to preclude future technologies such as smart and bidirectional charging.<sup>9</sup> Similarly, among existing buildings with more than 10 parking spaces undergoing major renovations, 100% of available parking spaces are required to have EV-capable installations.<sup>10</sup> Similar legislation is also under discussion in the European Union, where the proposed Energy Performance Building Directive would require new residential buildings with more than three parking spaces to be EV-ready.<sup>11</sup>

8 Brendan McEwen and Devon Miller, *EV Ready MURB, Workplace & Fleet Parking: Incentive Program and Policy Interventions to Support Future Access to EV Charging* (prepared for BC Hydro by AES Engineering and ORIGIN, April 2020), privately shared with the authors.

9 Government of France, Ministry for Ecological Transition and Territorial Cohesion, “Développement des Nouveaux Équipements et Réseaux Recharges des Véhicules Électriques, Stationnement Vélos et Très Haut Débit,” May 11, 2021, <https://www.ecologie.gouv.fr/developpement-des-nouveaux-equipements-et-reseaux-recharges-des-vehicules-electriques-stationnement>.

10 Government of France, «Code de la Construction et de L’habitation,» Article L113-12 (July 1, 2021), [https://www.legifrance.gouv.fr/codes/article\\_lc/LEGIARTI000041563727](https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000041563727).

11 European Commission, “Proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings,” COM/2021/802 final (December 15, 2021), <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889>.

## Financial incentive programs

Several jurisdictions have instituted incentive programs to alleviate the high costs that can be incurred with the installation of chargers in parking spaces. In Canada, for example, MUD owners can receive up to \$5,000 through the Zero Emission Vehicle Infrastructure Program.<sup>12</sup> In the United States, several jurisdictions provide additional incentives for MUDs located in disadvantaged communities, defined as those most impacted by environmental harms and with less access to social and economic opportunities.<sup>13</sup> In the state of New Jersey, for example, owners or managers of an MUD located in a disadvantaged community can receive an incentive of up to \$6,000 for charging installation, \$2,000 more than the standard incentive.<sup>14</sup> California's Reliable, Equitable, and Accessible Charging for multi-family housing program, which focuses on low-income and disadvantaged communities, has pledged up to \$20 million in total grant funding for projects to install reliable chargers within or near MUD properties.<sup>15</sup> In markets where different levels of government (national, state, and municipal) provide incentives, allowing participants to stack such benefits could be considered. Additionally, all available incentive programs could be grouped under one single publicly accessible platform so that interested parties can easily be made aware of their existence.

Many other jurisdictions provide incentive programs for energy-efficient retrofit measures (e.g., thermal insulation work or installation of heat pumps or solar panels), but these programs typically do not consider electric vehicle charging stations as eligible for funding.<sup>16</sup> Integrating smart-enabled EV charging stations in MUDs can help better manage electricity use within the building by monitoring electricity consumption and adapting EV charging accordingly while maximizing the use of renewable energy (e.g., by storing excess electricity generated by renewable energies into EV batteries).<sup>17</sup> Another advantage of integrating EV charging station installations into energy retrofit programs is that it could help streamline processes by allowing MUD owners to apply for multiple clean and efficient energy measures through a single application platform and reduce labor costs by allowing multiple electrical upgrades to be performed at once.

Such integrated approaches exist or are in development in multiple jurisdictions. California's Property Assessed Clean Energy (PACE) financing program is available to commercial and residential building owners to integrate energy and water efficiency measures, including the installation of electric vehicle charging stations.<sup>18</sup> PACE financing is accessible within designated areas and allows property owners to finance energy retrofits for their residences without a down

12 Government of Canada, "Zero Emission Vehicle Infrastructure Program Funding for Owners and Operators of Charging and Refueling Infrastructure," updated October 26, 2023, <https://natural-resources.canada.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/zero-emission-vehicle-infrastructure-program/25027#S2>.

13 U.S. Environmental Protection Agency, "EJ 2020 Glossary," updated July 31, 2023, <https://www.epa.gov/environmentaljustice/ej-2020-glossary#:~:text=Overburdened%20Community%20%2D%20Minority%2C%20low%2D,disproportionate%20environmental%20harms%20and%20risks>.

14 New Jersey's Clean Energy Program, "Electric Vehicle Incentive Programs," accessed August 21, 2023, <https://njcleanenergy.com/residential/programs/electric-vehicle-incentive-programs>.

15 California Energy Commission, "GFO-22-614 - Reliable, Equitable, and Accessible Charging for Multi-family Housing 2.0 (REACH 2.0)," accessed October 18, 2023, <https://www.energy.ca.gov/solicitations/2023-04/gfo-22-614-reliable-equitable-and-accessible-charging-multi-family-housing-20>.

16 Daniel Aragón, "Promoting Energy Savings in Residential Buildings: National Examples of Initiatives from European Countries," European Commission, June 27, 2023, <https://build-up.ec.europa.eu/en/resources-and-tools/articles/overview-article-promoting-energy-savings-residential-buildings>.

17 Amy Egarter et al., *Energy Efficiency and Electric Vehicles: How Buildings can Pave the Way for the Global EV Revolution* (Boulder, CO: Rocky Mountain Institute, 2018), <https://rmi.org/wp-content/uploads/2018/09/Energy-Efficiency-and-Electric-Vehicles-2018-final-v2.pdf>.

18 California State Treasurer's Office, California Alternative Energy and Advanced Transportation Financing Authority, "Property Assessed Clean Energy (PACE) Loss Reserve Program," accessed August 21, 2023, <https://www.treasurer.ca.gov/caeatfa/pace/index.asp>.

payment. In Germany, the government is planning to introduce a €500 million incentive program to support residential buildings in acquiring electric vehicle charging stations, solar photovoltaic panels, and battery storage systems through a combined offer.<sup>19</sup>

## Innovative business and financing models

In addition to financial incentive programs, some jurisdictions look to innovative partnerships and financing models to promote charging installation at MUDs and address equity concerns related to charging access. This is particularly relevant in MUDs located within low-income and disadvantaged communities, where tenants' financial resources are particularly constrained.

Public-private partnerships can offer an opportunity for the private sector to streamline the process of installing overnight chargers at MUDs, backed by financial support from public institutions. In France, the startup Logivolt specializes in MUD settings; it covers all the upfront costs related to the electrical installation of chargers and is reimbursed by building residents over time. This is made possible through a loan from Caisse des Dépôts, a French public financial institution. Each tenant interested in the service is charged an identical connection fee. Through its partners, Logivolt also installs, maintains, and operates chargers, which includes billing the participating tenants. The loan from Caisse des Dépôts is reimbursed through billing and subscription fees, and Logivolt remains the owner of the electrical installation until the end of the contract or when it is purchased by the building owner.<sup>20</sup>

Through the process of installing the chargers, Logivolt also identifies and applies for available incentives, therefore reducing costs to participating tenants. By playing this role of intermediary among all involved stakeholders (e.g., building owners, EV users, and charging station operators), Logivolt simplifies the administrative duties of overnight charger installation. As of September 2023, Logivolt had supported over 3,000 MUDs in partnership with its 11 operators.

