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Clean Cities
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GEORGETOWN CLIMATE CENTER

EV-READY CODES FOR THE BUILT ENVIRONMENT

Electric Vehicle Supply Equipment Support Study

Prepared for:
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and
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LIST OF ABBREVIATIONS

AC	Alternating Current
ANSI	American National Standards Institute
ANSI EVSP	American National Standards Institute Electric Vehicles Standards Panel
ARRA	American Recovery and Reinvestment Act
BC	British Columbia
BCD	Building Codes Division (Oregon)
CALGreen	California Green Building Code
DC	Direct Current
DOE	U.S. Department of Energy
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GHG	Greenhouse Gas
IBC	International Building Code
ICC	International Code Council
IgCC	International Green Construction Code
IRC	International Residential Code
MOU	Memorandum of Understanding
NEC	National Electrical Code
NEIS	National Electrical Installation Standards
NFPA	National Fire Protection Association
NTTAA	National Technology Transfer and Advancement Act
NYSERDA	New York State Energy Research and Development Authority
ODOT	Oregon Department of Transportation
PGE	Portland General Electric
SAE	Society of Automotive Engineers
SCE	Southern California Edison
SEC	Seattle Electrical Code
TCI	Transportation and Climate Initiative
UL	Underwriters Laboratory
VAC	Volt Alternating Current

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EXECUTIVE SUMMARY

Overview: EV-Ready Codes for the Built Environment

Electric vehicles (EVs) are being delivered to the Northeast and Mid-Atlantic markets in increasing numbers, and the battery-charging infrastructure that supports them is being deployed with different location and business models, technology configurations and utility communication networks. Each state, city and town will face a need consider the full scope of regulatory measures available to plan for the anticipated growth in the EV sector in order to facilitate and encourage consistent and accessible infrastructure deployment. The challenges presented by evolving technology and market transitions are significant but not insurmountable; however, they call for comprehensive planning and implementation strategies to account for stakeholder needs and to allow localities to capture the economic and environmental benefits associated with EVs.

The purpose of this report is to build on the discussion and knowledge base required to support electric vehicle supply equipment (EVSE) deployment through the elimination of barriers to widespread deployment by describing the role of building and electrical codes in encouraging or inhibiting the implementation of EVSE and to aid local and state practitioners in assessing local code-specific barriers and identifying the code provisions that would encourage a basic or advanced level of EV readiness in local policies and regulations. EVSE is the infrastructure required to charge an EV—from the cable that connects the vehicle to the charging unit up to the conduit that links the charging location to the utility grid and power supply.[1] The report will also highlight the processes and participants in creating, administering and amending such codes, and will explore the potential for jurisdictions to adopt codes that could encourage EVSE. The subject of analysis is the policy framework and state- and local-level adoption and amendment processes specific to the two key national model codes that impact EVSE installation and inspection: the National Electrical Code (NEC), published by the National Fire Protection Association (NFPA), and the International Building Code (IBC), published by the International Code Council (ICC). While there are other aspects of EVs and EVSE communications networks, as well as electrical utility issues that are standardized by different types of codes, these two relate most specifically to the construction and electrical equipment installation procedures associated with EVSE.

The report finds that the current national codes neither inhibit nor facilitate the implementation of EVSE, and that there are strong examples of jurisdictions where codes are successfully encouraging EV readiness. This report also finds that a proactive, rather than neutral, regulatory framework can assist in the deployment of a connected and strategically located EVSE infrastructure network in the places where drivers are most likely to charge. Structural codes are a part of that framework.

Case studies and expert interviews with codes officials, utility representatives and state and local government agencies were undertaken and describe ways in which codes adopted by states and other jurisdictions having authority can be an instrumental part of an EVSE-ready planning toolkit. A handful of states and jurisdictions across North America have already taken steps to include EV-ready provisions in some part of their structural code, and their experiences demonstrate many of the key reasons and benefits of approaching this type of infrastructure planning from the perspective of building and electrical codes. The lack of such code language at the state level in

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[1] Please refer to Appendix A for further description and illustration of EVSE systems and requirements.

the Georgetown Transportation and Climate Initiative (TCI) region is a missed opportunity that the Northeast and Mid-Atlantic region states can work to amend.

Case Studies

Through case studies of model jurisdictions, the report will examine the efforts of and lessons learned by states and local jurisdictions regarding incorporation of EVSE-specific provisions into the building code, and consider lessons learned for model code development. Case studies include: a profile of municipal planning in Vancouver, British Columbia, Canada; initiatives in state-level planning in Oregon; and regional approaches linking city, county and utility planning in Los Angeles, California. The case studies highlight three approaches to metropolitan area and regional cooperation to address the regulatory framework that supports and monitors EV infrastructure deployment. Looking at advanced efforts at state, metropolitan area and municipal levels in forward-thinking jurisdictions, several common factors emerge regarding the successful creation of policy and regulation supportive of EV infrastructure:

- Each jurisdiction took specific and multifaceted steps to encourage use of EVs.
- Each jurisdiction considered opportunities and challenges associated with regulation at multiple levels of government, or with multiple layers of agency, authority or private sector participation, demonstrating the wide range of possibility in working with codes and other components of the regulatory environment.
- Actors in each jurisdiction identified and overcame potential regulatory barriers.

Municipal Planning in Vancouver, BC

In **Vancouver**, a municipality created a collaborative working group to develop EV-readiness strategies with the intent of meeting long-range GHG reduction goals, and it became the first North American municipality to mandate EVSE-ready electrical installation in all new residential and commercial construction.

State-Level Planning in Oregon

Oregon amended the electrical code to reflect a need to address EV-charging infrastructure in an inefficient statewide market with many early adopters concentrated in specific geographic areas and corridors, opting instead to expedite and dramatically reduce costs associated with the permitting process for residential EVSE.

Linking City, County and Utility in Los Angeles, California

In the **Los Angeles** metropolitan area, high statewide standards required by CALGreen, the nation's first mandatory green building code, and local amendments work in concert with utility-led efforts to plan for EV readiness across complex jurisdictional boundaries.

Summary of Key Findings and Recommendations

Despite the complexities inherent in the state and local decision-making process of evaluating options for EV-ready planning, there are opportunities that can be created for supporting consistent EVSE deployment planning. Structural codes do not operate alone in the local regulatory environment; they are one tool available on the regulatory menu to jurisdictions seeking to govern infrastructure deployment. Despite the environmental benefits and growing EV market in many areas across the United States and throughout the region, each jurisdiction will need to assess the costs and benefits associated with its own goals pursuant to energy efficiency, transportation electrification, green construction, air quality and economic development in order to effectively prioritize EV-readiness steps.

Existing Codes Present No Significant Barriers to EVSE Deployment

While there are no specific barriers to EVSE installation embedded in the existing national model building and electrical codes, there is room within the codes as adopted by the states to more clearly encourage EV readiness. Despite differences between jurisdictions, the structural codes themselves—model and adopted—cover existing safety concerns related to existing automotive and charging technology and permit or facilitate conditions under which EVSE can be installed.

Recommendation to Promote General Code-Related EV Readiness

- Education and training programs for inspectors and installers have become the norm as an early evaluative step in EV-readiness planning. States seeking to evaluate the need of codes and permitting processes should initiate EVSE training for professionals in related fields.

Codes Can Achieve Regional EV Readiness

There are specific reasons to consider changing codes at the state and local levels. Because code amendments are one of several interrelated strategies to encourage EVSE deployment, in considering changes, it is important for jurisdictions to consider what codes can accomplish. Codes are generally revised at the national level every three years and at the local level every six years or more, and they will be updated at the national level to meet new structural or fire safety concerns, such as those related to new and emerging technologies. Local codes will not address this topic. Where codes have more impact is specification of scoping requirements that define numerical goals or limits for certain features in new construction (e.g., percentage of required parking spaces to be built EVSE-ready). Similarly effective, codes can provide for new permitting or inspection protocols and encourage the reduction of associated administrative costs.

Local conditions will factor heavily into the decision to regulate for EVSE based on codes. Variations across the TCI region will mean that states will make different choices. States such as New Jersey, for example, with a relatively evenly distributed, dense population and centrally located transportation corridors, may find scoping requirements in the building code to be a good solution. By contrast, Maine's lack of uniform population density with residential concentration around key urbanized centers may suggest a different approach.

Recommendations for State and Regional Code Policy Cohesion

- Reduce real consumer costs of EV adoption by addressing the extreme variation in permitting fees and lowering fees for residential installations, such as through classifying residential EVSE installations as minor label work.
- Incentivize and encourage incorporation of EVSE by modifying building codes when economically appropriate to require that a percentage of accessory parking associated with new development to be pre-wired for EVSE, providing flexibility for future capacity.
- Enable state and local participation in a forum for interstate cooperation.

EVSE Deployment Contributes to Economic Development

Codes factor into economic development planning. EVs and EVSE deployment influence such disparate areas as maintaining housing affordability; providing equitable access to transportation infrastructure; creating green jobs and marketing metropolitan areas to attract new businesses, residents and institutions.

For the development and construction community, there is a need to keep costs low enough to be easily absorbed into overall project costs. However, inclusion of ESVE readiness in the building phase can be more cost effective than retrofit and increase the value of individual units as well as the community at large.

Another aspect of economic development for EVSE is that jurisdictions encouraging EV readiness will likely gain growth associated with EVs and charging infrastructure. The presence or stimulation of markets for EV and EVSE has primed the pump in early adopting jurisdictions. For example, Vancouver's signing of memoranda of understanding with auto manufacturers highlights an approach to capture a portion of the EV market.

Recommendations for Outreach, Research and Economic Development:

- Incorporate or acknowledge EVSE deployment through TCI-region state-level economic development strategy.
- Fund further research and program assessment specific to the TCI region to enable local jurisdictions to make informed decisions about costs and benefits associated with public expenditures for EVSE, and to guide development of public-private partnerships.
- Fund ongoing demonstration programs, particularly those that focus on innovation and new technology.

High-Level Flexibility Leads to Meaningful Local Options

Standardization is an important goal for EVSE and EV adoption as a means to generate industry consistency, lower costs and avoid excessive fragmentation. At the same time, EVSE policy and planning should not tie hands at the local level. California's CALGreen is an excellent example of the ability of codes to create a high-level planning framework while retaining flexibility at the local level. Significantly, a local jurisdiction's codes must be in compliance with state-level legislation, meaning state laws play a central role in establishing the range and impact of local regulatory requirements. Challenges in this arena include the creation of seamless and simple regulations using consistent language in state and local laws that limit code revision to what is necessary for compliance. State codes can offer an a la carte menu of options, standardized at the state level but adopted through tiered systems and/or on a voluntary basis by the local jurisdiction. Well-written codes may also offer phased provisions or optional parameters, maximizing the adaptability and efficacy of local regulations.

Recommendations for Maximizing Consistency across Local Jurisdictional Boundaries:

- Adopt state code amendments containing voluntary scoping and implementation options, such as tiers of compliance and voluntary appendices.
- Make consistent information and technical support available to officials across state and local agencies through the Clean Cities' Coalitions.
- State agencies having jurisdiction should introduce locally vetted modifications to the discussion of national model codes in the next possible code cycle (2015).

Partnerships Will Guide Infrastructure Deployment

Successful local plans for EVSE rollout have been comprehensive in scope; because codes are one part of the local regulatory environment, they must work in concert with other statutory requirements, economic policies, local planning and regulatory processes. It is necessary for key factors to be in place to successfully advance policy, legislation and ordinances pertaining to EV infrastructure advancement.

Highly significant among these is a forum for cooperation. The reduction of barriers to EVSE deployment will not come from code amendments alone, but rather from the collaborative efforts that can produce such amendments as a part of a comprehensive deployment strategy. Large-scale and multi-agency coalitions and working groups, public-private partnerships and work with academic and research institutions have contributed to a broad-based understanding of intersections among local and regional goals in model jurisdictions.

The role of the private sector can be just as, if not more, important in preparing the region for more comprehensive EVSE deployment. Federal and state funding can be allocated to private infrastructure developers (e.g., ECOtality's EV Project) to gather data, test business models and pilot high-visibility EV charging. Private-sector outcomes will determine many aspects of EVSE.

Recommendations for Legislative Measures to Encourage Public-Private Collaboration:

- Enable the creation of special purpose clean energy districts to connect interests and regulatory processes in the TCI region.
- Enable data exchange and access to EV ownership and EVSE installation to improve utility performance and enhance utility involvement in local and regional planning.
- Create and/or engage EVSE working groups housed within the appropriate agency in each state to leverage TCI regional stakeholder information and influence and to promote high-level cooperation.

1. INTRODUCTION

Plug-in electric vehicles are being delivered to the Northeast and Mid-Atlantic markets in increasing numbers, and the battery-charging infrastructure that supports them is being deployed with different location and business models, technology configurations and utility communication networks. Electric vehicles (EVs) and charging infrastructure are coming to states, cities and towns that have highly individualized regulations—from taxes and EV incentive programs to zoning, permitting and structural codes. Anticipated growth in the EV sector creates a need to plan ahead to facilitate and encourage consistent and accessible infrastructure deployment. The challenges presented by evolving technology and market transitions are significant but not insurmountable; however, they call for comprehensive planning and implementation strategies to account for stakeholder needs and to allow localities to capture the economic and environmental benefits associated with EVs.

This report will build on the discussion and knowledge base required to support electric vehicle supply equipment (EVSE) deployment through the elimination of barriers to widespread deployment by describing the role of building and electrical codes in encouraging or inhibiting the implementation of EVSE. Further, the report will highlight the processes and participants in creating, administering and amending such codes, and will explore the potential for jurisdictions to adopt codes that could encourage EVSE. EVSE is the infrastructure required to charge an EV—from the cable that connects the vehicle to the charging unit up to the conduit that links the charging location to the utility grid and power supply.[2] The EV industry is a developing one, and the entities that create and govern the codes and administrative processes that regulate EVs and charging infrastructure are just beginning to work together to regulate and plan for the charging infrastructure that will anticipate and provide right-sized service for a growing number of EV users.

The regulatory environment that shapes the distribution of infrastructure is itself shaped at the national, state and local levels of government. At each intersection or level of decision making, the private market—including the auto industry, utility, real estate and environmental interests—influences the regulatory choices made by a jurisdiction. For example, a town with no ability to address EVSE through codes or zoning may not be able to assist and benefit from a developer seeking to install EV charging stations in a new apartment complex. Each state or local jurisdiction will need to assess the best implementation strategy for creating an EV-friendly regulatory environment based on unique local criteria. Standards and codes ideally will make it as easy as possible for the public and private realms to interact, resulting in widespread infrastructure distribution and stimulating investment in the EVSE sector.

Codes impact one of the most significant values derived from EV use—the ability of the EV driver to charge directly from the grid—anywhere, anytime. According to University of British Columbia (BC) researcher and city of Vancouver sustainability engineer Malcolm Shield, an estimated 80%–90% of EV charging will happen at home,[3] EV drivers will also need access at work and other common driving destinations in order to achieve this key EV value proposition.[4] Where, when and how drivers are able to charge is at the discretion of the state and local jurisdictions[5]

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[2] Refer to Appendix A for further description and illustration of EVSE systems and requirements.
[3] Malcolm Shield, (presentation, 2012 BC Power Symposium, Vancouver, BC).
[4] For at-home charging, multiunit dwellings and commercial locations.
[5] The term "local jurisdiction" refers broadly to municipalities, counties, towns or other designated administrative subdivisions having some powers of self-government. For the purposes of this report, local jurisdictions will primarily include incorporated municipalities or other legally separate entities with some

that regulate and permit new charging infrastructure. Of course, other significant market factors influence the value of EVs as well. For example, the regulation of electricity protects the consumer from the price fluctuations that affect petroleum fuel.

The extent to which codes and other regulatory tools can impact EV and EVSE markets has yet to be demonstrated in most U.S. cities. Case studies and expert interviews with code officials, utility representatives, planning and installation practitioners and state and local government agencies were undertaken and describe ways in which codes adopted by states and other jurisdictions having authority can be an instrumental part of an EVSE-ready planning toolkit. A handful of jurisdictions across North America have already taken steps to include EV-ready provisions in some part of their building or electrical codes, and their experiences demonstrate many of the reasons and benefits of approaching this type of infrastructure planning from the perspective of codes. A lack of specific code language addressing EVSE deployment allows for both flexibility in a developing market and the continued possibility for confusion about how to use codes to influence EV readiness, and it represents a missed opportunity in many areas for a smoother transition. This report highlights key challenges and opportunities associated with the building and electrical codes implemented nationwide. A first step is to understand which codes regulate the built environment and whether they cover EVSE, and then understand what can be gained, if anything, by altering them.

Critical and Transportation Infrastructure Development

The market for EVs is growing. There are now 11 highway-capable EV models and approximately 50,000 plug-in EVs already on the road across the United States. Anticipated changes in technology will continue to make these vehicles an increasingly viable consumer choice over the next decade. Just as gas stations provide a critical service to gasoline engine vehicles, charging infrastructure will be necessary to serve this expanding group of drivers. Further, the technological advancement projected for this field will continue to redefine this class of energy-efficient vehicles and, as such, it is critical that innovation and industry growth occur in accordance with uniform policy and high levels of safety.[6] Codes should be comprehensive but not overly restrictive to ensure this advancement.

1.1. Project Origins

The research leading to this report is supported by the New York State Energy Research and Development Authority (NYSERDA) in association with PON 2392, Electric Vehicle Supply Equipment Support, and it has been conducted by WXY Architecture and Urban Design in partnership with TCI, Energetics Incorporated and Bruce J. Spiewak, AIA, Consulting Architect LLC, with funding provided by the U.S. Department of Energy (DOE).

TCI is a collaboration of the transportation, energy and environment agencies from the 11 Northeast and Mid-Atlantic states and Washington, DC, focused on reducing greenhouse gas (GHG) emissions from the transportation sector. Jurisdictions participating in this TCI project are Delaware; Washington, DC; Maine; Maryland; Massachusetts; New Hampshire; New Jersey; New York; Pennsylvania; Rhode Island and Vermont. TCI states work closely with Clean Cities Coalitions throughout the region through the Northeast Electric Vehicle Network.

1.2. Codes Regulate the Built Environment

This report considers the policy framework and state- and local-level adoption and amendment processes specific to the two key national model codes that impact EVSE installation and

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corporate powers. Ideally these powers include the authority to amend and adopt codes, but this will vary from state to state.

[6] James McCabe (ANSI), interview, July 12, 2012.

inspection: the National Electrical Code (NEC), published by the National Fire Protection Association (NFPA), and the International Building Code (IBC), published by the International Code Council (ICC). While there are other aspects of EVs and EVSE that will require the attention of other standards and code-setting bodies, such as communications technology and utility connections, these two model codes relate most specifically to the construction and electrical installation associated with EVSE.

In concert with zoning and other state laws and local ordinances, these structural codes determine what, where and how different types of buildings and facilities can be built, modified and used. EV infrastructure will be a critical part of the built environment in future cities and towns, and developing an understanding of the way these regulations impact the deployment of EVSE is central to planning effective infrastructure deployment across the region.

Several central considerations in planning for EVSE deployment relate to code-based regulation:

- Safety requirements for charging infrastructure
- Interoperability of EVs and EVSE across boundaries, including manufacturers, service networks and jurisdictions, as well as future-proofing against technology changes
- Implications for the electrical grid
- Growth of EVs as a viable consumer choice in a transitioning market

Unlike zoning or parking ordinances, codes are developed at the national or international level in an advisory capacity. However, states and localities generally have jurisdiction and wide latitude to adopt their own building and electrical codes and administrative permitting processes. One of the best ways of generating uniformity in design, manufacture and installation of charging facilities is to ensure the key safety and user concerns and parameters are regulated through the national codes, so that local codes operate in service of these goals.[7] Other standardized aspects of EVSE deployment and site design, such as signage, handicapped accessibility, communications systems and user interface, will require uniformity as well for effectiveness and efficiency, but fall outside the scope of the codes addressed in this report. EV infrastructure will be a critical part of the built environment in our future cities and towns, and developing an understanding of the way these codes impact the deployment of EVSE is central to planning a broadly distributed infrastructure deployment across the region and encouraging EV adoption through the elimination of barriers to charging vehicle batteries at home, at work and in transit.

As the EV market grows, the process of code writing is also evolving toward increased cooperation. Codes and standards organizations such as the ICC, the NFPA and the American National Standards Institute (ANSI) recognize that for mutual economic development across state, regional and national divisions, it is important to have consistent rules across these boundaries and to actively work toward harmonizing codes and filling gaps.[8]

1.2.1. The Infrastructure Domain

Codes and standards related to EVs apply to the vehicle and related systems in four general categories: vehicle systems, batteries, vehicle interface and charging infrastructure. This report focuses most closely on the electrical and building codes—those that directly impact installation and have implications for site design and zoning regulations and that fall under the purview of state and local governments.

ANSI's 2012 comprehensive standards and code review document for vehicle charging infrastructure, *The ANSI EVSP Standardization Roadmap for Electric Vehicles*, defines this area of

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[7] Michael Pfeiffer (ICC), interview, July 20, 2012.
[8] Fred Wagner (Program Director, Energetics Incorporated and editor of ANSI's EVSP Roadmap), interview, August 13, 2012.

standardization as the "infrastructure domain," which "generally encompasses the technologies, equipment, components, and issues that fall within the confines of the charging infrastructure up to and including the connector portion of the charge coupler." This area of standardization includes the following:

- The charging system itself
- The vehicle interface, comprising the points of contact with the vehicle and power supply, as well as onboard communications systems
- Infrastructure-grid communications
- Electrical installation

Overall, standardization of EVSE relates to five central product and service goals: product design and durability, power use and communication with the utility grid, environmental impacts, user safety and interoperability of the device.[9] The last two goals fall under the infrastructure domain.

