American Cities Climate Challenge

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EV-Ready Ordinance Amendments: Research on Costs and Best Practices

Definitions

Electric Vehicle Supply Equipment (EVSE): the infrastructure required to charge an EV, including the cable that connects the vehicles, the charging unit, and the conduit that links the charging location to the utility grid and power supply.

Level 1 Charging Station: 120 Volt (AC). 100-mile charge takes 18 hours.

Level 2 Charging Station: 240 Volt (AC). 100-mile charge takes 4 hours.

Fast Charging: Majority are 50 kW (DC), 100-mile charge takes 35 minutes. 150 kW (DC), 100-mile charge in 12 minutes. 350 kW (DC), 100-mile charge in 5-7 minutes.

There are three basic options for EV infrastructure requirements:[1]

(1) EV-Capable: Install electrical panel capacity with a dedicated branch circuit and a continuous raceway from the panel to the future EV parking spot.
(2) EVSE-Ready Outlet: Install electrical panel capacity and raceway with conduit to terminate in a junction box or 240-volt charging outlet
(3) EVSE-Installed: Install a minimum number of Level 2 EV charging stations.

Economic Benefits of Electric Vehicles and EV-Ready Buildings

There are numerous reports and case studies available that make the economic case for EV's. These economic benefits come in the form of direct cost reductions to the PEV owner, cost reductions for electric ratepayers, cost reductions for society as a whole stemming from GHG reductions, improved air quality, additional employment and labor opportunities, and the avoided cost of EV-ready new construction compared to retrofit.

The University of Minnesota Extension analyzed an input-output model to understand the economic benefits of constructing 75 50 kW and 75 150 kW fast-charging stations in Minnesota. The research estimated the direct, indirect, and induced benefits of such construction. The authors found it would generate a total of $14.2 million in economic activity, which includes $4.6 million in labor income.[2]

M.J. Bradley and Associates conducted a cost-benefit analysis on five Northeast and Mid-Atlantic States to understand the economic benefits of PEVs. The research found that in addition to the economic benefits to the PEV owner, PEVs benefit the overall state economy as well as utility ratepayers. EV owners that take advantage of low electricity prices during off peak hours (Between 9pm and 9am) also balance the load of the grid. EV owners increase sales of

[1] http://www.swenergy.org/cracking-the-code-on-ev-ready-building-codes
[2] http://www.dot.state.mn.us/sustainability/docs/mn-ev-vision.pdf

electricity without overburdening the grid if they charge during off peak hours. This leads to increased electricity sales, which will, in turn, drive down electricity rates for all ratepayers.

The study grouped the economic benefits of the increased penetration of PEVs into three categories: (1) PEV Owner; (2) Utility Customer; (3) Society in the form of GHG Reduction, with results in Table 1. The Net Present Value (NPV) in annual benefits per PEV is calculated for 2030 and 2050 for five states with the results shown below. The net economic benefits of one additional PEV ranges from $107-$265 in 2030 and $349-$520 in 2050.[3]

Table 1: NPV Annual Benefits $/PEV

	2030				2050			
	PEV Owner	Utility Customer	GHG Reduction	Total	PEV Owner	Utility Customer	GHG Reduction	Total
CT	$45	$73	$90	$208	$310	$62	$132	$504
MA	$14	$90	$91	$195	$306	$81	$133	$520
MD	$94	$80	$61	$230	$338	$58	$124	$515
NY	$18	$166	$81	$265	$282	$112	$125	$519
PA	-$37	$81	$60	$107	$210	$60	$96	$349

Source: M.J. Bradley & Associates, LLC

Another economic consideration is the cost savings in requiring EV-readiness in new construction compared to retrofitting buildings in the future. Installing EV-ready infrastructure is significantly less expensive during new construction than for building retrofits. This is achieved through improved construction management coordination, improved permitting and inspection efficiencies, shorter and more direct raceway and conduit routing, avoided trenching costs, and correct sizing of electrical panels. Installing infrastructure during new construction can avoid retrofit costs including breaking and repairing walls and upgrading electric service panels. There are a multitude of case studies that present the economic case for new building construction compared to retrofit, summarized below.

The California Air Resources Board estimated the cost of EV charging infrastructure for new buildings compared to retrofits of existing buildings to accommodate EV charging stations. The estimated cost for EV charging infrastructure, including the raceway, panel capacity, and dedicated circuit, is $1,650 per parking space for new commercial buildings. The estimated retrofit cost to install EV charging infrastructure is between $3,750 to $6,975 per parking space.