Other private sector actors are providing solutions to EV drivers who lack access to overnight charging at their premises. Companies like Co Charger in the United Kingdom and itselectric in the United States make it easier for EV drivers to access nearby home charge points that offer affordable charging rates compared to public chargers.<sup>21</sup> This peer-to-peer charging system makes more chargers available to EV drivers in areas with otherwise limited charging options while creating a revenue stream for those who have private chargers. Additionally, itselectric partners with MUD owners to install and maintain curbside low-powered Level 2 EV chargers near MUD locations. The chargers are installed at no cost to the MUD property owners and can be used by tenants who have a membership with the company. Also noteworthy is the German government's *German EV Infrastructure Masterplan II*, which alludes to the intention to examine ways in which private individuals or companies can share their charge points with third parties for a fee or at no cost.<sup>22</sup>

19 Government of Germany, Federal Ministry for Digital and Transport, "Charging Infrastructure Conference 2023: Wissing Announces New Subsidies for Private Households and Companies," June 29, 2023, <https://bmdv.bund.de/SharedDocs/DE/Pressemitteilungen/2023/065-wissing-ladeinfrastruktur-konferenz-2023.html>.

20 Logivolt, "Offre Co-propriété," accessed in August 2023, <https://logivolt.fr/offre-recharge-copropriete/>.

21 Co Charger, "About Us," May 24, 2022, <https://co-charger.com/about-us/>; itselectric, "How It Works," accessed August 22, 2023, <https://www.itselectric.us/how-it-works>.

22 German Federal Ministry for Digital and Transport (BMDV), Charging Infrastructure Masterplan II § (2022), [https://nationale-leitstelle.de/wp-content/uploads/2023/01/Masterplan-Ladeinfrastruktur-II-der-Bundesregierung\\_Englisch\\_DIN\\_A4\\_barrierefrei.pdf](https://nationale-leitstelle.de/wp-content/uploads/2023/01/Masterplan-Ladeinfrastruktur-II-der-Bundesregierung_Englisch_DIN_A4_barrierefrei.pdf).



Utility companies could also bear the upfront costs of MUD charging infrastructure. In France, a national decree allows the utility company Enedis to pre-finance EV-ready electrical installations in MUDs. Enedis then recoups its investment by charging a fee to EV owners when they want to install a charger at their parking spot.<sup>23</sup> This fee is the same for all residents of the same building and has a minimum and a maximum cap intended to keep it affordable, regardless of whether tenants live in an old building (where the actual price would likely exceed the cap due to higher electrical installation costs), or in a newer building (where the actual price would be lower). Before taxes, the minimum price paid by the consumer is €410 and the maximum is €2,038, accounting for a 40% subsidy provided by the utility. These caps are defined in such a way that 15% of the most expensive installations have had costs lowered to the maximum price cap, and 21% of the least expensive have been raised to the minimum.

There are other utility-initiated programs tailored specifically to MUDs located in disadvantaged communities to support their capacity for overnight charging. In California, MUDs in state-designated disadvantaged communities can benefit from Southern California Edison's Turn-Key Installation Program, which designs, installs, operates, and maintains charging equipment.<sup>24</sup> MUD tenants that drive EVs are only responsible for the cost of charging. By identifying and prioritizing support for underserved communities lacking access to public-private partnership programs or other innovative options, utilities could further close the charging access gap.

## Technology solutions for electricity grid management

As the EV fleet grows, concerns may arise regarding the ability of the electricity grid to support the additional electricity load of charging events. At the MUD level, there is also the need to ensure that EV charging events do not exceed the electrical panel capacity of the building.

Electric vehicle energy management systems (EVEMSs) are one possible approach to electricity grid management.<sup>25</sup> EVEMSs are supported by smart charging software technologies which enable real-time data exchange between the electric vehicle, the charging operator, and the utility company. Upon analyzing the data, the system can make real-time decisions, such as equally sharing the amount of energy delivered to each of the plugged EVs. This approach, commonly referred to as power sharing, can help to ensure that simultaneous charging events do not exceed the electrical panel capacity of the MUD.<sup>26</sup>

Adaptive scheduling is another common EVEMS approach, wherein charging events are organized based on EV driver schedules. Driver inputs (e.g., desired range and departure time) inform scheduling algorithms to ensure that EVs have sufficient charging at the time requested by the driver. The system also considers the capacity of the electricity panel to ensure that charging

23 French Energy Regulatory Commission, "Délibération de la CRE du 12 avril 2023 portant proposition sur l'encadrement de la contribution prévue par le décret n° 2022-1249 du 21 septembre 2022 relatif au déploiement d'infrastructures collectives de recharge relevant du réseau public de distribution dans les immeubles collectifs à usage principal d'habitation," April 12, 2023, <https://www.cre.fr/documents/Deliberations/Proposition/encadrement-de-la-contribution-prevue-par-le-decret-n-2022-1249-du-21-septembre-2022-relatif-au-dploiement-d-infrastructures-collectives-de-recha>.

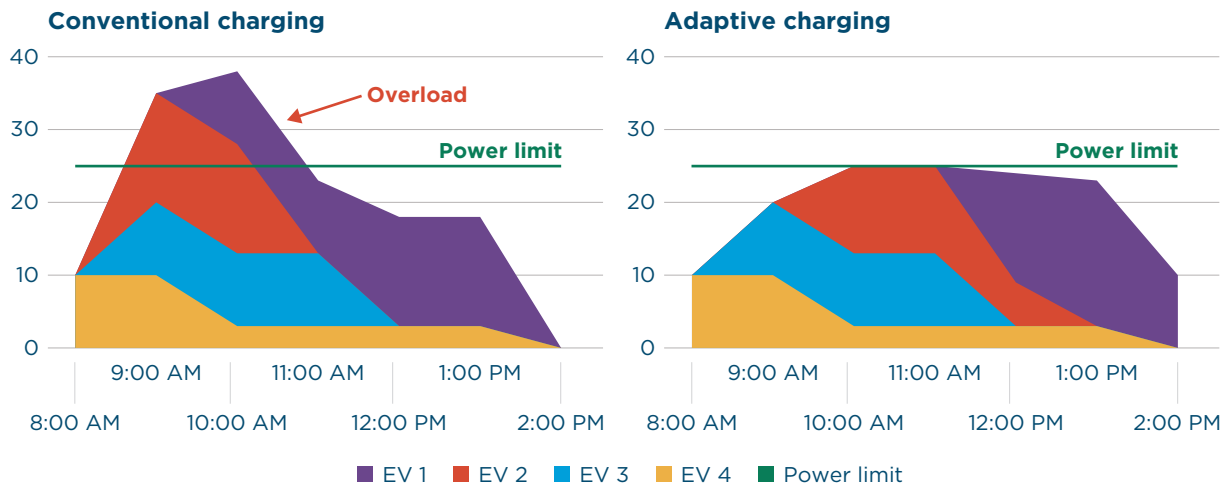
24 Southern California Edison, "Turn-Key Installation Program," accessed December 14, 2023, <https://www.sce.com/evbusiness/chargeready/turn-key-installation>.