There are codes and standards that apply to every aspect of the EVSE that connects the vehicle to the power source. These standards supply a basic framework for electrical safety for charging equipment that covers the EVSE from coupler to transformer in a variety of typical installation contexts. Electrical and building codes and standards govern the installation of the physical and electrical infrastructure that connects the EV to the grid.

1.3. Codes Contribute to EV Readiness

The central finding of this report is that while there are **no specific barriers to EVSE installation** embedded in the existing building and electrical codes, **there is room within the existing codes to more clearly encourage EV readiness** and, in some contexts, increased electrical safety.[10] Codes do not function to anticipate new technology, so they are not an appropriate tool to foster market development or specific technological innovation.

EV readiness in policy and regulation at the state and local levels will take a wide range of forms along the spectrum of allowing, incentivizing or requiring EVSE infrastructure deployment, including eliminating procedural barriers, considering potential for financial incentives or mandating pre-wiring for EVSE installation.

The current model codes do not inhibit the ability to safely install and use the most common types of EV charging units (level 1 and level 2 charging). Neither level 1 nor level 2 charging requires significant electrical work so long as the existing circuitry supports the device.[11] The safety of EVSE design and electrotechnical components is regulated by other standards that deal with products and production processes, such as those issued by the Society for Automotive Engineers (SAE), and provisions exist within the NEC in other chapters and articles for their safe installation based on the components and wiring requirements.

Code officials and local practitioners have noted that, in general, a state or local jurisdiction would have limited reason to amend the model codes, unless a state law or other similarly compelling requirement for compliance exists. For example, local environmental conditions such as high heat applications or high alkalinity of the soil would require specific instructions for certain electrical installations.

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[9] Electric Vehicles Standards Panel, *Standardization Roadmap for Electric Vehicles*, Version 1.0 (Washington, DC: American National Standards Panel, April 2012), http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Roadmap_April_2012.pdf.

[10] In some states, single-family residential self-installation of EVSE is permitted to bypass the inspection process, depending on the type of residential code adopted.

[11] See Appendix A for a review of levels of charge and their attributes.

ANSI senior director James McCabe notes that, at the national level, the main idea supporting the generation of national model codes is to provide a baseline for jurisdictions to be able to follow best practices in terms of safety as well as other concerns relevant to the locality. These baseline provisions address specific issues, including EVSE; according to ANSI, "Standards, code provisions, and regulations, as well as conformance and training programs…are a critical enabler of the large-scale introduction of EVs and the permanent establishment of a broad, domestic EV and infrastructure industry and support services environment."[12] EVSE appears to be a compelling reason for code changes in some cases. A number of states have adopted amended codes specific to EVSE. In these cases, climate action plans and carbon emissions reduction goals, executive orders regarding emissions and other environmental policies that turn to transportation electrification as a strategy have compelled states and local jurisdictions to make EV-ready amendments. A secondary reason for supporting EV-ready plans and policies is the economic benefits associated with attracting EVs, infrastructure and related services and production to an area. A handful of states and jurisdictions across North America have taken steps to include EV-ready provisions in some part of their structural code, and **the lack of EV-specific code language may be an opportunity** that the Northeast and Mid-Atlantic states can capitalize on as the region seeks to prepare for the arrival of consumer EVs in greater numbers.

1.3.1. EV-Ready Planning for Networked Infrastructure

EV-ready planning is a comprehensive approach to the creation of regulatory and physical environments that support EV and EVSE. EV readiness has different components, and policies and programs to bring EVs and EVSE to an area may include financial incentives such as discounted tolls, tax credits or grants to finance charging equipment. However, non-financial incentives can also be effective in paving the way for EV-charging infrastructure. Project Get Ready cites preferential parking spaces, access to HOV-style lanes and expedited permitting processes as examples of these incentives.[13] As outlined in the Project Get Ready Casebook and profiled in other similar studies, many cities have taken steps toward EV-ready development and the creation of an EV-friendly regulatory environment.

In the case of any type of regulation, EV readiness can be interpreted at a minimum as the removal of barriers to easy, safe and cost-effective EVSE installation. At maximum, codes can be utilized to impact the scope of EVSE deployment in a given jurisdiction.

In general, EVSE-ready policy does not necessarily require installation of charging stations, but instead takes the approach that future technology and consumer preferences may change. In this way, EV readiness can include up-front planning for current and future infrastructure needs while remaining conscious of costs. In several of the model jurisdictions profiled in this report, such planning initiatives range from limiting the cost and time associated with permitting and inspections to mandating a certain percentage of new construction parking spaces be pre-wired for future EVSE installation.

Stakeholders consulted for this report widely agree that EVSE policy and planning should not tie hands at the local level. As with most regulatory and governance issues, there is no one-size-fits-all plan of action for creating the ideal scenario for EVSE deployment. The jurisdictions profiled in this report have been actively engaging in initiatives that have the goal of accelerating EV adoption. These case studies demonstrate that while different localities have a range of goals, such as reducing greenhouse gas (GHG) emissions or petroleum imports, the use of state or

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[12] National Fire Protection Association, "Article 625 – Electric Vehicle Charging System Equipment," in *NFPA 70 National Electrical Code* (Quincy, MA: National Fire Protection Association, May 2001), http://www.nfpa.org/assets/files/pdf/A625-675.pdf.

[13] Electric Vehicles Initiative, *EV City Casebook* (Paris: International Energy Agency/Boulder, CO: Organization for Economic Cooperation and Development, 2012), www.rmi.org/Content/Files/EV_City_Casebook_2012_1.2.pdf.

local codes to promote EV readiness is an effective tool to achieve differing goals and can take several approaches.

1.4. Code Modifications are Just One Tool at a Jurisdiction's Disposal

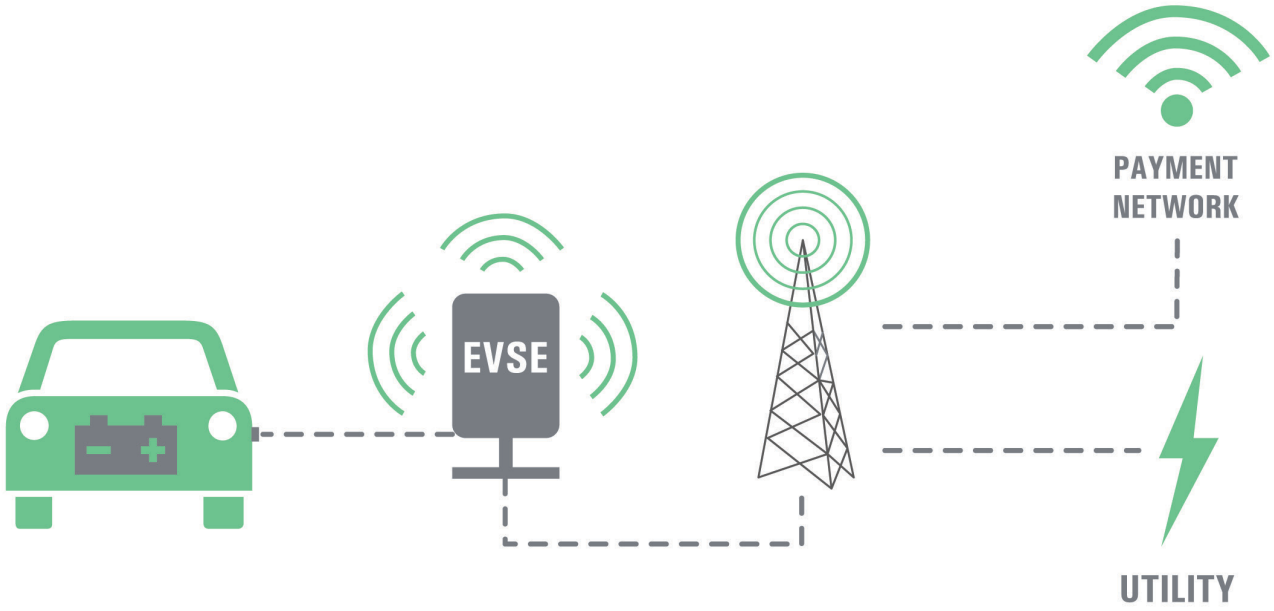
This report finds that the scope of best practices for EV readiness includes codes in two important ways: (1) establishing minimum parking requirements, and (2) addressing permitting or other administrative processes. Each of the jurisdictions profiled for this report has enacted its provisions for EVSE relatively recently (with some changes pending: Los Angeles County and the City of Vancouver will vote on new mandatory measures in August 2012).[14]

Modification of the state or local structural codes to encourage and incentivize EVSE installation is a direct action that enables jurisdictions to establish a pro-EV regulatory environment, either alone or in concert with state-level legislation; simplification of the administrative permitting process and changes to zoning and parking ordinances,

The national and local relationships to the model code development process are outlined in Section 2 of this report; case studies profiling EV-ready code actions taken by jurisdictions at different levels and lessons learned can be found in Section 3. This document provides a primer on the relevant structural codes and processes, as well as on opportunities and challenges for states and local jurisdictions seeking to regulate for and to encourage EVSE deployment.

[14] Beth Neaman (Southern California Edison), interview; Malcolm Shield (City of Vancouver), interview, July 18, 2012.

Codes and Standards Topics for EV and EVSE



VEHICLE DOMAIN	INFRASTRUCTURE DOMAIN	
Power Rating	**Electric Vehicle Supply Equipment**	**Infrastructure Communications**
Battery Safety Testing Storage Recycling	Charging Stations Power Quality Charging Levels/Modes Off-Board Chargers EV Couplers	Utility Metering Sub-Metering Load Balancing
Crash Tests/Safety	Vehicle as Supply	Charge Network Service Provider Payment Accessibility and Locating EVSE User Information Exchange Notification
On-Board Wiring	Alternative Power Sources	
Emissions	**Infrastructure Installation**	
User Interface Graphic Symbols	Site/Power Capacity Assessment Loads and Circuitry Ventilation - multiple vehicles	
	Urban Planning and Design Parking and Siting Environmental and Use Conditions Accessibility	
	Administration Permitting Inspection	

Figure 1: Code Issues for EVSE

1.5. Objectives and Methodology

The aim of this report is to aid local and state practitioners in developing an understanding of what, if any, barriers to EV readiness exist in the current codes, what code provisions would encourage a basic or advanced level of EV readiness and how model codes are created and translated from national or international policy to locally administered regulations.

The primary objectives of this report are the following:

- To help the municipal, state or regional planner understand and expand on the high-level implications of codes and related policies that regulate EVSE
- To establish the role of state and local jurisdictions and legislatures, private industry and interest groups in setting and implementing codes in the EV infrastructure domain
- To describe the general process and potential associated with amending and adopting building and electrical codes as well as the specific lessons learned from jurisdictions that have adopted EVSE-related amendments
- To distill best practices and formulate initial recommendations for EVSE-friendly codes and the generation of consistent regional infrastructure networks

Expert interviews formed the basis of this report and included in-depth consultation with EV and EVSE specialists at the nation's primary code-setting organizations, the ICC and the NFPA, which develop and publish the IBC and the NEC, respectively. For the purposes of this high-level review, the project team focused on engaging code experts at the national level and in model cities and states, but it should be noted that every state and many municipalities have agencies and/or departments that oversee the adoption, implementation and enforcement of state building and electrical codes. These experts in local policy and implementation should be consulted in further detail as well.

In-depth expert and stakeholder interviews with planning and transportation practitioners, policy makers, EVSE installers and licensed electricians and other stakeholders from the Northeast and Mid-Atlantic Clean Cities' communities and beyond were conducted between June and August of 2012.

This work is supported by secondary analysis and literature review of reports and existing studies, market-based analysis and mapping.

Through case studies of model jurisdictions, this report examines the efforts of, and lessons learned by, jurisdictions at state and local levels to incorporate EVSE-specific provisions into the building code, and considers lessons learned for model code development. Case studies include the following:

- Municipal planning in Vancouver, British Columbia, Canada
- State-level planning in Oregon
- Regional approaches linking city, county and utility planning in Los Angeles, California

These case studies were selected based on an analysis of new and existing research and recommendations by the U.S. Department of Energy (DOE) Clean Cities Coalitions, the Transportation and Climate Initiative (TCI) regional stakeholder group and ANSI, among others. These case studies profile options and opportunities at different levels of government in order to illustrate challenges and choices from various perspectives.

Criteria for case study selection included the following:

- The jurisdiction must have an implemented code change specific to EVSE
- Examples were sought to provide insight at multiple levels of government

- Case study localities should have addressed issues of jurisdictional boundaries
- Depth of local experience with EVSE and EVs
- Examples should offer breadth with respect to potential lessons learned

The case studies were selected based on an analysis of new and existing research and recommendations by the DOE Clean Cities Coalitions, the TCI regional stakeholder group and the American National Standards Institute (ANSI),[15] among others. These case studies profile options and opportunities at different levels of government in order to illustrate challenges and strategies from multiple perspectives.

The report offers brief recommendations to multiple stakeholder categories for the codes modification process and for critical, related elements of local infrastructure planning that should accompany and inform jurisdictional or state-level change.

1.6. Report Structure

Section 1: Introduction

Section 2: Codes in Policy and Practice: National Landscape
This section develops an understanding of and expands on the national code-setting system and how codes apply to EVSE deployment.

Section 3: Local Codes from Model States and Municipalities
This section examines the efforts of jurisdictions at state and local levels to incorporate EVSE-specific provisions into the building codes, and considers lessons learned for model code development.

Section 4: Summary and Next Steps
This section synthesizes implications of case study jurisdictions' efforts and outcomes on the code-setting process for permitting (administration) and siting (design and zoning), and suggests next steps in the form of key recommendations and future study.

Appendices

[15] ANSI is a standards-setting organization that published a critical reference for codes relevant to EV and EVSE. The EVSE Standardization Roadmap for Electric Vehicles, published in April 2012, is available at: http://publicaa.ansi.org/sites/apdl/evsp/ANSI_EVSP_Roadmap_April_2012.pdf.

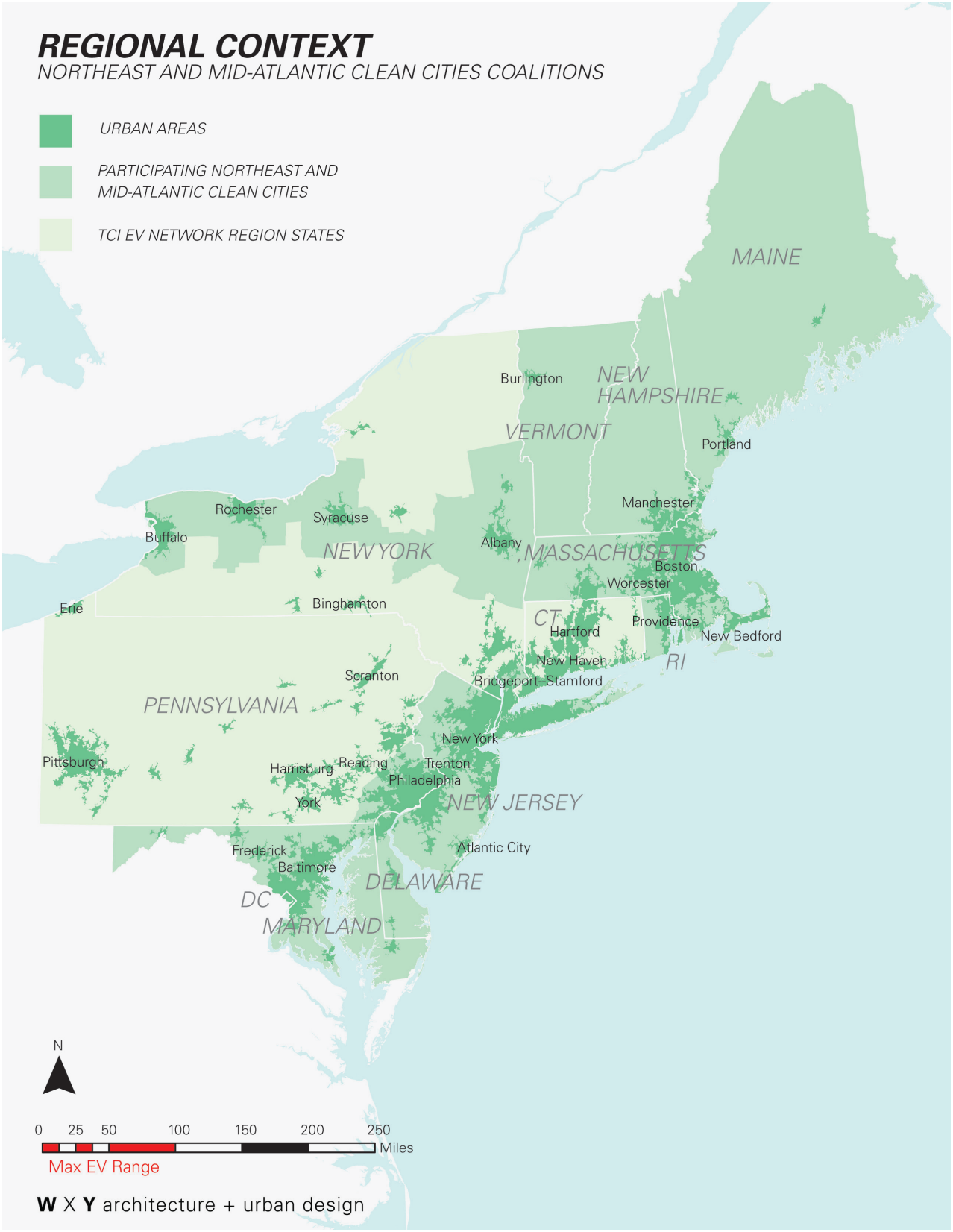


Figure 2: TCI Region Map. Sources: Transportation & Climate Initiative and U.S. Census Bureau via ESRI

2. CODES IN POLICY AND PRACTICE: NATIONAL LANDSCAPE

Section 2 of this report takes a general approach to understanding the purpose of codes, their role in regulating EVSE-specific issues and the respective roles of various stakeholders: federal, state and local governments as well as code-setting entities and businesses in the EV sector. Understanding the theoretical underpinnings and processes behind the establishment of the primary model codes will aid states and local jurisdictions in their decision-making processes regarding if and how to make amendments to include EVSE-specific provisions to their respective regulatory processes.

2.1. What are Codes and Standards?

Codes are systematic statements of a body of law, especially one given statutory force.[16] According to the NFPA,

> *A **code** is a model, a set of rules that knowledgeable people recommend for others to follow. It is not a law, but can be adopted into law. A **standard** tends be a more detailed elaboration, the nuts and bolts of meeting a code.* [17]

At the most basic level, codes provide the minimum requirements to ensure public health, safety and welfare, and constitute the administrative framework through which governments extend safety protections. There are model codes—those that are developed at the national level for adoption by states and local jurisdictions—for every aspect of the built environment. For this report, the code discussion is focused on the NEC and the IBC, created by the NFPA and the ICC, respectively. Both of these are model codes, adopted in all 50 states and the District of Columbia.[18]

If codes provide the "what," standards often provide the "how." Standards are benchmarks that can provide descriptive language indicating accepted ways of doing things. They are rules, conditions, guidelines or characteristics for products, processes, production methods and management system practices.[19] Within the regulatory environment, codes and standards work together to create a framework of safety requirements and best practices; codes typically reference consensus standards developed by standards-developing organizations. As such, standards play an important role, "enabling technological innovation by defining and establishing common foundations upon which product differentiation, innovative technology development

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[16] "Code," Merriam Webster, copyright 2012, http://www.merriam-webster.com/dictionary/code.
[17] "About Codes and Standards," National Fire Protection Association, accessed October 23, 2012, www.nfpa.org/itemDetail.asp?categoryID=1332&itemID=31068&URL=Press%20Room/A%20Reporter's%20Guide%20to%20Fire%20and%20the%20NFPA/About%20codes%20and%20standards.
[18] While adoption of a building or electrical code is not required by federal law, the IBC is adopted or in use in 50 states and Washington, DC. The NEC is adopted similarly and has the distinction of being the least-amended model code. Some jurisdictions, notably New York City, have or have previously written their own building provisions, oftentimes to deal with local complexities, such as New York City's high-density population.
[19] "OMB Circular A-119," Standards.gov, accessed October 23, 2012, http://standards.gov/a119.cfm.

and other value-added services" are developed and are "essential for enabling seamless interoperability across products and systems."[20]

The American standardization system relies on private-sector involvement led by nongovernmental code-setting entities, and it is supplemented by federal involvement, in particular regarding regulatory processes.[21] In the United States, codes and standards are developed in an advisory capacity at a national scale—for example, the model codes created by organizations such as the ICC and the NFPA, which develop the IBC and NEC, respectively.

2.1.1. Model Codes Adopted by States and Local Jurisdictions

When this report references codes, it will refer to both *model* codes and *adopted* codes. Model codes are those created at the national or international level. Model codes are adopted by states and local jurisdictions through the legislative process. Adopted codes are the version of the model code approved at the state or local level, enforced by the local administrative agency having jurisdiction.

