



READY to **ROLL!**

*Southeastern Pennsylvania's Regional Electric
Vehicle Action Plan*



**Volume II: Technology
Overview, Detailed Analyses,
and Appendices**

June 2013



The Delaware Valley Regional Planning Commission is dedicated to uniting the region's elected officials, planning professionals, and the public with a common vision of making a great region even greater. Shaping the way we live, work, and play, DVRPC builds consensus on improving transportation, promoting smart growth, protecting the environment, and enhancing the economy. We serve a diverse region of nine counties: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer in New Jersey. DVRPC is the federally designated Metropolitan Planning Organization for the Greater Philadelphia Region — leading the way to a better future.

The symbol in our logo is adapted from the official DVRPC seal and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.



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Ready to Roll! Southeastern Pennsylvania's Regional Electric Vehicle Action Plan is presented in two volumes, and is accompanied by an online information clearinghouse. Volume I, available for download at no charge via www.dvrpc.org, includes the regional readiness plan, comprised of:

- Projections for EV deployment by individuals and fleets;
- Projections for residential, workplace, private access, and public access EVSE deployment;
- Projected opportunities for EVSE integration with the smart grid;
- Estimates for potential costs associated with EVs and EVSE, as well as funding opportunities to offset these costs;
- Barriers to EV and EVSE deployment in the region and recommendations to overcome these barriers; and
- An overview of stakeholders and partners involved in the preparation of the readiness plan, including a discussion of the roles and responsibilities of each stakeholder.

Volume II (this volume) provides an in-depth overview of electric vehicle technology, detailed analysis of projected electric vehicle sales and usage in southeastern Pennsylvania, as well as further discussion of the policies and recommendations covered in Volume I.

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1 Electric Vehicle (EV) and Infrastructure Overview

Electric vehicles (EVs) support three domestic goals: greenhouse gas (GHG) emissions reduction, energy security and independence, and economic development. With regard to GHG emissions reduction, EVs are considered zero- to low-emission vehicles because they produce low levels of tailpipe emissions (if any) per mile, as compared to a conventional vehicle powered by an internal combustion engine (ICE). One analysis indicates that many but not all regions of the United States would experience decreased pollution as a result of EV deployment. Specifically, 61 percent of the U.S. population would experience decreased ozone levels as a result of a “medium” EV deployment of 50 percent of new car sales by 2035.¹

The life-cycle emissions reduction associated with an EV as compared to a conventional vehicle depends on the sources of electricity used to charge the battery. EVs using electricity produced from renewable energy sources (e.g., hydroelectric, wind, and solar) provide greater emissions reductions than EVs using electricity produced from fossil fuels. Southeastern Pennsylvania is ranked among the best regions in the country for EV deployment because of the relatively clean mix of resources used to generate electricity use in the region.²

With regard to energy security, most U.S. electricity is produced from a mix of domestic coal, nuclear energy, natural gas, and renewable resources, all of which can be sourced domestically. Because EVs can operate solely on electric power, they can help reduce U.S. reliance on imported petroleum, thus increasing energy security.

With regard to economic development, EVs present many opportunities to contribute to job growth in the United States. Advanced lithium-ion batteries, the primary battery type used in EVs, provide an opportunity for the country to revitalize its manufacturing base. While the United States commanded only two percent of the global advanced battery industry in 2008, a Deutsche Bank study shows that the nation is responsible for upwards of 16 percent of the world's lithium-ion battery manufacturing capacity and is projected to contain 40 percent of global capacity by 2015.³ One report predicts that this battery manufacturing and other EV-related industrial developments may result in a net employment gain of 130,000 to 350,000 jobs in the United States by 2030.⁴ A study of EV deployment in California determined that light-duty vehicle (LDV) electrification could contribute up to 100,000 additional jobs in the state by 2030,

¹ Charles Zhu, “Plug-in Electric Vehicle Market Overview,” accessed June 2013, <http://www.c2es.org/docUploads/pev-market-size.pdf>.

² Don Anair and Amine Mahmassani, “State of Charge: Electric Vehicles’ Global Warming Emissions and Fuel-Cost Savings across the United States,” Union of Concerned Scientists, accessed June 2013, http://www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf, 19-20.

³ DOE, “The Recovery Act: Transforming America’s Transportation Sector – Batteries and Electric Vehicles,” accessed June 2013, <http://www.whitehouse.gov/files/documents/Battery-and-Electric-Vehicle-Report-FINAL.pdf>.

⁴ Thomas Becker, “UC Berkeley Study Finds Separate Battery Ownership Accelerates Mass-Market Adoption of Electric Cars,” accessed June 2013, <http://www.prweb.com/releases/UCBerkeley/Electricvehiclestudy/prweb2628184.htm>.

assuming EV deployment is accelerated to 45 percent of the new LDV fleet by 2030.⁵ Additionally, a New York State Energy Research and Development Authority (NYSERDA) study assessed the economic impacts associated with large-scale EV deployment in New York State. Under a scenario in which EVs achieve approximately 40 percent of new car sales by 2025, NYSEDA estimated that New York would benefit by \$4.45 to \$10.75 billion per year and experience net job creation between 19,800 and 59,800.⁶

Deploying EVs and electric vehicle supply equipment (EVSE) in southeastern Pennsylvania will require stakeholder involvement. Federal, state, and local decision-makers are well positioned to establish a regulatory environment conducive for EV and EVSE deployment. Utilities and regulatory authorities, such as public utility commissions (PUCs), are necessary to distribute electricity to EV owners, EVSE owners and operators, and other energy suppliers. Property owners can install both public and private charging infrastructure. EV and EVSE manufacturers, retailers, distributors, and installers are necessary to ensure that the technology is available, affordable, deployed, and maintained. Finally, education and advocacy groups, such as Clean Cities coalitions, have the informational resources and connections to educate fleet managers and the general public about the technology so more people are aware of its benefits.

The Delaware Regional Valley Planning Commission (DVRPC) led a year-long effort with stakeholders to create *Ready to Roll!*. DVRPC established close partnerships with a variety of stakeholders, including the City of Philadelphia's Mayor's Office of Sustainability, PECO Energy Company (PECO), and Greater Philadelphia Clean Cities (GPCC), as well as other stakeholders that were engaged through the DVRPC EV Advisory Group. As discussed in Volume I, the City of Philadelphia's Mayor's Office of Sustainability provided DVRPC with data to aid the planning process and coordinate with decision-makers in various city agencies, such as the Streets Department and Office of Fleet Management, and identified opportunities to streamline the permitting process for EVSE installation. PECO has created partnership programs with federal, state, and local governments and organizations to advance early adoption of EVSE and EVs in its southeastern Pennsylvania service territory. PECO served as a liaison between DVRPC, its partners, and the Pennsylvania Public Utility Commission (PA PUC) to provide valuable data throughout the project. GPCC has played an active role in EV deployment in the region and received two Electric Vehicle Infrastructure Grants from the Pennsylvania Department of Environmental Protection (PA DEP). GPCC recruited additional partners and stakeholders, performed outreach to fleets, and assisted in data collection for the project. DVRPC and ICF International (ICF) conducted in-depth telephone interviews with representatives of original equipment manufacturers (OEMs) Nissan, General Motors (GM), Ford, and Tesla Motors.

⁵ David Roland-Holst, "Plug-in Electric Vehicle Deployment in California: An Economic Assessment," accessed June 2013, http://are.berkeley.edu/~dwrh/CERES_Web/Docs/ETC_PEV_RH_Final120920.pdf.

⁶ NYSEDA and EPRI, "Transportation Electrification in New York State," accessed June 2013, <http://www.nyserda.ny.gov/en/Publications/Research-and-Development/~media/Files/Publications/Research/Transportation/epri-phev.ashx>

The subsequent sections address key technical characteristics of EVs; review EV owner characteristics and behaviors in early adopter regions; summarize existing EV market research; provide ordinance, development, and enforcement guidance; and evaluate utility tariff structures.

1.1 EV Characteristics

Electricity is used as transportation fuel in three types of vehicles:

- **Hybrid electric vehicles (HEVs)**, which use both an ICE and an electric motor for propulsion. A current example is the Toyota Prius.
- **All-electric vehicles (AEVs)**, which only use an electric motor for propulsion and have a battery that charges solely by plugging into an external source (e.g., the electrical grid). A current example is the Nissan LEAF.
- **Plug-in hybrid electric vehicles (PHEVs)**, which use both an ICE and an electric motor with a battery that recharges by plugging into an external source. A PHEV operates as an AEV until the battery has been discharged, at which time the vehicle continues to operate as an HEV. A current example is the Toyota Prius Plug-in.
- **Extended-range electric vehicles (EREV)**, which are a subset of PHEVs. Like PHEVs, EREVs use both an ICE and an electric motor with a battery that recharges by plugging into an external source. However, once the battery of an EREV has been discharged, the vehicle's ICE powers an electric generator to add 'extended-range' driving. A current example is the Chevrolet Volt. It is also considered by some industry observers to be a marketing term for this subset of PHEVs.

This report uses the term EV to refer to vehicles that use electricity from an external source—PHEVs, AEVs, and EREVs.

Until very recently, EVs were limited to niche market sales, demonstration programs, aftermarket conversions, or legacy vehicles from deployment in the 1990s. In the past few years, however, the number of commercially available EV models has increased. For instance, both the Nissan LEAF and the Chevrolet Volt have been available since early 2011, and Ford, Mitsubishi, Tesla, and Toyota have introduced additional new EV models as of early 2013.⁷

1.2 Review of EV Architecture

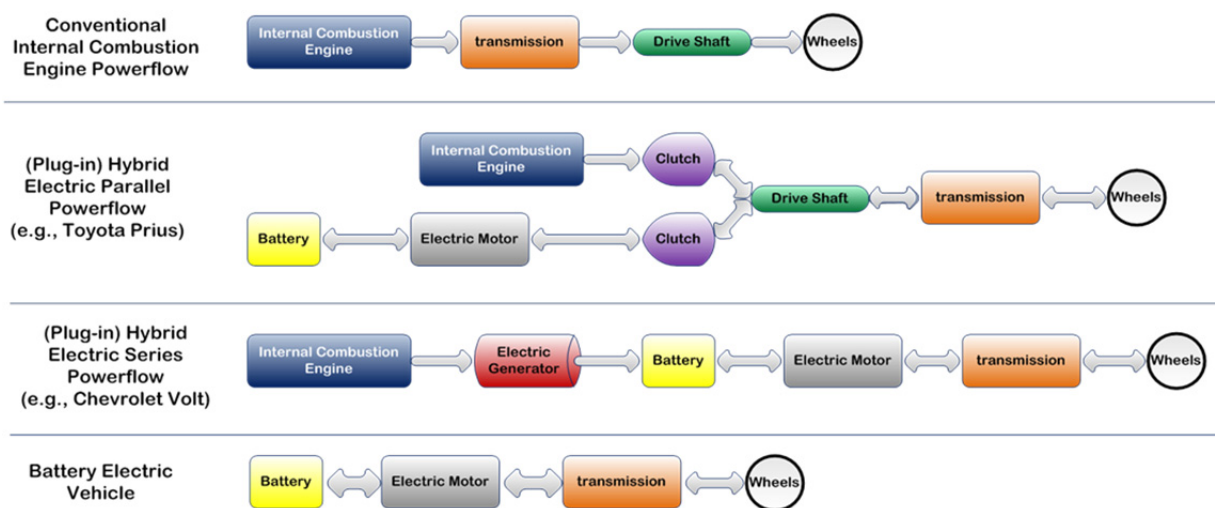
While both PHEVs and AEVs use an electric motor for propulsion, the two vehicle types have different architectures. Most PHEVs provide an all-electric driving range of 10 to 40 miles per charge (meaning that they can travel 10 to 40 miles using only battery power). As mentioned above, when the battery's charge falls to a predetermined level, the system switches to the ICE. PHEVs have lower battery costs than AEVs because of the smaller battery, but this is offset by the expense of outfitting a vehicle with two powertrains (electric and internal combustion).

⁷ See Section 5 for a summary of EVs currently available in the Greater Philadelphia market.

PHEVs have either a series or parallel configuration. The series PHEV is designed for electric motor propulsion only, with the ICE acting as a backup generator. As of June 2013, the only commercially available series PHEV on the market is the Chevrolet Volt. The parallel PHEV has two powertrains (electric and internal combustion), like an HEV, with additional battery capacity and a higher power electric system to extend its electric range. Ford and Toyota currently offer parallel PHEV models, and most OEMs other than Chevrolet and Cadillac are expected to use the parallel configuration.

AEVs operate solely on an electric powertrain and are therefore equipped with large battery packs. Mainstream AEVs typically have a driving range of less than 100 miles per charge.⁸ AEVs may be less expensive than comparable PHEVs, but they cannot be operated if they are not charged, and therefore require the availability of charging infrastructure. Figure 1 (below) illustrates the different drivetrain configurations of EVs and conventional vehicles.

Figure 1. Simplified Explanation of Different Drivetrain Configurations⁹



Source: Monica Ralston and Nick Nigro, "Plug-In Electric Vehicles: Literature Review," accessed June 2013, <http://www.c2es.org/docUploads/PEV-Literature-Review.pdf>, p. 8.

1.3 Battery Technology and Cost Review

The current generation of EVs uses lithium-ion batteries (the same chemistry used in cell phone and laptop batteries). Lithium-ion batteries are rechargeable, relatively lightweight, and have high energy content. Older battery chemistries used in EVs include lead acid and nickel metal hydride.

EV battery technology has been in development for over a decade, but several factors have prevented widespread deployment, including limitations in battery stability, energy capacity, and energy density. Despite recent advances in rechargeable lithium-ion battery technology,

⁸ EPA and DOE, "Electric Vehicles: Compare Side-by-Side," accessed June 2013, <http://www.fueleconomy.gov/feg/evsbs.shtml>.

⁹ Note that there are more drive train configurations, particularly for the parallel hybrid.

gasoline provides a car with about 50 to 100 times as much useful energy¹⁰ per pound as do the batteries used in current EVs.

Researchers are exploring ways to double or triple battery energy density through technologies such as lithium-sulfur systems, solid-state batteries, and silicon anodes in lithium batteries. These technologies may begin to appear in vehicles over the next decade as a result of extensive research funded by U.S. Department of Energy (DOE) grants. Toyota demonstrated a prototype solid-state battery in 2010 and may introduce this technology into a vehicle by 2020.¹¹ Solid-state batteries are similar to lithium-ion batteries, but they use a solid electrolyte (as supposed to the liquid electrolyte used in lithium-ion batteries). This results in a smaller, lighter battery. Panasonic is working with Tesla to develop a new generation of silicon anode-based batteries. Its Generation 1B battery systems, which may become available in 2017, will improve energy density by 30 percent relative to current cells.¹²

In addition to limitations in battery stability, energy capacity, and energy density, the current cost of battery production presents a significant barrier to EV deployment. As of 2012, the unsubsidized cost of an EV battery was approximately \$750 to \$800 per kilowatt-hour (kWh).¹³ Nissan estimates its battery costs to be approximately \$500 per kWh, but the company receives subsidies toward capital equipment and manufacturing plant construction (capital costs are approximately 10 to 12 percent of total battery costs).¹⁴ Because nearly 72 percent of the remaining costs associated with battery production (e.g., materials, purchased items, labor, and variable overhead) are considered variable costs, economies of scale are expected to bring the cost of the cell down as production of LEAFs, Volts, and other EVs increases. DOE also estimates that if a battery plant expands production from 10,000 to 100,000 units per year, it can reduce battery costs by 30 to 40 percent.¹⁵ Costs of battery cells may therefore fall to \$300 per kWh by 2025, as knowledge, scale of production, and size of the market increases.¹⁶

Over time, battery costs are also expected to decrease in conjunction with performance increases as a result of technology advancements. For example, the use of lithium-sulfur chemistry in next-generation batteries may increase the energy density of the battery pack and improve the driving range of EVs, while also diminishing potential safety hazards. Advances in battery technology are commonly cited as a prerequisite for widespread adoption of EVs because they will assist in decreasing vehicle cost, improving electric drive range, and ensuring vehicle reliability.

¹⁰ Between 70 and 75 percent of the energy in gasoline is lost between the engine and the wheels (as heat, friction, driving pumps, etc.). EVs are inherently much more efficient and lose only about 20 percent of the electrical energy between the battery and the wheels.

¹¹ Nikkei Electronics, "Toyota Announces 4-layer All-solid-state Battery," accessed June 2013, http://techon.nikkeibp.co.jp/english/NEWS_EN/20101122/187553/.

¹² Generation 1A battery systems are the initial batteries being currently produced. Generation 1B has the same chemistry as Generation 1A but with improved designs.

¹³ K.G. Duleep et al., "Assessment of Electric Vehicle and Battery Technology," ICF and Ecological Institute, 2011, 5.

¹⁴ K.G. Duleep et al., "Assessment of Electric Vehicle and Battery Technology," 11.

¹⁵ DOE, "The Recovery Act: Transforming America's Transportation Sector – Batteries and Electric Vehicles."

¹⁶ K.G. Duleep, "Technical Analysis for Alternative & Renewable Fuel & Vehicle Technology Program," 46.

1.4 Overview of EV Ownership Costs

Primary EV ownership costs include the purchase price and operation and maintenance costs.

Consumers' willingness to pay for new technology currently plays a large role in EV deployment. Nearly 70 percent of consumer survey respondents consider the manufacturer's suggested retail price (MSRP) to be the most important factor in their vehicle purchase decision.¹⁷

Consumers expect EVs to be cost competitive with similar ICE models, with a majority desiring a sticker price under \$30,000.¹⁸

Consumers' willingness to pay a premium for EVs depends on how much they value the features and benefits associated with the vehicles, as compared to ICE models. As of March 2013, for many consumers, the additional willingness to pay does not equal the difference in price (incremental cost) between an EV and a comparable ICE or HEV model.¹⁹ Table 1 provides a comparison of EV and similar ICE counterpart MSRP. Incentives for EV purchases can help address this price gap (for further discussion of EV incentives, see Section 9).

Table 1. Comparison of EV and Comparable Conventional Vehicle MSRP

EV	MSRP	Conventional Counterpart	MSRP	Federal Tax Credit	Price Difference Without Credit	Price Difference with Tax Credit
Chevrolet Volt	\$39,995	Chevrolet Cruze ECO	\$21,685	\$7,500	\$18,310	\$10,810
Ford Focus Electric	\$39,200	Ford Focus Titanium	\$24,200	\$7,500	\$15,000	\$7,500
Nissan LEAF S	\$28,800	Nissan Versa SL	\$18,590	\$7,500	\$10,210	\$2,710
Toyota Prius PHEV	\$32,000	Toyota Prius Three	\$25,765	\$2,500	\$6,235	\$3,735

Source: Chevrolet, 2013; Ford Motor Company, 2013; Nissan USA, 2013; Toyota, 2013.

Industry observers generally agree that the production cost of EVs will decrease over time, but they disagree as to how much vehicle *pricing* will change. The retail price of the EVs, especially for early models, does not necessarily correlate directly with the manufacturer's cost to produce the vehicle. It is possible that Nissan and Chevrolet are willing to sell their EV models (LEAF and Volt, respectively) at a loss initially in order to gain market share for the vehicles. The OEMs may hope that increased sales will lead to decreased unit production costs, which will enable the companies to recoup any initial losses in later years without changing the price of the vehicle.

¹⁷ Deloitte Consulting, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," accessed June 2013, http://www.deloitte.com.br/publicacoes/2007/MFG.Gaining_Traction_customer_view_of_electric_vehicle_mass_adoption.pdf, 14.

¹⁸ Deloitte Consulting, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," 14.

¹⁹ Deloitte Consulting, "Gaining Traction: A Customer View of Electric Vehicle Mass Adoption in the U.S. Automotive Market," 14.

It is possible that the incremental cost of EVs as compared to conventional vehicles will also change even if EV purchase prices remain constant. Conventional vehicles will likely become more expensive, as manufacturers comply with more stringent fuel economy and emissions standards.²⁰ The price increase for conventional vehicles will decrease the incremental cost for EVs.

Once individuals have purchased their vehicles, they incur vehicle operation (i.e., fuel) and maintenance costs. As illustrated in Table 2, EVs have significantly lower fuel costs as compared to similar conventional vehicles. However, the cost savings realized from EV operation (approximately \$0.10 per mile for AEVs, as compared to conventional vehicles) may decrease as manufacturers improve the fuel economy of conventional vehicles.

Table 2. Comparison of EV and Comparable Conventional Vehicle Cost Per Mile²¹

Electric Vehicle	EV Cost to Drive 25 Miles	Conventional Counterpart	Conventional Cost to Drive 25 Miles	Cost Differential per 25 miles	Cost Differential per Mile
Chevrolet Volt	\$1.05	Chevrolet Cruze ECO	\$2.91	\$1.86	\$0.074
Ford Focus Electric	\$0.96	Ford Focus Titanium	\$2.91	\$1.95	\$0.078
Nissan LEAF	\$1.02	Nissan Versa SL	\$2.58	\$1.56	\$0.0624
Toyota Prius PHEV	\$1.47	Toyota Prius Three	\$1.80	\$0.33	\$0.013

Source: EPA and DOE, "Compare Side-by-Side," accessed June 2013, <http://www.fueleconomy.gov/feg/Find.do?action=sbsSelect>.

The fuel cost savings from substituting electricity for gasoline are dependent upon the cost structure for electricity in a given region. Studies often estimate EV fuel costs based on fixed electricity prices (e.g., \$0.10 to \$0.12 per kWh). The price of electricity in the Northeast is typically high relative to the rest of the nation—New England states have average prices ranging from \$0.13 to \$0.20 per kWh.²² Consumers may receive varying rates depending on their residential load and charging patterns. Although they might incur additional charges by increasing their residential loads, they might also be able to charge their EVs at off-peak times in areas with lower overnight electricity rates. Thus, electricity costs might be lower or higher than estimated. In addition, analysts forecast a lower rate of inflation for electricity than for

²⁰ EPA and NHTSA, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," 40 CFR Parts 85, 86 and 600; 49 CFR Parts 523, 531, 533, 536 and 537, August 28, 2012.

²¹ Estimates are for the following 2013 vehicle models: LEAF (automatic) and Nissan Versa (1.8L, 4 cyl, automatic – variable gear ratios); Chevrolet Volt (1.4 L, 4 cyl, automatic) and Chevrolet Cruze Eco (1.4L, 4 cyl, automatic); Ford Focus Electric (front-wheel drive (FWD) – variable gear ratios) and Ford Focus (FWD, 2.0L, 4 cyl, automatic); Toyota Prius Plug-in Hybrid (1.8L, 4 cyl, automatic – variable gear ratios) and Toyota Prius Three (1.8L, 4 cyl, automatic - variable gear ratios).

²² Charles Zhu and Nick Nigro, "Plug-In Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review," accessed June 2013, <http://www.georgetownclimate.org/sites/default/files/TCI-EV-Lit-Review-1.pdf>.

gasoline.²³ The use of electricity as a transportation fuel reduces consumer exposure to volatility in the petroleum markets. For a detailed discussion of utility rate structures, see Section 10.

Another potential source of savings associated with EVs is reduced vehicle maintenance costs. EVs typically have regenerative braking, which requires significantly less maintenance (e.g., brake pad replacements) than normal braking. EVs without an ICE also do not require oil changes. Based on an interview with Ford representatives, EV owners save approximately \$200 to \$300 per year in avoided maintenance costs.²⁴

1.5 Vehicle Technology and Regulatory Trends in the Near, Mid, and Long Term

President Obama has called for an “all-of-the-above” strategy to promote energy independence, including reducing energy consumption and increasing domestic energy production. Although EV deployment would help achieve the goal of energy independence, other vehicle and fuel policies and technologies have also been deployed to help meet this goal:

- In the near term, OEMs can install fuel-saving technology to increase the fuel efficiency of conventional ICE vehicles;
- In the midterm, natural gas—increasingly abundant both nationally and in Pennsylvania—could support deployment of natural gas vehicles (NGVs); and
- In the long term, hydrogen fuel cells and other technologies could provide a breakthrough innovation that surpasses battery innovations.

This section presents an overview of the regulatory landscape and potential competitors and alternatives to EV deployment in the near, mid, and long term.

1.5.1 Near-Term Outlook

In the near term, EVs will primarily face competition from conventional fuel-saving technologies. Development in vehicle technologies will likely be driven by the Corporate Average Fuel Economy (CAFE) and GHG standards established by the National Highway Traffic Safety Administration (NHTSA) and the U.S. Environmental Protection Agency (EPA).

In the CAFE and GHG standards for vehicle model years (MY) 2012 to 2016, NHTSA and EPA increased the average fleet fuel economy requirements by approximately five percent per year. For MY 2016, the CAFE standards are estimated to increase fleet-average fuel economy to an average of 34.1 miles per gallon (mpg).

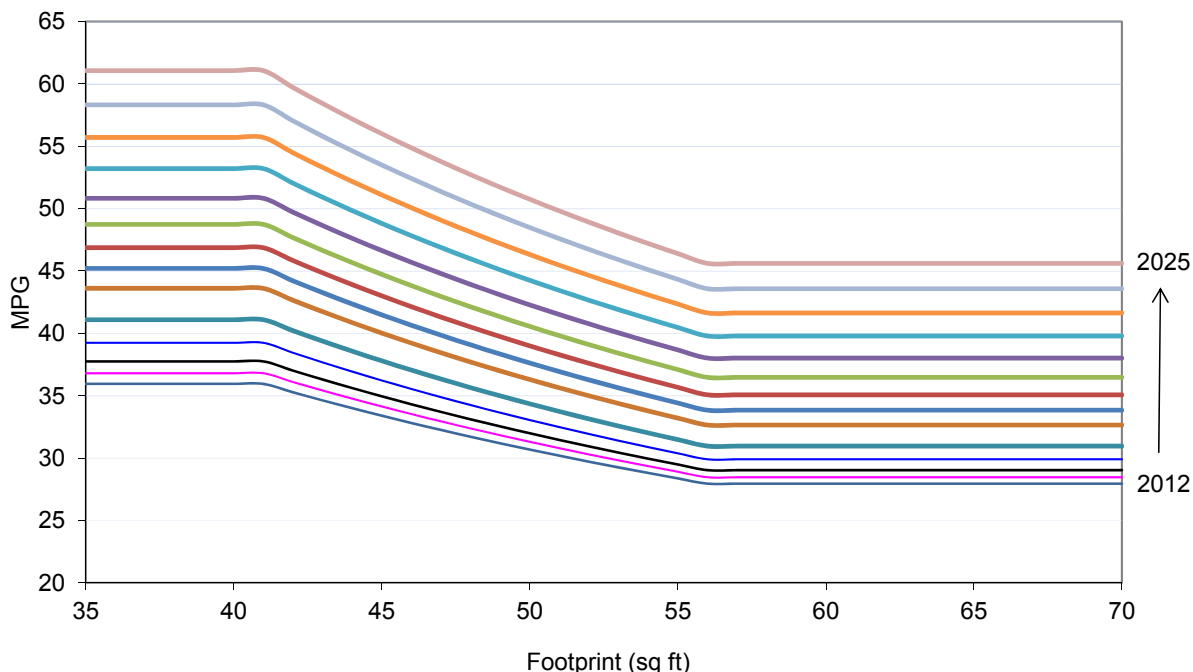
The CAFE standards use a formula based on a vehicle's footprint or area, which is determined by multiplying the track width by the wheelbase. A vehicle with a smaller footprint must meet a higher fuel economy than a vehicle with a larger footprint. Figure 2 illustrates the increasing

²³ EIA, “Annual Energy Outlook 2013: Table 3. Energy Prices by Sector and Source - United States,” accessed June 2013, <http://www.eia.gov/forecasts/aeo/data.cfm#enprisec>.

²⁴ Stephanie Janczak, Barbara Rogers, and Mike Tinsky (Ford Motor Company), phone interview, April 9, 2012.

stringency of the standards for LDVs from MY 2012 to 2025. The CAFE targets illustrated by these curves are designed so they do not favor small vehicles over large vehicles in order to maintain a variety of vehicle sizes and not limit consumer choice.

Figure 2. LDV CAFE Targets for MYs 2012-2025



Source: EPA and NHTSA, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," 40 CFR Parts 85, 86 and 600; 49 CFR Parts 523, 531, 533, 536 and 537, August 28, 2012.

The CAFE and GHG standards for MY 2017 to 2025 were finalized in August 2012. NHTSA and EPA estimate that the CAFE standards will require a LDV and a light-duty truck combined average of approximately 41 mpg in MY 2021 and approximately 49 mpg in MY 2025. EPA projects its GHG standards, which are harmonized with NHTSA's CAFE standards, to limit emissions of carbon dioxide (CO₂) to 163 grams per mile in MY 2025. The regulations do include some flexibility (e.g., credits for technologies like active aerodynamics). Furthermore, NHTSA and EPA will conduct a midterm review in 2017, during which OEMs are expected to advocate for a reduction in the stringency of the 2025 standards.

In the near term, OEMs will likely minimize compliance costs by implementing "conventional" fuel-saving technologies to meet the CAFE standards. OEMs have already introduced inexpensive technologies, such as low-friction lubricants, and well-known technologies, such as turbocharging, into their vehicles.

Table 3 (below) lists several technologies that, when combined, could improve fuel economy by over 20 percent by 2020, as well as additional innovations that could provide up to 16 percent additional improvement in fuel economy by 2025. These technologies may allow OEMs to

achieve compliance for ICE vehicles, while researching and developing more advanced fuel economy technologies. Note that improvements may not necessarily be additive.

Table 3. Estimates of Fuel Economy Improvements by Select Conventional Technologies

2016-2020	
Technology	Fuel Economy Improvement (%)
Weight Reduction	2 to 4.6
Drag Reduction	1.0
Tire Rolling Resistance	1.0
Idle Stop	2.5
Engine Friction Reduction	1.0
Gasoline Direct Injection Turbo Downsize	13.0
Electric Power Steering	1.5
Total	10 to 22
2021-2025	
Technology	Fuel Economy Improvement (%)
Weight Reduction	3.3 to 6.6
Drag Reduction	1.0
Tire Rolling Resistance	1.0
Engine Friction Reduction	1.0
2 nd Generation Gasoline Direct Injection Turbo	5.0
Camless Valves	4.0
Total	11 to 16

Source: H-D Systems, "Major OEM 2020-2025 CAFE and GHG Compliance Strategies," March 2012.

Table 4 documents the additional costs associated with implementing fuel-saving technologies that may be used in MY 2017 to 2025 vehicles. NHTSA and EPA estimated these figures to determine the feasibility of OEMs achieving the CAFE standards. All technologies included in the table are currently available, and every OEM produces at least one vehicle that uses one or more of the technologies. Mainstream adoption of these technologies is expected in the near to midterm.

Table 4. Estimated Increased Costs for a Midsize Sedan with V6 Engine in 2009²⁵

	2017 (\$/Car)	2018 (\$/Car)	2019 (\$/Car)	2020 (\$/Car)	2021 (\$/Car)	2022 (\$/Car)	2023 (\$/Car)	2024 (\$/Car)	2025 (\$/Car)
Technology									
Conventional Technologies									
Low-Friction Lube	4	4	4	4	4	4	4	4	4
Low-Rolling Resistance Tires	6 to 72	6 to 72	6 to 60	6 to 60	6 to 50	6 to 48	6 to 47	6 to 46	6 to 43
8-speed from 6-speed Transmission	80	78	71	70	69	68	67	66	65
Engine Friction Reduction	87 to 182	87 to 182	84 to 182	84 to 182	84 to 182	84 to 182	84 to 182	84 to 182	84 to 175
Cylinder Deactivation	192	189	173	170	167	165	162	160	157
Idle-Stop	394 to 446	385 to 436	348 to 395	340 to 385	332 to 376	324 to 368	317 to 359	310 to 351	303 to 343
Gasoline Direct Injection	413	407	370	364	359	353	348	343	338
Turbocharging	877	864	785	773	761	749	738	727	716
Conversion to Diesel	2,936 to 3,596	2,893 to 3,544	2,627 to 3,218	2,587 to 3,169	2,547 to 3,120	2,509 to 3,073	2,471 to 3,026	2,433 to 2,980	2,397 to 2,936
Mild Hybrid	3,116 to 3,944	3,053 to 3,864	2,554 to 3,233	2,496 to 3,160	2,440 to 3,089	2,386 to 3,021	2,334 to 2,954	2,283 to 2,890	2,234 to 2,827
Full Hybrid	4,947 to 5,352	4,881 to 5,281	4,111 to 4,448	4,049 to 4,381	3,989 to 4,315	3,930 to 4,251	3,872 to 4,188	3,815 to 4,127	3,759 to 4,067
Electric Powertrains									
PHEV 20-mile range*	12,296	11,084	10,333	9,356	9,302	9,248	9,195	9,144	7,605
PHEV 40-mile range*	15,900	13,100	12,349	10,969	10,914	10,860	10,807	10,756	8,894
AEV 75-mile range*	17,773	15,280	15,256	13,258	13,236	13,214	13,200	13,187	9,782
AEV 150-mile range*	26,983	23,106	23,083	19,977	19,955	19,934	19,920	19,907	14,716

Source: EPA and NHTSA, "DRAFT: Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards," 2011, 3-74 - 3-136.

