Reducing Barriers to Electric Vehicle Adoption through Building Codes

Jordan Shackelford, Alex Chase, and Michael McGaraghan, Energy Solutions
Stuart Tartaglia, Pacific Gas and Electric Company

ABSTRACT

Plug-in hybrid electric vehicles and fully electric vehicles (collectively EVs for this paper) are increasingly available and are beginning to present a compelling opportunity to shift towards a lower-carbon transportation future. However, relatively high up-front consumer costs can reduce the potential adoption rate of EVs. Along with vehicle costs, retrofitting residences with EV charging infrastructure can add significant expense for homeowners - sometimes several thousand dollars. Including basic charging infrastructure (240 volt, AC Level 2 ready) during new construction can reduce future costs and thus remove a potential barrier to EV adoption.

In 2010 and 2011, on behalf of California's investor-owned utilities (IOUs), including Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E), the authors developed an EV charging readiness building code proposal for residential new construction in California. On July 20, 2011, the California Building Standards Commission approved voluntary EV charging amendments to California's Green Building Standard, or CALGreen, that are expected to become effective in July of 2012. These voluntary requirements in CALGreen can then be easily adopted by local jurisdictions as mandatory local requirements.

We discuss the development of the California investor-owned utilities' EV charging readiness proposal, a collaborative process with utility EV experts and a variety of public stakeholders in California. Technical EV charging requirements and challenges are discussed, including residential issues such as branch circuit and electric service panel sizing and utility issues such as managing increased load on distribution transformers. Interactions with electric codes and other relevant standards are explored. We also highlight key differences between the adopted CALGreen language and the authors' code proposal and present our vision for future EV readiness in building codes in the State and beyond.

Introduction

Plug-in hybrid electric vehicles with gasoline range extension, and fully electric vehicles with no gasoline engine, may become an increasingly important part of the transportation sector. Recent auto manufacturer data shows that U.S. sales of the mass-produced Nissan Leaf and Chevrolet Volt exceeded 17,000 in 2011(RMI 2012). In 2012, approximately one dozen new models are expected to be released and another dozen are expected to follow in 2013.

Forecasts for EV growth vary widely. For the state of California, a review of various projections by the *Ready, Set, Charge* initiative found projected penetration rates of around 5% of new car sales in 2020 by the California Air Resources Board (ARB) and a projection of almost 15% of new car sales by the International Energy Agency in that same time period (ABAG 2011, 12). The overall California auto market, at 1.1 million new cars sold per year, represents over 10% of U.S. sales. Registered vehicles total 22 million in California in 2010. Estimates range from 500,000 to 1.5 million or more registered EVs in California by 2020

(Kavalec 2009, 2012), which equates to 2% to 6% of all expected registered vehicles in the state (CalTrans 2009, 61).

Vehicle electrification offers many advantages over gasoline combustion engines, including improvement in overall vehicle efficiency and significantly reduced emissions of CO_2 as well as criteria pollutants that affect local air quality. Summarized in Table 1 below are the California Energy Commission's (CEC) Full Fuel Cycle Assessment of 2007 (Pont 2007) estimates of air quality and greenhouse gas (GHG) benefits from electric vehicles relative to petroleum fueled vehicles in CA. The U.S. Department of Energy (DOE) Advanced Vehicles Database estimates similar CO_2 savings of 67% for EVs over gasoline-fueled vehicles (DOE 2011), based on the mix of generation sources feeding California's electricity grid (42% gas, 18% hydro, 16% nuclear, only 12% coal). For the U.S. on average, with coal power representing 50% of the generation mix nationally, DOE still reports savings of 38% of CO_2 emissions for EVs.

