Planning Commission Environment Committee review of the MITRE Corporation's *Electric Vehicle Charging Infrastructure Recommendations to Fairfax County*

October 21, 2015

INTRODUCTION

On July 19, 2011, the MITRE Corporation issued a report entitled "Electric Vehicle Charging Infrastructure Recommendations to Fairfax County." The report was prepared in partial fulfillment of a proffer commitment (RZ 2008-PR-011) to the support of county sustainability initiatives, particularly as they relate to the Tysons Corner Urban Center (referred in this report as "Tysons Corner" or just "Tysons"). The report, which is included as Appendix A to this document, was transmitted to the Board of Supervisors on August 18, 2011 and was referred by the board to the Planning Commission for review and recommendation.

This paper provides an overview of MITRE's report, the Planning Commission Environment Committee's review of the report, and the committee's recommendations in response to the report.

Portions of the background information presented in this report have been excerpted from other documents. The committee in particular thanks the Metropolitan Washington Council of Governments, Virginia Clean Cities and the county staff Environmental Coordinating Committee for their contributions to this report.

The majority of this report was prepared in early 2014, with a draft of the paper issued in April 2014. While there has been some updating in places, the paper largely reflects an April 2014 perspective.

MITRE'S REPORT

MITRE's report focused on the extent to which electric vehicle charging infrastructure should be a consideration in the design of development and redevelopment proposals in Tysons. The report provided an overview of electric vehicle charging technology and electric vehicles available at the time of preparation of the report, projections for adoption of electric vehicles, costs of construction of charging infrastructure and the relationship of potential future electric vehicle charging needs to land uses and commuting patterns associated with Tysons. MITRE presented the following primary recommendations resulting from its research:

1. *The County should strongly encourage developers to include the conduit infrastructure – space, conduit banks, conduit, and access points – for relatively easy and inexpensive installation of charging stations in the future. The County should encourage, but place less emphasis on the full installation of electric vehicle supply equipment (EVSE) – the transformers, switches, wiring, and charging stations*

themselves – at the time of initial construction given the uncertainties surrounding electric charging station demand.

2. *The fraction of parking slots for which the infrastructure should be included should represent a fully plug-in fleet for the groups of users that would use charging infrastructure at the facility. This means all parking spaces for a residential building (single- or multi-family). At commercial and retail facilities, this means the fraction of vehicles that arrive from locations geographically situated to require a charge before the return trip.*

3. *The County can most appropriately seed charging station supply by negotiating for the installation of full charging stations at the lowest expected adoption rate in the near future. Any supply seeding is best done at apartment buildings and should be limited to a maximum of 2% of all parking spaces.*

4. *The County should coordinate with its peer jurisdictions to encourage charging station manufacturers to form a standard defining the connection of the charging station to the facility in which it is installed. The standard should define both the electrical connection and physical mount with the purpose of making it possible to move charging stations to a new facility relatively easily and quickly.*

As stated in its report, MITRE presented these recommendations with an objective *"to prepare Tysons Corner for widespread plug-in adoption, but to do so as inexpensively as possible so as to encourage the desired population and job growth that will sustain Tysons Corner as a livable urban center."*

MITRE emphasized two conclusions that led to its primary recommendations:

1. There is considerable uncertainty regarding how rapidly and completely electric vehicle technology will be embraced by the general public—in MITRE's words, *"no demonstrably accurate estimate of plug-in vehicle market penetration is possible."* This led to MITRE's emphasis on designing sites to allow for the easy future installation of electric vehicle charging stations (identified in this report as "electric vehicle-ready" or "EV ready" design) rather than the provision of charging stations themselves.

2. Owners of electric vehicles will demand and rely on charging opportunities at home, and overnight charging at home will be their preference. Therefore, MITRE proposed a strong emphasis on electric vehicle-ready design for residential development. In Tysons, this would be townhouse and multifamily residential parking facilities with common parking areas.

With respect to recommendation #2, MITRE has recommended "EV-ready" design (see the discussion later in this report) for 100 percent of parking spaces for residential buildings (see conclusion #2 above) and 35 percent of parking spaces for commercial office buildings. The recommended 35 percent figure was developed based on commuting patterns into Tysons (and

again, the focus of the report was Tysons and not the entirety of the county). When the report was prepared, there were two models of electric vehicles widely available—the Chevy Volt and the Nissan Leaf. The Chevy Volt is a plug-in hybrid vehicle with an all-electric range of up to 40 miles. Once the grid-supplied charge has been depleted, a gas-powered engine drives an onboard generator to continue supplying electricity to operate the vehicle. The Nissan Leaf is a fully-electric vehicle; the MITRE report states that this vehicle has "a nominal range of 100 miles, although some estimates place a more realistic expected range at 80 miles."

MITRE evaluated commuting patterns into Tysons and cited information indicating that roughly 65 percent of inbound commuters into Tysons originate their trips from less than 20 driving miles from the middle of Tysons. Inside the 20-mile perimeter, a Chevy Volt would theoretically be able to make a round trip into and from Tysons using a grid-supplied charge without needing a charge during the day. Beyond the 20 mile range, the Volt would need at least some extent of charging to be able to be driven back to its origin without relying on the backup gas power. MITRE therefore recommended that this fraction of spaces (35 percent) be designed to be EV-ready for office buildings in Tysons. MITRE did not offer a similar recommendation for retail uses, suggesting that retail developers would have enough incentive to provide charging stations in order to attract customers. However, MITRE suggested a similar approach (determining the percent of trips from beyond 20 miles) if a specific threshold was determined to be needed. For hotels, MITRE recommended "that the county work with hotels in the region to determine need, with the need for conduit installation being primarily defined by the rental car population in a hotel's garage."

In addition to the four primary recommendations above, MITRE also recommended that the county maintain its current process for permitting electrical installations and that the county collect data to better characterize commuting patterns of the county's work population, electric vehicle registrations and use patterns for charging stations as they are installed (e.g., who uses them; when they're used; on what sorts of vehicles).

PLANNING COMMISSION ENVIRONMENT COMMITTEE REVIEW

The Planning Commission's Environment Committee met 12 times between January 10, 2013 and the April 10, 2014 issuance of the first discussion draft of this white paper to discuss MITRE's recommendations and their relationship to the county's land use policy. The committee has met five times on this issue between then and the date of this draft (May 12, 2015). While the MITRE report focused on Tysons, the committee's review was countywide in scope. There was a particular emphasis on the extent to which the policy concepts identified in MITRE's recommendations should be incorporated within Comprehensive Plan policy and implemented through the county's zoning process.

The Environment Committee began its review with a presentation from Matt Olson (MITRE's primary author of the report), who provided an overview of the report and its recommendations.

The committee then received a presentation from Kambiz Agazi, Fairfax County's Environmental Coordinator, who discussed electric vehicle-related efforts that have been pursued regionally at the Metropolitan Washington Council of Governments. Dr. Agazi highlighted the efforts of two electric-vehicle workgroups that were formed by COG (EV Infrastructure Planning and EV Policy and Processes), noting that the latter workgroup had considered permitting, inspections, requirements under the Americans with Disabilities Act, comprehensive plan policy and zoning considerations. He reviewed key findings and priority recommendations from a COG report on electric vehicles,[1] highlighting a recommendation that comprehensive plans and zoning ordinances/regulations should guide electric vehicle infrastructure development and ensure that the built environment can accommodate future electric vehicle supply equipment installations. It is the committee's intent to offer recommendations that would serve to implement this recommendation in Fairfax County.

The committee then heard from representatives of three companies that supply electric vehicle charging stations: Stephen Schey (Director, Infrastructure Planning and Analysis, ECOtality, Inc.[2]), Scott Miller (Vice President, Sales, North America East, ChargePoint), and Michael Krauthamer (Director, Mid-Atlantic Region, eVgo). Each of the presenters: (1) gave an overview of his company's efforts to provide, and model for providing, electric vehicle charging facilities; (2) provided information and perspectives regarding adoption of electric vehicle technology and the related demand for charging infrastructure; and (3) provided his thoughts regarding the MITRE report and its recommendations, along with the role of local government land use policy in addressing electric vehicle charging issues. In addition, Jeffrey Saxe (Kimley-Horn and Associates, representing eVgo) discussed zoning considerations associated with the design of an eVgo facility that had been developed within a shopping center parking lot in Centreville.

While the committee was considering the information provided by the above presenters, staff from the Department of Planning and Zoning was considering zoning questions associated with electric vehicle charging facilities. In particular, the aforementioned eVgo facility in Centreville generated questions and concerns regarding the circumstances under which electric vehicle charging facilities should be considered to be principal, auto-oriented uses as opposed to permitted accessory uses serving other principal uses. On July 12, 2013, DPZ staff issued "Applicable Zoning Provisions for Electric Vehicle Charging Stations," which provided detailed guidance on the conditions that would need to be met for a charging station to be deemed to be an accessory use. Lorrie Kirst, Deputy Zoning Administrator, reviewed this guidance with the committee. This document is included as Appendix B.

The Environment Committee thanks each of the above presenters for his/her presentation and his/her assistance.

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[1] Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

[2] In October 2013, ECOtality, Inc. filed for bankruptcy; its network of charging stations (the Blink network) was subsequently acquired by Car Charging Group, Inc.

Based on the MITRE report, the presentations described above, committee discussions and related issues identified by staff, the committee prepared a list of policy questions covering the scope of issues that the committee felt it should consider as it prepares recommendations for consideration by the full Planning Commission and Board of Supervisors. The list of policy questions, as circulated to stakeholders on July 26, 2013 (with two questions added subsequently during the public review process), is provided below.

Electric Vehicle Charging Equipment—
Policy questions for consideration by the Planning Commission Environment Committee

1. Should the Comprehensive Plan be amended to support the provision of electric vehicle charging stations and/or EV-ready design? (If yes, proceed to #2; if no, proceed to #12 (or perhaps even #17)
2. How should the Plan consider EV charging? Through countywide policy in the Policy Plan? Through Area Plan guidance? Through both?
3. What should be the area(s) of focus of a countywide policy in the Policy Plan? **3.1 Should there be a focus be on the provision of electric vehicle charging stations? If so, to what extent?** **3.2 Should there be a focus on EV-ready design (provision of space, conduit banks, conduit and access points)? If so, to what extent?**
4. If recommendations for the provision of EV charging stations and/or EV-ready design are to be incorporated into the Plan, to what extent should such efforts be pursued?
5. If recommendations are developed for only portions of parking lots to be provided with electric vehicle charging stations and/or EV-ready design, what should those proportions be?
6. If recommendations are developed for EV charging stations at office sites, is there a need to ensure that users will have access to chargers specifically designated for their use?
7. If Area Plan guidance is desired, within which sections of the Area Plans should this guidance be provided, and what should be the nature of this guidance?
8. If Comprehensive Plan policy regarding EV charging stations is developed, should it include any particular design guidance?
9. Should any particular model for the provision of EV charging stations be favored over any other? If so, would this need to be articulated in Plan policy?
10. Is it within our purview to consider whether providers of subscription-based EV charging should be asked to allow for charging by non-subscribers (for a fee)?
11. Should there be any concern regarding locations of EV charging stations (or EV-ready design) within parking lots, or should the owner/operator of a parking lot/use have full discretion to make such decisions?

Electric Vehicle Charging Equipment—
Policy questions for consideration by the Planning Commission Environment Committee
(continued)

12. Zoning questions/issues: Should the Zoning Ordinance be amended to facilitate the location of electric vehicle charging stations?
13. The MITRE Corporation recommended that Fairfax County coordinate with its peer jurisdictions to encourage the development of a standard for the connection of EV charging stations (both in terms of the electrical connection and physical mount) in order to improve the portability of charging stations. Is this of concern from a county policy standpoint? If so, what guidance should be incorporated into the Plan?
14. Are there any needs for county data collection?
15. Two of our presenters have recommended a consideration of incentives; one focused on incentives for commercial/business owners (e.g., letting owners know about a 30% federal tax credit against all costs [note that this credit expired at the end of 2013]; establishing a county tax incentive). Another presenter suggested assistance for building retrofitting and wiring. Is this within the purview of our discussion? If so, how should this be considered?
16. One of our presenters has recommended consideration of publicly-accessible charging stations at county facilities; this would send a message of support for this technology. Is this within our purview to consider? If there is any sort of subsidized public charging, would it have an adverse effect on the private market?
17. Is there a concern about the use of electricity for EV charging during peak hours? If so, is there an ability to promote the cutting off of charging during peak hours?
18. Is there a need for further public input prior to completion of the committee's review? If so, what form should this take?
19. How should the committee's recommendation(s) be forwarded to the Planning Commission and ultimately the Board of Supervisors?
20. Should there be a policy to remove charging stations if the technology becomes outdated?*
21. Is there a way to permit a limited number of EV charging stations as a pilot project on an existing development? I think the Planning Commission's discussion would benefit from some practicing examples in the county. If a high demand for permits occurs, then the PC and Board could consider more comprehensive planning and zoning amendments.*

*Questions 20 and 21 were not on the initial list of policy questions but were identified during the course of public review of the initial 19 questions.

The committee provided an opportunity for any interested party to comment on the list of policy questions. On August 1, 2013 and again on September 10, 2013, staff from the Department of Planning and Zoning circulated the draft list of policy questions to its stakeholder contact list (roughly 200 individuals, including representatives from the development industry, environmental community, Environmental Quality Advisory Council, architectural/design/consulting firms, Board of Supervisors staffs, citizen committees [including district land use committees], electric utilities, electric vehicle charging infrastructure suppliers and federal, state. regional and county agency staff), asking for recipients' thoughts as to whether there were additional issues that ought to be considered by the committee as well as any information or perspectives the recipient may have that may assist the committee in its review. The committee received written responses to this request from the Apartment and Office Building Association of Metropolitan Washington and the McLean Citizens Association Planning and Zoning Committee. In addition, staff identified less formal guidance that it had received through the course of the review, whether or not this guidance was offered in direct response to the policy questions. While the input received in response to these questions is not summarized here, it was considered carefully by the committee. The committee's reviews and recommendations in response to these questions are discussed later within this report.

In order to ensure that a broader range of perspectives could be considered in its review, the committee circulated to the stakeholder group a discussion draft of this white paper and held a workshop at which any interested party could, in an informal setting, discuss his/her perspectives and/or concerns with the committee. This workshop was held on May 8, 2014, and the committee met several times to discuss issues that were identified at the workshop. This paper has been revised, where applicable, per those discussions. The committee thanks workshop participants for their interest and assistance in providing their perspectives on the issues addressed within this report.

BACKGROUND ON ELECTRIC VEHICLES AND ELECTRIC VEHICLE CHARGING

Overview

Considerable detail on electric vehicles and electric vehicle charging (also referred to as "Electric Vehicle Supply Equipment") has been provided in other documents. Because of this, an exhaustive review is not provided here. The following documents are suggested for those who are interested in more comprehensive guidance on electric vehicle technology:

- Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

- Virginia Clean Cities, Virginia Get Ready: Initial Electric Vehicle Plan, October 13, 2010. http://www.virginiaev.org/wp-content/uploads/2010/11/EV-VGR-FINAL-October-13-2010.pdf

- New York State Energy Research and Development Authority and Transportation and Climate Initiative, Siting and Design Guidelines for Electric Vehicle Supply Equipment, November 2012. http://www.transportationandclimate.org/sites/default/files/EV_Siting_and_Design_Guidelines.pdf

- Ready, Set, Charge, California: A Guide to EV-Ready Communities, November 2011. http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf

- U.S. Department of Energy, Alternative Fuels Data Center, electricity website, http://www.afdc.energy.gov/fuels/electricity.html.

The following paragraph has been taken from a county staff summary from the FY 2014 Environmental Improvement Program[3]:

> *Plug-in vehicles are highway cars, trucks and buses that use electrical grid energy. A purely electric vehicle (EV) charges its storage device, usually a large battery pack, from the grid to power an electric motor, which moves the vehicle. A plug-in hybrid electric vehicle (PHEV) does the same, but also has another, onboard power source, usually a gas or diesel engine, that drives an onboard generator to continue supplying electricity once the grid-supplied charge has been depleted. This engine may or may not also provide power to the wheels. The grid energy takes the place of petroleum fuel that a similar, conventional vehicle would use, either substantially (PHEV) or completely (EV).*

Hybrid electric vehicles are powered by a combination of on-board batteries and internal combustion engines. They are not recharged by plugging into the electrical grid and are therefore not discussed further within this report.

There are several different types of charging systems for plug-in vehicles. These systems are summarized in numerous documents; the italicized text below has been taken from the Metropolitan Washington Council of Governments report noted above[4]:

> *Different types of charging equipment are now available, and charging performance will likely continue to improve. At home, EV drivers can charge their vehicles using a standard 120 V outlet, or if faster charging is desired, they can install special charging equipment, generally referred to as electric vehicle supply equipment (EVSE). Charging*

[3] Fairfax County Environmental Coordinating Committee, Environmental Improvement Program, Fiscal Year 2014, fact sheet for EIP14-AQ12-01(B): Local and Regional Preparation for Commercially Available Plug-in Vehicles, September 2012, http://www.fairfaxcounty.gov/living/environment/eip/fy2014-eip/fy2014-eip-complete-report.pdf

[4] Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

time can range from 30 minutes to 20 or more hours, depending on a number of factors, including current, battery capacity and chemistry, and the battery's state of charge. Three main EVSE classes are available today—Level 1, Level 2, and DC fast charge. Level 3 charging is not yet available to consumers. All four classes of charging equipment are described below.