²⁵ Expressed as U.S. dollars per vehicle. Does not include costs associated with EVSE.

At present, the fuel-savings technologies that OEMs incorporate into a conventional powertrain vehicle costs less than \$1,000 per technology. The most expensive technologies—turbocharging and gasoline direct injection—are also typically the most effective. Turbocharging technology consists of a fan that harnesses power from engine exhaust and forces compressed air into the cylinder. This compressed air injects additional fuel, producing more power. Turbocharging allows the vehicle to use a smaller engine without sacrificing performance. For instance, a turbocharged four-cylinder engine is estimated to have the same horsepower as a naturally aspirated six-cylinder engine. Turbocharging currently costs approximately \$700 to \$900 per vehicle and increases fuel economy by seven to eight percent.²⁶

Combining a turbocharged engine with gasoline direct injection (GDI) further increases the vehicle's fuel efficiency. A typical ICE mixes gasoline with air in a port and pumps that air/fuel mixture into the cylinder. GDI systems, by comparison, inject fuel directly into the cylinder to control the timing and shape of the fuel mist. This allows higher compression ratios and more efficient fuel intake, which deliver higher performance with lower fuel consumption. As Table 3 notes, combining GDI and turbocharging could result in a 13 percent fuel economy improvement and a combined cost of approximately \$1,300 per engine.

Using a diesel engine rather than a gasoline engine adds up to \$3,600 to the vehicle costs. Diesel engines are inherently more fuel efficient than conventional gasoline engines, and diesel fuel has higher energy density than gasoline. However, despite these benefits, diesel has four main barriers to market success. First, although diesel-powered vehicles typically have a higher fuel economy than gasoline vehicles, diesel fuel has greater carbon content on a volumetric basis than gasoline (resulting in approximately 15 percent greater GHG emissions) and thus is less attractive in the context of GHG standards. Second, compliance with nitrogen oxide (NOx) emissions regulations requires installation of expensive emissions reductions technologies.²⁷ Third, because diesel vehicles were plagued with performance and reliability issues in the 1980s, diesel has low consumer acceptance.²⁸ Fourth, the historically lower price of gasoline as compared to diesel has discouraged installation of diesel fueling infrastructure. As a result, the market share for diesel vehicles has consistently hovered around one percent of the total LDV market.^{29, 30} Currently, only German OEMs offer diesel vehicles in the United States, but more offerings may emerge in the next few years from U.S. manufacturers, including Chevrolet and Jeep. Diesel trucks, on the other hand, have dominated the heavy-duty market in the United States, and that trend will continue through the midterm. With future advances in gasoline engine technologies, diesel vehicles may not be cost competitive with other LDVs in the United States.

²⁶ DOE and EPA, "Engine Technologies," accessed June 2013, http://www.fueleconomy.gov/feg/tech_engine_more.shtml#dfi.

²⁷ U.S. Tier 2 emissions fleet average requirement of bin 5 require roughly 45 to 65 percent more NOx reduction compared to the Euro VI standards. EPA and NHTSA. "Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards," 3-94.

²⁸ EIA, "Light-Duty Diesel Vehicles: Efficiency and Emissions Attributes and Market Issues," accessed June 2013, <http://www.eia.gov/oiaf/servicerpt/lightduty/execsummary.html>.

²⁹ EIA, "Light-Duty Diesel Vehicles: Efficiency and Emissions Attributes and Market Issues."

³⁰ NHTSA, "New Passenger Car Fleet Average Characteristics," accessed June 2013, <http://www.nhtsa.gov/cars/rules/CAFE/NewPassengerCarFleet.htm>.

Another option for improving fuel economy in the near term is increasing the use of HEVs. This report groups HEV architectures into two general systems: mild hybrids and full hybrids, which add up to \$4,000 and \$5,400 to the base price of a conventional vehicle, respectively. An example of a mild hybrid is the Honda Civic's Integrated Motor Assist system. The Integrated Motor Assist system comprises an electric motor that connects to the engine's crankshaft and to the transmission through a torque converter or clutch. It provides sufficient torque for brake energy recovery. The motor also acts as the starter for the engine. However, unlike a full hybrid, a mild hybrid's motor cannot launch a vehicle on its own. An example of a full hybrid is the Toyota Prius. A full hybrid can operate on gasoline, a combination of gasoline and electricity, or on electricity alone for limited periods of time and can launch itself with only electric power. Supplementing gasoline with electricity recovered from vehicle operations allows the manufacturer to use a smaller ICE. Both types of HEVs provide emissions reduction benefits relative to comparable conventional ICE vehicles. Mild hybrids can reduce CO₂ emissions by 20 to 30 percent, and full hybrids can reduce CO₂ emissions by 20 to 35 percent.³¹ With these reductions, OEMs can comply with the GHG and CAFE regulations in the near to midterm, while keeping vehicle costs low relative to PHEVs and AEVs.

Because OEMs have a number of fuel-saving technologies they can use in the near term to comply with CAFE and GHG standards, experts do not expect a large increase in the market share of EVs in the near term. OEMs require, on average, a five-year lead time to design, develop, and test a new model, and OEM plans have already been determined through 2016. OEMs will add mature technologies into a vehicle's redesign cycle, gradually adding more advanced technologies to minimize costs and disruptions to the redesign cycle. As a result of this design cycle, the market share of new EVs will likely not increase dramatically in the near term.

CAFE and GHG standards could also have an indirect negative effect on EV deployment by affecting consumer buying patterns. Although NHTSA and EPA expect the standards to result in net cost savings for consumers due to lower fuel use, they do expect the average LDV purchase price to increase by \$154 to \$287 for MY 2017 and \$1,461 to \$1,836 for MY 2025.³² The increase in purchase price may encourage consumers to purchase a new vehicle before the regulations take effect. If consumers worry about the reliability of new EV technology and choose to purchase more familiar technology, EV market penetration may suffer. Alternatively, consumers may choose to purchase less expensive used vehicles or delay purchase of a new vehicle. As illustrated in Table 1 above, the price of an EV approaches double that of a comparable ICE without tax credits or other incentives. Although EVs save about \$2 in fuel costs per 25-mile trip, these savings may not make up the price difference for many drivers, and cost-sensitive consumers may purchase less expensive used or new conventional vehicles.

³¹ EPA and NHTSA, "Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards," 3-114 - 3-116.

³² EPA and NHTSA, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," accessed June 2013, http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cape/2017-25_CAFE_Final_Rule.pdf, 1015 and 1503-1505.

The future sustainability and growth of EV sales is uncertain. For instance, Nissan fell short of its goal of 20,000 LEAF sales in 2012—the company recorded only 9,819 sales.^{33, 34} Thus, OEMs will likely continue to focus on designing vehicles with conventional fuel-saving technologies, supplemented by low-volume EV production. Increasing fuel economy of conventional vehicles may pose significant competition to EV deployment.

1.5.2 Midterm Outlook

In the midterm, CAFE and GHG standards will continue to influence vehicle technology development. In addition, regulations and incentives that encourage natural gas development could influence the vehicle market, and EVs could face competition from NGVs.

In the MY 2017 to 2025 GHG and CAFE standards, EPA adopted temporary manufacturer incentives to encourage AEVs, PHEV, NGVs, and fuel cell vehicles (FCVs). These incentives build upon the MY 2012 to 2016 multiplier incentive, which allows OEMs to count EVs, FCVs, and NGVs as more than one vehicle in CAFE fleet calculations. For MY 2012 to 2016, the multipliers are 2.0 for AEVs and FCVs, 1.2 for PHEVs, and 0 for NGVs. For MY 2017 to 2021, the multipliers range from 1.3 to 2.0, as summarized in Table 5 (below). EPA will not offer multiplier incentives after 2021.

Table 5. Vehicle Multiplier Credits for Model Year 2012-2021

Model Year(s)	AEVs and FCVs	PHEVs	NGVs
2012-2016	2.00	1.20	0
2017-2019	2.00	1.60	1.6
2020	1.75	1.45	1.45
2021	1.50	1.30	1.30

Source: US EPA and NHTSA, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," 669, 680.

Natural gas presents many opportunities as a fuel for vehicles. It is both abundant and inexpensive in the United States. Because of the abundant supply, natural gas prices have dropped significantly during the years immediately preceding this study's publication. Prices will likely remain low in the foreseeable future.³⁵

Pennsylvania, in particular, may benefit from NGV deployment because it has a large supply of natural gas. According to the U.S. Energy Information Administration (EIA), Pennsylvania's natural gas production increased from approximately 500 thousand cubic feet per day (Mcf) to 3,500 Mcf between 2008 and 2011 due to horizontal drilling with hydraulic fracturing in the Marcellus, Utica, and Genesee/Burket shale formations.³⁶ The Pennsylvania Department of Conservation and Natural Resources estimates that the Marcellus Shale contains between two

³³ Crain Communications, Inc., "U.S. light-vehicle sales by nameplate, December and YTD 2012," *Automotive News*, June 6, 2013.

³⁴ Lindsay Chappell, "A big bet on EVs," accessed June 2013, <http://www.autonews.com/apps/pbcs.dll/article?AID=/2012/10/08/OEM01/310089981/a-big-bet-on-evs>.

³⁵ EPA and NHTSA, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," 678-9.

³⁶ EIA, "Horizontal drilling boosts Pennsylvania's natural gas production," accessed June 2013, <http://www.eia.gov/todayinenergy/detail.cfm?id=6390>.

trillion cubic feet (Tcf) and 500 Tcf of natural gas,³⁷ and the State of Pennsylvania has issued close to 12,000 well permits in the Marcellus Shale formation alone.³⁸ A study by Penn State University estimates that during 2010, natural gas drilling and production in the Marcellus Shale added \$11.2 billion to the regional economy and created 140,000 jobs. The study forecasts that by 2020, Marcellus Shale will have added \$20.2 billion to the regional economy and created 256,000 jobs.³⁹ However, because of the increase in supply and resulting decrease in natural gas prices, drilling companies have reduced operations in Pennsylvania. Drilling began on 618 new natural gas wells between January and April 2012. This represents a decline from the previous year, when drilling began on over 700 new natural gas wells in that same timeframe.⁴⁰ Promoting NGV deployment could help stimulate the demand for natural gas production in Pennsylvania and provide benefits for the Commonwealth's economy.

EPA estimates that natural gas may reduce tailpipe GHG emissions by approximately 20 percent relative to gasoline.⁴¹ However, it is critical to note that natural gas primarily consists of methane, which is a GHG with a 100-year global warming potential that is 21 times that of CO₂.⁴² Thus, even a small leak of natural gas into the atmosphere during extraction, transmission, fueling, or storage (in or out of the vehicle) significantly reduces and can even outweigh its other GHG benefits.

Although natural gas is a fossil fuel, NGVs can also be fueled with methane captured from landfills and animal waste, or methane purposely made from other biological sources. This so-called biogas can provide a renewable source of fuel for NGVs.

Another benefit of natural gas is its well-developed distribution infrastructure in the United States. Approximately 300,000 miles of interstate pipelines and 1.2 million miles of distribution lines exist throughout the nation.⁴³ Where no distribution lines exist, trucks can transport natural gas to fueling locations. Many homes have access to natural gas, which could enable home vehicle refueling. BRC FuelMaker offers a home refueling option for LDVs. However, sales of these devices have been low. Honda, which once promoted the \$4,500 unit, now recommends that owners of its NGV (the Civic GX) avoid refueling at home because of concerns regarding moisture and contaminants, which may void the vehicle's warranty.⁴⁴ NGV deployment would

³⁷ Pennsylvania Department of Conservation and Natural Resources, "Marcellus Shale," accessed June 2013, http://www.dcnr.state.pa.us/topogeo/econresource/oilandgas/marcellus/marcellus_faq/marcellus_shale/index.htm.

³⁸ Pennsylvania Department of Conservation and Natural Resources, "Marcellus Shale."

³⁹ Timothy J. Conside, Robert W. Watson, and Seth Blumsack, "The Pennsylvania Marcellus Shale Natural Gas Industry: Status, Economic Impacts and Future Potential," accessed June 2013, <http://marcelluscoalition.org/wp-content/uploads/2011/07/Final-2011-PA-Marcellus-Economic-Impacts.pdf>, 31.

⁴⁰ EIA, "Horizontal drilling boosts Pennsylvania's natural gas production," accessed June 2013, <http://www.eia.gov/todayinenergy/detail.cfm?id=6390>.

⁴¹ EPA and NHTSA, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," 677.

⁴² EPA, "Methane Emissions," accessed June 2013, <http://www.epa.gov/climatechange/ghgemissions/gases/ch4.html>.

⁴³ NGV America, "Available NGV Aftermarket Conversion Systems," accessed June 2013, http://www.ngvc.org/pdfs/Available_Vehicles_and_Engines.pdf.

⁴⁴ American Honda Motor Company, Inc., "Frequently Asked Questions," accessed June 2013, <http://automobiles.honda.com/civic-natural-gas/faq.aspx>.

therefore benefit from additional public fueling infrastructure. As of June 2013, there were 660 public natural gas fueling stations in the United States and 24 public stations in Pennsylvania.⁴⁵

A hurdle to widespread light-duty NGV deployment is lack of demand and vehicle cost. In the United States, sales average only a few thousand vehicles per year, or about 0.02 percent of the total vehicle market. Only one compact car, the Civic GX, is marketed directly by an OEM. Honda sells approximately 1,500 to 2,000 units of the Civic GX per year.⁴⁶ If sales do not increase, experts anticipate that Honda will stop producing the vehicle by 2015. Ford introduced a compressed natural gas (CNG) version of its Transit Connect in 2011 and announced over 120 orders in Los Angeles and Chicago.⁴⁷ Toyota expressed interest in CNG and showed a concept vehicle at the 2008 Los Angeles Auto Show. However, there is no indication that the concept vehicle will be produced. Overall, OEMs have not indicated support for the natural gas market in terms of LDV offerings. Aftermarket converters will likely offer most of the light-duty NGV products in the near to midterm.

Several aftermarket conversion companies specialize in CNG vehicle retrofits.⁴⁸ In the light-duty market, conversions typically occur on larger vehicles because smaller vehicles sacrifice trunk space for the CNG fuel tank. Most conversions occur on large pickup trucks and cargo vans, such as the Ford F-Series, Chevrolet Silverado, and Dodge Grand Caravan. Conversion systems must achieve EPA and/or California Air Resources Board (CARB) certification, which requires time and money. However, in 2011, EPA revised regulations to allow conversions of vehicles older than two years to demonstrate compliance through test data of exhaust and evaporative emissions only without certification.⁴⁹ This allowance may help reduce the cost of conversion certifications and, as a result, vehicle conversion.

Light-duty NGVs currently cost approximately \$7,000 to 15,000 more than their gasoline counterparts; the MY 2012 Civic GX base model starts at \$26,305, approximately \$2,000 more than the Civic Hybrid and \$10,000 more than the base gasoline-version Civic DX.⁵⁰ There are state incentives that may reduce those incremental costs. For example, Pennsylvania's Alternative Fuels Incentive Grant (AFIG) Program offers a \$1,000 tax rebate for qualified CNG vehicles.⁵¹

Medium- and heavy-duty vehicles (e.g., transit buses, delivery trucks, and tractor trailers) can also use CNG and liquefied natural gas (LNG) technology. In 2011, an estimated 52,000

⁴⁵ CNGPrices.com, "Compressed Natural Gas (CNG) stations and prices for Pennsylvania (PA)," accessed June 2013, <http://www.cngprices.com/stations/CNG/PA>.

⁴⁶ AOL Autos, "Exclusive: Honda Confirms Next-Gen Civic GX Natural Gas Vehicle," accessed June 2013, <http://translogic.aolautos.com/2010/09/15/exclusive-honda-confirms-next-gen-civic-gx-natural-gas-vehicle/>.

⁴⁷ Ford Motor Company, "A Taxi Trend: Ford Transit Connect Compressed Natural Gas Taxis Heading to Los Angeles and Chicago," accessed June 2013, http://media.ford.com/article_display.cfm?article_id=34802.

⁴⁸ NGVAmerica, "Available NGV Aftermarket Conversion Systems," accessed June 2013, http://www.ngvc.org/pdfs/Available_Vehicles_and_Engines.pdf.

⁴⁹ EPA, "EPA Announces Final Rulemaking for Clean Alternative Fuel Vehicle and Engine Conversions," accessed June 2013, <http://www.epa.gov/otaq/consumer/fuels/altfuels/documents/420f12058.pdf>, 4.

⁵⁰ American Honda Motor Company, Inc., "Options & Pricing," accessed June 2013, <http://automobiles.honda.com/civic-sedan/price.aspx>.

⁵¹ PA DEP, "Alternative Fuels Incentive Grant Program: Alternative Fuel Vehicle Rebates," accessed June 2013, http://www.portal.state.pa.us/portal/server.pt/community/alternative_fuels_incentive_grant/10492/alternative_fuel_vehicles/553206.

medium- and heavy-duty CNG and LNG trucks were on the road in the United States.⁵² Natural gas vehicles can have a shorter range per fueling event when compared to a diesel fueled vehicle due to a combination of lower fuel economy and onboard fuel storage limitations. However, heavy duty natural gas engines do not require complex and expensive after-treatment emissions reduction technologies to meet stringent standards, such as diesel particulate filters and selective catalytic reduction catalysts. Heavy-duty natural gas trucks and buses typically cost \$50,000 to \$100,000 more than their diesel counterparts, depending on vehicle size and range requirements.⁵³ However, PA DEP provides grants to reimburse purchases or retrofits of heavy-duty NGVs, with up to \$20 million through 2015.⁵⁴ DVRPC, together with several of the partners involved in the development of this plan, is managing the Pennsylvania Partnership to Promote Natural Gas Vehicles. This project, supported by DOE Clean Cities funding, will focus on CNG refuse and recycling vehicles, as well as school buses.

Natural gas provides a viable midterm solution to GHG emissions reductions because it is an inexpensive and abundant fuel with a well-developed distribution infrastructure. The market for NGVs is relatively small in the near and midterm, but product offerings could increase with supportive regulations and temporary incentives. Natural gas technology could also serve as a bridge to hydrogen FCV deployment.

1.5.3 Long-Term Outlook

In the long term, FCVs could present competition for EVs. One of the primary drivers for FCVs today is the potential compliance pathway for zero emission vehicle (ZEV) regulations in California.

There are currently several major challenges to deploying FCVs. For example, OEMs have stated that significant technological and economic gaps exist in the distribution of hydrogen from production facilities to fueling stations.^{55, 56} In order for FCVs to compete, expanded hydrogen distribution infrastructure will be necessary. Federal and state programs, together with the private sector, could provide the necessary investment.

Currently, hydrogen is distributed either as a compressed gas in cylinders or in liquefied form in tanker trucks. Compressed gas is space inefficient, requiring a large truck to carry 50 to 100 kg of hydrogen. Liquefaction and cryogenic storage are energy inefficient and expensive; approximately one-third of the energy content of hydrogen is used in the liquefaction process. Because of these challenges, most hydrogen is produced in large facilities close to the where it is used. This approach works well for large commercial chemical applications, where the fuel is

⁵² EIA, "How many alternative fuel and hybrid vehicles are there in the U.S.?", accessed June 2013, <http://www.eia.gov/tools/faqs/faq.cfm?id=93&t=4>.

⁵³ Baytech (CNG Aftermarket Converter), phone interview, 2009.

⁵⁴ PA DEP, "Natural Gas Vehicle Program," accessed June 2013, http://www.portal.state.pa.us/portal/server.pt/community/act_13/20789/natural_gas_vehicle_program/1157504.

⁵⁵ USA Today, "Automakers take fresh look at hydrogen fuel cells," accessed June 2013, <http://www.usatoday.com/story/driveon/2012/10/02/hydrogen-fuel-cells-2015/1605229/>.

⁵⁶ Angela G. Keane and Alan Ohnsman, "Fuel-Cell Frenzy Looks to Convert Obama Favoring Plug-Ins," accessed June 2013, <http://www.businessweek.com/news/2012-06-20/fuel-cell-frenzy-looks-to-convert-obama-favoring-plug-ins#p1>.

consumed at a single facility. However, it is not well suited for distributed consumption at local fueling sites.

One method of hydrogen production—steam methane reforming using natural gas as a feedstock fuel—shows promise for overcoming this distribution challenge. In this process, natural gas feedstock converts to hydrogen on site through high-temperature mixing with vaporized water, resulting in hydrogen and carbon dioxide. Further purification removes contaminants (e.g., sulfur) from the fuel to prevent damage to the FCV. However, gaps exist in several components of the on-site production cycle. EPA believes that investments in a natural gas infrastructure could lay the framework for the infrastructure necessary for on-site hydrogen production.⁵⁷ Future fueling stations could produce hydrogen using natural gas that is already being delivered to the site.

An alternative option to balance production and distribution costs may be developing a network of small- to medium-scale production facilities close to the network of hydrogen stations. Such a network would reduce the burden of downstream distribution, while avoiding the costs of on-site production. However, it may be limited by production-level capacity. Large centralized facilities can produce approximately one million kg of hydrogen per day. In contrast, distributed facilities would produce only 5,000 to 50,000 kg of the fuel daily. This low-volume production could support the nascent hydrogen fuel market to 2020, but it would not be enough to support a large population of FCVs.

Vehicle production cost also presents a barrier to FCV deployment. The current production cost of an FCV in production volumes of 100 to 200 vehicles per year is estimated at approximately \$100,000 (of which the fuel cell system alone accounts for about half the cost).⁵⁸ If manufacturers produce these vehicles at volumes of 10,000 to 20,000 a year, typical scale elasticities of -0.2 for the fuel cell system suggest vehicle prices in the \$50,000 range. This price would still be too expensive for the mass market, even with the currently available federal tax credit. In addition, current fuel cell systems cannot last the life of a vehicle (typically 15 years), and the cost of replacement is very high. Hence, market entry requires substantial cost reduction for fuel cell production.⁵⁹

An additional challenge is on-board storage of hydrogen. Historically, vehicles stored hydrogen in high-pressure tanks at 350 bar pressure. This limited storage to about three kg of hydrogen, which provides approximately 200 miles of range. Newer vehicles use 700 bar storage, which allows storage of about five kg of hydrogen and increases vehicle range to approximately 350 to 400 miles. However, the carbon fiber-wrapped tanks to store five kg of hydrogen at 700 bar storage currently cost about \$15,000 per vehicle and will be expensive even in high-volume production. Reducing the price of FCVs will require improvements in on-board hydrogen storage.

⁵⁷ EPA and NHTSA, "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards," 679.

⁵⁸ ICF, "Hydrogen Fuel Cell Vehicles: Latest Developments and Product Plans," August 2012.

⁵⁹ ICF, "Hydrogen Fuel Cell Vehicles: Latest Developments and Product Plans."

OEMs have made improvements in all aspects of fuel cell technology, including size, durability, and cost, and they anticipate that they will have made sufficient progress on these issues to allow for low-scale production in 2015 to 2016. For example, Toyota plans to release a fuel-cell sedan in 2015.⁶⁰

OEMs believe that FCV technology is the most economically feasible zero-emission technology for larger vehicles (EV battery size and weight pose disadvantages for larger applications). In the long term, OEMs like Toyota expect to produce AEVs for compact cars, PHEVs for midsize vehicles, and FCVs for light-duty to heavy-duty trucks.⁶¹

This overview of the near- to long-term outlook for clean vehicle technologies demonstrates that EVs are not the only pathway to a cleaner environment and petroleum independence. Other fuels and technologies, such as natural gas and fuel cells, could also provide viable solutions. The auto industry will continue to innovate and reduce the production costs of advanced technologies like batteries and fuel cells. In particular, if OEMs decrease production costs, and fuel producers and distributors expand the hydrogen fueling infrastructure, FCVs may experience increased market penetration in the long term.

This overview also highlights the role of policy and regulations in the commercial success of emerging technologies. The GHG and CAFE regulations have already encouraged use of conventional ICE technologies to increase fuel economy and will likely require deployment of EVs for compliance in the midterm. In the long term, the CAFE and GHG regulation vehicle multiplier incentives could generate competition between EV and FCV technology. The Commonwealth of Pennsylvania may add to these incentives by providing temporary tax credits and rebates for NGVs, which could increase natural gas demand and benefit the Pennsylvania economy.

⁶⁰ Alisa Priddle, "Toyota to start selling hydrogen fuel-cell car in 2015," accessed June 2013, <http://content.usatoday.com/communities/driveon/post/2012/08/toyota-to-start-selling-hydrogen-fuel-cell-car-in-2015/1#.UbD5EefV9c8>.

⁶¹ Toyota Motor Corp, "Toyota's Strategy for Environmental Technologies," accessed June 2013, http://www.toyota-global.com/innovation/environmental_technology/strategy_environmental_tech.html.

2 Charging Technology Overview

Drivers fuel conventional vehicles by pumping gasoline into the vehicle's tank at a gas station. The gasoline powers the vehicle's ICE. Alternatively, drivers fuel EVs by plugging them into EVSE to charge the battery. The battery powers the EV's electric motor. EVSE consists of EV connector plugs, power outlets, grounding conductors, and any other apparatus that delivers energy to the vehicle. "Charging station" is another term for EVSE.

Several factors constrain the charging process, including the limited rate at which the chemical reactions that charge the battery take place and constraint on the amount of electricity that flows into the charging device from the electricity grid or other source of electricity. Because the time needed to charge an EV is measured in hours, not minutes, the charging of an EV is fundamentally different from fueling a conventional gasoline-fueled vehicle. Experience to date indicates that most drivers will charge EVs primarily at home and at dedicated workplace charging facilities. They will also likely use EVs in applications where they will not have to regularly rely on publicly shared charging stations.

The provision of publicly shared EVSE is a topic of great concern within the EV community. The ability to charge away from home or work requires public EVSE that is well integrated into city, suburban, and rural infrastructure. Of the two types of EVs, AEVs will rely more heavily on public EVSE because of their complete reliance on electricity. Although availability of public EVSE will also encourage PHEV deployment, PHEVs operate on gasoline as a supplemental or backup fuel and are therefore less likely to make use of public EVSE. Though the cost of purchasing and installing EVSE is low compared to conventional retail stations, it is high relative to the return on investment from selling electricity. Additionally, EVSE have less throughput than a retail station.

In addition to the physical limitations of current EV technology, consumer concerns also affect the need for EVSE. As the market for EVs grows, the location and number of EVSE influences the growth. Range anxiety, or the fear of being stranded in an EV when its battery is fully discharged, is a significant consumer concern. Consumer uncertainty about how to use EVSE to charge EVs is another significant barrier. Range anxiety and EVSE unfamiliarity may fade as consumers are educated, but they remain obstacles to purchasing EVs. Readily available charging infrastructure could encourage EV sales by alleviating range anxiety, while increased sales will likely cause EV stakeholders to build more EVSE.

Numerous research studies identify the current and future EVSE requirements for EVs. For example:

- SFEnvironment's Workshop—"EV Chargers in Multifamily Buildings"—addressed concerns

about EVSE accessibility in multiunit dwellings (MUDs) in San Francisco, California.⁶² Like San Francisco, the Philadelphia region has a significant portion of residents residing in MUDs. DVRPC hosted a “Garage Free Summit” in February 2012 to discuss these issues. A summary of the event may be found in Appendix D.

- The University of California, Davis, conducted EVSE consumer behavior research and published the results in “Households’ Plug-In Hybrid Electric Vehicle Recharging Behavior”⁶³ and “The UC Davis MINI E Consumer Study.”⁶⁴
- Funded through a DOE grant, ECOtality and its partners developed The EV Project, which installed public and private EVSE and provided financial assistance for installation costs in cities across the country. This project generated data on consumer EVSE usage patterns. In August 2012, ECOtality added the Greater Philadelphia region to its EV Project target regions.⁶⁵ ECOtality’s experience with EV and EVSE deployment informs various aspects of this plan.

The following sections provide information about EVSE technology.

2.1 EVSE Types

EVSE technologies differ by the maximum power and the type of current that they provide. SAE International sets standards for EVSE technologies based on their power—Level 1 or Level 2—and current type—alternating current (AC) or direct current (DC). The primary EVSE types used in the United States are:

- **Level 1 AC** – These chargers use standard 120 volt (V), single-phase service at 15 to 20 amperes (A). They can plug in to a standard three-prong electrical outlet and do not require any electrical service upgrades. The National Electric Code (NEC) allows connections with cords not exceeding 25 meters in length; local codes may also apply.⁶⁶ Level 1 charging outlets should have ground fault interrupters installed and a 15 A minimum branch circuit protection. Level 1 EVSE is often included or sold with EVs. The main drawback of Level 1 EVSE is the time required to charge the EV (see Table 6 for example vehicle charging times).⁶⁷
- **Level 2 AC** – These chargers use 208 to 240V and up to 80 A, allowing for quicker vehicle charging (see Table 6 for example vehicle charging times). They use the SAE-approved J1772 connector and may require additional grounding, personal protection system

⁶² San Francisco Department of the Environment, “EV Chargers in Multifamily Buildings,” accessed June 2013, http://www.sfenvironment.org/sites/default/files/agenda/attach/electric_vehicle_multicharge_update_presentation.pdf

⁶³ Jamie Davies-Shawhyde and Kenneth Kurani, “Households’ Plug-In Hybrid Electric Vehicle Recharging Behavior: Observed Variation in Households’ Use of a 5kWh Blended PHEV-Conversion,” accessed June 2013, http://pubs.its.ucdavis.edu/download_pdf.php?id=1424.

⁶⁴ Thomas Turrentine et al., “The UC Davis MINI E Consumer Study,” accessed June 2013, http://pubs.its.ucdavis.edu/download_pdf.php?id=1470.

⁶⁵ ECOtality, “EV Project Offers Free Blink(R) Chargers to EV Drivers and Commercial Host Sites in Philadelphia,” accessed June 2013, <http://investor.ecotality.com/releasedetail.cfm?ReleaseID=697219>.

⁶⁶ M. Rawson and S. Kateley, “Electric Vehicle Charging Equipment Design and Health and Safety Codes,” California Energy Commission, August 1998.

⁶⁷ SAE International, “SAE Charging Configurations and Ratings Terminology,” accessed June 2013, <http://www.sae.org/smartgrid/chargingspeeds.pdf>.

features, no-load make/break interlock connection, and a safety breakaway for the cable and connector. If 208/240V service does not exist at the site, the utility must provide a service upgrade.

Table 6. Charging Levels included in SAE Standards

Level	Electric Potential Difference (V)	Current (A)	Max Power (kW)	Estimated Time for Chevrolet Volt to achieve full charge (hrs) ⁶⁸	Estimated Time for Nissan LEAF to achieve full charge (hrs) ⁶⁹
Level 1 AC	120	15 to 20	1.4 to 1.9	10	22
Level 2 AC	208/240	up to 80	19.2	4	7

Source: SAE International, "SAE Charging Configurations and Ratings Terminology," accessed June 2013, <http://www.sae.org/smartgrid/chargingspeeds.pdf>; Chevrolet, 2013; Nissan, 2013.

- DC fast chargers** – These chargers provide electricity converted from a 480V AC input and enable rapid vehicle charging. A DC fast charger can add 60 to 80 miles of range to an EV in approximately 20 minutes, making it well suited for heavy traffic corridors and public locations.⁷⁰ However, DC fast chargers cost significantly more to build and operate than Level 1 or Level 2 chargers, making the business model tenuous at best. These costs, including installation, equipment, and electrical upgrades, can range from \$17,000 to \$42,000, as discussed in Section 6.2. Some manufacturers are concerned that fast charging may shorten the life of batteries or present a safety hazard. In addition, some observers are concerned that fast chargers will put additional load on electrical grids at peak usage times.