Table 1. CEC Estimated Air Quality and GHG Benefits from Electric Vehicles

Pollutant	Battery Electric Vehicle	Plug-in Hybrid Electric Vehicle (PHEV)
GHG	72% reduction	48% reduction
Particulate Matter (PM_{10})	11% reduction	8% reduction
Other Pollutants	96% - 99% reduction	62% reduction

Adapted from Tables 3-15 and 3-16 of Pont 2007

The potential impact is significant. In California, the transportation sector is the largest contributor to the state's carbon emissions (at 38%); indeed representing 2% of global GHG emissions (ARB 2008). Given the clear emissions benefits of transitioning to electric transportation options, EVs have become a critical component of the state's strategies to reduce GHG emissions (see Legislative Developments below). In addition to reducing transportation emissions, plug-in vehicles should also save consumers money in the long run. Initial purchase prices are expected to be higher than other in-class vehicles (Ward 2009), but federal tax credits up to $7,500 per vehicle are currently available and President Obama has proposed increasing that amount to $10,000. The lifecycle cost savings from reduced gas bills are projected to be significant. The Electric Power Research Institute (EPRI) has estimated that at $3.00/gallon, lifecycle fuel savings for a compact plug-in hybrid could be $10,000 over the vehicle's lifetime (Electrification Coalition 2009, 40).

In spite of the benefits of electric transportation and the increased availability of EVs in the marketplace, they have yet to achieve significant market penetration. It should be noted that EVs from major original equipment manufacturers (OEMs) have only become available in significant numbers in the past 12 to 18 months. For EVs now available in the consumer market, perceived factors affecting adoption vary, from lack of consumer familiarity and comfort with the technology, including "range anxiety" for all-electric vehicles (limited miles per charge with no gasoline-powered range extension), to the higher initial cost of an EV purchase. Additional costs at adoption may include the need to install adequate charging infrastructure to provide the EV with electric fuel at the owner's residence, where it is forecasted that EV charging will most often be done.

If appropriate conductors, breakers, and other infrastructure are not in place for a dedicated "AC Level 2" charging circuit (240 volts and typically 40 amps rating), it can be

expensive to retrofit a home with one, requiring several hours of an electrician's time, equipment, possible electric service panel upgrade, and possible permitting hurdles. Retrofitting a residence with a charging circuit can cost over $2,000 (Morrow 2008, Table 6-12). On the other hand, supplying an appropriately sized circuit during new construction may be able to be done at very little extra cost. For example, California-based home builder KB Homes announced as early as 2010 an option to pre-wire new homes for Level 2 EV charging, at a reported cost of around $250 (AutoBlogGreen 2010).

Development of Proposal

To facilitate market adoption of EVs and address the residential charging readiness hurdle, PG&E and the California IOU Statewide Codes and Standards (C&S) team began to explore a building codes solution in 2009. The IOU C&S team recognized that building code requirements in California could be enhanced to facilitate adoption of plug-in technologies by providing more available, accessible, and affordable charging infrastructure. Many experts and stakeholders have pointed out that building codes are an effective option for addressing the hurdle of readily available residential charging infrastructure:

- The CEC-funded Plug-in Hybrid & Electric Vehicle Research Center at the University of California, Davis: "Stakeholders can work to modify building codes … to require upgrading electrical circuits in new and renovated garages to accommodate a Level 2 charging station… [to] dramatically decrease the cost of future charging station installations (Turrentine 2010, 41)."
- The Electrification Coalition, which promotes government action to facilitate mass scale electric vehicle adoption and includes Johnson Controls, FedEx, PG&E, Kleiner Perkins, Aerovironment, and Nissan as members, states: "…building codes should be modified to require that newly constructed homes and multi-family units have 220 volt outlets installed in garages or, at a minimum, have conduits installed that will facilitate the later installation of 220 volt lines (Electrification Coalition 2009, 117)."
- The Rocky Mountain Institute's Project Get Ready "Must Haves" for preparing communities to become EV ready include ensuring that building codes for new construction and for alteration/renovation projects support the operation of EVs (RMI 2009).