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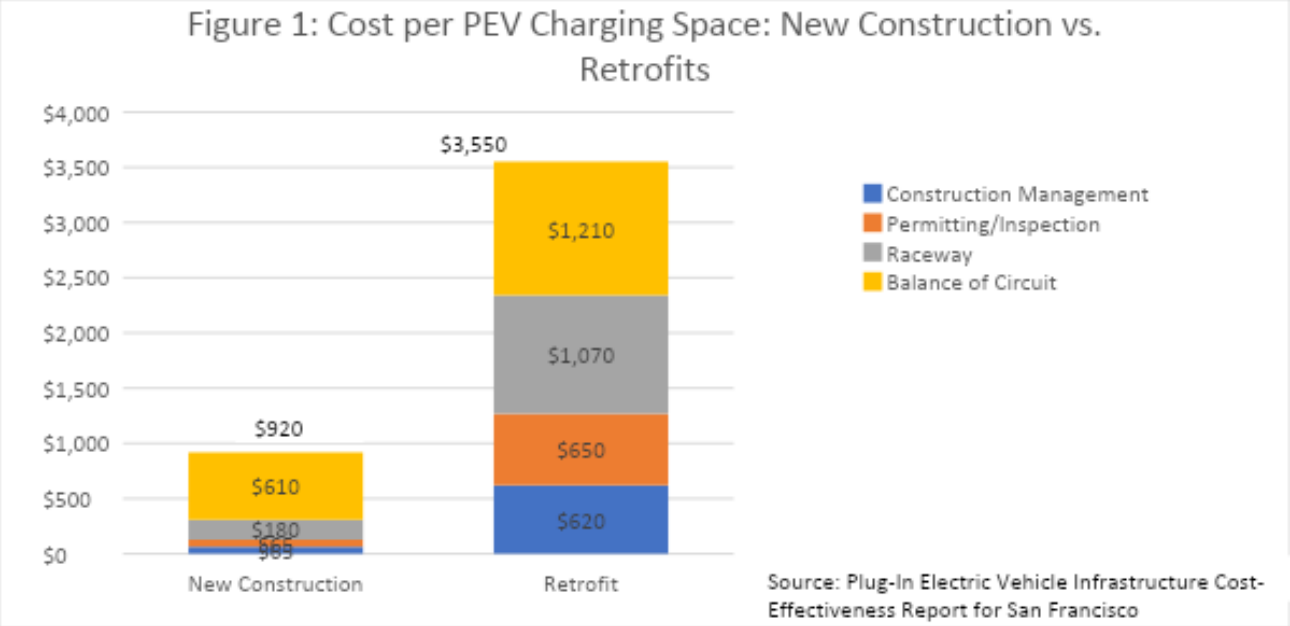
3 https://www.mjbradley.com/reports/mjba-analyzes-state-wide-costs-and-benefits-plug-vehicles-five-northeast-and-mid-atlantic

Therefore, the avoided cost associated with requiring EV-ready in new construction compared to retrofit ranges between $2,100 to $5,325 per parking space.[4]

Another case study, prepared for San Francisco, also looks at the avoided cost of EV-readiness in new construction compared to retrofits with results in Figure 1. The study found that the overall cost per parking space for new construction is $920 compared to a retrofit cost of $3,550.[5] Based on this analysis there is a cost savings of $2,260 per charging space, leading to an equivalent of $3,682,000 avoided cost based on the necessary 1,400 charging stations need in 2030.



A cost savings model prepared for the city of Oakland, CA, details the cost of new construction and retrofit for both EV-Capable (includes electrical service panel capacity, plans, and all underground conduits) and EVSE-Ready (includes EV-Capable components plus wire, circuit breakers, termination point and surface conduit) technology. The study found EVSE- Ready technology in new construction results in greater savings compared to EV-Capable technology. Even though there is a higher total cost initially to complete EVSE-Ready parking spaces, there is greater overall savings in the future. EV-Capable spaces may be installed for an upfront cost of $300-$500 per space and require an additional cost of $900-$1,100 per space to complete them