Level 1 Charging. *Level 1 EVSE uses a cord similar to a household extension cord to provide charging. On one end is a three-prong, 120-volt AC plug, and on the other is a J1772 standard connector to connect with the vehicle. Level 1 charging is typically used in residential settings when a higher-voltage circuit is not available or is not desired.* [Note: Higher voltage is available in homes but may not be accessible to the desired charging site without the assistance of an electrician.] *It is generally the preferred charging method for PHEVs. Level 1 charging can also be an economic and effective solution for any nonresidential location that wishes to make EV charging infrastructure available. Level 1 charging is particularly effective at locations where EV owners will park for long periods of time, such as the workplace. Level 1 charging is also well-suited to any location that wants to offer EV owners the ability to "top off" their batteries. Level 1 cordsets are typically included with the vehicle purchase and simply require access to a standard 120-volt outlet. The charging rate is generally two to five miles of range per hour of charging.*

Level 2 Charging. *Rather than using a standard plug, Level 2 EVSE requires installation of hardwired home charging or public charging equipment. It requires a 240-volt AC plug and a dedicated 40-amp circuit. Level 2 charging also uses a J1772 connector to connect to the vehicle. This equipment charges a typical EV battery overnight, and because most homes have 240-volt service available* [it is needed for electric dryers and ranges], *Level 2 charging is expected to become the predominant residential charging method for BEVs* [battery electric vehicles]. *It is also common at public charging stations. The charging rate is approximately 10 to 20 miles of range per hour of charging.*

Level 3 Charging. *This charging type is still in development but is expected to provide a faster AC charging option at public stations. It would operate at a higher voltage and current than Level 2 EVSE. Level 3 charging is expected to deliver a full charge in less than 30 minutes.*

DC Fast Charging. *Direct-current (DC) fast charging uses a 480-volt connection to provide 50kW or more to EV batteries. It provides a nearly full charge in less than 30 minutes, enabling charging along heavy traffic corridors and at public charging stations. The first generation of DC fast chargers primarily uses the CHAdeMO connectors, produced in Japan. However, in May 2012 the International Society of Automotive Engineers (SAE) developed a new plug design as the standard for American and European models. The new design, called DC Fast Charging with a Combined Charging System, offers a single port that is compatible with existing Level 1 and 2 plugs.*

A summary of the various levels of charging, again taken from the COG report (which in turn was developed using information from the Alternative Fuels Data Center), is provided below:

Electric Vehicle Supply Equipment Options

	Current Type	Amperage (amps)	Voltage (V)	Kilowatts (kW)	Charging Time (for fully depleted battery)	Primary Use
Level 1	Alternating current (AC)	Up to 15 amps	120V	Up to 1.8 kW	6 to 20 hours	Residential charging
Level 2	AC	Up to 80 amps	240V	Up to 19.2 kW	3 to 8 hours	Residential and public charging
Level 3 (in development)	AC	To be determined	To be determined	To be determined	Under 30 minutes	Public charging
DC Fast Charging	Direct current (DC)	Up to 200 amps	480V	50 to 150 kW	Under 30 minutes	Public charging

Source: Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

As noted earlier, the MITRE Corporation's recommendations were based in part on a strong preference of owners of electric vehicles to charge their vehicles at home. It is estimated that approximately 75 percent or more (and perhaps well over 75 percent) of all charging occurs at home (nearly all single family homes), with much of the charging occurring overnight. Charging at offices and other locations is secondary to home charging yet remains an important component of the charging environment—in its presentation to the committee, ChargePoint identified workplace charging as "the number two application and growing rapidly." [5,6,7,8] Demand for overnight charging is particularly noteworthy where "time-of-use" electricity rate structures incentivize such charging.[9,10,11]

[5] May 9, 2013 presentation to the Planning Commission Environment Committee from Scott Miller, Vice President, North America East, ChargePoint
[6] New York State Energy Research and Development Authority and Transportation and Climate Initiative, Siting and Design Guidelines for Electric Vehicle Supply Equipment, November 2012. http://www.transportationandclimate.org/sites/default/files/EV_Siting_and_Design_Guidelines.pdf
[7] May 2, 2013 presentation to the Planning Commission Environment Committee from Stephen Schey, Director, Infrastructure Planning and Analysis, ECOtality, Inc.
[8] The EV Project, quarterly reports as accessed from http://www.theevproject.com/cms-assets/documents/127233-901153.q2-2013-rpt.pdf
[9] May 2, 2013 ECOtality, Inc. presentation

There are several mechanisms through which charging stations have been and are being provided. The U.S. Department of Energy, in an effort to stimulate the electric vehicle market, embarked on a project ("the EV Project") to provide over 13,000 charging stations in select regions across the country, including 8,000 residential charging stations free of charge (along with a portion of the installation costs) to electric vehicle owners in exchange for their participation in data collection efforts. Additional charging stations were installed at publicly-accessible privately-owned locations, where owners of electric vehicles could charge their vehicles for a fee.[12]

Many providers of electric vehicle supply equipment sell their charging stations and associated software directly to customers and install and operate these stations as part of their public charging networks; the customers retain ownership of the equipment and can decide whether or not to offer charging for free or how much to charge for the use of their stations. A number of firms employ this approach and maintain networks of charging stations—there is, therefore, concern about whether an electric vehicle owner with an access card for one particular network would be unable to access other networks. There are efforts under way to enhance interoperability among networks so that the owner of an electric vehicle can access stations from any of a number of networks (much like a bank card from one particular institution can be used at automatic teller machines operated by other institutions).[13]

For the approach noted above, fees can be charged based on time spent connected to a charging station or based on energy used. A third model is a subscription-based model through which owners of electric vehicles can pay a subscription fee in exchange for installation of charging stations at their homes and/or access to a network of charging stations.[14] One of the electric vehicle charging equipment providers that presented to the committee (eVgo) operates on this model—for a monthly subscription fee, a charging station is provided at the subscriber's home, and the subscriber has access to the firm's network of DC fast chargers at retail outlets, where they can get a free and quick (15-30 minutes) charge. Access to these chargers is limited to subscribers.[15]

It is also noteworthy that charging stations are not the only model for operation of electric vehicles. At least one firm (Tesla Motors) has publicized rapid exchanges of depleted batteries for fully charged batteries for one of its models of electric vehicles; for Tesla Motors, battery exchange is intended to be a supplement to the lengthier charging process, which is also being made available to owners of Tesla's vehicles. It is not known how well this technology will be

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[10] The EV Project, quarterly reports.
[11] The EV Project, How do PEV owners respond to time-of-use rates while charging EV Project vehicles? July, 2013. http://www.theevproject.com/cms-assets/documents/125348-714937.pev-driver.pdf
[12] May 2, 2013 ECOtality, Inc. presentation.
[13] Personal communications from Coleen Quinn, Vice President, Government Market Development and Public Policy, ChargePoint, to Noel Kaplan, Department of Planning and Zoning, February 13, 2013
[14] ECOtality North America, Electric Vehicle Public Charging—Time vs. Energy, March 2013. (http://www.theevproject.com/cms-assets/documents/106078-254667.tvse.pdf)
[15] May 9, 2013 presentation to the Planning Commission Environment Committee from Michael Krauthamer, Director, Mid-Atlantic Region, eVgo.

embraced by customers or the extent to which, if any, a network of service stations offering rapid battery exchanges will be established to enable broader application of this concept.
In its presentation to the Environment Committee, ECOtality provided an overview of data that have been collected through the EV Project in regard to electric vehicle owner driving and charging patterns. ECOtality reported that, in late 2012, owners of Chevy Volts (a plug-in hybrid vehicle with an all-electric range of about 40 miles) drove these vehicles an average of 40.5 miles each day, with an average trip distance of 8.1 miles and an average distance between charging of 28.2 miles, while owners of Nissan Leafs (an all-electric vehicle with a range of about 100 miles) drove their cars an average of 29.2 miles per day, with an average trip distance of 6.9 miles and an average distance between charging of 26.3 miles.[16]

Adoption of Electric Vehicle Technology

The Electric Drive Transportation Association reports that, as of the end of February, 2015, cumulative United States sales of plug in electric vehicles (including plug in hybrids) were nearly 300,000, with over 118,000 sold in 2014. The market share of plug-in electric vehicle sales in 2014 was 0.72 percent, up from a market share of 0.62 percent in 2013, 0.37 percent in 2012 and 0.14 percent in 2011.[17] In addition, there has been a substantial increase in the number of electric vehicle models available. The U.S. Department of Energy's Alternative Fuels Data Center identified 14 models of all-electric or plug-in hybrid light duty vehicles for model year 2013 and 23 such models for model year 2014 (compared with only four for model year 2011).[18] An article prepared by the director of CleanTechnica identified 32 models of all-electric or plug-in hybrid vehicles, 21 of which were available for sale in the United States as of December 31, 2014 (with more anticipated in 2015). The models available for sale in the United States ranged in price (not considering a federal tax credit) from $22,995 to $135,700.[19] Baum and Associates identified 21 models of plug-in hybrids and battery electric vehicles introduced in the U.S. market in or prior to 2013, with an additional 20 models anticipated for calendar years 2014 and 2015.[20]

In its presentation to the Environment Committee, ChargePoint, citing Polk Research, identified 330 registered electric vehicles (including plug-in hybrids) in Fairfax County as of January 2013. By comparison, there were 5,873 such registrations in Los Angeles County, California, 3,246 in Santa Clara County, California, 3,226 in Orange County, California and lesser but substantial numbers in San Diego County, California and King County, Washington. According to ChargePoint, again citing Polk Research, the number of registered electric vehicles in Fairfax County increased to 596 as of December 2013, which was over 32 percent of the 1,856 electric

[16] May 2, 2013 ECOtality, Inc. presentation
[17] Electric Drive Transportation Association website, http://electricdrive.org/index.php?display=GeneralSearch&action=AddSearchTermAction&searchstring=sales+2014 viewed March 12, 2015
[18] Alternative Fuels Data Center Hybrid and Plug-In Electric Vehicles website, viewed December 26, 2013, http://www.afdc.energy.gov/vehicles/electric.html
[19] http://evobsession.com/electric-cars-2014-list/
[20] Alan Baum, Baum and Associates, Electric Vehicle Market Summary, May 2014.

vehicles registered state-wide at that time.[21] As of December 2014, there were a total of 1,196 registered electric vehicles in the county (again based on information from Polk Research), which was just over double the number from one year earlier. The proportion of electric vehicles registered in Fairfax County compared to state-wide registrations remained fairly constant, at just under 33 percent (1,196 county-registered electric vehicles vs. 3,628 EVs state-wide).[22]

The Metropolitan Washington Council of Governments has reported that, as of June 2012, there were 497 electric vehicle registrations in the Washington, D.C. region.[23] According to ChargePoint, there were nearly that many in Montgomery County, Maryland alone as of January 2013 (478). Clearly, the rate of adoption of this technology in the region is increasing substantially. While COG has noted that "it is difficult to predict exactly how many EVs that will be operating in the region in coming years," COG has provided the following guidance:

> *Using the most conservative estimate of regional EV adoption by 2015-2020, if EVs experience a 600% increase in five years—mirroring the rate of adoption of hybrids—the region could have 1,500 to 3,000 EVs operating on the roadways (up from the current number of approximately 500 vehicles). As a high estimate, if total EV sales in the next eight to 10 years reach fleet levels comparable to current levels of hybrids, the region could see anywhere from 50,000 to 75,000 EVs operating on the roadways by 2020.*

The COG report also displayed EV sales projections of between 15,000 and 30,000 electric vehicles by 2015, using a model from the Electric Power Research Institute.[24]

With respect to projections of future purchases of electric vehicles, the MITRE report summarized three sets of projections and stated the following: *"The various studies estimate PHEVs to represent anywhere between 2 and 20% of 2020 sales, with estimates diverging dramatically afterwards. The point of showing the disparity between (and even within each of) the studies is to demonstrate the difficulty—if not impossibility—of Fairfax generating an estimate of plug-in vehicle adoption good enough to proceed with large scale installation of charging infrastructure."*

The Environment Committee is aware of projections that have been cited in other publications:

- A document prepared by the Association of Bay Area Governments and a number of partner organizations cited 10 studies identifying sales projections of plug-in vehicles

[21] E-mails from Scott Miller, ChargePoint, to Noel Kaplan, Fairfax County Department of Planning and Zoning, April 27 and April 28, 2014.
[22] E-mails from Scott Miller, ChargePoint, to Noel Kaplan, Fairfax County Department of Planning and Zoning, April 22, 2015.
[23] Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)
[24] Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

(one specific to California and the others either national or global in scale). Of the five studies identifying projections for adoption within the United States, projections ranged from just over three percent of the 2020 market share to over 12% of the 2020 market share. The document stated the following: *"Typically, the low-range estimates assume that PEVs* [plug-in electric vehicles] *will continue to command a significant initial price premium, that governments will limit subsidies, and that gas price increases will be moderate. The high penetration scenario assumes significant consumer interest, rapid PEV cost reductions, significant government subsidies, and a major increase in gasoline prices"*[25]

- A report prepared by the City of Sunnyvale, California in November 2011 stated the following: *"Projections for the number of electric vehicles that will be on the road by 2020 in the United States vary widely and range from 1.8% to 3.3%, with one study forecasting over 6%."* The report included a table listing five studies with U.S. electric car sales projections for the year 2020 (with only limited overlap with the previous study cited), with market share projections (electric car sales as a percentage of total car sales) ranging from 5% to 18%. The high forecast assumed *"a low purchasing price and operating cost of electric vehicles, a battery leasing program, high oil prices, subsidy program, and significantly improved infrastructure to extend the range of electric vehicles.*"[26]

More recent perusals of websites by county staff suggest that adoption of EV technology may not be proceeding as rapidly as the more ambitious projections noted above. The U.S. Energy Information Administration, for example, projects that plug-in hybrid and electric vehicle sales will each only represent one percent of new vehicle sales in 2040.[27] An October 23, 2014 press release from Navigant Research states that plug-in electric vehicles are expected to comprise 2.4 percent of global light-duty vehicle sales by 2023.[28] The Electric Vehicle Transportation Center projects that, in 2023, based on an assumed annual growth rate ranging from 10 percent to 35 percent, U.S. sales of plug-in electric vehicles will be anywhere between 251,000 and 1,944,000 in the year 2023 (for purposes of comparison, total U.S. auto sales reached 15.6 million vehicles in 2013).[29] Baum and Associates has stated:

"While the growth in full electrics and plug ins is strong in terms of percentage change, the overall volume is not large. Future growth depends on increasing regulatory requirements (which are in place), trends in fuel prices, technology improvement, and the

[25] Ready, Set, Charge California, November 2011, http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf
[26] City of Sunnyvale, California, Amendment of the Building Code (Title 16) to Require Electric Car Chargers in New Residential Developments—Study Issue, Report to Mayor and Council No: 11-258, November 29, 2011 Council Meeting, http://sunnyvale.ca.gov/Portals/0/Sunnyvale/CouncilReports/2011/11-258.pdf.
[27] U.S. Energy Information Administration, Annual Energy Outlook 2014 Early Release Overview
[28] http://www.navigantresearch.com/newsroom/plug-in-electric-vehicles-are-expected-to-make-up-2-4-percent-of-global-light-duty-vehicle-sales-by-2023
[29] http://www.nydailynews.com/autos/auto-sales-reach-six-year-high-demand-peaked-article-1.1567645

> *related cost reduction as volume increases. While there will be growth in the near-term, the biggest impact is likely to be in 2020 and beyond."*

The report from Baum and Associates projects "robust" growth over the longer term and cites regulatory requirements for stricter mileage and emissions. [30]

While there are articles available on the Web that suggest adoption rates as high as 80 percent by 2030 or 2050,[31,32] one of the studies referenced on these websites dates from 2007 and appears to reflect more of an exercise in defining a high scenario for testing of greenhouse gas emissions implications than a prediction of future conditions.[33] The other study dates from 2009 and identifies three market scenarios, including two assuming high oil prices, with one of those two assuming subsidies from charging network operators—market share forecasts ranged from 64 percent to 86 percent. This study assumed that the electric vehicles would have removable, rechargeable batteries with 100-mile ranges, with a network of charging stations and battery switching stations.[34]

It has not been either the committee's intent or county staff's intent to provide an exhaustive study of electric vehicle market projections or to endorse or cast doubt either on low or high projections. This effort does, though, highlight the uncertainty of this issue and the difficulty in planning now for an uncertain future.

Costs

There are a number of factors affecting the cost of provision of an electric vehicle charging station. The installation cost of a particular type of charging station can vary considerably based on site-specific circumstances such as the need for trenching within a parking lot, the need for an engineered site plan, the need for upgrades to electrical panels, the number of charging stations being provided at one time (there could be economies of scale) and the distance between the electrical supply and the charging station. There are also cost differences among the types of chargers—both Virginia Clean Cities and the Electric Transportation Engineering Corporation, for example, identified the cost of "generic installation of two publicly available Level 2 charging stations when the two charging stations are located side-by-side" (facing each other) at between $15,000 and $18,000, while the cost of a similarly situated pair of DC Fast Chargers would be in the $65,000 to $70,000 range. For a simple single family residential installation of a Level 2 charger, these sources identified costs between $2,000 and $2,500, recognizing that a number of factors could cause these costs to vary. Virginia Clean Cities provided a similar caveat for a multifamily residential setting but identified estimated costs between $833 per

[30] Alan Baum, Baum and Associates, Electric Vehicle Market Summary, May 2014.
[31] http://www.designnews.com/author.asp?doc_id=270926&dfpPParams=ind_184,industry_auto,industry_alt,bid_318,aid_270926&dfpLayout=blog
[32] http://thetartan.org/2013/11/18/scitech/ev
[33] Electric Power Research Institute, Environmental Assessment of Plug-in Hybrid Electric Vehicles, Volume 1: Nationwide Greenhouse Gas Emissions, Final Report, July 2007.
[34] Center for Entrepreneurship & Technology, University of California, Berkeley, Electric Vehicles in the United States: A New Model with Forecasts to 2030, August 24, 2009.

charger for Level 1 and $1,520 per charger for Level 2 charging stations (for installation of five stations). ECOtality identified an average residential installation cost of $1,375, noting a wide range of averages among regions participating in the EV Project.[35,36,37] For an installation in a typical single family house with a garage in Fairfax County, there would already be a plug available for Level 1 charging, but Level 2 charging would require electrical work—to install a Level 2 plug, there would be a permit cost ($90 as of the date of preparation of this report) plus the cost for the electrician who would install the outlet.

Staff from the City of Sunnyvale, California identified the cost of a Level 2 charging unit at $1,800 to $2,200 and the cost of DC Fast Charger (identified as a "Level 3" charger in the city's report) as $20,000+.[38] Staff from the Fairfax County Department of Vehicle Services has estimated, for future charging stations for fleet use at county facilities, a typical equipment cost per Level 2 charging station at about $2,500-$3,000 per unit plus typical site preparation and installation costs of about $3,000-$3,500 per station, recognizing that installation costs will vary from site to site depending on a range of factors and that the installation of multiple charging stations at any one site would likely reduce the per-unit site preparation/installation costs.[39]

Virginia Clean Cities recognizes the significance of site-specific cost factors as follows:

> *"Because design and requirements of publicly available charging stations will vary significantly, costs can also vary within a wide range, depending on how much infrastructure work needs to be done to support the chargers (trenching, construction, concrete work, electric upgrades, etc.). Costs of EVSE installation can be reduced with strategic locating near electric service infrastructure, as well as planning for limited trenching in outdoor installations. Advanced planning, such as pre-installing conduit during parking lot refurbishment, can avoid costs of installing the conduit later."*[40]

A number of localities that have established policies or requirements relating to electric vehicle charging infrastructure (see the discussion later in this report, as well as Appendix C) have focused on what the committee has seen as being referred to as "electric vehicle-ready design," "EV-ready design" or "pre-wiring." Through this approach, electric vehicle charging stations themselves would not be provided, but sites would be constructed in a manner that would

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[35] Virginia Clean Cities, Virginia Get Ready: Initial Electric Vehicle Plan, October 13, 2010, http://www.virginiaev.org/wp-content/uploads/2010/11/EV-VGR-FINAL-October-13-2010.pdf

[36] Electric Transportation Engineering Corporation, Electric Vehicle Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene, April 2010. http://www.theevproject.com/downloads/documents/Electric%20Vehicle%20Charging%20Infrastructure%20Deployment%20Guidelines%20Oregon%2015%20Metro%20Areas%20Ver%203.2.pdf

[37] May 2, 2013 ECOtality, Inc. presentation.

[38] City of Sunnyvale, California, Amendment of the Building Code (Title 16) to Require Electric Car Chargers in New Residential Developments—Study Issue, Report to Mayor and Council No: 11-258, November 29, 2011 Council Meeting, http://sunnyvale.ca.gov/Portals/0/Sunnyvale/CouncilReports/2011/11-258.pdf.

[39] Personal communications from Dave DuVal, Department of Vehicle Services, to Noel Kaplan, Department of Planning and Zoning, July 5, 2011.

[40] Virginia Clean Cities, Virginia Get Ready: Initial Electric Vehicle Plan, October 13, 2010, http://www.virginiaev.org/wp-content/uploads/2010/11/EV-VGR-FINAL-October-13-2010.pdf

provide for easy, inexpensive retrofits of charging stations in the future. While different localities have pursued differing extents of efforts to cause sites to be EV-ready, this could include the provision of capacity within electrical rooms and panels to support the eventual installation of charging stations, the provision of conduit connecting the electrical rooms with the future charging station sites, and the provision of access at these sites to allow for the installation of charging stations and associated wiring. An alternative to the provision of electrical capacity could be the assurance that electrical rooms would be sized with sufficient physical space to allow for the future installation of electrical capacity needed to serve future electric vehicle chargers but that the capacity not be provided during initial construction. This is the approach to EV-readiness that the MITRE Corporation has recommended (with the implicit assumption that the electrical distribution system would be sized for the ultimate level of capacity that would be provided). Localities that have established EV-ready requirements have typically required installation of the electrical capacity to support the requisite number or percentage of EV-ready parking spaces. However, this is not the only available approach, and the approach suggested by MITRE would appear to have the benefit of encouraging a higher percentage of EV-ready parking spaces than might otherwise be pursued if the provision of electrical capacity was to be part of the initial effort.