California's statewide building code, known as Title 24, includes the California Green Building Standards Code (Part 11 of Title 24), commonly referred to as CALGreen. This is the section of Title 24 where the IOU C&S team determined EV readiness provisions would be the most appropriate. The CALGreen code was originally a voluntary set of provisions that local jurisdictions could choose to adopt. In January 2011 chapters four (residential) and five (non-residential) became mandatory for the entire state. The CALGreen code also includes appendices of voluntary measures that local jurisdictions may adopt for enhanced CALGreen "Tier I" or "Tier II" compliance. The 18 month revision cycle for CALGreen began in 2010 and the IOU C&S team believed that this was the appropriate time to propose new code measures to address EV charging readiness.

The EV residential charging readiness effort began with research to define EV charging infrastructure technical requirements, the utilities' priorities, and background research on California's green building codes development process. Working with IOU stakeholders, we

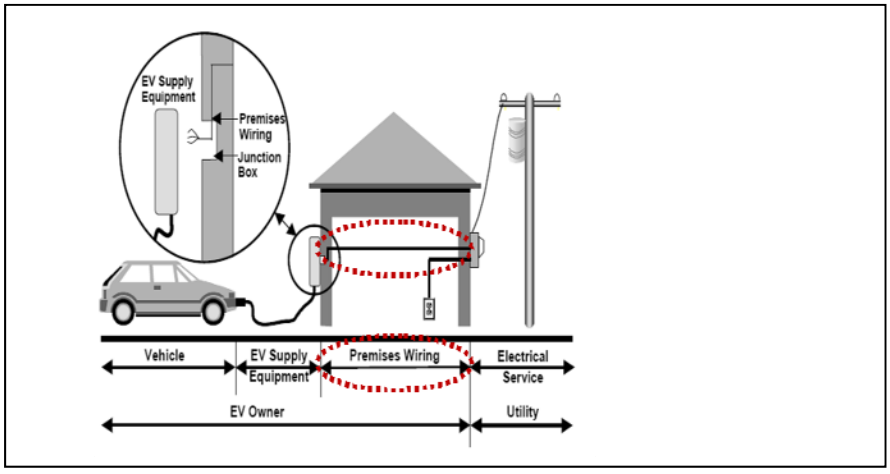
identified various technical parameters to address. We confirmed based on research of charging trends and preferences that any new code requirements should accommodate AC Level 2, 240 volt, 40 amp rated charging. Given the EV market state of maturity, the IOU stakeholders also preferred to scope voluntary measures for CALGreen rather than mandatory language. The IOUs chose to develop only residential charging readiness measures at this time rather than including commercial spaces as well; with the rationale that most plug-in vehicle charging will take place at residences so this is a higher impact code area, and also that supporting residential charging encourages off-peak, overnight charging of commuter vehicles at homes.

The overarching intent was to draft code provisions that minimize construction requirements and cost but maximize the level of basic charging circuit infrastructure for the locations where EVs will be parked and charged in the future. This would avoid the need for costly additional electrical work upon purchase of electric vehicles and eliminate a significant possible barrier to EV adoption. We determined that the most comprehensive strategy would be to require:

- Installation of conduit and conductor, or nonmetallic sheathed cable (more common in residential construction) appropriately sized for a dedicated 240 volt, 40 amp rated AC circuit running from the electric service panel to a capped junction box or other enclosure at the parking space
- Installation of a circuit breaker for the charging circuit and reservation of electric service panel capacity for EV charging loads.

The prewiring infrastructure targeted by the code measure, from the electric service panel to the parking location, is shown in the red circles in Figure 1. Note that the target infrastructure does not include the electric vehicle supply equipment (EVSE), the appliance wired to the charging circuit that supplies electricity to the vehicle's on-board battery charger, nor changes to the utility meter or distribution infrastructure.

Figure 1. Prewiring Premises for EV Charging



Adapted from Figure 1 in PG&E 1999

Technical Issues

A variety of specific technical challenges and questions surfaced as we developed the code proposal. Some of the more salient topics are listed here.