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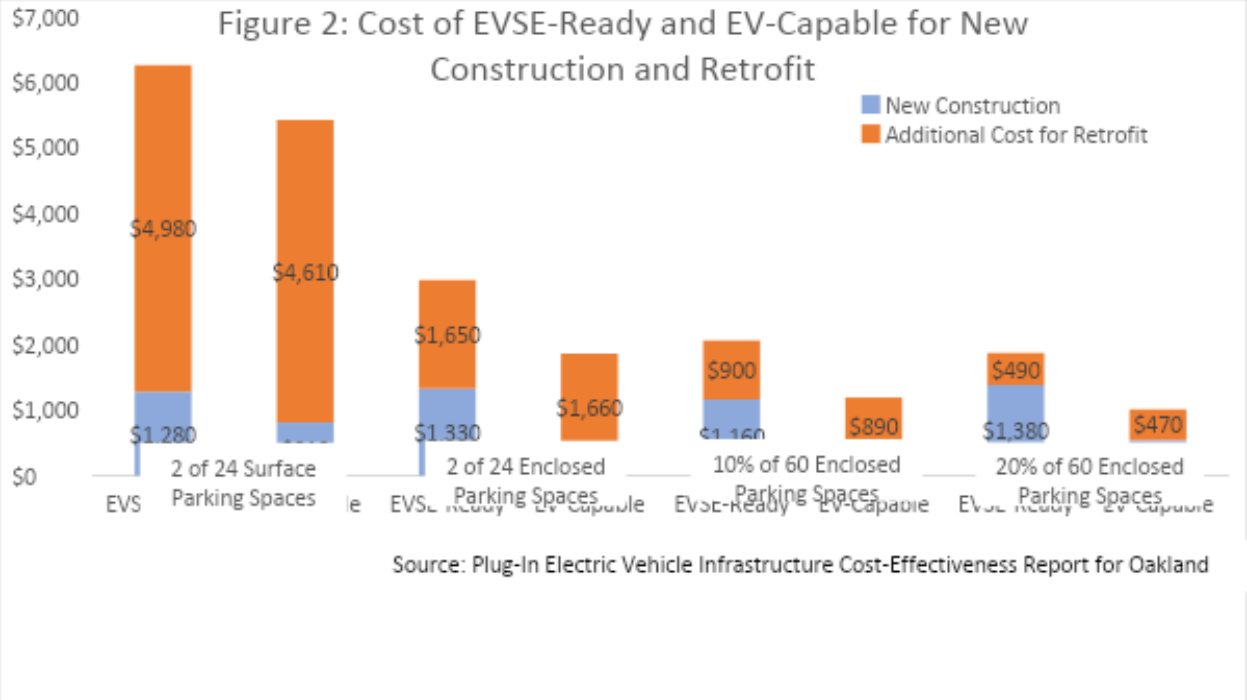
4 https://www.documents.dgs.ca.gov/bsc/2015TriCycle/CAC/Green/Exhibit-B-CARB-Cost-Analysis-and-Technical-Report.pdf

5 http://evchargingpros.com/wp-content/uploads/2017/04/City-of-SF-PEV-Infrastructure-Cost-Effectiveness-Report-2016.pdf

in the future.[6] This results in higher total costs than installing a complete circuit (EVSE-Ready) when a new building is constructed.

The results of the four scenarios for the Oakland case study are presented in Figure 2. The study concluded that "installing a complete electric circuit for PEV charging at the time of construction provides the largest cost savings compared to retrofit costs." As shown in Figure 2, installation cost per parking space decrease as the number of required EV-capable and EVSE-ready parking spaces increases. In the fourth scenario, installing 20% of the parking spaces EVSE-ready costs $115 per space. In the third scenario, installing just 10% of parking spaces EVSE-Ready costs $193 per parking space. [7]



Code Considerations for EV-Ready Adoption

There are two realms of code that cities must consider when putting in place EV-ready codes. EV-ready codes can apply to both residential new construction and/or commercial new construction. While the majority of charging happens at home, it is important to ensure

6 https://energy-solution.com/wp-content/uploads/2016/09/PEV-Infrastructure-Cost-Effectiveness-Summary-Report-2016-07-20b.pdf

7 https://energy-solution.com/wp-content/uploads/2016/09/PEV-Infrastructure-Cost-Effectiveness-Summary-Report-2016-07-20b.pdf

EV-readiness in both commercial and residential new building construction. This offers more options for EV owners to charge their cars, leading to a more convenient driving experience.