Standards for DC fast-charging technology are still evolving at the time of this publication. In 2012, SAE International finalized the J1772 Revision Number B standard for the DC fast-charging coupler, which revises the J1772 connector standard by adding an additional connection.⁷¹ The new J1772 is called a "Combo" connector, capable of charging with Level 1 and 2 AC chargers as well.

2.2 EV Charging Times

Generally, an EV's battery size, on-board charging system, and characteristics of the EVSE system determine charging time. However, other factors, including ambient temperature, may also influence charging time.

The Chevy Volt and Nissan LEAF both include a 3.3 kilowatt (kW) on-board charger. This means that, even though a Level 2 AC charger can deliver power at six or seven kW, the EV's

⁶⁸ Chevrolet, "2013 Chevy Volt," accessed June 2013, <http://www.chevrolet.com/volt-electric-car.html>.

⁶⁹ Nissan, "Charging at Home," accessed June 2013, <http://www.nissanusa.com/leaf-electric-car/home-charging>.

⁷⁰ DOE, "Plug-In Electric Vehicle Handbook for Public Charging Station Hosts," accessed June 2013, <http://www.afdc.energy.gov/pdfs/51227.pdf>.

⁷¹ SAE International, "SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler," accessed June 2013, http://standards.sae.org/j1772_201210/.

on-board system limits the rate of delivery to 3.3 kW. The Tesla Roadster can charge at a rate of 10 to 20 kW and, according to Nissan, future Nissan LEAF models will include a 6.6 kW on-board charger, which could cut its current charging time in half.⁷²

Beyond an EV's charging capabilities, extreme temperatures can impact charging times, even though EVs do have thermal management systems that reduce the effects of hot or cold temperatures on the battery pack.⁷³ For example, an external temperature of 120 to 130 degrees °F can increase the charging time for DC fast charging from an average of 20 minutes to over 30 minutes.⁷⁴

Table 7 presents estimated charging times for EVs currently on the market. In general, Level 1 EVSE works best for vehicles with small batteries, such as the Volt and Prius, which require fewer than eight hours to fully charge. On the other end of the spectrum, light- and medium-duty truck EVs will take over 20 hours to fully charge with Level 1 EVSE. A vehicle's charging rate is generally limited by the on-board charger. For example, a Nissan LEAF is limited by its 3.3 kW on-board charger and would take six hours and 32 minutes to charge, even if the Level 2 charger had a faster charging rate of 7.5 kW. Alternatively, a Tesla Roadster with a larger on-board charger could theoretically charge at a higher speed but may be limited by the speed of the EVSE at 7.5 kW, resulting in a total charging time of five hours and 39 minutes.

Table 7. Estimated Charging Times by EV Model

Vehicle	Maximum Charge Rate of On-board Charger (kW)	Vehicle Usable/Max Capacity (kWh)	Estimated Charge Time with Level 1 AC (1.4 kW)	Estimated Charge Time with Level 2 AC (7.5 kW) ⁷⁵
Nissan LEAF (AEV)	3.3	21.6/24	15 hrs, 25 min	6 hrs, 32 min ⁷⁶
Tesla Roadster (AEV)	10-20	42.4/53	30 hrs, 17 min	5 hrs, 39 min ⁷⁷
Chevrolet Volt (PHEV)	3.3	10.4/16	7 hrs, 25 min	3 hrs, 9 min
Toyota Prius Plug-in (PHEV)	3.3	3.5/4.4	3 hrs, 8 min	1 hr, 20 min

Source: Vehicle usable/max capacity calculations from ICF International, 2013; Chevrolet, 2013; Nissan, 2013; Tesla Motors, 2013; Toyota, 2013.

2.3 Strategies and Technologies to Accommodate Increasing Electricity Demand Due to EV Charging

As EVs become more common, the additional electricity demand from EV charging may require utilities to upgrade distribution infrastructure. Utilities may also choose to implement new load management strategies and technologies, such as dynamic pricing and smart grid technology.

⁷² David Peterson (Nissan North America), phone interview, March 30, 2012.

⁷³ Sustainable Transportation Strategies, "Siting Electric Vehicle Charging Stations," accessed June 2013, <http://www.sustainabletransportationstrategies.com/wp-content/uploads/2012/05/Siting-EV-Charging-Stations-Version-1.0.pdf>, 29.

⁷⁴ David Peterson (Nissan North America), phone interview, March 30, 2012.

⁷⁵ Even though Level 2 charging allows up to 7.5 kW, it is limited by the On-board charger which in most cases is 3.3 kW.

⁷⁶ Even though Level 2 charging allows up to 7.5 kW, it is limited by the On-board charger which in most cases is 3.3 kW.

⁷⁷ With the Tesla, limited by a 7.5kW charger, would take a longer period of time.

Electricity demand changes throughout the day. Residential demand often peaks in the early evening, when people return home from work or school and begin to cook, watch television, adjust the heating and air conditioning, and use other electric devices. Charging EVs during these peak hours could strain the electric distribution grid by increasing peak electricity demand. Fully recharging an EV uses the equivalent of about a day's worth of electricity usage for a single-family home.

A dynamic pricing strategy could help to manage the additional load associated with EV charging. Dynamic pricing refers to assigning different rates based on time-of-use (TOU). For example, a utility could charge a higher rate during peak hours and a lower rate during off-peak hours (e.g., between 11 p.m. and 7 a.m.). This would encourage electricity usage during off-peak hours to level out demand. EV controls typically allow the user to program the vehicle's charging system to delay charging until a specified time, allowing the user to take advantage of off-peak rates.

PA PUC recently approved a PECO proposal for an initial dynamic pricing and customer testing program. This program will serve as a first step toward developing a tariff structure to encourage off-peak EV charging. It can provide a model for other electricity distribution companies that serve customers in southeastern Pennsylvania, none of which currently offer a tariff specific to EV owners.

Utilities outside of the region are also exploring electricity rate strategies to encourage off-peak charging. Section 10 provides examples of utility pilot programs, utility tariff options, and utility grid impact analysis, such as:

- The Edison Electric Institute (EEI) report, "The Utility Guide to Plug-in Electric Vehicle Readiness," provides an overview of topics relevant to utilities in southeastern Pennsylvania, including PECO.⁷⁸
- Researchers from the University of California, Davis, published a paper titled "Electricity Grid: Impacts of Plug-In Electric Vehicle Charging," which analyzed projected grid impacts from EV charging.⁷⁹ In the paper, the authors encourage decision-makers to consider the deployment of EVs on a regional basis and ensure that appropriate technology and policy incentives were implemented to maximize the benefit of EVs.

In addition to dynamic pricing, smart grid technology presents another opportunity to mitigate grid impacts from EV charging. A smart grid is an electric grid in which computers control the delivery of electricity. A smart grid would facilitate the use of two technologies currently in development: smart grid communication technology and vehicle-to-grid (V2G) technology.

⁷⁸ EEI, "The Utility Guide to Plug-in Electric Vehicle Readiness," accessed June 2013, http://www.eei.org/ourissues/EnergyEfficiency/Documents/EVReadinessGuide_web_final.pdf, 34.

⁷⁹ Christopher Yang and Ryan McCarthy, "Electricity Grid Impacts of Plug-In Electric Vehicle Charging," accessed June 2013, http://pubs.its.ucdavis.edu/download_pdf.php?id=1290, 19.

Smart grid communication technology enables two-way communication between the grid and an EV. Smart grid communication technology can control the timing of EV charging to avoid infrastructure overloads and lower electricity costs. For instance, during periods of high demand, the smart grid could temporarily withhold delivery of electricity to the EV. If a utility offered dynamic pricing, an EV owner could program the vehicle to charge only when electricity rates fell below a specified threshold. Integrating smart grid communication technologies into the electric grid would benefit both EV owners and electricity suppliers by improving the efficiency of the power market.

One example of smart grid communication technology is under development in Denmark. A consortium comprising utilities, corporations, the Danish Technical University, and the Danish Energy Association has been working on the "Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks" (EDISON) project.⁸⁰ EDISON creates software and hardware standards for smart grid EV integration. For example, for software, communication protocols must allow data transfer between EVs, EVSE, EV owners, and utilities; for hardware, EVSE must provide a physical connection between the grid and the EV. EDISON's architecture connects the EV to the EVSE and the EVSE to the utility. The EV owner communicates to the utility through a mobile application or website, specifying when the EV should charge, based on the electricity rate.

V2G allows an EV with surplus energy stored in its battery to act as a mini-power plant and provide electricity back to the grid. This electricity can either reduce the need to generate electricity in peak hours (known as peak-shaving) and control minor fluctuations in power quality (known as regulation). Some observers expect V2G to become more significant as the number of EVs increases, especially when deployment is concentrated in a particular region.⁸¹ A large population of EVs with stored energy could provide a significant amount of electricity back to the grid.

The peak-load leveling effect of smart grid technology (and dynamic pricing) has multiple benefits. In addition to preventing strain on distribution infrastructure and lowering electricity costs for consumers, peak-load leveling could facilitate greater investment in renewable energy sources like wind and hydroelectric facilities. Reducing the peak load could make it possible for renewable energy to meet the electricity demand, displacing electricity production from fossil fuels.

However, several technical issues need to be resolved before widespread deployment of smart grid technology can take place. This is especially true in the case of V2G technology. Discharging stored energy could strain the vehicle battery, reducing battery life and voiding warranties. It could also create safety concerns by overheating the battery and causing a fire. Finally, it is not clear to what extent vehicle manufacturers and owners will choose to participate in such programs.

⁸⁰ Danish Energy Association, "About the Edison Project," accessed June 2013, http://www.edison-net.dk/About_Edison.aspx.

⁸¹ The flip side to the peak-load leveling coin would be valley filling where the EV is charged during periods of low demand, thus evening out the load on the grid.

Utilities, including PECO, have already begun implementing tariff structures to shift electricity demand to off-peak hours. Although it requires additional development, smart grid technology could also provide load management benefits. Understanding these potential benefits of dynamic pricing and smart grid technology will help utilities, like PECO, plan for the additional electricity demand that could come with EV charging.

Utilities might consider installing and using smart grid technologies, taking advantage of opportunities to gather granular data on EVSE and vehicle usage patterns and integrate with future V2G technology opportunities.

3 EV Consumer Overview

This section summarizes EV consumer demographics and behaviors based on survey data and discussions with OEMs and researchers.

3.1 EV Consumer Demographics

The results of various consumer surveys suggest that early EV adopters tend to have similar characteristics. The results of a Pike Research survey indicate that individuals under the age of 30 or with higher education demonstrate higher interest in EVs.⁸² A Deloitte survey determined that the majority of EV buyers are males with above-average income who live in urban or suburban settings.⁸³ Survey results obtained through Pacific Gas & Electric's Consumer EV Billing Program in California indicate that many EV consumers in early adopter regions have the following characteristics: above-average median income, home ownership, smaller household sizes, an above average number of vehicles per household, and an increased likelihood of driving to work.⁸⁴

These survey data correspond to interviews DVRPC and ICF conducted with three major OEMs: GM, Ford, and Nissan. GM characterized Chevrolet Volt buyers in two major categories. The first category includes older (50 or more years old), technologically savvy, image-conscious individuals with above-average household income. GM noted that these buyers are less concerned about environmental issues and more interested in the technology itself. The second group includes 30 to 40 year-old males who are more environmentally conscious and also image conscious. For both groups, GM determined that approximately 90 percent of the consumers are male. A variety of vehicle survey data suggest that women, who tend to be more concerned with vehicle reliability and dependability than men are, tend not to be EV early adopters.⁸⁵ Nissan described the average Nissan LEAF consumer as a well-educated male over the age of 55 with an above average income, although Nissan expects this demographic to change over time.⁸⁶ The average consumer of the Ford Focus AEV has an annual household income between \$120,000 and \$140,000, is environmentally conscious and interested in reducing operating costs, and desires access to high-occupancy vehicle (HOV) lanes (where available).⁸⁷

In addition to these characteristics, previous HEV ownership also provides an indicator of EV adoption. In an Electric Power Research Institute (EPRI) survey, HEV owners were more than

⁸² Pike Research, "Executive Summary: Electric Vehicle Consumer Survey," accessed June 2013, <http://www.pikeresearch.com/wordpress/wp-content/uploads/2011/12/EVCS-11-Executive-Summary.pdf>, 2.

⁸³ Deloitte Consulting, "Gaining traction: A customer view of electric vehicle mass adoption in the U.S. automotive market," accessed June 2013,

http://www.deloitte.com.br/publicacoes/2007/MFG.Gaining_Traction_customer_view_of_electric_vehicle_mass_adoption.pdf, 6.

⁸⁴ Pacific Gas & Electric Company, "Electric Vehicle Penetration Study Using Linear Discriminant Analysis," accessed June 2013, http://www.energy.ca.gov/2012_energypolicy/documents/2012-02-23_workshop/comments/Pacific_Gas_and_Electric-Electric_Vehicles_Penetration_Study_2012-03-01_TN-63900.pdf, 4.

⁸⁵ Britta Gross (General Motors Company), phone interview, March 16, 2012.

⁸⁶ David Peterson (Nissan North America), phone interview, March 30, 2012.

⁸⁷ Stephanie Janczak, Barbara Rogers, and Mike Tinsky (Ford Motor Company), phone interview, April 9, 2012.

twice as likely to respond that they “definitely” intend to purchase or lease an EV vehicle, compared to non-HEV owners.⁸⁸

3.2 EV Consumer Behavior

Existing research on the behavior of EV consumers focuses on driving and charging patterns. This section presents information on these two behaviors.

3.2.1 Driving

Some EVs may require vehicle owners to adjust their driving habits to adapt to a lower vehicle range and to integrate charging into their routines. Researchers have noted that EV owners typically have a shorter-than-average commute and adjust their trips to reduce fuel consumption.⁸⁹ This “eco-driving” behavior may reduce energy consumption and emissions beyond the reductions inherent in switching from a conventional vehicle to an EV.

In a University of California, Davis trial study, consumers in New York City and Los Angeles leased the BMW MINI E, an electric version of the MINI Cooper. Researchers tracked how the consumers adapted to limited vehicle range. The consumers employed a variety of methods, such as using a conventional vehicle for longer trips, trip chaining (i.e., combining multiple errands into one trip), avoiding unnecessary trips, using Global Positioning System (GPS) tools to track vehicle distance, and turning off in-car climate controls to increase range. The most frequent adaptation was to simply use a second, conventional vehicle—94 percent of the MINI E users used this method.⁹⁰

3.2.2 Charging

Each EV driver has different needs. For example, the Toyota Prius Plug-In and Chevrolet Volt can charge completely overnight using Level 1 EVSE. The Nissan LEAF, on the other hand, needs Level 2 EVSE to completely charge a depleted battery within seven hours. That said, up to 15 percent of LEAF owners use Level 1 EVSE at home, presumably because they can achieve sufficient range with a partial charge, or they can access EVSE outside the home.⁹¹

The University of California, Davis MINI E Consumer Study supplied its participants with a residential Level 2 charging station and a Level 1 “convenience charger” for use outside the home. The Level 2 charging station completed a charge in three to five hours, while the Level 1 convenience charger required nearly 26.5 hours. The study concluded that EV consumers preferred the Level 2 EVSE, which fully charged their vehicles by morning and avoided the need to “top-off” the battery between activities using public EVSE.⁹²

⁸⁸ EPRI and Southern California Edison, “Characterizing Consumers' Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results,” accessed June 2013, <http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=00000000001021285>, 3-2.

⁸⁹ Deloitte Consulting, “Gaining traction: A customer view of electric vehicle mass adoption in the U.S. automotive market,” 6.

⁹⁰ Thomas Turrentine et al., “The UC Davis MINI E Consumer Study,” 52-4.

⁹¹ David Peterson (Nissan North America), phone interview, March 30, 2012.

⁹² Thomas Turrentine et al., “The UC Davis MINI E Consumer Study,” 62.

Instead of Level 1 or Level 2 EVSE, consumers might prefer to use DC fast charging in the future, particularly for AEVs. Wider implementation of public DC fast charging will likely influence EV adoption: two in five HEV owners and one in three ICE vehicle owners say that public DC fast-charging capabilities would “definitely” influence their EV acquisition decision.⁹³

Consumer willingness to pay influences the EVSE purchase decision. A Pike Research survey showed that only 28 percent of respondents would be willing to pay over \$500 for EVSE, with the average respondent willing to pay up to \$400.⁹⁴ This willingness to pay may vary with the proximity and availability of public and workplace infrastructure. This research suggests that most consumers will opt for Level 1 EVSE because the equipment and installation costs for Level 1 EVSE are minimal.⁹⁵ The costs rise for Level 2 and DC fast charging. According to the Georgetown Climate Center, residential Level 2 EVSE costs approximately \$2,000, including installation.⁹⁶

Multiple types of EVSE exist at this time (for a discussion of EVSE types, see Section 2). It is unclear which level of charging consumers will prefer in the long term. Level 1 EVSE is readily available and inexpensive but may not meet the needs of all EV drivers. Level 2 EVSE may charge a vehicle in half the time of Level 1 EVSE but is more expensive and carries additional installation requirements. DC fast charging has not yet become readily available but shows potential to meet the charging needs of future EV drivers.

⁹³ EPRI and Southern California Edison, “Characterizing Consumers’ Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results,” 3-2.

⁹⁴ Pike Research, “Executive Summary: Electric Vehicle Consumer Survey,” 3.

⁹⁵ Technically speaking, Level 1 charging only requires an extension cord that can plug into a standard outlet.

⁹⁶ Charles Zhu and Nick Nigro, “Plug-in Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review,” 8.

4 EV Market Segment Overview

Significant gaps remain in EV market segment data, particularly for the northeastern United States. OEMs currently rely on data from sources like R.L. Polk & Co. to determine which markets to target for certain vehicles.⁹⁷ Those data remain proprietary and are not available for this report. However, OEMs and EVSE network providers, such as ECOtality and ChargePoint (formerly Coulomb Technologies), have shared information to improve the project team's understanding of EV market segments.

The following sections describe the three main vehicle market segments: personal vehicles, commercial fleets, and government fleets. This market segment review focuses on observations from OEMs and market surveys, as opposed to forecasts and predictions.

4.1 Personal Vehicles

Public support for EVs does exist in the United States. At the end of 2011, approximately 40 percent of Pike Research survey respondents indicated that they are “extremely” or “very” interested in purchasing an EV.⁹⁸ Although this support has not yet translated into market success for the vehicles, EVs will likely become more appealing to a broad range of consumers in the mid to long term. In addition to exposure to EVs on the roads, EV education efforts, such as “ride-and-drive” events, will help the general public become more familiar with the technology. Familiarity will likely increase EV adoption.

As detailed in Section 5, the project team has developed three EV consumer profiles for this report: early adopters, likely adopters (also referred to as mid-adopters), and unlikely adopters (also referred to as late adopters). Early adopters will dominate EV purchases for the next several years. In the 2015 to 2020 timeframe, mid-adopters (including likely and possible adopters) are expected to enter the EV market. Late adopters (also referred to by the industry as unlikely adopters) will probably not begin purchasing EVs until 2020 and beyond.

Generally, EV interest among consumers increases as fuel prices increase. According to a Deloitte survey, if the price of gasoline increased from \$3.50 per gallon to \$5 per gallon, the respondents who reported being more likely to purchase an EV increased from 30 percent to 78 percent.⁹⁹

However, high fuel price alone will not drive EV sales. Consumers will be more likely to purchase EVs if upfront vehicle prices drop, driving range increases, and charging speed improves. With regard to upfront cost and cost of ownership, the decreasing price of fuel-efficient vehicles like HEVs and subcompact cars, as well as the recent stabilization of gasoline prices, may reduce the expected cost savings associated with EV ownership.

⁹⁷ Britta Gross (General Motors Company), phone interview, March 16, 2012.

⁹⁸ Pike Research, “Consumer Interest in Plug-in Electric Vehicles Declines to 40%,” accessed June 2013, <http://www.pikeresearch.com/newsroom/consumer-interest-in-plug-in-electric-vehicles-declines-to-40>.

⁹⁹ Charles Zhu and Nick Nigro, “Plug-in Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review,” 14.

4.2 Commercial Fleets

Commercial fleet vehicles (e.g., taxis, delivery trucks, and transit buses) comprise less than three percent of the nation's total vehicle fleet but travel more miles per vehicle than the average passenger vehicle.¹⁰⁰

Fleet managers tend to focus on total cost of ownership, and their vehicles tend to have high fuel consumption patterns, regular routes, and centralized refueling locations. For these reasons, EV technology may be well suited for many fleet applications.¹⁰¹ Fleet managers may appreciate the potential for fuel savings. The Electric Drive Transportation Association (EDTA) reports that fleet managers express willingness to spend an additional 10 to 14 percent for an HEV or EV because of projected fuel savings.¹⁰² As another benefit, EVs produce less noise than conventional fleet vehicles and would thus disturb neighbors less than conventional fleet vehicles. This is a particularly important consideration for urban delivery vehicles.

While small, light-duty passenger EVs have attracted the most media attention, EV technologies have been deployed for light trucks as well as medium- and heavy-duty vehicles. Limited data exist on the benefits of medium- and heavy-duty EVs in fleets. However, urban fleets typically have recurring routes with return-to-base operations that would allow for recharging. They also tend to operate on a stop-and-go duty cycle. Thus, EV technology could be a good fit for their needs. Examples of currently available fleet vehicles range from the Smith Electric delivery truck to the Proterra commuter bus.

Managers of commercial fleets have an opportunity to accelerate EV deployment. The American Recovery and Reinvestment Act (ARRA) of 2009 provided grants to facilitate the small-scale deployment of medium-size electric trucks in limited markets. A pilot project funded by an ARRA grant deployed all-electric delivery trucks produced by Smith Electric Vehicles. The project resulted in the electrification of commercial delivery fleets, such as those used by Duane Reade pharmacies in New York City.¹⁰³ General Electric also announced plans to purchase 25,000 EVs by 2015 for its global fleet.¹⁰⁴

4.3 Government Fleets

EVs can provide fuel cost savings that may benefit federal, state, and local government fleets. Executive Order 13514, signed by President Obama in 2009, orders federal agencies to reduce fuel consumption by two percent each year from a 2005 baseline through 2020 for a total reduction of 30 percent. EVs will likely make up part of the strategy to comply with this mandate,

¹⁰⁰ Research and Innovative Technology Administration, "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances," accessed June 2013, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_11.html.

¹⁰¹ Charles Zhu and Nick Nigro, "Plug-in Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review," 11.

¹⁰² Pike Research, "Consumer Interest in Plug-in Electric Vehicles Declines to 40%."

¹⁰³ Smith Electric Vehicles, "All-Electric Smith Newton Expands Eco-Friendly Presence in New York City," accessed June 2013, <http://www.smithelectric.com/all-electric-smith-newton-expands-eco-friendly-presence-in-new-york-city/>.

¹⁰⁴ General Electric Company, "GE Announces Largest Single Electric Vehicle Commitment, Commits to Convert Half of Global Fleet by 2015," accessed June 2013, <http://www.genewscenter.com/Content/detail.aspx?NewsAreald=2&ReleaseID=11440>.

according to the Federal Fleet Management Guidance of 2010.¹⁰⁵ In 2012, the General Services Administration (GSA) purchased over 100 EVs as part of a pilot program and leased the EVs to 20 federal agencies. GSA anticipated that federal agencies would save nearly \$116,000 in fuel costs annually by using the EVs.¹⁰⁶

Public fleets in the Northeast have taken steps to deploy EVs. New York City, for example, has the nation's largest HEV fleet and is working to build the nation's largest EV fleet. In 2011, 430 out of New York City's 26,000 fleet vehicles were EVs;¹⁰⁷ the vehicles were used by departments as diverse as the New York Police Department and the Department of Corrections. Moreover, the city is working to accelerate EV penetration within its 13,000 yellow taxi fleet vehicles. Beginning in the spring of 2013, Nissan plans to provide six LEAFs and will support charging stations for a pilot program in preparation for a much larger deployment of all-electric taxis.¹⁰⁸

The City of Philadelphia can bolster EV and EVSE deployment through the acquisition and use of EVs in various public fleets. The city has worked with PhillyCarShare to encourage car sharing among city employees and reduce the size of the municipal fleet.¹⁰⁹ The high initial cost of current EVs makes it difficult for cash-strapped public sector fleet managers to justify purchasing the vehicles. However, an increase in the number of EVs on the streets due to public fleet investments will increase resident exposure and familiarity to the technology, which may spur residents to invest in EVs themselves.

4.4 Local Fleet Survey

As discussed above, public and private entities operate vehicle fleets in southeastern Pennsylvania. Some of these fleets are varied and include a range of vehicle types, from passenger cars to large trucks. Others include mostly a single class of vehicle. The vehicles themselves may operate largely on predictable, dedicated routes, or their activity may be varied and unpredictable. To understand better the congruity between the needs of fleet operators and the characteristics of EVs, DVRPC and GPCC interviewed a sample of fleet managers representing a cross-section of vehicle fleets in southeastern Pennsylvania.

DVRPC and GPCC surveyed managers through face-to-face meetings and phone interviews and collected fleet profile information, type and size of fleet, and perceptions of EVs and EVSE. Table 8 below represents the responses DVRPC and GPCC received from interviews with fleet managers.

¹⁰⁵ The White House, "Executive Order 13514—Federal Leadership in Environmental, Energy, and Economic Performance," accessed June 2013, <http://www1.eere.energy.gov/femp/pdfs/eo13514.pdf>, 52118.

¹⁰⁶ Government Fleet, "Federal GSA's EV Pilot Program Expects to Save \$116K in Fuel Costs," accessed June 2013, <http://www.government-fleet.com/channel/green-fleet/news/story/2012/06/federal-gsa-s-ev-pilot-program-expects-to-save-116k-in-fuel-costs.aspx>.

¹⁰⁷ Mayor's Office of Long-Term Planning & Sustainability, "PlaNYC: Progress Report 2012," accessed June 2013, http://nytelecom.vo.llnwd.net/o15/agencies/planyc2030/pdf/PlaNYC_Progress_Report_2012_Web.pdf, 20.

¹⁰⁸ New York City Taxi and Limousine Commission, "Call for Participants in Electric Taxi Pilot Program," accessed June 2013, http://www.nyc.gov/html/tlc/downloads/pdf/industry_notice_11_26.pdf.

¹⁰⁹ PhillyCarShare, "City of Philadelphia Fleet Management Program," accessed June 2013, <http://www.mayorsinnovation.org/pdf/PhiladelphiaFleetManagement.pdf>, 1.

All of the fleet managers indicated that their primary concern and the predominant barrier to EV-fleet integration was the incremental price of EVs compared to conventional ICE vehicles. This concern was closely followed by the limited types of EV available on the market, as LDVs are not necessarily the best fit for many fleet applications.

4.5 Detailed Findings

All fleet managers that participated in the survey seemed to have some familiarity with EVs, and all fleet managers expressed some level of interest in EVs. GPCC reports that each fleet interviewee attended at least one regional workshop or seminar on EVs and EVSE.

Interviewees were attracted to the EVs due to their reduced environmental impacts, and private fleet managers noted that the vehicles could play a central role in meeting corporate sustainability objectives.

However, each raised specific concerns. Fleet managers most commonly cited the up-front cost of EVs as a barrier. For example, PhillyCarShare, which operates 21 Chevrolet Volts as part of the carshare fleet, expressed concern about the payback period for these vehicles within a carshare context. Despite fuel cost savings, PhillyCarShare has had to increase the hourly rate for EVs as compared to other vehicle options in the fleet to account for a higher vehicle purchase price. Because most customers seek out the lowest hourly rate, this strategy has been problematic. Unlike other vehicles, EVs are also harder to relocate from one parking station to another due to the cost of moving EVSE. Enterprise Holdings, the owner of PhillyCarShare, indicates that in traditional rental car scenarios, they do see customers willing to pay a premium rental cost for EVs. They expect this willingness may be due to fuel savings associated with EVs, which benefit the customer directly as opposed to the carshare fleet owner. Enterprise Holdings indicated that because of these issues, the premium price on the Volt would work better in the regular rental car model.

In certain locations, grants and incentives can reduce the upfront capital investment associated with EVs. For example, United Parcel Service (UPS) purchased 130 EVs in California, where financial incentives offset nearly the entire incremental cost.¹¹⁰ Another firm cited concerns about EV resale value uncertainty, which is an important consideration for many fleets.

¹¹⁰ Mike Britt (UPS), phone interview, September 11, 2012.

Table 8. Overview of DVRPC Fleet Survey Participant Profiles and EV Concerns/Considerations

Fleet Owner	Fleet Size	Vehicles in DVRPC Region	Fuels currently in use	Estimated miles per week per vehicle	Determinants of fleet vehicle choice	Biggest barrier to using EVs in fleet
AAA	264	80	Gasoline, Diesel, CNG	Tow trucks: 1,000 Other vehicles: 500	Price and usage	Range, cost, and choice of vehicles
AQUA AMERICA	1,100	200	Gasoline, Diesel, Biodiesel, CNG, Electric, Hybrids	400	Lifecycle cost and dealer support	Infrastructure and OEM vehicle availability
ARAMARK	10,000	500	Gasoline, Diesel, Biodiesel, Propane, Hybrids	250-500	Price and need	Capital cost. If batteries were categorized as fuel, rather than capital, might be easier.
Asplundh	30,000	5,000	Gasoline, Diesel	Light-duty trucks: 750 Class 6+: 150	Practicality and need	Not suitable fleet application
City of Philadelphia	6,300	6,300	Gasoline, Diesel	Varies	Need and budget	Driver acceptance and limited EVSE availability
COMCAST	35,000	2,500	Gasoline, Diesel, E-85	500	Price and need	No EVs currently on market meet fleet profile
PECO	1,450	1,450	Gasoline, Diesel, Biodiesel, CNG, Electric, Hybrids	200	Practicality and need	Applicability and cost of battery
PhillyCarShare	300	300	Gasoline, Hybrids, Electric	70-80	For Volts: City Charging Program	Return on investment
United Parcel Service	200,000	5,000	Gasoline, Diesel, Biodiesel, Propane, CNG, LNG, Landfill methane, Hydrogen, Electric	Delivery trucks: 200-300	Lifecycle cost and range	Cost and infrastructure upgrades

Source: DVRPC, 2013.

The accounting practices of some companies limit their ability to include fuel savings as part of their decision-making process for purchasing new vehicles for their fleets, restricting amortizing the higher costs of EVs through fuel savings. One of the surveyed firms explained that the costs of vehicle acquisition were included in a local unit's budget, whereas fuel costs were part of a fleet-wide operating budget. Thus, local fleet managers making the fleet purchase decisions were motivated to consider only initial vehicle costs, not long-term fuel costs. In cases where fuel cost, vehicle price, and maintenance cost are considered as part of a total cost of ownership platform, it is easier to develop a business case for the purchase of EVs into a fleet.

Infrastructure and fueling costs can also pose barriers to adoption. For some firms, charging vehicles at night would not significantly increase peak electricity costs because the charging is occurring when other operations using electricity are closed or operating at reduced levels. However, for a firm like UPS, peak charging time for EVs—from about 7 p.m. to 4 a.m.—coincides with peak operations at warehouse and processing sites. As a result, new electricity infrastructure would be required and capacity charges would likely increase.

Many surveyed fleet managers also indicated that available EV models did not match fleet needs. In most instances, these fleets identified overall size, payload capacity, and other desired characteristics as a priority for purchasing decisions. In these instances, newer versions of vehicle models currently in use tend to be purchased to replace older models, and EV equivalents are limited. Some companies, such as UPS, have very specific needs and make specific component choices for their vehicles. This includes UPS's EVs, which restrict batteries used by certain manufacturers due to safety concerns.

Though most fleet managers interviewed believed that the operational range of EVs could work for their fleets, some have less predictable day-to-day routes and expressed concerns about vehicle range in a region without widespread EVSE availability. Some also expressed concern about the lengthy charging time of EVs.