- **Circuit termination method:** National Electric Code (NEC) Article 625; Electric Vehicle Charging System; Scope, also adopted in the California Electric Code, includes various provisions on the electrical conductors and equipment that connect an EV to a supply of electricity by conductive or inductive means, and the installation of the EVSE. There was some ambiguity in the NEC language as to the interconnect method between the charging circuit and the EVSE and whether the NEC calls for EVSE to be hardwired to the branch circuit, or allows for EVSE to be plugged into a rated outlet so long as the EVSE is permanently installed such that unplugging it during a charging event is very unlikely. We noted that market-available charging equipment is not consistent on this point, with some designed to plug into outlets and others for hardwiring. It therefore may not be useful to terminate the branch circuit in an outlet, because it may not accommodate hardwired EVSE equipment or NEC requirements. To address this, the proposal called for the charging circuit to terminate in a capped junction box or other enclosure.
- **Sub-metering**: The code proposal team explored the feasibility of accommodating sub-metering EV charging in the code provision. One option discussed was inclusion of a dual meter adapter where the utility service drop meets the home meter. However, it seemed unnecessary to require this for all homes, and some jurisdictions prohibit dual meter adapters altogether. It was also noted that some EVSE may eventually be capable of utility-grade power metering. We determined that sub-metering infrastructure was out of the proposal scope, which was concerned only with preparing a simple circuit that could eventually be used for charging an EV.
- **Grid impacts**: Incentivizing off-peak charging is a priority for utility companies preparing for increases in EV charging. Distribution infrastructure overloading is also a concern, as many local distribution transformers are not sized to simultaneously accommodate several EV charger loads along with standard residential loads, especially at peak periods of electricity demand. AC Level 2 chargers can draw 3 to 6kW or more of power on the proposed 40 amp circuit; a load that may exceed that of an entire home. An EPRI study found that some transformers would be overloaded by the addition of a single AC Level 2 charger operating during peak hours (Electrification Coalition 2009, 102). However, the IOUs have been directed by a recent California Public Utilities Commission (CPUC) decision that customers adopting EVs are not currently responsible for the transformer upsizing costs (CPUC 2011). Smart charging infrastructure that networks, monitors, and manages plug-in vehicle chargers throughout a service territory may be the eventual solution to mitigate risk from multiple residential customers on the same transformer charging vehicles at the same time (e.g. scheduling charging events from multiple residences on one transformer at different periods throughout the night). We determined that this issue was outside the scope of simple charger circuit provisioning, and noted that utilities are trying to address the peak charging issue in California with time-of-use pricing for homes with plug-in vehicle chargers, encouraging charging during off-peak hours through favorable pricing.

- **Circuit sizing**: The team investigated whether the proposed 40 amp, AC Level 2 circuit requirement would be appropriate for the EVs of today as well as those in the future. Most vehicles available on the market today charge at 3.3 kW on a AC Level 2 charger (at this rate a Chevy Volt charges in 4 hours and a Nissan Leaf in a little over 7 hours (ABAG 2011, 40)), while AC Level 2 chargers can accommodate as much as 7.2 kW on a 40 amp circuit. We determined with IOU EV experts that at this point there is no trend toward battery sizing for consumer plug-in vehicles that could not reasonably be served by 40amp AC Level 2 overnight charging.
- **Service panel capacity and upsizing**: The team considered whether reserving capacity on the electric panel for the EV charging circuit would require an upgrade in typical panel size, at several hundred dollars additional cost. During CALGreen proceedings, the Department of Housing and Community Development (HCD), the entity responsible for the residential section of CALGreen, developed sample residential load worksheets in which they calculated that for a 2,000 ft^2 house with "average appliance loads," the EV requirement would bump the service panel size from 200 amps to 400 amps. In its research, ARB learned that the City of Los Angeles' experience with hundreds of EV charging installations indicates that panel sizing does often bump from 200 amps to 250 amps (not 400 amps), increasing upfront cost by $100-$350. ARB notes that with average cost of new homes in the $200,000-$300,000 range, the incremental panel cost is a relatively minimal cost (ARB 2011).
- **Multi-family, multi-unit dwellings**: We determined, with input from stakeholders such as the City of San Francisco, that plug-in vehicle adoption in multi-family dwellings will be important in urban areas and that EV charging provisions for a percentage of parking spaces in such residences is important. Based on a range of EV adoption expectations from the IOU EV experts, we settled on a target of provisioning 10% of multi-family parking spaces for vehicle charging through installation of charging circuits and appropriate service panel capacity.