About half of all vehicles in the U.S. are owned by residents of one-or two-family dwellings with access to an off-street parking space (i.e. garage or driveway), while the other half do not have reliable access to a dedicated parking space.[8] It is necessary that one-and two-family dwellings are EV-ready to accommodate charging as there continues to be increased demand for EVs across the country.

The other half of vehicle owners who do not live in one- and two-family dwellings most commonly live in multifamily properties such as apartment and condominium complexes without the ability to retrofit parking for EV charging. These multifamily tenants face a barrier to owning EV's as the majority of charging infrastructure is in one- and two-family garages.[9] In order to reduce this barrier and allow for more versatile charging across the city, municipalities should adopt standards to install EV charging infrastructure in both multifamily dwellings and commercial buildings such as workplaces and grocery stores. This offers more flexibility to EV owners as they can choose to charge their vehicle during work hours if necessary and at their apartment complexes.

a) Residential Code Considerations: Typically, EV-ready residential building codes call for EV-capable or EVSE-ready infrastructure for all new one- and two-family residential projects to accommodate Level 2 charging. Examples include:

Municipality	One or two-family EV-code	Link to code
Boulder County, CO	EVSE-Ready Outlet	https://assets.bouldercounty.org/wp-content/uploads/2017/03/building-code-2015.pdf
City of Boulder, CO	EVSE-Ready Outlet	https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT10ST_CH6ELCO_10-6-3ELVECHRENEMUDW
Atlanta, GA	EV-Capable	https://api.municode.com/CD/Ordinances/10376/888744?forceDownload=true and https://drive.google.com/file/d/1sM2Y_ttE1vvVOrGbfdjxyY8DPiO4v4oL/view
State of California	EV-Capable	https://codes.iccsafe.org/content/chapter/2057/
Aspen, CO	EV-Capable	https://www.cityofaspen.com/DocumentCenter/View/243/Title-8-Buildings-and-Building-Regulations-1-2-PDF
City and County of Denver, CO	EV-Capable	
Fort Collins, CO	EV-Capable	
San Francisco, CA	EV-Capable	https://sfbos.org/sites/default/files/o0092-17.pdf
Palo Alto, CA	EV-Capable	http://library.amlegal.com/nxt/gateway.dll/California/paloalto_ca/title16buildingregulations*/chapter1614californiagreenbuildingstanda?f=templates$fn=default.htm$3.0$vid=amlegal:paloalto_ca$anc=JD_16.14.420

[8] http://www.swenergy.org/cracking-the-code-on-ev-ready-building-codes
[9] https://www.arb.ca.gov/cc/greenbuildings/pdf/tcac2018.pdf?bay

Vancouver, BC	EV-Capable	
Los Angeles, CA	EV-Capable	http://library.amlegal.com/nxt/gateway.dll/California/lamc/municipalcode/chapterixbuildingregulations/article9greenbuildingcode?f=templates$fn=default.htm$3.0$vid=amlegal:losangeles_ca_mc$anc=JD_99.04.106.4.2.
State of Oregon	EV-Capable	

Overall, EV-ready codes for one- and two-family dwellings must ensure that all new residential construction is EV-capable, so that those residents who have an EV can easily complete the installation. Residential installations should be able to accommodate Level 1 and/or Level 2 charging so the resident has the option to choose which Level of charger to install. However, Level 1 charging does not require additional electrical work as it is simply a standard household outlet. Therefore, codes should ensure that the electrical panel has additional amperage to cover a Level 2 charging load to accommodate potential homeowner demand.

b) Commercial Code Considerations: Typically, EV-ready commercial building codes call for a percentage of total parking spaces in a given parking lot be EV-capable or EVSE-ready to accommodate Level 2 charging for new construction. Examples include:

