EV CHARGING FOR ALL COALITION

Electric Vehicle Building Codes Toolkit

A Guide For Adopting Equitable US Codes

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Introduction

This toolkit is an educational resource to help electric vehicle (EV) advocates and policymakers understand and facilitate the process of adopting equitable EV readiness building codes in cities, states, and territories throughout the US. It contains best practices for thinking about equitable EV code policy; model code language; a spreadsheet listing codes and resources for all 50 states, insular areas (Puerto Rico, Guam, CNMI, USVI, American Samoa) and the District of Columbia; a video illustrating the need for equitable EV charging access; a slide deck; and a recorded webinar with tips on how to use the toolkit.

The US Model EV Codes Toolkit was created by the EV Charging for All Coalition (EVCAC). It was made possible by a grant from General Motors and Plug In America. For more information, please visit chargingforall.org.

What are building codes, and why do they matter?

Building codes are regulations that set minimum requirements for the design and construction of our built environment. The systems covered include structural, electrical, plumbing, heating and air conditioning as well as EV charging infrastructure. EV charging readiness codes set minimum quantity, safety, and performance requirements for EV charging equipment installed during new construction and, in some cases, in the event of significant alterations to existing buildings and parking facilities.

This is particularly important to residential construction, as over eighty percent of EV charging is done at home, and lack of home charging is now cited as the biggest barrier to EV adoption. This barrier is most acutely felt by residents of multi-family homes, as described in more detail in the Equity Considerations section below.

By far the least expensive time to install EV charging infrastructure is during new construction. Adding EV charging later as a retrofit can cost four to ten times as much as it would have cost if installed during the original construction. Adopting EV readiness codes is a critical tool to expand EV access in a cost-effective manner. Figure 1 illustrates the relative costs of installing make-ready infrastructure to enable the installation of Level 2 EV Supply Equipment (EVSE).

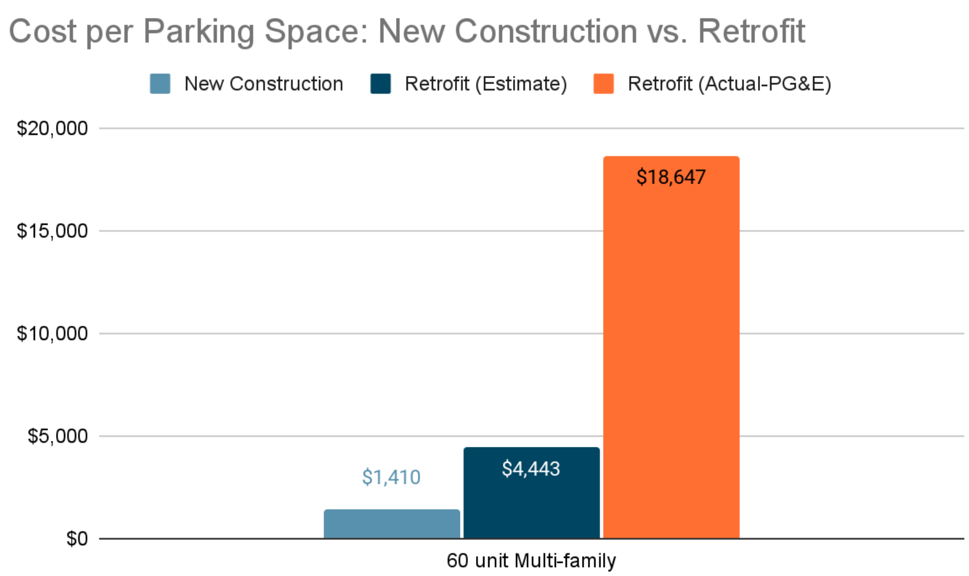

Fig 1: The least expensive time to install EV infrastructure is during new construction.[1]

[1] Data sources:
https://www.pge.com/pge_global/common/pdfs/solar-and-vehicles/your-options/clean-vehicles/charging-stations/program-participants/EV-Charge-Network-2020-Q2-Report.pdf

https://bayareareachcodes.org/wp-content/uploads/2020/03/PCE_SCVE-EV-Infrastructure-Report-2019.11.05.pdf

https://ww2.arb.ca.gov/sites/default/files/2020-08/CARB_Technical_Analysis_EV_Charging_Nonresidential_CALGreen_2019_2020_Intervening_Code.pdf

https://docs.google.com/document/d/1vtGgAlbJdEA5UfOgb_KD4ExYcyO6TfWEedhP59JrM5I/edit

Who writes the building codes?