Code Adoption Process and Outcomes

In spring of 2010, as the Department of Housing and Community Development (HCD) and Building Standards Commission (BSC) were gearing up to initiate the 18-month CALGreen revision cycle (to amend the 2010 CALGreen code), the IOUs communicated with both agencies to understand the code change process and the opportunities for IOU involvement. In response to the first draft Express Terms developed by HCD in fall 2010, the IOUs submitted our proposed residential EV charging-ready requirements. Initially HCD did not incorporate the IOU proposal into its next draft Express Terms, sent to the BSC in November 2010.

However, in a Code Advisory Committee (CAC) meeting and in follow up discussions, the EV charging readiness concept was proposed and endorsed by several other stakeholders, including the California Air Resources Board (ARB). HCD staff then developed voluntary residential charging readiness measures very similar to those proposed by the IOUs and ARB and included these provisions in the language posted for the public comment period, in spring of 2011. In HCD's Initial Statement of Reasons, it noted that the regulation "is in response to requests from ARB and external stakeholders to provide electrical capacity … for electric vehicle charging stations in single-family residences and 10% of parking stalls in multi-family buildings (HCD 2011a)."

HCD's final EV residential charging readiness provisions were submitted to the BSC and approved in June of 2011 as CALGreen 2010 Voluntary Section A4.106.6. Though the adopted language that HCD settled on is less comprehensive than the IOU proposal, the adopted provisions were a positive code development for EV readiness in CA as they will provide local jurisdictions with a set of optional prescriptions to better prepare new residential construction for future EV charging. Table 2 provides a step-by-step timeline of the code proposal developments and outcomes starting in 2010 and leading up to the approved CALGreen provisions and follow-on activities.

Table 2. CALGreen EV Charging Readiness Measure Adoption Timeline

Timeframe	Major Developments and IOU Inputs
April – May 2010	– IOU C&S team confers with CEC, BSC and HCD to discuss participation in CALGreen update. – C&S team holds stakeholder call with San Francisco Department of Environment, the Bay Area Climate Collaborative, Silicon Valley Leadership Group, the EV Communities Alliance, and Bay Area EV Corridor project. Background on CALGreen revision process and timeline is given; collaboration opportunities and various technical issues are discussed.
November 2010 – January 2011	– HCD circulates draft Express Terms for November 29 focus group to discuss proposed changes to 2010 CALGreen. No EV charging readiness measures are included. – We introduce IOU EV measure concept at the focus group. Attendees, including ARB, express support. We submit a draft IOU proposal to HCD. – HCD does not include EV charging readiness in the Express Terms submitted to the BSC, but encourages the IOUs and ARB to bring proposals up at CAC meetings.
March – April 2011	– We compare IOU and ARB draft proposal for the CAC, and agree that coordination on language is beneficial, but proposals will be submitted independently. We submit proposal and rationale to the BSC for consideration during the CAC meeting on April 5. – At the CAC meeting, ARB and the IOUs bring up EV readiness measures. ARB notes the importance of residential EV charging for CA's GHG reduction goals. The CAC chair encouraged HCD to follow up on the proposals. – HCD's revised Express Terms in April include Section A4.106.6, devoted to voluntary provisions for EV charging circuits in single-family and multi-family residential new construction. 45-day public comment period ensues April 22 - June 6.
May – June 2011	– HCD holds work group meeting on May 17 to discuss the EV charging provisions. The California Building Industry Association is present, as well as other building industry representatives, and CEC, ARB, and HCD staff. – Most stakeholders at the workshop express interest in EV provisions, but concerns are raised over pre-wiring vs. empty raceway, service panel sizing and impacts of reserving charging circuit capacity, and future EV charging rates. – HCD circulates revised provisions that do not include pre-wiring, breakers, or panel capacity, instead calling for empty raceway for future charging circuit. – On June 6 PG&E submits a support letter for the original April 21 language rather than the revised language. The letter applauds HCD for including Section A4.106.6 in the previous Express Terms and offers some modifications on the April 21 language.
July 20, 2011	– The BSC approves final amendments to CALGreen expected to become effective July 2012.