Municipality	Multi-family Code	Commercial Code	Link
Boulder County, CO	EVSE-ready outlet for 2% of parking		https://assets.bouldercounty.org/wp-content/uploads/2017/03/building-code-2015.pdf
City of Boulder, CO	EVSE-Ready outlet for 10% of parking		https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT10ST_CH6ELCO_10-6-3ELVECHRENEMUDW
Atlanta, GA	EV-capable for 20% of parking		https://api.municode.com/CD/Ordinances/10376/888744?forceDownload=true and https://drive.google.com/file/d/1sM2Y_ttE1vvVQrGbfdjxyY8DPiO4v4oL/view
State of California	EV-capable for 3% of parking	EV-capable for 5% of parking	https://codes.iccsafe.org/content/chapter/2057/
Aspen, CO	EV-capable for 3% of parking		https://www.cityofaspen.com/DocumentCenter/View/243/Title-8-Buildings-and-Building-Regulations-1-2-PDF
San Francisco, CA	EV-capable for 100% of parking	EV-capable for 10% of parking	https://sfbos.org/sites/default/files/o0092-17.pdf
Palo Alto, CA	EVSE Ready outlet or installed for 100% of parking	EV-capable for 25% of parking OR EVSE-installed for 5% of parking	http://library.amlegal.com/nxt/gateway.dll/California/paloalto_ca/title16buildingregulations*/chapter1614californiagreenbuildingstanda?f=templates$fn=default.htm$3.0$vid=amlegal:paloalto_ca$anc=JD_16.14.420
Salt Lake City, UT	EVSE Installed for 1 in every 25 spaces		http://sterlingcodifiers.com/codebook/index.php?book_id=672&chapter_id=49083#s928646
State of Washington	EV Capable for 5% and Panel capacity for future EVCS for 20%		
New York City, NY	EV-Capable for 20% of parking		https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2014CC_BC_Chapter_4_Special_Detailed_Requirements.pdf&section=conscode_2014
Vancouver, BC	EV-Capable for 20% of parking		
Los Angeles, CA	EV-Capable for 5% of parking		http://library.amlegal.com/nxt/gateway.dll/California/lamc/municipalcode/chapterixbuildingregulations/article9greenbuildingcode?f=templates$fn=default.htm$3.0$vid=amlegal:losangeles_ca_mc$anc=JD_99.04.106.4.2.

State of Hawaii	EV-Capable for 1% of parking		
Oakland, CA	EVSE-Ready outlet for 10% of parking. Panel capacity for 20% of parking. EV-Capable for 90% of parking.		https://library.municode.com/ca/oakland/codes/code_of_ordinances?nodeId=TIT15BUCO_CH15.04OAAMCAMOBUCOCO_PT11CAGRBUSTCO_15.04.3.11130CGSE5.106.5.106.5.3.4AM
State of Oregon	EV-Capable for 5% of parking		
Montgomery County, MD	EVSE-Installed for 2% of parking		

All commercial charging should accommodate Level 2 charging capability. For workplace charging stations, Level 2 is ideal for employees to obtain a full charge during the time they are at work. Additionally, multi-family dwellings should accommodate Level 2 charging so multiple tenants can obtain a full charge on a given charging station. Commercial buildings such as grocery stores should deploy DC fast charging stations so that consumers can quickly charge their vehicles when they are running errands.

There is no consensus on the "correct" percentage of EV-ready spaces that should be available. The Southwest Energy Efficiency Project (SWEEP) provides a sample code to draft commercial building code language. The code calls for 10 percent of parking spaces in multi-family dwelling and commercial structures with more than 10 parking spaces be EV-capable for Level 2 charging. As shown earlier, while EVSE-Ready construction is more costly upfront, it results in greater savings compared to only requiring EV-Capable. Further, to break down the value per space in the Oakland case study, requiring 20% of parking spots in a 60 spot parking lot be EV-capable leads to a cost per space of $115. Requiring 10% of parking spots in a 60-spot parking lot be EV-capable lead to a cost per space of $193. Therefore, requiring 20% of parking spaces be EV-capable leads to the lowest cost per space. The following section presents examples of EV-Ready codes and ordinances in place across the country.

Example Municipal Codes

CITY OF BOULDER:

Residential Building Code:
(https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT10ST_CH5.5REBUCO_10-5.5-2ADINRECOMO)

E3901.13 Electric vehicle charging requirements for new construction. Every new dwelling unit in a detached one- and two-family dwelling or townhouse shall include the following in at least one of the provided off-street parking spaces:

1. A 240-volt dedicated electric vehicle charging receptacle outlet, and
2. A 120-volt dedicated electric vehicle charging receptacle outlet.

The electric vehicle charging receptacle outlets shall be labeled as an electric vehicle outlet.

E3901.14 Electric vehicle charging requirements for renovations. For every dwelling unit where a garage is converted to habitable space, at least one 120-volt or 240-volt dedicated electric vehicle charging receptacle outlet shall be provided adjacent to at least one of any provided parking spaces.