25 Logan Pierce and Ahn Bui, *Promoting Equity in the Electric Vehicle Transition: Barriers and Solutions to Charging at Multi-Family Homes in the United States* (Washington, D.C.: ICCT, forthcoming).

26 Wallbox, "What is Smart Charging," accessed August 21, 2023, [https://wallbox.com/en\\_us/faqs-what-is-smart-charging](https://wallbox.com/en_us/faqs-what-is-smart-charging).

events do not cause overload, which could lead to a power shutdown or fire.<sup>27</sup> Figure 2 provides an illustrative example of power sharing among four EVs showing how the same total amount of energy can be provided over the same time period but with a lower maximum power.

**Figure 2.** Comparison of adaptive scheduling and conventional charging.



Furthermore, as mentioned by experts in stakeholder interviews, buildings usually have spare electrical capacity at night that could be used to charge EVs. As an example, RVE, an EVEMS company, has developed a set of devices that do not add load to the panel and constantly assess a dwelling’s spare electrical capacity to use it to charge the connected EV.<sup>28</sup> In other words, instead of sharing power between different EVs (as shown in Figure 2), the EV shares available power with different appliances in the tenant’s unit.

The use of EVEMS may pose challenges, however. For instance, it could translate into longer charging events, because power is shared or delivered based on a schedule, which might not be ideal in cases of unplanned or spontaneous trips.<sup>29</sup> Also, since they require networked chargers equipped with software, their upfront cost is higher than chargers that are not equipped with such technologies. To take a specific example, the Blink HQ 200 networked residential charger costs about \$1,000 more to purchase and install than the non-networked Blink HQ 100.<sup>30</sup> This could lead to affordability concerns, as further explained below.

Still, by effectively managing the electricity load, EVEMSs provide numerous benefits, including avoiding the costs and long timeframe associated with grid and electricity panel upgrades. They can also favor the use of cleaner renewable energy, which could result in lower charging costs while reinforcing the environmental benefits of EVs.<sup>31</sup>

27 Zachary Lee, “Adaptive Charging Breaks Down Barriers to Electric Vehicle Adoption,” California Institute of Technology, June 4, 2019, <https://ev.caltech.edu/info/>; CSE and SANDAG, *Multi-unit dwelling electric vehicle charging*.

28 RVE, “Smart and Simple Energy Management for All Buildings,” accessed August 22, 2023, <https://rve.ca/en/>.

29 Zachary Lee, “Adaptive Charging Breaks Down Barriers.”

30 Blink Charging, “Networked vs. Non-Networked Chargers for Hosts,” accessed August 21, 2023, <https://blinkcharging.com/understanding-networked-vs-non-networked-chargers-for-host-locations/>.

31 Egerter et al., *Energy Efficiency and Electric Vehicles*.

## Education and awareness

One of the main barriers identified in the stakeholder interviews presented in the appendix is the lack of information or clarity on the process of EV charger installations, including among building owners and managers, grid operators, and EV-owning MUD residents. The installation of an EV charger in an MUD requires several steps, such as securing approval from the landlord or homeowner association, obtaining knowledge of the types of chargers and electrical upgrades necessary for installation, finding possible grants or subsidies to cover upfront costs, and hiring an electrician. Equipping these stakeholders with the information and tools to navigate through the process is, therefore, imperative to increasing access to overnight chargers in MUDs.

Official guidelines or consultation services can help MUD building managers and residents to make informed decisions about EV charge point planning and installation and guide them through successful deployment. As part of its electric vehicle policy, the Government of Delhi, India, recently published a *Residential EV Charging Guidebook*, which provides step-by-step guidelines on how to estimate demand and plan for chargers, in addition to summarizing common challenges and solutions for resident associations.<sup>32</sup> Regional and city-level guidelines containing necessary information to successfully deploy EV charging infrastructure in MUDs can help diverse stakeholders orient themselves in jurisdictions where rules, requirements, and rights related to EV charger installation may vary.

Similarly, the Vehicle Charging Innovations for Multi-Unit Dwellings (VCI-MUD) project, funded by the U.S. Department of Energy, offers a comprehensive toolkit for MUD building managers and residents, which is based on data, surveys, and interviews from real-world examples in different states.<sup>33</sup> The toolkit illustrates successful approaches to EV charging by providing examples of innovative models and technologies, ranging from the shared use of charging infrastructure with public or commercial properties to mobile EV chargers.

Consultation services can provide credible, customized information regarding EV charger installation in MUDs. In the Netherlands, homeowner associations and housing cooperatives that have their own parking facilities can receive a 75% discount (up to a maximum of €1,500) for a consultation service led by a licensed expert, which includes an assessment of their electrical installation needs, identification of available incentives, a review of safety measures, and an overview of the cost distribution between the association and the users of the chargers.

In British Columbia, initial insights on tenants' charging needs and options are available through an EV advisor program that offers up to five hours of free consultation. For more detailed assessments, the government provides rebates that cover 75% (up to \$5,000) of the cost for the creation of a detailed EV-ready plan developed by a licensed electrician. The plan must include an electrical capacity assessment identifying peak load experienced in the MUD and the spare electrical capacity available when all tenants' electricity needs are met. A charging performance assessment of how much power is needed to accommodate charging events is also required.<sup>34</sup>

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32 Shri Jasmine Shah et al., *Residential EV Charging Guidebook* (February 2022), [https://ddc.delhi.gov.in/sites/default/files/multimedia-assets/residential\\_ev\\_charging\\_guidebook.pdf](https://ddc.delhi.gov.in/sites/default/files/multimedia-assets/residential_ev_charging_guidebook.pdf).

33 VCI-MUD, "Multi-Unit Dwelling EV Charging," accessed December 14, 2023, <https://vci-mud.org/>.

34 BC Hydro, "EV Charging Rebates for Apartment and Condo Buildings," accessed December 14, 2023, <https://electricvehicles.bchydro.com/incentives/charger-rebates/apartment#EV%20Advisor>.

## Charging solutions for EV owners without access to private parking

For EV drivers residing in MUDs, a lack of private parking spaces could limit opportunities for overnight home charging. In some cases, even when private parking space is available, the installation of a charger may come at a cost that the tenant or the MUD owner cannot afford.