The language ultimately adopted for the 18-month revision to CALGreen and effective summer of 2012 is contained in the Final Express Terms for Proposed Building Standards of HCD for CALGreen, dated July 7, 2011 (HCD 2011b). The approved amendments differed from the IOU proposal in that they did not include installation of conductor (wiring), circuit breakers, and panel capacity, but rather installation of raceway (empty channel for conduit or conductor runs) to accommodate the future installation of a dedicated branch circuit. In HCD's posted rationale for the changes in the Express Terms, they explain that pre-wiring requirements in

single-family construction were removed in favor of empty raceway to provide more flexibility on circuit sizing and to avoid additional expenses due to circuit provisioning possibly requiring an upgrade of the electrical service panel. HCD chose to include raceway as a minimum compliance option as an economical method to do some up-front preparation of the site for an eventual charging circuit, allowing consumers and builders more options when the circuit is actually installed at some point in the future. While this will reduce future costs somewhat, electrical retrofit work will still be necessary whereas the IOU proposal intended the circuit to be nearly ready to "plug-and-play" once the EVSE was purchased.

For multifamily residences, only underground raceways and related equipment are required in the CALGreen language, which calls for only 3% of parking spaces to be provisioned in this way (as opposed to 10% as suggested by the IOUs), as "an acceptable starting point" based on comments received from the CEC. However, the language does provide local agencies the option of requiring pre-wiring, allowing for "other pre-installation methods that provide sufficient conductor sizing and service capacity to install AC Level 2 EVSE."

Other Important Standards and Legislative Developments

Automotive and Charger Standards

The plug-in vehicle market is moving fast, and other important standards are under development. An important issue the IOU C&S team is tracking closely is the Society of Automotive Engineer (SAE) standard J2894 for EV battery and charger system energy efficiency. Though the building codes effort did not include any EVSE, and therefore had no efficiency component, the C&S team regularly provides input and analysis to the CEC on appliance efficiency benefits and impacts. The first part of J2894, "Power Quality Requirements for Plug-in Electric Vehicle Chargers" was published by SAE in December, 2011. In the third quarter of 2012, the CA utilities expect the second part of J2894 to finalize and the SAE standard may be a good starting point for consideration by CEC to adopt into Title 20, CA's appliance and equipment efficiency standards. The standard would set parameters such as requirements for minimum power factor, maximum total harmonic distortion, and minimum power transfer efficiency.

In the past several years, SAE has also reached a uniform approach to charging connections, centered on the J1772 universal connector standard. The standard covers the general physical, electrical, communication protocol, and performance requirements for conductive charge systems and couplers. In 2009, the standard defined the voltage and current levels for AC Level 1 and 2 charging. Again, because the building standard is only related to circuit provisioning, it does not address the actual connection between EVSE and the EV directly, but continued standardization across the EV and EVSE markets should help accelerate technology adoption and in turn, the usage of any EV charging readiness provisions in new construction. Other standards of note are UL's 2202, which covers safety standards for EV charging equipment, and several recently issued or updated SAE standards, including J2847/1 (Communication between Plug-in Vehicles and the Utility Grid), J2847/2 (Communication Between Plug-in Vehicles and Off-Board DC Chargers), and J2931/1 (Digital Communications for Plug-in Electric Vehicles).