Exception: A dedicated charging outlet is not required if off-street parking is not provided.

The electric vehicle charging receptacle outlets shall be labeled as an electric vehicle outlet.

Commercial Building Code:
(https://library.municode.com/co/boulder/codes/municipal_code?nodeId=TIT10ST_CH6ELCO_10-6-3ELVECHRENEMUDW)

10-6-3. - Electric Vehicle Charging Requirements for New Multifamily Dwellings.

Every newly permitted multifamily dwelling with more than twenty-five parking spaces shall include the following:

1) Ten percent of parking spaces shall have one 240-volt and one 120-volt dedicated charging receptacle outlet.
   a) Accessible Spaces. Ten percent of accessible parking spaces, but in no case less than one accessible parking space, shall have one 240-volt and one 120-volt dedicated charging receptacle outlet. Parking in accessible spaces where electric vehicle supply equipment is installed shall not be limited to electric vehicles when no other comparable accessible space is available.
   b) Designation. Fifty percent of the parking spaces with a required dedicated charging receptacle outlet for electric vehicles shall be designated for electric vehicle charging.
2) At least two parking spaces shall have a Level 2 dual port electric vehicle charging station. These two parking spaces with a Level 2 dual port electric vehicle charging station shall be designated for electric vehicle charging.

10-6-4. - Electric Vehicle Charging Requirements for New Commercial Structures and R-1 and R-2 Occupancies.

Every newly permitted commercial structure with more than twenty-five parking spaces and buildings serving a Group R-1 or R-2 occupancy shall comply with the following:

1) Ten percent of parking spaces shall have one 240-volt and one 120-volt dedicated charging receptacle outlet.
   a) Accessible spaces. Ten percent of accessible parking spaces, but no less than one accessible parking space, shall have one 240-volt and one 120-volt dedicated charging receptacle outlet. Parking in accessible spaces where electric vehicle supply equipment is installed shall not be limited to electric vehicles when no other comparable accessible space is available.

b) Designation. Fifty percent of the parking spaces with a required dedicated charging receptacle outlet for electric vehicles shall be designated for electric vehicle charging.

2) In commercial structures with more than twenty-five parking spaces, at least two parking spaces shall have a Level 2 dual port electric vehicle charging station. These two parking spaces with a Level 2 dual port electric vehicle charging station shall be designated for electric vehicle charging.
3) Buildings serving a Group R-1 or R-2 occupancy shall have a Level 2 dual port charging station in one percent of, but no less than two, parking spaces. Parking spaces with a required Level 2 dual port electric vehicle charging station shall be designated for electric vehicle charging.

CITY OF ATLANTA:

Ordinance (https://drive.google.com/file/d/1sM2Y_ttE1vvVQrGbfdjxyY8DPiO4v4oL/view)

Section 1: Electric Vehicle Charging Infrastructure Readiness Requirement for New Commercial Construction:

1) Definitions
2) All new Group A, B, E, I, M, R-1, R-2 and S-2 occupancies, as regulated by the International Building Code, are required to provide EVSE infrastructure to accommodate the future installation of Electric Vehicle Supply Equipment. The infrastructure shall be provided per this section.
3) The EVSE infrastructure shall be installed per the requirements of the current edition of the National Electrical Code as adopted and amended by the State of Georgia for enforcement by the City of Atlanta.
    a. The off-road parking provided for buildings containing Group A, B, E, I, M, R-1, R-2 and S-2 occupancies shall have EVSE infrastructure installed at the parking spaces dedicated for the use of the building.
    b. The ratio of electric vehicle parking spaces to non-electrical vehicle parking spaces shall be 1:5 and only applies to the total new parking spaces.
    c. Designated dual-port EVSE may be dual-usage for ADA accessible EV charging spaces and non-ADA accessible EV charging spaces with ADA compliant hardware. The use of the space for accessible parking takes precedence over the need to use this space for EV charging.
4) All new off-road parking, or the expansion of existing off-road parking for buildings supporting Group A, B, E, I, M, R-1, R-2 and S-2 occupancies shall include EVSE infrastructure based on the total number of parking spaces established in subsection (b).
5) The EVSE infrastructure shall include a raceway, which is continuous from the branch circuit/feeder panel location to the future PHEV/EV parking space. The raceway shall be sized and installed per the National Electrical Code; however, in no case shall the EVSE

infrastructure raceway be less than one inch in size. The EVSE infrastructure raceway shall include a pull rope or line installed for future conductor installation, with the raceway sealed and labeled for future use.