In the U.S., there is no federal building code – instead, codes fall under the purview of state and/or local governments, depending on each state's or territory's code-making power:

> **Home Rule** states delegate code-making authority to local jurisdictions. Some home-rule states, such as Colorado, provide model codes and technical assistance to municipalities to assist with implementation.
>
> **Reach Code, or Minimum Standard** states have the authority to set minimum code standards statewide, and grant local jurisdictions the power to create stretch or reach codes that exceed the state requirements.
>
> **Dillon's Rule** states (sometimes called Min-Max) reserve the sole authority to determine codes. Local jurisdictions in these states typically do not have the power to create their own codes; however the state may also offer municipalities the option to adopt specific alternative pre-crafted 'stretch' codes that exceed the state minimum, or even the authority to exceed a specified metric within the state code.

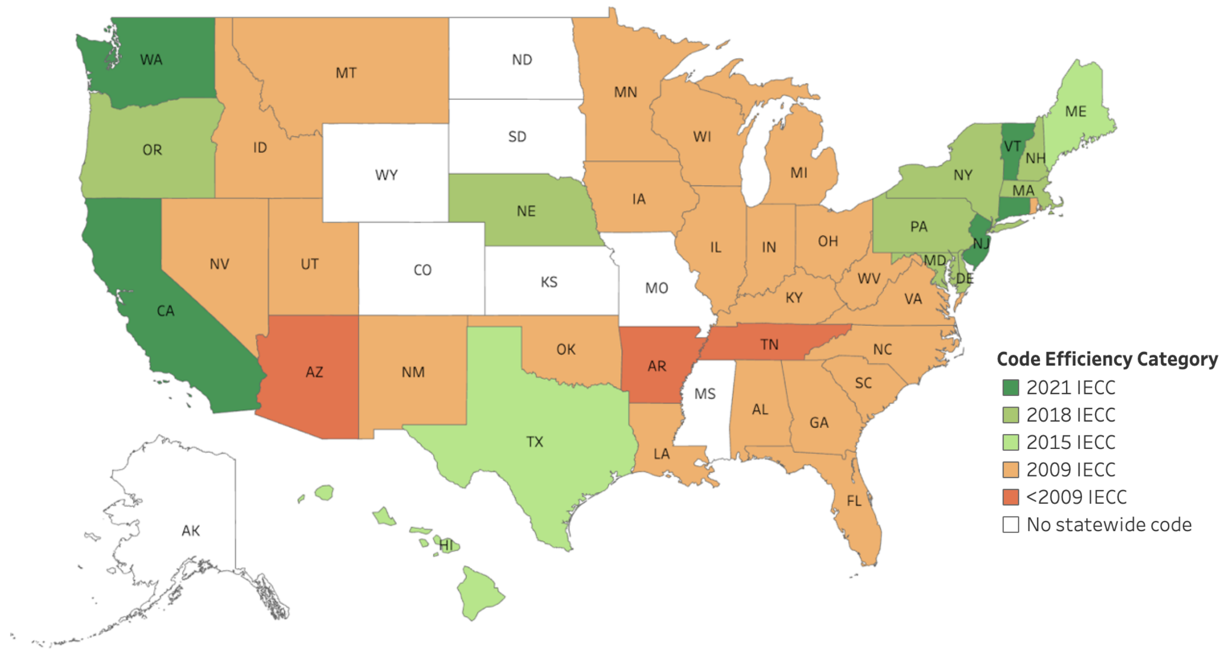

Fig. 2: Residential code efficiency varies significantly by state.[2]