The IBC and NEC are adopted in their entirety or with amendments into law by the states; states further stipulate whether local jurisdictions are then permitted or required to adopt local amendments. Statewide adopting authorities, policies and procedures differ greatly from state to state, and again from local jurisdiction to jurisdiction, regardless of whether the state or jurisdiction is adopting a code as is or with amendments.[22] In part, this is a consequence of a limited federal role.

All codes are voluntary, carrying no legal status until they are adopted by states and/or local governments. Only adopted codes have the force of law. In this way, code-setting organizations are effectively responsible for developing and revising policy documents that advocate for public safety and consistency within the industries covered by the given code. When a jurisdiction adopts a model code or standard, it becomes enforceable under state or local law through the administrative process of the authority having jurisdiction, which may be a state, county or municipal government—and typically regulation requires action at multiple levels. Local amendments spell out code enforcement in the language of the code itself. Furthermore, code appendices offer optional compliance requirements that, when adopted, provide flexibility for jurisdictions to meet the demands of local conditions.

In the United States, conformance with electrical and building codes relies on four interrelated mechanisms: (1) product safety standards and certification, (2) plan approval, (3) application of installation codes and standards and 4) inspection. [23]

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[20] Subcommittee on Standards, *Federal Engagement in Standards Activities to Address National Priorities: Background and Proposed Policy Recommendation* (Washington, DC: National Science and Technology Council, October 2012), http://standards.gov/upload/Federal_Engagement_in_Standards_Activities_October12_final.pdf.
[21] Office of Management and Budget, "Circular No. A-119 Revised," The White House, February 10, 1998, http://www.whitehouse.gov/omb/circulars_a119.
[22] International Code Council, "Code Adoption Process by State," (Washington, DC: International Code Council, n.d.), http://www.iccsafe.org/gr/Documents/AdoptionToolkit/HowStatesAdopt_I-Codes.pdf.
[23] See note 13.

2.1.2. Pathway to Local Codes

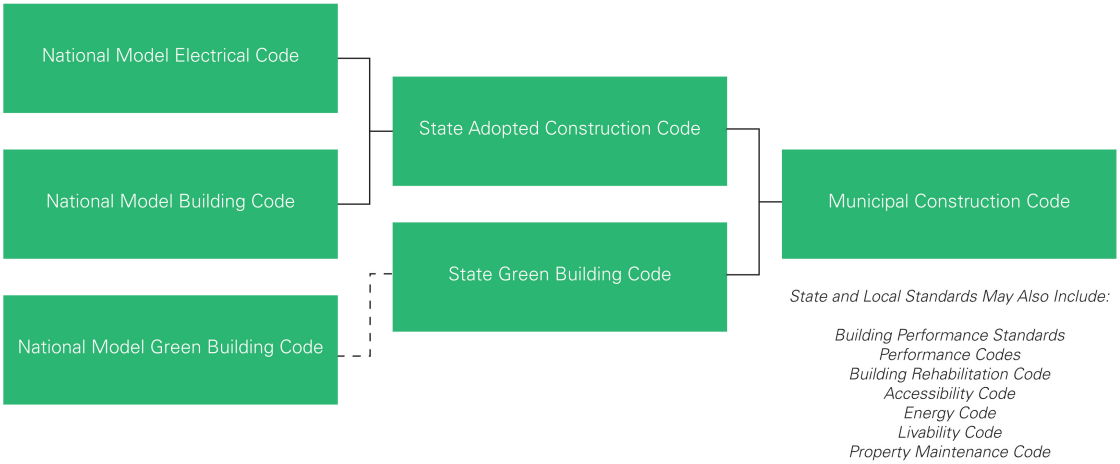

Figure 3: Hypothetical Code Adoption Pathway

2.1.3. Safety Considerations are Central to Codes

Codes ensure user safety and the long-term durability of EVSE hardware and its connection to the power source. There are three widely recognized elements to the safe installation of electrical equipment, including EVSE:

- The use of certified and listed equipment
- Development of clear building and installation plans
- Enforcement through permitting and inspection

EV infrastructure will be installed in a variety of different conditions, such as in single-family homes, on-street parking and public parking lots.[24] In each individual electrical installation, both electrical and building codes will dictate clear processes and procedures for site planning and electrical installation. While a great majority (an estimated 90%) of the charging infrastructure installations will be in residential settings, EVSE will be present in public and shared spaces as well, introducing potential safety hazards into the public realm. Although charging stations most closely resemble such innocuous household appliances as a dishwasher or clothes dryer, safety for all those who come in contact with powered appliances is paramount for the organizations that develop codes and the agencies and inspectors who administer them.[25]

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[24] Washington State passed legislation requiring jurisdictions throughout the state to specifically allow EVSE, including battery swapping, by target dates. Washington State's efforts are also explored in the next chapter.

[25] Although not determined to be major code-related concerns, the safety issues associated with typical EVSE designs and site installations that may lead to increased risk of shock or fire due to heightened continuous electrical loads will be discussed further in this report and in the EVSE site design guidelines.

2.1.4. Interoperability

Interoperability refers to the compatibility of products, systems and processes. Interoperability standards increase user value and improve user experience by providing not only a seamless interface but also peace of mind in terms of relying on the long-term viability of a technology investment or consumer purchase. Such standards reduce the risk of large-scale public and private investments in technology becoming prematurely obsolete.[26] More broadly, interoperability standards can also help maximize levels of coordination and compatibility within the EV industry domestically and internationally. This type of standardization contributes to market stability and could help increase adoption rates, supporting growth even in a transitioning marketplace. Interoperability also has an administrative component. From the perspective, for example, of permitting processes, the amendment of codes at the state level can make charging infrastructure more seamless to install and inspect, as well as to plug in to.

Finally, interoperability standards also relate to uniform signage, easy-to-use site design and other systems that ensure universal access and a safe user experience.

2.1.5. Adaptability

Changes in technologies and infrastructure in terms of the linkage of the EV with the electrical grid are invariable, and it is paramount that these new processes occur in a way that protects the environment.[27] In order to ensure a smooth transition to a future where the EVs are a widespread transportation option, a range of changes in regulatory environments will be necessary.

International consistency will underpin trade between the global automotive industry and local markets as well as compatibility of the charging infrastructure.[28] Compatibility of products in an international marketplace is a critical aspect of reducing production costs. Furthermore, the United States EV industry has the opportunity to advocate for the acceptance of its own standards at the international level, aiding in the competitiveness of U.S.-designed or U.S.-made products. EVSE manufacturers and network service providers see their role in setting standards as changing the marketplace and setting a path for the industry.[29]

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[26] "Memorandum for the Heads of Executive Departments and Agencies: Principles for Federal Engagement in Standards Activities to Address National Priorities," The White House January 17, 2012, http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-08_1.pdf.
[27] Stephen Brown, David Pyke and Paul Steenhof, "Electric Vehicles: The Role and Importance of Standards in an Emerging Market," *Energy Policy* 38, no. 7 (July 2010): 3797–3806, http://www.sciencedirect.com/science/article/pii/S0301421510001631.
[28] Ibid.
[29] Steven Dorresteijn, "Epyon: Your Partner in Fast Charging Solutions" (presentation, March 2011).

2.1.6. Code-Related Goals and Applicable Codes by Type

Issue	Code Type	Model Code
Structural Safety	Building Code	IBC, International Residential Code (IRC), International Green Construction Code (IgCC)
Fire Safety	Electrical and Building Code	IBC, IRC, NEC
New Technology	Electrical Code, Installation Standards	NEC, National Electrical Installation Standards (NEIS)[30]
Energy Efficiency	Building Code, Installation Standards	IgCC, NEIS
Scoping Requirements	Building Code	IBC, IRC, IgCC
Administrative Streamlining	Electrical and Building Code	IBC, IRC, IgCC, NEC

2.2. National Codes and the Federal Role

The U.S. federal government plays no official role in developing model codes or setting national standards, although it occasionally utilizes these documents to guide legislation and policy. In a 1997 article, University of Washington professor Peter J. May notes, "With the notable exception of building provisions for the disabled, the federal role is largely restricted to funding research programs in areas such as energy efficiency."[31] Instead, there is extensive reliance on private-sector code-setting bodies for the development of relevant standards.[32] The National Technology Transfer and Advancement Act (NTTAA) requires federal agencies to rely on standards developed by the private sector for regulatory or procurement processes unless there is impetus to do otherwise.[33] The NTTAA directs the National Institute of Standards and Technology to bring together federal, state and local agencies and governments to achieve greater reliance on voluntary standards, such as nationally accepted model codes, and decrease dependence on in-house single-agency standards.[34] The purpose of such legislation is to achieve openness, transparency and multi-stakeholder engagement through the engagement of the private sector in government process.[35]

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[30] NEIS provides quality and performance standards for electrical construction work that go beyond the NEC. As standards, they are beyond the scope of this document's analysis. However, it is important to note that NEIS has developed helpful EVSE-specific guideline materials for licensed electricians, and it is engaged in instructing technical courses to familiarize professionals with higher-level requirements and best practices associated with EVSE than required in the NEC's minimum installation safety standards. For more information, see: www.neca-neis.org.

[31] Peter J. May, "State Regulatory Roles: Choices in the Regulation of Building Safety," *State & Local Government Review* 29, no. 2 (Spring 1997):70–80.

[32] Ibid.

[33] See note 8.

[34] Standards.gov homepage, accessed July 24, 2012, http://standards.gov/.

[35] See note 28.

Many national policies intend to increase clean energy and EV use and their associated markets. President Obama's initiative to increase the number of EVs on U.S. highways to 1 million vehicles by 2015 includes the proposition that vehicles, parts, support equipment, batteries and other components will be made and serviced in the United States. Clean energy goals represent another area where the federal government is currently making significant policy and financial investments, and in which there is potential opportunity for the federal government to accelerate standards development activities in the process of promoting market-based innovation and competitive market outcomes.[36]

The national framework has also included funding, such as through the American Recovery and Reinvestment Act (ARRA) or DOE, which has been channeled into such related initiatives as the EV Project, a $230 million investment in EV infrastructure deployment and data collection that offers EV owners access to charging stations free of cost, as a means of both incentivizing uptake and evaluating the effectiveness of the charging infrastructure and network business models.[37]

However, it is the states and local jurisdictions that will directly confront feasibility, market development, application for and allocation of transportation and energy grant funding and evaluation of costs and benefits of public EVSE infrastructure programs.

2.2.1. Private-Sector Participation Links Code-Setting Process to Local Development

There is extensive reliance on private-sector code-setting bodies for the development of relevant standards.[38] Model codes are developed by private-sector not-for-profit membership organizations that unite concerns for public safety with those of industry. It is the role of these organizations to carry out the process through which the model building and electrical codes are created.[39]

This process features a high level of industry representation with a clear market component and is "informed by market needs…play[ing] a foundational role in facilitating competition, innovation and global trade."[40] Codes and standards are thus keystones of EV-ready economic development policies and practices. From the international level to the local level, government decision making surrounding the EV and EVSE industries and EV and EVSE deployment will react to changes in technology and markets—stimulating market uptake of new products, technologies and services; increasing safety to assure for consumer; increasing interoperability for affordability and consumer access; and making strides in innovation for creation of new business models and job growth potential. Code-making bodies and standards organizations effectively broker the transaction between industry interests and government interests in the intersecting arenas of economics and public safety.

2.3. Overview of National Model Codes and their Purview

Understanding the respective purviews of the various code-setting bodies and the range of potential goals and outcomes associated with code modifications points to the ways in which local changes can inform model codes in the future. For the purposes of this report, the ICC and NFPA will be considered the primary code-setting bodies, due to their focus on infrastructure. Their standards govern the built environment from structural and electrical perspectives and provide the critical link between vehicles and the power grid.

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[36] Ibid.
[37] "Overview," The EV Project, accessed October 23, 2012, http://www.theevproject.com/overview.php/.
[38] See note 33.
[39] See note 9.
[40] See note 42.

2.3.1. NFPA and the NEC[41]

The NFPA is an international nonprofit organization focused on reducing the risk and damage from fire and other hazards through research, training and the development of codes and standards. The NEC is the infrastructure standard for electrical construction in the United States, developed by the NFPA and in use since 1897. The primary concern of the NFPA is electrical safety.[42] The NEC provides requirements for typical hard-wired connections for all types of electrical installations, including wiring methods, equipment construction, grounding and protection and equipment location to prevent exposure to energized live parts. The scope of the NEC with respect to EV infrastructure[43] includes the relevant conductors and equipment external to the vehicle, the connection of the EVSE to the electricity supply, the conductive or inductive means required to make the connection and the installation process itself.[44] The electrical code will deal exclusively with the installation of the infrastructure, including electrical safety provisions that impact siting and design, such as minimum heights and maximum cord lengths, and should be amended for electrical safety purposes only, such as those that pertain to local environmental conditions.[45]

NEC Article 625 provides specific requirements for the following:

- Placement of unit (height from ground)
- Length of cable (25 feet max)
- Number of cables per unit
- Connections and couplers
- Rating (level of charge)
- Markings
- Overcurrent protection
- Personnel protection
- Interactive systems
- Ventilation
- Supply circuits
- Indoor versus outdoor installations

EVSE Provisions

The NFPA introduced EVSE in the 1996 edition of the NEC, a response to the expected release of a number of EV models by large original equipment manufacturers to meet the initial phase of the zero emission vehicle mandate. Revisions have been included in the 1999, 2002, 2005, 2008 and 2011 editions of the NEC based on changes and evolution in battery, automobile and supply equipment technology, along with other industry and user-based needs.[46] The NEC also acknowledges EVs and charging infrastructure in Article 625 of the code.[47]

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[41] NEC consists of an introduction and nine chapters. Chapters 1–4 of the NEC cover general requirements that are widely applicable to electrical wiring and installations of all kinds. These first chapters set up the fundamental rules and cover specific technical installation requirements for electrical installations; later chapters in the code establish more specific thematic rules that regulate installations by topic, for example, EVSE. Chapters 5–7 cover special occupancies, equipment and conditions, and supplement the regulations set out in the first part of the code. The remaining chapters cover communications systems, reference tables and appendices. These last chapters are only requirements when specifically referenced in other parts of the code; otherwise they are for informational purposes.

[42] Mark Earley (NFPA), interview, July 18, 2012.

[43] NFPA NEC 70 Article 625 defines EVs as those that are highway-worthy autos. It additionally distinguishes between battery electric vehicles, plug-in hybrid electric vehicles and hybrid electric vehicles.

[44] See note 15. Inlets and corresponding couplers are currently standardized not by the NEC, but by the SAE J1772 standard.

[45] The NEC deals with the consumer side of the electrical installation, while a separate code developed by the Institute for Electrical and Electronics Engineers (IEEE) called the National Electrical Safety Code deals with the manufacturer side.

[46] Donny Cook, "Electric Vehicles and Electric Vehicle Charging" (presentation).

[47] Furthermore, Article 626 regulates electrical systems on freight trucks.

Electrical Loads and EVSE Safety

Because the NEC is exclusively concerned with electrical installation, the model code only directly determines design parameters that dictate safety requirements related to circuitry design.[48] Even the lower-voltage level 1 charger generates system impacts due to the fact that the eight or more hours required to charge a vehicle represent a unique instance for residential applications because such installations do not typically generate continuous loads of more than three hours.[49] Continuous electrical loads generate more heat in the local system, which is a cause for concern, and have implications for the utility grid. The continuous loads of EV charging stations present the central challenge to efficient and safe ongoing use, both in the home and on local transformers. Alternating current (AC) levels 1 and 2 are considered continuous-duty loads; that is, they are on for more than three hours. The NEC provides minimum requirements for performing site assessments.[50]

Although the cumulative effects of EV battery charging on both the circuitry at the point of installation and at the local network scale is outside the scope of this report, and at present EVSE is or could be considered minor work in many jurisdictions, these effects should still be taken into account. The safety implications that may arise from either overloading household circuits or local transformers, or collectively burdening utilities with increased loads at prime charging hours, may become issues for homeowners and for the utility grid. In general, the NEC provides guidelines for overload protection and load calculations, as do the EVSE installation standards published by professional organizations and interest groups.[51] Jurisdictions are also taking steps toward increasing requirements for reporting EVSE installation to local utilities.

NFPA views system capacity issues related to EV charging loads as central to the EVSE installation discussion because a homeowner or developer—or even a municipality—installing EVSE does not want to "surprise" the utility. For new installations (new construction with EVSE or EVSE-ready installation), the load issue will come to light through the permit application or inspection process where one exists. However, for existing installations (the addition of EVSE to a previously constructed circuit), this issue is not addressed by the current code.[52] While ideally this is an issue that could be addressed locally through relationship-building between utilities and local or state governments, it is the case in most TCI region states (e.g., New Jersey and Rhode Island) that the privacy issues associated with notifying utilities of an EV purchase or EVSE home charging units remain an ongoing concern that, without legislation mandating EV reporting (Maryland), has yet to be solved.

Expected NEC 2014 Revisions

The NEC is currently in the middle of the development cycle for its updated 2014 edition, which is scheduled for publication in fall 2013. Significant work is underway on Article 625, pertaining to EVs. In addition, revisions of the sections pertaining to alternative energy are expected. There is a need for the code to more specifically recognize some new DC-related technologies, even

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[48] See note 44.

[49] According to NFPA expert Mark Early and utility representative and EVSE program manager Beth Neaman at SCE, other household appliances, such as refrigerators or air conditioning units, draw a similar amount of power in cycles. The cyclical nature of the electrical loads associated with virtually all other standard household electrical equipment makes the 6–8 hour continuous charge a substantial power drain on a typical household system.

[50] See note 15. Specifically, articles 210, 215 and 220, which include rules related to calculations/loading of services, feeders and branch circuits in all occupancies. Annex D of the NEC provides load calculations in examples that include several EVSE scenarios including multifamily dwellings, store buildings, multi-structure industrial facilities and single-family residences.

[51] For example, see Advanced Energy's guide: http://www.advancedenergy.org/transportation/evse/Charging%20Station%20Handbook%20Rev2011.pdf and the National Electrical Contractors Association EVSE installation guide: http://www.necanet.org/index.cfm?fa=newsAboutNecaItem&articleID=5536.

[52] See note 44.

though DC has been addressed in the NEC since its first edition in 1897. The DC initiative underway is primarily focused on low-voltage DC as well as updating general DC requirements throughout the code.[53] A key factor in all of these articles is interactivity. A new article is in development that will cover energy management in interactive electrical systems that are capable of storing and supplying energy back to the grid. Energy management systems can be used in a variety of applications, but for EVSE they provide a means by which the charging infrastructure and vehicle battery can help store and supply power in a way that reduces peak demand.[54]

2.3.2. The ICC and the IBC

The ICC is a member-based association that works to help the building safety community and construction industry provide safe and sustainable construction through the development of codes and standards that apply to the design, construction and compliance process.[55] The IBC is used around the world.[56] As publisher of the IBC, the International Residential Code for One- and Two-Family Dwellings (IRC), the International Fire Code, which is used in 43 states as the fire code and the International Green Construction Code, the ICC has a significant role in establishing standards for much of the built environment.

For simple, plug-and-play outdoor EVSE installations, the building code is not a major consideration. For certain built environment conditions, such as inside a garage, it is presumed that the applicable version of the building code will have required all that is necessary from a fire safety standpoint.[57]

IRC: Purview and Challenges

The IRC governs construction for single-family homes of up to three stories. The residential code is written for the designer and builder of a single-family home who may not necessarily be a licensed architect; as such, it attempts to be entirely self contained, meaning that it does not require the designer or builder to reference any additional standards or codes.[58] The commercial code (the IBC) refers to other standards, including the NEC, based on the assumption that licensed professionals who are well versed in the standards and their applications will be carrying out the work.

Residential installations will compose an estimated 80%–90%[59] of the EV charging stations installed, followed in number by office locations and then by publicly accessible charging.[60] One of the most significant opportunities for improvement to the model building code thereby comes from the IRC–for single-family home installations in jurisdictions where the IRC has been adopted and where the local code does not require an electrician to perform work on a private residence. The typical homeowner is likely not going to be concerned with or knowledgeable of the capacity of his home's electrical system. A homeowner installing a charging station purchased independently and without consulting the local utility may create safety hazards due to additional and continuous loads associated with EV charging.[61] It is particularly critical to be wary of these

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[53] See note 10.
[54] "NFPA 70 National Electric Code," National Fire Protection Association, www.nfpa.org/70.
[55] Although ICC is an accredited ANSI standards developer, ICC develops its code using its own "Governmental Consensus Process" (added by David Karmol).
[56] See note 8. Despite the fact that the model IBC is adopted in all 50 states and Washington, DC, it is not considered an American National Standard due to the fact that the IBC is not vetted through the American National Standards accreditation process (see next section).
[57] See note 44.
[58] Bruce Spiewak, phone interview, July 20, 2012.
[59] See note 5.
[60] Brian Kiley, interview July 27, 2012; See note 17.
[61] Kiley, interview.

safety hazards in homes built in the 1960s and before, which would benefit from a service upgrade for safety purposes. Although the number of installations fitting this particular scenario may represent a small amount of total residential EVSE, it is a clear area for potential improvement.