5 EV and EVSE Deployment in Southeastern Pennsylvania

Mass-market EVs have been on the road since late 2010, and nearly 60,000 EVs were on the road across the United States by the end of 2012. EV sales are currently concentrated in California, but southeastern Pennsylvania is well suited for widespread EV deployment given its high population density, urbanization, short commuting distances, and relatively high median income.

This section discusses the current EV availability and deployment in southeastern Pennsylvania. It also presents an analysis of EV demand and deployment potential for the region. This analysis uses a variety of data, including the following:

- Survey data on characteristics of EV owners;
- Demographic data from the American Community Survey (ACS), an ongoing statistical survey that samples a percentage of the population every year;¹¹¹
- Vehicle registration data from the Pennsylvania Department of Transportation (PennDOT), which include data on HEVs, EV ownership, and total vehicle ownership;
- Data on current or planned EVSE locations from PennDOT;
- Household travel data from DVRPC's 2000 household survey (the most recent available);
- Employment density data from DVRPC;
- Travel modeling and traffic count data from DVRPC; and
- Oil pricing forecasts developed by EIA as part of the Reference Case in the Annual Energy Outlook 2012.

Finally, the section describes a tool for regional consumers to estimate the cost of EV ownership in southeastern Pennsylvania and summarizes incentives or initiatives that could spur deployment in the region.

5.1 Current EV Availability in Southeastern Pennsylvania

Using available information, survey data, and forecasting results, Table 9 (below) presents the EVs that are currently available or that may soon become available in southeastern Pennsylvania.

¹¹¹ The ACS five-year estimates for years 2006 to 2010 provided the most reliable and robust dataset for this exercise.

Table 9. Prospectus of Current and Future EVs Available in Southeastern Pennsylvania

EV Type	Make/Model	Year of Introduction	Engine	Motor (kW)	Battery (kWh)	Electric Range (miles)	MSRP (2012)
PHEVs	Cadillac ELR	2016	N/A	N/A	N/A	N/A	N/A
	Cadillac XTS	2016	N/A	N/A	N/A	N/A	N/A
	Chevrolet Impala	2016	1.4L I-4	55	16	40	N/A
	Chevrolet Volt	2010	1.4L I-4	55	16	40	\$39,995
	Dodge Ram	2016	N/A	N/A	12.9	N/A	N/A
	Ford C-MAX Energi	2012	2.0L I-4	N/A	7.6	21	\$33,345
	Ford Fusion Energi	2013	2.0L I-4	35	7.6	21	\$38,700
	Hyundai Elantra	2015+	1.6L I-4	15	1	20-25	N/A
	Toyota Prius Plug-in	2012	1.8L I-4	60	4.4	41562	\$32,000
	VW Golf	2015	1.4L I-4	N/A	N/A	15	N/A
	AEVs	Audi A3	2015		N/A	N/A	N/A
Audi E-Tron		2013		N/A	53	150	N/A
Chevrolet Spark		2013		N/A	N/A	80	\$26,685
Fiat 500e		2013		83	24	N/A	\$31,800
Ford Focus Electric		2012		100	23	105	\$39,200
Honda Fit EV		2013		100	20	82	\$37,415
Hyundai/Kia B-Class		2015		N/A	16.4	N/A	N/A
Infiniti EV		2015		N/A	N/A	N/A	N/A
Mitsubishi i-MiEV		2011		49	16	50-70	\$29,125
Nissan LEAF		2010		N/A	N/A	70-105	\$28,800
Tesla Model S		2012		N/A	40-85	160-300	\$49,900 to \$69,900
Tesla Model X		2014		N/A	60-85	200-270	\$49,900 to \$97,900
Toyota iQ		2013		N/A	N/A	50	N/A
Toyota RAV4		2013		N/A	50	80-120	N/A
VW Golf (Blue-E)		2016		85	26.5	93	N/A

Source: American Honda Motor Company, Inc., 2013; Chevrolet, 2013; Chrysler Group, 2013; Ford Motor Company, 2013; ICF, 2013; Mitsubishi Motors, 2013; Nissan, 2013; Tesla Motors, 2013; Toyota, 2013.

The project team also conducted a survey of dealerships in southeastern Pennsylvania that currently sell and service EVs. Table 10 lists the locations of these dealerships (as of February 2013).¹¹²

¹¹² At the time of publication, not all vehicles included in Table 9 are commercially available. Therefore, Table 10 includes only dealers of the three EV models available in the region. As additional models become available, this list is expected to change.

Table 10. Southeastern Pennsylvania Dealerships Selling and Servicing EVs

Name of Dealership	Location (street address, city, state)
Chevrolet Volt	
Armen Chevrolet-Saab of Ardmore	125 E Lancaster, Ardmore, PA 19003
Bryner Chevrolet	1750 The Fairway, Jenkintown, PA 19046
Carfagno Chevrolet	1230 E Ridge Pike, Plymouth Meeting, PA 19462
Chapman Chevrolet	6925 Essington Avenue, Philadelphia, PA 19153
Del Chevrolet, Inc.	1644 Lancaster Ave, Paoli, PA 19301
Gordon Chevrolet	6301 E Roosevelt Blvd, Philadelphia, PA 19149
Lafferty Chevrolet Company	829 W Street Road, Warminster, PA 18974
Reedman-Toll Auto World	1700 East Lincoln Hwy, Langhorne, PA 19047
Spencer Chevrolet	840 Baltimore Pike, Springfield, PA 19064
Nissan LEAF	
Ardmore Nissan	265 East Lancaster Avenue, Ardmore, PA 19003
Chapman Nissan	6723 Essington Avenue, Philadelphia, PA 19153
Concordville Nissan	452 Wilmington W Chester, Concordville, PA 19331
Conicelli Nissan	1222 W. Ridge Pike, Conshohocken, PA 19428
Exton Nissan	200 West Lincoln Highway, Exton, PA 19341
Faulkner Nissan	900 Old York Road, Jenkintown, PA 19046
Fred Beans Nissan of Doylestown	4469 Swamp Road, Doylestown, PA 18902
Fred Beans Nissan of Limerick	55 Autopark Boulevard, Limerick, PA 19468
Loughead Nissan	755 S Chester Rd., Swarthmore, PA 19081
Montgomeryville Nissan	Route 309 At Stump Road, Montgomeryville, PA 18936
Nissan of Devon	459 W Lancaster Ave, Devon, PA 19333
O'Neil Nissan	849 W Street Road, Warminster, PA 18974
Peruzzi Nissan Automotive Group	165 Lincoln Highway, Fairless Hills, PA 19030
Mitsubishi MiEV	
Desimone Mitsubishi	6101 Frankford Avenue, Philadelphia, PA 19135
Springfield Mitsubishi Pa	313 Baltimore Pike, Springfield, PA 19064

Source: DVRPC, 2013.

According to information gathered through the project team's outreach, OEMs and certified dealers have no plans to certify nondealers (i.e., facilities not directly affiliated with the OEMs) for any EVs currently deployed in southeastern Pennsylvania.¹¹³

5.2 Current EV Deployment in Southeastern Pennsylvania

According to data provided by PennDOT, there were 120 Chevrolet Volts and 18 Nissan LEAFs registered in the five counties of southeastern Pennsylvania as of April 2012.¹¹⁴

¹¹³ ICF confirmed this information from Ford and is awaiting confirmation with Nissan and Chevrolet.

Several entities are leading the EV and EVSE deployment efforts in the region. PhillyCarShare has deployed 21 Volts in Philadelphia, which use 18 new Level 2 EVSE as part of a \$140,000 AFIG grant from PA DEP.¹¹⁵ PECO has also added two Chevrolet Volts to its fleet and installed EVSE at its main office building in Center City and its facilities in West Conshohocken and Berwyn. PECO intends to use the experience from these stations to learn how EVSE interact with and impact the electric grid.¹¹⁶ PECO is also partnering with EPRI to study the use of EVs in its service territory. In addition, ECOtality added Greater Philadelphia as a target region for the DOE-funded EV Project in August 2012. The EV Project provides residents and business owners interested in installing EVSE with free equipment and financial assistance to cover installation costs.¹¹⁷ DVRPC is collaborating with ECOtality, whose experience informs various aspects of this plan. This section presents an overview of lessons learned through The EV Project in southeastern Pennsylvania. As DVRPC and its partners continue to work toward the deployment of EVs and EVSE in the region, other success stories are expected to emerge.

5.2.1 Lessons from The EV Project

ECOtality and its partners, Nissan USA, GM, DOE, and the Idaho National Laboratory, launched the Greater Philadelphia portion of The EV Project on August 16, 2012. The EV Project is a nationwide initiative in which ECOtality, with assistance from DOE, offered incentives for the installation of EVSE and focused on both residential and publicly accessible locations. The EV Project was active in 21 cities in 11 states throughout the United States. As of March 11, 2013, The EV Project has met its goal for residential charging units and is no longer accepting applications.¹¹⁸ DVRPC served on the steering committee for The EV Project in Greater Philadelphia and provided preliminary results from DVRPC analysis to help orient organizers in the region. DVRPC obtained “lessons learned” from The EV Project to identify installation barriers and recommendations throughout southeastern Pennsylvania to better inform regional EV planning.

In the Greater Philadelphia region, ECOtality provided EVSE, which connect to the Blink Network, for free. It also provided up to \$1,000 per unit to cover installation costs to businesses.¹¹⁹ Similarly, ECOtality provided Blink EVSE for free and up to \$400 to cover installation costs to individuals wishing to install EVSE at their homes.¹²⁰ ECOtality offered these incentives in both southeastern Pennsylvania and southern New Jersey. At the close of the project, ECOtality had installed 125 commercial EVSE units in Greater Philadelphia.¹²¹ The

¹¹⁴ DVRPC, 2013.

¹¹⁵ See Appendix D. It is not clear whether these vehicles are included in the PennDOT figures.

¹¹⁶ PECO, “PECO’s work with EVs,” accessed June 2013,

<https://www.peco.com/Environment/GreenVehicles/ElectricVehicles/Pages/PECOsCommitment.aspx>.

¹¹⁷ ECOtality, “EV Project Offers Free Blink Chargers to EV Drivers and Commercial Host sites in Philadelphia.”

¹¹⁸ ECOtality, “The EV Project,” accessed June 2013, <http://www.theevproject.com>.

¹¹⁹ Marc Sobelman (ECOtality), e-mail message to author, March 27, 2013.

¹²⁰ Marc Sobelman (ECOtality), e-mail message to author, March 27, 2013.

¹²¹ Marc Sobelman (ECOtality), e-mail message to author, March 27, 2013.

majority of these chargers are publicly accessible, although some are restricted to certain users. As of March 28, 2013, 310 residential chargers were installed in the region.¹²²

According to Marc Sobelman, Regional Manager for ECOtality, introducing EVs and EVSE to the Greater Philadelphia region presented opportunities and challenges similar to those in other EV Project regions. The largest challenge was overcoming site owner concerns about installation costs. Most sites considered needed electric upgrades and long conduit runs, which require cutting and boring of asphalt and cement, and would increase installation costs and thus result in greater upfront costs to site owners. In most cases, the \$1,000 subsidy for commercial sites and \$400 subsidy for residential sites would not cover the complete installation cost, and the host was expected to fund the remainder.

In some cases, installation costs were reduced by encouraging site owners to revise the EVSE installation location to one closer to existing electric infrastructure or areas requiring fewer disturbances of existing sidewalks, curbs, and other hard infrastructure. Hosts, such as Temple University and Parkway Corporation, benefited from such revisions. For some site owners, additional incentives were also available to offset installation costs. PECO offered an additional \$1,000 for up to two EVSE units to cover installations by governments, institutions, and nonprofits.¹²³ Temple University, the University of Pennsylvania, the Children's Hospital of Philadelphia, and others took advantage of this incentive.

Mr. Sobelman commented that organizational bureaucracy also posed a barrier. Often the individuals overseeing parking facilities and operations for organizations lacked the proper authority within their organizational structure. While they could provide access to ECOtality-contracted electricians and answer technical questions, they were not able to make decisions about EVSE installations. At some of these sites, host agreements could not be executed by the end of the eligibility period.

Mr. Sobelman also noted that many site owners decided to take a "wait and see" approach to EVSE installation. The relatively small population of plug-in electric vehicles in Greater Philadelphia caused site owners to question the demand for EVSE and therefore the benefits of installing such equipment at their sites.

In Greater Philadelphia, ECOtality encountered site hosts' requirements for unionized contractors. This particular requirement was more prevalent in Philadelphia than other EV Project regions but was not a significant barrier. ECOtality contracted with five firms, four of which were unionized, to perform installations in the area. The EV Project-certified contractors also met the highest licensing and certification requirements required by any municipality in the region, a condition of their certification by ECOtality, in order to prevent any challenges in permitting and installation.

¹²² Marc Sobelman (ECOtality), e-mail message to author, March 27, 2013.

¹²³ PECO, "PECO Smart Driver Rebate," accessed June 2013, <https://www.peco.com/Savings/ProgramsandRebates/Business/Pages/SmartDriver.aspx>.

ECotality encountered very few regulatory barriers to EVSE installation and proactively met regulatory requirements, including unclear municipal regulations (e.g., Americans with Disabilities Act [ADA]). In Montgomery County, a proposed publicly accessible EVSE site at Montgomery County Community College encountered concerns about its effect on traffic. In response, the site will be limited to students, faculty, and staff.¹²⁴ ECotality also reported that varying permit fee schedules between municipalities did not prevent installations or significantly increase installation costs.

ECotality reported that the strong network of supporting organizations in Greater Philadelphia, including DVRPC, PECO, and GPCC, eased the firm's entry into this market. This network helped ECotality identify potential hosts, provided mapping of plug-in electric vehicle hotspots, and, in the case of PECO, provided additional financial incentives.

At the time of publication, ECotality had not provided details about the geographic distribution of EV Project installations or specific characteristics of installation locations. In its continuing work to support and monitor the adoption of alternative fuel vehicles, DVRPC will identify and analyze data from the locations to better understand patterns of EV use and charging.

5.3 Estimated EV Demand in Southeastern Pennsylvania

The project team analyzed various household data and combined those data with existing research regarding EV adoption to develop the following information:

- **Consumer profiles.** The project team analyzed household characteristics to estimate the upper limit on the number of early, likely, and possible EV adopters in the region. The team also considered vehicle circuit length to refine the estimates of potential adopters developed in the household profile analysis.
- **Potential EV demand.** The project team developed estimates of EV demand in southeastern Pennsylvania at the Census block group level using data on household income, home ownership, dwelling type, and education from the five-year ACS and data on HEV, EV, and total vehicle ownership from PennDOT.
- **Potential for Public and Workplace EVSE.** DVRPC also identified areas with the highest potential for public and workplace installation of EVSE, using spatial data on employment, roadway and interchange volume, and major destinations.

To estimate EV demand, the project team combined information about the characteristics of current EV owners with assumptions about the importance of these characteristics moving forward. For instance, surveys indicate that most EV owners own their home and live in a single-family residence, which often provides access to a dedicated garage. In the future, however, a confluence of factors (e.g., more affordable EVs and/or more EV offerings, streamlined installation procedures, and increased deployment of public EVSE) will likely decrease the importance of having access to a dedicated garage.

¹²⁴ Marc Sobelman (ECotality), e-mail message to author, February 12, 2013.

The following sections describe the data and methodology used to estimate EV demand in southeastern Pennsylvania, as well as the results of this analysis. Because of the small number of EV owners in the study area, there are not sufficient data on the characteristics of EV buyers to carry out an objective statistical analysis. Thus, the approach described here is inherently subjective. However, it is grounded in existing research on EV buyers (see Section 5.3.2) and on the project team's knowledge of consumer vehicle purchasing patterns.

5.3.1 Background: Survey Research of EV Owners

Surveys of EV owners informed the analysis of EV demand in southeastern Pennsylvania. Table 11 summarizes the information gathered through various surveys regarding the characteristics of early EV adopters.

Table 11. Early EV Adopter Survey Statistics

	Income	Home Ownership	Dwelling Type	Vehicles Available	Hybrid ownership
1. California EV survey vehicles: only LEAFs region: California	54%, \$150k + 25%, \$100k-\$150k 18%, \$50k-\$100k 3%, <\$50k	n/a	91% in single-family w/ an attached garage 6% single-family, detached garage 3% in apartment <1% other	n/a	n/a
2. Bay Area LEAF survey vehicles: only LEAFs region: SF Bay Area, CA	n/a	n/a	n/a		34% HEV owners
3. Tal et al, California Survey vehicles: mostly LEAFs region: California	46%, \$150k + 37%, \$100k-150k 16%, declined	96% own their home	96%, single-family house		32% owned a HEV before they purchased EV 11% replaced a HEV w/ an EV 25% own HEV and EV
4. Chevrolet information	Average income, \$170k	n/a	n/a	n/a	7% of buyers replaced a Toyota Prius HEV with the Volt
5. Nissan information	Household income, \$159k	Home value of \$640k			

Source: California Center for Sustainable Energy, "California EV Owner Survey," data collected in February 2012, accessed June 2013, <http://energycenter.org/index.php/incentive-programs/clean-vehicle-rebate-project/vehicle-owner-survey>; Bay Area Air Quality Management District, "Bay Area LEAF Survey," data analyzed by ECOtality and ICF, October 2012; Tal, G, Nicholas, MA, Woodjack, J, Scrivano, D, "Who Is Buying Electric Cars in California? Exploring Household and Fleet Characteristics of New Plug- In Vehicle Owners," accessed June 2013, <https://sites.google.com/a/ucdavis.edu/gil-tal/evs-market>; Crisi Landy, Chevrolet, "The Customer Experience: Reaching Buyers Beyond Early Adopters," accessed June 2013, <http://umtri.umich.edu/content/Crisit.Landy.GM.Marketing.PT.2012.pdf>; Nissan EV Information, handout from EVS26.

The existing research presented above has several shortcomings, including potential overlap in the survey populations, as well as survey timing, which excluded key developments in the EV market. Regarding population overlap, surveys [1]-[3] and [5] in Table 11 likely included some of the same LEAF buyers. With respect to survey timing, survey [1], which was one of the most extensive, took place in February 2012, shortly before the Chevrolet Volt qualified for HOV lane access in California and the Toyota Prius Plug-In became available to consumers. Thus, the survey gathered information about AEV buyers (i.e., LEAF buyers) but did not collect information about PHEV buyers (e.g., Volt or Prius Plug-In buyers).

Since the introduction of the Volt and Prius Plug-In, the EV market has shifted toward PHEVs—the Volt and Prius Plug-In now outsell the LEAF by a combined factor of 5 or 6 to 1. This shift has implications for EV demand projections because different consumers purchase different types of EVs. For example, drivers with garage access are more likely to purchase an AEV than drivers with no garage. Garage access does not affect PHEV decisions as much.

Acknowledging the shortcomings of the research, the project team used the survey data to identify common characteristics of EV owners: high income, current or previous HEV ownership, single-family home ownership, access to at least one other vehicle, and high education level (not shown in Table 11 above).

5.3.2 Consumer Profiles

5.3.2.1 Household Profiles

The project team defined four household profiles, or categories of EV consumers, and determined how many households in southeastern Pennsylvania matched each profile. This analysis helps to estimate the number of households that will purchase EVs in the region.

Based on the analysis of factors influencing EV adoption, the project team developed criteria for the following household profiles: early adopters, likely adopters, possible adopters, and unlikely adopters. The team prioritized “access to other vehicles” when defining the profiles, and households with fewer than two cars immediately fell into the “unlikely adopters” category. The criteria for each profile are provided below.

- **Early Adopters:** Early adopters have a high income that enables them to finance the \$5,000 to \$25,000 incremental cost of EVs, and the \$1,000 to \$2,000 purchase and installation cost of EVSE. Early adopters also live in single-family homes and own their own home, given that installing EVSE at a MUD or finding a MUD that offers residential EV charging stations can currently prove challenging.
- **Likely Adopters:** Likely adopters have similar characteristics to early adopters, but they have slightly lower incomes.
- **Possible Adopters:** Possible adopters may hesitate to purchase an EV because of cost or may wait for a more robust EVSE network to build up before purchasing an EV. These households have varying income levels and dwelling types

Unlikely Adopters: Unlikely adopters include households with fewer than two vehicles, income less than \$75,000, or income less than \$100,000 and a rented home. Of all the household profiles, unlikely adopters react most to vehicle pricing, due to household income. Depending on future vehicle pricing (as a result of factors such as decreased battery cost, increased gasoline prices, or innovative financing), higher income individuals in the unlikely adopters profile could move into the possible adopter or likely adopter categories in the mid to long term. Table 12 reviews the characteristics of the four household profiles.

Table 12. Early, Likely, Possible, and Unlikely EV Adopter Characteristics

Profile	Characteristics			
	Income	Rent or Own	Dwelling Type	No. of Vehicles
Early Adopter	\$150K +	Own	Single Detached	At least 2
			Single Attached	
Likely Adopter	\$100 to \$150K	Own	Single Detached	At least 2
			Single Attached	
	\$100K +	Rent	Single Detached	
Possible Adopter	\$150K +	Own	Multifamily building	At least 2
	\$100K +	Rent	Single Attached	
	\$75K to 100K	Own	Single Detached	
			Single Attached	
Unlikely Adopter	-	-	-	Fewer than 2
	< \$75K	-	-	-
	< \$100K	Rent	-	-

Source: DVRPC, 2013.

The project team used the DVRPC household travel survey¹²⁵ to help quantify the potential consumer market associated with each profile. The most recent household survey was conducted in 2000 and includes information on 2,588 vehicles in five counties. The data were based on 24-hour diaries and follow-up phone interviews with households. The DVRPC survey requested information on each trip taken, which allowed researchers to calculate daily vehicle circuit length, defined as the round trip distance (in miles) that each household vehicle traveled on the survey day, regardless of driver.

The team determined how many DVRPC travel survey respondents fell within each EV adopter category (including only the respondents that reported trip circuit lengths). Table 13 shows the number of households, as well as the share of all respondents, in each category.

¹²⁵ DVRPC, "Transportation for the 21st Century Household Travel Survey: Travel Survey Results for the DVRPC Region," accessed June 2013, <http://www.dvrpc.org/reports/01028.pdf>.

Table 13. Early, Likely, Possible, and Unlikely Adopters in Southeastern Pennsylvania based on DVRPC Travel Survey

Profile	No. of Households	Percentage of Respondents Reporting Circuit Lengths
Early Adopter	114	4%
Likely Adopter	320	12%
Possible Adopters	417	16%
Unlikely Adopters	1,674	65%

Source: DVRPC, 2013.

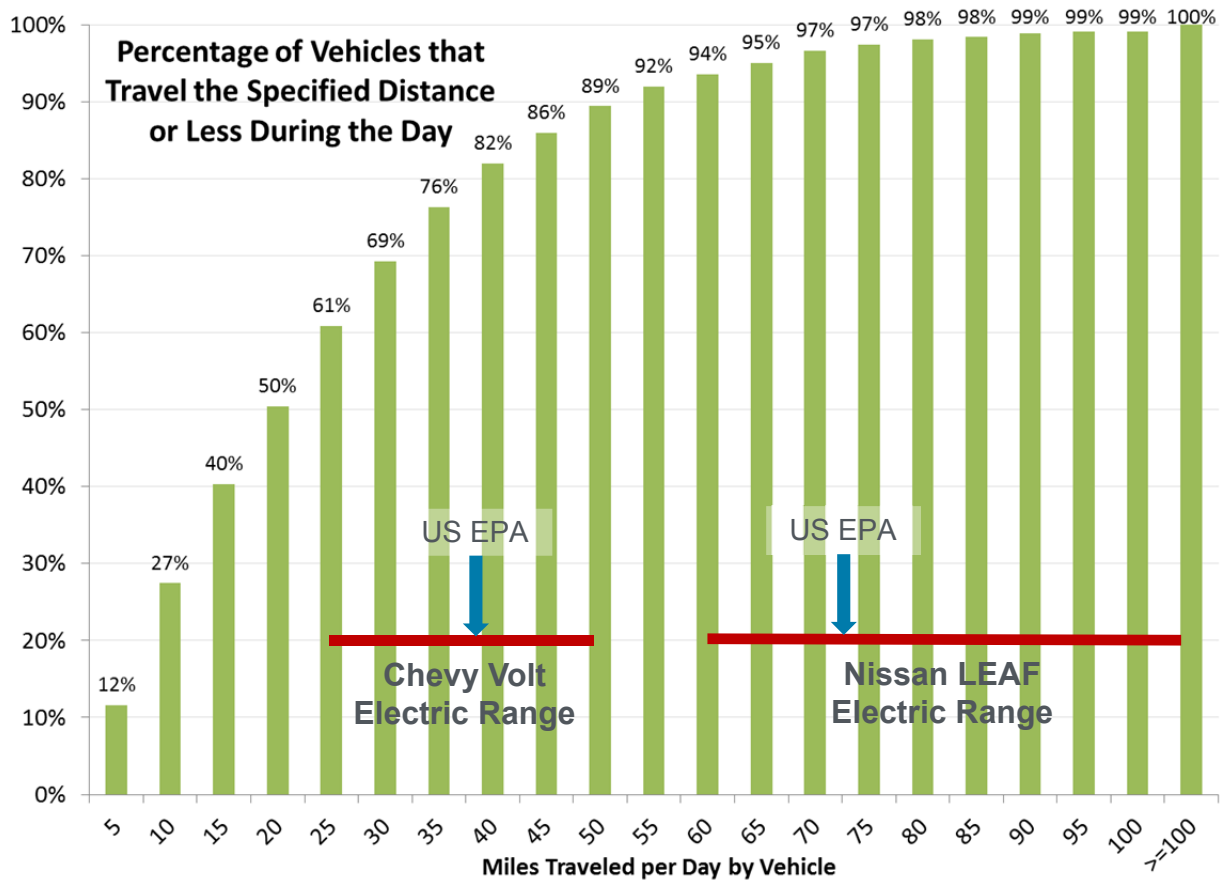
This household profile analysis estimated the number of early, likely, possible, and unlikely EV adopters in the region. Based on this analysis, early adopters are expected to represent approximately four percent of the households in southeastern Pennsylvania, while likely adopters and possible adopters are expected to comprise 12 percent and 16 percent, respectively. The percentage of households represented by each profile aligns with other market forecasts of near-term EV deployment.

5.3.2.2 Vehicle Circuit Lengths and Profiles

To further refine the characterization of consumer profiles, the project team also considered the ability of EVs to meet a given driver's commuting needs. In other words, to what extent can EVs available today and EVs forecast to be available to consumers fulfill their commuting needs? Figure 3, below, indicates the distribution of the distance traveled by vehicles garaged in southeastern Pennsylvania that are used to commute to work. The blue vertical arrows indicate the distance each vehicle can travel on a single charge, according to the US EPA. The red horizontal bars indicate what the literature indicates the range is in practice.

This chart shows, for instance, that on a typical day, 82 percent of all passenger vehicles used in the region travel 40 miles or less (more or less within the all-electric range of the Chevrolet Volt) and that 97 percent travel 70 miles or less (within the range of the Nissan LEAF). This information is derived from DVRPC's most recent household travel survey. Although this information is more than a decade old, it is the most recent available (DVRPC expects the next household travel survey to be completed in 2013). Given the relatively mature development of southeastern Pennsylvania, DVRPC does not expect a dramatic shift in the pattern of commuting.

Figure 3. Percentage of Vehicles Traveling Specified Distances for Commuting



Source: DVRPC, 2013.

The table below breaks down these data regarding vehicle circuit lengths further to refine the estimates of early, likely, and possible EV adopters developed in the household profile analysis. Table 14 shows the number of early adopter, likely adopter, and total respondents that reported each vehicle circuit length range.

Table 14. Vehicle Circuit Lengths in Miles Derived from DVRPC Travel Survey

Profile	Percentage of Drivers Traveling Various Vehicle Circuit Lengths (in miles)			
	0 to 19	20 to 39	40 to 59	60 and over
Early Adopter	43%	31%	16%	11%
Likely Adopter	40%	37%	14%	8%
All respondents	50%	32%	12%	6%

Source: DVRPC, 2013.

As shown in Table 14, above, about 90 percent of early adopters and likely adopters have vehicle circuit lengths less than 60 miles; this vehicle circuit length is within the range of AEVs on the road today. Furthermore, about 75 percent of early adopters and likely adopters have vehicle circuit lengths that could be traveled in all-electric mode in the Chevrolet Volt (with an all-electric range of about 40 miles). Finally, about 40 percent of early adopters and likely adopters have vehicle circuit lengths that are within the all-electric range of PHEVs, such as the Ford C-MAX Energi. Moreover, many of these vehicle circuit lengths could be satisfied using PHEVs with an even lower all-electric range, such as the Toyota Prius Plug-in.

As previously mentioned, the household profile analysis estimated that early adopters represent four percent of the total households. However, according to the circuit length analysis, about 10 percent of early adopters have circuit lengths greater than 60 miles. Most PHEVs can travel between 10 and 40 miles per charge; most AEVs can travel 50 to 120 miles per charge. Because some AEVs cannot cover 60 miles or more on one charge, the trip circuit length analysis supports lowering the forecast for early adopters to account for the drivers that will not be able to use EVs to meet their driving needs.

5.3.3 Potential EV Demand in Southeastern Pennsylvania

Based on the survey research conducted to date (see Table 11) and data availability, the project team identified the following key characteristics to determine potential EV demand in southeastern Pennsylvania:

- Income;
- Hybrid ownership;
- Home ownership;
- Dwelling type; and
- Education.

The project team gathered data on all of the parameters identified above at the census block group level. The five Pennsylvania counties in the study area—Bucks, Chester, Delaware, Montgomery, and Philadelphia—comprised 2,979 census block groups.

After identifying key parameters for analysis, the project team developed a framework to assign scores to each census block group based on demographic and HEV ownership data. The scores represent likelihood for EV demand, with higher scores indicating greater likelihood of demand. The following sections explain the scoring process for each parameter.

5.3.3.1 Income

Income is currently a good indicator for EV ownership. The project team considered the income brackets identified in Table 15.

Table 15. Income Groupings Assessed in EV Demand Analysis

Group	Income Level (in USD)
1	\$0 to \$49,999
2	\$50,000 to \$74,999
3	\$75,000 to \$99,999
4	\$100,000 to \$149,999
5	\$150,000 to \$199,999
6	\$200,000+

Source: DVRPC, 2013.

Each census block group was scored based on the percentage of its population in each of these income brackets. In other words, if a census block group had 100 percent of its residents in the \$200,000+ income bracket, it received the maximum score. The income score accounted for 60 percent of the total score used to assess potential demand.

5.3.3.2 HEV Ownership

At the request of DVRPC, and in accordance with all laws and regulations governing the provision of such data, PennDOT provided relevant data on all passenger vehicles registered in the five counties of southeastern Pennsylvania. Specifically, PennDOT provided data for the data elements shown in Table 16 below.

Table 16. Data Elements for PennDOT Data on Passenger Vehicles Registered in Southeastern Pennsylvania

Data Element	Brief Description
Address	Owner or Lessee, as appropriate. Address information was discarded once location was geocoded.
Make Code	Vehicle Make (e.g., GM)
Model Code	Vehicle Model (e.g., Volt)
Fuel Type	Identifies fuel that is used in the vehicle (i.e., gasoline, diesel, hybrid, propane, natural gas, electricity, or other)
VIN	Vehicle Identification Number

Source PennDOT, 2013.

This dataset, current as of mid-April 2012, provided information on 2,225,595 passenger vehicles. DVRPC staff used indicators in the Fuel Type, Make Code, Model Code, and Vehicle Identification Number (VIN) fields to identify the total number of HEVs and EVs in the region. The project team determined that there were 18,674 HEVs or EVs in the region, of which 13,421 were Toyota Priuses. DVRPC geocoded the vehicle addresses and aggregated the data by census block and census block group for subsequent analyses.

HEV ownership typically correlates with income, as well as other factors (e.g., environmental stewardship and gasoline price sensitivity), which also correspond with interest in EVs. The project team used household HEV ownership to develop a score for each census block group based on its percentile ranking in HEV ownership relative to all census block groups in the study region. The groupings used in the analysis are shown in Table 17 below.

Table 17. HEV Ownership Groups Considered in EV Demand Analysis

Group	Percentile of HEV ownership
1	60 th percentile
2	80 th percentile
3	90 th percentile
4	95 th percentile
5	98 th percentile

Source: DVRPC, 2013.