Many governments utilize public land to provide charge points for those who do not have access to home charging. In Europe, some cities have deployed overnight charging options in on-street parking spaces via lamppost charging and community charging hubs. The UK Government's infrastructure strategy emphasizes local governments' role in providing charge points that could serve EV drivers without access to private parking; the United Kingdom's On-Street Residential Chargepoint Scheme, which covers up to 60% of capital costs of on-street charge points, had delivered over 6,000 charge points as of September 2023. A separate Local Electric Vehicle Infrastructure fund aims to expand low power, on-street charging infrastructure and was allocated £8 million in its first year of implementation (2022-2023).<sup>35</sup> Similarly, California offers funding of up to \$24 million for EV charging stations that are installed in underserved and disadvantaged communities under the Convenient, High-Visibility, Low-Cost Level 2 Charging program, therefore promoting equity and accessibility.<sup>36</sup>

In Baden-Württemberg, Germany, funding is available for E-Quartierhubs, which are off-street parking spaces equipped with shared charging infrastructure. Funding is provided only if the project reduces on-street parking, creating opportunities for public transport accommodation, cycling, pedestrian traffic, or recreational activities. The application must be submitted through a municipality to ensure cooperation with public parking management agencies. Participating garage operators receive a subsidy that covers up to 75% of the construction of an E-Quartierhub.<sup>37</sup> If carefully planned within close proximity to existing MUDs, E-Quartierhubs could provide solutions to MUD tenants without access to home charging.

In China, the Unified Construction and Operation program was introduced to address home charging needs in residential areas by establishing unified planning, construction, and service standards and facilitating collaboration among local governments, housing management, utilities, and homeowner associations.<sup>38</sup> Under this program, the charging station operator pre-finances the upfront costs of charger installation and operation and is compensated by the charging station users over time at a metered residential electricity rate. Pilot programs were successfully

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35 UK Government, "On-Street Residential Chargepoint Scheme Guidance for Local Authorities," December 1, 2022, <https://www.gov.uk/government/publications/grants-for-local-authorities-to-provide-residential-on-street-chargepoints/grants-to-provide-residential-on-street-chargepoints-for-plug-in-electric-vehicles-guidance-for-local-authorities>; UK Government, "Apply for Local Electric Vehicle Infrastructure (LEVI) Funding," March 30, 2023, <https://www.gov.uk/guidance/apply-for-local-ev-infrastructure-levi-funding>.

36 California Energy Commission, "GFO-22-610 Convenient, High-Visibility, Low-Cost, Level 2 Charging (CHILL-2)," accessed October 18, 2023, <https://www.energy.ca.gov/solicitations/2023-03/gfo-22-610-convenient-high-visibility-low-cost-level-2-charging-chill-2>.

37 Baden-Württemberg Ministry of Transport, "Förderaufwurf E-Quartiershubs," accessed December 14, 2023, <https://vm.baden-wuerttemberg.de/de/politik-zukunft/elektromobilitaet/foerderung-elektromobilitaet/foerderauef-e-quartiershubs-1?highlight=E-Quartiershubs>.

38 Shanghai Municipal People's Government, "Notice of Shanghai Municipal Transportation Commission, Municipal Development and Reform Commission, Municipal Commission of Housing and Urban-Rural Development, Municipal Commission of Economy and Information Technology, Municipal Housing Administration Bureau, Municipal Public Security Bureau, Municipal Fire and Rescue Corps on Issuing of the Procedures of Shanghai Municipality on the Construction and Management of Electric Vehicle Charging Facilities in Residential Quarters," September 19, 2023, <https://www.shanghai.gov.cn/202311th/20230919/ca8c019a7b084f1a9f7384c862de71cc.html>.

implemented in Wenzhou and Jianshan, and at least 15 are planned in Beijing in 2023–2024 with funding from the municipal government.

Other approaches noted above, such as peer-to-peer charging and public-private partnerships, can also provide solutions to EV drivers without access to home charging. Workplace chargers could additionally play an important role by providing an opportunity for MUD tenants to charge while at work, which could reduce the need for an overnight charging option.

## Mitigating EV fire risks in parking garages

EV fires are rare, and less frequent than conventional vehicle fires.<sup>39</sup> However, when they do occur, they are generally harder to extinguish, requiring that adequate safety measures be put in place.<sup>40</sup> Some governments, including in Austria, the Netherlands, and the United States, have introduced policies and regulations to mitigate risks associated with EV fires in parking garages. Such measures typically require the installation of sprinklers in new garages, the optimization of ventilation systems for smoke dissipation, the availability of a shutdown power devices to allow for chargers to be disconnected from the power grid when a fire occurs, the placement of charging stations close to the parking entrance, and the development of a plan that lists or maps charger locations and their shutdown devices to inform firefighters' interventions.<sup>41</sup>

In jurisdictions where such regulations have not yet been introduced, governments could propose guidelines. In the United Kingdom, interim guidelines introduced in 2023 outline several measures to mitigate EV fire risks, including increasing the distance between parked vehicles to limit fire propagation.<sup>42</sup> Guidelines could also support more consistent requirements from insurance companies against EV fires. Indeed, interviewees mentioned that insurance companies' requirements are inconsistent, making them hard for building developers and managers to navigate. Some of the interviewees also mentioned that it will be important for local governments, as well as MUDs, to closely collaborate with fire authorities to develop training and guidance on EV fire risk and safety.

## Addressing affordability concerns related to the installation of EV chargers in low-income and disadvantaged communities

The desire to support convenient overnight charging access for all may raise concerns regarding housing affordability, especially within low-income and disadvantaged communities. For these

39 EV Fire Safe, "EV Fires – Overview," accessed December 14, 2023, <https://www.evfiresafe.com/ev-battery-fire-overview>.

40 Peiyi Sun et al., "Correction To: A Review of Battery Fires in Electric Vehicles," *Fire Technology* 56, no. 1411 (2020): <https://doi.org/10.1007/s10694-020-00958-2>.

41 Austrian Institute of Construction Engineering (OIB), "OIB-Richtlinie 2.2: Brandschutz bei Garagen, überdachten Stellplätzen und Parkdecks," May 2023, <https://www.oib.or.at/de/oib-richtlinien/richtlinien/2023/oib-richtlinie-22>; vb&t Makelaars, "Nieuwe Bouwregels Opladen Elektrische Voertuigen (EV's) in Parkeergarages," March 18, 2022, <https://www.vbtbrandveiligheidsmilieu.nl/nieuwe-bouwregels-opladen-elektrische-voertuigen-evs-in-parkeergarages/>; Brian O'Connor, "Fire Safety for Electric Vehicles and Other Modern Vehicles in Parking Structures," National Fire Protection Association, November 28, 2022, <https://www.nfpa.org/News-and-Research/Publications-and-media/Blogs-Landing-Page/NFPA-Today/Blog-Posts/2022/11/28/EVs-and-Parking-Structures>.