The EV-ready approach recognizes that there is considerable uncertainty regarding the rate of adoption of this new technology and that costs of preparing sites for the eventual installation of charging stations will be lower for new construction than for retrofits of electrical systems and/or conduit within existing developed sites.

In support of establishment of EV-ready design requirements, the City of Sunnyvale, California provided estimates of wiring costs for charging stations for new construction and for existing buildings, based on surveys of three local electrical contractors. For single family detached and townhouse residential development, the city estimated costs of up to $800 per station for wiring during new construction; for the provision of wiring to existing buildings, the city estimated per station costs between $1,000 and $1,200 for single family detached dwelling units and $1,000 to $1,500 for townhouses. The city did not provide a per station cost estimate for service to existing multifamily residences but did estimate a total cost of wiring of $7,000-$10,000 for a cluster of up to six charging stations for a multifamily residential construction project. The city's report stated that, in light of a number of factors creating variability in costs for such wiring, "it is not realistic to provide general estimates for this type of work, but it is safe to estimate it would be several thousand dollars."

As presented earlier in this document, MITRE's first recommendation focused on the EV-ready concept. In support of this approach, MITRE offered estimates of additional per-space costs of conduit installation for electric vehicle charging stations during initial site construction and as retrofits to existing developed sites. For surface lots, MITRE estimated a $1,800 per space cost for conduit construction during initial construction, as opposed to a $2,900 per space cost for retrofits. The estimated costs for conduit installation in garages were considerably lower (due to the ability to attach conduit to the ceilings or walls of a garage, compared with the need to bury conduit beneath the surface parking lot) but still reflected a substantial difference between initial construction ($400 per space) and retrofits ($1,200 per space).

In its response to the list of policy questions, the Apartment and Office Building Association identified an estimated cost of $3,500 per unit of electric vehicle infrastructure equipment.

In testimony presented to support New York City's electric vehicle-ready requirements, a representative of ChargePoint provided the following cost information[41]:

- Typical cost for installation of a charging station on a wall with surface conduit, assuming sufficient available amperage in the electrical panel: $1,000.
- Typical cost for installation of a residential charging station (again assuming availability of sufficient electrical capacity): $700-$1,200.
- Average cost for a workplace charging port installed in an open parking lot: $7,000, of which $6,000 is related to trenching or boring. Adding ChargePoint's $3,350 list price for a dual-port charging station, the total cost of installation would be $10,350 for a retrofit with trenching, compared to $4,350 for a retrofit on a site with conduit already installed.

Permitting

County permitting processes accommodate both residential and commercial installations of charging stations. An electrical permit is required if a new circuit in the panel is being installed to accommodate the charging equipment. The process for a residential installation involves a single-use electrical permit obtained the same day. The commercial installation process can involve a single trade permit and be a fast-track plan review but does require design plans from a contractor. The electrical permitting fee for a residential or commercial charging station is, as of the date of preparation of this report, $90. Electrical permits can be obtained online (see www.fairfaxcounty.gov/fido) or in person at the permit application center on the second floor of the Herrity Building, 12055 Government Center Parkway, Fairfax, VA 22035.

Stand-alone charging stations might require a building permit, sign permit and site plans that would increase the cost and time. A building permit may be necessary if a new concrete pad is being installed as a foundation for the equipment. Normal inspection procedures will apply to charging station installations.

Potential Impacts to the Electric Grid

The Metropolitan Washington Council of Governments has reported: *"With significant penetration of EVs still years away, EV charging load is not anticipated to have significant effects on generation and transmission infrastructure."* However, COG has also reported that the clustering of electric vehicle charging within neighborhoods *"is a current concern for electrical utilities, and infrastructure planning must be undertaken to prevent service disruption."* COG has reported that this is not a concern for Level 1 charging (i.e., an owner

[41] ChargePoint, Inc., Testimony Before the Joint Buildings and Transportation Committee [New York City], November 12, 2013.

plugging his or her vehicle into a standard 120 volt outlet) but would be a concern for Level 2 charging.[42]

The phenomenon of neighborhood clustering has been documented in a report prepared as part of the EV Project.[43] That report notes that the visibility of an electric vehicle in one person's driveway may cause neighbors to also consider the purchase of electric vehicles, resulting in possible concentrations of electric vehicles within small areas. These concentrations may have implications to transformers serving more than one house. The report confirmed that such clusters have become evident among participants in the EV Project.

With respect to the broader implications of EV charging on the grid, and particularly whether there may be peak hour impacts, COG has reported the following:

> *The potential for EV charging to impact the electrical grid at the generation and transmission level depends highly on the size of the charging load and its timing relative to daily and seasonal electrical demand. On the one hand, adding large amounts of EV charging load to the grid at times of already high demand can amplify peak load and stress the electrical grid. As EV adoption increases significantly, unmanaged EV charging, particularly in the afternoon hours on the hottest summer days, could cause congestion that leads to brownouts or blackouts. However, increasingly stringent appliance efficiency standards and building codes will significantly reduce the likelihood of this occurring.*
>
> *On the other hand, if EV charging is conducted at off-peak times, such as overnight, it could have the beneficial effect of evening out the load curve, called valley filling. This allows generating facilities to run more consistently, thereby providing more efficient and less costly electrical power.*
>
> *While generation and transmission infrastructure impacts are not a significant current concern for utilities, this issue must be monitored to prevent future negative grid impacts. Other federal, state, and local policies related to appliance energy efficiency standards and building efficiency codes will help counter the effect of increasing EV loads. The EV Project, a partnership between the U.S. Department of Energy, ECOtality North America, and a number of corporate, nonprofit, and local government stakeholders, is helping fulfill this role in Washington, DC, and a number of states across the country."*[44]

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[42] Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

[43] ECOtality North America, "What Clustering Effects have been Seen by the EV Project?", August 2013 (http://www.theevproject.com/cms-assets/documents/126876-663065.clustering.pdf)

[44] Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

Another report prepared as part of the EV Project notes that "time-of-use" rate structures can have a significant effect on charging behavior of owners of electric vehicles, in that typical home Level 2 chargers allow a user to program starting and stopping times for charging, making it easy for an owner to charge his or her vehicle when the electricity rates are most advantageous. The EV Project report concluded that time-of-use rate structures are effective in influencing charging behavior and can therefore be effective in addressing peak hour electricity use concerns, and this was also noted in ECOtality's presentation to the committee.[45,46] While such rate structures could potentially aggravate clustering impacts at the neighborhood scale,[47] they can also benefit the grid by utilizing overnight generation capacity that might not otherwise be used.

COG has noted that DC Fast Charging is not being used for residential charging (because of high voltage and amperage levels) but that this type of charging in nonresidential settings would have greater potential than Level 2 charging to impact utility infrastructure. COG has recommended that utilities be made aware of specific deployment plans for DC fast charging infrastructure.[48]

Benefits

During the course of its review, the committee has been advised of a range of benefits of electric vehicles, including the following:[49,50,51,52,53,54,55,56]

- Reduced fueling costs and comparable total costs compared with internal combustion engine vehicles.

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[45] ECOtality North America and Idaho National Laboratory, "How do PEV owners respond to time-of-use rates while charging EV Project vehicles?", July 2013 (http://www.theevproject.com/cms-assets/documents/125348-714937.pev-driver.pdf)
[46] May 2, 2013 ECOtality presentation
[47] ECOtality North America, "What Clustering Effects have been Seen by the EV Project?", August 2013 (http://www.theevproject.com/cms-assets/documents/126876-663065.clustering.pdf)
[48] MWCOG, October 2012 (see earlier reference)
[49] May 9, 2013 ChargePoint presentation.
[50] May 9, 2013 eVgo presentation.
[51] Anair, Don and Amine Mahmassani, State of Charge, Union of Concerned Scientists, June 2012. http://www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf
[52] The EV Project, Lessons Learned—The EV Project Greenhouse Gas (GHG) Avoidance and Cost Reduction, July 2012. http://www.theevproject.com/cms-assets/documents/106077-891082.ghg.pdf
[53] U.S. Department of Energy, U.S. Environmental Protection Agency, Fuel Economy Guide, Model Year 2014 (Updated January 7, 2014) (http://www.fueleconomy.gov/feg/pdfs/guides/FEG2014.pdf)
[54] Virginia Clean Cities, Virginia Get Ready: Initial Electric Vehicle Plan, October 13, 2010, http://www.virginiaev.org/wp-content/uploads/2010/11/EV-VGR-FINAL-October-13-2010.pdf
[55] Elgowainy, A., J. Han, L. Poch, M. Wang, A. Vyas, M. Mahalik and A. Rousseau, Argonne National Laboratory, Well-to-Wheels Analysis of Energy Use and Greenhouse Gas Emissions of Plug-In Hybrid Vehicles, June 2010, http://www.ipd.anl.gov/anlpubs/2010/06/67242.pdf
[56] U.S. Environmental Protection Agency, Application of Life-Cycle Assessment to Nanoscale Technology: Lithium-Ion Batteries for Electric Vehicles, April 24, 2013, http://www.epa.gov/dfe/pubs/projects/lbnp/final-li-ion-battery-lca-report.pdf

- Lower operational costs compared with internal combustion engine vehicles.

- Improved fuel economy compared with internal combustion engine vehicles.

- Improved energy independence/security associated with the lack of consumption of petroleum (for all electric vehicles) or reduced consumption of petroleum (for hybrid-electric vehicles).

- Elimination of direct tailpipe emissions.

- Ability to charge overnight, resulting in the use of base loads that would be generated by power plants whether or not electric vehicles were being charged.

- Reduced emissions of greenhouse gases and most air pollutants. It is important to note that, while electric vehicles produce no tailpipe emissions, they do have emissions impacts relating to the generation of the electrical energy that charges their batteries. Greenhouse gas emissions associated with electric vehicles will, therefore, depend on the source of energy that powers the grid (recognizing that the overnight charging referenced in the previous bullet could result in the use of electricity that would have been generated whether or not the electric vehicle was being charged). In most regions of the country (including the northeast and mid-Atlantic areas), "well to wheel" analyses of greenhouse gas emissions, considering natural resource extraction, transport, conversion to energy, transmission losses and tailpipe emissions, indicate that electric vehicles compare favorably in regard to greenhouse gas emissions with internal combustion engine vehicles.

A Consideration of Endorsement and Accommodation

There has also been recognition among committee members that there may be differing perspectives about the benefits that have been identified for electric vehicles, and much remains unknown about the extent to which this new technology will be embraced by the general public and the extent to which there will be long-term future demand for charging infrastructure.

On balance, the committee sees much to recommend with electric vehicle technology and that the pursuit of commitments to the provision of electric vehicle supply equipment and/or EV-ready design would be a worthy effort within the broader context of green building policy implementation. However, even if a less supportive perspective was to be taken, the committee would see a need for countywide policy that would recognize the emergence of this technology and that would support efforts to accommodate the future charging demands it may create. During its deliberations, committee members frequently heard the "chicken and egg" analogy when discussing adoption of electric vehicle technology and provision of charging stations. Electric vehicles have a very different fueling model from other motorized vehicles, and the lack of preparation for electric vehicle charging may, in itself, create an impediment to the adoption of this technology. In addition, the lack of a policy regarding electric vehicle charging may insufficiently serve those members of the public who choose to embrace this technology.

The committee notes the need to serve the public through the allowance and approval of petroleum fueling stations even though there are many concerns our petroleum-based fueling system generates. Again, it is the view of the committee that electric vehicle technology merits endorsement, but even if others do not share this view, the committee would see a need to position county policy such that future demands for charging infrastructure could be accommodated. The committee therefore recommends policy direction on this issue, whether or not there is a broader endorsement of electric vehicle technology.

CURRENT POLICY, EXPERIENCES AND POLICY DIRECTION

Prior to July 1, 2014, the Comprehensive Plan did not include guidance directly addressing electric vehicles or electric vehicle supply equipment. However, Objective 13 of the Environment section of the Policy Plan, along with Policy a under that objective, broadly supported energy efficiency and conservation:

> ***Objective 13: Design and construct buildings and associated landscapes to use energy and water resources efficiently and to minimize short- and long-term negative impacts on the environment and building occupants.***
>
> > *Policy a. Consistent with other Policy Plan objectives, encourage the application of energy conservation, water conservation and other green building practices in the design and construction of new development and redevelopment projects.*[57]

On July 1, 2014, as part of a broader Comprehensive Plan amendment updating the county's green building policy, the Board of Supervisors adopted a new policy (Policy g) under Objective 13 that reads as follows:

> *Encourage provision of or readiness for charging stations and related infrastructure for electric vehicles within new development and redevelopment proposals, particularly for residential where other opportunities are not available.*

Area Plan guidance for the Tysons Corner Urban Center includes support for a broad range of environmentally-sustainable development practices and recommends that redevelopment projects in Tysons "incorporate design elements and practices that will reduce the use of energy and water resources."[58] While the provision of electric vehicle charging stations or EV-ready design is not identified explicitly in the list of examples that follow, county staff has suggested such efforts in negotiations with applicants for zoning approvals in Tysons. In addition, in recognition of the conceptual and final development plan phases of the zoning process for applications pursuing rezoning to the PTC (Planned Tysons Corner Urban District) zone, staff has suggested

[57] Fairfax County Comprehensive Plan, 2013 Edition, Policy Plan volume, Environment section. http://www.fairfaxcounty.gov/dpz/comprehensiveplan/policyplan/environment.pdf
[58] Fairfax County Comprehensive Plan, 2013 Edition, Area II Plan, Tysons Corner Urban Center. http://www.fairfaxcounty.gov/dpz/comprehensiveplan/area2/tysons1.pdf

to applicants that they consider commitments for their conceptual development plans that would require, during the final development plan stage, the assessment of the feasibility and costs that would be associated with EV-ready design. A number of such commitments (one linked to the building permit process rather than final development plan) have been received. Additional commitments have been received for the provision of at least one pair of charging stations within each section of the development project along with at least some extent of EV-ready design to facilitate additional charging stations in the future.

POLICIES AND REQUIREMENTS OF OTHER LOCALITIES

As part of its review of issues raised by the MITRE Corporation's report, the Environment Committee has considered requirements and guidelines for the provision of electric vehicle charging stations and/or EV-Ready design that have been applied in other jurisdictions in the United States (along with Vancouver, British Columbia). County staff has compiled a summary of these requirements and guidelines (as well as a model ordinance from a task force in Georgia), which is current through March 2014 (except for the entry for Montgomery County, Maryland, which has been updated in light of the county's more recently-adopted requirement) and which is included as Appendix C. In compiling this summary, staff has received direct guidance from staffs of many of the jurisdictions identified in the summary (county staff has interviewed representatives from 13 other localities). This has helped staff better understand the context and intent behind the requirements and guidelines. Localities that have provided direct guidance to staff are identified within the summary.

Staff has stressed to the committee that this summary remains a work in progress—staff strongly suspects, based on its experiences during its research, that there are localities it is not yet aware of that have requirements and/or guidelines pertaining to electric vehicle charging. Staff also has not updated this list (except for Montgomery County, Maryland), and it therefore should be recognized that there may be additional localities that have established guidelines or requirements since staff's research was conducted (or that there may have been changes to the guidelines/requirements that have been reported). That being recognized, there is a sufficient amount of information in this summary to highlight a number of key findings:

- Perhaps the most notable finding is that there do not appear to be many localities that have such requirements or guidelines. While it is possible, if not likely, that there are additional jurisdictions with electric vehicle charging-related requirements and/or guidelines, it is not anticipated that the number of such jurisdictions would be substantial, and even if the number of jurisdictions in the summary was to double, it would still indicate that only a small percentage of localities have addressed this issue. The vast majority of localities nationwide have no requirements or guidelines.

- It will be particularly difficult to identify localities that may lack any formal requirements or guidelines but that pursue commitments from developers on a less formal basis. The City of Mountain View, California provides a good example, and, based on staff's

conversations with representatives from other localities, there are likely to be a number of others. Fairfax County falls into this category at this time.

- Most of the localities with requirements or guidelines are located in California, and there are two concentrations of such localities: The San Francisco Bay area and the Los Angeles area. This is, perhaps, not surprising given that U.S. electric vehicle registrations are highest in these areas.[59]

- Most of the localities that have established requirements require EV-ready design, for Level 2 chargers, for all single family residences.

- For common residential parking and nonresidential parking, the percentages of parking spaces subject to the local guidelines and requirements are far less than the percentages recommended for residential and office development in Tysons in the MITRE Corporation report. However, it should be recognized that electrical capacity to support these percentages is generally being required, while MITRE has recommended that there simply be sufficient space in electrical rooms to accommodate the future electrification of parking. It should also be noted that one locality surveyed (Seattle, Washington) does not require the installation of conduit.

- While MITRE has recommended an EV-ready design for all parking spaces for multifamily residential buildings in Tysons, no other locality has applied a figure higher than 20%, although the City of Vancouver, British Columbia requires that electrical rooms of multifamily buildings have sufficient space to allow for future EV charging for all parking spaces (currently tied to Level 1 charging).

- Most of the localities focus their requirements/guidance on EV-ready design rather than the provision of charging stations, although there are some exceptions.

- County staff has interviewed staff from 13 other localities, and none based their requirements/guidance for shared residential and/or nonresidential parking lots on the type of analysis that MITRE performed to develop its recommendations for Tysons. Several of the locality representatives who were interviewed by county staff indicated that projections for future EV demand did factor implicitly (and in at least one case explicitly) into their requirements or recommendations, and short-term (e.g., 5-10 year) projections were generally considered. Other localities referenced state or regional guidelines or the design efforts that would be needed to gain a credit under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) rating systems. One locality based its EV ready requirement for common residential parking areas on technical considerations associated with parking lift systems, which are prevalent in that locality.

[59] May 9, 2013 ChargePoint presentation

- Two of the locality representatives who were interviewed by county staff expressed concern that electric vehicle technology may ultimately be a transitional technology to another form of alternately fueled vehicle. In particular, hydrogen fuel cell vehicles were cited as a technology that may, in the long term, capture a substantial portion of future vehicle sales. While there appear to be many challenges associated with this technology,[60] it was cited by both interviewees as potentially limiting, in the long-term, the potential sales of electric vehicles. One interviewee indicated that hydrogen vehicles would have the advantage of being more in line with current refueling habits of the American public than would electric vehicles; he also expressed concern with the potential for building into a building's electrical system more capacity than would ultimately be needed.

- Other locality representatives cautioned against pursuit of overly aggressive EV-ready targets in light of uncertainty about future adoption rates of electric vehicle technology. These representatives have noted the challenge in trying to be proactive in setting the stage for accommodation of future demands while not requiring infrastructure that will never be used.

- Two of the locality representatives (one in the San Francisco Bay area and one in the Detroit, Michigan area) stressed the willingness of developers in their localities to provide electric vehicle charging and/or EV-ready design, as these measures are considered to be relatively inexpensive. One representative stated that, based on his experiences with negotiations, "you don't need to demand" commitments; "just ask nicely."

COMMITTEE RECOMMENDATIONS

The committee's recommendations are presented in reference to the policy questions identified earlier in this report. Questions 18 and 19 are not addressed here, as they focus on the committee's internal review process.

It is noted that the scope of many of the policy questions extends beyond Comprehensive Plan policy and its implementation through the zoning process. As the MITRE report focused largely on matters relating to Comprehensive Plan policy (i.e., what the county should encourage developers to provide in regard to electric vehicle charging infrastructure), the committee has chosen to focus its recommendations on Plan policy-related matters. However, there are a number of issues for which the committee has recognized a desire for follow-up consideration, and these are noted within the discussions below.

Key committee recommendations as they relate to Comprehensive Plan policy are highlighted in bold type. At the end of this section of the report, these recommendations are summarized, and a list of recommended follow-up considerations is provided.