2.3.3. ANSI

ANSI is a member-based nonprofit organization that plays many interrelated roles within the world of standardization. In general, ANSI acts as the administrator and coordinator of the U.S. private-sector system of voluntary standardization, overseeing the creation, promulgation and use of thousands of guidelines that apply to many economic sectors. The organization provides accreditation services whereby standard-setting bodies can be recognized as conforming to due process procedures for standards development, and certification programs can be recognized as complying with national and international norms. In its role as accreditor of standards developers, ANSI does not participate in a discourse on the technical merits of a given standard, but rather approves standards if the process followed by the standard-creating organization adheres to ANSI's essential requirements for due process. ANSI's membership comprises government agencies, organizations and companies from the private sector, international bodies and individuals.

ANSI is itself the official representative member from the United States to the International Organization for Standardization and, via the U.S. National Committee, the International Electrotechnical Commission, both of which are involved in the development of international standards related to EVs and charging infrastructure manufacturing.[62] As a member of these international organizations, ANSI represents the interests of its own members and their respective standards across a variety of industries in the international realm, and it serves those interests by advocating where requested for the adoption of U.S. standards as the international norm.[63]

ANSI's general interest as a standards umbrella organization in optimizing processes and harmonizing standards and codes created by multiple organizations has spurred action on the front of EVs and charging infrastructure. Inspired by standards' roadmaps created by both Germany and the European Union, ANSI established an organizational arm to address this emerging area of work. The ANSI Electric Vehicles Standards Panel (ANSI EVSP) is a cross-sector coordinating body within ANSI whose objective is to foster coordination and collaboration on standards to enable the safe, mass deployment of EVs and EVSE, engaging stakeholders to generate international-level coordination, adaptability and engagement.[64] Key stakeholders include the automotive industry, utilities and power authorities, electrotechnical manufacturers and other standards organizations. The primary product of the ANSI EVSP has been a roadmap document (*ANSI EVSP Standardization Roadmap for Electric Vehicles)* released in spring 2012. The roadmap catalogs all relevant entities operating in the EV standards space, identifies central issues to EV and EVSE standardization and codes, discusses product and infrastructure standards related to EVs and identifies existing needs and gaps as well as existing efforts at harmonization. The analysis provided by the roadmap is a critical review of existing codes and standards across all aspects of EVs and EVSE, and the roadmap will be an important resource for the field and EV-ready planning going forward.[65] One of the key takeaways from the roadmap

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[62] "About ANSI Overview," American National Standards Institute, accessed October 23, 2012, http://www.ansi.org/about_ansi/overview/overview.aspx?menuid=1.
[63] See note 8.
[64] "Electric Vehicles Standards Panel," American National Standards Institute, accessed October 23, 2012, www.ansi.org/evsp.
[65] See note 13.

exercise is the confirmation that for EVSE installation, safety issues are largely accounted for in current standards and model codes.[66]

2.3.4. The Code Revision Process

Codes and standards are updated regularly in set cycles with the intent to incorporate new science, lessons learned from disasters and new technologies and products.[67] Both the ICC and the NFPA operate on a three-year code revision cycle, with designated periods for proposals from the industry and public for additions or amendments to the code. Following the proposal period, the proposed changes are made publicly available for comment and review.[68] The relevant committees within each organization then determine which, if any, of the proposals will enter the next version of the model code.

The process by which model codes are developed and revised is open to input from the public, which includes all concerned parties ranging from industry to local government to concerned practitioners, as well as from internal committees in the case of the NFPA. The ICC receives code change proposals from its members and from the public, but it does not generate changes within the organization. Similarly, a majority of code change proposals for the NFPA originate as public proposals, although the NFPA's internal committees and working groups generate new code concepts as well.[69]

The NFPA's committee-based proposal allowance permits the organization's members to become more proactive in the code cycle; task forces and technical committees, comprising NFPA members, examine the technology landscape to ensure all relevant safety concerns are addressed in the next revised model code.

It is important to consider impacts and rank priorities for code changes. Cost barriers that impede local jurisdictions, even states, from updating the code on the standard three-year cycle are real and reflect a larger economic situation more than disinterest in pursuing the adoption of the most up-to-date standards.[70] The added costs of training and staff time should be taken into consideration, even with temporary amendments or interim changes to the code. The NFPA permits interim changes in the event that the organization becomes aware of a significant new technology that poses immediate safety concern. Such changes are referred to as "tentative interim amendments."[71]

The key to developing and proposing successful model code changes is not only the development of a widely applicable rule or process, but the language used in writing the proposed changes; code language must provide clear guidance but be generic with regard to projects or products.[72]

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[66] See notes 10 and 13.
[67] "NFPA, ICC Create Coalition to Advance Public Safety in the Built Environment," National Fire Protection Association, June 5, 2012, http://www.nfpa.org/newsReleaseDetails.asp?categoryid=488&itemId=57256&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+nfpacodesandstandards+%28NFPA+codes+and+standards%29.
[68] As of writing, both the NEC and IBC are in the public review phase for the next edition of the codes, which will be available in 2013.
[69] See note 44.
[70] See note 60.
[71] See note 44.
[72] See note 9.

2.4. New Technology Outlook

Innovations will define the technological and electrical components that relate to evolving safety and infrastructure issues in EVSE installation. Codes and standards must be forward-thinking as policy and planning tools to anticipate the need to cover changing infrastructure technology. However, while it is critical that interface and infrastructure standardization are undertaken so as to anticipate and be compatible with future technological advancements in EV electrotechnical systems, safety and environmental sustainability, it is widely accepted that codes should support existing technology rather than attempt to anticipate the next innovation.[73] The development of such standards and their inclusion in model codes is a work in progress. Upcoming innovations and areas for consideration can be divided into several key categories: updates to the stations themselves, innovation in power sources and connection to the utility grid. In all of these areas, public education will be critical component of future success.

2.4.1. Charging Stations, Design and Networked Communications

There are gaps regarding emerging issues, including standards for DC fast charging.

- DC fast charging will be useful for long-distance travel and public charging stations and in commercial applications
- Future standards in connector design should take into account current how-to-use issues. International energy technology firm Efacec, one of the leading DC fast-charging manufacturers in the U.S. market,[74] reports that 90% of the calls to the company's customer service line are regarding how to plug in the DC connector, which has not yet been standardized.[75]

Currently, no standards exist to cover wireless charging.

- Inductive or in-ground wireless charging presents another interesting future advancement and codes challenge.
- This topic is presently being addressed under SAE 2954 and Underwriters Laboratory (UL) 2750, but not in the NEC or the IBC.

No international standards exist to address battery swapping safety and interoperability.

- The ANSI EVSP roadmap has identified this gap as a priority.
- Washington State has referenced battery swapping stations in a proposal for local zoning ordinances to address EVSE.
- Battery banks will be addressed in a current code proposal for NEC section 625.4 to include power sources of up to 600 volts DC.

Communications standards are lacking and will impact site design and construction best practices.

- Smart grids, communications systems that connect the EV driver's mobile device to the vehicle, such as through mobile technology, or the vehicle to the grid, such as through

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[73] See notes 17 and 29.
[74] "Transportation," Efacec, accessed October 23, 2012, www.efacecusa.com/Transportation.aspx.
[75] Mario C. Santos, EPRI Infrastructure Working Council on Electric Transportation meeting, Chicago, IL (presentation), June 28, 2012

charge point monitoring software, are areas of communications-related standards that require additional work.[76]

- No standards currently exist to provide for generic locating and reserving of public charging stations, the interconnectivity (e.g., through roaming) of EVs between EVSE service providers, offline access control at private charging stations or communications from EV meters to the vehicle or sub-metering scenarios.[77]

Electrical loads and alternative power standards that address reverse power flow, both communications and safety aspects, are still in development.

- Sections of the relevant codes from SAE need to be completed to include this information, although existing standards cover information design, use cases and safety aspects for reverse power flow.[78]
- Codes relating to the load balancing required for energy storage systems are another potential area of development.

Alternative power sources represent an interesting future option for generating power, and while many areas and companies are experimenting with this technology, model and local codes have not yet seen the need to address it.[79] Generally this area is already covered by standards, but there remain areas on which to improve:

- The NEC does not specifically address the integration of EV/EVSE with a facility high-voltage DC power distribution system for either charging or reverse power flow.
- NEC requirements are needed for high-voltage DC power distribution systems and the integration of DC loads within the system.
- Solar is addressed by ANSI/UL 1703 and NEC article 690 for safety of photovoltaic equipment, and small wind systems are covered in NEC article 694.
- Communication with various state utility commissions should take place to make sure that vehicle-to-grid technology can be used as a part of a state's distributed power system. Distributed power can be an effective tool for leveling the spikes in power requirements.

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[76] The National Institute of Standards (NIST) has released a February 2012 document: "NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0." In that document, there is a complete summary of the efforts to date on the development of plug-in electric vehicle interoperability standards (http://www.nist.gov/smartgrid/framework-022812.cfm).

[77] See note 13.

[78] Ibid.

[79] Ibid.

3. LOCAL CODES FROM MODEL STATES AND MUNICIPALITIES

3.1. Local Planning for a Regional Infrastructure Network

A key strategy for capturing the many benefits of EVs will be the development of policies and programs that aim to deploy EVSE infrastructure to meet today's charging needs and prepare cities, towns and regional corridors for growing EV use. Every jurisdiction is different, yet there are select, key factors necessary in order to successfully advance policy, legislation and ordinances pertaining to EV infrastructure. The building and electrical codes examined in this study represent just one tool available to governments, and may or may not be the ideal solution to regulate EV-charging infrastructure deployment everywhere. EV-ready planning should include consideration of the following goals:

- Ensuring that new construction is wired for EVSE
- Clearing administrative pathways for residential service upgrades and EVSE retrofit
- Guaranteeing safe, consistent and accessible infrastructure installations and implementing good site planning and design
- Ensuring that new construction can support a higher pull on the utility grid, with the potential of adding future vehicle battery charging capacity and eventually energy storage devices
- Aligning EVSE deployment with policy and environmental mandates to achieve emissions reductions, air quality improvements, transportation technology advances and energy independence

Each of these goals will require actions by state and local governments and authorities, private-sector stakeholder, nonprofit EV proponents and other EVSE stakeholder groups. In planning for EV readiness, the question is what jurisdictions or agencies can do to enhance EV readiness. For example, zoning and parking ordinances, along with permitting, comprise potential approaches at the local level that can work alone or in combination with the structural codes for the implementation of EV-ready policies. These are just a few of the policy levers available to jurisdictions. Legislation, environmental benchmarks, economic development planning, real estate incentives or advocacy-based outreach and education are also critical approaches that were determined as a result of this report's research. These policies should be noted as areas for further study as a part of the emerging EVSE ecosystem.

Considering the limitations in current EV battery technology and the range anxiety associated with a vehicle's battery, the primary existing infrastructure need is the development of a consistent, accessible charging network. However, for EVs, infrastructure begins at home. Ensuring safe, accessible and cost-effective EVSE installation in a variety of vehicle home contexts—the places that vehicles will receive their regular charge—represents the first step in EV-ready planning. Connecting home charging to other charging scenarios would enable EV owners to increase the effective range of their vehicles by making it possible to charge at home, at work and in commercial and public locations, thus extending vehicle reliability over longer trips and better integrating EVs into regional transportation networks. Effectively doing this requires cooperation among jurisdictions, and interviews and case studies also indicate the importance of a high-level, flexible EVSE code framework at the state or regional level designed to encourage local adaptability.

Timing and Costs Complicate Code Regulation

Irregular timing of technology development and rates of EV adoption combine with a wide variation in administration and local conditions—such as extreme weather or high population density—and may encourage localities to amend national model codes to better suit the safety and public welfare requirements necessary. Many states across the country have passed environmental or other related laws that may include provisions or language that require changes to the state-level codes in order for the included jurisdictions to be in compliance with the full spectrum of regulation.[80] There are also high costs associated with changing codes—from staff time to inspector training—and many states and local jurisdictions opt to amend codes once every six years rather than three.[81] Finally, the staggered timelines for revision by code-setting bodies and for review at the local level means that the local jurisdictions adopting codes are often simply behind the times, if being up-to-date is viewed from the perspective of adopting the most recent edition of the code. Together, these factors create a high degree of inadvertent variation across jurisdictional boundaries.

Acknowledging the high costs to local jurisdictions, this report does not at this time recommend changes to the local code revision cycle that would require states or municipalities to update their codes more regularly.

3.1.1. Opportunities to Harmonize Regulations and Promote EV Adoption

Some sources suggest that states or other local jurisdictions should have no reason to deviate from a national model code unless there are provisions written into the applicable state or local laws that require the jurisdiction to do so.[82] Yet federal, state and local laws can lead jurisdictions to amend national model codes. Legislation is typically the incentive to act on codes, and it may include goals related to economic opportunity, environmental conditions or local factors.

There is no one-size-fits-all policy approach to increase EV readiness and serve EV users—or to achieve environmental benefits. Each state or local jurisdiction needs to evaluate the objectives (compliance, economics, and environment) behind any potential policy, code or other change, and follow a path that best suits the available and appropriate menu of options for that jurisdiction. Code modifications can help municipalities, states and regions to promote EV adoption by raising the bar on infrastructure development requirements.

There are implications for the administrative enforcement of local codes that, in turn, impact anyone interested in installing EVSE. Perhaps most significantly, inconsistent business or regulatory environments create complications for those entities providing EVSE infrastructure, from developers to charge networks. Administrative timelines and costs vary widely, and infrastructure providers must navigate a new system with every infrastructure deployment.

Tackling these issues will require cooperation and advocacy. Creating regulatory consistency will be a dual function of the ongoing work of code-setting organizations to incorporate EV- and EVSE-specific provisions, and of the place-based efforts made by the jurisdictions with authority over state and local codes.

The case studies in this section discuss several scenarios in which local and state codes require amendments that arise for particular policy reasons, such as the following examples:

- State or local code changes may be required in order to comply with environmental, transportation or clean energy target legislation established at the federal or state level.

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[80] See note 60.
[81] Ibid.
[82] See note 8.

- The building code can include scoping requirements, enabling jurisdictions to self-tailor regulations through a selection of the most appropriate mandatory and optional provisions.

3.1.2. Model Jurisdictions: Case Study Overview

The purpose of the following case studies is to profile different approaches, scales and outcomes to changing building codes to more seamlessly allow the incorporation of EVSE infrastructure. The three case studies focus on process and outcomes, highlight best practices for implementation and seek to understand benefits of "EV-ready" codes. The purpose is not necessarily to provide a standard format for writing local codes—ideally greater harmonization will continue to happen at the international and national levels.[83] Instead, the case studies attempt to show the process and outcomes of changing codes to be more EVSE-friendly under different circumstances. What are the key components of EV-readiness? What experiences are replicable? What are the lessons learned from state and local processes for encouraging EVSE deployment?

The case studies in this section elaborate on ways that jurisdictions are currently modifying existing model codes in order to create and implement improved local codes that speak to the needs of jurisdictional authority. Although there is wide variance among local jurisdictions, the process of revising codes is available to states and local authorities and also provides flexibility that leaves room for state-level interpretation. Within a framework of consistent guidelines, this flexibility could be utilized to generate more uniform codes, and determine when and where states and jurisdictions choose to adopt them.

The case studies also outline scenarios in which economic drivers (such as a local EV-related manufacturing base, a desire to generate high-tech jobs or a desire to improve quality of life to attract residents and workers) are relevant, particularly in the way they interact with local conditions (such as the relative economic and environmental cost associated with the local energy supply).

[83] See note 5.

VANCOUVER, BRITISH COLUMBIA, CANADA

Summary
Vancouver is the first North American city to require EV charging station connection points for EVs in all new homes and developments.

Focus
Municipal building code

Code Outcomes
Modification of the city's building by-laws to require EVSE-ready wiring in new single-family and multifamily residential construction. Twenty percent of multifamily new construction and 100% of single-family new construction must be built EVSE-ready.

New code updates for 2012 will increase the residential service request to 220 volts to accommodate uniform level 2 charging, and will introduce a 10% EVSE-ready parking requirement to new commercial construction.

3.2. Vancouver: An EV-Ready Building Code

Vancouver, BC, in Canada is known as one of the most forward-thinking cities with respect to its transportation electrification policies and efforts. Yet the city staff stresses that the city is ahead of the curve not because the city is somehow better or more knowledgeable, but because the municipality had the opportunity to move ahead quickly with EVSE planning. EV infrastructure plans and pilots have only just launched in BC. By incorporating EVSE into long-range goals for buildings, transportation and economic planning, the city has taken a holistic approach to EV infrastructure deployment. At the center of Vancouver's strategy is the city's building by-law—the city's building code.

Above and Beyond Approval

The original proposal for a by-law amendment required 10% of the parking stalls within multifamily residential developments to be wired for EVSE installation. Vancouver's City Council approved the by-law amendment and doubled the required amount of parking stalls to be wired for EVSE to 20%.

Unique Considerations

Along with Halifax, Vancouver is one of just two Canadian cities with jurisdictional authority to modify its building by-laws at the municipal level.

Utility

BC Hydro, a Crown corporation, provides much of BC with clean hydropower, with 93% of the electricity in the province generated by clean or renewable resources, meaning that EVs have the

potential to dramatically reduce GHG emissions in a local well-to-wheel analysis in addition to eliminating them at the tailpipe.[84]

Pilot Funding

The city of Vancouver secured $800,000 (Canadian) for an EV infrastructure pilot project. Project financing includes funds in the amount of $120,000 from BC Hydro, the Vancouver power authority. A portion of the total funding also came from the provincial government (a partial allocation of an approximately $14.6 million BC-wide EVSE project that will install 1,000 charging stations throughout the province—570 public, 400 in multiunit residential buildings and 30 DC fast chargers on the Canadian spur of the Pacific Coast Electric Highway). A minimum of 67 charging stations will be part of the Vancouver pilot.[85]

3.2.1. Cutting-Edge Code Policy Supports EV-Ready Green Buildings

In July 2008, as a part of the Green Homes Program, the Vancouver Council enacted new regulations in the building by-law[86] aimed at reducing the environmental impacts of new one- and two-family homes; the amendments to the code made the Vancouver building by-law one of the "greenest" residential codes in the world.[87] With the successful implementation of the Green Homes Program goals, and to move forward with provisions in the city's EcoDensity Charter,[88] the Vancouver Council passed a second building by-law amendment to require the electrification of a portion of residential parking stalls in all new buildings containing three or more dwelling units; the provisions were required for all new projects applying for permits after April 20, 2011.[89] The by-law required a minimum of 20% of parking stalls associated with multifamily dwellings to be outfitted with an electrical inlet and conduit/panel capacity to accommodate level 2 EVSE installation, and stated that it is the responsibility of the electrical engineer of record to assess the electrical system capacity required. Further, in buildings with an electrical room containing a transformer, the room is required to contain enough physical space capacity to accommodate future installation of the equipment necessary to provide charging stations at 100% of the building's parking stalls.[90]

3.2.2. Location Advantages: Vancouver's EV Suitability

Vancouver is a compact, high-density city with a population of about 600,000 people in roughly 114 square kilometers (44 square miles).[91] Demographics support the EV market, indicated by the high level of alternative vehicle technology uptake (in Vancouver and in BC, the Toyota Prius sold at more than twice the national rate). In a city with a relatively small land area, about 95% of car trips are less than 30 kilometers (19 miles) and about 70% of car trips are less than 10 kilometers (6 miles), making EVs highly viable for daily transportation. Furthermore, Vancouver's power supply is unique for two reasons. First, less than 10% of the province's power comes from non-renewable sources (natural gas); like much of the Pacific Northwest, BC has a supply of

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[84] "Plug-In Vehicles," BC Hydro, accessed October 24, 2012, http://www.bchydro.com/about/sustainability/climate_action/plugin_vehicles.html.
[85] See note 17.
[86] City of Vancouver, By-Law No. 9691 (Building By-Law, January 30, 2007), http://former.vancouver.ca/blStorage/9691.PDF.
[87] City of Vancouver Committee on Planning and Environment, *Green Rezoning Policy Report* (February 4, 2009).
[88] http://vancouverpublicspace.ca/index.php?page=ecodensity-liveability.
[89] City of Vancouver By-Law No. 9936.
[90] City of Vancouver Community Services Group, Bulletin 2011-002-BU/EL, March 17, 2011.
[91] With a population density of approximately 13,000 residents per square mile, Vancouver compares most closely to Boston or Chicago among major U.S. cities. In land area, Vancouver is comparable to Boston and San Francisco.

clean, renewable energy, largely hydropower. As a result, a transition to EV use would represent an approximate 98% reduction in carbon dioxide emissions.[92] Second, Vancouver has the largest price differential between gas and electricity in North America.[93] Together, these factors exponentially increase the environmental and economic benefits of EV adoption, providing serious policy and financial incentives for the city to invest in studying and deploying EV charging infrastructure.

In addition to these incentives, Vancouver has the advantage of already being known as one of the world's most livable cities.[94] The benefits of the "Pacific Northwest mindset" and 40 years of forward-thinking local policy from the Vancouver City Council also contributed to the ease of adoption of the Building By-law amendments.

These factors should not be seen as setting Vancouver apart as an anomaly; every city is unique in its combination of economic, energy and planning policies and agendas; real estate development industry; political will; stakeholder buy-in and realistic action items. Instead, other cities should look to a broad range of market, environmental and political factors to consider the feasibility of a particular path to EV readiness in their communities.