HEV ownership accounted for 25 percent of the total score used to assess the potential EV demand at the census block group level.

5.3.3.3 Home Ownership

Households that own their property are more likely to purchase an EV, according to market research conducted by Nissan and Chevrolet and surveys conducted by the University of California, Davis. Home ownership reduces both financial and nonfinancial barriers to EVSE deployment. In the near term, home ownership will continue to be an important factor in EV adoption.

Because home ownership correlates with income, the project team used this parameter to distinguish among census block groups that already have high scores based on their income profiles. The project team assigned additional points to each census block group that had a higher-than-median income and higher-than-median home ownership for the region. This parameter contributed five percent of the total potential score for a census block group.

5.3.3.4 Dwelling Type

Dwelling type plays a role in EV adoption because drivers generally charge their EVs at home.¹²⁶ Dwelling type affects the ease with which drivers can install and access EVSE at home.

Typically, single-family detached homes present the fewest barriers to EVSE deployment because they often include a dedicated garage or parking spot. Consumers living in MUDs tend to encounter more barriers to EVSE deployment, including homeowner association (HOA) restrictions, high installation costs (installation at MUDs can require trenching or additional

¹²⁶ Nearly all AEV buyers and approximately 50 percent of PHEV buyers install Level 2 EVSE at their homes

metering), and limited space for or access to electric infrastructure.¹²⁷ However, barriers to EV ownership for MUD residents are expected to diminish as regions streamline EVSE installation procedures and deploy more public EVSE.

The dwelling type factor was incorporated in the analysis only for census block groups where both income and percentage of single-family residences were above the median. Because the project team expects barriers for EV deployment at MUDs to diminish, it weighted this parameter at six percent of the total score.

5.3.3.5 Education

This analysis included education as a parameter for EV ownership to add granularity to the geographic distribution of EVs in the region. Education was considered only for census block groups with above-median income and above-median number of households with higher education. This parameter accounted for three percent of the total maximum score.

5.3.3.6 Results

The project team used the aforementioned parameters to develop an EV score for each census block group. The scores for each census block group are shown in Figure 4; note that the scoring was normalized to a scale of 0 to 100.

The scores shown in Figure 4 below were used in conjunction with the EV forecasts (see Section 5.4) to develop a map of likely EV ownership in the study region, as shown in Figure 5 below. These data were also used to develop estimates for the percentage of EVs in each census block group by 2020, as shown in Figure 6.

¹²⁷ R.L. Graham, et.al, "Wise Investment in Electric Vehicle Charging Infrastructure through Regional Planning," presented at EVS26, Los Angeles, CA, 2012.

Figure 4. Areas With the Highest Potential for EV Ownership in Southeastern Pennsylvania

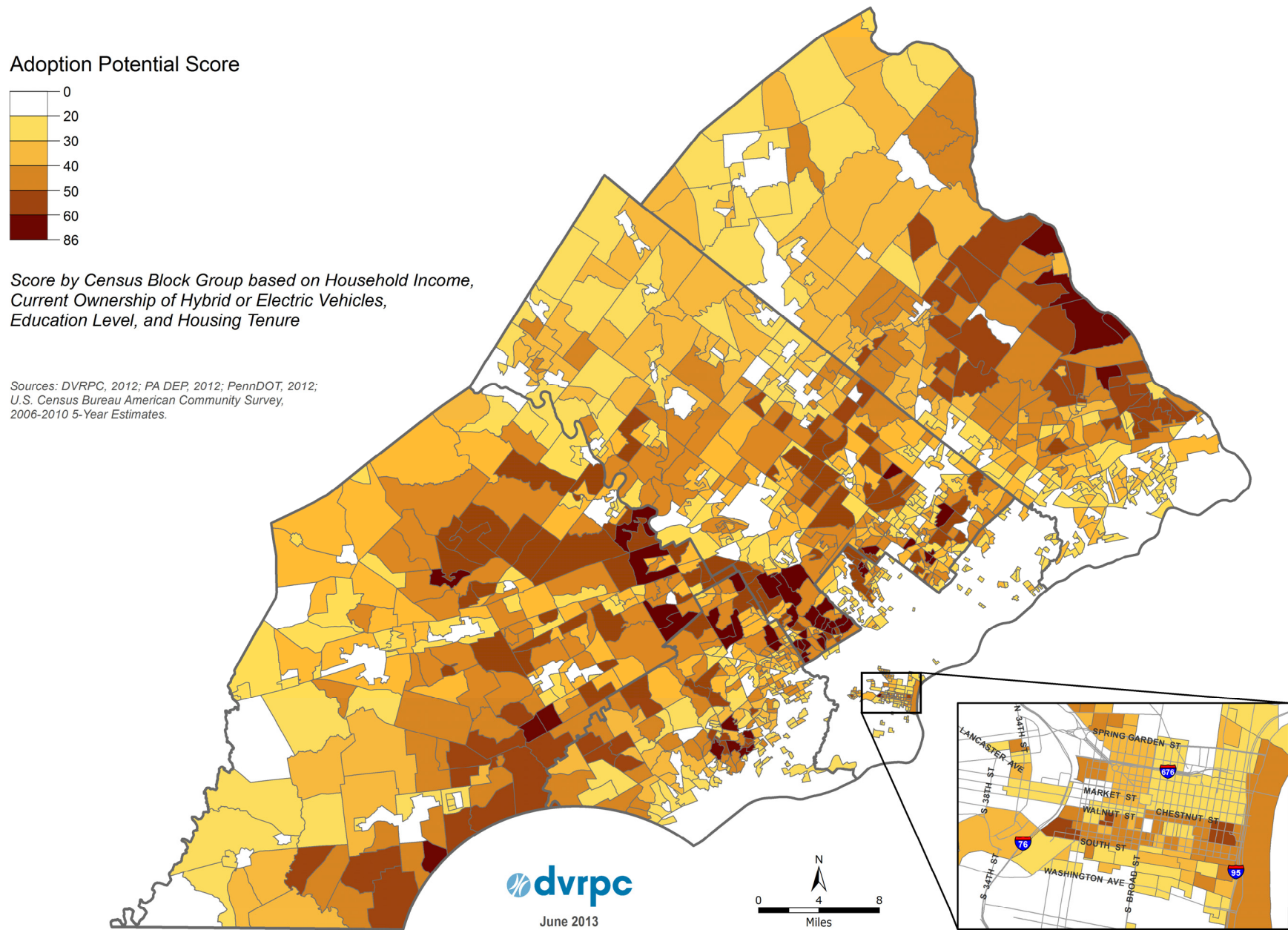


Figure 5. Projected EV Distribution in Southeastern Pennsylvania, 2020

1 Dot = 1 Vehicle

Sources: DVRPC, 2012; PA DEP, 2012; PennDOT, 2012;
U.S. Census Bureau American Community Survey, 2006-2010 5-Year Estimates.

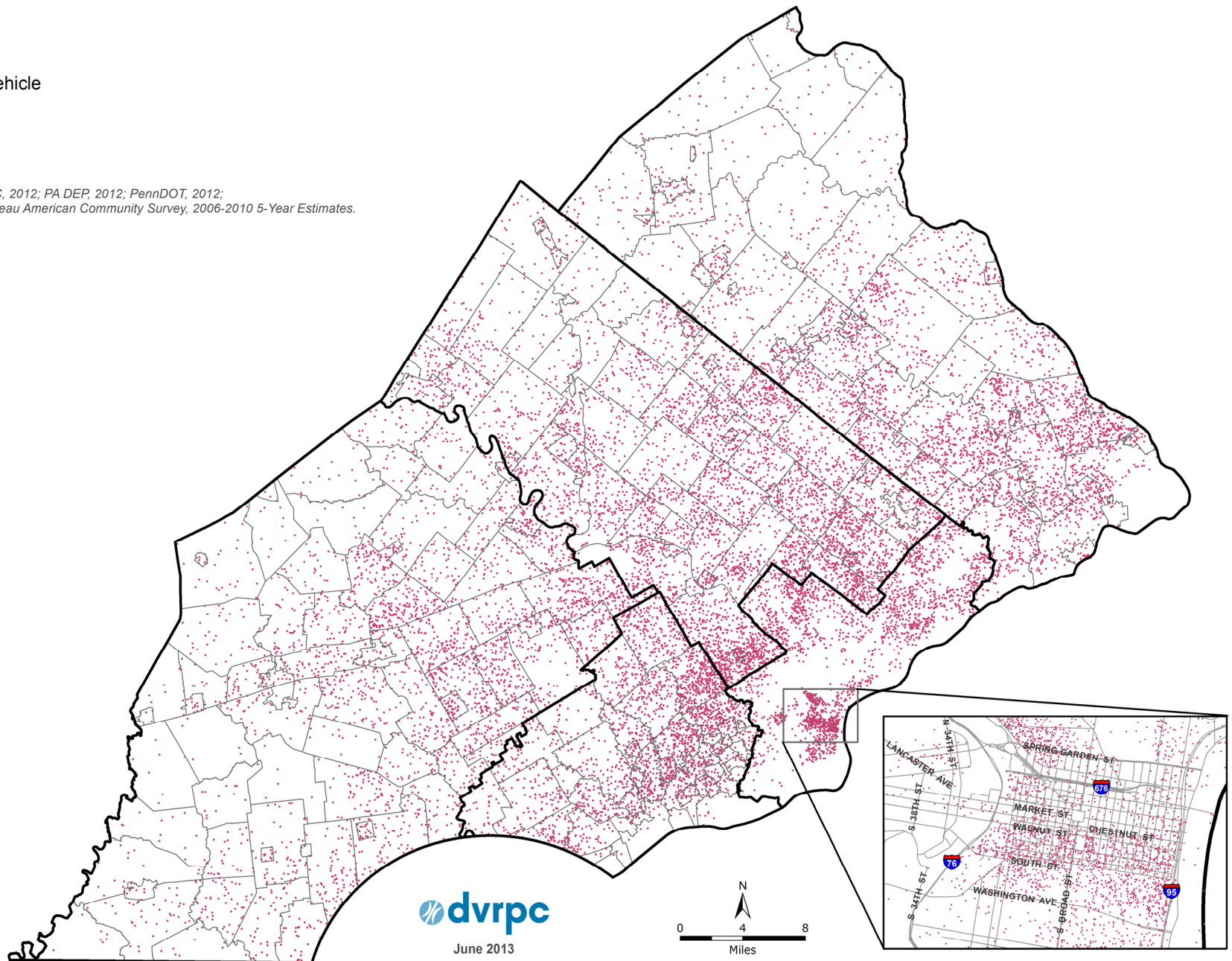
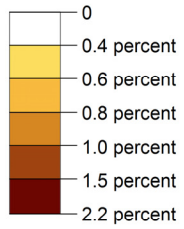
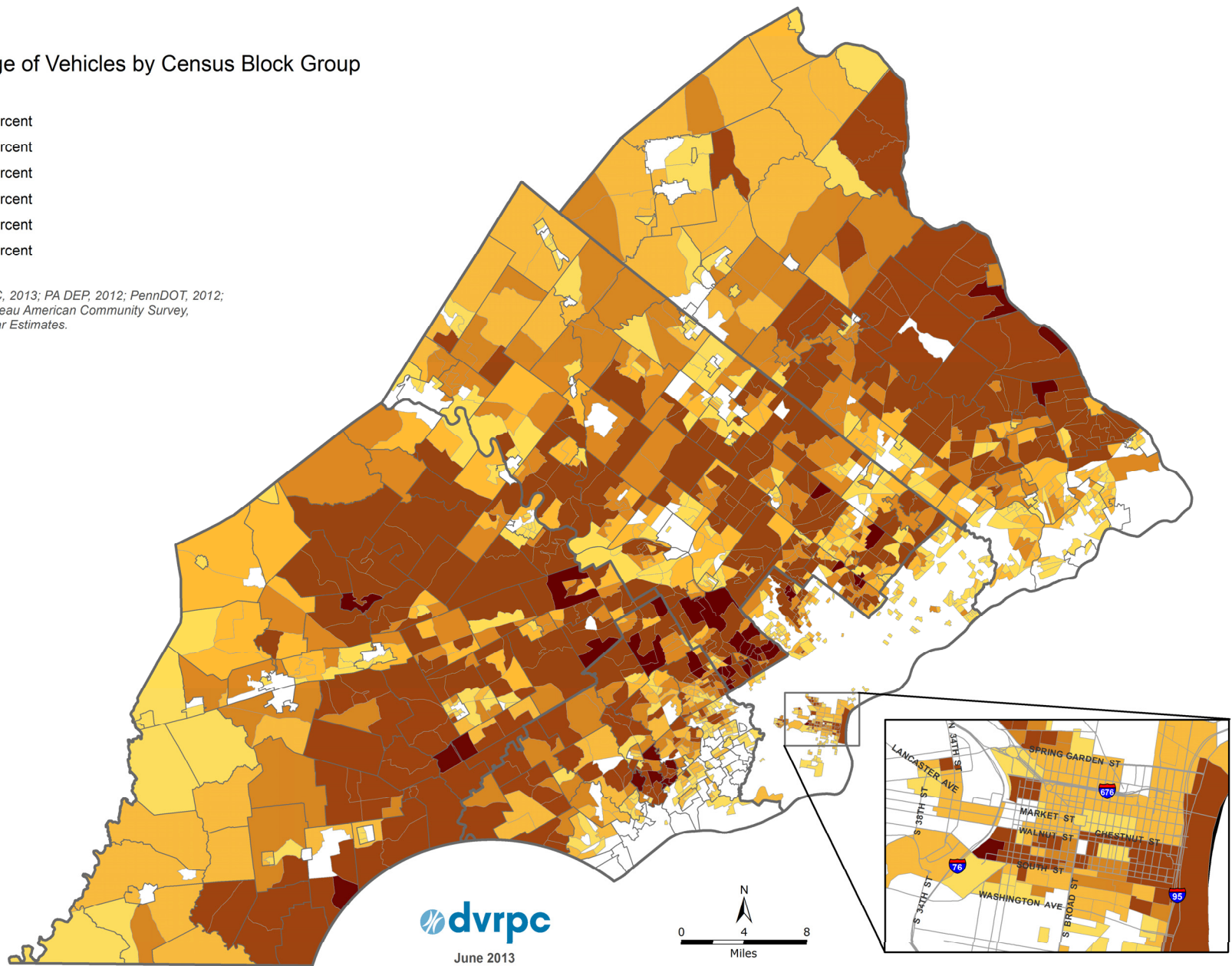


Figure 6. Projected Percentage of Vehicles that are EVs, 2020

Percentage of Vehicles by Census Block Group



Sources: DVRPC, 2013; PA DEP, 2012; PennDOT, 2012; U.S. Census Bureau American Community Survey, 2006-2010 5-Year Estimates.



These data can help policymakers and stakeholders in the region prepare for EV adoption. For instance, as discussed in Section 10, PECO used these data to understand the potential utility grid impacts of EV adoption in the study region. Similarly, EVSE providers can use these data for planning purposes as they seek to deploy supporting charging infrastructure in the study region. Finally, local governments can use these data to help understand where EV owners are most likely to reside and to provide targeted support to expedite readiness in areas with high potential. Generally, these data should be used to weight EV distribution in any forecasting exercises relevant to the region.

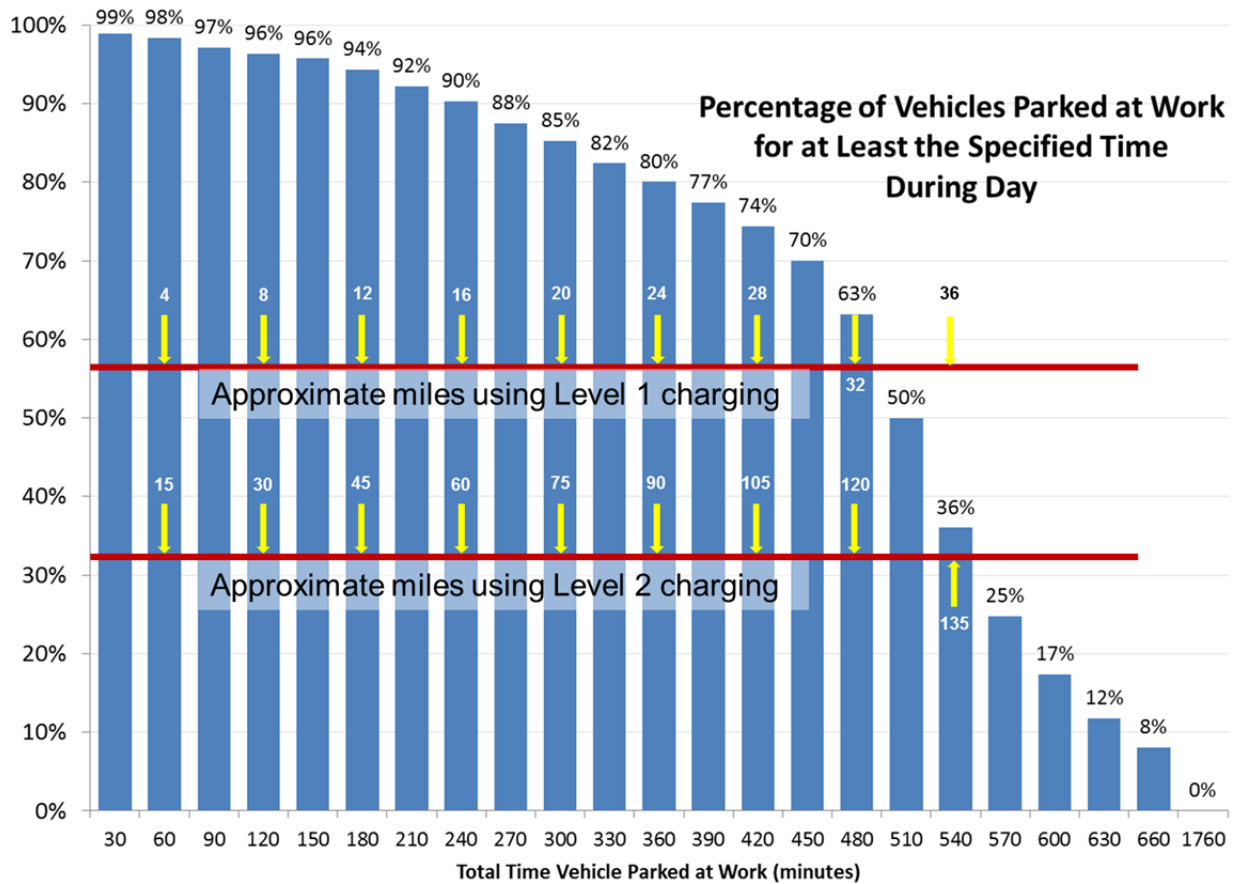
5.3.4 Areas with Highest Potential for Public and Workplace EVSE

In section 5.3.2.2, the project team highlighted the importance of commuting distances as a determinant for the suitability of EVs to meet a given driver's commuting needs. Another key determinant regarding the long-term potential for EVs is the amount of time that a vehicle remains parked at work. Although most EV drivers will likely charge their vehicles at home, the availability of nonresidential EVSE—particularly workplace EVSE—will be a key aspect of EV adoption moving forward. The opportunity to charge at work may provide additional security to AEV owners or increase the number of all-electric miles traveled by PHEV owners. Figure 7 shows, for those vehicles used to commute to work, the percentage of vehicles that are parked at work for at least the specified time.¹²⁸ For instance, this chart shows that 90 percent of all vehicles are parked for at least four hours (240 minutes) and that 80 percent are parked for at least six hours (360 minutes). These data are derived from DVRPC's household survey.

The figure below also includes the miles of all-electric range that Level 1 and Level 2 charging at workplaces could potentially provide. For instance, an EV parked for 240 minutes (or four hours) will be charged with enough electricity to travel 16 miles using Level 1 charging or 60 miles at Level 2 charging. This figure helps demonstrate the significant potential for workplace charging in the study region. It also indicates that much of this charging can be met with less expensive Level 1 charging.

¹²⁸ Note that for cars that are moved during the day (e.g., to buy lunch), the total of all time parked at work is indicated.

Figure 7. Percentage of Vehicles Parked at Work, for Specified Time Intervals



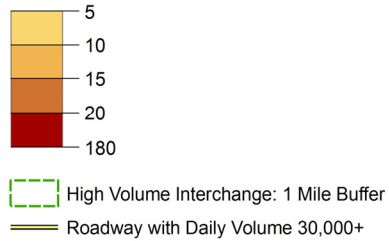
Source: DVRPC, 2013.

DVRPC carried this analysis one step further and identified the areas with the highest potential for public and workplace installation of EVSE using spatial data on employment, roadway and interchange volume, and major destinations. DVRPC identified the areas of greatest employment density within employment centers. It also identified high-volume transportation roadways and intersections using travel modeling and traffic count data. Major destinations of regional importance include airports, large general hospitals, major business parks, and major shopping centers, as well as cultural establishments, including museums, major music venues, casinos, large movie theaters, and sports stadiums. Figure 8 shows the locations of these venues along with locations of current or planned EV charging stations (provided by PA DEP).

Figure 8. Areas with Highest Potential for Public and Workplace Charging

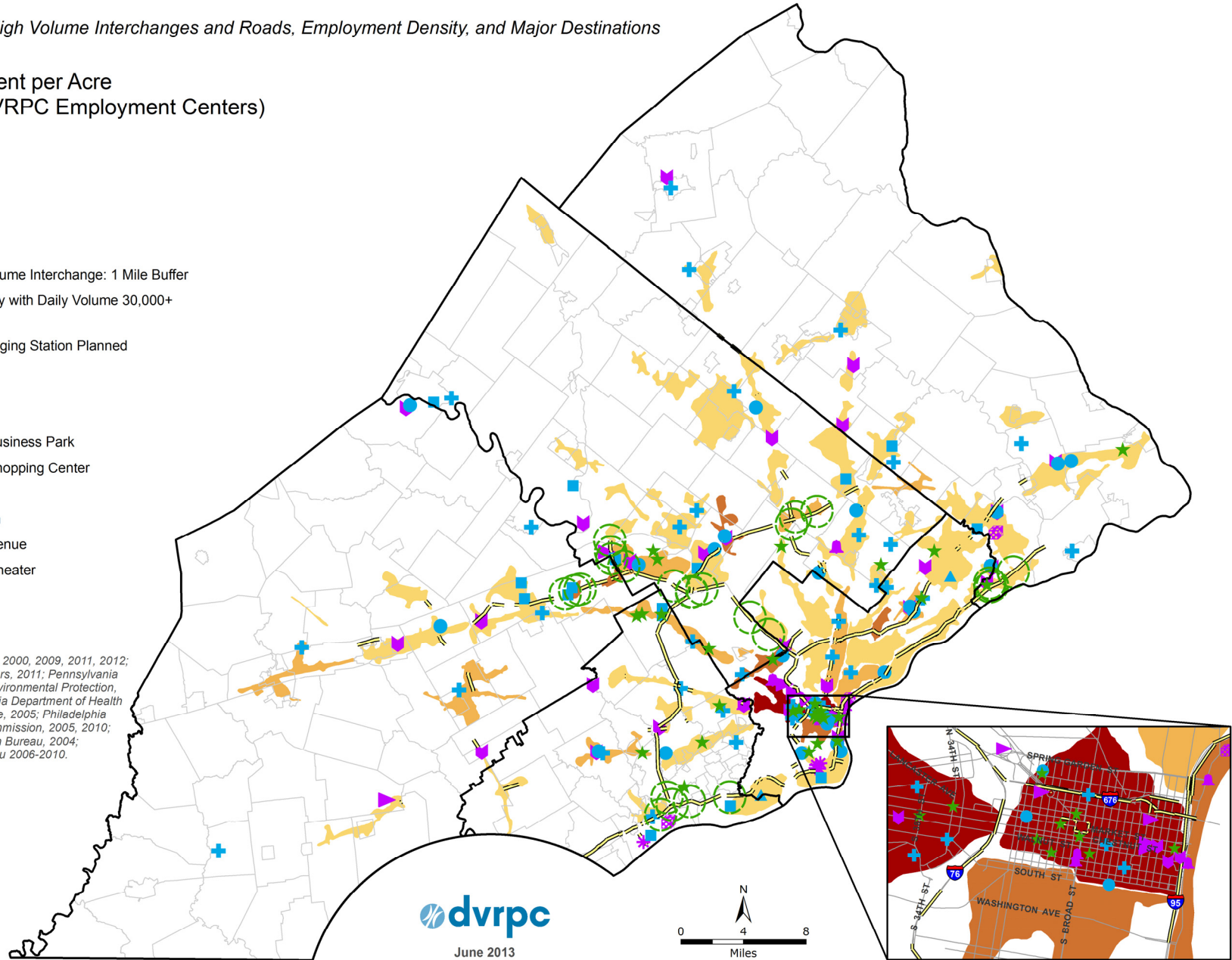
Based on High Volume Interchanges and Roads, Employment Density, and Major Destinations

Employment per Acre
(within DVRPC Employment Centers)

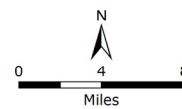


- ★ EV Charging Station Planned
- ▲ Airport
- + Hospital
- Major Business Park
- Major Shopping Center
- ⊠ Casino
- ▶ Museum
- ⬇ Music Venue
- ⬇ Movie Theater
- * Stadium

Sources: DVRPC, 2000, 2009, 2011, 2012; FAA, 2009; Hoovers, 2011; Pennsylvania Department of Environmental Protection, 2012; Pennsylvania Department of Health and Public Welfare, 2005; Philadelphia City Planning Commission, 2005, 2010; National Research Bureau, 2004; US Census Bureau 2006-2010.



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These maps are not intended to constrain the deployment of public and workplace EVSE. Instead, they provide useful guidance for stakeholders and local governments seeking to support EVs on the road by providing additional charging opportunities. As early EV adopters seek more opportunities to charge in nonresidential locations, it will be important to have a highly visible network of EVSE. This network will help expand the charging opportunities for early adopters, while also sending the right market signals to likely EV adopters, i.e., that there will be ample opportunity to charge their vehicles, thereby maximizing vehicle operations savings, while mitigating any perceived inconvenience of limited range.

5.4 2012-2015 Projections of EV Deployment in Southeastern Pennsylvania

This section builds upon the EV demand analysis to forecast future EV deployment in southeastern Pennsylvania, based on sales data, an understanding of existing regulatory and economic drivers, and existing EV deployment projections for other regions.

Prior to recent vehicle price cuts for the Nissan LEAF, sales of PHEVs such as the Toyota Prius Plug-In, Chevrolet Volt, and Ford C-Max Energi were increasing more rapidly than sales of the Nissan LEAF (an AEV). Other OEMs have also reduced lease pricing and are offering cashback incentives to consumers for AEVs; however, it is unlikely that the near-term trend in AEV sales out-performing PHEV sales will continue. For instance, in a recent survey of automobile executives conducted by KPMG, nearly one third of respondents indicated that their firm's biggest investments over the next five years will be in plug-in hybrid technology, second only to ICE downsizing.¹²⁹ Based on these data, the project team assumed that PHEVs will outsell AEVs through 2020.

In addition to sales data, the project team considered regulatory drivers, such as the federal CAFE standards, when developing its EV deployment projections. EVs provide a compliance pathway for the CAFE standards. However, research suggests that fuel-efficiency improvements, rather than EV technology, will contribute most to compliance. These improvements include more efficient engines, improved transmission design, and better matching between engines and transmission, as discussed in Section 0. In fact, the scenarios used to reach the 2025 CAFE standard forecast that only three to four percent of the vehicle fleet will need to be EVs in order to meet the standard.¹³⁰ Thus, the project team considered the federal CAFE standards to provide only a marginal regulatory driver for EV deployment.

In the absence of strong regulatory drivers, such as the ZEV Program in California, economic motivations drive EV purchases in southeastern Pennsylvania. Economic drivers include vehicle price, cost of ownership, consumer income, and gasoline price. The project team analyzed oil pricing scenarios developed by EIA as part of the Reference Case for the *Annual Energy Outlook 2012*.

¹²⁹ "KPMG's Global Automotive Executive Survey 2013: Managing a multidimensional business model," KPMG International, 2013.

¹³⁰ Charles Zhu and Nick Nigro, "Plug-In Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review."

Furthermore, the team considered various industry studies that contain EV sales forecasts for the United States and the global market, presented in Table 18 below.

Table 18. Summary of Notable EV Market Share and Sales Forecasts¹³¹

Source of Forecast	Geography Addressed	Forecast Year	Predicted Market Share			Predicted Unit Sales (million)		
			PHEV	AEV	EV	PHEV	AEV	EV
Pike Research	US	2015				0.20	0.06	0.26
Deloitte Consulting	US	2015			0.3-0.5%			0.05-0.08
		2020			1.9-5.3%			0.3-0.8
Boston Consulting Group	North America	2020	0-5%	0-5%	0-10%	0-1.35	0-1.35	2.70
JD Power & Associates	Worldwide	2020		1.8%			1.30	
	US	2020		<1%			0.10	
Bain & Company	Worldwide	2020	2-20%	5-30%	7-50%			
McKinsey & Company	Worldwide	2020	0-6%	0-2%	0-8%	0-4.5	0-1.5	0-6
		2030	0-24%	0-8%	0-32%	0-22	0-7	0-29

Source: Lusk School of Public Affairs, UCLA, 2011; Jeffrey Dubin et al., "Realizing the Potential of the Los Angeles Electric Vehicle Market," accessed June 2013, <http://lusk.ucla.edu/sites/default/files/LA%20EV%20Final%20Report%20-%20Formatted%20-%20Final%20-%20High%20Quality%20for%20printing.pdf>, 10.

The team also considered the projections in a 2010 study conducted by New York City and McKinsey & Company, which found that 21 percent of New York residents fall into the category of "early adopters." The study estimated that 14 to 15 percent of the city's inhabitants that purchase a vehicle by 2015 may buy EVs.¹³² In a separate study, McKinsey & Company surveyed consumer sentiment in three megacities—New York City, Shanghai, and Paris—and projected that EVs could account for 16 percent of new vehicle sales in these areas by 2015. The study also predicted that demand would likely outstrip supply.¹³³ Because of the regional differences between New York and Philadelphia (and its surrounding region), the project team considers this level of sales (16 percent) as an upper limit of the potential for southeastern Pennsylvania.

Finally, the project team considered the sales forecast by the Center for Automotive Research (CAR), cited in a literature review by the Center for Climate and Energy Solutions (C2ES) for the Transportation and Climate Initiative (TCI), Georgetown Climate Center, and NYSERDA. CAR forecasts that Pennsylvania will have nearly 16,000 EVs on the road by 2015.

¹³¹ Blank sections indicate information that was not provided in a given forecast.

¹³² Jeffrey Dubin et al., "Realizing the Potential of the Los Angeles Electric Vehicle Market," 11.

¹³³ Charles Zhu and Nick Nigro, "Plug-In Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review," 13.

To arrive at this number, CAR applied a fixed percentage to total nationwide sales based on retail HEV registrations in 2007 to 2009. Pennsylvania accounted for 3.4 percent of HEV registrations during that time period. CAR applied this percentage to nationwide sales forecasts to estimate the number of EVs in 2012 to 2015.

This approach is problematic for several reasons. First, the mature market for HEVs, which have been on the road since 2000, does not necessarily predict a market for an emerging technology, such as EVs. Second, the nationwide EV sales forecasts for 2011 and 2012 used in the CAR report are considerably higher than actual sales for those years (see Table 19).