[60] http://en.wikipedia.org/wiki/Hydrogen_cars

General Comprehensive Plan Guidance (Policy Questions 1 through 5 and 7)

1. Should the Comprehensive Plan be amended to support the provision of electric vehicle charging stations and/or EV-ready design?
2. How should the Plan consider EV charging? Through countywide policy in the Policy Plan? Through Area Plan guidance? Through both?
3. What should be the area(s) of focus of a countywide policy in the Policy Plan? **3.1 Should there be a focus be on the provision of electric vehicle charging stations? If so, to what extent?** **3.2 Should there be a focus on EV-ready design (provision of space, conduit banks, conduit and access points)? If so, to what extent?**
4. If recommendations for the provision of EV charging stations and/or EV-ready design are to be incorporated into the Plan, to what extent should such efforts be pursued?
5. If recommendations are developed for only portions of parking lots to be provided with electric vehicle charging stations and/or EV-ready design, what should those proportions be?
7. If Area Plan guidance is desired, within which sections of the Area Plans should this guidance be provided, and what should be the nature of this guidance?

Policy Questions 1 and 2: Should the Plan be amended? If so, should the Plan guidance be countywide or area-specific?

It is the view of the Environment Committee that, while **there is a clear need to address electric vehicle charging within the Comprehensive Plan, this has already been accomplished through general guidance adopted on July 1, 2014 as part of a broader Plan amendment addressing the county's green building policy.** There is now explicit, albeit general, guidance in the Plan addressing this issue, and the committee views this language as being sufficient to position county policy to accommodate future demands for charging infrastructure. Given the evolving nature of electric vehicle technology and uncertainties regarding how rapidly this technology will be embraced by the car-buying public, the committee cautions against amending the current policy guidance to add more specificity; the breadth of the current language is sufficient to ensure its adaptability to changing conditions. The committee also does not consider there to be a compelling reason to limit policy guidance to one or more specific areas through a focus on Area Plan guidance; nor is it the committee's perspective that there is information that would, at this time, suggest a need for differing policy guidance among different areas within the county. **The committee supports the recently-adopted guidance and does not see a need to augment that with new Plan text.**

Policy Question 3: Should Plan policy focus on the provision of electric vehicle charging stations or on electric vehicle-ready design?

It is the committee's view that, at this time, Plan policy should support the provision of electric vehicle charging stations but that, in light of considerable uncertainties regarding how this new technology will be embraced and adopted by the general public, a focus on EV-ready design, as recommended by MITRE, would be appropriate. Further, with respect to Plan policy, the committee agrees with MITRE's emphasis on electric vehicle charging efforts for residential uses. It is the committee's view that the Plan text adopted on July 1, 2014 satisfies the need for policy guidance supporting EV-ready design and an emphasis on residential charging. Owners of electric vehicles will want to charge their vehicles at home, and the lack of residential charging opportunities would serve as an impediment to adoption of this technology. Further, if common residential parking areas and electrical rooms in associated buildings would not be designed to facilitate at least some level of easy retrofitting for electric vehicle charging stations, and if electric vehicle technology was to be embraced broadly by the public, owners of these parking areas and electrical systems (which may be townhouse and/or condominium homeowners associations) would be faced with the expense and inconvenience of potentially costly and disruptive retrofits in order to satisfy the demand for charging in those parking areas. The committee agrees with MITRE that it would be better to prepare for this potential demand proactively when sites are developed.

While the committee supports MITRE's suggested emphasis on residential charging opportunities, the committee also sees benefit in providing such opportunities in parking lots and garages associated with transit stations, as there will likely be a demand for charging in such facilities, particularly for vehicles with limited electric ranges. The committee also supports EV-ready design for office and other nonresidential uses but considers nonresidential charging opportunities to be secondary in importance to residential charging opportunities. That being said, the committee anticipates that demand for charging could be greater at hotels than at other nonresidential uses—owners of electric vehicles and drivers of electric rental vehicles who stay at hotels will likely want to charge their vehicles overnight during their stays. It may, therefore, be appropriate to place greater emphasis on negotiation for commitments to EV-ready design for hotel parking facilities than for other nonresidential uses. The committee does not feel, though, that specific Plan text emphasizing transit stations or hotels would be appropriate at this time in light of uncertainties associated with adoption of electric vehicle technology.

A considerable challenge regards the extent to which charging stations should be provided and the extent to which developing sites should be designed to facilitate future retrofits of charging stations when the demand for such stations rises. Insufficient planning could lead to the burdens on homeowners/condominium associations/parking facility owners. Yet overdesigning these sites with more electric vehicle chargers or EV-ready design that would be needed would add needless expense at the time of development. As discussed earlier, the rapidly changing nature of electric vehicle technology and uncertainty regarding rates of adoption of this technology suggest to the committee that any policy guidance that is adopted in the Comprehensive Plan should be general in nature and adaptable to changing circumstances.

In light of the above discussion, **the committee sees considerable merit in retaining the existing general Plan guidance, recognizing that, as experiences are gained over time, refinements can be pursued. At this time, it is the committee's view that the existing Plan text providing general support for this technology is appropriate, and any more specific guidance regarding implementation of this policy should, at least at this time, be pursued through either guidance documents such as this one and/or prototype proffer guidance that can be provided to zoning applicants for their consideration. The current Plan guidance is broad and general enough to be adaptable to changing circumstances, while emphasizing the need for charging opportunities on residential sites. There should be occasional reviews and reports by the committee (or other Planning Commission entity) that would serve to refine these suggestions as EV technology and adoption develop.**

In light of charging times associated with the various levels of charging, the committee recommends that there be an emphasis on EV-ready design for Level 2 charging; Level 1 chargers would not be sufficient to provide full overnight charging in many cases. The committee recommends, however, against specifying this detail within Plan policy, as this sort of detail would be best addressed through case-by-case negotiation and it is not the committee's intent to preclude consideration of any particular level of charging.

The suggested implementation approaches should be offered to zoning applicants for their consideration for incorporation within their proffer packages or within development conditions that would be agreeable to the applicants. **Prototype proffers/development conditions should be prepared that can be offered to applicants for their consideration. The committee stresses its view that such prototypes should not be viewed as expectations; rather, EV-related commitments that are pursued by applicants should instead be evaluated more broadly as components of overall proffer/development condition packages.**

Policy Questions 4 and 5: To what extent should the provision of charging stations and/or EV-ready design be pursued? What proportions of parking facilities should be covered?

As noted above, the committee supports, at this time, MITRE's recommendation for an emphasis on electric vehicle-ready design, although the committee would certainly welcome commitments from applicants to the provision of charging stations, particularly for residential development proposals. **It is not clear, though, that any particular percentage of "seeding" of charging station supply would be appropriate.** Further, in regard to extent of EV-readiness, the committee does not at this time support the percentages recommended by MITRE for application in Tysons (100 percent for residential parking and 35 percent for office buildings) as they relate to the provision of conduit, in light of MITRE's assumption of a fully plug-in fleet and the requirements and guidance from the limited number of localities that have them, all of which are well below the MITRE recommendations.

There is no easy answer to the question regarding what percentage of any particular parking area should be designed to be electric vehicle-ready. The requirements/guidelines of the localities identified as having them range from one to 20 percent for common residential parking areas

(and, in one case, 100 percent for the sizing of electrical rooms) with generally lower levels for nonresidential parking.

One approach may be to consider electric vehicle charging efforts that would be integrated with broader commitments to green building design. Through this approach, the percentage of parking spaces that would be provided with charging stations (or that would be designed to be EV-ready) would meet or exceed the threshold(s) needed to gain credit under the green building rating system that would be pursued for that proposal. For several of the rating systems under the U.S. Green Building Council's LEED® v4, for example, electric vehicle chargers at Level 2 or greater would need to be provided for at least two percent of all parking spaces (along with a minimum percentage of preferential parking for energy-efficient vehicles) to satisfy one of the options for the "Green Vehicles" credit. [61] If the green building rating system being pursued would not have any credits relating to electric vehicle charging stations or EV-ready design, the LEED threshold (or perhaps a higher percentage for EV-ready design) could be suggested.

A benefit of the approach outlined above is that it would support and be integrated within an applicant's broader green building effort. A drawback is that, at least for LEED, there would be no differentiation between residential and nonresidential projects. It would also focus on the provision of charging stations rather than EV-ready design, and there may be more benefit to a more aggressive EV-ready design effort with fewer (or no) charging stations up front. Finally, the percentage identified by LEED is toward the low end of the range of requirements/guidelines that have been applied by other localities.

It is the view of the committee that a linkage to applicable green building rating systems for EV-ready design (in regard to provision of conduit and sizing of the electrical distribution system —see the discussion below regarding the sizing of electrical rooms) could be suggested as a starting point for discussion for office and other nonresidential proposals but that more ambitious suggested thresholds would be appropriate for residential proposals and mixed use proposals with residential components. **The committee also recommends that more ambitious efforts be pursued for parking facilities associated with hotels and with transit opportunities (e.g., parking near Metrorail stations, Virginia Rail Express stations and bus transit, such as park-and-ride lots. It is also the committee's view that any suggested starting points for discussion should not necessarily be the end points—the committee would like the county to promote this technology proactively and not simply pursue a least-common-denominator approach when negotiating proffer commitments with zoning applicants. To that end, the county should encourage, on a case-by-case basis, EV-ready design efforts beyond what may be linked to a particular green building rating system (e.g., two percent coverage), recognizing that flexibility will be needed in all negotiations.**

The committee sees a need for more substantial efforts for residential development proposals, particularly for proposals incorporating common parking areas. The committee has discussed one possible approach that would link the percentage of EV-readiness to the high end of the range of guidelines and requirements established by other localities—that is, 20 percent of the

[61] http://www.usgbc.org/node/2613735?return=/credits/new-construction/v4

total parking capacity, and a previous draft of this white paper suggested such an approach, based on the high end of the range of short-term electric vehicle sales projections. There has, though, been some concern expressed during the committee's more recent discussions that this level of effort may not be supportable by more recent information suggesting that earlier projections of electric vehicle adoption rates of up to 20 percent may not be realistic, at least in the short term. Conversely, there is also a perspective among committee members that establishing lower EV-readiness targets based on current concerns about short-term adoption rates may be limiting in terms of the longer-term potential for this technology, and that setting a low threshold as a starting point for discussion would result in only limited commitments to EV-ready design that could fall short in meeting future demands.

An alternative approach that was discussed by the committee (that could be applied to both residential and nonresidential projects) recognized that there may be a considerable amount of time that passes between zoning approval and building construction and occupancy. In light of the "moving target" nature of the concern about appropriate levels of EV-readiness, it was suggested that, rather than committing to a specific percentage of EV-readiness, applicants could commit to the performance of surveys closer to the time of building occupancy to gauge the demand for EV-readiness in parking facility design. Challenges to this approach would include: an applicant's ability to conduct a meaningful, accurate survey; the ability to consider future conditions and not just the rates of EV adoption at the time of the survey; the parameters that staff would use to determine the sufficiency of any such survey; staff resources that would need to be available for reviews of surveys; the potential for disputes between applicants and staff in regard to survey results and recommendations; the need to ensure that parking facility design would incorporate the results of the surveys; and appropriate development process triggers (e.g., site plan approval vs. building plan approval).

The challenges associated with the survey concept suggest that this approach should not be identified as a preferred approach. However, the establishment through proffers or development conditions of more specific targets may also be problematic in light of the uncertainties noted above. It is the view of the committee, therefore, that a hybrid approach should be suggested through which relatively high thresholds of EV-ready design could be applied, along with considerable flexibility in proffer or development condition language to reduce these thresholds based on surveys conducted closer to the time of construction. Further, the committee sees merit in engaging each applicant, during the zoning process, in a discussion about EV-ready design that would lead to the tailoring of case-specific commitments that could accommodate flexibility in the future, and such discussions may result in hybrid approaches to dealing with this question.

In light of the above considerations, the committee recommends that prototype proffers be developed that would apply this hybrid approach. For residential zoning proposals and mixed use proposals with residential components where other charging opportunities would not be available, an initial threshold target for EV-readiness (in regard to the provision of conduit and sizing of the electrical distribution system —see the discussion below regarding the sizing of electrical rooms) of 10 percent of parking capacity could be incorporated within this prototype. While not as aggressive as the 20 percent threshold that had currently been discussed by the committee, a 10 percent threshold would still be

much greater than the current rate of EV sales and would therefore be sufficient to accommodate considerable growth into the future; the committee recommends that this threshold be revisited periodically and revised in the future as may be appropriate.

For nonresidential applications, an initial target for EV-readiness of between two and five percent could be incorporated into the prototype, with the higher end of this range applied to parking facilities associated with hotels and with transit opportunities.

The committee recommends that this prototype be provided to applicants as a starting point for discussion and that staff engage each applicant in a discussion that would ensure that the applicant would give due consideration to his/her receptivity to EV-ready design. The committee again stresses that, in offering the suggested thresholds in the EV-readiness prototype proffer language, that particular level of service would be a starting point for a discussion that would, ideally, lead to a commitment that would be tailored to the needs and circumstances associated with each application.

Under any of the approaches above, the provision of conduit (and, by extension, the sizing of the electrical distribution system) would not be as extensive as the levels that MITRE has recommended. However, there may be merit in pursuing MITRE's more aggressive approach to the sizing of electrical rooms to ensure that, if future EV charging demands were to be substantial, the capacity of a site to accommodate these demands would not be limited by the inability of an electrical room to accommodate additional electrical capacity. The MITRE Corporation has recommended that electrical rooms for residential buildings in Tysons be sized to allow for future electrification of all parking spaces and that, for office buildings, EV-readiness be pursued for 35 percent of the parking capacity. **The committee agrees with MITRE's conclusion that there is a particular need for EV-ready design for residential buildings and therefore would support efforts to ensure that electrical rooms would be large enough to support the possible full electrification of residential parking lots. However, the committee recommends that considerable flexibility be applied to this question**; **the county should welcome alternative ideas as may be presented by applicants, particularly if reasonable concerns arise regarding possible unintended consequences and/or costs of this idea.**

With respect to the sizing of electrical rooms in office buildings, the committee questions the applicability of the 35 percent threshold identified by the MITRE Corporation in light of the fact that this threshold was based on Tysons-specific commuting assumptions, an assumption of full electrification of the vehicle fleet and the all-electric range of one model of hybrid-electric vehicle (the Chevy Volt). The committee sees a lesser need for specific thresholds in light of charging patterns (people will want to charge their cars primarily at home) and in light of lesser thresholds that have been established in other communities. **The committee therefore recommends that the question of a specific threshold for office buildings (and for other nonresidential buildings) be left open at this time and that applicants be asked to identify specific thresholds within the commitments they prepare through the zoning process. This question could be revisited in the future based on experiences in pursuing such**

commitments and any further guidance that may be available in the future regarding rates of electric vehicle adoption and demand for workplace charging.

With respect to the sizing of electrical rooms for other uses (e.g., retail, institutional, hotels), the committee recommends a similarly open approach at this time: staff should, in most, if not all, cases, encourage applicants to include commitments to at least some extent of EV-ready design, but no particular minimum thresholds for sizing of electrical rooms should be pursued at this time. The committee recommends that this issue be revisited in a few years after experiences have been gained regarding adoption of EV technology, market-driven efforts to supply charging equipment (or EV-readiness) in these settings and proffer negotiations.

Regardless of what threshold(s) of EV-ready design is/are suggested at this time, the committee sees a need for periodic evaluations of commitments that have been received as well as data regarding electric vehicle registrations in Fairfax County and regional and national trends in adoption of this technology. These evaluations could lead to adjustments in suggestions regarding the desired minimum levels of EV-ready design.

The committee recommends that the electric vehicle charging policy issue be revisited in several years in order to learn from experiences and adjust the informal guidance that will have been applied based on these experiences and industry projections available at that time.

Site Design Considerations (Policy Questions 6, 8 and 11)

6. If recommendations are developed for EV charging stations at office sites, is there a need to ensure that users will have access to chargers specifically designated for their use?
8. If Comprehensive Plan policy regarding EV charging stations is developed, should it include any particular design guidance?
11. Should there be any concern regarding locations of EV charging stations (or EV-ready design) within parking lots, or should the owner/operator of a parking lot/use have full discretion to make such decisions?

Question #6 recognizes that employees who rely on charging at their offices will want to have assurance that they'll have access to charging stations while they're working. While this is a legitimate concern, **the committee's view is that it would be best to leave this question up to the employer/parking lot operator rather than to specify how a charging station at an office should be used.** As experiences with such charging stations are gained, this question could, perhaps, be reconsidered.

Question #8 was raised in recognition that, for unsheltered parking areas, there may be a desire among owners of electric vehicles to have charging stations designed with canopies that would

serve to protect people from rain and snow while they're plugging their cars into the stations. This generated a broader question as to whether Comprehensive Plan policy should be concerned with the design of charging stations. During the course of the committee's review, the Department of Planning and Zoning developed "Applicable Zoning Provisions for Electric Vehicle Charging Stations." This document identifies a series of conditions that would need to be met for a charging station to be considered as a permitted accessory use rather than a principal auto-oriented use. Included in these conditions are design considerations, including a condition that, for a charging station located in a parking lot or the top level of a parking structure that is open to the sky, there be no canopy or any type of roofed structure (in light of implications relating to visual impacts). **In the committee's view, there may be a desire for further discussion regarding the design-related conditions of this zoning guidance (see question #12). However, the committee does not view this as a Comprehensive Plan issue.**

For question #11, **it is the committee's view that the parking lot owner/operator should generally have discretion to locate charging stations on their sites as they see appropriate**. If there are locational concerns, they would best be considered on a case-by-case basis during the zoning process, considering the site-specific context. There may be benefits and drawbacks on any particular site to locating electric vehicle charging spaces near, or far from, building entrances, and construction cost issues (costs are generally lower where charging stations are located near electrical supplies) add to this complexity. The committee does not view this as a question for which Comprehensive Plan guidance would be appropriate at this time.

Models of Provision of Charging (Questions 9 and 10)

9. Should any particular model for the provision of EV charging stations be favored over any other? If so, would this need to be articulated in Plan policy?
10. Is it within our purview to consider whether providers of subscription-based EV charging should be asked to allow for charging by non-subscribers (for a fee)?

As noted earlier in this report, there are several models for the provision of electric vehicle charging. While one approach would be to allow access to a charging station for anyone to use (with payment as determined by the station owner), another approach would limit access to a charging station either for one or more specified users or to subscribers.

It is the view of the committee that, in light of the relative infancy of electric vehicle charging, **it would be premature for the county to endorse any one model of electric vehicle charging over another,** recognizing that there may be implications of the various models to zoning determinations (e.g., when a charging station would be considered to be an ancillary use as opposed to a primary use). **The committee also does not view the role of the Comprehensive Plan to either specify models of charging or to suggest levels of access to charging stations.**

Zoning Issues (Question 12)

12. Zoning questions/issues: Should the Zoning Ordinance be amended to facilitate the location of electric vehicle charging stations?

As noted earlier, during the committee's review, the committee discussed zoning considerations with staff from the Department of Planning and Zoning. DPZ has prepared "Applicable Zoning Provisions for Electric Vehicle Charging Stations" that identifies a series of conditions that would need to be met for a charging station to be considered as a permitted accessory use rather than a principal auto-oriented use. This document is included as Appendix B to this report.

The committee appreciates staff's recognition of the need for zoning guidelines and its response to the zoning-related questions that were generated by a case-specific circumstance. However, it is the committee's view that the provisions affecting a determination as to whether a charging station would be a permitted accessory use or a principal auto-oriented use warrant further discussion. There is clearly a need to distinguish between accessory uses and principal uses, and care is needed to ensure that appropriate boundaries are defined that provide reasonable protections while facilitating this technology. In addition to the question of accessory vs. principal use, there is a need to consider the relationship of EV parking spaces to overall minimum parking requirements (i.e., should an EV space count towards the minimum parking requirement or not?) Staff is also aware of concerns about a provision in the aforementioned "Zoning Provisions" that indicates that Non-Residential Use Permits are required for all proposed charging stations. The committee therefore sees a need for a more direct consideration of electric vehicle charging within the Zoning Ordinance and recommends, as a follow-up action, the identification of this issue on the Zoning Ordinance Amendment Work Program. The committee sees some level of urgency to this question and recommends that this Zoning Ordinance review be pursued sooner rather than later.