42 UK Government Office for Zero Emission Vehicles, "Covered Car Parks - Fire Safety Guidance for Electric Vehicles," July 11, 2023, <https://www.gov.uk/government/publications/covered-car-parks-fire-safety-guidance-for-electric-vehicles>.

communities, apprehensions could arise if the integration of EV charging in new or retrofitted buildings translates into higher rents or electricity bills.

To alleviate concerns, governments could invite representatives to stakeholder dialogues to ensure community perspectives are taken into consideration. Such efforts could go hand in hand with raising awareness about the socioeconomic and environmental benefits of the EV transition, such as cost savings through lower fuel and maintenance costs and improved air quality. This could be achieved through workshops in which a direct dialogue can take place between community members and EV expert groups. Furthermore, governments can facilitate access to jobs within the EV supply chain for members of low-income communities. For example, California provides an entry-level charger installation and service training program in low-income, disadvantaged, and rural communities.<sup>43</sup>

The choice of charger technology could also mitigate concerns related to housing affordability. Acterra, a California-based environmental non-profit organization, recommends the use of low-powered Level 2 chargers with a wall outlet to accommodate low-income multi-unit residents. Using higher-powered charging stations could result in higher electricity bills or rent, potentially leaving low-income residents vulnerable to displacement.<sup>44</sup> Acterra also recommends that the Government of California regulate charging point operators in low-income areas to ensure fairness regarding the fees they charge for their services.<sup>45</sup>

## Summary of policies and other approaches to maximizing overnight charging in multi-unit dwellings

Table 3 below lists policies and other approaches that governments can use to maximize overnight charging in MUDs, noting selected advantages and challenges of each measure. The table also provides examples of jurisdictions where those measures have been applied. Where policy options address roadblocks identified in stakeholder interviews (see the appendix), the table notes the roadblock in parentheses next to the type of approach.

43 Brian Fauble et al., *California's Deployment Plan for the National Electric Vehicle Infrastructure Program* (Caltrans and the California Energy Commission, 2022), <https://rebuildingca.ca.gov/static/2022-ca-nevi-deployment-plan-a11y-8acc5dc59e4a797c873f28e1bfb74805.pdf>.

44 Linda Hutchins-Knowles, "Helps us make EV charging accessible to all," Acterra, September 7, 2021, <https://www.acterra.org/blog/2021/9/17/ev-charging>.

45 Remarks by Acterra representative Jared Johnson, Electric Vehicle Symposiums (EVS) 36, June 2023.

**Table 3.** Policies and approaches to maximize access to overnight charging in multi-unit dwellings.

Policy option	Example	Advantages	Challenges
<b>Regulations (Building and parking infrastructure)</b>			
<b>Right-to-plug laws</b>	Connecticut right-to-plug law allows unit owners or renters to install an EV charger; the owner or renter is responsible for the associated costs	Ease the process of charger installation and clarify financial responsibility	Potentially expose tenants to high costs of EV charger installation and operation
<b>Building codes</b>	France requires that 100% of parking spots be pre-equipped and electrical panels be dimensioned to provide power to at least 20% of parking spots in new and retrofitted MUDs	Ensure new and retrofitted buildings are EV-ready	Potential risk of displacing lower-income residents
<b>Incentive programs (Cost)</b>			
<b>Including charging infrastructure installation as eligible under retrofit incentive programs</b>	California's PACE program enables owners of residential buildings to apply for multiple energy retrofit measures through a single application	Tenants or owners apply for multiple incentives through a single application	Might slow down the process of receiving incentives due to the involvement of many stakeholders
<b>Providing incentives to overcome the upfront cost and installation of chargers</b>	Canada's Zero-Emission Vehicle Infrastructure Program offers \$5,000 for the acquisition and installation of a charger	Helps to overcome upfront cost barriers	Public funding may be limited
<b>Innovative business approaches and equitable financial schemes (Cost)</b>			
<b>Public-private partnerships</b>	Logivolt provides loans to charge point operators to make MUD parking EV-ready and install and manage chargers; Logivolt then collects subscription fees from users to reimburse initial costs	Alleviate financial and administrative burdens of installing EV chargers at MUDs and distribute costs evenly across users	May take a long time to earn back investments
<b>Utility-run programs targeting disadvantaged or overburdened communities</b>	Southern California Edison's Turn-Key Installation Program designs, installs, and maintains chargers only with associated utility bill	Prioritize MUDs in disadvantaged areas to promote equity	Limited incentive without government funding; potential lack of awareness among those eligible
<b>Peer-to-peer charging</b>	Companies like Co Charger and itselectric provide charger sharing services	Uses existing infrastructure by allowing sharing through apps	Requires availability of private chargers and willingness to share
<b>Technology solutions for load management (Grid electrical capacity)</b>			
<b>Integrating electric vehicle energy management system (EVEMS) to manage load on MUD electricity panel and grid</b>	Use of adaptive charging, whereby charging events are spread out based on EV driver schedules	Helps to manage load on the grid, maximize renewable energy use, prevent electrical panel upgrade costs, and reduce charging costs	Requires more expensive networked chargers

Education and awareness			
<b>Providing incentives for expert consultation to inform EV charger planning in MUDs</b>	The Netherlands' consultation incentive covers 75% of the consultancy cost up to €1,500	Provides MUD owners with key information on charger installations (e.g., costs, electrical upgrades, power requirement, and safety)	May be difficult to educate and raise awareness without the use of technical language
<b>Developing guidelines and online toolkits to educate stakeholders</b>	The Vehicle Charging Innovations for Multi-Unit Dwellings toolkit, funded by the U.S. Department of Energy, raises awareness based on case studies showcasing successful approaches	Educates different stakeholders on the process of acquiring EV chargers	May be difficult to educate and raise awareness without the use of technical language
Solutions for parking orphan MUD			
<b>Providing curbside charging infrastructure</b>	The UK On-Street Residential ChargePoint Scheme covers up to 60% of capital costs of on-street charge points	Allows nearby charging solutions for EV owners who lack access to private at-home charging	Potential exposure to higher charging costs and competition with public space utilization
<b>Providing off-street charging infrastructure</b>	Baden-Württemberg's E-Quartierhub program provides funding for off-street charging options while reducing on-street parking	Provides nearby charging solutions for those without access to private at-home parking while decreasing competition for street space	May not always be feasible, and high cost of installing chargers off-street such as in underground parking lots
<b>Installing public chargers in low-income and disadvantaged communities</b>	California's Convenient, High-Visibility, Low-Cost Level 2 Charging program	Allows nearby charging options in low-income and disadvantaged communities	Potential exposure to higher charging costs
EV fire risks mitigation			
<b>Identifying measures to mitigate risks associated with EV fires in enclosed spaces</b>	Proposed legislation in the Netherlands would require the installation of shutdown power devices on charging infrastructure	Mitigates risks of fire propagation or explosion	More research and data are needed to fully comprehend the causes of EV fires
<b>Providing non-legally-binding EV fire safety guidelines in consultation with fire agencies</b>	Interim guidelines introduced in the United Kingdom include several measures to mitigate EV fire risks	Creates a baseline for all insurance companies to align requirements	Not legally binding, so insurance companies could require additional measures
Addressing affordability concerns (Process and stakeholder engagement)			
<b>Community outreach and engagement</b>		Help ensure communities have a voice in decision-making and benefit from the EV transition	Language barriers or poor internet connections for virtual meetings could dim effectiveness
<b>Use of affordable charger technologies</b>		Reduces risks that high-cost chargers translate to higher bills or rent	Could potentially reduce opportunities to use smart charging