California Legislative Context

Legislative support for transportation electrification is an important driver for plug-in vehicle adoption in California. The state has been aggressive in tackling clean transportation and legislating EV goals, passing several key bills and developing several programs and resources. Table 3 identifies some of California's more important initiatives affecting EV adoption in the State.

Table 3. Major California Clean and Low-Carbon Transportation Initiatives

Assembly Bill 32, the California Global Warming Solutions Act of 2006	Outlines California's major initiatives for reducing climate change and sets the 2020 greenhouse gas emissions reduction goal into law. It directs ARB to begin developing early actions to reduce GHG emissions as well as preparing a scoping plan to reach the 2020 limit.
Assembly Bill 118, the California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007	Provides incentive funding for alternative fuels and advanced vehicle technologies and states that "plug-in hybrid and battery electric vehicles are essential to California's low carbon transportation future." The CEC and ARB coordinate closely in the implementation of the Bill.
Low Carbon Fuel Standard, created by Executive Order S-1-2007, and pursuant to Assembly Bill 32	Calls for a reduction in the carbon intensity of transportation fuels of at least 10% by 2020. The LCFS includes credits for electricity as a low carbon transportation fuel, as discussed previously.
Assembly Bill 1493, the Clean Car Standards, also known as the Pavley Greenhouse Gas Vehicle Standards of 2002	Provides the basis for ARB's regulatory efforts to reduce GHG emissions in new passenger vehicles, including efforts to accelerate the numbers of plug-in and zero-emission vehicles in California. The EPA granted California a federal preemption waiver and the authority and to implement GHG emission reduction standards for new passenger cars and trucks in 2009.
Assembly Bill 1007, the State Alternative Fuels Plan of 2005	Required the CEC to prepare a plan to increase the use of alternative fuels in CA. The plan includes recommendations to increase the use of alternative fuels to 20% of on-road transportation fuel use by 2020 and 30% by 2030.

Public Utilities Commission Proceeding

The CPUC's Alternative Fuel Vehicles Proceeding (Rulemaking 09-08-009), has been taking place in parallel with the IOU C&S building codes effort for EV charging readiness. The proceeding is intended to "develop consistent statewide policies and standards to guide and encourage development of EV metering, home EV charging infrastructure, commercial and public charging infrastructure, tariff schedules, and, if advisable, incentive programs (CPUC 2010)." The Phase 1 Decision "*On Whether a Corporation or Person that Sells Electric Vehicle Charging Services to the Public is a Public Utility*" was passed in August 2009 and concluded that the PUC will not regulate providers of EV charging services as public utilities. The rulemaking was sought to help IOUs prepare for the projected statewide market growth of EVs.

The Phase 2 Decision "*Establishing Policies to Overcome Barriers to Electric Vehicle Deployment"* was passed July 2011, and furthers the CPUC's efforts to evaluate policies to overcome barriers to widespread adoption of EVs (CPUC 2011). Among other things, the decision:

- Affirms the IOUs' existing EV rates, with some exceptions.
- Considers new and lower cost metering technologies for EV charging and sets out a process to develop an EV metering protocol, and does not direct the IOUs to require sub-metering, but determines that if an individual utility customer chooses a sub-metering option to obtain EV rates, that customer bears the cost of the separate meter.

- Determines that, on an interim basis and until June 30, 2013, the costs of any distribution or service facility upgrades necessary to accommodate basic residential EV charging will be treated as shared cost (i.e. are not the responsibility of individual customers).
- Requires utilities to perform load research to inform future CPUC policy.
- Addresses utility ownership of EVSE, ruling against IOUs owning EVSE at customers' facilities.