While the committee sees a need to consider zoning issues further, **the committee views this question as being separate from issues that should be considered in the development of Comprehensive Plan guidance.**

Standardization of Charging Station Connections (Question 13)

13. The MITRE Corporation recommended that Fairfax County coordinate with its peer jurisdictions to encourage the development of a standard for the connection of EV charging stations (both in terms of the electrical connection and physical mount) in order to improve the portability of charging stations. Is this of concern from a county policy standpoint? If so, what guidance should be incorporated into the Plan?

The MITRE report included the following recommendation:

> The County should coordinate with its peer jurisdictions to encourage charging station manufacturers to form a standard defining the connection of the charging station to the facility in which it is installed. The standard should define both the electrical connection and physical mount with the purpose of making it possible to move charging stations to a new facility relatively easily and quickly.

MITRE's view on this question was not shared by the providers of electric vehicle charging stations who were contacted for support in this effort. The following perspectives were expressed:

- Interchangeable units are not practical, and there is no need for such standardization. Products are not interchangeable, and there is not a great expense in mounting a charging station.

- While there could be some benefit to applying this idea to single family homes, this is not really an issue elsewhere; it is not a challenge to hook a station into a site.

- It is not necessarily the case that all charging stations can work on the same kind of mount; there may be some level of variability.

- There may be efforts to develop electric vehicles that can enhance the grid, and it is not clear if a standardized mount could work against this idea.

In light of this input, **the committee does not recommend that any action from the county be pursued on this matter at this time. However, the committee recommends that county staff remain active in regional reviews of electric vehicle issues.**

Data Collection (Question 14)

14. Are there any needs for county data collection?

With respect to data collection, the MITRE report recommended the following efforts, again specific to Tysons. These efforts would support refinements to policy guidance consistent with information regarding charging demand, along with efforts that would support utilities in their preparations for charging demands.

> ". . . the County (to the extent possible within in the bounds of privacy concerns, proprietary competitive data, and simple data gathering feasibility) is wise to develop the mechanisms to gather and monitor data describing:
> - A more precise understanding of the Fairfax work population and where it lives within Fairfax and within the nearby counties;
> - The other inbound population of Tysons and where it lives;
> - Use patterns for charging stations as they are installed in Tysons. Who uses them? When are they used? On what sorts of vehicles?
> - PHEV and BEV registrations for Tysons and the jurisdictions within 100 miles of the area."

T**he committee does not see a need for data collection beyond what has already been done in order to refine the policy recommendations identified earlier**, but the committee agrees that, as a follow-up consideration, **it would be appropriate for the county to review experiences with electric vehicle registrations in the county, the provision of charging stations, information from electric vehicle charging equipment suppliers regarding how these charging stations are being used and experiences with charging stations that may be installed per proffers or development conditions. The committee recommends that the electric vehicle charging policy issue be revisited in several years in order to learn from experiences and adjust the informal guidance that will have been applied based on both these experiences and industry projections available at that time.**

Incentives (Question 15)

15. Two of our presenters have recommended a consideration of incentives; one focused on incentives for commercial/business owners (e.g., letting owners know about a 30% federal tax credit against all costs [note that this credit expired at the end of 2013]; establishing a county tax incentive). Another presenter suggested assistance for building retrofitting and wiring. Is this within the purview of our discussion? If so, how should this be considered?

The committee sees good reason to endorse electric vehicle technology but recommends that the focus of its review be on the development of Comprehensive Plan policy and implementation through the zoning process.

County Facilities (Question 16)

16. One of our presenters has recommended consideration of publicly-accessible charging stations at county facilities; this would send a message of support for this technology. Is this within our purview to consider? If there is any sort of subsidized public charging, would it have an adverse effect on the private market?

County staff has been studying the possibility of establishing publicly-accessible charging opportunities within county-owned parking areas. Infrastructure to support the future installation of electric vehicle charging stations has been incorporated within several recent capital facility projects, including three projects (the Stringfellow Road Park and Ride Lot; the Reston Police Station; and the Mid County Human Services Center) for which EV-readiness has been applied to publicly-accessible portions of parking lots. Parking spaces in these areas could conceivably be used for public charging in the future. County staff has concluded that, if publicly-accessible charging opportunities were to be pursued, it would be appropriate to do so through the leasing of spaces in appropriate parking lots (e.g., park and ride lots) to a private sector provider, which would provide charging services for a fee that the provider could base on electricity use or time spent in one of the EV-charger parking spaces. Staff has indicated that there are a number of questions that would still need to be resolved before such service could be provided. Staff is opposed to the concept of providing free charging in its lots, and any charging facilities that would be established to support fleet electric vehicles would not be accessible for public charging.

County staff does not anticipate that there would be difficulty in continuing to pursue some extent of EV-ready design for county capital facility projects. However, retrofitting charging stations into parking areas of existing county facilities may present any of a number of site-specific challenges; any potential site for EV charging retrofits would need to be evaluated to determine the cost and difficulty of the retrofit (e.g., the need for trenching to install wiring) as

well as the capacity of the electrical system of the associated building to accommodate the additional load demand.

The committee remains interested in the potential for establishing publicly-accessible charging opportunities in county-owned parking facilities as well as information regarding what other localities have done in this regard, but the committee views this as an issue that is not related to the development or implementation of Comprehensive Plan policy. The committee recommends, as a follow-up consideration item, a consideration of opportunities for providing electric vehicle charging at county facilities where there would likely be a demand for charging.

Peak Hour Use of Electricity (Question 17)

17. Is there a concern about the use of electricity for EV charging during peak hours? If so, is there an ability to promote the cutting off of charging during peak hours?

As noted earlier in this report in the guidance provided by the Metropolitan Washington Council of Governments[62], there could conceivably be issues at some point in the future associated with peak hour charging, although information presented to date suggests that the majority of charging will occur at home during overnight hours, which may benefit the grid by evening out the load curve, allowing generating facilities to operate more consistently. The committee notes that utilities have the ability to establish rate structures that will incentivize overnight charging if peak hour charging does become a concern.

It is the committee's view that the timing of charging is not within the purview of local government decision-making and is beyond the scope of this review. The committee feels that, as a follow-up consideration, though, it would be appropriate for the county to coordinate with electric utilities in regard to any data needs they may have from the county that may assist them in identifying any potential stresses to the electrical system.

[62] Metropolitan Washington Council of Governments, Electric Vehicles in Metropolitan Washington: Understanding the Region's Current EV Readiness and Options for Expanding Their Use, October 2012. (http://www.mwcog.org/uploads/pub-documents/oF5dW1c20121016122213.pdf)

Future Charging Station Removal (Question 20)

20. Should there be a policy to remove charging stations if the technology becomes outdated?*

The concern implied by this question is that a proliferation of charging stations on a site may appear to some to present a visually unappealing environment and that this adverse visual impact may persist even if the charging stations were to stop being used. While the committee is not aware that removal of charging stations would be particularly difficult or costly, and while it is quite possible that owners of parking areas would not want to retain obsolete charging stations on their properties, the committee is also not aware that there is, or could be, any requirement that would compel the owner or operator of the parking area to remove obsolete charging stations.

Recognizing that this hypothetical circumstance could arise at some point in the future, the committee notes that this would not be an issue limited to sites that would have gone through zoning review. **The committee therefore does not consider this to be a Comprehensive Plan policy concern**. Further, if a policy and/or implementation emphasis was to be placed on measures that would establish electric vehicle-ready sites as opposed to the up-front provision of charging stations, the potential for this circumstance to arise would be diminished. Out of sensitivity to this concern, however, **the committee recommends that proffers or development conditions not be crafted in a manner that could require the retention of obsolete technology on a site.** If a proffer or development condition would focus on EV-readiness, though, this would not be a concern.

Pilot Project (Question 21)

21. Is there a way to permit a limited number of EV charging stations as a pilot project on an existing development? I think the Planning Commission's discussion would benefit from some practicing examples in the county. If a high demand for permits occurs, then the PC and Board could consider more comprehensive planning and zoning amendments.*

There is nothing to prevent any owner of an existing development from adding one or more charging stations to his/her site, and a number of charging facilities have already been established in parking lots in the county. **It is not clear if a pilot project is necessary or that such a project would inform policy, as such an effort would not reflect future demands for electric vehicle charging. The committee agrees that there is a need to review experiences with electric vehicle charging and demand projections over the next few years and adjust policy and/or implementation approaches.**

Summary of Committee Recommendations

The Environment Committee recommends the following:

1. In light of considerable uncertainties regarding how electric vehicle technology will be embraced and adopted by the general public, a focus on EV-ready design, as recommended by MITRE, would be appropriate.

2. The committee also agrees with MITRE's emphasis on electric vehicle charging efforts for residential uses.

3. The committee notes that Policy Plan guidance addressing electric vehicle charging was adopted by the Board of Supervisors on July 1, 2014 as part of a broader Plan amendment addressing the county's green building policy. This policy guidance is general in nature, does not specify any particular quantitative thresholds and provides an emphasis on electric vehicle charging for residential uses. The committee supports the adopted Plan guidance and does not see a need to augment it with new Plan text, as this guidance is broad and general enough to be adaptable to changing circumstances.

4. The Plan guidance noted above should be supplemented with more specific suggestions regarding implementation. These suggestions could be communicated through informal reports/guidance such as this paper and/or through prototype proffer guidance that can be provided to zoning applicants for their consideration. There should be future refinements of these suggestions as EV technology and adoption develop.

5. In light of charging times associated with the various levels of charging, the committee recommends that there be an emphasis on EV-ready design for Level 2 charging, although it is not the committee's intent to preclude consideration of any particular level of charging.

6. The suggested implementation approaches should be offered to zoning applicants for their consideration for incorporation within their proffer packages or within development conditions that would be agreeable to the applicants. Prototype proffers/development conditions should be prepared that can be offered to applicants for their consideration. Such prototypes should not be viewed as expectations; rather, EV-related commitments that are pursued by applicants should instead be evaluated more broadly as components of overall proffer/development condition packages.

7. As noted above, the committee agrees with the MITRE Corporation's recommendation for an emphasis on electric vehicle-ready design. While commitments from applicants to the provision of charging stations should be encouraged (particularly for residential development proposals), it is not clear that any particular percentage of "seeding" of charging station supply would be appropriate at this time.

8. The committee would support, consistent with MITRE's recommendation, efforts to ensure that electrical rooms would be sized such that electrical capacity could, in the future, be provided to support electric vehicle charging for 100 percent of the parking area for residential uses. However, the committee recommends that considerable flexibility be applied to this question; the county should welcome alternative ideas as may be presented by applicants, particularly if reasonable concerns arise regarding possible unintended consequences and/or costs of this idea.

9. For offices and other uses, the committee recommends that the question of a specific threshold for sizing of electrical rooms be left open at this time and that applicants be asked to identify specific thresholds within the commitments they prepare through the zoning process. This question could be revisited in the future based on experiences in pursuing such commitments and any further guidance that may be available in the future regarding rates of electric vehicle adoption and demand for workplace or other nonresidential charging.

10. The committee does not recommend that the quantitative targets for installation of conduit (and, by extension, the sizing of the electrical distribution system) that have been recommended by the MITRE Corporation for application in Tysons (100 percent for residential uses and 35 percent for office uses) be established at this time. Nor does the committee view that there is an easy answer to the question of what percentage of any particular parking area should be provided with conduit and sizing of the electrical distribution system to facilitate the eventual installation of EV charging stations. However, the following approaches could be pursued as suggestions to applicants as starting points for discussion:

    - For office and other nonresidential proposals, a linkage to applicable green building rating systems could be suggested; this would support and be integrated within broader green building commitments. However, the committee recommends that more ambitious efforts be suggested for parking facilities associated with hotels and transit opportunities.

    - For residential proposals and mixed use proposals with residential components where other charging opportunities would not be available, there are differing perspectives among committee members regarding suggestions that should be made in regard to extent of EV-readiness in parking facilities, but there is consensus that, if percentage thresholds are to be suggested, they should be higher for residential proposals than nonresidential proposals.

    - An alternative approach would be to base the EV-readiness commitment to a survey that would be conducted at a time closer to building construction and occupancy than zoning approval. In that there are numerous challenges associated with this concept, it is not the committee's preferred approach, but the committee sees benefit in a hybrid approach through which relatively high thresholds of EV-ready design could be applied (e.g., 10 percent for certain

residential and mixed use/residential proposals and two to five percent for nonresidential proposals) along with considerable flexibility to reduce these thresholds based on surveys conducted closer to the time of construction.

- Prototype proffers should be developed based on the above recommendations. Staff should engage applicants in a discussion of EV-ready design, and the prototype proffers should be viewed as a starting point of this discussion that would, ideally, lead to commitments that would be tailored to the needs and circumstances associated with each application.

11. Levels of EV-readiness that are suggested as starting points for discussion, particularly for nonresidential uses, should not necessarily be the end points—the committee would like the county to promote this technology proactively and not simply pursue a least-common-denominator approach when negotiating proffer commitments with zoning applicants. To that end, the county should encourage, on a case-by-case basis, EV-ready design efforts for nonresidential uses beyond what may be linked to a particular green building rating system (e.g., two percent coverage), recognizing that flexibility will be needed in all negotiations.

12. Policy guidance should not address charging station design or locational issues. Any such concerns would best be considered on a case-by-case basis during the zoning process, considering the site-specific context.

13. In regard to MITRE's recommendation for coordination with other area jurisdictions on standardization of connections of charging stations, the committee recommends no action at this time. However, the committee recommends that county staff remain active in regional reviews of electric vehicle issues.

14. With respect to data collection, the committee recommends that the county review experiences with electric vehicle registrations in the county, the provision of charging stations, information from electric vehicle charging equipment suppliers regarding how these charging stations are being used and experiences with charging stations that may be installed per proffers or development conditions. The committee also recommends that the county coordinate with electric utilities in regard to any data needs they may have from the county that may assist them in identifying any potential localized stresses to the electrical system.

15. Policy guidance should not address dedicated charging spaces at office facilities, models of provision of electric vehicle charging, levels of access to charging stations, zoning provisions, incentives, establishment of charging stations at county-owned parking facilities, peak hour charging, removal of obsolete charging stations or establishment of a pilot project. However, the committee does recommend follow-up consideration of zoning issues and charging opportunities at county-owned parking facilities (see below).

16. Proffers or development conditions should not be crafted in a manner that could require the retention of obsolete technology on a site.

17. The committee recommends that the electric vehicle charging policy issue be revisited in several years in order to learn from experiences and adjust the informal guidance that will have been applied based on these experiences and industry projections available at that time.

The Environment Committee has chosen to focus its recommendations on matters relating to Comprehensive Plan policy and its implementation. However, there are a number of issues for which the committee has recognized a desire for follow-up considerations. These are as follows:

A. The committee sees a need for direct consideration of electric vehicle charging within the Zoning Ordinance and recommends the identification of this issue on the Zoning Ordinance Amendment Work Program. The committee appreciates staff's development of "Applicable Zoning Provisions for Electric Vehicle Charging Stations" as necessary guidance regarding conditions under which charging stations can be considered to be accessory uses as opposed to principal auto-oriented uses but feels that more formalized Zoning Ordinance provisions are needed. There is a need to ensure that, in distinguishing between accessory uses and principal uses, appropriate boundaries are defined that provide reasonable protections while facilitating electric vehicle charging technology. In addition to the question of accessory vs. principal use, there is a need to consider the relationship of EV parking spaces to overall minimum parking requirements (i.e., should an EV space count towards the minimum parking requirement or not?) County staff is also aware of concerns about a provision within the guidance document that establishes that Non-Residential Use Permits are required for all proposed charging stations. The committee sees some level of urgency to the need for a Zoning Ordinance amendment and recommends that this Zoning Ordinance review be pursued sooner rather than later.

B. There should be consideration of opportunities for providing publicly-accessible electric vehicle charging at county facilities where there would likely be a demand for charging. Experiences of other localities that have provided such opportunities should be considered.

C. County staff should remain active in regional reviews of electric vehicle issues.

D. The county should review experiences with electric vehicle registrations in the county, the provision of charging stations, information from electric vehicle charging equipment suppliers regarding how these charging stations are being used and experiences with charging stations that may be installed per proffers or development conditions.

E. The county should coordinate with electric utilities in regard to any data needs they may have from the county that may assist them in identifying any potential stresses to the electrical system.

Appendix A

MITRE

Electric vehicle charging infrastructure recommendations to Fairfax County

Task 5 of sustainability study under Proffer #9, RZ 2008-PR-011

July 19, 2011

Approved for Public Release: 11-2916. Distribution Unlimited.

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Executive Summary

Plug-in vehicles feature prominently in the vision for a livable, sustainable Tysons Corner. They promise cleaner, quieter transportation that is less dependent on the political stability of other parts of the world, but they come at the price of being a fundamentally different way of powering the automobile fleet. Charging will largely be done over long periods of time at distributed locations, rather than at particular fueling stations. As Tysons Corner evolves from a suburban office park to an urban center, the evolution to an electric automotive fleet will affect urban layout, building design, and utility services.

Fairfax County is attempting to determine the effects of widespread plug-in vehicle adoption on infrastructure requirements and to determine design approaches that can be considered through the county's zoning process to encourage appropriate investment. MITRE, in support of the County's sustainability objectives, has considered the problem under Proffer #9, RZ 2008-PR-011. This document is the result.

We present a background for plug-in vehicles, charging stations, and other estimates of plug-in vehicle market penetration. We emphasize the impossibility of a demonstrably accurate estimate of market penetration, the fact that vehicle charging will be done primarily at home, and that modifications to initial parking area construction can reduce the overall cost and risk of installing charging stations. Four primary recommendations result:

1. The County should strongly encourage developers to include the conduit infrastructure – space, conduit banks, conduit, and access points – for relatively easy and inexpensive installation of charging stations in the future. The County should encourage, but place less emphasis on the full installation of electric vehicle supply equipment (EVSE) – the transformers, switches, wiring, and charging stations themselves – at the time of initial construction given the uncertainties surrounding electric charging station demand.
2. The fraction of parking slots for which the infrastructure should be included should represent a fully plug-in fleet for the groups of users that would use charging infrastructure at the facility. This means all parking spaces for a residential building (single- or multi-family). At commercial and retail facilities, this means the fraction of vehicles that arrive from locations geographically situated to require a charge before the return trip.
3. The County can most appropriately seed charging station supply by negotiating for the installation of full charging stations at the lowest expected adoption rate in the near future. Any supply seeding is best done at apartment buildings and should be limited to a maximum of 2% of all parking spaces.
4. The County should coordinate with its peer jurisdictions to encourage charging station manufacturers to form a standard defining the connection of the charging station to the facility in which it is installed. The standard should define both the electrical connection and physical mount with the purpose of making it possible to move charging stations to a new facility relatively easily and quickly.

The objective is to prepare Tysons Corner for widespread plug-in adoption, but to do so as inexpensively as possible so as to encourage the desired population and job growth that will sustain Tysons Corner as a livable urban center.

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1 Introduction

MITRE fully supports Fairfax County's sustainability objectives for Tysons Corner. As part of Proffer #9, RZ 2008-PR-011, we are conducting an analysis of emerging building, automotive, and energy technologies – specifically, how they may affect future Tysons Corner development and how they can best be harnessed to aid the transformation of Tysons Corner in to a sustainable, livable urban center.