Table 19. Comparison of CAR Forecast and Actual EV Sales

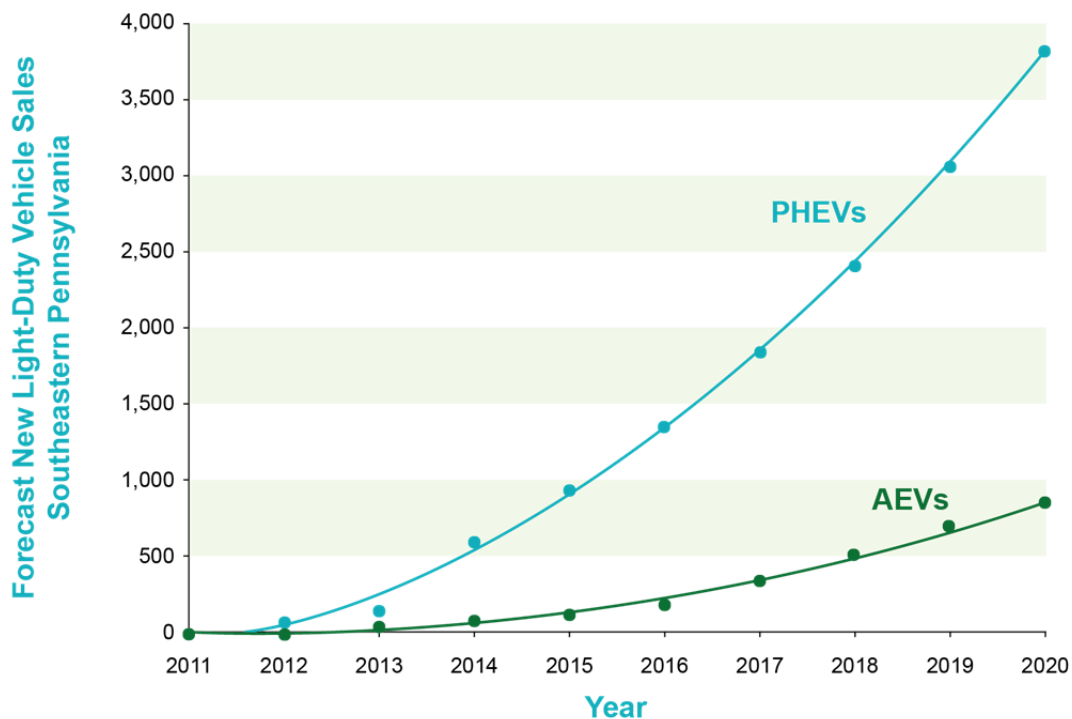
Year	Center for Automotive Research Forecast EV Sales	Actual EV Sales
2011	27,000	17,735
2012	77,000	52,835
2013	116,000	32,305*
2014	136,000	--
2015	140,000	--

Source: CAR, "Deployment Rollout Estimate of Electric Vehicles: 2011-2015," accessed June, 2013, <http://www.cargroup.org/assets/files/deployment.pdf>, 17-18; EDTA, "Electric drive vehicle sales figures (U.S. Market) - EV sales," accessed June, 2013, <http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952..>
 * 2013 figures through May 2013

For its EV deployment forecast, the project team supplemented the CAR estimates with additional data that reflect events that were unpredictable at the time of the CAR report, such as the impact on vehicle supply chains of a massive earthquake and subsequent tsunami on the east coast of Japan in March 2011.

The project team estimated that EV sales would comprise approximately 2.6 percent of total new vehicles sales in southeastern Pennsylvania by 2020, of which PHEVs and AEVs would account for 2.1 percent and 0.5 percent, respectively, as shown in Figure 9 below.

Figure 9. Projected PHEV and AEV Sales



Source: DVRPC, 2013.

Forecasting EV sales or even EV availability for the mid to long term involves uncertainty. As encountered during interviews with Nissan, Ford, GM, and Tesla, few EV OEMs will release reliable marketing information or sales projections. In addition, the EV industry is young and changes constantly, making its future difficult to predict. For example, many regions assumed that the Ford EV Transit Connect would be available into the future, but the company that developed the vehicle's electric-drive powertrain, Azure Dynamics, filed for bankruptcy protection in 2012.¹³⁴ With the understanding that all forecasts contain uncertainty, various researchers have calculated EV sales estimates, using market data and knowledge of deployment drivers. The EV deployment forecast for southeastern Pennsylvania, presented in Figure 9, provides a best estimate of the EV sales to expect in the region in coming years.

5.5 EV Ownership Costs in Southeastern Pennsylvania

The project team developed a Microsoft Excel-based tool to calculate total cost of ownership for EVs, which is available through the DVRPC Electric Vehicle Clearinghouse.¹³⁵ The tool allows users to compare the total cost of vehicle ownership for EVs and their conventional counterparts (i.e., ICE vehicles). The user selects an EV model and answers brief questions about his or her driving habits and access to charging infrastructure. The tool then produces a customized report that summarizes the costs associated with acquiring, operating, and maintaining the EV

¹³⁴ Azure Dynamics, "Azure Dynamics Announces Commencement of CCAA Proceedings," accessed June 2013, <http://www.bloomberg.com/apps/news?pid=newsarchive&sid=a6bivrxntL41>.

¹³⁵ See www.dvrpc.org/EnergyClimate.

compared to a comparable conventional vehicle. The report also presents the net savings or costs of owning an EV over the period of vehicle ownership. The simple user interface will make it easy for users to adjust their inputs (e.g., altering driving behavior, vehicle model, and EVSE type) and evaluate the cost implications of different scenarios.

In the following sections, the development of the tool is introduced by reviewing the tool's user inputs, cost calculations, and underlying assumptions. Appendix A, Appendix B, and Appendix C include tables and data extracted from the Microsoft Excel spreadsheets used to develop the tool.

5.5.1 User Inputs

The tool offers a simple interface for users to enter information about their driving patterns, vehicle preferences, and access to charging infrastructure. The user must provide five data points:

- **Weekday vehicle miles traveled (VMT):** The user enters an estimated number of miles traveled on a typical weekday.
- **EV model type:** The user selects from a list of EV models that are either currently available or soon to be released.
- **Access to Level 1 charging infrastructure:** The user reports whether he or she has access to an outlet for basic charging. If the user does not know, the instructions encourage him or her to report no access. The calculator then provides a conservative cost estimate, assuming that the user would be required to purchase, install, and permit Level 1 charging infrastructure.
- **Access to workplace charging infrastructure:** The user reports whether he or she has access to charging infrastructure at the workplace. If the user does not know, he or she is instructed to report no access. The calculator then assumes that the user will charge the vehicle once daily.
- **Discount rate:** The user enters a discount rate for the calculator to use to calculate the present value of future ownership costs. The user can choose to use the default value.

5.5.2 Cost Calculations

Once the user has provided the inputs discussed above, the tool calculates the total cost of ownership for the selected EV and its ICE vehicle counterpart.^{136, 137} The total cost of ownership consists of costs incurred over the entire period of vehicle ownership, converted to their net present value and summed. The tool aggregates the results for three major cost elements of vehicle ownership: acquisition, operations, and maintenance.

Acquisition costs include the vehicle purchase price (the MSRP, excluding tax, license, registration, options, and destination charges), Pennsylvania state vehicle sales tax, and a

¹³⁶ The tool focuses on cost elements that vary between EVs and ICE vehicles. It does not consider costs common to all vehicles (e.g., vehicle registration, taxes, parking fees, and tolls).

¹³⁷ ICE counterparts were determined by ICF based on similar vehicle characteristics, vehicle performance, and market research.

federal tax credit for EV purchase (available for approved EVs based on battery capacity), where appropriate.

Acquisition costs also include any upfront costs associated with investing in new charging infrastructure. The tool calculates costs of ownership for two scenarios: one in which the user relies on Level 1 charging and another in which the user upgrades to Level 2 charging. Under the Level 1 scenario, if the user already has access to Level 1 infrastructure (e.g., an outlet in a garage), the tool assumes no cost for acquiring charging infrastructure.¹³⁸ If the user does not have existing infrastructure, the cost for acquisition includes basic hardware, installation labor, and permitting fees. Under the Level 2 scenario, the costs to purchase, install, and permit the charging infrastructure are higher. Comparing the costs of ownership under the two charging scenarios allows users to evaluate the cost implications of choosing a particular charging type. The costs take into account the federal EVSE tax credit available through 2013.

Operation costs consist of fuel consumption costs. The tool uses current regional electricity and gas prices as baseline fuel prices.¹³⁹ It then projects fuel prices for future years, using the trends in national fuel prices forecast by EIA in the *Annual Energy Outlook 2012*.¹⁴⁰

To translate fuel prices into fuel consumption costs, the tool determines how many miles the user will drive in electric or gasoline mode. The user enters an estimate of his or her weekday VMT. The model assumes that all users travel a predetermined number of recreational VMT each year. The share of VMT in each mode varies with the vehicle type. If the user selects an AEV, the tool assigns all VMT to electric mode. If the user selects a PHEV, the tool assigns the portion of the weekday VMT that will be driven in the PHEV's all-electric mode. Any VMT beyond the PHEV's all-electric range are considered gasoline miles. If the user specifies access to workplace charging in the "User Inputs" page, the tool doubles the PHEV's daily electric range, assuming that the vehicle will be charged twice daily. The tool assumes that 30 percent of the recreational VMT use electricity and 70 percent use gasoline. For the ICE vehicles, all miles are gasoline miles. The tool then converts weekday VMT to annual VMT.¹⁴¹

Finally, the tool multiplies the total annual VMT (including weekday VMT and recreational VMT) by the vehicle's efficiency (reported in kWh per mile for electric mode and in mpg for gasoline mode) and then by the unit price for the respective fuel in each year. The sums of electricity and gasoline consumption costs for each vehicle are aggregated to yield operations costs.

Maintenance costs reflect the costs to maintain, repair, and replace vehicle parts (e.g., oil filters, air filters, spark plugs, timing chains, and brakes). The literature on EV maintenance

¹³⁸ The tool assumes that an EV owner receives a charging cord when purchasing the vehicle.

¹³⁹ PECO provides the current price of electricity for Philadelphia, Delaware, Bucks, Montgomery, Chester, and York counties. The U.S. Bureau of Labor Statistics reports the current average price of gasoline in the Philadelphia-Wilmington-Atlantic City area.

¹⁴⁰ To forecast future fuel prices, ICF calculated the annual percent increases in the national electricity and gasoline price forecasts presented in the EIA's Electricity Supply, Disposition, Prices, and Emissions table and Petroleum Product Prices table, respectively. The baseline regional prices were multiplied by the percent increases to estimate the future fuel prices for each of the 10 years included in the analysis.

¹⁴¹ The tool assumes that the user's estimate of a typical weekday will be representative of 250 driving days each year (5 days a week x 50 weeks a year). Thus, the tool multiplies any weekday VMT values by 250 to yield annual values.

indicates that AEVs and PHEVs have significantly lower maintenance needs than ICE vehicles. Some maintenance needs are completely eliminated (e.g., AEVs do not require oil changes or air filter replacements) and others are significantly reduced because of the different mechanical structures (e.g., AEVs and PHEVs require less frequent brake pad replacement than ICE vehicles). The tool assumes maintenance costs per mile and calculates the total maintenance costs by multiplying these per mile values by the user's estimated total VMT.

5.5.3 Model Assumptions

The tool relies on a set of research-based assumptions. These assumptions are listed below:

- All EVs that fall within the qualifying battery capacity range receive a federal tax credit corresponding to the battery capacity.
- All EVSE receives a federal tax credit corresponding to EVSE hardware cost.
- Users own a vehicle for a period of 10 years. The tool does not capture resale value as it is currently constructed. The model, however, could capture resale value in future iterations.
- To identify comparable ICE vehicles, the project team considered vehicle characteristics and performance from similar vehicles in the manufacturer's offerings, except in the case of Tesla. For the Tesla equivalents, pricing data for several luxury models from multiple manufacturers were considered for comparative purposes. For Tesla Model S (40 kWh battery), the least expensive models of the three listed vehicles were used. For Tesla Model S (60 kWh battery) and Tesla Model S (85 kWh battery), the midrange and high-end models of the three listed vehicles were used, respectively.
- Original vehicle batteries are used for the entire period of vehicle ownership. The tool does not capture secondary life as it is currently constructed. However, the model could capture the residual value of the battery in future iterations.
- Charging cords come with EVs at the time of purchase. This cost is embedded in the vehicle cost.
- Users drive approximately 2,000 recreational miles per year. For PHEVs, 30 percent of those miles are driven in all-electric mode.
- Users pay for all charging. Free public charging or private charging using renewable energy could reduce the operational costs for EVs below those reported by the tool.
- Users charge once daily unless they have access to workplace charging, in which case they charge twice.
- National fuel price trends are representative of regional fuel price trends.
- There are no additional maintenance costs associated with residential EVSE.
- The cost of maintenance for PHEVs is approximately one-half that of ICE vehicles. The cost of maintenance for AEVs is approximately one-third that of ICE vehicles. More detail on vehicle maintenance is supplied in Appendix B.
- Installation of charging infrastructure takes place at single-unit residences. The model, however, could account for different residence types in future iterations.

5.6 Incentives and Initiatives to Promote EV Deployment in Southeastern Pennsylvania

This section outlines several incentives and initiatives that will support EV deployment by each EV consumer category, as identified in the household profiles analysis in Section 5. EV and EVSE incentives are discussed in further detail in Section 9.

5.6.1 Early Adopters

The early adopter market segment, which accounts for approximately four percent of households in southeastern Pennsylvania, will likely dominate EV purchases for the next several years. Existing vehicle purchase incentives will support consumption by early adopters and some likely adopters (and perhaps possible adopters, if the incentives are extended). Recommended incentives for early adopters include:

- Purchase incentives that are designed to ensure that early adopters are unable to use all allocated resources;
- Nonresidential infrastructure incentives through public-private partnerships (PPPs);
- Residential infrastructure incentives focused on MUDs and other locations where vehicle purchasers cannot access a garage; and
- Nonfinancial incentives, such as parking incentives.

5.6.2 Likely and Possible Adopters

Mid-adopters, which include likely and possible adopters, are most likely to buy a new car, but they may not have the income to afford an EV. Compared to early adopters, mid-adopters present a greater challenge for EV market penetration. They tend to react more to price than early adopters or unlikely adopters do. The following incentives may promote EV uptake by mid-adopters:

- Purchase incentives that combine incentives for vehicle exchange or retirement;
- Nonfinancial incentives, such as parking incentives (will be more effective with mid-adopters than early adopters); and
- Targeted outreach and education (will likely yield the highest benefits because consumers may not be well informed about EVs, including cost of ownership benefits or vehicle attributes like power and performance).

5.6.3 Unlikely Adopters

Accelerating the introduction of EVs for unlikely or late adopters will become critical in the post-2020 timeline. Late adopters tend to focus on vehicle attributes (e.g., comfort and luxury), price, and total cost of ownership. The increase in fuel economy of conventional vehicles will present a significant barrier to EV penetration in the unlikely adopter market segment because it decreases the difference in total cost of ownership between EVs and conventional vehicles.

Although EV technology will improve, OEMs have no significant incentive to make EVs more fuel efficient because baseline PHEVs and AEVs are already very fuel efficient.

The incentives outlined for early and mid-adopters will also capture unlikely adopters. Ultimately, though, value and vehicle attributes will be the main drivers for this segment of consumers.

6 EVSE Installation Considerations and Processes

This section discusses the EVSE installation process, including permitting, utility notification, and compliance with ADA regulations. This section also outlines the costs associated with EVSE acquisition, installation, and operation.

6.1 EVSE Installation Process

Before the delivery of an EV, the consumer generally prepares his or her residence for EV charging. He or she may seek out a certified contractor to install EVSE at the residence and ensure that the residence has adequate electrical capacity.

350Green, an EVSE installer, found inconsistency among installation guidelines throughout the country.¹⁴² To overcome this challenge, some regions have provided EVSE installation checklists to facilitate the process for interested consumers. For example, PECO provides an EVSE Checklist for its customers (see Figure 10 below).

Figure 10. PECO EV Checklist

PECO EV Checklist

If you are considering buying an EV or have already purchased an EV, here is some helpful information:

- Review vehicle charging options and manufacturer recommendations.
- Work with an electrical contractor to evaluate your home's wiring, electrical outlets, electrical panel, and other equipment to ensure it can support the charging requirements of your new electric vehicle.
- Have a qualified electrical contractor obtain all required permits, file an application with PECO, and complete any upgrades needed. All upgrades must meet appropriate National Electrical Code (NEC), Underwriters Laboratories (UL), state, and local code requirements and be inspected by a third-party inspector. To find a licensed electrical contractor, visit the Electrical Association of Philadelphia website.
- Determine if your purchase qualifies for federal or state tax credits and other incentives. To learn more, visit the DOE Laws & Incentives database or the PA DEP website, or call 866-294-3854.
- Register your vehicle with PECO and receive a \$50 PECO Smart Driver Rebate. View full terms and conditions.

For more information on EVs, visit www.goelectricdrive.com.

Source: PECO, "Your resource for everything EV," accessed June 2013, <https://www.peco.com/Environment/GreenVehicles/ElectricVehicles/Pages/Overview.aspx>.

¹⁴² Bay Area Air Quality Management District, "Planning Concepts Document," August 2012, 58.

Checklists, such as this one, help consumers understand the EVSE installation process. However, some consumers may face more difficult challenges, such as those living in apartment buildings and other MUDs, as highlighted in Table 20.

Table 20. Challenges to Installation of EVSE at MUDs

Physical Challenges	<ul style="list-style-type: none"> • Availability of capacity in the electrical panel. • Availability of space for additional meters in the meter rooms. • Distances between utility meters, parking spaces, and unit electrical panels.
Cost of Installation and Operation	<ul style="list-style-type: none"> • Restrictive facility configurations (master meter, remote parking, etc.). • Cost allocation to residents (based on usage, equipment, parking, and shared service areas). • Inability to take advantage of off-peaking charging rates. • HOA fee structures.
Codes, Covenants, and Legalities	<ul style="list-style-type: none"> • Differences in ownership. • Differences between actors who make the investment versus those that reap benefit. • Agreements between property owners and residents/renters. • Deeded parking spaces assigned to individual residents.

Source: S SFEnvironment, "EV Chargers in Multifamily Buildings," 2012.

Challenges to EVSE installation at MUDs include HOA restrictions; high costs; and limited space for or access to charging infrastructure (power). With regard to HOA restrictions, an interested consumer must first determine whether the HOA or other managerial entity will permit EVSE installation. According to discussions at the Garage Free Summit hosted by DVRPC in February 2012, some HOAs in southeastern Pennsylvania restrict EVSE installation (for a detailed summary of the Garage Free Summit, see Appendix D). Reasons for restricting EVSE installation may include equity concerns related to reserving dedicated EV parking spaces and the cost of infrastructure upgrades needed for EVs out of communal funds. Experience in other regions suggests that targeted education and outreach can help overcome these barriers.

Cost presents a barrier depending on the type of parking facilities (e.g., garage, dedicated parking spot, or surface lot) and the existing electrical infrastructure at the MUD. Installing EVSE at a surface lot is particularly expensive, as is installation that requires trenching or additional metering. Cost of installation may become a significant challenge for southeastern Pennsylvania depending on the demand for EVs in high-density areas, as discussed in Volume I, Section 1.

To install EVSE, consumers generally need to obtain a permit. Permitting processes differ across jurisdictions; some are verbal, and others are in person or online. Sometimes, the EV

owner obtains a permit for completion of work by a certified electrician. 350Green identified permitting and ADA compliance (described below) as the two biggest barriers to EVSE installation.¹⁴³ Regions interested in EVSE deployment have begun identifying ways to standardize and streamline the permitting process.

Utility notification goes hand in hand with EVSE permitting as part of the installation process. Informing utilities of EVSE installation helps the utility prepare for the additional electric load from EV charging, which can be significant. As previously noted, charging a single EV can double the load of an entire household. This potential stress on the grid has led policymakers and utilities to consider developing a utility notification requirement or, at a minimum, guidance for new EV owners. For example, the State of Maryland has granted the Motor Vehicle Administration permission to provide the address of a registered EV owner and information about the vehicle to electric companies for their use.¹⁴⁴ Any utility notification process should maintain consumer privacy.

Utility notification can occur when the EV owner purchases the vehicle (done by the dealer), registers the vehicle with the department of motor vehicles, or submits the permit for EVSE installation. In southeastern Pennsylvania, PECO does not have a requirement for utility notification, but it offers rebates to encourage its customers to notify the company after registering a newly purchased EV with PennDOT.¹⁴⁵

Finally, public EVSE installations must comply with ADA accessibility standards for sidewalks, parking spaces, and other public facilities. ADA accessibility standards influence the placement, dimensions, and number of ADA-accessible EV parking spaces. With regard to placement, placing accessible EV parking spaces close to ordinary disabled parking spots may be most practical and could have the additional benefit of showcasing EVs. However, the general public may resent that EVs receive preferential parking spaces. Some EV advocates encourage placing public EVSE in a location that is convenient, but not preferential, and dictated as much by proximity to the electrical panel as to the front door.

Some regions have developed guidance for ADA-accessible EVSE. For instance, California developed Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations in 1997.¹⁴⁶ These guidelines focus on state-funded projects, but they provide some initial guidance for local governments. Current guidance under development in California suggests that the first charging station in a parking lot with ADA-accessible parking should be ADA-accessible, as well as every twenty-fifth additional station.

¹⁴³ Bay Area Air Quality Management District, "Planning Concepts Document," August 2012, 58.

¹⁴⁴ DOE, "Plug-in Electric Vehicle (PEV) Information Disclosure."

¹⁴⁵ PECO, "PECO Smart Driver Rebates."

¹⁴⁶ California Department of General Services, "Interim Disabled Access Guidelines for Electrical Vehicle Charging Stations, 97-03," accessed June 2013, http://www.documents.dgs.ca.gov/dsa/pubs/policies_rev_01-01-11.pdf.

6.2 Economics of EVSE Acquisition, Installation, and Operation

EVSE costs may include hardware, permitting, installation, maintenance, and operation costs. These costs vary depending on the type of EVSE installed and the characteristics of the installation site. In particular, installation costs can increase significantly if installation requires utility upgrades, trenching or cement cutting to route circuitry, or compliance with certain regulations (e.g., ADA). This section discusses EVSE costs for the following locations:

- Single-family homes with dedicated parking;
- MUDs and workplace; and
- Public installations (e.g., parking lots and on-street parking).

6.2.1 Single-Family Home with Dedicated Parking

For most single-family homes, the electrical service available in the garage or through dedicated parking is suitable for Level 1 EVSE. Level 1 charging uses a 120V connection and does not require additional or special equipment, and a simple cord and plug arrangement will suffice. Few factors increase the cost of Level 1 EVSE unless the utility requires a separate meter to take advantage of special EV utility rates.

GM has reported that about 50 percent of Volt drivers opt for Level 1 charging. However, Level 1 EVSE may not work well for owners of EVs with larger batteries, such as the Nissan LEAF, because of the time it requires to fully charge a depleted battery using Level 1 (up to 20 hours). Instead, EV owners may opt to install dedicated Level 2 EVSE. Table 21 lists the estimated costs for Level 2 EVSE, including hardware, permitting, and installation. The information used to determine these cost estimates is discussed below.

Table 21. Estimated Costs for Single-Family Home Level 2 EVSE

Element	Low Estimate	High Estimate
Hardware	\$500	\$1,100
Permitting	\$100	\$250
Installation	\$300	\$1,000
Total	\$900	\$2,350

Source: DVRPC, 2013.

The hardware cost estimates reflect a range of costs reported by EVSE suppliers. Many EV manufacturers partner with EVSE suppliers to install Level 2 EVSE. For example, GM has partnered with SPX, which sells EVSE priced from \$490 to over \$1,000. Nissan and Mitsubishi have partnered with AeroVironment, which sells EVSE for about \$1,100. Toyota has partnered with Leviton, which sells EVSE starting at approximately \$1,000. Retailers, such as Best Buy and Home Depot, sell Level 2 EVSE ranging from \$750 to \$1,000. Other suppliers sell EVSE

well above \$5,000,¹⁴⁷ but this analysis used a high estimate of \$1,100 for the price of Level 2 EVSE hardware.

This analysis estimated a range of \$100 to \$250 for permitting costs and \$300 to \$1,000 for installation costs. EV charging has the potential to increase a home's electricity load. Careful planning and professional EVSE installation can help to avoid a circuit overload. When necessary, an electrician will install an additional circuit with its own circuit breaker to accommodate EV charging. New circuit wiring must meet local electrical code standards, which may require a permit followed by an inspection. Permitting costs can vary considerably, from \$100 to over \$250. In fact, 350Green, an EVSE installer, encountered some municipalities that require a use permit for EVSE. Use permits can be very expensive and are typically required for land uses that have a potentially negative impact on the surrounding neighborhood. The City of Berkeley, California, charges \$1,800 for a use permit, which makes the installation of Level 2 EVSE cost-prohibitive.¹⁴⁸

In addition to permitting costs, the labor required to install new circuitry adds to the total cost associated with EVSE. The range of installation costs shown in Table 21 above reflects the hours required from a professional electrician at an estimated hourly rate of \$75 per hour. The number of hours worked depends on the level of difficulty to install the infrastructure. A new circuit box, conduit to the garage, and EVSE networking capabilities of the EVSE could increase the total costs of installation closer to \$2,500.

Single-family homes without a garage could face additional hurdles associated with obtaining approval from a neighborhood association. Local zoning requirements may also require a public hearing and a lengthy preapproval process. Although an EPRI study showed that 95 percent of EV customers prefer home charging, in cases where EVSE installation costs become prohibitive, workplace charging may provide another option for EV charging.¹⁴⁹ For this reason, C2ES identifies workplace charging in addition to home charging as a priority location for the development of EV charging infrastructure in its report, "An Action Plan to Integrate Plug-In Electric Vehicles with the U.S. Electrical Grid."¹⁵⁰

DC fast charging is not considered to be a practical application for home charging, so the costs have not been estimated for this option.

As of March 2013, PECO did not offer an EV rate and did not require installation of a separate meter for EV charging.

¹⁴⁷ Plug In America, "How Will You Charge Your Ride?," accessed June 2013, <http://www.pluginamerica.org/accessory-tracker?type=All&level=2&nrtl=All>.

¹⁴⁸ Bay Area Air Quality Management District, "Planning Concepts Document," August 2012, 58.

¹⁴⁹ EPRI and Southern California Edison, "Characterizing Consumers' Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results."

¹⁵⁰ C2ES, "An Action Plan to Integrate Plug-In Electric Vehicles with the U.S. Electrical Grid," accessed June 2013, <http://www.c2es.org/docUploads/PEV-action-plan.pdf>.

6.2.2 MUD/Workplace

A study by AeroVironment noted that MUD charging has more in common with workplace charging than with single-family home charging because building managers and employers are more likely than the tenants and employees to own the EVSE.¹⁵¹ Tenants and employees are more likely to cover the operational costs. Because of these similarities, this analysis groups MUD and workplace charging. Table 22 summarizes the costs of MUD and workplace charging for Level 1, Level 2, and DC fast -charge EVSE, assuming two ports per installation.

Table 22. Estimated costs for MUD and Workplace EVSE Installations

Cost Element	MUD and Workplace Installations					
	Level 1 EVSE		Level 2 EVSE		DC Fast Charge EVSE	
	Low	High	Low	High	Low	High
Hardware	\$200	\$500	\$500	\$2,000	\$10,000	\$30,000
Permitting	\$100	\$500	\$100	\$1,000	\$500	\$1,000
Installation	\$500	\$5,000	\$2,000	\$6,000	\$3,500	\$6,000
Trenching/Concrete	\$3,000	\$5,000	\$3,000	\$5,000	\$3,000	\$5,000
Total, installed ¹⁵²	\$3,800	\$11,000	\$5,600	\$14,000	\$17,000	\$42,000
Networking (annual)	\$120	\$300	\$120	\$300	\$120	\$300
Maintenance (annual)	\$100		\$100		\$100	

Source: Electric Transportation Engineering Corporation, "Electric Vehicle Charging Infrastructure Deployment Guidelines for Greater San Diego," May 2010, 55-8; ICF International, 2013. The original study's high-cost scenario assumes a \$25,000 cost associated with trenching and concrete. However, this is considered more of an outlier than a true indication of the high cost that might be expected and inflates the costs significantly. Rather, the project team used a trenching cost of \$5,000..

Table 22 presents cost estimates for the first EVSE installation at each location. Installing a second EVSE at the same location does not double the cost, as the infrastructure and permitting costs can be shared. Thus, in many cases it may make sense to install multiple EVSE at a single charging station location. All of the cost elements, except hardware, yield some benefit with an increased number of installations. However, hardware represents a small portion of the overall cost for Level 1 and Level 2 EVSE. Even for DC fast-charge EVSE, hardware accounts for about 25 to 60 percent of the total cost of the first installation; the remaining portion will yield savings with multiple installations at the same location. Furthermore, the cost of DC fast-charge EVSE hardware has declined, as evidenced by Nissan's recent partnership with Sumitomo to market a charger for \$15,500.¹⁵³

The installation costs for MUD or workplace EVSE presented in Table 22 exceed those for a single-family home installation because many parking lots or garages lack adequate electrical service nearby. Although typically considered a prime location for EVSE deployment, parking

¹⁵¹ Charles Botsford, "The Economics of Non-Residential Level 2 EVSE Charging Infrastructure," EVS26, Los Angeles CA, 2012.

¹⁵² The total cost does not include the annual costs associated with networking. These are shown for illustrative purposes only.

¹⁵³ Nissan, "DC Quick Charger," accessed June 2013, <http://nissanqc.com/>.

garages may only have enough spare electrical service to accommodate two or three Level 2 EVSE, each of which requires a dedicated 240V, 40 A circuit. Deploying more EVSE would require additional subpanels and, in many cases, larger transformers and main panels. Installing multiple ports may require replacing the circuitry and installing a conduit to an area dedicated to EV parking spots. Based on discussions with manufacturers and reviews of product literature, adding a conduit could require trenching and concrete work in addition to compliance with signage, structure, access, and safety requirements. If the company uses a TOU rate, there may also be additional demand charges.

Fee-based charging provides another option for overcoming the installation cost barrier for workplace and MUD EVSE. AeroVironment estimates potential revenue of \$520 to \$838 per year per port, which could help recoup installation costs.¹⁵⁴

Table 22 also includes annual costs for maintenance and networking. MUD and workplace EVSE installations incur these costs, whereas single-family home installations typically do not. Maintenance costs of \$100 per year cover semiannual inspections of the EVSE and repairs for vandalized equipment. Networking costs cover fees for a cellular network to transfer data related to payment and usage. EVSE could also have smart grid capabilities (discussed in detail in Section 10), which could control charging time to reduce stress on the grid.

When installing EVSE, building managers and employers must also consider ADA regulations for accessible parking. Compliance with ADA regulations can present challenges to EVSE installation. For example, ADA-accessible EV parking spaces may have lower potential to recoup the costs of the EVSE installation through fee-based charging because of underutilization. To address this challenge, building managers and employers could create EV parking spaces with enough width to accommodate access for a person with a disability but without a sign indicating the spot as disabled parking. Although intended for EV use, such a parking space would still allow use by disabled persons.

6.2.3 Publicly Accessible EVSE

EVSE deployment efforts have focused on providing access to residential and publicly accessible EVSE. Publicly accessible EVSE costs are similar to those for MUD and workplace EVSE.

Maintenance for publicly accessible EVSE can impose a significant financial burden, which public agencies may overlook or underestimate in the rush to deploy infrastructure. Public agencies incur maintenance costs regardless of whether they maintain ownership or pay for a maintenance service through a service provider. In addition to general maintenance, ECotality previously identified vandalism as a concern, although recent interviews with the company indicate that it is a less significant issue than they originally anticipated.¹⁵⁵

¹⁵⁴ Charles Botsford, "The Economics of Non-Residential Level 2 EVSE Charging Infrastructure," accessed June 2013, http://www.e-mobile.ch/pdf/2012/Economics_of_non-residential_charging_infrastructure_Charles-Botsford-EVS26.pdf, 5.

¹⁵⁵ Steve Schey (ECotality North America), phone interview, April 11, 2012.

The cost of operating publicly accessible EVSE can also be significant. EVSE can impact electricity costs for parking garage operators, primarily through higher TOU rates (during on- and midpeak hours) and demand charges (separate charges based on maximum usage during a time period for electric service by a commercial or industrial customer). Parking garages typically do not pay high demand charges because they generally have stable electricity demand limited to lighting and ventilation. However, EV charging often changes the service profile of those facilities, increasing the demand charge.