Whether at the state or local level, lawmakers and government officials usually do not build their codes from scratch. Instead, they start with common draft language — called a model code — which they may adjust to suit local needs and priorities. The model codes are produced primarily by the nonprofit International Code Council (ICC) through a stakeholder consensus process; these model codes often reference additional standards developed by other organizations such as the National Fire Protection Association (NFPA) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

The ICC model code that would typically include EV infrastructure is the International Energy Conservation Code (IECC), which is updated every three years. Despite many efforts to include EV readiness provisions in the IECC, the most recent (2021) published IECC still does not include model codes for EV infrastructure. The draft 2024 IECC contains some EV provisions, but as of this publication date, these provisions are being

[2] US Dept. of Energy Building Energy Codes Program, Status of State Energy Code Adoption.

threatened with appeal and it is not clear if they will actually make it into the final 2024 IECC.

In the absence of a national model EV code, states, counties, territories and cities around the country have crafted their own EV readiness codes. These range in scope and stringency, and sometimes in definitions; however, virtually all of them treat single-family and multi-family housing differently – with multi-family homes often receiving only a small fraction of the EV charging access provided to single-family homes. This unequal treatment builds on a long history of systemic inequities in US housing policy; the net result is that the vast majority of parking built for multi-family housing – even brand-new housing – continues to lack EV charging infrastructure. It is therefore not surprising that most EV drivers currently live in single-family homes.

The EV Charging for All Coalition works to expand equitable access to EV infrastructure for all residents, regardless of the type of housing they live in. Establishing equitable EV readiness building codes is an important place to start.

Best practices for EV charging at multifamily housing

Definitions

Charging Equipment

Electric Vehicle Supply Equipment (EVSE), more commonly known as an EV charger or charging station, transfers electricity from the power source into the EV.

Cordsets are portable EVSEs; they typically come with every Electric Vehicle and can be carried in the car. One end of the cordset plugs into the car's charge port; the other end plugs into a wall socket, or receptacle. Cordsets come in L1, LPL2, and L2 configurations (see definitions below).

Readiness

Make-Ready refers to infrastructure (panel capacity, breaker, conduit, wiring, and/or junction box) that precedes and supports future installation of either a charging receptacle or EVSE.

As illustrated in Figure 3, there are broadly three levels of EV charging readiness:

EV Capable is typically defined as having panel capacity and conduit (at least through construction *pinch points*) to the parking space; however it lacks the breaker, wire and outlet or EVSE necessary for a driver to plug in and charge. It is "capable" of being upgraded at a later date to ready-to-charge status.

EV Ready is typically defined as having panel capacity, installed breaker, and an associated completed circuit that terminates at either an EVSE or a **receptacle** (colloquially referred to as a *socket* or *wall plug*). Some EV Ready definitions allow for the circuit to terminate in a junction box – requiring an electrician to install either a receptacle or EVSE to make the circuit fully operable. See the recommended residential and commercial model code language below for exact definition wording.

EVSE Installed is an EV Ready circuit that includes installation of a hard-wired EV charging station.