Local Efforts

It is at the local level that building code provisions pertaining to plug-in vehicle charging readiness will be administered and enforced and some cities are already leading the way. In California, the City of San Francisco's Cleaner Fuels and Vehicles Program has expressed plans to pursue EV charging provisions in single- and multi-family residential as well as hotels and other commercial and municipal building construction, with the stated intent of avoiding expensive retrofit wiring as EV adoption increases (SF Environment 2010). The City of Los Angeles has gone even further, adopting EV charging requirements in the new Green Building article of the Los Angeles Municipal Code, Chapter IX that are more aggressive than those of 2010 CALGreen. For one and two family dwellings, the code now requires a 208/240 volt, 40 amp grounded AC outlet for EV charging, or panel capacity and conduit for the future installation of a 208/240 volt, 40 amp circuit. Similar provisions are included for at least 5% of spaces in parking facilities at townhouses, apartments, and non-residential garages.

Our Vision for the Future of EV Readiness

Plug-in hybrid and fully electric vehicles offer enormous potential to shift towards a lower-carbon transportation future; ensuring homes are EV ready will help us fully realize this future. Equipping new homes with EV charging circuits at the time of new construction can minimize the up-front cost of EV adoption. We envision a future in which all local and state building codes include comprehensive charging readiness provisions. We see the recent developments of residential charging-ready building codes, both at the local level, such as in Los Angeles's new green building code, and at the state level, such as in California's 2010 CALGreen update, as important first steps for increasing plug-in vehicle readiness. The main opportunities going forward are to improve and strengthen these provisions and to encourage the adoption of similar provisions in other localities in the state and other states around the country. This will require an ongoing process to track the effects of adopted codes, to reevaluate and monitor the costs, benefits and technical considerations, and to develop strategies for coordination amongst the many cities and states tasked with building code development.

The 2010 CALGreen revision process that led to Section A4.106.6's voluntary EV readiness requirements was a noteworthy achievement for the state. California's BSC should now track which local jurisdictions are referencing and adopting the new Section A4.106.6 of CALGreen to gauge its influence on building practices and requirements around the state. As cities and states continue to adopt such standards and charging infrastructure subsequently becomes more commonplace in residential new construction, it will be important for local and state agencies and electric utilities to track these developments to quantify impacts and ensure that construction requirements match the needs of present day and future EVs. Factors such as circuit sizing to meet vehicle charging needs, residential load calculations for electric service

panel sizing to accommodate EV charging circuits, and distribution impacts such as transformer loading and upsizing, should be closely monitored. The utilities will also want to continue developing policies and solutions for measuring electricity used for EV charging. The costs associated with EV building code compliance should also be tracked (conduit and conductor installation, service panel upsizing, etc.) and compared to the full cost of retrofitting existing homes with new charging infrastructure so that the economic benefit of EV readiness in new construction can be monitored.

All of this information will feed directly into what we believe is the next key step for building standards development: the strengthening of the voluntary EV readiness requirements. This would involve provisioning fully equipped charging circuits in single family homes and in a percentage of multi-family parking spaces, similar to what the City of Los Angeles requires. This next step may already be underway. In the summer of 2011 HCD announced that the triennial cycle for CALGreen revisions, which will lead to CALGreen 2013, was kicking off. Consistent with the goals we envision for the next step in EV readiness building code, ARB has proposed that for the 2013 CALGreen cycle, the EV charging standards be strengthened, calling for electric service panel capacity reservation (absent from the 2010 amendments) and a Tier II voluntary threshold that would further require a dedicated circuit, breakers, wiring, and receptacle with a safety cover; essentially a completely "EVSE ready" option. Another important step to strengthen the code will be to increase the percentage of parking spaces in multi-family dwellings that are required to be EV ready.

The final goal in building standards development will be a transition from voluntary code language that local jurisdictions choose to adopt, to mandatory statewide requirements for residential EV charging circuits. If more robust voluntary measures are adopted in the 2013 triennial cycle for CALGreen, the next triennial cycle leading up to CALGreen 2016 (effective 2017) may be the appropriate time to transition from voluntary to mandatory measures statewide. Our hope is that other states leading the charge towards EV adoption will follow a similar codes development process in this timeframe.

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