## Conclusions

Because a growing share of EV owners are expected to live in MUDs in the future, it is urgent to identify measures to maximize overnight charging in multi-family residences.<sup>46</sup> Based on a review of the literature, discussions with government representatives, and stakeholder interviews, the authors draw the following conclusions:

**Incentive programs and innovative business approaches could help to ensure an equitable EV transition and a stronger business case for MUD charging.** Many stakeholders perceive the cost associated with charger acquisition and installation as one of the main barriers to maximizing overnight charging in MUDs. Multiple jurisdictions operate incentive programs that help to alleviate these costs. These programs are particularly important in low-income and disadvantaged communities, where constrained financial budgets reduce tenants' ability to purchase such equipment. The emergence of new business models and financing schemes could make EV chargers accessible to all while strengthening the business case for MUD charging.

**Education and awareness programs can help stakeholders navigate the process of charger installation.** Considering the relative novelty of the electric vehicle charging market, many stakeholders have yet to develop a solid understanding of the different processes, technologies, business approaches, and support programs that could be leveraged to increase overnight charging at MUDs. This knowledge would ideally be provided through multiple existing channels of communication where prospective EV buyers could learn more about the processes to acquire and install an EV charger. Similarly, from a MUD owner or manager's perspective, having access to expert advisory and consultation services can inform deliberations over whether to install EV chargers in their properties. Community outreach and engagement efforts will also be important in low-income and disadvantaged communities to ensure that they are not excluded from the environmental and economic benefits of the EV transition.

**Developing charging solutions for EV owners without access to private parking can ensure access to convenient overnight home charging.** A lack of private parking and high costs associated with charger installations could limit opportunities for convenient access to overnight charging in MUDs. Solutions could include deploying chargers near MUDs or innovative business models such as peer-to-peer charging. In addition, workplace chargers could reduce the need for overnight charging or be used by nearby residents to charge at night.

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<sup>46</sup> Bernard, *A Technical Analysis of Private Overnight Charging Access*.

## Appendix

This appendix presents the outcome of interviews of five stakeholder groups conducted to better understand the topic of overnight charging access, especially for MUDs. Each interview touched on the following topics: barriers already resolved, remaining roadblocks to deployment, solutions to these roadblocks, and the stakeholder’s role in maximizing overnight charging access.

This appendix is organized in two parts. First, we describe the stakeholders’ roles in helping to increase overnight charging access and summarize the interviewees’ views on current solutions and remaining challenges. We then summarize the challenges and solutions to overnight charging access identified by the interviewees. This latter part is organized around five themes: building and parking infrastructure, process and stakeholder engagement, education and awareness, electrical grid capacity, and cost.

The authors thank all the interviewees presented in Table A1 for their insights on maximizing overnight charging access for EV owners. This appendix is not intended to be an exhaustive overview of the perspectives of all MUD overnight charging stakeholders, but a summary of the interviews conducted by the authors.<sup>47</sup>

**Table A1.** List of stakeholders interviewed with their affiliation.

Stakeholder group	Stakeholder type	Organization name	Jurisdiction	Interviewee
Charging solution providers	Charge point operators	WAAT & AFOR	France	Patrick Kic
	Technology providers	RVÉ	Canada	Caroline Selber
Electricity stakeholders	Electric utilities	Enedis	France	Isabelle Deleuze and Vesna Mermet
		Hydro-Québec	Québec, Canada	Daniela Levasseur
Real Estate	Housing providers	California Housing Development Corporation (CHDC)	California, United States	Vivian Rahwanji
Regulators	Energy regulators	California Energy Commission	California, United States	Mike Nicholas, Tiffany Hoang, and Adam Davis
	Local authorities	Amsterdam municipality	Amsterdam, Netherlands	Tommy Borger
		Berlin eMO	Berlin, Germany	Daniel Bussin
		Dundee city authority	Dundee, Scotland	Fraser Crichton
EV users and electromobility advocacy organizations	Education	MURBLY	Canada	Caroline Selber
	Research and Industry organizations	AVERE	Europe	Raphael Héliot and Thomas Neumann
	Building residents and EV drivers	EVA Scotland	Scotland	Neil Swanson
		Norwegian EV Association	Norway	Sveinung Kvalø
		Forth mobility	United States	Whitaker Jameson

<sup>47</sup> Perspectives discussed in this report are the recommendations and observations of the interviewees and do not necessarily reflect the views of the ICCT or members of the ZEV Alliance.

## Stakeholder groups

### CHARGING SOLUTION PROVIDERS

A charging point operator is an entity responsible for the management, operation, and maintenance of a charger, while the mobility service provider provides products and services such as charging subscriptions and the corresponding charging card. An energy management system company provides smart technology solutions to manage the energy delivered from chargers to EVs, which allows an optimized utilization of the existing electric capacity. For charge point operators and energy management system companies, responsibilities could extend to informing owners or residents about the various technical solutions for providing charging. Both could intervene when parking is already equipped with an electrical system by proposing optimized charging options to residents, or before the installation of the electrical system by suggesting solutions and acting as the middleman between building managers and electricity utilities.

According to the interviewees, technical solutions and financing options exist, required workforce skills are known, and chargers are readily available. Remaining roadblocks include the time it takes to install chargers, proper energy management, and inadequate stakeholder knowledge and information sharing.

### ELECTRICITY STAKEHOLDERS

An electric utility is an organization that operates electricity lines and distributes electricity. Their role could be to suggest demand management solutions and undertake necessary upgrades to ensure that long-term demand is accounted for where management solutions are insufficient. Their role can also be to inform building owners or managers about the various technical solutions to make their parking EV-ready. They are a key stakeholder to engage with throughout the process of equipping the MUD with EV charging capability, from drafting the building EV readiness plan to delivery of the charging infrastructure. It is important to give them advanced notice that grid connections will be required.

According to the interviewees, technical solutions to help increase overnight charging access already exist, and worker shortage is not a long-term issue, as the sector will identify skill shortages and provide workforce training. Cost and stakeholders' lack of knowledge are the only remaining roadblocks.