This document concerns plug-in vehicles and plug-in vehicle charging infrastructure. It satisfies Task 5 of the study that MITRE is performing per the aforementioned proffer commitment. The specific components of Task 5 are:

> "Describe the following as they relate to the establishment of electric vehicle charging stations:
>
> a. Guidance regarding the anticipated future need for electric vehicle charging stations in Tysons Corner, including an estimate of the number of charging facilities that may be needed in the future and concentrations relating to broad land use categories (e.g., number of multifamily dwelling units per charging station; office and retail square footage per charging station)
>
> b. Guidance regarding impacts to infrastructure in Tysons Corner that would occur as a result of full implementation of electric vehicle charging stations in Tysons Corner per 5.a above
>
> c. A general overview (not site-specific details) of infrastructure (including voltage requirements and amperage reserves) and site design elements that would be necessary for the establishment of electric vehicle charging stations at typical redevelopment sites in Tysons Corner (including design accommodations that could be made for the possible future establishment of charging stations on sites)."

MITRE's response to this guidance is a series of building construction recommendations that would, if implemented, lower the overall cost for future installation of a full plug-in vehicle charging infrastructure. We show the course of reasoning from which they were derived. We first provide some background information to set the context of the discussion. Population and employment forecasts for Tysons Corner are referenced. We note the various types of plug-in vehicles, and we discuss multiple other studies that have attempted to estimate future plug-in vehicle market penetration. An overview of the current state of charging technology concludes the background review. From the background section, we move into the discussion of recommendations. We make explicit our underlying assumptions and then present their consequences on Tysons Corner charging infrastructure. Finally, we present specific recommendations to the County.

We have excluded from this document a discussion of the effects that plug-in vehicle adoption will have on the electrical grid in general. That analysis is best done in conjunction with the other part of the proffer study on general energy use and system level effect.

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2 Background

2.1 Demographics

2.1.1 Fairfax County

Fairfax County currently is home to more than 1 million people and 580k jobs (Fairfax, 2011).

Figure 1 shows the Mid-Atlantic area centered in Tysons Corner. The concentric rings show driving distances (not straight-line distances) from Tysons Corner and are spaced twenty miles apart. Each ring shows estimates of both resident population and the source of commuters into Tysons Corner. The figure shows the data on a map. Table 1 summarizes the data.

Table 1: Total resident and Fairfax County commuter populations living within given distance from middle of Tysons Corner

Driving distance from Tysons Corner	Resident population (millions)	Inbound Fairfax commuters (x100k)	Percent of inbound Fairfax commuters
< 20 miles	3	367	67%
20 – 40 miles	5.4	496	91%
40 – 60 miles	8	526	97%
60 – 80 miles	9.1	539	99%
80 – 100 miles	10.4	540	99%
> 100 miles		545	100%

Sources: Total population – US Census, 2010; Commuters – AASHTO, 2011; Driving distances – ESRI Network Analyst.

Two points should be noted about the commuter data. First, the total number of commuters in this table does not match the current 580k jobs because it is a result of statistical sampling done 2006 through 2008. We assume for the sake of this study, that even as the number of commuters increases, the geographic distribution of their homes remains constant. Also, we assume that the geographic distribution of commuters' homes is the same for Tysons as for the entirety of Fairfax. Second, the data is a total count of workers traveling within and to Fairfax County for work. There is no attempt to determine the frequency of those trips.

2.1.2 Plan for Tysons Corner Urban Center

Focusing more specifically on Tysons Corner itself, the 2007 Fairfax County Comprehensive Plan, with the 2010 Tysons Corner Urban Center Amendment, plans a more livable area with a sustainable integration of work, play, and home. The plan provides, "… a framework for growth beyond 2030." 17,000 people currently live in Tysons Corner, but studies upon which the amendment are based estimate 31,000 residents in 2020 and up to 86,000 by 2050. Likewise, there are currently 105k jobs in Tysons Corner. In 2020, a forecast suggests that this number may be as high as 140k and by 2050, 210k. The Comprehensive Plan for Tysons Corner indicates goals of 100,000 residents and 200,000 jobs by 2050 (George Mason, 2008).

The recommendations below are made in the context of these projections and in the context of constructing buildings that will stand for the next forty years or more.

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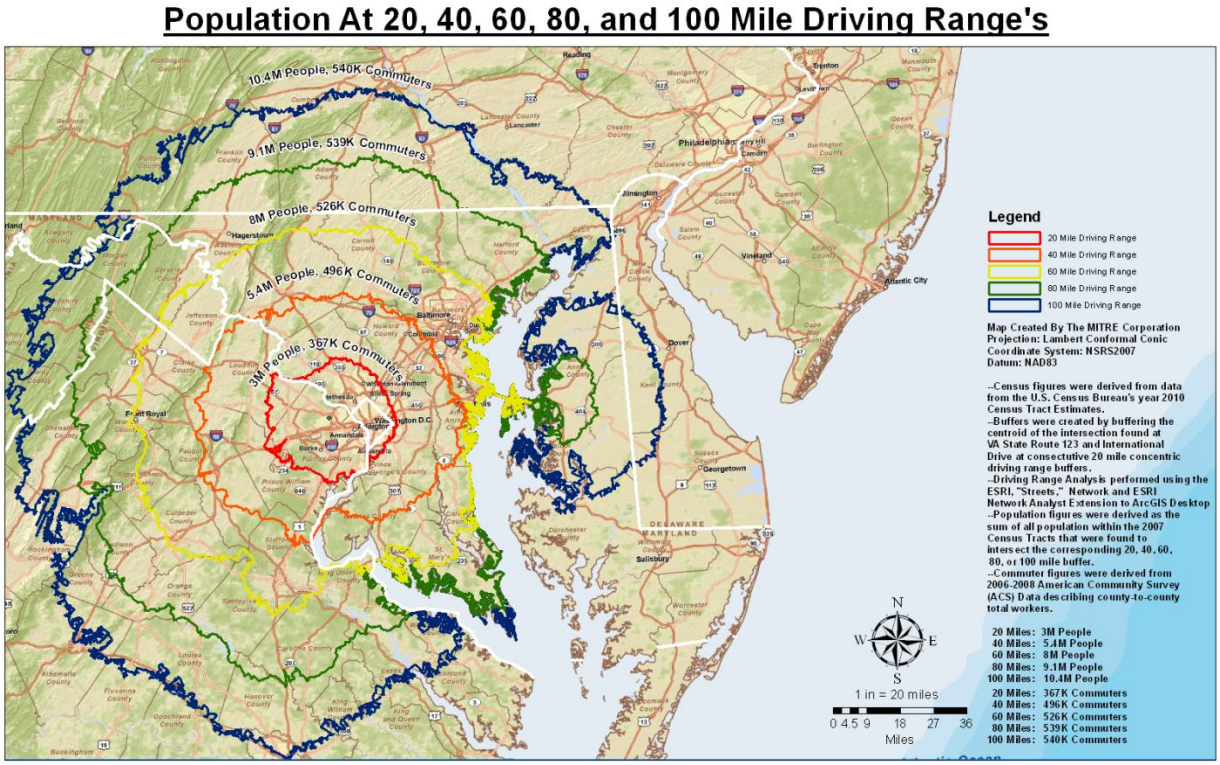

Figure 1: Driving distances from Tysons Corner

2.2 Battery electric and plug-in hybrid vehicles

2.2.1 Models

We consider two types of vehicles in this document: battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV). As its name implies, a BEV's sole power source is its on-board battery. The Nissan LEAF is the current most visible mass market BEV with a nominal range of 100 miles, although some estimates place a more realistic expected range at 80 miles. A PHEV has both a battery and an internal combustion engine. It operates on a combination of electric and gas or diesel power in a proportion determined by its electronic control system in response to such factors as power demand, temperature and state of charge of the battery. During the first portion of a trip, the battery, which has been charged from the grid prior to the trip, bears a greater burden for moving the vehicle. When the battery charge is used down to a predetermined level, the car automatically reverts to a "charge sustaining" mode and continues to operate just like a non-plug-in hybrid. In this mode, the battery's electrical charge is alternately used for propulsion and replenished by engine power (directly or through regenerative braking) and is "sustained" in a relatively narrow range. The Chevy Volt, the currently most visible example of a PHEV, is designed in such a way as to use only battery power (no engine power) during the "charge-depleting" portion of the trip. Both BEVs and PHEVs, of course, plug into the electrical grid for the bulk of their charge.

Throughout this document the terms *electric vehicle* or *plug-in vehicle* will refer to both PHEV and BEV without distinction. If we need to differentiate between the two, the appropriate acronym is employed.

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2.2.2 Adoption

2.2.2.1 Market forces

Estimates of plug-in vehicle market penetration are highly varied, but do cite common factors both pushing and hindering adoption. As we show in the following, each factor includes significant estimates and guesses. We present the list to emphasize the lesson that estimating future electric car adoption is an inexact art and that any such estimate is likely wrong.

2.2.2.1.1 Encouraging adoption

Factors encouraging adoption can generally be boiled down to two: financial and convenience. More altruistic mechanisms certainly exist, but they are not widespread enough to greatly affect aggregate market penetration of plug-in vehicles.

Financial encouragement for electric adoption comes in the form of rising gasoline prices. Average gasoline price has more than doubled in real terms since the late 1990s (US EIA, 2011). As world demand increases, this general upward trend for gasoline will likely continue. This trend will be exacerbated in the face of any future turmoil in oil producing countries. US electricity prices over the same term have not seen the same increases (US EIA, 2011), and locally, if a vehicle is charged at night using time-of-day pricing, even at current prices, gasoline can be an order of magnitude more expensive per mile than electricity delivered from the grid (Dominion, 2011).

Financial encouragement also derives from government policy. At a national level, tax rebates have been offered for the purchase of hybrid vehicles. Should this become a national priority, similar such programs will again be offered. In time, should greenhouse gas regulation come to pass, plug-in vehicles will likely have additional fuel cost advantage over traditional vehicles as greenhouse gas intensity of grid generation is less than that of distributed gasoline-burning engines (EPRI, 2007).

Convenience comes also in the form of government policy. Locally, high occupancy vehicle (HOV) exemptions for hybrids have been a primary force for their adoption by commuters seeking to bypass heavy traffic without the hassle of finding and coordinating with other passengers.

2.2.2.1.2 Discouraging adoption

Factors discouraging adoption are many. We begin with concerns closest to the driver and proceed to more general constraints.

The first concern is general to all new technologies, not specifically those of plug-in vehicles. PHEV and BEV are new to the mass market, and as with the introduction of any new technology, early adopters will have to demonstrate the technologies' fitness before general adoption will begin.

The most obvious car-specific concern is vehicle range. BEVs cannot be driven beyond charging station range. PHEVs can but upon the switch to gasoline, lose the price per mile advantage over a traditional hybrid. Thus the economic benefit of PHEVs is only apparent if they remain close to charging infrastructure.

Vehicle initial cost is the next inhibitor. Include the cost of a charging station and its installation in the home, and plug-in vehicles require a larger up-front investment for the buyer than do

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internal combustion vehicles. Adoption will only become widespread if the ownership costs of such vehicles (fuel, maintenance, government levies) generally decrease to the point that the return on investment offsets the larger up-front cost.

This initial cost disadvantage for plug-in vehicles will likely fall over time as automakers increase investments in research and development. The ability and willingness of automakers to make such investments, however, depends heavily on the general economic climate, the rate of adoption, and targeted government subsidies, each of which presents its own difficult estimation problem.

A subset of the cost disadvantage is specific to a collection of difficulties in the battery supply chain that limit production. Currently battery manufacturing is constrained by simple production under-capacity, raw material availability, and technical immaturity.

Finally, the electrical grid itself is likely not suitable for large-scale adoption of electric cars. While not a constraint in the near term where numbers will be limited, the grid will require large investments over time to respond to the increased overall demand and the specific use patterns of the electric fleet. This investment will be passed along to the consumer, and if it is specifically passed to electric car owners, plug-in vehicles will lose a degree of their fuel cost advantage.

2.2.2.2 Estimates

Having presented some of the forces affecting plug-in vehicle adoption, we present three studies – one sponsored out of the Department of Energy (referenced as 'Sentech' below), one from the National Academy of Sciences, and one from an electricity industry group – that estimated the future US plug-in fleet. Each ignores the possibility of revolutionary technology, geopolitical upheaval, or large domestic political shifts. Even without such large market distorting events, we see that each presents a collection of highly variant alternatives.

Noticeably absent are any assessments by the automakers themselves. Such analyses would be proprietary and closely held, but the vastly different approaches the automakers themselves are taking with fleet electrification shows that not even they have a handle on what the market is going to look like in the coming decades. GM entered the EV market in the 1990s with the EV1, but discontinued the model. Non-plug-in hybrids first emerged in the late 1990s. Toyota made the explicit early decision not to include a plug on the Prius, but has reconsidered the decision for future models due to this year's introduction of GM's PHEV Volt. Nissan is skipping hybrid technology altogether with its EV Leaf this year.

The point here is that automotive market experts and even the automakers themselves are uncertain as to what the future holds for plug-in vehicles. The County, therefore, cannot expect to develop a good estimate of plug-in vehicle market penetration, and, as such, it should adopt a posture that does not hinge on a particular estimate.

To provide context for these studies, sales of new passenger vehicles in the US totaled roughly 17 million units annually from 2000 through 2007. With the general economic downturn, that total fell to 13.5 million in 2008 and 10.6 million in 2009 (Census, 2011). Roughly 250 million such vehicles are currently registered in the US (Census, 2011).

Figure 2 summarizes our source studies.

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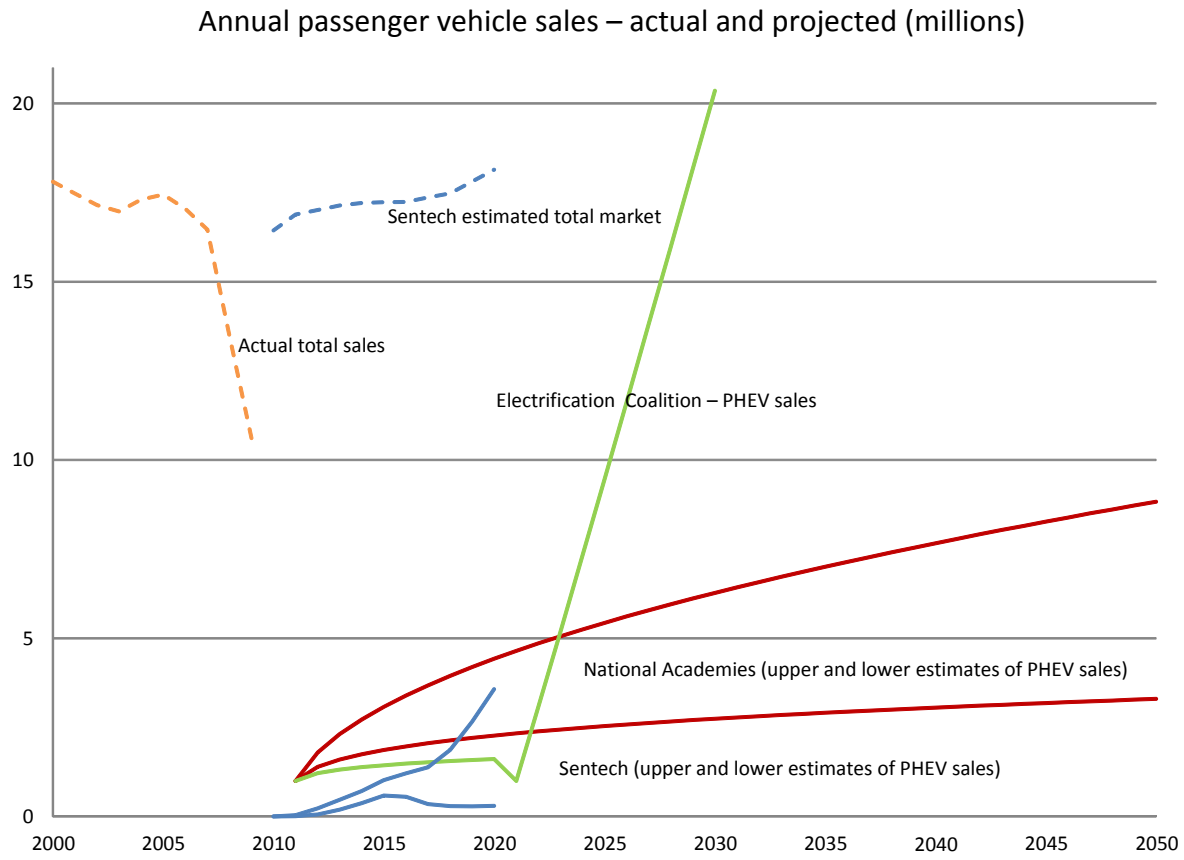

Figure 2: Annual passenger vehicle sales – actual and projected (millions)
Sources: US Census, 2011; Sentech, 2010; derived and estimated from National Research Council, 2010; derived and estimated from Electrification Coalition, 2009.

The various studies estimate PHEVs to represent anywhere between 2 and 20% of 2020 sales, with estimates diverging dramatically afterwards. The point of showing the disparity between (and even within each of) the studies is to demonstrate the difficulty – if not impossibility – of Fairfax generating an estimate of plug-in vehicle adoption good enough to proceed with large scale installation of charging infrastructure. Instead, as we recommend below, the County should strongly encourage the development of infrastructure that allows for the minimum of retrofit costs and, therefore, the lowest long-term cost of fleet electrification and necessary charging station availability.

2.3 Charging stations

Charging stations constitute the plug-in vehicle's connection point to the grid. Table 2 shows a summary of the three general classes of charging stations (Virginia Clean Cities, 2010).

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Level of Charging	Level 1	Level 2	DC Fast Charge (Level 3)
Voltage	120 VAC	240 VAC	480 VAC (off board charger provides AC to DC conversion)
Amperage	15 - 20 Amp	40 - 80 Amp	85 Amp
Instantaneous Demand	1.2 - 1.6 kW	3.3 - 7.7 kW	60 kW
Charge Time			
PHEV 40 Vehicle	5 - 13 hours	2.5 - 5 hours	N/A
EV100 Vehicle	8 - 15 hours	3 - 5 hours	15 to 30 minutes

Table 2: Charging station summary

Level 1 can be as simple as a standard three-prong plug into a standard wall socket (Level 1 EVSE does exist to improve safety and improve grid integration, but it does not improve charging speed). The time required to fully charge a vehicle at Level 1 makes it an impractical general solution.

Level 2 is the answer to this impracticality. There is a defined standard (Society of Automotive Engineers J1772), and mass produced plug-in vehicles have sockets to fit. Despite their high current rating, the power demand shown is indicative of practical use where less current is used to improve longevity of the battery itself (not the individual charge). Level 2 is the assumed primary mechanism for most charging as it strikes a balance between practical speed and battery protection. It is intended for installation in the home and at other locations where the car is expected to sit unused for a number of hours at a time.

Level 3 is not yet standard, though multiple competing standards have emerged. It is the closest analogy to the current gasoline pump. Multiple rapid charges, however, negatively affect the longevity of current batteries, and so such chargers are assumed to be of use primarily in emergencies (Burke, et al, 2007; Hybrid Cars, 2010).

2.4 Construction costs

Construction costs serve as the final bit of input data for the analysis. Cost estimates for the parking structures help frame the analysis. The estimates are drawn from industry standard resources (RS Means CostWorks) and from private historical databases belonging to builders MITRE uses for our own construction efforts. They include design, construction, and labor. They do not include the cost of the land itself.

Table 3: Per parking space new construction estimated costs

	Estimated per space new construction cost
Below grade garage	$33-38k
Above grade garage	$12-17k
Surface lot	2.5-3.5k

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With regards to the installation of plug-in vehicle charging infrastructure, the intent is to minimize the overall cost of establishing adequate charging supply. EVSE can be fully installed during initial construction, but if the demand never makes full use of that charging supply, money is wasted. EVSE can also be retrofitted into a building later when demand emerges, but retrofit is more expensive than is inclusion during initial construction. The per space construction costs (Table 3) must be borne regardless of whether EVSE is considered during initial construction or whether it is to be delayed for retrofit. The analysis thus turns on the difference between installation during initial construction and installation as part of a retrofit.