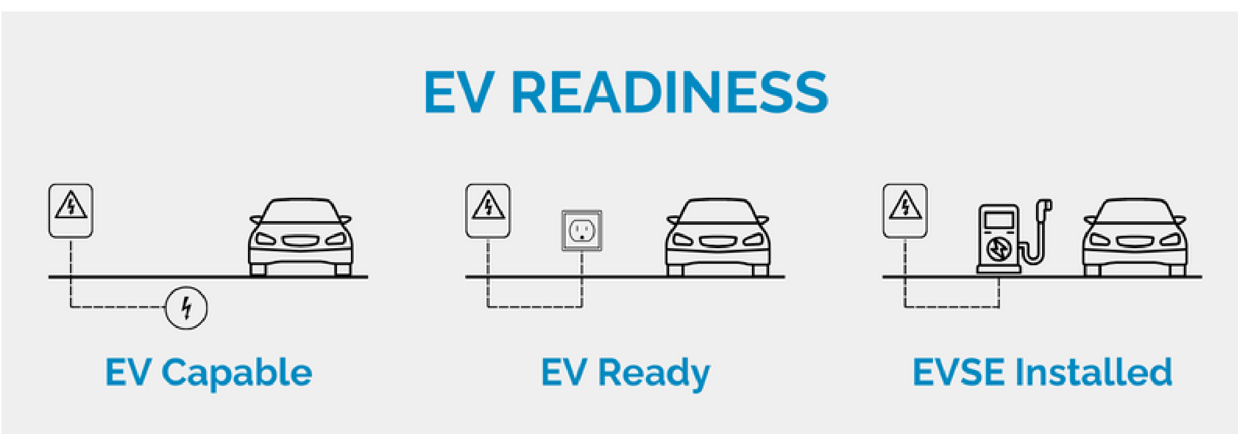

Figure 3: EV charging definitions

Power Delivery

All three levels of readiness, described above, can support differing amounts of electrical power delivered. Power delivery for EV charging is typically understood as follows:

Level 1 (L1) – alternating current, 110/120v, 20a at the breaker. Delivers approximately 3.5 miles of driving range per hour of charging.

Low Power Level 2 (LPL2) – alternating current, 208/240v, 20a at the breaker. Delivers approximately 13 miles per hour of charging.

Level 2 (L2) – alternating current, 208/240v, 40a at the breaker. Delivers approximately 25 miles per hour of charging.

Direct Current Fast Charging (DCFC) – Direct current, ranging from 120 to 1000 VAC 3φ, and from 75A to 525A at the breaker. Delivers between 150-500 miles per hour of charging. As automobile companies increase the ability of their EVs to accept DCFC, this is subject to change.

Equity considerations

Residents of multi-family housing (MFH) often lack access to the convenience, cost savings and reliability of home-based EV charging – either because they lack off-street parking or because their off-street parking lacks access to an electrical receptacle or EVSE, more commonly known as an EV charger. This lack of access translates into a cascading lack of financial, health, and environmental benefits which fall largely along racial and economic lines.

In the US, Black and Latinx drivers are disproportionately low-income, less likely to own their home, more likely to live in multifamily housing, and more likely to live in segregated neighborhoods. The challenges for multi-family residents to gain access to EV infrastructure are also formidable.

Landlords are less incentivized than single-family homeowners to provide EV charging in residential parking spaces, not least of all because they would then be obligated to manage what might be an unprofitable system for charging their residents' vehicles. Despite the passage of so-called *right-to-charge* laws like California's SB1016, residents of condominiums also face similar challenges to access, even when a certain percentage of parking is EV Capable. Common obstacles to both apartment and condominium residents wanting to install EV charging include: determining the availability of EV wiring and panel capacity; obtaining permission from the landlord or Home Owners Association (HOA); hiring a qualified electrician; ensuring access for their unit to wired spaces; securing a permit; and paying for installation of the wiring, circuit breaker, and receptacle or EV Service Equipment (EVSE - colloquially referred to as charging stations). Renters have a further disincentive, as they are making this investment on someone else's property, and leaving it behind when they move. These are often insurmountable hurdles, even for the most determined resident.

Changing the building codes for multi-family housing to provide more ubiquitous EV charging at the time of initial construction is therefore one important step in dismantling the structural inequities that perpetuate racial and class disparities in health and economic well-being in the US.

Additional Considerations

Building Costs

Adding EV charging infrastructure as a retrofit is a difficult and often expensive process. By far the least expensive and easiest time to install EV charging is during new construction: installing infrastructure to support a full Level two[3] (L2) EVSE, for example, typically costs approximately $1400, If installed as a retrofit, that same L2 EVSE space

[3] Level 2 is typically understood to be 208/240v, 40a at the breaker while Low Power Level 2 (LPL2) is 208/240v, 20a at the breaker. Level 1 is typically 110/120v, 20a.

can cost up to 12 times more. Installing Low Power Level 2 (LPL2) EV-Ready[4] receptacles in lieu of the L2 EVSE will achieve further cost savings. Overall, installing one LPL2 receptacle per unit costs less than 0.5% of a building's typical construction budget.