6) The electrical equipment room, when provided for new Group A, B, E, I, M R-1 and R-2 occupancies must have a dedicated space for the future installation of EVSE. This space shall be identified on all construction documents submitted for review, and the dedicated space shall not allow for violation of the National Electrical Code prescriptive requirements regulating working space clearances around equipment, or violation of the National Electrical Code prescriptive requirements governing the entrance to and egress form electrical equipment working space.

[MORE LANGUAGE OMITTED HERE FOR SPACE]

Section 2: Electric Vehicle Charging Infrastructure Readiness Requirement for New Residential Construction

All new Group R-3 occupancies, as regulated by the International Building Code, and all new single-family dwellings, two family dwellings and townhomes regulated by the International Residential Code are required to provide EVSE infrastructure to accommodate the future installation of Electrical Vehicle Supply Equipment. The infrastructure shall be provided per this section.

1) The EVSE infrastructure shall be installed per the requirements of the current edition of the National Electrical Code (NFPA 70) as adopted and amended y the State of Georgia for enforcement by the City of Atlanta.
2) All dwellings regulated by this section shall provide sufficient electrical capacity for a 240-volt branch circuit for the future installation of Electric Vehicle Supply Equipment.
3) An area shall be provided within the attached or detached garage for placement of EVSE
4) Absent an attached or detached garage, an underground electrical conduit shall be provided between the dwelling and the designated parking space for the dwelling. The EVSE infrastructure shall include a raceway, which is continuous from the branch circuit/feeder panel location to the future PHEV/EV parking space designated for the dwelling. The raceway shall be sized and installed per the National Electrical Code; however, in no case shall the EVSE infrastructure raceway be less than one inch in size. The EVSE infrastructure raceway shall include a pull rope or line installed for future conductor installation, with the raceway sealed and labeled for future use.

[MORE LANGUAGE OMITTED]

SWEEP NEW COMMERCIAL BUILDING EV-READY CODE MODEL
(http://www.swenergy.org/data/sites/1/media/documents/publications/documents/Sample%20IBC_EV%20Building%20Code%20Proposal.pdf)

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INTERNATIONAL BUILDING CODE (IBC)

SECTION XXX

ELECTRIC VEHICLE CHARGING

Section 420.1 Electric vehicle charging. For every newly permitted multi-family dwelling and commercial structure with more than 10 parking spaces, 10 percent of the total number of parking spaces shall be capable of supporting future electric vehicle charging stations (EVCS) and shall be identified on the construction documents. Construction documents shall indicate the location of the proposed EVCS. At least one EVCS shall be located in common use areas and available for use by all residents.

420.2 Single EVCS required. When only one EVCS space is required, a 208/240-volt individual branch circuit or a listed raceway to accommodate a future individual branch circuit shall be installed. The raceway shall not be less than trade size 1 (nominal 1-inch inside diameter). The raceway shall originate at the main service or subpanel and shall terminate into a listed cabinet, box or other enclosure in close proximity to the proposed location of the electric vehicle charger. Construction documents shall identify the raceway termination point. The service panel or subpanel circuit directory shall provide capacity to install a 40-ampere minimum dedicated branch circuit and space(s) reserved to permit installation of a branch circuit overcurrent device. Electric vehicle supply equipment shall be installed in accordance with NFPA 70.

420.3 Multiple EVCS required. Construction documents shall indicate the raceway termination point and proposed location of future EVCS and electric vehicle chargers. Constructions documents shall also provide information on amperage of future electric vehicle supply equipment (EVSE), raceway methods(s) wiring schematics and electrical panel service capacity and electrical system, including any on-site distribution transformer(s), have sufficient capacity to simultaneously charge all electric vehicles at all required EVCS at the full rated amperage of the EVSE. Plan design shall be based upon 40-ampere minimum branch circuit. Raceways and related components that are planned to be installed underground, enclosed, inaccessible or in concealed areas and spaces shall be installed at time of the original construction. Electric vehicle supply equipment shall be installed in accordance with NFPA 70.

420.7.3 Identification. The service panel or subpanel circuit directory shall identify the overcurrent protective device space(s) reserved for future electric vehicle charging as “EV CAPABLE”. The raceway termination location shall be permanently and visibly marked as “EV CAPABLE”.