It turns out that conduit installation drives the higher costs of retrofit. It is far cheaper to embed conduit during initial construction than it is to drill through concrete (in a garage) or dig a tunnel and resurface asphalt (in a surface lot). The cost of installing transformers, switches, cable, and the charging stations themselves are equivalent whether they are being done during initial construction or as part of a retrofit. So, since we are considering the difference between initial construction and retrofit, we focus on the additional per space cost imposed by conduit installation.

Table 4 shows the estimates of the costs incurred during initial construction and during retrofit. Again, we rely on a mix of industry standard sources (RS Means) and the private historical databases of contractors with whom we have relationships.

Table 4: Additional per space estimated cost of EVSE conduit installation during…

	Initial construction	Retrofit
Surface lots	$1800	$2900
Garage	$400	$1200

The differences between garage and surface lot installation are a consequence of the fact that the conduits must be buried in a surface lot installation. In the garage, the conduit can be attached to the ceilings or wall.

3 Assumptions

This analysis rests on the fundamental assumption that plug-in vehicles will become widespread only if they become as convenient and economical as other non-plug-in vehicles (internal combustion and traditional hybrids). Likewise, plug-in vehicle charging infrastructure will only emerge where and when profit can be derived (after all, we couldn't put gasoline in our cars if we didn't put dollars into someone's pocket in the process). This simple notion leads to a number of consequences that affect the recommendations.

We further assume that plug-in vehicle owners will have the ability to fully charge their vehicles at home. Without that ability, the owner would be utterly reliant on an infrastructure that currently does not exist and will emerge in some currently unknown form. We accept our infrastructure dependence with internal combustion engines because most areas are saturated with gas stations and because the time to fill a car for a range of multiple hundreds of miles is minimal. These conditions are not satisfied for the plug-in fleet, and so home charging is a must.

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3.1.1 Charging is done at home

With the assumption that the plug-in vehicle owner will spend the money to establish a charging capability at home, the question is how much he will rely on commercial charging stations.

If we consider only convenience, even a Level 3 charging station will likely require 30 minutes to fill an EV100. It is unreasonable to assume plug-in vehicle drivers will line up to fill the batteries before the commute home every day. Additionally, Level 3 rapid charging reduces the battery's useful lifespan (Burke, et al, 2007; Hybrid Cars, 2010). So between the impracticality of the charger and the wear it induces on the battery, we conclude that Level 3 charging (at least in the context of Fairfax County) will be an emergency activity for only a small fraction of plug-in vehicles in the near future.

So we turn to Level 2 charging, where we accept longer charging times and charge where we spend most of our time: at home and at work. Cost considerations push the driver to charge at home in this case. If charging stations become widespread, Dominion will impose time-of-day pricing on the charging station owners (Dominion, 2011). This helps to control peak demand, and it prevents a political fight over raising other rates to provide flat-rate pricing on charging stations. Since most drivers are away from home during the day when wholesale electricity prices are higher, the electricity they use away from home is more expensive.

While the electricity consumed away from home is itself generally more expensive, the fact that the charging station is owned by a for-profit entity – remember, money has to be made – also increases the cost of away-from-home charging. The charging model may simply be the price of electricity plus some fee (now that electricity resale is legal in Virginia for this application) (Virginia, 2011). It may also be in the form of a per session fee, a per minute fee (to absorb the opportunity cost of a car blocking the station but not charging), or an access rights model. In any of these cases, the charging station owner passes along the cost of electricity and then turns a profit for himself. Indeed, home charging is the cheapest charging.

3.1.2 Geography and drivers for focus

We now return to the map in Figure 1 **Error! Reference source not found.**to consider the effects of the home charging predominance.

All PHEV and BEV drivers who live in Tysons Corner will primarily charge their vehicles in Tysons Corner at night. The majority of people living in Tysons Corner will reside in large multi-family buildings and, therefore, do not have the individual option to install their own charging station if the building has not already either provided a charging station or the infrastructure into which a charging station can easily be installed. Thus, the County should put particular focus on residential buildings. If charging stations are not available to allow owners to charge their vehicles overnight, they cannot purchase plug-in vehicle, nor can people who already own plug-in vehicles tenant the building. This both slows new adoption of plug-in vehicles and potentially makes the area less attractive to people moving here from locations with better charging resource availability.

Moving outside of Tysons Corner itself, non-residential charging stations encourage PHEV adoption, but they are not sufficient. They make the commute less expensive – electric-only retains a price advantage over gasoline-augmented operations here in Tysons Corner even with a profit-making charging station on a hot summer afternoon (PJM, 2011; EcoWorld, 2006; Toyota,

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2011) – and, therefore, build the case for plug-in vehicles, but they are not a necessary condition since the vehicle can continue with its internal combustion engine.

The savings are a function of the electric-only range of the PHEV (the pluggable Prius will be a PHEV12; the Chevy Volt at PHEV40) and the commute distance. The outer extreme of this case is represented by the 20-mile (40-mile return commute) ring which includes all of Fairfax, Arlington, Alexandria, and the District and contains about 65% of the Tysons Corner workforce (we do not have data granularity to estimate the fraction of the Tysons Corner workforce within the 6-mile ring). For commutes less than half of the electric-only range, the non-residential chargers in Tysons are of no use; the charging is done at home. For commutes longer than half of the all-electric range, the non-residential charging stations simply reduce the operating costs of PHEV.

Turning now to all-electric vehicles, the 40-mile and 80-mile rings are of interest. The 40-mile ring is the effective half range of an EV100. EV100 owners inside this ring will require little in the way of charging infrastructure in Tysons. They will charge at home. Roughly 90% of Fairfax's workforce resides within this ring.

At the 80-mile ring (and this may be generous), we reach the effective outer range of the EV100 vehicles. A commuter originating between the 40-mile and the 80-mile rings (roughly 8% of the current workforce) will require charging resources to return home. Outside the 80-mile ring, the trip will not be attempted, and the County can safely ignore such drivers.

In summary, the Tysons Corner charging stations service distinct groups for distinct purposes;

- PHEV and EV ownership within Tysons Corner is made feasible with residential charging. There can be no plug-in ownership without home charging.
- Charging stations available to non-residents make the commute cheaper for PHEV drivers who come from further than half of their all-electric ranges. PHEV owners from inside this distance are unaffected by Tysons Corner charging infrastructure since they can fully charge at home.
- Commutes to Tysons Corner are made feasible for EV owners who live between 40 and 80 miles away. Otherwise outside EV owners are relatively unaffected by Tysons Corner charging infrastructure.

3.1.3 Technology evolution

These rings represent the state of 2011 technology, but a building shell is likely to be used for 40 to 50 years, so what happens as technology improves?

In general, improved battery and charging station technology will increase overall demand for plug-in vehicles and, therefore, charging infrastructure. An inspection of the rings, however, reveals consequences for Tysons Corner in particular.

Within Tysons Corner itself, improved technology will increase the fraction of resident vehicles that require home charging, and, any new residential building should assume that a large fraction of the resident fleet will be electric in the coming decades.

In thinking about the population commuting into Tysons, we consider the cases of charging speed and battery capacity independently.

If battery capacity improves, the rings move further out, but the effect on aggregate demand is indeterminate. Drivers from more densely populated inner rings that would have previously used

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commercial charging stations no longer require that capability to return home. At the same time, plug-in drivers from less densely populated outer regions are newly within range of Tysons. This would indicate a net reduction in demand, but it must be assumed that as technology improves, the total fraction of vehicles that are plug-in will increase.

If charging speed improves then quick charge stations become more feasible, and the infrastructure begins to resemble more that of the current gasoline infrastructure. This may reduce demand for Level 2-style stations at office and retail locations, but it will not affect demand for home charging as home charging will still be the cheapest, most convenient charge mechanism.

If replaceable batteries become more prevalent, then some hybrid of home charging and swap stations will likely emerge. Home charging infrastructure is still required, but the fewer charging stations are required at offices and at retail location. To date, however, no vehicle on the market or proposed for the near future market features such batteries.

4 Policy recommendations

The County's development requirements and expectations must balance with the County's other objectives. The county wants to attract business and residents, so the costs it imposes cannot be too high. The county may want to enable and encourage the electrification of region's automotive fleet, so the charging infrastructure it requires should not lag or inhibit demand.

Here, we attempt to strike a balance between these objectives and recommend a course of action for the County. Having described the environment in which these decisions are made and described the assumptions underpinning our analysis, we present our policy recommendations here. We propose a long term, sustainable course; a plan for the short term; and recommendations for data collection, which will aid future market analysis of charging station demand.

4.1 Long-term recommendation

4.1.1 General

As we saw in the background sections above, considerable uncertainty exists regarding the adoption of plug-in vehicles. This uncertainty induces large financial risks for anyone installing and operating a commercial charging station. If demand is lower than expected, the charging station is a wasted investment. If demand is higher than originally expected and if the infrastructure into which additional charging capacity would be installed is constrained, then there exists a retardant on plug-in vehicle adoption. This uncertainty also induces political risk for the County. If it undertakes any strategy that depends on some assumption of adoption, a critic can always find a competing study arguing for more or less charging structure.

The best long-term policy response then is one that does not require the County, a resident, or a developer to estimate vehicle adoption or charging station demand. Here, we propose recommendations for initial building construction that are intended to reduce the risk associated with uncertain charging station demand.

The proposed building recommendations are intended to reduce the overall cost of electrifying a parking area with Level 2 charging stations, while allowing the owner or third-party to match

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demand with investment over time by installing charging stations at minimal cost in the future. In the long-term case, profits can be earned with commercial charging stations. The objective of minimizing future installation costs is to increase the quantity and reduce the price at which supply and demand are equivalent.

Initial parking area construction satisfying three conditions is relatively inexpensive and serves as a basis for future installation at least expense. The following conditions are thus recommended:

- A newly constructed facility should have the physical space to allow the installation of enough transformer capacity to enable intended operations as well as allow electrification of the parking area. The transformer capacity to fully electrify the lot, however, need not necessarily be installed during initial construction. Full installation can occur as demand emerges in the future.
- The building's electrical room should have enough physical space to allow the future installation of a switchboard (with the capacity for sub-metering) for the charging stations. Again, the full switchboard need not be installed immediately.
- Initial parking area construction should include the conduit bank and conduit between the facility's electrical room and the spaces allotted for possible future electrification. An access point (junction box or hand hole) at each possible future charging station location is recommended. Access points (manholes, hand holes, and junction boxes) to draw cable from the electrical room to the charging stations are recommended as well.

The recommendations are a hedge against the uncertainty of charging station demand. The installation of conduit and access points are the primary drivers of difference between the cost of installing a charging station during initial construction and installing one in which the whole of the system is retrofit into a facility. The intent of the recommendation is that of insurance. If the cost is low enough, even if the lot is never electrified, the lost investment is bearable, but if large demand for charging stations indeed emerges, the recommendations greatly reduce the cost of servicing that demand.

4.1.2 Building class specifics

The transformer space and empty conduits are relatively small investments during initial construction, but they are not zero. Here, we consider the various classes of buildings and offer bounds on the fraction of parking spaces that should be designated for future charging station installation. In a previous section, we noted the three classes of plug-in vehicle drivers who will use the Tysons Corner charging infrastructure: Tysons Corner residents, PHEV drivers who live further than half of their all-electric ranges from Tysons Corner, and EV owners who live between 40 and 80 miles from Tysons Corner. They define the need.

4.1.2.1 Residential

It is with the development of residential buildings that the County should be most aggressive in negotiating for commitments from developers. Plug-in vehicles require home charging. If home charging is not available, there will be no plug-in vehicles.

Given the uncertainty of future demand, for residential development, we propose that the transformer space, switch space, and conduit recommendations in the previous section apply to

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all newly constructed parking spaces. The objective is to allow an inexpensive, full migration to a plug-in fleet within the lifespan of the parking area. In Tysons Corner specifically, since most parking will be in garages – and likely underground garages at that – the cost of this conduit infrastructure is a tiny fraction of total cost, and its initial inclusion is roughly 30% of the costs of retrofit (see Table 4).

Though this analysis is focused specifically on Tysons Corner, we strongly recommend that all residential development (single family homes, townhouses, condominiums, and apartments) in broader Fairfax be subject to this guidance on conduit and space. Because of the dependence on home charging, we have to assume that long-term homeowners will constitute the bulk plug-in vehicle buyers as they have the stability to assume access to home charging for the whole of the vehicle's lifespan. Apartment dwellers may be less inclined to purchase plug-ins because they are generally more transient. The availability of a charging station at the next home is unknown, and without home charging a plug-in becomes impractical. Thus, the payoff for the policy is likely to be highest in developments where the owners are the occupants.

In the house, townhouse, and condominium markets, the developer, by definition, is not the long-term owner of the residence, and so he has the incentive to respond only to current market pressure. The installation of conduit during initial construction is an insurance policy against possible future market forces. Though the developer's cost of initial installation is a larger fraction of the overall construction cost for most home applications – presumably such costs are more in line with surface lot installation – the existence of such conduit greatly affects future adoption rates of plug-in vehicles since any retrofit costs implied by the purchase of a plug-in vehicle will depress demand. Such conduit is not yet a selling point for homes in the region, however, and so it is not yet a commonly-offered feature. Thus, to minimize hurdles to widespread adoption, the County is wise to strongly encourage the inclusion of conduit for all residential development across the county.

4.1.2.2 Commercial office buildings

For commercial office buildings, we recommend the transformer, switch, and conduit recommendations apply to 35% of newly constructed spaces – the fraction of spaces equivalent to the fraction of vehicles that arrive into Tysons from outside 20 miles. This would allow the full adoption of plug-in in the fleet arriving from outside the 20 mile ring (inside of which the Tysons charging infrastructure largely unnecessary). As zoning ordinances are modified in coming years – presumably, with the arrival of Metro, reducing the number of spaces required for an office building – this fraction would rise on the newer, smaller lots since more of the incoming vehicular traffic would be from outlying areas not served by Metro.

4.1.2.3 Retail

Most retail activities are substitutable across the Mid-Atlantic region, and so we have to guess that most retail customers in Tysons Corner live within a short radius. However, since retail is fundamentally about attracting customers to a particular destination and since the higher prices of plug-in vehicles imply relatively affluent buyers, retail developers have the incentive to make an adequate number of charging stations available. We thus assume that retail development will require the least nudge from the County to provision for charging stations.

Should the County find itself in the position of having to provide that nudge, we recommend the same guidelines as those for office buildings with conduit infrastructure being encouraged for the

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fraction of vehicles coming from outside a 20-mile radius. That fraction of traffic, however, is unknown and certainly not presented in the Census resources from which we can determine work commuting patterns. Thus, the county is wise to work with its retail base to determine the source of the populations inbound for retail.

4.1.2.4 Hotels

Hotels offer the logistical opportunity for a Level 2 charge. We do not have any data describing the mix of vehicles that park in Tysons Corner hotels, so instead, we recommend that the County work with hotels in the region to determine need, with the need for conduit installation being primarily defined by the rental car population in a hotel's garage.

4.1.3 Charging station standards

The definition of a standard connection point for the charging station to the vehicle (SAE J1772) has been a necessary step towards the widespread adoption of plug-in vehicles. Without the standard connection point, drivers of the various plug-in models would have to carry around various connectors and adaptors in hopes of accessing charging resources more potent than a standard wall outlet.

We propose that the County coordinate with peer jurisdictions, which are also looking to ease the widespread adoption of plug-in vehicles, in an attempt to force a standard connection point for the charging station itself to the facility into which it is to be installed. The connection point is both the electrical connection and the piece by which the station is physically mounted to the wall, ground, or ceiling. The first and most obvious purpose is simply to reduce the overall cost of installation.

The second purpose of a standard mount is to allow for easy movement of charging station to a new location. We see the standard mount allowing multiple business models that reduce the risk associated with uncertain charging station demand. A third party vendor may manage a fleet of charging stations that it deploys and adjusts to service demand for multiple facilities. An apartment management company may rather provide a connection point and allow plug-in drivers to attach their own (sub-metered) charging stations, so that it does not have to deal with the risk of too many or too few charging stations. In both cases, the facility owner eliminates his need to monitor and respond to developments in the plug-in vehicle marketplace, and the flexibility afforded by a quick, easy installation ensures that supply is more responsive to demand.

From a driver's perspective, the standard mount also reduces risk. As the standard mount becomes more widespread, a plug-in owner knows he can take his charging station with him should he decide to find to a new home, and he knows he can sell his charging station to another plug-in owner should he no longer need the station or upgrade the station. Because the risk of vehicle ownership is potentially decreased, demand for plug-ins is potentially increased.

The definition of such a standard is certainly not the responsibility of Fairfax or any local jurisdiction. The point in making the recommendation here is that Fairfax is in a position with its peer jurisdictions to encourage the charging station vendors to proceed along this path.

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4.2 Short term

4.2.1 Charging stations – seeding supply

Plug-in vehicle adoption has always been considered a 'chicken and egg' problem with cars not being purchased because charging stations are not available and charging stations not being installed because of inadequate numbers of plug-in vehicles. Thus, the County may recommend implementation of a handful of charging stations at each new building site and proffers that deliver charging stations to public areas.

Above, we see that residential charging is the key to widespread plug-in vehicle adoption, and we reasoned that plug-ins are more likely (in the near term) to be purchased by people who own their own homes and intend to stay there for the lifespan of the car. If the County wishes to speed adoption by apartment dwellers inside Tysons Corner, it may recommend the installation of charging stations at new apartment developments. If so, we recommend that the number of full stations be equivalent to the lowest estimate of market penetration for plug-ins (see 2.2.2.2). The region may have a higher rate of hybrid adoption over the recent years, but that margin will be swamped by the broader trends which drive nationwide adoption. In the lowest estimate presented above, plug-ins are estimated to constitute less than 2% of cumulative sales, and so we recommend that the upper-bound of any County negotiation for fully installed charging stations be limited to 2% of the parking spaces at an apartment building in Fairfax. This is in addition to the strong recommendation for the conduit infrastructure.

For office and retail buildings, we have recommended the County pursue commitments to the provision of infrastructure that would allow for inexpensive charging station installation in the future. We do not, however, recommend any expectation for full station installation. Plug-in vehicle adoption will be a function of home charging capacity; charging availability at work or retail locations alone is not sufficient to allow adoption. Luckily, if we return to the map and the concentric rings, office and retail charging is only a necessity for BEV drivers who live between 40 and 80 miles from Tysons Corner (and only 8% of inbound Fairfax commuters live at that distance). For PHEV drivers who live more than half of their all-electric range from Tysons Corner, the charging stations would indeed reduce commuting costs, but we cannot believe that a prospective PHEV owner would purchase such a vehicle while being dependent on cheap workplace charging to make the economic case for purchase. Any proffer for provisioning charging stations thus supports a very small fraction of inbound commuters (BEV owners from 40 to 80 miles away) or a group of drivers who would have purchased their vehicles anyway (PHEV owners). The lesson is that for office and retail development, developers may be able to better benefit the community with proffers that include improvements other than the provisioning of a large number of charging stations.

4.2.2 County procedures

The County itself can continue to support plug-in adoption by continuing to maintain its current easy, efficient process for permitting electrical installations at existing facilities. Plug-in buyers need this process to make the installation of charging stations at home to remain as easy as it is. If the process is slowed, then adoption of plug-in vehicles will also be slowed.

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4.3 Data generation and monitoring

A primary purpose of the recommendations would be to allow charging station deployment to coincide with charging station demand. This would allow the business justification for commercial charging capacity to emerge and, therefore, would make plug-in vehicle ownership more convenient (and feasible for a larger population). To speed the development of the business case, the County (to the extent possible within in the bounds of privacy concerns, proprietary competitive data, and simple data gathering feasibility) is wise to develop the mechanisms to gather and monitor data describing:

- A more precise understanding of the Fairfax work population and where it lives within Fairfax and within the nearby counties;
- The other inbound population of Tysons Corner and where it lives;
- Use patterns for charging stations as they are installed in Tysons Corner. Who uses them? When are they used? On what sorts of vehicles?
- PHEV and BEV registrations for Tysons Corner and the jurisdictions within 100 miles of the area.