Battery Life

With current battery technology, repeated use of DCFC may have negative effects on battery life, reducing the lifetime value of the EV. While frequent low depth of charging (DOD) extends battery life significantly, full charging (DOD 100%) can lead to 27% loss of capacity after 2.5 years. Route-based DCFC is critical for enabling long-distance travel, however relegating MFH residents without home-based charging to rely on nearby DCFC charging is not an equitable solution.

Dwell Time

Even the fastest EV charging takes time. Placing EV charging where cars are typically parked for long stretches (like they are at home and at work) enables lower-cost, lower-powered, more convenient charging solutions.

Electrical Grid Constraints

While the electric grid is capable of supplying enough electricity to meet the current demands of EVs, it will be critical to design charging infrastructure that balances grid load as EV adoption accelerates. Providing Low Power L2 and Level 1 residential charging is one strategy to minimize negative impacts to the electrical grid.

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[4] See the bottom of page 7 of the CALGreen 2022 ISOR for cost estimates by California Department of Housing and Community Development.

Load Management

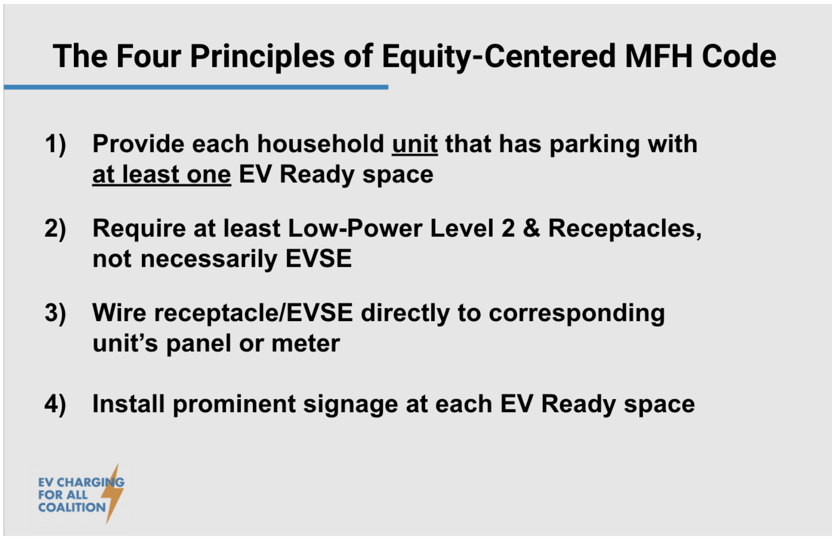
Energy Management Systems, or EMS, (Also called Automated Load Management Systems, or ALMS) are another tool for managing energy demands from EV charging. Load management enables calibration of how much electricity each charging station uses when multiple EVSE units are connected to the same circuit, ultimately keeping electrical loads under the building's capacity, and removing the hassle factor of needing to shuffle parking spaces – effectively sharing *power* rather than sharing parking *space*.

There are both hardware and software load management solutions. On the hardware side, on-site battery storage can be used to store power during off-peak hours and avoid expensive demand charges. On the software side, technology plays a similar role in distributing energy across spaces – allowing more chargers to be installed for the same given electrical service while ensuring all EVs are charged and ready to go by morning.

While EMS can help to minimize the additional cost of electrical infrastructure upgrades by spreading the same amount of power out over more parking spaces, it also requires a third-party entity to manage it, which necessarily adds both upfront capital costs and ongoing operational costs. For these reasons, EMS may be an appropriate solution for commercial and workplace structures, where economic incentives align to ensure equitable pricing for drivers; with appropriate pricing controls in place, it may also be useful for retrofitting older multi-family housing, particularly when the cost to bring in additional electric capacity is exorbitant. In some instances, however, it may be most cost-effective to simply install extremely low-cost non-networked chargers and either give the power away or collect a small fixed monthly amount.