3.2.3. Policy Origins

In March 2005, Vancouver's Council approved a Community Climate Change Action Plan to reduce GHG emissions to 6% below 1990 levels by 2012, and two years later, in March 2007, the City Council passed a motion directing city staff to plan for significant, long-term GHG reductions with the goal of carbon neutrality. In May of the same year, the Vancouver Council adopted a building by-law that included environmental protection objectives, opening the door to the facilitation of future development of the city's Green Building Strategy.[95]

BC Plug-In Electric Working Group

In response to these city-wide goals, a working group emerged from an early partnership started by the former Climate Programs Engineer for the city of Vancouver, the power authority BC Hydro and the BC provincial government, when it was realized early on that three people—or even three agencies—could not guide the entire planning process. Ultimately, the BC Plug-In Electric Working Group was composed of 10–12 carefully selected institutional members representing different levels and agencies within the provincial and city governments, nongovernmental organizations, the electrical utility and academia. In its bimonthly meetings, the working group sought to understand the large-scale questions in the context of what small steps could be taken.[96]

The first of those steps was recognizing the ability of the province to secure EVs for sale in the local market. BC signed memoranda of understanding (MOUs) with vehicle manufacturers, notably receiving early shipments of the Mitsubishi i-MiEVs. After establishing that getting the vehicles to the area for sale was the first step, the city and province, through the working group, began to consider the required infrastructure.

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[92] See note 17.
[93] See note 5.
[94] Consistently ranked highly by *The Economist*, *Monocle* and *Mercer*: http://www.mercer.com/press-releases/quality-of-living-report-2011#City-Rankings.
[95] "Policy Report on Development and Building" (Vancouver: City of Vancouver, June 9, 2008), http://www.docstoc.com/docs/5427511/CITY-OF-VANCOUVER-POLICY-REPORT-DEVELOPMENT-AND-BUILDING-Report.
[96] See note 17.

The BC Plug-In Electric Working Group united interests and expertise from local and provincial government, utilities and energy resources and academia around creating a comprehensive EV-ready and infrastructure deployment strategy.

Building Code Amendments[97]

The BC Plug-In Electric Working Group looked to areas that the city could control; that is, the regulatory tools available that would have the ability to build awareness and interest as well as hard infrastructure for EV charging.[98] With the working group and other stakeholders, the city's Office of Sustainability, Planning, Development and Engineering, the office responsible for making final recommendations, realized that a primary challenge is the ability of the EV owner to install or access a charging station at his home.[99] In 2008, Vancouver began working on its building code, or building by-laws. The ability of the city to do so is unique (with Halifax being another exception to the rule) in Canada; municipalities typically do not have jurisdictional authority over the building code. The building code rose to the top as the most critical option for city policy changes to drive EV development because of its ability to garner larger interest, policy buy-in and market uptake.[100]

In Vancouver, amending the building by-laws for the EV provision was not a process that differed from amending the code for other reasons. Essentially, there is a standard approach and process that must be followed for such an amendment. Because the potential change would necessarily impact real estate developers—from whom the city can expect a certain degree of push back on proposed changes that will increase construction costs— BC Plug-In Electric Working Group attempted to craft a standard that would keep any cost increase below 2% of total construction costs.[101] This 2% maximum construction cost increase limits the scope of any building code amendment in the city.

The amendments included the following:

- Single-Family Dwellings: Vancouver Building By-law No. 9691 (2008), which requires each dwelling unit to be constructed with a cable raceway capable of supporting level 2 charging infrastructure.
- Multifamily Dwellings: Vancouver Building By-law No. 9936 (2009), which requires 20% of the parking stalls in multifamily construction (three or more dwelling units) to be equipped with a receptacle to accommodate EVSE use.

For the city, addressing the residential building code was a "clear decision area."[102] Not only does it fall clearly within the jurisdiction of the city and the code, but the city took the position that a majority of future EV charging will be done at home. In planning for infrastructure deployment with a limited budget,[103] it was critical for Vancouver's planners and the BC Plug-In Electric Working Group to consider the tools available that could create the maximum impact.

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[97] See Appendix D for code language from Vancouver.
[98] See note 17.
[99] See note 98.
[100] See note 17.
[101] Vancouver's 2% figure is standard for any building by-law amendment, largely due to the fact that such a minimal overall increase is effectively lost in the project details. Additional development costs are not always passed on directly. Vancouver's current Climate Programs Engineer, Malcolm Shield, explains that the total development value is based on a combination of developer profit, hard costs, soft costs and land costs. Considering that the price to the buyer is fixed by the market value of the unit—the developer will not shift its profit margin—and that hard and soft costs are effectively fixed, the increased cost associated with EV-ready construction will be reflected in the one remaining variable: land price.
[102] See note 17.
[103] CAD 800,000 for the infrastructure deployment program.

3.2.4. A Measured, Holistic Approach

Another key element to Vancouver's planning approach is the holistic nature of the issues and actions considered by the Vancouver City Council and the BC Plug-In Electric Working Group. The city's relatively limited resources created a need to plan very carefully due to smaller project budgets than those available for similar projects in U.S. cities.

However, the combination of working in a number of related but distinct areas to advance the city's EV readiness contributes to the broad perception of Vancouver's success and leadership in the EV field. In reality, Vancouver has just six public charging stations owned and run by the city. By the end of 2012, this number will increase by between 20 and 25 stations as a part of the publicly funded pilot.[104]

Next steps for the city will prioritize rolling out the charging infrastructure trial, assessing sites and understanding the best locations for EVSE location. Steps forward will also include continued innovation through industry partnerships and a focus on understanding EVs as an aspect of multimodal transportation planning. In many ways, Vancouver's approach to EVSE deployment demonstrates that the proof is not in the numbers, but in the creation of a strategy that leads to a more favorable EV market.

Vancouver, BC, Stakeholder Outreach by Category

Category	Action
Business Partners	car2go car sharing partnered with the city to share a fleet vehicle, kept in a high-visibility parking spot. The vehicle is designated for public use during the day and is available to car2go customers during non-business hours.
Business Partners	TELUS has designed concepts for integrated EV and cellular infrastructure that will be deployed in Vancouver parks.
Utility Relations	Development of energy price structures BC Hydro acts as consumer resource for EV and EVSE
EV-Ready Roadmap	Project Get Ready/Rocky Mountain Institute created a plan for an EV-ready Vancouver, including a menu of EV-ready action items.

3.2.5. Key Takeaways

Summary:

- Foster continued growth of EV policy and working groups
- Implement small-scale change for big results in the long-term
- Encourage flexibility at the municipal level to adapt to markets and local conditions
- Link clean power sources to EV planning efforts, maximizing environmental impacts

In **Vancouver**, a municipality created a collaborative working group to develop EV-readiness strategies with the intent of meeting long-range GHG reduction goals. Because of the ready availability of clean hydropower, the replacement of gas engine vehicles with EVs was

[104] See note 17.

determined to have a disproportionately dramatic effect on GHG emissions, making the stimulation of the EV market a smart choice for the area. In meeting the anticipated needs of future EV owners, the Vancouver City Council took advantage of its unique ability among Canadian cities to modify its building codes in order to require a substantial percentage of parking stalls in new construction to be EV-ready. At little added cost to developers, amending the scope of the local building code to include mandatory minimum requirements for the future electrical installation of charging stations illustrates a relatively simple, feasible solution to a complex problem. In doing so, Vancouver became the first North American city to require EVSE connection in all new development.

In the **TCI region**, fostering continued growth of EV policy and working groups created by states, municipalities and regional planning organizations is a very important step. Working groups can look to Vancouver's successes in negotiating with the development community to recommend EV-ready strategies that are considerate of economic development as well as public benefits associated with transportation electrification.

Another important lesson learned from Vancouver's sustainability planning in the EV arena is the understanding that the "low-hanging" fruit, in this case the building codes, can have large-scale impacts. Moving ahead on one focused policy can create a ripple-effect once acceptance has been achieved and benefits understood in one area.

Vancouver has the unique ability to amend building codes at the municipal level. Each US state has the ability to draft code amendments, and can include provisions that set broad policies and standards, but allow flexibility to municipalities to accommodate local conditions and markets, much like in British Columbia and Vancouver.

The predominant use of hydropower in Vancouver and throughout the Pacific Northwest makes the relative impact of reducing tailpipe emissions including GHGs and CO_2 a dramatic one. However, jurisdictions in the TCI region have the opportunity to take advantage of the extended benefits of cleaner power sources as well. Nearly every electrical utility is now providing consumers with the option to choose clean or renewable power sources. While anticipation of the expansion of this type of service in the TCI region is outside the scope of this report, the potential to continue to link EV charging and clean power through utility participation in policy and planning is an important consideration to pursue. In the interim, state and municipal officials can refer to the existing literature (e.g. impact studies produced by local utility companies) to estimate the relative positive benefit of introducing EV charging to the local grid.

LOS ANGELES, CALIFORNIA

Summary
High statewide standards required by CALGreen, the California State Green Building Code, and local amendments work in concert with utility-led efforts to plan for EV readiness across complex jurisdictional boundaries.

Focus
State and local Green Building Code and utility infrastructure and service planning.

Code Outcomes
CALGreen includes mandatory provisions and optional appendices. The city of Los Angeles takes a more restrictive approach and requires EV-ready construction of all new single-family and multifamily dwellings and of commercial properties. Los Angeles County is considering mandatory measures that will create greater harmony among the region's many individual jurisdictions.

3.3. Los Angeles: Green Construction Codes and Utility Planning

Best practices from the city of Los Angeles, Los Angeles County and the surrounding metropolitan area illustrate the importance of multi-agency cooperation across jurisdictional boundaries and demonstrate that there are multiple potential leaders among EV and EV infrastructure stakeholders.

In southern California, emission reduction goals and working with aging energy infrastructure are central concerns relating to the regulatory environment surrounding EVSE. However, regulation of any kind in Los Angeles is a complex process because the county's many jurisdictions are not only irregularly bounded, but they also have the opportunity to adopt their own codes.

Measures specific to EVSE included in the state's mandatory green building code, called CALGreen, in concert with utility-led work on infrastructure in the Los Angeles metropolitan area, have created a standard framework for incorporating charging infrastructure into the built environment in the form of a mandatory state green building code and two tiers of voluntary appendices. These appendices include a set of universal choices and requirements for EVSE for jurisdictions choosing a more stringent route. State-level work on codes has resulted in unique local opportunities to enforce or mandate more restrictive codes. Jurisdictions voluntarily adopt right-sized regulations to meet local needs, but the details of optional code appendices have been set out in advance, creating a consistent typology across the state. The city of Los Angeles is one example of a jurisdiction seeking a higher degree of regulation and EV readiness; it already requires EV-ready wiring in one- and two-family homes, and it is in the process of reviewing a proposal to adopt the extended voluntary CALGreen appendix covering EVSE into the mandatory code at the county level.

The intersection of local and state code-based strategies and the unifying activities of utility service providers give rise to an EV-friendly environment that crosses jurisdictional boundaries.

3.3.1. California Green Code

The new California Green Building Code, governed by the California Building Code Commission, is unique.[105] The new standard was introduced in 2008, with the mandatory measures included therein enforceable as of January 2010. Currently, the EV- and EVSE-related codes are included as voluntary appendices, available for adoption by local jurisdictions by amendment via the local code adoption ordinance.[106] A key feature of the CALGreen code and appendices is a two-tiered system that is designed to allow jurisdictions to adopt codes that go beyond the state's mandatory provisions.[107] The tiers enable standard options for local jurisdictions that choose to adopt more stringent regulations.

The intent of the optional, or voluntary, approach was to allow the industry and enforcement agencies to prepare for the new code before it became mandatory. However, several jurisdictions immediately adopted the 2008 code as mandatory. A process of revision based on further stakeholder conversations, working groups and feedback on the implementation of the 2008 edition of CALGreen enabled improvements at the state level prior to the introduction of the 2010 mandatory code. [108]

CALGreen addresses the issue of compliance and training by incorporating the new code into existing code enforcement infrastructure and requiring public agencies to incorporate the new provisions into their inspection process.[109] Unlike some state building codes, California's Green Code is available online, increasing access to new standards. In addition, the state's Building Standards Commission is pursuing training related to the code through partnerships throughout the state.[110] As in Vancouver, the state of California's new regulations only increase the construction costs associated with a new home by a minimal amount.[111]

CALGreen requires the designation of parking stalls for zero-emission vehicles as an aspect of the nonresidential mandatory measures.[112]

EV Charging in State and City Codes

CALGreen's 2010 edition contains voluntary measures for nonresidential construction that require 10% (tier 1) and 12% (tier 2) of total parking spaces be designated for zero-emission or fuel-efficient vehicles. Further, EV supply wiring is required for EV charging stations for between one and four parking spaces, depending on the lot or garage capacity.[113]

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[105] CALGreen is available online at: http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.

[106] The voluntary appendices A4 and A5 of the California Green Building Code thus depend on the choice of builders in each jurisdiction to execute. That is, the appendices make guidelines for EVSE available if and when a developer chooses to incorporate such infrastructure into a project.

[107] "The 2010 California Green Building Standards Code" (California Buildings Standards Commission, n.d.), http://www.documents.dgs.ca.gov/bsc/CALGreen/The-CALGreen-Story.pdf.

[108] Ibid.

[109] Ibid.

[110] Ibid.

[111] The California Building Standards Commission estimates that all new green building regulations, not just EVSE, will increase the average cost of home construction by about $1,500.

[112] California Building Standards Commission, *Guide to the (Non-Residential) California Green Building Standards Code*, Second Edition (Sacramento, CA: November 2010), chapter 5.2, http://www.documents.dgs.ca.gov/bsc/CALGreen/Master-CALGreen-Non-Res-Guide2010-sec-ed-final-3-1-11.pdf.

[113] CALGreen Nonresidential Voluntary Measures A5.106.5.3 requires one 120 VAC 20 amp and one 208/240 V 40 amp, grounded AC outlets or panel capacity and conduit installed for future outlets.

As of January 1, 2011, all single-family residences, multifamily dwellings and commercial properties constructed in the city of Los Angeles will have EV-specific requirements.[114] EV supply wiring is mandatory for residential construction as per Article 9, Division 4 of the city's adopted version of CALGreen. The city ordinance requires a minimum of one 208/240 V 40 amp, grounded AC outlet for each dwelling unit or the panel capacity and conduit for future EVSE installation for each unit. For multifamily occupancies or single-family attached occupancies with shared parking, Los Angeles currently requires a minimum of 5% of total parking spaces to be wired with EVSE capacity and requires EV readiness through additional service capacity.

Currently, Los Angeles County is discussing the mandatory adoption of the non-residential CALGreen appendix, a proposal that, if passed, would include an amendment of the State Green Code to require new commercial construction of 10,000 square feet or more to be EVSE-ready, representing a decrease in the minimum building size to trigger EV-ready electrical systems.[115] This proposal would include more construction and building typologies.

3.3.2. State Policy Origins

California aims to reduce its GHG emissions by 33% by 2020. In 2004, then Governor Arnold Schwarzenegger signed an executive order to create the "Green Building Action Team" to address efficiency for state-owned buildings. Another order the following year established the "Climate Action Team," which called for the overall reduction of GHG emissions in the state. The emission reduction goals were solidified in law with landmark legislation AB32. CALGreen standards were developed in cooperation with the California Air Resources Board, the Department of Housing and Community Development, the Division of the State Architect and the Office of Statewide Health Planning and Development.[116]

In California, a West Coast sustainability mentality meets a high dependence on personal transportation. Emissions can be broken down into the activities that produce them. The state's on-road emissions from the transportation sector represent the largest source of California's gross inventory of emissions (more than 35%).[117] By contrast, the California Air Resources Board found that emissions from commercial and residential buildings remained steady from 2000–2009, even as the number of housing units and commercial and institutional floor space grew substantially. Observation of steady emissions despite increasing building area indicates that fuel use per unit of consumption has actually declined.[118] A serious policy discussion of what measures could achieve GHG emission reductions goals pointed to the building code, where an existing willingness to adopt green building practices became an opportunity to incentivize EV adoption.

The mandatory standards adopted in 2010 were initially introduced as voluntary measures two years prior. CALGreen, adopted unanimously by the California Building Standards Commission, allows cities with more stringent green building codes to retain their existing standards—or to modify them further to be more restrictive.[119]

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[114] See note 17.
[115] Ibid.
[116] See note 110.
[117] Air Resources Board, "Trends in California Greenhouse Gas Emissions for 2000 to 2009" (Sacramento, CA: California Environmental Protection Agency, December 2011), http://www.arb.ca.gov/cc/inventory/pubs/reports/ghg_inventory_00-09_trends.pdf.
[118] Ibid.
[119] Kristina Shevory, "California Adopts Green Building Codes," *The New York Times*, October 24, 2012, http://green.blogs.nytimes.com/2010/01/15/california-adopts-green-building-codes/.

EVs in Southern California

Home to early adopters in clean energy technologies, the Los Angeles metropolitan area is anticipating a surge in consumer and municipal uptake of EVs based on market forecasts utilized by Southern California Edison (SCE).[120]

California already has several decades of experience working with and planning for EVs. While this has proved beneficial, it also generates unique challenges: in Los Angeles and throughout the state there are hundreds of existing low-technology charging stations from the first release of EVs in the state, dating to the mid-1990s. The state's experience has resulted in an existing inclusion of EVs within the motor-vehicle-related occupancies section of the California Building Code, section 406.7, which provides the minimum EV-related code requirements referenced in the Green Building Code.

3.3.3. Challenges Related to Jurisdictional Boundaries

Cooperative efforts in EV readiness across the Los Angeles metropolitan area are not limited to the county and city of the same name. There are 88 incorporated cities, numerous unincorporated areas and almost 10 million residents within Los Angeles County, and the irregular municipal boundaries of the city of Los Angeles envelop or abut many of these. This arrangement produces an astonishing number of city officials: there are more than 450 mayors and city council members in the county.[121]

Furthermore, there is a strong home-rule tradition in California that has impacts on collaboration around energy and infrastructure—and nearly everything else.[122] However, there is also an established tradition of regional planning, area Councils of Governments and Metropolitan Planning Organizations playing roles in large-scale plans.

A recent report on the government structure of Los Angeles summarizes the difficulties that surround representation, regulation and enforcement in the metropolitan area:

> *Los Angeles is a different kind of city. It is huge in land area, decentralized in living arrangements, marked by an individualistic culture that pays little attention to politics and government. Many residents of Los Angeles have never seen an actual map of Los Angeles. Others are not certain whether they live in Los Angeles City, in another smaller city, or in an unincorporated county territory. While public officials are important and powerful, they do not have the visibility that marks public office in eastern and Midwestern cities like New York City and Chicago.*[123]

This poses specific political and administrative challenges for designing strategies relating to EV readiness that can help the region achieve more uniformity and smooth its transition to a more EV-friendly environment.

3.3.4. California Utilities and Energy Market Impacts on EV Readiness

The Los Angeles area has produced one possible solution to the challenges created by fragmented jurisdictional governance, although not by government actors: intense involvement of the utilities in programming and training, research and upgrading and monitoring the electrical

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[120] See note 17.
[121] "Mayors and City Councils Cities of Los Angeles County," accessed October 24, 2012, http://www.laalmanac.com/government/gl10.htm.
[122] Conor Friedersdorf, "Los Angeles is 88 Cities, Many of Them Corrupt," *The Atlantic*, April 28, 2011, http://www.theatlantic.com/national/archive/2011/04/los-angeles-is-88-cities-many-of-them-corrupt/237980/.
[123] Raphael J. Sonenshein, "Los Angeles: Structure of a City Government" (Los Angeles: The League of Women Voters of Los Angeles, 2006), http://www.lwvlosangeles.org/files/Structure_of_a_City.pdf.

service. This report will focus on SCE, an investor-held utility with a wide-reaching territory covering much of the Los Angeles mega-region, and touch briefly on initiatives of the Los Angeles (City) Department of Water and Power. SCE is the primary utility service provider for the county as a whole, but the city of Los Angeles has its own, fully integrated utility that performs power generation, transmission and distribution for the city only.

A full discussion of the recent history of energy deregulation and supply in California is complex and beyond the scope of this document. However, it is worth mentioning that the California energy crisis of the early 2000s has had direct effects on the current state of EV infrastructure planning in the state. A settlement reached in the spring of 2012 between the California Public Utility Commission, the agency responsible for the regulation of investor-owned utilities in the state, and NRG Energy, a subsidiary of Dynegy Inc., which was found to have manipulated the energy market during the post de-regulation crisis a decade ago, will generate an investment of $100 million dedicated to EV charging infrastructure throughout the state.[124] More than half of this settlement funding will go toward the installation of 200 commercial charging stations.[125] Despite some industry concerns over the energy company effectively being granted the monopoly-like benefits of a competitive advantage as a "first mover" in the DC fast charging market,[126] the outcome for EV users, the utility grid and the built environment will be the introduction of a significant (nearly 200%) increase in fast-charging stations in the state. The NRG settlement will include an additional $40 million toward wiring of homes, multi-unit dwellings (MUDs) and public locations for EV readiness.

Best Practices for Utility-Led Infrastructure Planning

SCE takes a pro-active approach to EV readiness. Particularly with the introduction of more widespread fast charging, the need to approach EV-ready infrastructure from the perspective of the energy grid is clear, as it becomes increasingly important for utilities and power authorities to be knowledgeable of the required service capacity within their respective territories.