### REAL ESTATE

A housing provider is an entity responsible for the development, management, and operation of the residential building where current and future EV owners can potentially charge their vehicles. Housing developers play a key role in determining the pace of EV readiness in new and existing buildings. Their decisions can be based on various factors, including building codes and other regulations, recognition of the growing popularity of EVs, and interest in increasing their properties' value. Charging solution providers and electric utilities can work closely with housing developers to bring overnight charging access to residents.

According to interviewees, cost is still the biggest barrier to EV adoption and overnight EV charging for people living in multi-family homes. This includes the cost of purchasing or leasing an electric vehicle and the cost of charging it. If charging is available but has low utilization, the cost of charging may be too high for EV users.

## REGULATORS

Local governments have an important role to play in developing public and private electric vehicle charging infrastructure due to their authority over zoning, parking, building codes, and permitting and inspection processes. They can help to identify available public lands to install chargers, identify gaps in charging infrastructure deployment, allocate funds, and implement mechanisms to bring in the private sector. Government agencies coordinate to ensure a harmonized approach and common understanding of EV uptake and corresponding charging needs to ensure equitable charging infrastructure access for all. Their role is especially important in the early stages of EV adoption before the private sector has stepped in to provide the needed chargers.

According to the interviewees, work is underway in many areas, such as standardization of fire safety procedures, the development of community charging hubs, and knowledge sharing, but several roadblocks remain. These include the lack of knowledge among EV drivers and housing owners, limited electric capacity in buildings, cost, and the need for clear regulations on EV readiness, especially for new buildings.

## EV USERS AND ELECTROMOBILITY ADVOCACY GROUPS

EV owner associations help accelerate the adoption of electric vehicle by educating the public about the benefits of driving electric, providing relevant resources to their members, and voicing their concerns. The associations can support EV owners as they advocate for more charging access in their residences. Similar to EV owner associations, electromobility advocacy groups advocate for the transition to electric transport and can represent a broader coalition of industry, academia, and EV users. Electromobility research and academia groups investigate factors that contribute to the development of the electric mobility transition and can develop policy and operational recommendations to support the needs of other stakeholder groups.

Some interviewees highlighted that implementing right-to-plug regulations is one of the first steps to addressing overnight chargers for residents who can afford the cost. However, the overall cost and the cost per EV owner is cheaper if all tenants agree on the electrification of the entire parking facility at once.

## Solutions to MUD overnight charging roadblocks

Below is a summary of the roadblocks to expanding charging in MUDs mentioned by the various stakeholder groups during the interviews. Each of these roadblocks are addressed with detailed solutions suggested by the interviewees. These roadblocks and solutions are grouped into five themes: building and parking infrastructure, process and stakeholder engagement, education and awareness, electrical grid capacity, and cost. The stakeholders that could be involved in resolving the roadblock are noted in distinct colors for each stakeholder group.

## Building and parking infrastructure

**Roadblock:** The need for clarification of current regulations and the development of new regulations related to electric vehicle parking and charging requirements, especially for new buildings.

**Solution (regulators and real estate):**

- Governments can clarify the regulations concerning providing electricity to EV chargers. For example, questions remain regarding whether building owners would be regulated like electricity providers if energy generated by solar panels is used for EV charging. This uncertainty entails risks for apartment building owners, as they could be taxed more heavily in certain jurisdictions if that would be the case.
- Governments can mandate building codes that future-proof new buildings and those undergoing major renovation, as building developers may not voluntarily make buildings EV-ready in order to keep costs low.
- Electrical panels should be incrementally upgradeable and installed outside the building to avoid considerable construction work in the future when the panel capacity rises above the threshold in which it can be installed inside the building.

**Roadblock:** There is no standard fire safety procedure, leading to unharmonized requirements from insurance companies.

**Solution (regulators and real estate):**

- Regulators could develop a fire safety guidance document that can be referred to by insurance companies and building owners. This document does not need to be legally binding but would serve as a common reference to harmonize practices.
- Collaborate with fire authorities on fire risk-related topics and trainings.
- Install water systems that can keep a fire under control until firefighters arrive if sprinklers cannot be installed because of insufficient water pressure.
- As necessary, lower the amperage of the circuit used by chargers to an amperage that will still suit charging needs and comply with fire regulations. This also helps to avoid maxing the panel capacity for other future EV owners.

**Roadblock:** Public on-street charging sometimes conflicts with urban planning objectives such as historical district preservation and public space utilization priorities.

**Solution (regulators and businesses):**

- Open school parking lots with chargers at night or during non-school days to neighborhood residents.
- Develop more workplace charging.
- Provide other solutions for buildings that do not have garages, such as pop-up chargers that are fully retractable underground to leave pavements clear when not in use, chargers near shopping hubs, and charging hubs across the city that are coupled with solar roofs and dynamic load management.

- Provide discounts on parking fees if residents park on the outskirts of the city for at least one week per month and develop last-mile programs to accommodate the trip back home.
- Incentivize companies to open their infrastructure or grid capacity at night for public use. A booking system could be put in place so that companies can monitor usage.
- Promote peer-to-peer charging rentals.
- Reduce underground parking fees to the same price as on-street parking for EV driver charging.

**Roadblock:** No off-street parking and charging availability.

**Solution (regulators and charging point operators):**

- EV owners can request a charger deployment near their home.
- Install pop-up chargers at charging hubs close to shopping areas or at bus stops that are underutilized.

## Process and stakeholder engagement

**Roadblock:** There is no one-size-fits-all solution for chargers in apartment buildings.

**Solution (regulators):**

- Provide incentives for building managers to hire an adviser who can help determine the best charging solution for each particular case.

**Roadblock:** The charger installation process in apartment buildings is too complicated.

**Solution (regulators and building managers):**

- In many countries, a majority of owners have to agree before the parking electricity network can be upgraded to allow for a cost-efficient installation of chargers. An alternative solution could be that those seeking to install chargers would have to present to the managing board of the building that they have a plan which considers such things as fair pricing, allocation of costs, and fire safety provisions. If the board does not approve the plan, those seeking to install chargers can take the matter to civil court.
- In many locations, MUD building managers hold unit owner assemblies only once per year. The topic of charging infrastructure installation may only be discussed in person during these assemblies, which can significantly slow down the process. Regulators could allow this topic to be discussed more often and potentially voted on online.
- Regulators could make it mandatory that electric vehicle supply equipment issues be discussed during annual unit owner assemblies.
- Local governments can implement right-to-charge laws.

**Roadblock:** It takes too long to provide grid connections.

**Solution (regulators, electric utilities, and charge point operators):**

- Notify the electric utility as soon as possible of plans to install charging; do not wait until a tenant or owner has an EV or until the building runs out of capacity for EV chargers.