Planning for Vehicle-to-Home Resilience

To help avoid power outages during times of strain on the grid, EVs can provide additional resilience by powering homes directly with the electricity stored in their batteries. In places where multi-family units have individual home electric meters, directly wiring an EV charging circuit to the corresponding home meter – rather than through the building's commercial common meter[5] – is critical to ensuring all residents the life-saving benefits offered by bidirectional vehicle-to-home charging.



Four Principles of Equity-Centered Multifamily Housing EV Codes

The EVCAC has developed four equity-centered, low-cost principles to follow when developing EV readiness codes for multi-family housing. These principles ensure equitable charging access for residents while simultaneously minimizing costs for builders. They are:

1. Provide each household unit that has parking with at least one EV Ready space.

Most existing EV codes mandate one EV charging space for every single-family home, but only a small percentage of charging spaces for multi-family homes. Electricity for EV charging needs to be distributed equally to everyone, the way hot water is now required, by code, to be provided in all residences – regardless of the type of housing. Equity also requires mandating *plug-and-play* EV Ready spaces for multi-family homes,

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[5] Multifamily buildings, even in regions with individually-metered apartments or condominiums, typically have a common house meter for shared electrical loads such as hallway and parking lighting, swimming pool heaters, etc. When run through this common commercial meter, EV loads without EMS can also trigger high *demand charges* from the utility when multiple EVs charge at the same time.

since these residents typically lack the authority, awareness, incentives and resources to call in an electrician and upgrade any potentially EV Capable spaces to EV Ready.

2. Require at least Low-Power Level 2 (vs. Full Power Level 2) and Receptacles (not necessarily EVSE).

These are cost-saving measures for builders that align incentives and deliver sufficient range for the vast majority of driving needs. Receptacles are much less expensive than full EVSEs, and most EVs come with cordsets that drivers can simply plug into a receptacle. Many EV-driving MFH residents prefer to use their own charging cordsets, which can go with them if and when they move out and can be sold with the car. Similarly, more spaces can be served by delivering Low-Power Level 2 vs. Full-Power Level 2 with the same electrical panel capacity. For example, overnight, a car plugged in at Low-Power Level 2 can expect to add about 90 miles of range – far more than the 37-mile US daily average. This means that Low-Power Level 2 charging is adequate for the vast majority of MFH residents.

3. Wire the receptacle/EVSE directly to the corresponding unit's electric panel or meter.

At properties where charging is added as a retrofit, apartment and HOA managers typically bring in a third-party commercial provider to manage the charging service. This arrangement puts residents into a near-captive, monopolistic home-charging situation, and results in charging costs to the driver that are typically three to five times higher than the residential utility rates paid by single-family residents. Direct wiring has multiple benefits for the resident, the builder and the HOA/ complex manager, and guarantees that multi-family residents can pay the same regulated utility rate as those living in single-family housing.

4. Install prominent signage at each EV Ready space.

Having signage at the space – not just hidden in the electrical panel – communicates to residents that these spaces are pre-wired for charging an EV. This encourages EV adoption and increases the likelihood that the investment in charging infrastructure is put to use. Prominent signage is important for EV Ready spaces served with a receptacle, which residents may not otherwise understand is capable of charging an EV; and it is especially important for EV Capable spaces.

Model Code Language

Proposed Model Codes

The 2024 IECC model codes will likely contain some EV provisions; however, they are insufficient for the current explosive growth in EV adoption, and inequitable to multi-family residents. EVCAC recommends the following amendments to the proposed 2024 Residential and Commercial IECC to ensure equitable and affordable access:

- IECC 2024 Residential Amendments
- IECC 2024 Commercial Amendments

The 2023 National Electrical Code contains a provision requiring 40A panel service for all EV branch circuits. At present, this provision denies builders the option of Level 1 or LPL2 EV circuits, adding to the cost of construction. EVCAC recommends updating state electrical codes to ensure panels are sized appropriately for installed EV infrastructure. Low-Power Level 2 (208/240V, 20 A) service should be the minimum standard for new construction, and L1 service should be the minimum for retrofits.