Currently, SCE is involved with many organizations, pursuing a comprehensive stakeholder outreach initiative that includes other utilities, auto manufacturers, state and local governments, nonprofit entities working on EV readiness, consumer groups and community-based organizations. The primary goal behind the utility's outreach programs is the creation of a uniform message about EVs and EV charging infrastructure. The mission of the utility is to provide safe and reliable electrical service; this is the reason behind SCE's involvement in the EV infrastructure space. This relates specifically to the utility's ongoing role in upgrading the grid throughout its service area.

A unique need in California is the upgrading of existing charging infrastructure dating from the first wave of EV use in the 1990s; hundreds of older charging stations are due for an upgrade. In order to approach infrastructure upgrades in a cost-effective manner, the utilities are seeking to prioritize upgrades in the areas that are most critical. This is an issue that impacts both the distribution infrastructure (power generation and other parts of "the grid") and residential systems. The coastal climate of Los Angeles (which has not typically required residential electrical system capacity for air conditioning), combined with an aging building stock means that the capacity of many area homes may only be 40 amps—not quite able to accommodate a level 2 charger with a four- to six-hour continuous load.[127] The purchase of EV charging stations from home renovation retailers such as Home Depot for self installation—regardless of whether it is allowable in the residential building code—represents a "concern" for utilities. Part of this

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[124] For a timeline of the 2000–2001 energy crisis, see: http://www.pbs.org/wgbh/pages/frontline/shows/blackout/california/timeline.html.
[125] http://www.forbes.com/sites/pikeresearch/2012/04/27/nrg-settlement-far-from-settled/.
[126] See: http://ecotality.com/wp-content/uploads/2012/04/Motion-for-Public-Review-of-NRG-Settlement.pdf.
[127] See note 17.

concern arises out of the technology use of EV early adopters; these are often households that have already adopted other new technology that already drains home system capacity, such as plasma televisions.[128]

Monitoring EVSE deployment happens from the utility perspective in several ways: through cooperation with the auto manufacturers and dealers to obtain data on EV orders within the service area, cooperation with EV charging service providers that sell or lease charging stations and via notification systems such as permits issued for EVSE installation or for electrical service upgrades. Failing access to that type of data, the utility monitors and assesses spikes in energy use as a general practice.[129]

Additional incentives from the utility address rates, research and outreach. SCE provides an option for dedicated metering, including special EV rates. The EVSE is metered separately on a dedicated line, billed using a time-of-use rate. The installation of a separate meter does not present a code or permitting issue and is typically easy to execute. Finally, SCE leads and partners in energy-related research. Recent projects include an unreleased study assessing the charging and driving patterns of EV drivers in the SCE service territory. Working with the University of California, Los Angeles and the University of California, Santa Barbara on public infrastructure research, SCE has produced a number of research documents, the dissemination of which has occurred through transportation and regional planning organizations such as area councils of government and metropolitan planning organizations.[130]

3.3.5. Key Takeaways

Summary:

- Encourage environmental benefits in the transportation sector through regulating the built environment
- Create consistent code options for local jurisdictions by offering tiered requirements
- Work with and expand the role of utility companies in planning for EVs

In the **Los Angeles** metropolitan region, city, county and state governments have taken innovative approaches to greening buildings and the transportation sector. These efforts have been complemented by the proactive stance taken by the major electrical utility providers in the Los Angeles region. CALGreen, as the nation's first mandatory green building code, sets a high bar. The code's overall goals deal directly with the state's mandate to reduce GHG emissions, and an EV-ready policy included in the code recognizes that regulation in one high-emissions sector (buildings) can impact and incentivize greener consumer behavior in another sector (transportation). The state's approach to phasing in the code's mandatory provisions sheds light on the ways in which other jurisdictions might adopt similar code amendments, and the inclusion of "tiers" of compliance in the voluntary appendices makes it possible for the adopting jurisdiction to choose the level of deployment and enforcement most appropriate for the local market and community. Los Angeles is leading the shift to mandatory EVSE codes; both city and county have or will likely soon pass and upgrade the requirements for EV-ready construction. For a metropolitan area with an incredible number of local jurisdictions, a top-down but flexible approach such as CALGreen is a good solution. In addition, the utilities, such as Southern California Edison, are finding a niche role as a stakeholder and coordinator for EV-ready action that spans jurisdictions.

In the **TCI region**, codes that make buildings greener can create environmental benefits for the transportation sector as well, e.g. through the inclusion of dedicated EV parking spaces. The top-

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[128] See note 17.
[129] Ibid.
[130] Ibid.

down, flexible approach to setting standards by using tiers and voluntary code appendices is a best practice that could be translated to state building codes throughout the TCI region. Indeed, like California, many east coast states have a wide range of population densities across highly populous and dense urban areas and rural and agricultural areas. Codes become a tool that lets local jurisdictions assess local conditions by opting in or out of certain levels of regulation, while offering a consistency in requirements and developer and consumer expectations across a state.

Further, the focus of the reduction of transportation sector emissions is not something unique to the west coast, nor is the potential adoption of environmental standards that have originated in west coast states. Another related California initiative, Title 13 of the California Code of Regulations, sets standards for low emission vehicles, and these standards have been adopted into law by TCI region states and jurisdictions, including Washington, DC, Maryland, New Jersey, New York, Pennsylvania, Connecticut, Massachusetts and Vermont.[131]

The opportunity for expanding utility companies' roles in EV planning is illustrated by SCE's various initiatives. Considering the importance of utilities as partners and stakeholders (e.g. in EV working groups or councils) is an important step in any jurisdiction toward EV readiness. Many of the issues that TCI stakeholders cited in initial project outreach are concerns of the utilities, for example: peak rates and electricity pricing per kilowatt hour, the inclusion of dedicated (split) or smart meters that can aid EVSE installations in multi-family housing, reporting of EV purchases or EVSE installations to manage loads on local transformers.

[131] State-by-state references to California's Low Emission Vehicle standards can be found through the U.S. DOE: http://www.afdc.energy.gov/laws/search

OREGON

Summary
The Oregon Building Codes Division has developed new administrative rules to streamline permitting and inspection protocols for EVSE installation statewide.

Focus
Electrical code amendment facilitates permitting process

Code Outcomes
New, streamlined permit and inspection protocols apply uniformly throughout the state. These include Oregon's minor label program. Code changes currently address levels 1 and 2.

3.4. Oregon: State-Level Electrical Code Amendments

The state of Oregon is known as a national leader in sustainability, and as such this case study addresses state-level efforts to amend the regulatory environment governing EV infrastructure. As a sustainability leader, Oregon is home to a few unique considerations relevant to this discussion. First, as a region included in ECOtality's EV Project, Oregon has received substantial EVSE-related funding through ARRA.[132] Second, Oregon has a concentration of existing EV automotive component producers in niche manufacturing.[133] Both points are evidence of existing understanding of the value of growing the EV market.

Another distinction worth noting is actually common throughout the Pacific Northwest; more than half of the state's energy comes from hydropower. Portland General Electric (PGE), Idaho Power Company and Pacific Power provide electricity throughout the state, in addition to numerous smaller providers. As Portland's power supplier, PGE is particularly engaged in expanding EV adoption, raising awareness and generating industry economic opportunity in partnership with public and private organizations.[134]

Cooperation has been at the center of Oregon's EVSE efforts. The Governor's Alternative Fuel Vehicle Infrastructure Working Group has guided research and policy approaches for the state, recommending code changes to the Building Codes Division (BCD). BCD worked with PGE on a pilot program to install an initial five-charge point pilot project in Portland and Salem beginning in 2008. In 2010, the working group created the Transportation Electrification Executive Council in order to address the need to coordinate public, private and civic leadership in the area of EVs and

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[132] An EV Project report on EVSE deployment for the Portland, OR, and Salem, OR, areas can be found here: http://www.theevproject.com/downloads/documents/Electric%20Vehicle%20Charging%20Infrastructure%20Deployment%20Guidelines%20Oregon%2015%20Metro%20Areas%20Ver%203.2.pdf.
[133] *Report of the Alternative Fuel Vehicle Infrastructure Working Group* (Portland, OR: Multnomah County, January 2010), http://www.psrc.org/assets/3751/W_OregonReport_2010.pdf.
[134] "Electric Vehicles in Oregon," Portland General Electric, accessed October 24, 2012, http://www.portlandgeneral.com/community_environment/initiatives/electric_vehicles/evs_in_oregon/default.aspx.

EVSE. As mentioned above, cooperative efforts extend to the private sector. A coalition of Oregon cities are participants in the EV Project, a public-private partnership administered by DOE and funded by ARRA and the private investment of ECOtality, Inc. The EV Project has facilitated cooperation among public and private organizations, utilities, financial partners and the EV industry.[135]

Lessons from Oregon demonstrate how legislative effort and relatively simple electrical code changes can help specify an EV-ready policy that speaks to overall emissions reduction and sustainability goals through a safety-focused policy. The code change process has also focused on establishing best practices in the permitting and administrative arena that have made these processes more uniform and dramatically reduced the cost of permits for EVSE installation.

3.4.1. Electrical Code Change Aimed at Expediting Permitting and Inspections

Oregon's participation in the EV Project provided funding and introduced vehicles into the market, as well as accelerated demand for charging infrastructure. The state of Oregon's approach to streamlining the permitting and inspection process addresses this relatively high-demand condition. Overall, Oregon is actively coordinating a range of activities to facilitate widespread EV and EVSE deployment.

Targeting the structural codes presented unique opportunities and challenges for the State of Oregon. The state's building codes are different from most other states; codes adopted at the state level set both the minimum requirements for construction statewide and the maximum requirements that local jurisdictions can enforce. In effect, state-level building code changes would establish a uniform policy for all new construction across the entire state, much like Vancouver's Building By-laws, but over an inefficiently large geographic area, causing cost burdens in many areas, particularly those outside the urbanized Pacific coast corridors. The working group concluded that while building code changes would reduce the construction costs associated with retrofitting buildings to be EVSE-ready in the future, the increased costs for developers at the present moment would be premature.[136]

In this light, finding a way of ensuring a positive user experience, reducing the administrative costs and ensuring a path for emerging technology and its safe installation without adapting the scope or structural aspects of the building code was a challenge to the state in its approach to supporting EVSE. The solution was to ask BCD to develop a home EVSE installation process that could be completed within just a few days of purchase.

3.4.2. Minor Label Program

In 2008, BCD adopted statewide permit and inspection protocols through a rule that establishes the types and number of permits and inspections required to install EVSE. One of the central aspects of Oregon's code change is the inclusion of EVSE in the state's minor label program. Oregon's statewide process speeds simple EVSE installations by enabling licensed electricians to pre-purchase permitting minor installation "labels" online and inspecting only 1 out of 10 EVSE installations.

The electrical minor label program was developed and implemented in the late 1980s to allow electrical contractors to use labels in lieu of individual permits for limited, simple installations, repair and maintenance. Previously, these installations were limited to 30 amps at 40 volts; however, in examining EVSE, BCD determined that the installation of a simple 40 amp circuit in a

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[135] "Oregon EV Companies," EVRoadmap.com, accessed October 24, 20120, http://www.evroadmap.com/orevcompanies.html.
[136] See note 135.

residential setting could also fall into this same scope of work.[137] Under the minor label program, a licensed electrician can purchase booklets of 10 minor installation labels for $140; each label allows for standard EVSE installations. The program defines standard EVSE installations as those installations that are within sight of the electrical panel supplying the charging unit, have a branch circuit that does not exceed 40 amps/240 volts and are not located in a damp place.[138] Under this program, just 1 in 10 of the electrician's completed jobs is inspected by BCD. An additional benefit of the program addresses some concerns raised by the electrical safety community around lack of control over residential installation under the IRC: only licensed professionals are permitted to purchase minor labels.

The inclusion of EVSE in the state's minor label program can be considered a best practice. Reducing the cost to the state in terms of inspections and to the EV owner makes the installation of at-home charging infrastructure that much more accessible—each permit for a basic installation costs $14, compared to permitting costs that still reach up to $700 in some areas of the Los Angeles region. The Oregon code amendment does not contradict the conclusion that the NEC provisions sufficiently cover existing technology needs; instead, it emphasizes the potential for states or local jurisdictions to amend the code to create a more pro-EVSE regulatory environment.

In addition, local jurisdictions that participate in BCD's ePermitting services are able to offer the required feeder permit for EVSE online, simplifying the process even further.[139]

3.4.3. Policy Origins: Alternative Vehicle Evolution

Consistent, predictable standards provide guidance to cities and counties on the issues surrounding emerging technologies, according to BDC.[140] In order to assist in the creation of consistent standards at the state level, the state of Oregon has adopted and continued to revise new standards that establish permitting and inspection requirements for EVSE that apply in every county and city across the state.

BCD is housed within the State Department of Consumer and Business Services, which is the state's business regulatory and consumer protection agency. The Codes Division provides code development, administration, inspection, plan review, licensing and permit services to the construction industry.[141]

The EVSE-related standards are one in a series of steps taken by BDC's Green Building Services section toward positioning Oregon as a green building innovation center; prior activities included the approval of new water conservation methods and the development of amendments to the building code to allow for greater energy efficiency.

The Oregon code amendment does not contradict the conclusion that the NEC provisions sufficiently cover existing technology needs; instead it emphasizes the potential for states or local jurisdictions to amend the code to create a more pro-EVSE regulatory environment.

Oregon has supported alternative fuel vehicles since 1991, when the state established an alternative fuel vehicle tax credit program, the precursor to the contemporary strategy of

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[137] Dennis Clements, personal correspondence, July 27, 2012.
[138] Alternative Fuels Data Center, "Oregon Deploys Plug-In Vehicles and Charging Infrastructure," U.S. Department of Energy, April 25, 2011, http://www.afdc.energy.gov/case/1000?print.
[139] See note 135.
[140] "New Building Codes Standards Support Electric Vehicle Growth," Oregon Department of Consumer and Business Services, October 14, 2008, http://www.cbs.state.or.us/bcd/notices/electric_vehicles_nr.pdf.
[141] Ibid.

focusing on GHG reduction.[142] The focus on the transportation sector seems to be a natural fit, given the relatively clean sources of electricity in the state (more than 50% of the state's electricity is generated by hydropower) and that statewide, about 38% of the GHG emissions come from transportation.[143] In September 2008, Oregon Governor Ted Kulongoski signed Executive Order 08-24, creating the Governor's Alternative Fuel Vehicle Infrastructure Working Group, which is charged with developing policies and infrastructure for Oregon to "attract car manufacturers seeking to bring the next generation of electric and alternative fuel vehicles to market in North America."[144]

Oregon: Goals and Strategies Supporting Code Changes

Goal	Strategy
Reduce Emissions	Reach GHG emissions targets of 10% below 1990 levels by 2020 and 75% below 1990 levels by 2050
Capture Energy Expenditures	Recapture a portion of the 90% of non-tax dollars spent on fuel by Oregon residents that leave the state. Oregon spends $8 billion annually on gasoline
Maximize Clean Energy	Oregon has relatively clean (low GHG) electricity sources, including hydropower
Develop Industry	Investment for Oregon's concentration of businesses in the EV sector

The working group seeks to marry emissions reductions goals with economic ones, encouraging EV adoption rates while fostering local and statewide job growth in the electrified transportation sector.[145]

In addition to the 2008 Executive Order, Oregon passed earlier enabling legislation that targeted emerging technologies and included provisions for swift regulatory action by BDC where such action is necessary to support emerging technology adoption. A follow-up executive order in 2010 established a panel to assist in creating an agenda for EV and infrastructure deployment and related services throughout the state.[146] This panel, called the Governor's Transportation Electrification Executive Council, is meant to address the "need to focus and coordinate public, private and civic leadership in ensuring that Oregon is well-positioned to capitalize on the economic benefits of transportation electrification," in addition to enhance strategic infrastructure deployment, identify opportunities and barriers to EV adoption and facilitating outreach, among other areas of related work.[147]

3.4.4. Local Plans in a Restrictive State Framework

According to the Oregon Department of Transportation (ODOT), Oregon residents in metropolitan areas travel an average of just 17.5 miles per capita per day—well within the range of any EV on the market today.[148] Portland, Oregon, has created complementary municipal policy. Although local jurisdictions are not able to create more rigorous building or electrical codes or

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[142] See note 140.
[143] See note 135.
[144] See note 142.
[145] City of Portland and Multnomah County, "Climate Action Plan 2009 - Year Two Progress Report" (Portland, OR: Office of Sustainability, April 2011), http://www.portlandoregon.gov/bps/article/393345.
[146] Office of the Governor, "Executive Order 10-09" (Salem, OR: State of Oregon, September 22, 2010), http://cms.oregon.gov/Gov/pdf/eo_1009.pdf.
[147] Ibid.
[148] See note 135.

standards, they are able to pursue other strategies to increase their EV market share and capitalize on the environmental benefits of transportation electrification. To this end, Portland has established more vigorous, but harmonious GHG standards: the Portland City Council created policies that support the city's effort to meet the emission-reduction goals of its 2011 Climate Action Plan.[149] The plan estimates that in order to meet city goals, 13% of all non-commercial vehicle miles traveled on Portland roads in 2030 will need to be traveled by EVs.

Portland has pursued a strategy of showcasing technology in partnership with Portland State University and Portland General Electric, opening "Electric Avenue" in 2011. The City of Portland has 11 (Multnomah County has four) electric fleet vehicles.

3.4.5. Innovative Partnerships Programs Channel Funding

Oregon demonstrates policy and practice integration across state and local levels. ODOT and the state's Office of Innovative Partnerships and Alternative Funding have worked with industry and government partners on EV projects and pilots, including ECOtality's EV Project, facilitating the West Coast Green Highway and administering a Tiger II EV infrastructure grant.

In September 2010, ODOT received $700,000 in federal stimulus funding to install up to eight fast-charging stations in southern Oregon. In October of the same year, ODOT was awarded an additional $2 million from the TIGER II program in order to enable the state to build necessary infrastructure to support and expand the range of existing EVs.[150] The stations "will be placed no more than 50 miles apart on highways outside of metro areas to create a continuous network."[151]

Transportation Corridor Planning: The EV Corridor Connectivity Project

These partnership programs have focused to a great extent on expanding infrastructure along major transit corridors, building and extending what is known as the West Coast Electric Highway, a tri-state network of EV DC fast charging stations along Interstate 5, connecting Northern California to British Columbia. The goal of developing a regional transportation corridor framework creates the need to address the installation scenarios with a quick and easy process. This means that partnerships must extend to collaboration among state departments of transportation—this west coast corridor project should be taken as a model for connecting Northeast and Mid-Atlantic states, where smaller land areas will require cooperation among even more interstate agencies.

Utility Role

Consistent processes are also required in a state where, in contrast to British Columbia's sole power authority, retail electricity service is offered by numerous different utilities. These include three investor-owned public electric companies, 19 electric cooperatives, six peoples' utility districts and 13 municipal utility districts.[152] In this business environment, it may be desirable for the state to pursue minimum electrical requirements that must be enforced across these boundaries.

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[149] Christina Williams, "Portland Passes Wide-Ranging Electric Vehicle Policy," Sustainable Business Oregon, July 20, 2010, http://www.sustainablebusinessoregon.com/articles/2010/07/portland_to_adopt_electric_vehicle_policy.html .

[150] Washington State was awarded a similar grant of more than $1.3 million. For more information, see: http://westcoastgreenhighway.com/projects.htm.

[151] "U.S. Transportation Secretary LaHood Announces Agreement for Electric Vehicle Charging Stations in Northwest Oregon," U.S. Department of Transportation, April 8, 2011, http://www.fhwa.dot.gov/pressroom/fhwa1114.htm.

[152] See note 135.

Future Actions

In 2010, the working group recommended that BCD revisit the appropriateness of building code amendments requiring a dedicated EV conduit in new construction. Similar to Vancouver's calculation of a 2% increase in construction costs, Oregon assumes a market trigger of about 5% new EV market sales to justify the additional expenses of a non-health or safety building code requirement.[153]

3.4.6. Key Takeaways

Summary

- Reduce real consumer costs of EV adoption by addressing the extreme variation in permitting fees and lowering fees for residential installations
- Consider the demographic and economic impacts for urban, suburban and rural communities when choosing state-level routes to EV readiness
- Incorporate EVSE into existing regulations where possible
- Codes are complemented by other types of EV-ready planning

Oregon amended the electrical code to reflect a need to address EV charging infrastructure in a market with many early adopters concentrated in specific geographic areas and corridors. Because the state's building codes set the minimum and maximum requirements enforceable by local jurisdictions, the geographic concentration of the population along the Pacific coast would make mandatory EV-ready building policies economically inefficient in much of the state. However, a clear need to reduce costs and ease the transition to increased EV use led state officials to recommend an expedited and inexpensive permitting process. Further, two municipal and corridor planning efforts—Portland's EV priorities in its Climate Action Plan and the West Coast Green Highway—illustrate the ability of local jurisdictions and state authorities to complement code-specific policies by setting environmental and transportation-oriented goals. In addition, the inclusion of EVSE in the state's minor label program reduces costs to the state and to the EV owner, making installation of at-home charging infrastructure that much more accessible—each permit for a basic installation costs $14.00.[154] The Oregon code amendment does not contradict the conclusion that the NEC provisions sufficiently cover existing technology needs; instead, it emphasizes the potential for states or local jurisdictions to amend the code to create a more pro-EVSE regulatory environment.