EVSE providers will need to develop a strategy to overcome the costs associated with providing publicly accessible EVSE. A recent Ernst & Young survey examined the business strategies of 143 EVSE companies.¹⁵⁶ The survey did not identify any clear value proposition for EVSE hosts (e.g., parking lot owners). Similarly, in a moderated discussion hosted by Ernst & Young regarding the EVSE market, participants noted a “need to fill gaps between who manages, owns and pays for the charging station.”¹⁵⁷

Currently, approximately 90 percent of publicly accessible EVSE is free to the user.¹⁵⁸ Experts agree that free charging is not sustainable. Instead of providing free charging, private investors tend to seek a return on their investment. For instance, ChargePoint charges \$3 for every 30 minutes, up to five hours, and a flat fee of \$36 for five to 24 hours for use of EVSE at the Oakland Airport in California. Additionally, Walgreens charges \$2 per hour, with a minimum charge of \$2, for the use of their EVSE.

At the time of publication, dozens of companies participate in the charging infrastructure space. Moving forward, public entities in southeastern Pennsylvania can maintain involvement with multiple demonstration projects and maintain a neutral position on EVSE providers. Over the next several years, the industry will likely consolidate and develop better business models for publicly accessible EVSE.

¹⁵⁶ Ernst & Young, “Beyond the Plug: Finding value in the emerging electric vehicle charging ecosystem,” accessed June 2013, [http://www.ey.com/Publication/vwLUAssets/Finding_value_in_the_electric_vehicle_charging_ecosystem_pdf/\\$FILE/Beyond%20the%20plug%20-%20Finding%20value%20in%20the%20electric%20vehicle%20charging%20ecosystem.pdf](http://www.ey.com/Publication/vwLUAssets/Finding_value_in_the_electric_vehicle_charging_ecosystem_pdf/$FILE/Beyond%20the%20plug%20-%20Finding%20value%20in%20the%20electric%20vehicle%20charging%20ecosystem.pdf).

¹⁵⁷ Ernst & Young, “Cleantech matters: moment of truth for transportation electrification,” 2011 Global Ignition Sessions Report, 2011, accessed June 2013, [http://www.ey.com/Publication/vwLUAssets/Moment_of_Truth/\\$FILE/Moment_of_Truth.pdf](http://www.ey.com/Publication/vwLUAssets/Moment_of_Truth/$FILE/Moment_of_Truth.pdf).

¹⁵⁸ Charles Botsford, “The Economics of Non-Residential Level 2 EVSE Charging Infrastructure”.

7 Regulatory Framework to Facilitate EVSE Deployment

Communities can prepare for EVs by developing a coherent regulatory framework that facilitates EVSE deployment. The regulatory framework should be flexible enough to accommodate changing technology and consumer preferences.¹⁵⁹ Communities can use a variety of regulatory mechanisms to support EV and EVSE deployment, including comprehensive plans, sustainability plans, EV readiness plans, permitting and inspection policies, zoning codes, building codes, signage standards, parking rules, and procurement policies.

In addition to the multidimensional nature of EVSE deployment, the structure of jurisdiction in southeastern Pennsylvania is highly fragmented. The region's five counties comprise 238 municipalities, each of which has unique interests and the legal "home rule" ability to shape regulations based on those interests, resulting in a patchwork of regulations and policies across the region. This diversity of regulatory issues, stakeholders, and governmental bodies presents challenges for successful EVSE deployment in southeastern Pennsylvania.

Communication and coordination across the region can help to promote a consistent regulatory framework to support regional EV readiness. This section presents guidance on developing a regulatory framework to support EVSE deployment. The section discusses six specific regulatory framework mechanisms to support consumer adoption of EV technologies in southeastern Pennsylvania: building and electrical codes, zoning codes, permitting and inspection processes, parking rules, signage standards, and procurement policies.

7.1 Building and Electrical Codes

Two types of codes that can influence EVSE deployment are building and electrical codes. Communities in southeastern Pennsylvania cannot amend building and electrical codes to address EVs and EVSE because Pennsylvania does not permit municipalities to exceed the state-level Uniform Construction Code (UCC). Thus, communities in the region must consider alternative approaches for utilizing the building and electrical codes in a way that supports EV and EVSE deployment. This section will include: a discussion on existing building and electrical codes (including international and national model codes and the Pennsylvania UCC) and how these codes address EVSE; options for promoting EV and EVSE through voluntary actions in lieu of building and electrical code requirements; and a discussion on the requirements for licensing for electrical contractors in southeastern Pennsylvania and how these requirements may affect EVSE deployment.

7.1.1 Role of Building and Electrical Codes in EVSE Deployment

Building codes and electrical codes are collections of rules that govern infrastructure development and are developed by experts to ensure public health and safety. According to a

¹⁵⁹ WXY Architecture + Urban Design, "EV-Ready Codes for the Built Environment: Electric Vehicle Supply Equipment Support Study," prepared for NYSERDA.

recent study by TCI, stakeholders identified no specific barriers to current EVSE technology installation in the current regional codes.¹⁶⁰ Representatives of the electrical industry serving on the DVRPC EV Advisory Group agree that current building and electrical codes in the region are not a barrier.

7.1.2 International and National Model Codes¹⁶¹

Code-making bodies at the international and national levels establish model codes, which states and municipalities can then adopt as law. The International Code Council (ICC) develops model building codes, including the International Residential Code (IRC) and the International Building Code (IBC). The National Fire Protection Agency (NFPA) develops a model electrical code, called the National Electrical Code (NEC).

ICC Codes

The IRC applies to construction and design of one- and two-family residential dwellings. The code is entirely self-contained (i.e., it does not reference or incorporate other codes). Section E3405 of the IRC includes specifications for the location, spacing, and clearance for electrical equipment. The IRC does not address EVSE. The IBC, on the other hand, governs construction and design of commercial buildings. Chapter 27 of the IBC, titled “Electrical,” requires that all electrical work covered by the IBC comply with the NEC.

NEC

The NEC applies to commercial, residential, and industrial electrical work. The code provides a standard for the safe installation of electrical wiring and equipment and includes requirements for wiring methods, equipment construction, grounding and protection, and equipment location to prevent exposure to energized live parts. The NEC addresses EVSE installation through Article 625, which was introduced in 1995 and incorporated into the 1996 NEC. Subsequent NEC updates (1999, 2002, 2005, 2008, and 2011) have included revisions to Article 625 to align with the evolution of EV technology and use. These updates reflect changes in battery, automobile, and EVSE technology, as well as consumer and industry needs. Article 625 covers “the electrical conductors and equipment external to an electric vehicle that connect an electric vehicle to a supply of electricity by conductive or inductive means, and the installation of equipment and devices related to electric vehicle charging.”

The NEC also addresses certain siting and design considerations impacting safety, such as setting maximum cord lengths, height of equipment from ground level, number of cables per unit, and certain design considerations depending on the voltage of the charger. The NEC provides general calculations for overload protection as well, though additional provisions for the safety of electrical loads will further be addressed through local permitting and utility notification processes.

¹⁶⁰ WXY Architecture + Urban Design, “EV-Ready Codes for the Built Environment: Electric Vehicle Supply Equipment Support Study.”

¹⁶¹ For a more in-depth overview of building and electrical codes and their relation to EVs, see the TCI report: EV Ready Codes for the Built Environment (<http://www.transportationandclimate.org/ev-ready-codes-built-environment>).

Because the NFPA updates the NEC by consensus through subject specialty code panels every three years, the NEC always lags slightly behind electrical industry innovation.

7.1.3 Building and Electrical Codes in Southeastern Pennsylvania

Pennsylvania has adopted provisions from the ICC codes, including the IRC and the IBC (and thus the NEC), into its UCC, which regulates structural, mechanical, and electrical codes at the state level. The IRC provisions govern all residential buildings in Pennsylvania, while the IBC provisions apply to all buildings not covered by the IRC. Pennsylvania has historically revised the UCC on a triennial basis to incorporate changes in the ICC codes. Thus, the current UCC incorporates the 2009 ICC codes, with select provisions from the 2012 IBC.^{162, 163}

Because the IRC does not address EVSE, no building or electrical codes currently cover EVSE in residential buildings in Pennsylvania. The lack of building and electrical code provisions for residential EVSE does not prohibit EVSE installation. Moreover, because residential EVSE installations comprise Level 1 or Level 2 EVSE that typically do not require expertise beyond the usual scope of electrician knowledge, specific building and electrical codes for EVSE are less essential for these installations than for public or commercial EVSE. That said, municipalities may choose to provide guidance on EVSE installations for their electricians and inspectors through the licensing process, permitting and inspection process (see Section 7.3), or training programs (see Section 8).

The UCC is enforced by local government unless a municipality “opts out” of local enforcement.¹⁶⁴ Although municipal codes must meet the state-adopted UCC, in most cases they are not permitted to exceed the UCC provisions. Exceptions may be made only for municipalities that demonstrate “clear and convincing local climatic, geologic, topographic or public health and safety circumstances or conditions.”¹⁶⁵ Code exceptions related to EVSE provisions are unlikely to meet this requirement.

Thus, municipalities in southeastern Pennsylvania will most likely not pursue building and electrical code amendments to support EVSE.

Building & Electrical Codes in Southeastern Pennsylvania

Pennsylvania Uniform Construction Code: Requires compliance with International Residential Code (for residential buildings) and International Building Code (for all other buildings), among other ICC Codes

International Residential Code: Self-contained, no EVSE provisions

International Building Code: Chapter 27, “Electrical,” requires compliance with the National Electric Code

National Electric Code: Article 625 covers EVSE

¹⁶² The 2009 Pennsylvania Code includes the 2008 NEC. If the state legislature extends the adoption cycle to 2015, that edition will include the 2011 NEC. Meanwhile, other states will be beginning the 2014 NEC adoption process. For NEC adoption cycles by state, see Appendix J.

¹⁶³ Pennsylvania Department of Labor & Industry, “UCC Codes,” accessed June 2013, http://www.portal.state.pa.us/portal/server.pt/community/uniform_construction_code/10524/ucc_codes/553803.

¹⁶⁴ Of the 238 municipalities in southeastern Pennsylvania, only Salford Township in Montgomery County has opted out of local UCC enforcement. In this case, the Pennsylvania Department of Labor & Industry has jurisdiction over all work performed in the township and county.

¹⁶⁵ Pennsylvania Department of Labor & Industry, “Municipal Code Changes,” accessed June 2013, <http://www.portal.state.pa.us/portal/server.pt?open=514&objID=553801&mode=2>.

7.1.4 Voluntary Actions in Lieu of Code Amendments

Because municipalities in Pennsylvania may not exceed the UCC, there are a variety of voluntary options to advance EV readiness. For example, the DVRPC EV Advisory Group suggested that communities encourage voluntary rewiring or installation of electrical conduit to prepare for potential future EVSE. Rewiring or installation of electrical conduit during the construction process can be much less expensive than retrofitting a building to accommodate EVSE later. This is particularly true for installation of electrical conduit when the conduit passes through a wall or underneath the ground. Depending on the conduit configuration, the actual installation of wiring can either be deferred until it is needed for EVSE installation or installed along with the conduit. It is generally understood that encouraging rewiring or installation of conduit is a cost-effective and well-received long-term approach for supporting EVSE. The City of Philadelphia is considering accomplishing this by including information on the lower cost of providing conduit in new construction versus the higher cost of installing conduit after a building has been constructed. In addition to minimizing the cost for developers, rewiring or installation of electrical conduit can increase the overall value of a development and a community by making them attractive to a wider range of consumers, including EV drivers.

7.1.5 Building and Electric Codes in Other Regions

To promote EVSE more proactively, local governments in states where jurisdictions are allowed to exceed the code have amended building and electrical codes to make planning for EVSE installation a standard practice in construction and electrical work. For example, communities can amend building codes to establish specifications for structural integrity to ensure that buildings can safely accommodate EVSE. They can also set goals or requirements for inclusion of specific building features, such as EVSE installation, rewiring, or installation of electrical conduit to support future EVSE installation. Preparing for potential future EVSE by rewiring or installing electrical conduit is generally a cost-effective approach for supporting EVSE. Requirements to install EVSE, on the other hand, might be premature given the uncertainty in future use of EVs. Before deciding on an amendment to local building codes, governments might want to consult with local developers to learn which types of developments are most suitable for EVSE rewiring or installation.

Communities can also amend electrical codes to support EVSE deployment. Electrical codes can include space, wiring, and electrical capacity requirements to ensure that electrical systems can safely support EV charging. Electrical codes that address EVSE installation can require that installations meet minimum specifications to ensure safety.

EV-ready communities have benefited from harmonizing their EVSE-related building and electrical code requirements with those of surrounding jurisdictions to make it easier for consumers to find qualified contractors in the area and for professionals to work in multiple jurisdictions.

7.1.6 Licensing Requirements for Electrical Contractors in Southeastern Pennsylvania

Pennsylvania does not require state licensing for electrical contractors.¹⁶⁶ As such, the responsibility to establish such requirements falls to each of Pennsylvania's 2,562 municipalities.¹⁶⁷ Some municipalities, such as Haverford Township, require electricians and electrical contractors to be licensed.¹⁶⁸ However, other municipalities do not require licensing.¹⁶⁹ Individuals seeking information on local requirements must contact the municipality where construction work will occur.

Level 1 and Level 2 EVSE installation generally does not require significant electric work if the existing circuitry can support the additional electrical load and connection. However, issues may arise as a result of a lack of familiarity with EVSE equipment or complex EVSE installations, such as with DC fast-charge installations or where loads exceed circuit or service capacity. Residential installations may face challenges in locations where municipalities do not require homeowners to hire a licensed electrician to perform electrical work.

At the outset of this project, DVRPC was concerned that inconsistencies between municipal requirements might pose a barrier to EVSE deployment, as a given electrician would require licensing in multiple municipalities. However, based on research and community outreach conducted through this project, DVRPC has determined that inconsistencies in municipal-level licensing have not presented a significant barrier to EVSE deployment thus far. Electricians in the region have been able to negotiate the municipal system quite readily, and the political barriers to changing this system appear greater than the benefit such a change would bring. Rather than pursue state- or county-level licensing, municipalities might choose to coordinate electrician training on EVSE installation (see Section 8 for more detail on training for electricians).

7.2 Zoning Codes

Zoning codes identify the allowable types of development and use of property within a jurisdiction. By addressing EVSE explicitly in zoning codes, municipalities can help developers understand their options with respect to EV and EVSE deployment.

This section discusses best practices for facilitating EVSE deployment through zoning codes. It also discusses zoning for EVSE in southeastern Pennsylvania and provides case studies of EVSE zoning actions in other communities in the United States.

¹⁶⁶ National Electrical Installation Standards, "State Electrical Regulations," accessed June 2013, http://neca-neis.org/state/index.cfm?fa=state_regs.

¹⁶⁷ Pennsylvania Department of Labor & Industry, "Contractor Licensing," accessed June 2013, http://www.portal.state.pa.us/portal/server.pt/community/uniform_construction_code/10524/contractor_licensing/553817.

¹⁶⁸ Township of Haverford Pennsylvania, "Contractor Licenses," accessed June 2013,

<http://www.haverfordtownship.com/department/division.php?fDD=8-41>.

¹⁶⁹ Barbara Cox, e-mail message to author, August 10, 2012.

7.2.1 Role of Zoning in EVSE Deployment

Communities can facilitate EVSE deployment through their zoning codes in several ways. The following list identifies three ways that EV-ready communities have introduced EVSE into their zoning codes:

- Allow EVSE in particular zoning districts. Communities addressing EVSE in zoning codes typically identify EVSE as a permitted use in most or all districts. Communities may also choose to permit EVSE as a principal use or an accessory use for each district.
- Require installation of electrical conduit, rewiring, or EVSE installation in particular zoning districts. A community can go beyond simply allowing EVSE as a permitted use in the zoning code by requiring EVSE installation for specific kinds of development. For example, a community may require EVSE installation in developments of a certain square footage, including construction of new buildings, off-street parking facilities, or additions to existing buildings or parking facilities. Communities may also choose to specify the type of land uses required for EVSE, such as multihousehold residential uses or commercial land uses.
- Provide incentives for developers to include electrical conduit, rewiring, or installed EVSE in new construction. Incentives, such as density bonuses, may encourage developers to include EVSE in their design plans. Density bonuses allow developers to build more square footage than normally allowed by the standard floor-area ratio in exchange for installing EVSE. As another example, municipalities could reduce the number of parking spaces required for developments that include electrical conduit, rewiring, or installed EVSE.

Municipalities might choose between these three approaches based on conversations with developers in their jurisdictions. Developers might express a preference for one approach over the other, depending on their enthusiasm for EVSE deployment.

In addition to allowing, requiring, or creating incentives for EVSE, communities have identified other best practices for zoning codes, including:

- Define EVSE-related terms for consistent use in regulatory documents. Definitions can clarify the intent and scope of new EVSE-related regulations and reduce confusion about how to interpret, implement, and enforce the new regulations.
- Establish design criteria for EVSE. Developing criteria related to size, light, maintenance, accessibility, lighting, etc. can help ensure that EVSE installations are useable, safe, and consistent with other community development goals. For more information on ADA-accessible EVSE, see Section 7.3.

The zoning code amendment process takes time. Thus, zoning tends to be a long-term approach to facilitating EV and EVSE deployment. Because the process is slow, communities that want to support EVSE deployment in the long term might consider prioritizing zoning amendments that might affect future development over other regulatory actions. At the very least, communities can review existing zoning codes to see if the codes preclude EVSE

deployment in the near term and/or provide guidance to developers on what the current zoning allows.

7.2.2 Zoning for EVSE in Southeastern Pennsylvania

The Borough of Phoenixville (Chester County) is in the process of drafting zoning code language to promote EVs and EVSE as part of a revitalization effort, which includes trying to attract new community members and industries. The borough's Policy Committee chose to develop zoning codes to allow for "big picture" planning. The borough is working to become a greener and healthier place to live and is trying to be progressive in its new developments. The zoning code will target significant developments (potentially MUDs and other public infrastructure, given that there is less new development of single-family homes in the borough) and will likely include conditional use requirements. Developers in the area work closely with the borough and conditional use requirements are typically part of the negotiations.

The City of Philadelphia recently adopted a revised zoning code after a multiple-year revision process. Although the current zoning code does not address EVSE, the city may incorporate specific EVSE provisions in future zoning code amendments.

In addition, the City of Philadelphia has developed EV- and EVSE-related definitions and included them in its municipal code (The Philadelphia Code, Title 12. Traffic Code, Section 12-1131. Electric Vehicle Parking).¹⁷⁰ The Pennsylvania Department of Transportation Vehicle Code also includes definitions related to EVs (Pennsylvania Code, Title 75. The Vehicle Code, Chapter 1. General Provisions).¹⁷¹ Municipalities in southeastern Pennsylvania could include definitions in their zoning codes that are modeled after these existing definitions to enhance regional consistency.

7.2.3 Zoning Code Resources

Some regions and municipalities have already developed and adopted zoning code provisions specific to EVSE. The zoning provisions developed by these communities can serve as models for communities in southeastern Pennsylvania that wish to revise their zoning codes to address EVSE.

Puget Sound Regional Council (PSRC), Washington

PSRC has provided sample zoning ordinance language for jurisdictions in the State of Washington. The language from the model ordinance can be modified as needed based on local considerations and can be tailored for communities outside of Washington. For example, jurisdictions might determine that allowing EVSE in particular zoning districts may or may not be appropriate or beneficial. In such cases, jurisdictions can revise the "Whereas" statements to identify the districts in which EVSE will be allowed.¹⁷²

¹⁷⁰ See Appendix H.

¹⁷¹ Pennsylvania Department of Transportation, "The Vehicle Code (Title 75)," accessed June 2013, http://www.dmv.state.pa.us/vehicle_code/index.shtml.

¹⁷² PSRC, "Electric Vehicle Infrastructure: A guide for local governments in Washington State," 11-14.

Kansas City, Missouri

The City of Kansas City revised its zoning code to address EVSE. The city allows EVSE to count toward off-street parking requirements. Its zoning code specifies that “electric vehicle charging stations may be counted toward satisfying minimum off-street parking space requirements.” The Kansas City zoning language could provide a model for communities in southeastern Pennsylvania.¹⁷³

Bellevue, Washington

The City of Bellevue published an ordinance that amends the Land Use Code to allow EVSE and provides glossary definitions.¹⁷⁴ The city also revised its Land Use Code to allow EVSE and related infrastructure in all land use districts where accessory parking, auto parking, park and rides, street and highway rights-of-way parking, gasoline service stations, auto repair, or vehicle maintenance is allowed.¹⁷⁵

Kane County, Illinois

In 2012, Kane County endorsed an EVSE ordinance, which was developed by a county working group based on laws in Puget Sound (Washington) and Auburn Hills, Michigan. The goal of the ordinance is to demonstrate that Kane County is EV-friendly by providing a consistent county-wide EVSE regulatory framework and removing zoning barriers. In addition to input from county working groups, the ordinance included input from the public, municipal planners, local governments, attorneys, utilities, electricians, researchers, and EV vendors. The Illinois Electric Vehicle Advisory Council identified Kane County's EVSE ordinance as a “national model” for local initiatives across the country.¹⁷⁶

Dupont, Washington

The City of Dupont amended the general development requirements in its land use code to include a section on EV facilities. The section specifies the purpose of EVSE code provisions; the use requirements for EVSE and EV parking spaces; the locations where EVSE are permitted; the process for EVSE installation, permitting, and review; and the design criteria for EVSE.¹⁷⁷

7.3 Permitting and Inspection Processes

As with electrician licensing, each municipality in Pennsylvania controls its own permitting and inspection process. Standardized permitting and inspection on a regional level would help alleviate confusion associated with inconsistent processes from municipality to municipality.

¹⁷³ City of Kansas City, Missouri, “Chapter 88: Zoning and Development Code,” accessed June 2013, <http://cityclerk.kcmo.org/liveweb/Documents/DocumentText.aspx?q=9TPpZcbh%2blXautG8lWiqrZr3SDYecOVraOb4rusTVSZwhKCFutuOhadUPV%2fiIW>.

¹⁷⁴ City of Bellevue, Washington, “Ordinance No. 5989,” accessed June 2013, <http://www.bellevuewa.gov/Ordinances/Ord-5989.pdf>.

¹⁷⁵ City of Bellevue, Washington, “Title 14: Transportation Code,” Bellevue City Code, accessed June 2013, <http://www.codepublishing.com/wa/bellevue/?/Bellevue14/Bellevue14.html>.

¹⁷⁶ Kane County, Illinois, “Kane Electric Car Ordinance Called National Model,” accessed June 2013, <http://www.countyofkane.org/Documents/Focus%20on%20the%20County/Kane%20Electric%20Car%20Ordinance%20Called%20ational%20Model.pdf>.

¹⁷⁷ City of Dupont, Washington, “Dupont Municipal Code, Chapter 25.126: Electric Vehicle Facilities,” accessed June 2013, <http://www.mrsc.org/mc/dupont/dupont25/dupont25126.html>.

However, this is a difficult process politically, as it would entail changes to the permitting and inspection framework, not just that for EVSE installation. That said, regional coordination could encourage consistency on permitting timelines, permitting costs, and inspection requirements. It could also help municipalities coordinate with ongoing efforts of local EV dealers, electrical contractors, inspectors, and PECO. This section provides guidance on best practices for EVSE permitting and inspection processes.

7.3.1 EVSE Installation, Permitting, and Inspection Process in Southeastern Pennsylvania

This section describes the general permitting and inspection process best practices, current practices for permitting and inspection in southeastern Pennsylvania, opportunities for incorporating EVSE into existing permitting and inspections, and examples of municipal action undertaken to date in support of EV and EVSE deployment. The permitting and inspection for residential, commercial and MUD, and on-street EVSE have important differences. This section discusses best practices for each type of installation separately.

Successful permitting and inspection processes have a defined timeline, a clear set of requirements, and a minimal number of inspections or reviews. Standardizing and streamlining the process could make it more convenient and less costly for consumers, electricians, municipalities, and PECO. By saving staff time, an improved process could make it financially feasible for municipalities to lower permitting fees.¹⁷⁸ Installation and inspection work should be conducted by a licensed electrical contractor to ensure quality installation of EVSE equipment (see Section 8 for a discussion of EVSE installation training for electricians and inspectors).

Municipalities in southeastern Pennsylvania have noted that a permit for EVSE installation will not likely differ from a standard electrical permit. Yet there are a number of best practices within the permitting process that municipalities can incorporate into their permitting process.

Residential

In southeastern Pennsylvania, the residential EVSE installation process generally follows that of any standard electrical installation. The process typically begins with a site survey conducted by an electrical contractor. Once the contractor has completed the site assessment, he or she must apply for a permit for the installation—municipalities generally accept or deny permit applications within 15 days for a residential building and within 30 days for a commercial building. For example, the City of Philadelphia Licenses and Inspections Office guarantees that all applicants will receive a permit decision within 30 business days.¹⁷⁹ Permit costs vary by municipality. Some use a fixed fee schedule based on the cost of installation. The City of Philadelphia charges a \$25 filing fee for each one- or two-family dwelling permit and \$25 per \$1,000 of electrical work, plus \$7 in state and city surcharges.¹⁸⁰ Electrical permits in the Borough of

¹⁷⁸ WXY Architecture + Urban Design, "EV-Ready Codes for the Built Environment: Electric Vehicle Supply Equipment Support Study."

¹⁷⁹ Sarah Wu (City of Philadelphia Mayor's Office of Sustainability), phone interview, August 6, 2012.

¹⁸⁰ City of Philadelphia, "Licenses & Inspections: Electrical Permits Fees," accessed June 2013, <https://business.phila.gov/Documents/Permits/ElectricalPermitFees.pdf>.

Phoenixville cost one percent of the estimated electrical construction costs, with a minimum cost of \$100.¹⁸¹ Other municipalities base the fee schedule on the type of equipment installed.¹⁸²

After the assessment and permit have been obtained, the EVSE is installed and inspected. The City of Philadelphia requires that all electrical work to be carried out by licensed electrical contractors. Other municipalities may not require licensed electrical contractors to conduct installations. However, like any electrical installation, EVSE installations by inexperienced or untrained contractors are more likely to result in a problem, such as loss of current, which can cause significant inconvenience for the EV owner, especially if he or she does not have protection from an inspection identifying the problem and assigning responsibility to the installing electrical contractor.

Of the municipalities that require inspection of electrical installations (including EVSE), some have inspectors on staff, others contract with third-party inspection agencies, and still others provide a list of independent inspection agencies from which individuals can choose. As an example, the City of Philadelphia requires an inspection for every electrical installation, and the licensed electrical contractor must identify the third party responsible for the inspection when applying for the electrical permit.¹⁸³ Upper Makefield Township provides a list of independent inspection agencies that can inspect electrical work and the contractor or homeowner must identify his or her third-party inspection agency of choice when applying for the electrical permit.¹⁸⁴ Inspections are usually completed within 24 hours of notice, and costs are competitive and market-based, depending on the size and complexity of the installation.¹⁸⁵

In addition, some EV manufacturers require EV purchasers to use EVSE installers preapproved by the manufacturer unless the purchaser signs a waiver to protect the manufacturer from installation issues. These approved third-party companies walk customers through the permitting, installation, and inspection process.¹⁸⁶

Commercial and MUD

In some jurisdictions, commercial and MUD installations are able to follow the residential installation permitting and inspection process. In the regions highlighted above, such “simple” commercial installations may also benefit from current streamlined permitting processes.¹⁸⁷ However, some commercial and MUD EVSE installations are more complex and may raise concerns that do not apply to single-family residential units, including liability, property rights,

¹⁸¹ Borough of Phoenixville, “Schedule of Fees,” accessed June 2013, <http://www.phoenixville.org/PDF/Applications%20&%20Forms/Schedule%20of%20Fees.pdf>.

¹⁸² GPCC, “Roundtable Electric Vehicle Discussion Summary,” accessed July 25, 2012.

¹⁸³ City of Philadelphia, “Licenses & Inspections: Electrical Permit Basics,” accessed June 2013, <https://business.phila.gov/Pages/ElectricalPermit.aspx?stage=Start&type=Real%20Estate%20or%20Property%20Rental§ion=Permits%20%26%20Certificates&BSPContentListItem=Electrical%20Permit>.

¹⁸⁴ Upper Makefield Township, “Electrical Permit,” accessed June 2013, http://www.uppermakefield.org/sites/default/umsfiles/electric_permit.pdf.

¹⁸⁵ GPCC, “Roundtable Electric Vehicle Discussion Summary,” accessed July 25, 2012.

¹⁸⁶ GPCC, “Roundtable Electric Vehicle Discussion Summary,” accessed July 25, 2012.

¹⁸⁷ ECoTality, “EVSE Permitting and Installations for The EV Project,” accessed June 2013, <http://www.cpuc.ca.gov/NR/rdonlyres/B97A5206-5E19-4060-A3B9-0F8703629937/0/eTecEVSEPermittingandInstallationsfortheEVProject.pdf>.

and electrical upgrades. In these more complex cases, the states and municipalities tend to have different permitting and inspection requirements.¹⁸⁸

Public lots and private lots for public use may require a site assessment and load calculations to assess transformer and local electrical distribution capacity. The installation process would require contacting the local power supplier (e.g., PECO) to determine how much electrical load can be added during peak charging hours and arrange for a service upgrade, if necessary.

In the case of MUD installations, a HOA representative may also participate in the assessment, permitting, installation, and inspection processes.

These projects begin with a site survey by an electrical contractor. Some municipalities require an inspector to be present for the initial site survey. Depending on the number and type of EVSE, the installation may necessitate an electrical upgrade. The commercial entity or MUD homeowner should submit an Electric Service Application to PECO to assess if an electric service upgrade is required.¹⁸⁹ During the meeting, the contractor, site inspector, utility, and any other stakeholders (e.g., HOA) schedule a time for the utility to perform the service upgrade, which will require an inspection before restoring power.

Permit costs in southeastern Pennsylvania depend on the municipality and generally differ between commercial and residential EVSE installations. In the City of Philadelphia, the commercial permit filing fee is \$100 (as opposed to \$25 for a residential permit), but the additional fee is identical to that assessed for residential installations (\$25 per \$1,000 of electrical construction costs), as are the city and state surcharges.¹⁹⁰ In the Borough of Phoenixville, as with a residential electrical permit, a commercial permit costs one percent of the electrical costs; however, the minimum permit is \$200 (as opposed to \$100 for a residential permit).¹⁹¹

On-Street

Permitting and inspection efforts have emphasized residential and commercial/workplace charging more than on-street EVSE installation. Because on-street EVSE is in the public right of way, its siting may be controversial and subject to neighborhood approval. Cities that are pursuing such installations have taken a variety of approaches.

Most municipalities in southeastern Pennsylvania do not have a process established for EVSE permitting and inspections for residential and commercial installations, much less on-street EVSE. In municipalities that have begun to address on-street EVSE installations, such as the City of Philadelphia, the installations are subject to the same electrical permitting process as

¹⁸⁸ Los Angeles, for example, requires that more complex projects be inspected before use. In all cases, if a utility service upgrade is required, the customer must contact the local utility to coordinate the upgrade. In the Raleigh area, the customer may give authority to Progress Energy (now merged with Duke Energy) to work directly with the electrical contractor, which can expedite the process.

¹⁸⁹ Sarah Wu (City of Philadelphia Mayor's Office of Sustainability), phone interview, August 6, 2012.

¹⁹⁰ City of Philadelphia, "Licenses & Inspections: Electrical Permits Fees."

¹⁹¹ Borough of Phoenixville, "Master Schedule of Fees," accessed June 2013, <http://www.phoenixville.org/PDF/Applications%20&%20Forms/Schedule%20of%20Fees.pdf>.

residential and simple commercial installations.¹⁹² However, the primary concerns arising from on-street EVSE are not the electrical permitting, but rather the placement of such infrastructure in the public right of way. These issues remain unresolved in the region.

The City of Philadelphia passed an ordinance that allows individual homeowners to apply for dedicated on-street parking if they own an EV and do not have dedicated off-street parking to charge their vehicle. In addition to applying for an electrical permit, individuals wishing to take advantage of this opportunity must submit a plan showing the EVSE, dedicated parking space, and adjacent roadways and sidewalk and must meet a list of specific EVSE placement requirements in order to receive approval from the Philadelphia Parking Authority (see Appendix E and Appendix F for full regulation).¹⁹³

7.3.2 Opportunities to Facilitate Permitting and Inspection in Southeastern Pennsylvania

Expedited permitting and inspection processes currently exist in states that regulate the licensing of electrical contractors and certification of electricians. However, EVSE permitting and installation can be made easier in southeastern Pennsylvania without establishing state-level systems. Municipalities can set permit and inspection terms for residential EVSE installation to allow abbreviated requirements, quicker timelines, fewer inspections, and lower fees, where appropriate.