NEC Proposed EV Comment

Photo credit: Georgetown University

Existing EV Readiness Codes

The following are some sample existing EV readiness codes already implemented in cities and states around the country. See the Fifty-State+ Spreadsheet for contact information to learn more, and for a complete summary of codes in all fifty states and territories.

California (Reach Code state)

Statewide:

- Final approved 2022 CALGreen Triennial EV code (took effect January 1, 2023)
- Approved 2022 CALGreen Intervening EV Code (to take effect July 1, 2024) – see in particular the voluntary *Tier I, Option B* (Initial Statement of Reasons)

Cities:

- San Jose, California 2023 (proposed) - provides EV charging access to 100% of multi-family housing units with assigned parking. This proposed reach code update is expected to be voted on by the San José City Council in the fall of 2023.

Connecticut (Dillon's Rule state)

Statewide:

- Connecticut's Mandatory Electric Vehicle (EV) Charging Station Building Standards, enacted May 10, 2022 and effective Jan. 1, 2023, require new state buildings with project costs greater than $100,000 to install Level 2 EV charging stations at a minimum of 20% of light-duty vehicle (LDV) parking spaces. New commercial or multi-unit dwelling buildings with at least 30 LDV parking spaces must be capable of supporting Level 2 or direct current fast charging (DCFC) stations at 10% of such spaces. See CT EV Codes Resources for more information.

Colorado (Home Rule state)

Statewide:

- The Colorado General Assembly passed the Building Energy Codes law in 2023, establishing an Energy Code Board to review, approve, and recommend energy codes for new buildings and retrofits to existing buildings. On Jun 1, 2023 the Energy Code Board published the Colorado Model Electric Ready and Solar Ready Code, which requires one EV Ready space delivering 40A/240V per unit for single-family and duplex housing. It also requires some EV Readiness in commercial parking structures. See CO EV Codes Resources for more information.

Cities:

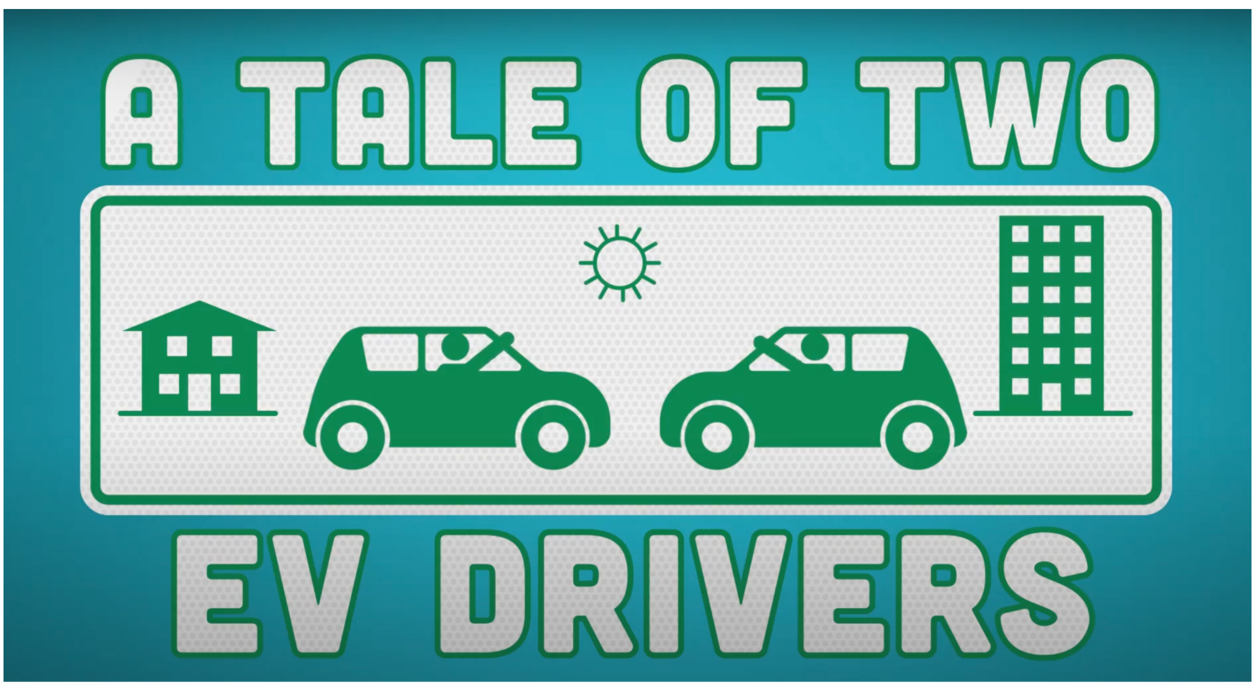
- Denver, CO 2022 Building Code requires a mix of EVSE, EV Ready and EV Capable in commercial and residential structures. (Note that it uses different definitions of EV Capable and EV Ready.)