With a good handle on this information, the County would be better positioned to respond to changes and trends in the emerging markets of commercial charging stations and plug-in vehicles. Potential charging business owners would be better able to gauge demand. And Dominion would be better able to understand its supply requirements.

5 Conclusion

We close with an emphasis on two points. First, no demonstrably accurate estimate of plug-in vehicle market penetration is possible. And second, when plug-in vehicles do arrive to market in large numbers, their owners will completely rely on, will prefer, and will predominantly charge them overnight at home.

These two points naturally lead to the recommendations

1. Developers should be strongly encouraged to include the space, conduit banks, conduit, and access points for easy and inexpensive installation of charging infrastructure in the future. They should not be asked to install the transformers, switches, wiring, or charging stations themselves, however.
2. The fraction of parking slots for which the infrastructure should be included should represent a fully plug-in fleet for the groups of users that would use charging infrastructure at the facility. This means all slots in a residential building. At commercial and retail facilities, this means the fraction of vehicles that arrive from locations geographically situated to require a charge before the return trip.
3. The County can most appropriately seed charging station supply by negotiating for the installation of full charging stations at the lowest expected adoption rate in the near future. Any supply seeding is most efficiently done at apartment buildings and should be limited to a maximum of 2% of all parking spaces.
4. The County should coordinate with its peer jurisdictions to encourage charging station manufactures to form a standard defining the connection of the charging station to the

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facility in which it is installed. The standard should define both the electrical connection and physical mount with the purpose of making it possible to move charging stations to a new facility relatively easily and quickly.

The overall points are that transformer space and conduits are more expensive to retrofit into a facility than to include during initial construction. Their inclusion at the outset would allow the cheapest possible overall cost of installing a full charging infrastructure, and their inclusion in such quantity would be a low-cost insurance policy against the inability to estimate plug-in vehicle market penetration rates over the expected life spans of newly constructed buildings.

The County thus would ensure that development in Tysons Corner would remain an attractive investment and that the area would be fully prepared for whatever occurs with plug-in vehicle adoption.

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6 Acronyms

BEV	Battery Electric Vehicle
BEV100	Battery Electric Vehicle with 100-mile range
EV	Electric Vehicle
EV100	Electric Vehicle with 100-mile range
EVSE	Electric Vehicle Supply Equipment
PHEV	Plug-in Hybrid Electric Vehicle
PHEV12	Plug-in Hybrid Electric Vehicle with a charge-depleting range of 12 miles
PHEV40	Plug-in Hybrid Electric Vehicle with a charge-depleting range of 40 miles

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County of Fairfax, Virginia

MEMORANDUM

APPLICABLE ZONING PROVISIONS FOR ELECTRIC VEHICLE CHARGING STATIONS

July 12, 2013

Electric vehicle charging stations may be deemed a permitted accessory use serving another principal use, such as an office park, industrial park, institutional use, shopping center, retail sales establishment, or multiple family development, when the following conditions are met:

1. The charging station is located in a parking structure or parking lot that serves a principal use. The charging station shall not result in the reduction of parking spaces to less than what is required to serve the principal use.
2. The charging station shall be located so as not to interfere with any vehicular or pedestrian circulation or block any fire lanes or access into the site.
3. Signs promoting or advertising the electric charging station shall not be permitted on the charging station or on the lot. However, small directional signs not exceeding 2 sq. ft. in size and located no closer than 5 feet to any lot line shall be permitted.
4. When located in a parking lot or on the top level of a parking structure that is open to the sky, no canopy or any type of roofed structure shall be associated with the electric charging station.
5. Any outdoor lighting associated with an electric charging station shall be full cut-off and consistent in color and design with the other existing light poles and/or outdoor lighting.

The number of charging stations that may be permitted as an accessory use may vary from site to site based on, but not limited to, the size of the lot, size of the principal structure(s), type(s) of principal use(s) served, and visibility from off-site.

An electric vehicle charging station that does not comply with the above criteria is considered a principal use and is deemed an automobile-oriented use under the Zoning Ordinance. Automobile-oriented uses are defined in Article 20 of the Zoning Ordinance as follows:

> AUTOMOBILE-ORIENTED USE: Any use of land not otherwise defined which provides a service directly to a motor vehicle, or which provides goods or services to the occupants of a motor vehicle while seated therein.

Department of Planning and Zoning
Zoning Administration Division
Ordinance Administration Branch
12055 Government Center Parkway, Suite 807
Fairfax, Virginia 22035-5505
Phone 703-324-1314 FAX 703-803-6372
www.fairfaxcounty.gov/dpz

Automobile-oriented uses are permitted by right in the C-8 District when located in a shopping center and are subject to use limitations contained in Sect. 4-805 of the Zoning Ordinance. Automobile-oriented uses are also permitted by right in the PDH, PDC and PRC Districts when depicted on an approved development plan. Automobile-oriented uses that do not meet the use limitations contained in Sect. 4-805 require special exception approval by the Board of Supervisors (Board) in the C-8 District. In addition, automobile-oriented uses are permitted with special exception approval by the Board in the C-5, C-6, C-7 and C-9 Districts. Information pertaining to the special exception process is available from the Zoning Evaluation Division at 703-324-1290 or at http://www.fairfaxcounty.gov/dpz/zoning/development/.

Any proposal for a specific location of an accessory electric vehicle charging station that is proposed to serve a principal use must be submitted to the Ordinance Administration Branch of the Zoning Administration Division at the address or facsimile number on this letterhead or by email at ordadmin@fairfaxcounty.gov. Proposals must include a letter of consent from the property owner, architectural/building plans for the electric vehicle charging station, a site plan showing the proposed location of the electric vehicle charging station and the number of parking spaces, if any, the electric vehicle charging station will utilize.

All electric vehicle charging stations, whether permitted as an accessory or a principal use, may be subject to electrical and/or building permit approval and may require site plan approval if there is more than 250 square feet of land disturbing activity. The issuance of a Non-Residential Use Permit (Non-RUP) shall be required prior to the establishment of any electric vehicle charging station. Information pertaining to electrical and building permits is available from the Department of Public Works and Environmental Services (DPWES) at 703-222-0801 (option 1). Site plan information is available from DPWES at 703-324-1575, and Non-RUP information is available from the Zoning Permit Review Branch at 703-222-1082.

Appendix C: Electric Vehicle Charging and EV-Ready Design Requirements and Guidelines: Other Jurisdictions

As of April 4, 2014 (with an update only to the entry for Montgomery County, Maryland)

Provided below is an overview of research that staff from the Department of Planning and Zoning has conducted in regard to policies and requirements of other jurisdictions relating to electric vehicle charging. This table reflects the programs that staff is aware of as of the date of publication of this report. Staff has stressed to the committee that it is possible, if not likely, that there are additional programs it is not aware of.

Jurisdiction	Single family residential	Common residential parking areas	Nonresidential
Auburn Hills, Michigan	Level 2 EV-readiness strongly encouraged, but not required, for all new single and multiple-family homes with garages serving individual dwelling units	Level 2 EV-readiness (including electrical capacity and conduit) strongly encouraged, but not required, with a minimum ratio of 2% of the total parking recommended for future Level 2 charging. The City incorporated a higher level of EV-readiness (5%) in a public parking garage with direct entry into an apartment complex to serve both the apartment and the general public.	Level 2 EV-readiness (including electrical capacity and conduit) strongly encouraged, but not required, for all new and expanded typical non-residential parking areas (e.g., 1,000 spaces or less), with a minimum ratio of 2% of the total parking recommended for future Level 2 charging. There is a note that larger parking areas may not require as many charging stations.
Berkeley, California	At least one space must be EV-ready (Level 2 charger) for each new single family home	Condition of approval: At least 10% of a project's parking spaces must be EV-ready for Level 2 chargers (at least one space for lots with less than 10 spaces)	Condition of approval: At least 3% of a project's non-residential parking spaces must be EV-ready for Level 2 chargers (only on facilities with over 20 parking spaces)

Compiled by the Fairfax County Department of Planning and Zoning

Underscored localities are those from which DPZ staff has received direct guidance from the localities' staffs.

Italicized information is not direct—it has been provided from sources other than the locality in question.

Unless otherwise specified, "EV-ready" includes provision of conduit and electrical capacity. References to Level 2 charging are, in some cases, simplifications, as specific voltage and amperage levels are sometimes identified instead of the required level of charging.

<table>
<tr><th>Jurisdiction</th><th>Single family residential</th><th>Common residential parking areas</th><th>Nonresidential</th></tr>
<tr><td>Beverly Hills, California</td><td>EV-ready for one Level 1 and one Level 2 charger for all dwelling units except apartments</td><td>Low-rise residential only: CALGreen adopted (see below), but the older CALGreen requirements are also identified, so it is not clear which applies. The older CALGreen requirements were as follows, with both Level 1 and Level 2 charging capacity specified by Beverly Hills:
<table><tr><th>Total Number of Parking Spaces*</th><th>Number of required spaces</th></tr><tr><td>1-50</td><td>1</td></tr><tr><td>51-200</td><td>2</td></tr><tr><td>201 and over</td><td>4</td></tr></table></td><td>Nonresidential and high rise residential: CALGreen adopted (see below), but the older CALGreen requirements are also identified, so it is not clear which applies. The older CALGreen requirements were as follows, with both Level 1 and Level 2 charging capacity specified by Beverly Hills:
<table><tr><th>Total Number of Parking Spaces*</th><th>Number of required spaces</th></tr><tr><td>1-50</td><td>1</td></tr><tr><td>51-200</td><td>2</td></tr><tr><td>201 and over</td><td>4</td></tr></table></td></tr>
<tr><td>Boulder County, Colorado
(does not apply to incorporated localities)</td><td>Level 2 chargers, wiring or conduit required for all new garages or carports accessory to one- or two-family dwellings or townhouses. No requirement where there isn’t a carport or garage.</td><td>No requirement—Not a common land use in unincorporated Boulder County</td><td>No requirement</td></tr>
<tr><td>Emeryville, California</td><td>No requirement</td><td>At least 3% of all parking spaces must have charging stations (multifamily facilities with 17 spaces or more)</td><td>At least 3% of all parking spaces must have charging stations (hotel/motel facilities with 17 spaces or more)</td></tr>
</table>

Jurisdiction	Single family residential	Common residential parking areas	Nonresidential
City of Lancaster, California (Largely applied by the California Office of Planning and Research—Model Building Code guidance)	For garages serving single family and duplex residences, EV-ready design to allow for future installation of EV charging (Level 2) No specification for houses without garages	Ten or fewer units in new multiple-family projects: 20% of total required parking must be provided with a gang box connected to a conduit linked to electrical service to allow for future charging station installation. Does not specify Level 1 or 2. More than 10 units in new multiple-family projects: 10% of total required parking must be provided with a gang box connected to a conduit linked to electrical service to allow for future charging station installation. EV chargers must be provided in half of those spaces. Does not specify Level 1 or 2. (Note: 20% applied in the state guidance document)	EV-ready design for 2% of total parking, with 50% of those spaces to have charging stations, for the following: • Hospitals with 500 or more beds (and 20%+ expansions) • Colleges with 3,000 or more students (and 20%+ expansions) • Hotels or motels with more than 500 rooms • Certain industrial, manufacturing or processing plants • (a) Office buildings, (b) office parks, (c) shopping centers and (d) trade centers that employ 1,000 or more persons or contain: 500,000 square feet of gross floor area (uses a and b) or more than 250,000 square feet of gross floor area (uses c and d) • Sports, entertainment or rec. facilities that accommodate at least 4,000 persons per performance or that contain 1,500 or more fixed seats • Transit projects, including transit stations and park and ride lots

Jurisdiction	Single family residential	Common residential parking areas	Nonresidential
Los Angeles, California	100% of all one- or two- family dwellings and townhouses must have a Level 2 charger or be EV-ready for future Level 2 installation	At least 5% of all parking spaces must have a Level 2 charger or be EV-ready for Level 2 chargers	At least 5% of the total number of parking spaces must at least be EV-ready for Level 2 chargers.
Montgomery County, Maryland	No existing or proposed requirement	New parking lots with 100 or more spaces must provide EV-ready design for at least one charging station per 100 parking spaces. Charging level not specified. Negotiated Traffic Mitigation Agreements typically result in the provision of at least two charging stations and EV-ready design for a minimum of 5% of parking spaces.	New parking lots with 100 or more spaces must provide EV-ready design for at least one charging station per 100 parking spaces. Charging level not specified. Negotiated Traffic Mitigation Agreements typically result in the provision of at least two charging stations and EV-ready design for a minimum of 5% of parking spaces.
Mountain View, California*	*	*	*
Mountlake Terrace, Washington For multi-household residential and nonresidential, requirements for new construction of 10,000 square feet or more where A new building or off-street parking facility is developed; A certain threshold for building additions is met; or Parking capacity at an existing site is increased by more than 50%	EV-ready required for one level 2 charging station—applies to all new single family detached dwellings and townhouses where there are eight or fewer on a site	10% of the parking spaces must have EV charging stations An additional 10% of the spaces must be EV-ready for Level 2 chargers Applies to all multifamily projects and townhouse projects where there are more than 8 dwelling units.	The following uses must have charging stations for 3% of their parking spaces: Office, Medical, Lodging, Institutional, Municipal and Other uses as defined in the City code The following uses must have charging stations for 1% of their parking spaces: Retail, Industrial, eating and drinking establishments; Recreational/Entertainment/Cultural An additional equivalent percentage of spaces must be EV-ready for Level 2 chargers

Compiled by the Fairfax County Department of Planning and Zoning

Underscored localities are those from which DPZ staff has received direct guidance from the localities' staffs.

Italicized information is not direct—it has been provided from sources other than the locality in question.

Unless otherwise specified, "EV-ready" includes provision of conduit and electrical capacity. References to Level 2 charging are, in some cases, simplifications, as specific voltage and amperage levels are sometimes identified instead of the required level of charging.

Jurisdiction	Single family residential	Common residential parking areas	Nonresidential
New York City, New York	No requirement	For alterations of parking areas including an increase in the size of electrical service (with some exceptions), electrical raceway to the electrical panel serving the facility must be capable of providing at least 3.1 kW of electrical capacity (for garages) or 11.5 kVA (for open parking lots) to at least 20 percent of the parking spaces, with sufficient physical space provided in the electrical room for 3.1 kW for each of these spaces.	For alterations of parking areas including an increase in the size of electrical service (with some exceptions), electrical raceway to the electrical panel serving the facility must be capable of providing at least 3.1 kW of electrical capacity (for garages) or 11.5 kVA (for open parking lots) to at least 20 percent of the parking spaces, with sufficient physical space provided in the electrical room for 3.1 kW for each of these spaces.
Palo Alto, California	New detached single family dwellings required to either install a charger with a minimum 30 amp breaker or to install electrical capacity (for a 50 amp circuit) and raceway (to accommodate a 100 amp breaker), establishing EV-readiness well above minimums needed for a Level 2 charger	No requirements yet. Anticipated for review during Phase 2 in 2014	No requirements yet. Anticipated for review during Phase 2 in 2014 (including requirements for public rights of way)
Rolling Hills Estates, California	Wiring for one Level 2 Charger must be installed in the garage of any new residential unit (includes additions and demolitions/rebuilds of greater than 50% of existing floor area). No requirement where there isn't a garage.	No requirements	No requirements

Jurisdiction	Single family residential	Common residential parking areas	Nonresidential
*San Francisco, California***	**	**	**
Santa Clara County, California	One and two family dwellings required to be pre-wired and have panel capacity for a Level 2 charger (includes new construction and rebuilds)	Pre-wiring and panel capacity required for 3% of spaces, but not less than one space More than 100 spaces: Level 2 charging stations would be required for at least 1% of the total parking	Less than 100 spaces: Pre-wiring and panel capacity would be required for at least 5% of the spaces for Level 2 charging (at least one space where total parking is less than 20 spaces) More than 100 spaces: Level 2 charging stations would be required for at least 1% of the total parking. Includes commercial, office, industrial and institutional buildings Level 2 pre-wiring and panel capacity would be required for an additional 4% of the total parking.
Seattle, Washington	For residential occupancies, the electrical code requires space to be reserved in electrical service equipment and location for electric vehicle charging system panel board to support Level 2 or higher EV installation	For residential occupancies, the electrical code requires space to be reserved in electrical service equipment and location for electric vehicle charging system panel board to support Level 2 or higher EV installation	No requirements at this time—requirements similar to those for residential occupancies anticipated in the future
Sunnyvale, California	100% of residential garages/carports attached to individual dwelling units must have EV-ready design for Level 2 chargers.	At least 12.5% of all spaces in residential shared parking facilities must have EV-ready design for Level 2 chargers.	At least 3% of all parking spots for industrial, R&D and office buildings with 100 parking spaces or more must have EV-ready design for Level 2 chargers
Temecula, California	Residential garages must be EV-ready for Level 1 charger	Does not appear to apply to shared garages	No requirements

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Unless otherwise specified, "EV-ready" includes provision of conduit and electrical capacity. References to Level 2 charging are, in some cases, simplifications, as specific voltage and amperage levels are sometimes identified instead of the required level of charging.

Jurisdiction	Single family residential	Common residential parking areas	Nonresidential
Vancouver, British Columbia	All new one and two family homes with garages or carports must be EV-ready for Level 1 charging. No requirement where there isn't a carport or garage.	For multifamily buildings or multifamily components of mixed use buildings (3 or more dwelling units), at least 20% of owner/occupier parking spaces must be EV-ready, and electrical rooms of such buildings must include sufficient space for future EV charging for 100% of these spaces (Level 1 required)	No requirements at this time.
Plug-in Georgia (an Atlanta-based task force—model ordinance)	Electrical conduit or cable raceway, electrical banks and access points required to facilitate Level 2 charging for all parking spaces.	Electrical conduit or cable raceway, electrical banks and access points required to facilitate Level 2 charging for all parking spaces. Electrical room must have sufficient space for 100% charging capacity	Electrical conduit or cable raceway, electrical banks and access points required to facilitate Level 2 charging for a graduated number of spaces, generally at least 8% of total parking (and higher).
State of Hawaii (statewide)	No requirement	At least one parking space must have a charging station in any 100 + space publicly-accessible parking facility--; *at least 1% of the parking spaces must be designated exclusively for electric vehicles.*	At least one parking space must have a charging station in any 100 + space publicly-accessible parking facility; *at least 1% of the parking spaces must be designated exclusively for electric vehicles.*

Jurisdiction	Single family residential	Common residential parking areas	Nonresidential
California's "CALGreen" green building code—Residential and Nonresidential Voluntary Measures—available at the discretion of the locality; EV charging is an elective measure (applicants choose a certain number of electives within each section of the code in addition to mandatory and prerequisite items)	For one and two family dwellings, a raceway sufficient to accommodate a dedicated branch circuit must be installed, to terminate in close proximity to the proposed location of the charging system, in a cabinet, box or enclosure (Level 2)	For multifamily dwellings, at least three percent of the total parking spaces (but not less than one) must be capable of supporting future EVSE (Level 2)	Tier 1: At least 3% of the total parking spaces, but not less than one, shall be capable of supporting installation of future EVSE (Level 2) Tier 2: At least 5% of the total parking spaces, but not less than two, shall be capable of supporting installation of future EVSE (Level 2)

*Mountain View, California: There are no specific requirements or policies, but staff routinely negotiates with developers for commitments to EV charging stations and/or pre-wiring (particularly for larger projects) and frequently gets such commitments, usually on the order of 1% of the total parking, with many developers pre-wiring additional spaces on their own—there is a market for EV charging and related infrastructure in this area. Google in particular (based in Mountain View) has a strong interest and has provided many stations at its campuses. Developers are often interested in these commitments as part of their LEED and/or greenhouse gas reduction strategies.

** *According to a November 29, 2011 report from Sunnyvale, California, "the City of San Francisco studied this issue [pre-wiring for residential construction] and ultimately decided not to require new construction to be pre-wired."*