- Bring in third parties to reduce electric utilities' workloads. Request that the utility provide a new electricity delivery point outside or inside of the building or a transformer to have some flexibility related to the power needed. Another entity, such as a charge point operator, can be commissioned for the cabling work and maintenance.
- The electric utility could expand its workforce to meet increasing demand.
- Fines could be levied against the entity in charge of delivering the grid connection if it takes more than an allotted time. Permits to install EV chargers could also be approved by default if they have not been rejected within a certain time period.

**Roadblock:** Sharing chargers between EV owners can be challenging due to apartment parking policies and competition between EV owners over parking spaces.

**Solution (regulators, building managers, and research and industry organizations):**

- Incentivize tenants to swap parking spots or institute a booking system for parking spots with an EV charger. This policy is usually hard to implement because tenants are not willing to give up a good parking spot; therefore, a financial incentive could be helpful.
- Invest in research and development to find a solution for movable chargers. Such chargers could be moved to accommodate all chargers in a row.

## Education and Awareness

**Roadblock:** Information exists but is not efficiently channeled to MUD owners and managers, real estate developers, tenants, landlords, and EV owners.

**Solution (regulators, electric utilities, research and industry organizations, and electromobility advocacy groups):**

- Car dealers, potentially with incentives and support from automakers, can inform EV buyers of charging options at the time of purchase so that EV owners can give advance notice to their electricity utility and MUD managers.
- Governments can subsidize experts to inform and train MUD owners and managers, MUD associations, and tenant associations, among others. For instance, these experts could attend annual MUD owner assemblies to inform all participants about charging options. Alternatively, the experts could produce technical reports that help MUD managers make informed decisions that are tailored to their buildings.
- Governments could make training on charging access mandatory for condominium boards.
- Government, utility, and non-profit agencies can tailor informative material specifically to each stakeholder. The information and educational programs can be tailored more to underrepresented and marginalized EV user groups, and be made available in different languages.
- Stakeholders can create organizations to spread awareness of EV charging in multi-unit dwellings among residents, building managers, and building representatives.

## Electrical grid capacity

**Roadblock:** Electrical grid capacity is not sufficient to enable electric vehicle charging.

**Solution (technology providers, regulators, electric utilities, and real estate):**

- To optimize energy management, governments and/or building managers could take an integrated approach in buildings by installing heat pumps, solar panels, and EV chargers. However, bundling incentives could lengthen the process, and types of labor needed for these installations differ. Therefore, incentive stacking is encouraged, and incentive recipients can be informed of all incentive programs upon application.
- Regulations can be put in place whereby a municipality can request a connection to nearby buildings for on-street EV chargers if the buildings have additional capacity, and the building owner receives financial compensation.
- MUDs should be EV-capable at the time they are built, with trenching in place. However, some interviewees did not recommend buildings be pre-cabled or have EVSEs installed to avoid stranded assets as the technology may evolve. Other interviewees highlighted the cost-effectiveness of fully equipping the parking lot at the time of construction.
- Retrofit buildings' electrical systems to accommodate chargers. It is considerably cheaper per parking space to provide one charger per dwelling unit all at once instead of incrementally adding charger capacity.<sup>48</sup>
- Install energy management solutions to limit electricity network impact.

**Roadblock:** Efficiently and fully using a building's remaining electrical capacity can be challenging.

**Solution (technology providers, regulators, and electric utilities):**

- Because many buildings have remaining capacity at night that could be used to charge EVs, charging firm RVE offers a set of devices to optimize available electrical capacity and use it to charge EVs. These devices, which do not add load to the panel, can accommodate various solutions depending on the accessibility of residents' meters.
- Electric utilities could quickly share, free of charge, information on power consumption of a building with MUD managers to allow for an accurate assessment of remaining capacity and the possibility of installing chargers.
- Understanding the maximum number of EVs, and the typical distance they travel, is important for establishing power sharing or an energy management system in a given facility. For example, for an 80 amp circuit breaker and a mean daily travel distance of 45 km or less among EVs to be charged, 10 EVs can be supported.

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<sup>48</sup> Brendan McEwen, "Retrofitting EV Chargers into a Multifamily Building: The Merits of a 100-per-Cent EV-Ready Approach-Publications," AES Engineering, March 2, 2021, <https://aesengr.com/publications/retrofitting-ev-chargers>.



## Cost

**Roadblock:** Clarity is needed on how to fairly distribute costs among stakeholders. It is cheaper to electrify an entire parking lot all at once than to incrementally add EV chargers and connect them to the grid. However, not all residents may need an EV charger at the time that the parking is made EV-ready.

**Solution (regulators, charge point operators, and building managers):**

- Regulators can allow utilities to pre-finance EV-ready electrical installations and set up a structure so that they are reimbursed over time. For example, the French government passed a pre-financing decree that allows its electricity utility to pay the upfront cost of EV-ready installations and be reimbursed when EV owners decide to install chargers at their parking spot. There is a cap and a minimum on the cost paid by EV owners; projects costing less than the minimum threshold help pay for projects above the cap.
- Foster public-private partnerships and provide long term loans. For example, Logivolt brings in a public financial institution as a third party to finance the EV readiness of MUD parking. The loan is given to the charge point operator, which installs the chargers and evenly spreads the costs among residents when they ask for a charger.
- Offer options to MUD managers to transfer ownership of the chargers if they do not see the commercial benefit or do not want the responsibility of charger management. For example, in Dundee, Scotland, MUDs can transfer ownership to the Dundee City Council after a year.
- As EVs approach price parity with internal combustion engine vehicles, funding used for EV purchase incentives could be transitioned to funding charging infrastructure.
- MUD residents can share the cost of pre-cabling, which can then be spread throughout electricity billing cycles to reduce the cost per cycle.

**Roadblock:** For individuals who receive an EV as a benefit in kind from their place of employment, it can be difficult for the company to reimburse the fuel cost, as there is a need to differentiate electricity used for charging and electricity used for other home appliances.

**Solution (electric utilities and technology provider):**

- Install smart meters at home so that companies are billed directly without any interim costs borne by the EV owner.

**Roadblock:** Providing charging at market rates is not equitable in affordable housing developments because many renters or homeowners cannot afford electric vehicles and charging.

**Solution (regulators and charge point operators):**

- Increase grant funding for affordable housing residents for EVs and charging.
- Couple grants for EV charging with solar panel installation grants to generate revenue so that residents incur almost no net cost for charging.

**Roadblock:** Stakeholders use different return-on-investment calculations for making investment decisions. Developers and utilities might not consider investments with a longer return.

**Solution (regulators, real estate, and electric utilities):**

- State or national governments could incentivize or otherwise encourage developers and utilities to accept a longer return on investment. This may, for example, make housing and charging developers more willing to invest in underserved areas that might take a longer time to join the electric transition.

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