District of Columbia (Non-State/Insular Area)

Washington, DC [Electric Vehicle Readiness Amendment Act of 2020.] Requires new construction or substantial improvement of a commercial building or a multi-unit building that includes three or more off-street parking spots to include EV make-ready infrastructure for at least 20% of the parking spaces; requires the Mayor to issue rules to implement the provisions of this act, including rules to establish a waiver process when a property owner demonstrates severe financial hardship; and requires the Department of Energy and Environment to establish incentives for property owners to install electric vehicle make-ready infrastructure in a greater percentage than required under the act.

Additional Resources

1. Video: A Tale of Two EV Drivers



This short video clearly illustrates the differences in cost and convenience between charging at a single-family home and charging at an apartment complex without an assigned charging space. Organizations advocating for EV codes in their communities are encouraged to download the video and use it to support their outreach efforts. We provide two versions:

1) Version One ends with the EVCAC website link.
2) Version Two includes an additional blank tail at the end – feel free to use this longer version and add your local information and call to action at the end.

2. Fifty-state+ spreadsheet

This compendium lists current building codes in all fifty states plus Washington, DC and US Insular Areas (Puerto Rico, Guam, Commonwealth of the Northern Mariana Islands, US Virgin Islands, American Samoa).

3. Webinar recording: how to use the toolkit

On October 5, 2023, EVCAC presented a webinar introducing this toolkit, called *Creating Better EV Building Codes: What You Need to Know*. Watch the webinar here.

4. Slide deck for community education

This slide deck is used in the webinar; feel free to download a copy and use any or all of these slides to educate your community about the importance of EV readiness building codes.

Acknowledgements

Lead author: Vanessa Warheit

Research intern: Diya Khandra

Special thanks to these reviewers who provided feedback during various phases of the work:

- Adam Berry, Colorado Energy Office
- Dennis Corelis, Architect
- Dwight MacCurdy, SMUD (ret.)
- Guy Hall, Electric Vehicle Association
- Ingrid Malmgren, Plug In America
- Katherine Cunningham, The Ad Hoc Group
- Kim Cheslak, Pacific Northwest National Labs
- Linda Hutchins-Knowles, Charge Across Town
- Lauren Weston, Acterra
- Marc Geller, Plug In America
- Michael Joseph, CalSTART
- Philip Kobernick, Peninsula Clean Energy
- Rick Tempchin, Alliance for Transportation Electrification
- Sarah Kostka, Sven Thesen & Associates
- Sven Thesen, Sven Thesen & Associates

While reviewers were critical to improving the quality of this analysis, views expressed in this report are not necessarily a reflection of their or their organization's opinions.