The **TCI region** can use the electrical code to focus on reducing costs of permitting and installing most EVSE, particularly in situations where the electrical work is routine. Stakeholders throughout the region, as well as those interviewed from other jurisdictions for this report, cited wide variation in and often high cost of permitting as a barrier for EV adoption. Establishing a flat and consistent fee for residential EVSE installation at the state level is a clear step toward regulatory consistency that has real results for individual EV owners.

The ability of the state of Oregon to establish in the state level building code the minimum and maximum requirements for construction across the state, state officials determined that route not to be the most cost effective, instead choosing to pursue electrical code changes to reduce costs. TCI region states should first assess the costs and benefits associated with pursuing a particular code policy change, considering the uniqueness of their state's regulations.

Furthermore, Oregon's regulation is exemplary in its simplicity. While the organization, goal setting, and other aspects of state-level planning discussed in this case study are important and

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[153] Ibid.

[154] A minor label program designates certain simple electrical construction work as "minor work." Permits are still required, but costs and timelines are reduced. Oregon's program for EVSE is discussed further in section 3.4.

essential steps, the conclusion to include EVSE in an established state permitting program provided a reasonable solution easily adopted by local permitting authorities throughout the state.

Finally, Oregon's electrical code changes occurred within a larger framework of EV-ready planning that has ensured compatibility/co-development of plans for municipalities, such as Portland's use of EV planning in meeting emissions goals for the city, and for regional efforts, such as the West Coast Green Highway. TCI region states can look to examples like Oregon to see that EV-ready initiatives are not mutually exclusive, and that code changes can support one aspect of encouraging EV adoption, while partnerships, local plans and initiatives in other sectors can complement work done to amend codes by extending access and ownership throughout the state.

4. SUMMARY AND NEXT STEPS

4.1. Case Studies in Summary

The case studies included in this report highlight three approaches to metropolitan area and regional cooperation to address the regulatory framework that supports and monitors EV infrastructure deployment. Looking at advanced efforts at the state, metropolitan area and municipal levels in forward-thinking jurisdictions, several common factors emerge regarding the successful creation of policy and regulation supportive of EV infrastructure:

- Each jurisdiction took specific and multifaceted steps to encourage use of EVs.
- Each jurisdiction considered opportunities and challenges associated with regulation at multiple levels of government, or with multiple layers of agency, authority or private-sector participation, demonstrating the wide range of possibility in working with codes and other components of the regulatory environment.
- Actors in each jurisdiction identified and overcame potential regulatory barriers.

In **Vancouver**, a municipality created a collaborative working group to develop EV-readiness strategies with the intent of meeting long-range GHG reduction goals. Because of the ready availability of clean hydropower, the replacement of gas engine vehicles EVs was determined to have a disproportionately dramatic effect on GHG emissions, making the stimulation of the EV market a smart choice for the area. In meeting the anticipated needs of future EV owners, the Vancouver City Council took advantage of its unique ability among Canadian cities to modify its building codes in order to require a substantial percentage of parking stalls in new construction to be made EV-ready. At little added cost to developers, amending the scope of the local building code to include mandatory minimum requirements for the future electrical installation of charging stations illustrates a relatively simple, feasible solution to a complex problem.

In **Los Angeles**, the city, county and state have taken innovative approaches to greening buildings and the transportation sector. These efforts have been complemented by the proactive stance taken by the major utility companies that provide service to the Los Angeles region. CALGreen, as the nation's first mandatory green building code, sets a high bar. The code's overall goals deal directly with the state's mandate to reduce GHG emissions, and an EV-ready policy included in the code recognizes that regulation in one high-emissions area (buildings) can impact and incentivize greener consumer behavior in another (transportation). The state's approach to phasing in the code's mandatory provisions sheds light on the ways in which other jurisdictions might adopt similar code amendments, and the inclusion of "tiers" of compliance in the voluntary appendices makes it possible for the adopting jurisdiction to choose the level of deployment and enforcement most appropriate for the local market and community. Los Angeles is leading the shift to mandatory EVSE codes; both city and county have or will likely soon pass and upgrade the requirements for EV-ready construction. For a metropolitan area with an incredible number of local jurisdictions, a top-down but flexible approach such as CALGreen is a good solution. In addition, the utilities, such as SCE, are finding a niche role as a stakeholder and coordinator for EV-ready action that spans jurisdictions.

Oregon amended the electrical code to reflect a need to address EV charging infrastructure in a market with many early adopters concentrated in specific geographic areas and corridors. Because the state's building codes set the minimum and maximum requirements enforceable by local jurisdictions, the geographic concentration of the population along the Pacific coast would make mandatory EV-ready building policies economically inefficient in much of the state.

However, a clear need to reduce costs and ease the transition to increased EV use led state officials to recommend an expedited and inexpensive permitting process. Further, two municipal and corridor planning efforts—Portland's EV priorities in its Climate Action Plan and the Green/Electric Highway—illustrate the ability of local jurisdictions and state authorities to complement code-specific policies by setting environmental and transportation-oriented goals

The inclusion of EVSE in the state's minor label program reduces costs to the state and to the EV owner, making installation of at-home charging infrastructure that much more accessible—each permit for a basic installation costs $14. The Oregon code amendment does not contradict the conclusion that the NEC provisions sufficiently cover existing technology needs; instead, it emphasizes the potential for states or local jurisdictions to amend the code to create a more pro-EVSE regulatory environment.

4.2. Central Themes and Preliminary Recommendations

Considering complexities in the state and local decision-making process of evaluating EV-ready options, there are opportunities that can be created to encourage consistent EVSE deployment planning. Structural codes do not operate alone in the local regulatory environment; they are one tool available on the regulatory menu for jurisdictions seeking to govern infrastructure deployment. Despite the environmental benefits and growing EV market in many areas across the United States and throughout the region, each state and local jurisdiction will need to assess the costs and benefits associated with its own goals pursuant to energy efficiency, transportation electrification, green construction, air quality and economic development in order to effectively prioritize EV-readiness steps.

4.2.1. Existing Codes Present No Significant Barriers to EVSE Deployment

While there are no specific barriers to EVSE installation embedded in the existing national model building and electrical codes, there is room within the codes as adopted by the states to more clearly encourage EV readiness. Despite differences between jurisdictions, the codes themselves—model and adopted—cover existing safety concerns related to existing automotive and charging technology and permit or facilitate conditions under which EVSE can be installed.

Neither level 1 nor 2 EVSE requires significant electrical work so long as the existing circuitry supports the electrical load and connection. Each installation presents unique wiring and construction challenges that can increase costs, but they are typically accounted for by the existing structural codes and standards.

For existing technology, at present there are no specific structural codes issues cited by the stakeholders, code experts or model jurisdictions interviewed for this report that prevent or inhibit EVSE installation. However, challenges to consistency and safety may arise out of a lack of familiarity with EVSE equipment, complex commercial installations (such as with DC fast-charge installations, or where loads exceed circuit or service capacity) or the single-family residential code (the IRC), because not all jurisdictions require homeowners to hire a licensed electrician to perform electrical work.

Recommendations

- Consistent with their respective missions, code-setting bodies must continue to engage stakeholders in a participatory process geared toward bringing new technologies and implementation strategies to the fore as new industry standards. Organizations such as the ICC and NFPA, for example, should further engage in outreach, actively seeking best practices from local jurisdictions.

- States that do not have some form of mandatory inspection program for construction permitted under the IRC or similar local single-family construction code should institute a more comprehensive process.
- Education and training programs for inspectors and installers have become the norm as an early evaluative step in EV-readiness planning. States seeking to evaluate the need of codes and permitting processes should initiate EVSE training for professionals in related fields.[155]

4.2.2. Codes Can Help Achieve EV Readiness and Regional Cohesion

There are specific reasons to consider changing codes at the local, state and national levels. Because code amendments are one of several interrelated strategies to encourage EVSE deployment, in considering changes, it is important to consider what codes can accomplish:

- Codes can specify scoping requirements of numerical goals or limits for certain features in new construction (e.g., percentage of required parking to be built EVSE-ready).
- Codes can provide new permitting or inspection protocols and encourage the reduction of associated administrative costs.
- Codes are revised regularly and will be adapted at the national level to meet new structural or fire safety concerns, such as those related to new and emerging technologies.

The TCI region can achieve a level of cohesive EV readiness through the building and electrical codes if similar efforts are made across the region. Local conditions will factor heavily into the decision to regulate for EVSE based on codes. Variations across the TCI region will mean that states will make different choices. States such as New Jersey, for example, with a relatively evenly distributed, dense population and centrally located transportation corridors, may find scoping requirements in the building code to be a good solution. By contrast, Maine's lack of population density and residential concentration around key urban centers may suggest a different approach.

In addition to state and local governments, Clean Cities' Coalitions and other similar groups can play a central advocacy role in this assessment at the jurisdictional scale. In Vancouver, the EV Working Group became an important source of information sharing and program development. Within the TCI region, there are examples of several similar initiatives. Maryland has created by law the Maryland State Electric Vehicle Council, housed within the state's Department of Transportation.[156]

Incentivize EVSE Parking

A hypothetical proposal for a new optional appendix to the model building code could include in its scope provisions requiring 10% of parking spaces in new construction residential garages to be EVSE-ready, creating a uniform approach across jurisdictions that adopt that regulation.

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[155] Stakeholders have indicated that while training is a clear component of ongoing successful EVSE installations, the training is more educational than technical; once an installing licensed electrician is aware of the EVSE device and components, it will be clear how to proceed with the installation. One exception is the level 3 or direct current (DC) fast-charging units, which are newer to the market and therefore have not yet been specifically addressed by these primary standards. However, even the new technology currently on the market is regulated for safety.

[156] The Maryland EV Council is discussed in detail in the companion to this report, the *EVSE Toolkit: Administrative and Planning Strategies for Local Jurisdictions*.

Over the long term, state code and local amendments and regulatory changes may influence the language of the model codes.[157] Regulation at the state level may provide the greatest consistency to metropolitan areas and corridors. The case of California illustrates the benefit of consistent, voluntary options.

Recommendations:

- Following the lead of states such as Oregon and New Jersey, each of the TCI states should conduct a review of its codes and policies to determine if residential EVSE installation can be classified as "minor label" or "minor work."
- Incentivize and encourage incorporation of EVSE by modifying building codes when appropriate to require that a percentage of accessory parking associated with new development to be pre-wired for EVSE (for example, 20%), providing flexibility for future capacity.
- Enable state and local participation in a forum for interstate cooperation.

4.2.3. EVSE Deployment as Economic Development

Codes, and the requirements that they set out, factor into economic development planning. EVs and EVSE deployment influences such disparate areas as maintaining housing affordability, providing equitable access to transportation infrastructure, creating green jobs and marketing metropolitan areas to attract new businesses, residents and institutions.

Cost Reductions

For the development and construction community, there is a need to keep costs of EVSE installation low enough to be easily absorbed into overall project costs.

Another aspect of economic development for EVSE is that jurisdictions encouraging EV readiness will likely gain growth in industry associated with EVs and charging infrastructure. The presence or stimulation of markets for EV and EV charging has primed the pump in early adopting jurisdictions. For example, Vancouver's signing of MOUs with auto manufacturers highlights an approach to capture a portion of the EV market. In most localities, however, EV readiness will bring additional electrical and green energy jobs and other economic opportunities.

Decisions to pursue an EV-focused GHG emissions reduction strategy partly through code amendments may, as it did in Los Angeles, result in additional economic benefits. With a municipally owned utility in the mix (Los Angeles Department of Water and Power), Los Angeles' support of EVs not only reduces the 43% of GHG emissions associated with on-road vehicle travel, but money previously spent on imported fuel and energy sources can stay in the city and region.[158] In this instance, local administrative action has the benefit of reducing consumer costs,

Incorporate EVSE Infrastructure Planning into Urban Development Strategies

For a downtown revitalization plan, the incorporation of EV charging stations can aid marketing strategies. Portland's Electric Avenue highlights the potential of bringing a unique amenity to Main Street.

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[157] See note 62. State and model code revisions may take up to 12 years, depending on the jurisdiction's code cycle and date of proposed change.

[158] See note 16.

[3] "Renewable Energy Financing District/Solar Energy Improvement Special Assessments," Energy.gov, July 1, 2009, http://energy.gov/savings/local-option-renewable-energy-financing-districtsolar-energy-improvement-special-assessments.

[4] "Special Purpose Districts in Washington," Municipal Research and Services Center of Washington, accessed October 24, 2012, http://www.mrsc.org/subjects/governance/spd/spdmain.aspx.

capturing dollars through locally based services and improving air quality.

Raising Awareness and Profiles

Local jurisdictions also have the opportunity to create or alter perceptions of the EV market. The importance of securing vehicles has been illustrated anecdotally throughout this research process. A stakeholder described an attempt to add EVSE provisions into the parking calculations for zoning requirements in Dover, New Hampshire, that involved a similar approach to mandating parking through the building code.[159] The stakeholder's proposal suggested that developers make 2% of all parking spaces EVSE-ready for all developments exceeding 50 spaces; when the local planning board voted on the provision, the reason cited for not establishing a mandatory requirement was that there were no EVs registered in the area yet.[160] From this example, an awareness of use creates trust that administrative efforts will be worthwhile.

Portland, Oregon, has created a prominent strip of EV parking in a busy downtown area, giving prominence to EVs and creating a unique addition to the urban environment at the same time. Such profile-raising strategies show that in many places across the country local governments consider EVs a valuable commodity. Provisions for EVSE deployment can be seen as an amenity that allies the locality with green branding that can aid in attracting businesses and residents, while setting legitimate goals for sustainable energy, buildings and job growth. The question remains for new EV markets as to how the West Coast states' and provinces' approaches can be translated to the East Coast.

Finally, while codes can influence markets to some extent, codes should not be used to predict the future of EVSE infrastructure. Instead, they should be written so as to freely adapt to any installation or new technology scenario. The fact that DC fast charging and wireless charging are not yet fully accounted for in the national codes is not alarming; rather, it indicates a lack of prescriptive regulations that can negatively impact innovation and growth in the sector.

Recommendations:

- Incorporate or acknowledge EVSE deployment through TCI-region state-level economic development strategy.
- Fund further research and program assessment specific to the TCI region to enable local jurisdictions to make informed decisions about costs and benefits associated with public expenditures for EVSE, and to guide development of public-private partnerships.
- Fund ongoing demonstration programs, particularly those that focus on innovation and new technology.

4.2.4. High-Level Flexibility Creates Meaningful Local Options

EVSE policy and planning should not tie hands at the local level. California's CALGreen is an excellent example of the ability of codes to create a high-level planning framework while retaining flexibility at the local level. Codes ideally provide consistent regulation by making changes at the highest level of government reasonable.

Compliance is a Local Issue

Significantly, a local jurisdiction's codes must comply with state-level legislation, meaning state laws play a central role in establishing the range and impact of local regulatory requirements. Challenges in this arena include the creation of seamless and simple regulations using consistent language in state and local laws that limit code revision necessary to comply.

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[159] James Poisson (Master Electrician, New Hampshire Department of Environmental Services. TCI Regional Stakeholder), phone call, June 29, 2012.
[160] Ibid.

Codes can offer an a la carte menu of options, standardized at the state level but adopted through tiered systems and/or on a voluntary basis by the local jurisdiction. CALGreen, for example, lets jurisdictions prioritize code changes by providing a clear menu of options. Well-written codes may also offer phased provisions or optional parameters, maximizing adoptability and efficacy of local regulations. A pilot phase may precede mandatory enforcement of new code provisions, allowing local governments and other stakeholders to adjust to new requirements.

Outreach is a Local Obligation

In addition, jurisdictions motivated to adopt EVSE-specific codes can take on an advocacy role through local awareness building and outreach about EV benefits. The process of revising model codes at the national and international levels is open to public proposals, and local jurisdictions that have adopted EVSE code modifications have the opportunity to directly influence national EVSE policy through the proposal of changes to national model codes.

Improving upon the existing EV and EVSE knowledge base in many jurisdictions represents an important step for government officials, industry and utility stakeholders and the public. Development of an understanding of how structural codes, permitting processes and zoning ordinances relate both separately and together to EV-ready planning will require awareness building and updated training for installers, inspectors and state and municipal officials. Stakeholders, including interested members of the public, should have equal access to important EV and EVSE information and be permitted to participate in or otherwise approve of local and state-level changes.

Recommendations:

- Adopt code appendices containing voluntary scoping and implementation options, further including code phasing and tiers.
- Make consistent information and technical support available to officials across state and local agencies through the Clean Cities' Coalitions.
- State agencies having jurisdiction should introduce locally vetted modifications to the discussion of national model codes in the next possible code cycle (2015).

EV Readiness: Phasing and Tiers

Voluntary/Mandatory: Requirements included as an optional appendix; voluntary requirements create consistency among jurisdictions that choose to adopt.

Local and Developer Burdens: Code language should be enforceable in the local jurisdiction and not cause undue local burdens.

Tiered Codes: Optional appendices to the building code should be structured with additional options, or tiers, that set standards for increasing levels of participation and enforcement.

Pilot Phases: Test new codes and allow contractors, inspectors and other local stakeholders to develop a knowledge base prior to full enforcement of any new code.

4.2.5. Partnerships Guide Infrastructure Deployment across Boundaries

Successful local plans for EVSE rollout have been comprehensive in scope; because codes are one part of the local regulatory environment, they must work in concert with other legislative rules, economic policies, local planning and regulatory processes. Key factors must be in place to successfully advance policy, legislation and ordinances pertaining to EV infrastructure, and several central themes rise to the top.

Highly significant among these themes is a forum for cooperation. The reduction of barriers to EVSE deployment will not come from code amendments, but rather from the collaborative efforts that can produce such amendments as part of a comprehensive deployment strategy.

Large-scale and multi-agency coalitions and working groups, public-private partnerships and work with academic and research institutions have contributed to a broad-based understanding of intersections among local and regional goals in model jurisdictions. Partnerships are central to comprehensive planning efforts, and academia, utilities, power authorities and a range of government agencies and nonprofit groups should be involved in the planning process regardless of scale.

A key enabler for EV infrastructure deployment and installation is the local electric utility. Utilities are possibly the single most important stakeholder in the EVSE conversation and should be involved extensively. Utility companies can be privately held or public authorities.

The role of the private sector can be just as important as that of the public sector in preparing the region for more comprehensive EVSE deployment. Federal and state funding has been channeled to private infrastructure developers (ECOtality's EV Project, for example) to gather data, test business models and pilot high-visibility EV charging. Private-sector outcomes and developing business models will determine many aspects of EVSE and EV adoption.

Recommendations:

- Enable the creation of special purpose clean energy districts to connect interests and regulatory processes in the TCI region.
- Enable data exchange and access to EV ownership and EVSE installation to improve utility performance and enhance utility involvement in local and regional planning.
- Create and/or engage EVSE working groups housed within the appropriate agency in each state to leverage TCI regional stakeholder information and influence and to promote high-level cooperation.

Special-Purpose Clean Energy Districts

Special-purpose districts are independent governmental units that exist separately from general purpose government districts—states, counties, and municipalities—and deliver public services within that area. Special-purpose districts can cross jurisdictional boundaries, including states if established by interstate compact. They require state enabling legislation. Power, sewer or water authorities are examples of existing special-purpose districts. Incorporation as a special-purpose district provides benefits associated with policy, governance and the ability to tax, in some cases. Special-purpose districts often do not include cities within their bounds, but they can.

Special-purpose districts that work in concert with the electric utilities serving the jurisdictions included within its boundaries could present an opportunity for local areas with little ability to enforce green construction or other voluntary EVSE-specific provisions to enact sustainability measures at a collective scale.

EVSE-focused Clean Energy Districts would accomplish the following:

- Act as independent government units to connect energy goals across the region.
- Provide jurisdictional authority to include/permit/enforce EVSE-related standards across existing lines.
- Bring energy-related infrastructure regulations to areas outside major metros while uniting the work, goals and resources of multiple jurisdictions across boundaries.
- Access shared or collective resources.

New Mexico has created renewable energy financing districts with the purpose of enabling participating property owners to access financing for the installation of renewable energy technology. [3] Washington State allows air pollution control authorities.[4]

The proper level of focus of the special-purpose district would need further exploration. An EVSE-specific special-purpose district could address regional transportation electrification. Or, a clean energy district could provide a wider range of services and planning on behalf of the underlying zones.

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APPENDIX A: CHARGING LEVELS

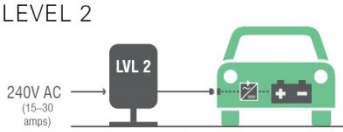
LEVELS OF CHARGE: DIAGRAMS AND ATTRIBUTES

LEVEL 1

ATTRIBUTES:

- A standard outlet can potentially fully recharge an EV battery in 8–12 hours, though larger batteries, such as on the Tesla Model S, would require between 1 and 2 days
- This level is often sufficient for overnight, home charging
- Standard outlets can also provide an option for "peace of mind" charging using onboard equipment on the go
- Uses standard J1772 coupler
- In-vehicle power conversion

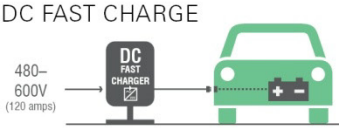
LEVEL 2



ATTRIBUTES:

- Free-standing or hanging charging station units mediate the connection between power outlets and vehicles
- Requires installation of charging equipment and often a dedicated 20–80 amp circuit, and may require utility upgrades
- Well-suited for inside and outside locations, where cars park for only several hours at a time, or when homeowners seek added flexibility of use and a faster recharge
- The public charging network will comprise primarily level 2 charging stations
- Public context requires additional design features, such as payment and provider network interfaces or reservation systems
- Uses standard J1772 coupler
- In-vehicle power conversion, charging speed limited by the onboard charger

DC FAST CHARGE



ATTRIBUTES

- Free-standing units, often higher profile
- Enable rapid charging of EV battery to 80% capacity in as little as 30 minutes
- Electrical conversion occurs in EVSE unit itself
- Relatively high cost compared to level 2 chargers, but new units on the market are more competitively priced
- Draws large amounts of electrical current, requires utility upgrades and dedicated circuits
- Beneficial in heavy-use transit corridors or public fueling stations
- Standard J1772 coupler approved in October 2012

APPENDIX B: SUMMARY OF EVSE STANDARDS

Organization/Code Text	Standard	Description
Society of Automotive Engineers (SAE)	J1772	Electrical and mechanical aspects of the cord set, references Underwriters Laboratory for safety and shock protection and the National Electrical Code for cord and coupler
	J2293	Electric vehicle (EV) energy transfer system
	J2293-1	Functionality requirements, system architecture
	J2293-2	Communication requirements, system architecture
National Fire Protection Association (NFPA)/National Electrical Code (NEC)	NEC 110.11	Deteriorating agents
	NEC 110.28	Enclosure types
	NEC 110.26	Electrical equipment spacing
	NEC 110.26 (A)(2)	Width of working space
	NEC 110.27 (B)	Guarding of live parts to prevent physical damage
	NEC 210.70 (A) (2)	Lighting outlets required, dwelling units
	NEC 300.4	Protection of conductors against physical damage
	NEC 334.15	Exposed work safety requirements
	NEC 334.30	Securing and supporting nonmetallic sheathed cable
	NEC 625.1-625.5	General instructions for electric vehicle supply equipment (EVSE): scope, definitions, other articles, voltage, listed/labeled
	NEC 625.9 (A-F)	Wiring methods for EV coupler
	NEC 625.13-625.19	EVSE equipment construction
	NEC 625.21-625.26	EVSE control and protection
	NEC 625.28-625.30	EVSE supply equipment locations
	NEC 626	Electrified truck parking spaces
Underwriters Laboratory (UL)	UL 62	Flexible cords and cables: required by NEC 625
	UL 2202	EVSE charging station design and construction
	UL 2231	Charging station shock prevention: grounding and ground fault interruption
	UL 2251	Cord design and safety of plug, cord, receptacle, connectors, load rating
	UL 2594	Charging station safety: off-board equipment supplying power to vehicle

APPENDIX C: OTHER LOCAL PLANNING TOOLS

Local governments have five important tools at their disposal that can be used to more successfully and seamlessly integrate electric vehicle supply equipment (EVSE) into the planning and administration of states, cities and towns. Simply put, these tools will ideally achieve the following through electric vehicle (EV)-focused policies:

- Zoning will require EVSE parking in the private realm.
- Parking will enable EVSE in the public realm.
- Codes will require wiring in parking structures and set standards for safety, operation and administrative processes.
- Permitting changes will streamline the administrative process for private installers of EVSE.
- Procurement and partnerships will build consensus and increase awareness for EVSE deployment.

The tools are summarized below and on the following page.

Zoning

Determines where and in what fashion EVSE is allowed, incentivized or required

- Establishes allowable uses based on the municipal zoning code
- Considers deployment of EVSE within the larger context of planning and land use
- Incentive zoning, such as the exchange of development bonuses for the inclusion of EVSE pre-wiring or infrastructure in new development, is a potential area for EVSE deployment, but it remains largely untested
- By setting development standards through zoning ordinances, municipalities can use this tool to shape the scope (how many and where) of EVSE deployment

Parking

Sets the scope and enforcement requirements for parking with state or local laws

- Applies to publicly accessible EVSE, including on-street chargers and units in municipal lots and garages, and is therefore an important part of infrastructure development
- Similar to zoning, parking ordinances provide a way to require a certain number or percentage of spaces and to restrict the use of charging stalls to EVs
- Unlike zoning, parking ordinances are not tied to new development
- Opportunities exist for private parking management

Codes	**Ensure that EVSE installations are safe, and specify the scope of EVSE-ready construction** • Changes to the building and electrical codes are not necessary from a safety standpoint, but they can help make places EV-ready • State and local codes may need to change to meet certain requirements, such as emissions reduction goals. This is an ideal opportunity to incorporate EVSE • Municipalities that are able to adopt their own codes benefit from a highly flexible state code—one that provides different standards for different situations • Building and electrical codes present different EV-ready opportunities
Permitting	**Streamlines the administrative process so that it is uncomplicated, fast and affordable** • Updating and streamlining permitting eases implementation of EVSE and reduces fees to the consumer • Permitting is a local administrative process and, as a result, may be a source of fragmentation across the region, evidenced by wide variations in permit fees • Third-party inspection firms offer opportunities for partnership and inspector training throughout the region
Procurement & Partnerships	**Work closely with private or quasi-public partners to implement infrastructure in the public realm** • Partnerships include working groups, which can unite government agencies with private industry and experts • Regional planning organizations such as metropolitan planning organizations and councils of government are important for building consensus and getting the word out • Governments can procure EVs for municipal and state fleets to increase awareness and meet sustainability goals • The role of the private sector can be just as, if not more, important in preparing the region for more comprehensive EVSE deployment

APPENDIX D: CODE LANGUAGE DOCUMENTATION

This section includes examples of building and electrical code amendments relevant to electric vehicle supply equipment (EVSE) installation. Amendments relevant to the case studies are included, along with other representative sample codes from jurisdictions in the United States and Canada.

Sample Building Code Amendments for EVSE

Require sufficient area for electrical infrastructure

Meet Future Increased Capacity Needs: Vancouver Building By-law No. 9936 (2009)

Adopted Code Language:

13.2.1.2 Electrical Room

(1) The electrical room in a multi-family building, or in the multi-family component of a mixed use building, that in either case includes three or more dwelling units, must include sufficient space for the future installation of electrical equipment necessary to provide a receptacle to accommodate use by electric charging equipment for 100% of the parking stalls that are for use by owners or occupiers of the building or of the residential component of the building.

Require a percentage of parking stalls to be pre-wired for EVSE

A strategy to encourage electric vehicle (EV) readiness through the pre-wiring of garages and parking stalls at time of construction for current or future installation of charging stations. The goal is to provide future capability for dedicated EVSE in single- and multifamily homes, as well as commercial locations.

Single-Family Dwellings: Vancouver Building By-law No. 9691 (2008)

Adopted Code Language:

12.2.2.10. Cable Raceway

(1) Each dwelling unit shall have a cable raceway leading from the electricity circuit panel to an enclosed outlet box in the garage or carport.

(2) A raceway not smaller than size 21 shall be provided to accommodate future conductors of a separate branch circuit intended to supply a future receptacle for use with the electric vehicle charging system.

(3) An outlet box for the receptacle referred to in Sentence (2) and approved for the purpose shall be provided in a parking space or parking stall of a storage garage or carport intended for use with the electric vehicle charging system.

(4) The raceway described in Sentence (2) shall be installed between the dwelling unit panel board and the outlet box referred to in Sentence (3).

Multifamily Dwellings: Vancouver Building By-law No. 9936 (2009)

In 2008, the Vancouver City Council enacted new regulations in the city's building code that require a portion of the parking stalls in all new multifamily (three or more units) residential construction to accommodate EV charging. The provisions went into effect in April 2011.

Adopted Code Language:

13.2.1.1. Parking Stalls

(1) Each one of 20% of the parking stalls that are for use by owners or occupiers of dwelling units in a multi-family building that includes three or more dwelling units, or in the multi-family component of a mixed use building that includes three or more dwelling units, must include a receptacle to accommodate use by electric vehicle charging equipment.

Single-Family and Multifamily Dwellings: CALGreen, Green Construction Code (Voluntary)[161]

Adopted Code Language:

A5.106.5.3 Electric vehicle charging. Provide facilities meeting Section 406.7 (Electric Vehicle) of the California Building Code as follows:[162]

A5.106.5.3.1 Electric vehicle supply wiring. For each space required in Table A5.106.5.3.1, provide one 12- VAC 20 amp and one 208/240 V 40 amp, grounded AC outlets or panel capacity and conduit installed for future outlets.

Table A5.106.5.3.1

Total Number of Parking Spaces	Number of Required Spaces
0–50	1
51–200	2
201 and over	4

A4.106.5.4 Electric vehicle (EV) charging. Dwellings shall comply with the following requirements for the future installation of electric vehicle supply equipment (EVSE).

A4.106.6.1 One- and two-family dwellings. Install a listed raceway to accommodate a dedicated branch circuit. The raceway shall not be less than trade size 1. The raceway shall be securely fastened at the main service or subpanel and shall terminate in close proximity to the proposed location of the charging system into a listed cabinet, box or enclosure…

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[161] "Revision Record for the State of California – Supplement" in *2010 California Green Building Standards Code*, Title 24, Part 11 (July 1, 2012), www.iccsafe.org/cs/codes/Errata/State/CA/5570S1002.pdf.
[162] The California Building Code sets out definitions of EVs and installation requirements for ventilation and electrical systems. The code can be found here: https://law.resource.org/pub/us/code/bsc.ca.gov/gov.ca.bsc.2012.02.1.html.

Exception: Other pre-installation methods approved by the local enforcing agency that provide sufficient conductor sizing and service capacity to install Level 1 EVSE.

Note: Utilities and local enforcing agencies may have additional requirements for metering and EVSE installation, and should be consulted during the project design and installation.

A4.106.6.1.1 Labeling requirement. A label stating "EV CAPABLE" shall be posted in a conspicuous place at the service panel or subpanel and next to the raceway termination point.

A4.106.6.2 Multifamily dwellings. At least 3 percent of the total parking spaces, but not less than one, shall be capable of supporting future electric vehicle supply equipment (EVSE)

A4.106.6.2.2 Multiple charging spaces required. When multiple charging spaces are required, plans shall include the location(s) and type of the EVSE, raceway method(s), wiring schematics and electrical calculations to verify that the electrical system has sufficient capacity to simultaneously charge all the electrical vehicles at all designated EV charging spaces at their full rated amperage. Plan design shall be based upon Level 2 EVSE at its maximum operating ampacity. Only underground and related underground equipment are required to be installed at the time of construction.

Required Parking Stalls: Hawaii Senate Bill No. 2747 Relating to Electric Vehicle Parking (2012)[163]

Language of the Adopted Act:

Section 2. Section 291-71, Hawaii Revised Statues, is amended to read as follows:

"291-71 Designation of parking spaces for electric vehicles; charging system.

a) Places of public accommodation with at least one hundred parking spaces available for use by the general public shall have at least one parking space near the building entrance designated exclusively for electric vehicles and equipped with an electric vehicle charging system by July 1, 2012. Spaces shall be designated, clearly marked, and the exclusive designation enforced. Owners of multiple parking facilities within the State may designate and electrify fewer parking spaces than required in one or more of their owned properties; provided that the scheduled requirement is met for the total number of aggregate spaces on all of their owned properties."

Provide flexible, tiered voluntary appendices in the state building code

The California Green Construction Code (2010 edition) includes the following sections, providing for a tiered system of options for local jurisdictions that choose to adopt and enforce codes specific to low-emission vehicles and for EVSE.

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[163] "SB2747 SD1 HD2," Hawaii State Legislature, accessed October 24, 2012, http://www.capitol.hawaii.gov/measure_indiv.aspx?billtype=sb&billnumber=2747.

Adopted Code Language: CALGreen Green Construction Code[164]

A5.106.5.1 Designated parking for fuel-efficient vehicles. Provide designated parking for any combination of low-emitting, fuel-efficient and carpool/van pool vehicles as shown in Table A5.106.5.1.1 or A5.106.5.1.2.

Provide 10 percent of total designated parking spaces for any combination of low-emitting, fuel-efficient and carpool/van pool vehicles as follows:

Table A5.106.5.1.1 Tier 1 10% of Total Spaces	
Total Number of Parking Spaces	**Number of Required Spaces**
0–9	0
10–25	2
26–50	4
51–75	6
76–100	9
101–150	11
151–200	18
201 and over	At least 10% of total

Table A5.106.5.1.2 Tier 2 10% of Total Spaces	
Total Number of Parking Spaces	**Number of Required Spaces**
0–9	1
10–25	2
26–50	5
51–75	7
76–100	9
101–150	13
151–200	19
201 and over	At least 12% of total

[164] California Building Standards Commission, *2010 California Green Building Standards Code* (Sacramento, CA: California Building Standards Commission, January 1, 2011), www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.

Write local codes to include multifamily and commercial installation scenarios in addition to single-family scenarios.

Sunnyvale, California[165]

Adopted Code Language:

Building Division Requirements

An electrical permit is required for installation of electric vehicle chargers…

New Residential Construction

- Garages/carports attached to individual dwelling units (typically single-family detached and townhouses) shall be pre-wired for a Level 2 electric vehicle charger.
- Shared parking facilities (typically condominiums and apartments) shall have 12.5% of the required spaces pre-wired for Level 2 electric vehicle chargers.

Non-Residential and Multi-Family Requirements

- The electric vehicle charging spaces may be counted towards the number of required low-emitting/fuel efficient parking in the CALGreen or LEED, as applicable.
- A sign shall be posted at the electric vehicle charging spaces stating "Electric Vehicle Charging Only."

Accessibility Requirements (CBC Chapter 11B)

- In each group of charging stations, one space shall be provided with an accessible loading area (a minimum of 5' wide and 18' in length and striped). These spaces do not need to include signage dedicating them for disabled access use. These spaces shall not be counted as accessible parking spaces, as required by California Building Code.
- Operational controls and receptacles for the charging station controls (i.e. on/off buttons, payment readers, etc.) shall be located between 15" and 48" from finished floor/grade.

Create a more stringent municipal code

For municipalities having jurisdiction, the ability to develop their own or choose voluntary measures provided by the state to create more stringent standards for EVSE may be a good opportunity. In 2011, Los Angeles adopted provisions of the Green Building Code into its municipal code. The city adopted as mandatory provisions of CALGreen, adapting the provisions to require a slightly-higher-than-Tier-1 level of compliance.

Los Angeles Municipal Code (2010)[166]

Adopted Code Language:

99.04.106.6. Electric Vehicle Supply Wiring

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[165] http://sunnyvale.ca.gov/Portals/0/Sunnyvale/CDD/Residential/Electrical%20Car%20Chargers.pdf.
[166] City of Los Angeles Ordinance No. 181480 (December 15, 2010), http://ladbs.org/LADBSWeb/LADBS_Forms/PlanCheck/2011LAAmendmentforGreenBuildingCode.pdf.

1. For one- or two-family dwellings and townhouses, provide a minimum of:
   a. One 208/240 V 40 amp, grounded AC outlet, for each dwelling unit; or
   b. Panel capacity and conduit for the future installation of a 208/240 V 40 amp, grounded AC outlet, for each dwelling unit.

The electrical outlet or conduit termination shall be located adjacent to the parking area.

2. For other residential occupancies where there is a common parking area, provide one of the following:
   a. A minimum number of 208/240 V 40 amp, grounded AC outlets equal to 5 percent of the total number of parking spaces. The outlets shall be located within the parking area; or
   b. Panel capacity and conduit for future installation of electrical outlets. The panel capacity and conduit size shall be designed to accommodate the future installation, and allow the simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to 5 percent of the total number of parking spaces. The conduit shall terminate within the parking area; or
   c. Additional service capacity, space for future meters, and conduit for future installation of electrical outlets. The service capacity and conduit size shall be designated to accommodate the future installation, and allow simultaneous charging, of a minimum number of 208/240 V 40 amp, grounded AC outlets, that is equal to 5 percent of the total number of parking spaces. The conduit shall terminate within the parking area.

When the application of the 5 percent results in a fractional space, round up to the next whole number.

Article 9, Division 5: For Newly Constructed Nonresidential and High-Rise Residential Buildings

99.05.106.5.2 Designated Parking. Provide designated parking, by means of permanent marking or a sign, for any combination of low-emitting, fuel-efficient, and carpool/van pool vehicles as follows:

Table 5.106.5.2 Tier 2 10% of Total Spaces	
Total Number Of Parking Spaces	**Number Of Required Spaces**
0–9	0
10–25	1
26–50	3
51–75	6
76–100	8
101–150	11
151–200	16
201 and over	At least 12% of total

99.05.106.5.3.1. Electric Vehicle Supply Wiring. Provide a minimum number of 208/240 V 40 amp, grounded AC outlet(s), that is equal to 5 percent of the total number of parking spaces, rounded up to the next whole number. The outlet(s) shall be located in the parking area.

Article 9 Division 12: Voluntary Measures for Newly Constructed Nonresidential and High-Rise Residential Buildings

A5.106.5.3.2. Additional Electric Vehicle Supply Wiring. Provide a minimum number of 208/240 V 40 amp, grounded AC outlet(s), that is equal to ten percent, rounded up to the next whole number, of the total number of parking spaces.

Sample Electrical Code Amendments for EVSE

Amend the state electrical code to streamline the permitting process

The Oregon Building Codes Division started developing administrative rules to streamline permit and inspection protocol for the installation of EVSE within the state. The language of the rule below applies to levels 1 and 2 charging.

Oregon Electric Vehicle Charging Station Statewide Permit and Inspection Protocol, 918-311-0065[167]

To ensure a path for the emerging technology and enable the installation of charging stations for electric vehicles, the following permit and inspection protocols will apply throughout the state, notwithstanding contrary provisions contained in the Oregon Electrical Specialty Code.

(1) Building officials and inspectors shall permit and allow installation of an electric vehicle charging station that has a Building Codes Division's special deputy certification label without further testing or certification.

(2) Persons installing an electric vehicle charging station must obtain a permit for a feeder or branch circuit from the inspecting jurisdiction. No other state building code permit is required.

(3) The jurisdiction may perform up to two inspections under the permit issued in subsection (2) above.

(4) Inspection of the installation is limited to examining the feeder or branch circuit for compliance with the following Oregon Electrical Specialty Code provisions:

(a) Overcurrent protection, per articles 225 and 240;

(b) Physical protection of conductors, per article 300;

(c) Separation and sizing of the grounding and neutral conductors, per article 250.20;

(d) Provisions for locking out the breaker for maintenance, per chapter 4.

(5) For the purpose of this rule, the service, feeder or branch circuit, and charging station pedestal will be considered a single structure as defined by the Oregon Electrical Specialty Code. The structure's owner may opt to install a grounding

[167] Electric vehicle charging station installation amendment Stat. Auth: ORS 455.065.

electrode system to supplement lightning protection, but cannot be required to do so.

(6) An electrical contractor employing a general supervising electrician in accordance with OAR 918-282-0010 is authorized to use a minor installation label to install a new branch circuit limited to 40 amps 240 volts for the purpose of installing a wall mounted Electric Vehicle Supply Equipment (EVSE) unit in the garage of one and two family dwellings, and connect a listed wall mounted EVSE unit to that branch circuit. The electrical panel where the circuit originates must be in the garage within sight from the EVSE unit. This provision does not apply to installations in wet or damp locations.

Amend the municipal electrical code

Seattle, Washington

In Seattle, Washington, the 2008 edition of the city's adopted version of the electrical code identified and added some notable changes specific to EVs, with the purpose of making it easier to install home and commercial EVSE. The Seattle Electrical Code (SEC) adds article 625.27 to address required space for physical equipment and space planning in order to install future conduit, panel and disconnect for EVSE. In addition, provisions in the SEC address outlet load calculations for residential EVSE, as well as feeder and conduit specifications for multifamily residential occupancies. Seattle's electrical code modifications speak to the potential to utilize a jurisdiction's electrical codes to meet localized market demands and projections; the city was planning ahead in the 2008 code edition to account for EVSE installation once the first Nissan LEAF vehicles hit the Seattle market in 2010.[168] Article 625.27 of the SEC may offer best practice guidance to local jurisdictions seeking to plan in advance for EVs, and may also inform the National Fire Protection Association's next revision of the national model electrical code. The full SEC is available online.[169]

Adopted Code Language

ARTICLE 625, Electric Vehicle Charging System

625.27 Requirements for Future Installation of Outlets.

To facilitate future installation of electric vehicle outlets in residential occupancies, the following shall be provided:
(1) Space shall be reserved in the electrical service equipment for installation of an overcurrent protective device to serve electric vehicle charging system branch circuits.
(2) A location shall be designated, together with the required working clearances, for the electric vehicle charging system panelboard.
FPN No. 1: See also 220.57, Electrical Vehicle Outlets, for calculating demand loads.
FPN No. 2: Consideration of the location of the future electric vehicle outlets is recommended when designating a location for the electric vehicle outlet panelboard.
FPN No 3: Residential occupancies are defined in Chapter 3 of the Seattle Building Code.

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[168] "Plug-In Electric Vehicles" (Seattle, WA: City of Seattle, n.d.), https://www.seattle.gov/environment/documents/Electric%20Vehicles%20FAQ_Update_070511.pdf.
[169] Department of Planning and Development, *2008 Seattle Electrical Code Quick Reference*, Ordinance 122970 (Seattle, WA: City of Seattle, June 5, 2009), http://www.seattle.gov/dpd/static/2008%20qr%20complete_latestreleased_dpdp016577.pdf.