The City of Philadelphia's solar permitting process for residential and commercial installations may serve as a model for how the electric permit process could be streamlined when a building permit and an electrical permit are both required, such as new construction. Under Philadelphia's solar permit process, a project that meets certain criteria becomes eligible for streamlined review for electrical and building permits, whereby the requirement for a building permit is waived.

As noted in the Education and Outreach Plan (Section 8), the region's permitting officials, inspectors, and electrical contractors would benefit from training regarding EVSE installation requirements. Bringing together important actors and educating them on the EVSE installation process can encourage communication throughout the EVSE installation process and facilitate a smoother permitting and inspection process.

The Education and Outreach Plan also suggests developing educational materials that outline the steps that EV owners must take to install EVSE, including flow charts of the installation process from start to finish (including communication with PECO and permitting and inspection requirements), written step-by-step instructions, and a list of requirements for EVSE permitting and inspection (see Appendix B and Appendix C for examples). These materials could be posted on county, municipal, and regional websites, made available in zoning and permitting

¹⁹² Sarah Wu (City of Philadelphia Mayor's Office of Sustainability), phone interview, August 6, 2012.

¹⁹³ City of Philadelphia Department of Streets, "Regulation Governing the Establishment of Electric Vehicle Parking Spaces, Pursuant to Section 12-1131 of The Philadelphia Code," accessed August 6, 2012.

offices, and distributed through car dealerships in order to educate potential and new EV owners.

The Education and Outreach Plan presents other ideas, including creating checklists for electricians and inspectors. Electrician checklists may be circulated at outreach events, as well as at licensing and EVSE installation training courses, such as Electric Vehicle Infrastructure Training Program (EVITP) courses.¹⁹⁴ Inspector checklists may be circulated to municipalities and municipality-approved third-party inspection agencies.¹⁹⁵ According to a report produced for NYSERDA, educating electricians and inspectors has become the norm in communities seeking to be EV-ready.¹⁹⁶ Furthermore, training many electricians will help encourage competition among them and reduce costs for consumers. In areas where few electricians have the specialty knowledge required to install EVSE, installers have charged up to 75 percent more for EVSE installations.¹⁹⁷

Permit fee standardization presents an opportunity for communities in southeastern Pennsylvania to encourage EVSE installation. Some communities in southeastern Pennsylvania calculate fees using a percentage of the total job cost, which might deter consumers from pursuing more costly EVSE installations. Municipalities might consider matching the permit fee with the cost of processing the permit, rather than the cost of installation. Combined with streamlining the permit process, especially for routine residential installations, this fee standardization could significantly lower the burden of EVSE permitting for consumers.

7.3.3 Permitting and Inspection Resources

There is a range of efforts underway on the federal, state, and municipal levels to streamline the permitting and inspection processes for residential EVSE installation. Standard commercial installations that do not require service upgrades or involve additional considerations (e.g., ADA requirements) may also benefit from these efforts.

Federal

DOE has developed a permitting template for residential EVSE installations in an effort to encourage EVSE deployment readiness.¹⁹⁸ The template can be used “as is” or customized based on jurisdiction requirements. Richmond, Virginia, and the Commonwealth of Massachusetts have used pieces of the template, and the template is under consideration by other municipalities.

¹⁹⁴ DOE, “Electric Vehicle Infrastructure Training Program,” accessed June 2013, <http://www1.eere.energy.gov/cleancities/evitp.html>.

¹⁹⁵ For example checklists, see: <http://www.advancedenergy.org/transportation/evse/Charging%20Handbook.pdf>.

¹⁹⁶ WXY Architecture + Urban Design, “EV-Ready Codes for the Built Environment: Electric Vehicle Supply Equipment Support Study.”

¹⁹⁷ TCI, “Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools,” accessed June 2013, http://www.transportationandclimate.org/sites/default/files/EVSE_Planning_and_Policy_Tool_Guide.pdf.

¹⁹⁸ M. Simpson, “EVSE Residential Permit Template,” accessed June 2013, http://www1.eere.energy.gov/cleancities/toolbox/pdfs/residential_permit_template.pdf. For template, see: http://www.afdc.energy.gov/pdfs/EV_charging_template.pdf.

This template includes technical installation requirements unique to EVSE that DOE identified as applicable in most jurisdictions, including labeling requirements, wiring methods, breakaway requirements, overcurrent protection, and indoor and outdoor siting considerations. The template includes four sections:

- Jurisdiction information (e.g., form layout and applicant and site identification);
- Code requirements (e.g., applicable NEC chapters and articles);
- Certification statement (e.g., licensee signature and owner signature); and
- Checklist (e.g., follow-up actions and tax paperwork).

This template should be very helpful to municipalities in southeastern Pennsylvania as they develop permitting requirements for residential EVSE installations.

State

In Pennsylvania, there are no relevant regulations at the state level that affect EVSE installation or inspection. This is not the case in many other states. While state-level regulatory changes are beyond the scope of this plan, a review of practices in other states (as described in Section 9) may be of interest to Pennsylvanians.

As one example, the State of Oregon has streamlined the EVSE permitting and inspection process on the state level. Licensed electrical contractors buy booklets of 10 “minor installation labels” for \$140 under the Oregon Minor Label Program.¹⁹⁹ Each label allows an electrical contractor’s licensed electrician to perform one “minor” electrical installation, such as a standard EVSE installation. Oregon has defined a “standard EVSE installation” as one that is within sight of the electrical panel that supplies the EVSE, has a branch circuit with a load that does not exceed 40 A/240V, and is not in a damp location.²⁰⁰ If the existing electric connection is adequate for the additional required load, an electrician may perform such a standard EVSE installation under the Oregon Minor Label Program. More complex installations (such as those requiring service upgrades or involving multiple EVSE) have different permitting requirements.

Under this system, the electrical contractors that install the EVSE take full responsibility for compliance with code requirements, including load calculations. Electrical contractors must log the address and scope of work using the same online system used to request the minor installation labels; the local jurisdiction inspects one in 10 of the electrical contractor’s jobs. If an EVSE installation fails the inspection, the contractor must purchase a regular electric permit from the local jurisdiction, correct the defect, and schedule a reinspection for the site at his or her own expense. Also, if this happens, the contractor can no longer participate in the Minor Label Program.

While such a system is not viable under current Pennsylvania law, it may provide some ideas to municipal officials in facilitating EVSE installations.

¹⁹⁹ State of Oregon, “BCD Minor Label Program,” accessed June 2013, <https://minorlabels.dcbs.oregon.gov/>.

²⁰⁰ DOE, “Oregon Deploys Plug-In Vehicles and Charging Infrastructure,” Alternative Fuels Data Center, accessed June 2013, <http://www.afdc.energy.gov/case/1000>.

Municipal

Three municipalities that have implemented streamlined permitting processes are: Houston, Texas; Los Angeles, California; and Raleigh, North Carolina. Although all three cities are in states with different regulatory environments, they each provide ideas that may be relevant for southeastern Pennsylvania. This section provides descriptions of each municipality's process.

Houston, Texas

The City of Houston has extended its existing online express permitting process to standard residential EVSE installations and has implemented a pilot program to expedite single-family residential EVSE inspections. As a result, a standard residential EVSE project, including assessment, permitting, installation, and inspection, can be completed in one day.²⁰¹

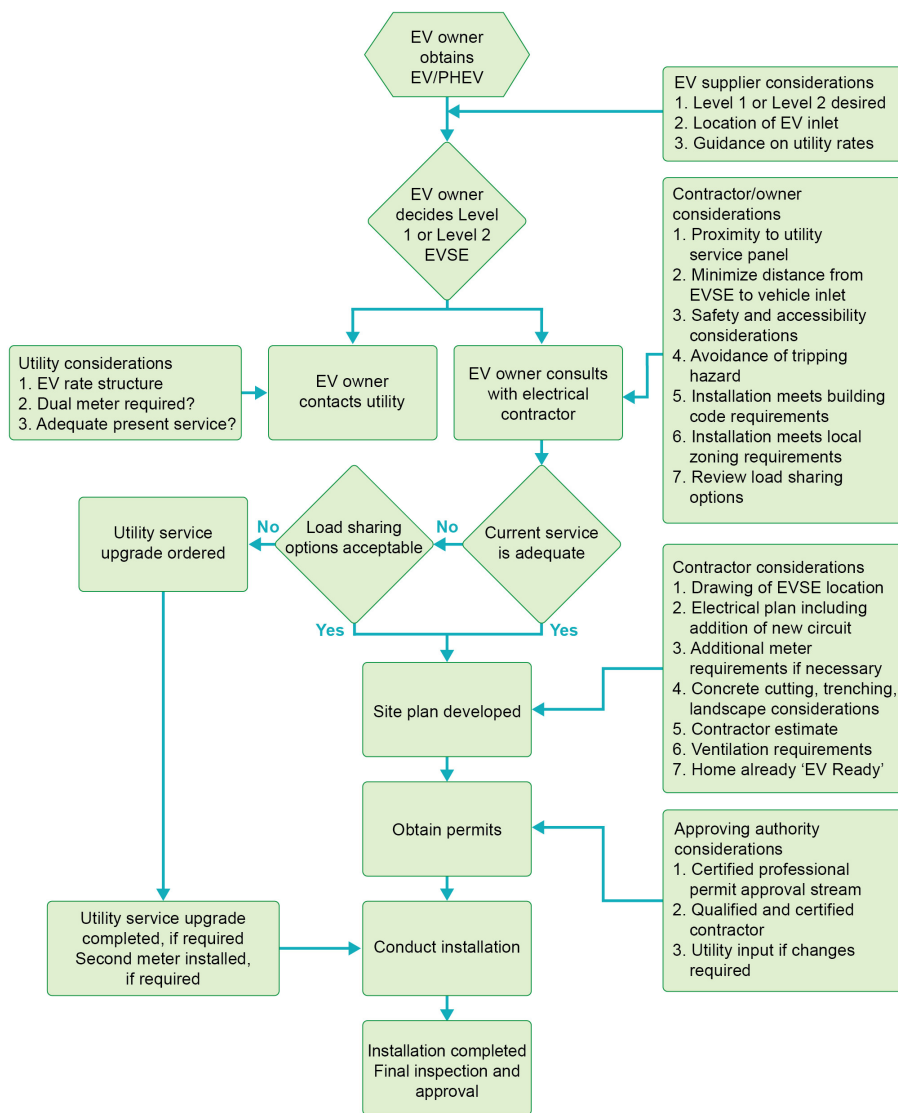
First, a Licensed Master Electrician (or the contractor who hired the electrician) assesses the EVSE site to determine whether it will qualify as a standard EVSE installation, meaning that it will require no utility service upgrade. Following this assessment, the electrical contractor applies for a permit via the Houston Code Enforcement Group's online express permitting process for a fee of \$35. This process issues online permits automatically and instantaneously to state-licensed electrical contractors for standard EVSE installations.

The electrician then installs the EVSE and requests an inspection from the Code Enforcement Group. In Houston's pilot program, if the Code Enforcement Group receives an inspection request before 12 p.m., it will be completed in the same day. For requests made after 12 p.m., inspections will be completed within the next 24 hours. Thus, an inspection can be performed on the same day as installation. For a flow chart of the Houston residential permitting and inspection process, see Figure 11, which can serve as a point of comparison to the City of Philadelphia draft flow charts in Appendix E and Appendix F.

The city is also working closely with CenterPoint Energy on grid-integration issues. In addition, ECOtality, which has deployed EVs and EVSE in the area through The EV Project, is notifying utilities of all EV sales related to The EV Project to ensure that they are aware of any potential interconnection needs. The collaboration between Houston, CenterPoint Energy, and ECOtality provides an example of how collaboration and partnerships around EVs, EVSE, and electric utilities could work in southeastern Pennsylvania.

²⁰¹ DOE, "Houston's Plug-In Vehicle Activities and Processes," Alternative Fuels Data Center, accessed June 2013, <http://www.afdc.energy.gov/case/1003>.

Figure 11. City of Houston Residential EVSE Installation Process Flow Chart



Source: City of Houston, Texas, "Recommended Electric Vehicle Charging Infrastructure Deployment Guidelines for the Greater Houston Area," accessed June 2013, <http://www.greenhoustontx.gov/ev/pdf/evdeploymentguidelines.pdf>.

Los Angeles, California

The City of Los Angeles has applied its existing online Express Permit System to EVSE installations. Through this system, a state-licensed electrical contractor assesses an EVSE site to determine whether a service upgrade will be necessary. If no upgrade is required, the electrical contractor can receive a permit automatically and instantaneously through the Express Permit System. The cost for a standard permit is \$75. Customers may start using their EVSE immediately after installation, with an inspection following within 24 hours. The city has created a separate EVSE inspection division within the Department of Building and Safety to ensure rapid inspection turnaround. Because all of Los Angeles falls under the jurisdiction of the

Department of Building and Safety, customers and their contractors experience a consistent process throughout the city.²⁰²

The city is also working with local utilities to incorporate metering into the installation process so that customers who want TOU rates will not have to take an additional step to upgrade their meters. Though Los Angeles has a different regulatory environment than southeastern Pennsylvania, this expedited permitting and inspection regime has its parallel in Philadelphia's streamlined process for solar PV described below.

Raleigh, North Carolina

The City of Raleigh is applying its existing "stand alone" permitting and inspection process to EVSE installations. Through this process, a licensed electrical contractor or EVSE customer visits one of two inspection centers to obtain a permit for \$74. Raleigh's permit application process is referred to as a "walk through" process because the permit is completed as the applicant walks through the process with permitting personnel. It takes approximately one hour to obtain the permit. Once the EVSE has been installed, either the licensed electrical contractor or homeowner calls the city to schedule an inspection. If the call is received by 4 p.m., the inspection is performed the next day, and the EVSE is approved for use as soon as it passes the inspection. From start to finish, a basic residential EVSE installation, including the assessment, permitting, installation, and inspection, can be completed in as few as two days.

In order to ensure that Raleigh's permitting process is clear and accessible to all parties (e.g., EVSE owner and installing electrician), the city has developed a flow chart that moves through each step of the process (see Appendix G) and posted a YouTube video for residents, which outlines the information required and steps necessary and answers to common questions about the installation of residential EVSE.²⁰³ Raleigh views the "walk through" process as an opportunity to train permitting staff and electrical contractors about EVSE. The city plans to switch to a faster online permitting process as staff and contractors become better educated and well versed in EVSE installations.²⁰⁴

7.3.4 Compliance with ADA and Accessibility

An additional consideration for EVSE permitting is compliance with ADA requirements and the applicable standards in the Pennsylvania Code, Chapter 60: Universal Accessibility Standards. Because public charging stations offer a service to the general public, accessibility regulations prohibit discrimination of individuals on the basis of disabilities. In addition, accessibility is particularly important for EVSE, as drivers need to maneuver around the vehicle to use the charging equipment.²⁰⁵

²⁰² DOE, "Los Angeles' Plug-In Vehicle Activities and Processes," Alternative Fuels Data Center, accessed June 2013, <http://www.afdc.energy.gov/case/1002>.

²⁰³ City of Raleigh, North Carolina, "How-To Charge Your Electric Car at Home," accessed June 2013, http://www.youtube.com/watch?v=_x4YezUX8lo&lr=1&uid=makWAtClzgsRXZUNczyNEA.

²⁰⁴ DOE, "Raleigh, North Carolina's Plug-In Vehicle Activities and Processes," Alternative Fuels Data Center, accessed June 2013, <http://www.afdc.energy.gov/case/1001>.

²⁰⁵ TCI, "Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools."

Accessibility considerations for EVSE include quantity of accessible chargers, location, and physical dimensions (e.g., slope and equipment height). EVSE are typically installed where accessible parking is already provided. Some accessibility considerations relevant for EVSE include the requirement that no objects, such as electrical cords, obstruct the access aisle and that the equipment's operating mechanisms are placed in such a way as to be usable for drivers with disabilities. Local permitting agencies must ensure that equipment meets requirements in the Universal Accessibility Standards and ADA.

Various organizations have proposed standards for ADA-accessible EVSE. For example, PSRC provides guidance on accessible EV charging stations. PSRC based its guidance on accessibility provisions for hotel rooms (an accessible hotel room can be used by anyone but is located and designed for persons with disabilities). Like hotel rooms, a percentage of EV charging stations should be accessible to all users because they offer a service to the general public. PSRC guidance addresses quantity and location of ADA-accessible EVSE.²⁰⁶

Ready, Set, Charge California! recommends that local agencies consider two courses of action regarding "accessible EVSE"—one for new construction and one for existing parking facilities (see Table 23 for recommendations)—and suggests that, as local agencies adopt ordinances, codes, private and public development standards and regulations for EVSE, they update these guidelines to reflect current laws and regulations.²⁰⁷

²⁰⁶ PSRC, "Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State."

²⁰⁷ Association of Bay Area Governments et al., "Ready, Set, Charge California!" accessed June 2013, http://www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf.

Table 23. Installation Options for ADA Accessible EVSE from Ready, Set, Charge California!

	New Construction ²⁰⁸	Existing Parking Facility
1st EVSE	The first EVSE shall be accessible and be installed in an existing van-accessible parking space or in a new 17-foot wide EV parking stall meeting all requirements of a van-accessible parking space. If in a new space, it does not have to be designated with D9-6/R7-8b signs (disabled parking symbol/VAN-accessible) or contain a striped access aisle.	The first EVSE should be accessible and may be installed in the existing van-accessible space, in an existing accessible parking space, in a standard parking space (nine-foot wide minimum) adjacent to an “access aisle,” or in a standard parking space with a three-foot wide (minimum) unstriped path of travel between the battery charging station and the vehicle inlet.
2nd EVSE	The second EVSE should be accessible and be installed in an existing accessible parking space or in a new 14-foot wide charger meeting all requirements of an accessible parking space. If in a new space, it does not have to be designated with a D9-6 (disabled parking sign) or contain a striped access aisle. The first two accessible chargers may share the same access aisle.	The second EVSE should be accessible, and may be installed in a standard parking space (9-foot wide minimum) with a 3-foot wide (minimum) un-striped path of travel. The first two accessible EVSE may share the same path of travel.
3rd EVSE	The third EVSE and beyond may be installed in a standard parking space no less than nine feet wide.	The third EVSE and beyond may be installed in a standard parking space no less than nine feet wide.

Source: Association of Bay Area Governments, et al., 2011.

7.4 Parking Rules

Parking rules specify the requirements for location, accessibility, use, design, and fees of public parking spaces. This section discusses the role of parking rules in facilitating EVSE deployment and provides examples of parking ordinances that address EVSE.

7.4.1 Role of Parking Rules in EVSE Deployment

Communities can develop parking rules specific to parking spaces with EVSE. EVSE-specific parking rules can permit EVSE in public areas and can help maximize the benefit of investment in public EVSE by ensuring that parking spaces with EVSE are safe, available for EVs that need to charge, and financially sustainable.

A parking ordinance could include important definitions (consistent with definitions used in other regulatory documents discussed in this section) and specifications for location, accessibility, use, design, and fees associated with the public parking spaces. With respect to use, a common approach is to specify that only EVs or, to be more specific, only EVs that are currently charging

²⁰⁸ Includes existing facilities increased in size by 50 percent or greater or by 30 parking spaces or greater (percentage size increase or number of parking spaces to be determined by local agency).

may use a parking space with EVSE. Municipalities can also customize use requirements by setting time limits for use of the space. A parking ordinance can establish the consequences for violation of the parking rules, which could include a fine or other penalty.

Before implementing any changes to the parking rules, municipalities may wish to consult with local parking managers and other stakeholders that will play a role in enforcing the parking rules. One challenge faced with EV deployment is the misuse of parking spaces with EVSE (e.g., use by a non-EV or EV that is not charging). Participation of parking managers could help to improve the successful implementation of any parking rules. Reasons that parking managers may want to participate in EVSE planning include the potential for green branding, additional customer amenities, and Leadership in Energy and Environmental Design (LEED) certification.²⁰⁹

Another consideration is that strict parking rules might result in underutilization of EV parking spaces when no EVs require them, which could frustrate non-EV drivers or parking managers. Thus, communication with key stakeholders prior to implementing any changes could help to identify potential concerns and develop an optimal approach to managing use of EV parking spaces.

7.4.2 EVSE Parking Rules in Southeastern Pennsylvania

In 2007, the City of Philadelphia passed an ordinance that amended The Philadelphia Code to provide for designation of EV on-street parking spaces where only EVs could park and for penalties for illegally parking in an EV space.²¹⁰

7.4.3 Parking Rule Resources

Many municipalities are considering the adoption of parking ordinances, and several have begun to enact them. The following examples can serve as models for communities in southeastern Pennsylvania who wish to regulate EV parking spaces.

Raleigh, North Carolina

In April 2012, the City of Raleigh passed a parking ordinance stating that the city council may designate certain public parking spaces for use by only EVs. This ordinance states that, once the city has designated a space as reserved for EVs, no one may park a non-EV in that space or park an EV in the space without charging the vehicle. Any vehicles that violate the ordinance will be fined \$50 and are subject to removal. The ordinance also requires that EV drivers observe current parking space time limits.²¹¹

Davis, California

The City of Davis has passed a number of ordinances related to EV-reserved parking spaces. Per these ordinances, no one may park a non-EV in a space designated by authorized signage

²⁰⁹ TCI, "Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools."

²¹⁰ City of Philadelphia, "Bill No. 070788: An Ordinance," accessed August 6, 2012, <http://legislation.phila.gov/attachments/4385.pdf>.

²¹¹ City of Raleigh, North Carolina, "Ordinance No. 2012 – 35," accessed June 2013, <http://library.municode.com/index.aspx?clientId=10312>.

as an EV parking space; EVs may only park in such a parking space for up to four hours Monday through Saturday, 8 a.m. to 6 p.m., unless otherwise noted.²¹²

7.5 Signage Standards

According to a 2010 survey, EV drivers attributed 22 percent of the problems encountered at public charging stations to spaces with EVSE being occupied by conventional vehicles.²¹³

Therefore, it is important to distinguish between signage to help EV drivers locate EVSE (sometimes called “guidance signage” or “directional signage”) and signage to ensure that the parking spaces with EVSE are available for EV drivers when they arrive to charge their vehicles (sometimes called “regulatory signage”). Both guidance and regulatory signage should be clear and consistent to avoid confusion and to educate non-EV owners. DVRPC’s proposed outreach program would develop guidance for municipalities in the region to promote consistent regulations and signage for dedicated public EV parking spaces with EVSE.

This section first provides context on the development of federal and state signage standards. It then develops a model scheme for guidance signage and regulatory signage for publicly accessible EVSE.

7.5.1 Federal and State Signage Standards

The Code of Federal Regulations requires that the Federal Highway Administration (FHWA) publish the Manual on Uniform Traffic Control Devices (MUTCD).²¹⁴ A traffic control device is any sign on a public street or highway that is intended to regulate, warn, or guide traffic. The federal MUTCD establishes the national design standard for all signs, including color, size, shape, fonts, and use of symbols. It also establishes standards for placement of signs to ensure that they are visible, legible, and enforceable.²¹⁵ Many local agencies utilize MUTCD-compliant signs in publicly owned parking facilities to be consistent with those used on adjoining public roadways.

The Code of Federal Regulations also requires that all states either adopt the MUTCD or develop a state MUTCD or federal MUTCD supplement to be reviewed by FHWA to ensure general conformance with the federal MUTCD.²¹⁶ Pennsylvania chose to adopt the federal MUTCD, including any amendments made by FHWA, and publish a state supplement for any additional state requirements.^{217, 218}

²¹² City of Davis, California, “Municipal Code 22.16.0,” accessed June 2013, <http://qcode.us/codes/davis/>.

²¹³ Plug In America, “Memorandum from Plug In America on Web-based Electric Vehicle Consumer Survey,” accessed June 2013, http://psrc.org/assets/3952/2010_0505.PIA_Report_EV_Driver_Survey.pdf.

²¹⁴ Code of Federal Regulations, “Title 23, Part 655, Subpart F,” accessed June 2013, <http://ecfr.gpoaccess.gov>.

²¹⁵ ECOTality, “Lessons Learned – The EV Project EVSE Signage,” accessed June 2013, <http://www.theevproject.com/downloads/documents/Signage%20Initial%20Issue%204-20-2012.pdf>.

²¹⁶ FHWA, “Manual on Uniform Traffic Control Devices: MUTCDs & Traffic Control Devices Information by State,” accessed June 2013, http://mutcd.fhwa.dot.gov/resources/state_info/index.htm.

²¹⁷ FHWA, “Manual on Uniform Traffic Control Devices: Pennsylvania,” accessed June 2013, http://mutcd.fhwa.dot.gov/resources/state_info/pennsylvania/pa.htm.

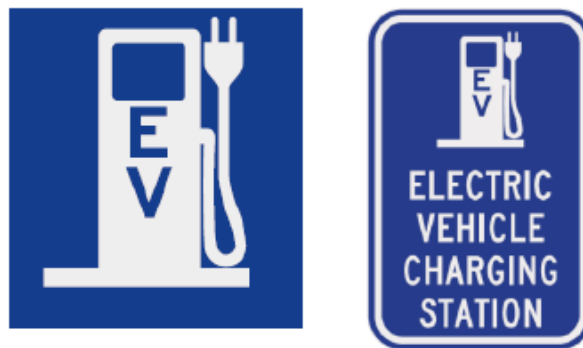
²¹⁸ Commonwealth of Pennsylvania, “Pennsylvania Code 212.2,” accessed June 2013, <http://www.pacode.com/secure/data/067/chapter212/subchapAtoc.html>.

The process by which FHWA approves signage for incorporation into the federal MUTCD generally involves systematic experimentation. State or local public agencies approach FHWA to request testing of a new traffic control device or reapplication of an existing device. FHWA then provides recommendations that the state can include in the state MUTCD or MUTCD supplement.²¹⁹ Because of a lack of federal and state guidance in the sphere of EVSE signage, EVSE signage tends to vary from city to city and state to state.

7.5.2 Guidance Signs

In April 2011, FHWA issued an Interim Approval for the use of an alternate D9-11b sign (Figure 12) in response to an experimentation request from the Oregon Department of Transportation and Washington Department of Transportation. FHWA considered the substitution of the electrical cable and connector in place of the gas hose and nozzle as an appropriate and recognizable representation of an EV charging station.²²⁰ The federal MUTCD includes this alternate sign as a general guidance sign, meaning that states and municipalities may use it to assist EV drivers in identifying parking spaces equipped with EVSE. States and municipalities may use advance turn and directional arrow signs in combination with the alternate D9-11b sign at appropriate decision points to help EV drivers locate public chargers (see Figure 13 for MUTCD directional arrow signs). Additional states, including Michigan, have since adopted the alternate D9-11b sign and, if a federal rulemaking occurs to include the sign in the MUTCD, all agencies would be required to use it as a permanent sign on public roadways.²²¹

Figure 12. D9-11b (Alternate) Interim Approved Symbol



Source: "Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State," 2010.

²¹⁹ ECotality, "Lessons Learned – The EV Project EVSE Signage."

²²⁰ County of Sonoma, California, "Electric Vehicle Charging Station Program and Installation Guidelines," accessed June 2013, http://www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf.

²²¹ County of Sonoma, California, "Electric Vehicle Charging Station Program and Installation Guidelines."

Figure 13. Advance Directional Arrow Signs as Designated in MUTCD



Source: Puget Sound Regional Council, "Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State," 2010.

Figure 12 and Figure 15 display the "standardized signs" referenced in this statement. Figure 14 presents an example of an EV charging station with the D9-11b Alternate sign on both the sign post and the parking surface (optional).

Figure 14. EV Parking Stall with D9-11b (Alternate) Symbol on Pavement



Source: ECOTALITY, "Lessons Learned – The EV Project EVSE Signage," 2012.

Because federal and state standards for EVSE guidance signage are limited, there may be an opportunity for DVRPC to work with PennDOT, counties, and municipalities to foster consistency in the design and placement of municipality guidance signage. In addition to charging station signs, municipalities may also place guidance signs with directional arrow signs at key junctions or decision points immediately surrounding EVSE.

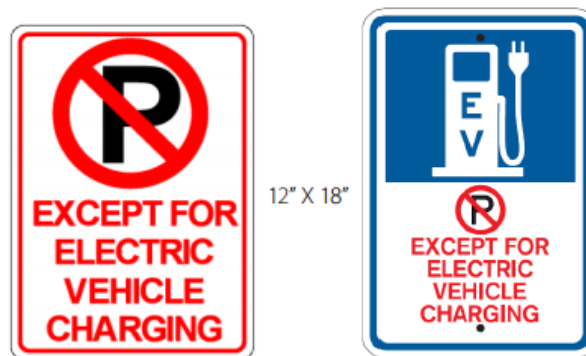
7.5.3 Regulatory Signs

Regulatory signs provide information about EVSE space-use requirements. The purpose of such signs is to reserve parking spaces with EVSE for EV use only and to specify the time duration that EVs may park and/or charge at a given charging station.

Regulatory signs are important because, as noted earlier, a common issue cited by EV drivers is conventional vehicles using parking spaces with EVSE, thus preventing them from accessing charging equipment. As with guidance signs, regulatory signs may differ slightly between municipalities and regions but should nonetheless convey a clear message, as required by the

MUTCD. ECOTality reported that, in various EV projects, signs that follow the MUTCD's red-on-white "No Parking" standards work best to keep non-EV drivers from parking in EVSE spaces.²²² Figure 15 presents ECOTality's recommended sign format and wording.²²³

Figure 15. ECOTality "No Parking" sign (left), Combined "No Parking" and MUTCD 9D-11b (Alternate) Sign



Source: ECOTality, 2012; U.S. Department of Transportation and FHWA, "Manual on Uniform Traffic Control Devices: Interim Approval for Optional Use of an Alternative Electric Vehicle Charging General Service Symbol Sign (IA-13)," accessed June 2013, http://mutcd.fhwa.dot.gov/resources/interim_approval/ia13/index.htm.

ECOTality determined that including the term "charging" in Figure 15 was more effective than "No Parking Except for Electric Vehicles," which opened the door for HEV drivers to mistakenly park (but not charge) in the spaces.²²⁴

In 2012, the City of Auburn Hills, Michigan, collaborated with the Michigan Department of Transportation to develop a regulatory sign that employs the MUTCD 9D-11b Alternate image (Figure 12). The city intended its sign for use in conjunction with local parking ordinances—drivers can receive parking tickets for not adhering to the sign. Hawaii is also reviewing the use of Michigan's model signage (shown in **Figure 16**), and DOE has suggested that FHWA consider the signage as the national standard for consistency and education.²²⁵

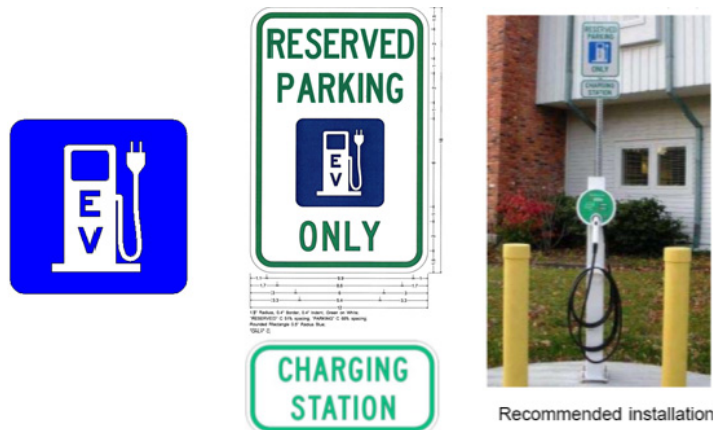
²²² ECOTality, "Lessons Learned – The EV Project EVSE Signage."

²²³ Note that it is important for nationally approved symbols, such as the "no parking" icon in Figure 8 to be at the recommended dimensions specified in the federal MUTCD to ensure enforceability.

²²⁴ Plug In America, "Memorandum from Plug In America on Web-based Electric Vehicle Consumer Survey."

²²⁵ Michigan Clean Energy Coalition, "Plug-In Ready Michigan – an electric vehicle preparedness plan: Planning and Zoning," accessed June 2013, <http://cec-mi.org/wp-content/uploads/2011/11/04-Planning-and-Zoning.ppt>.

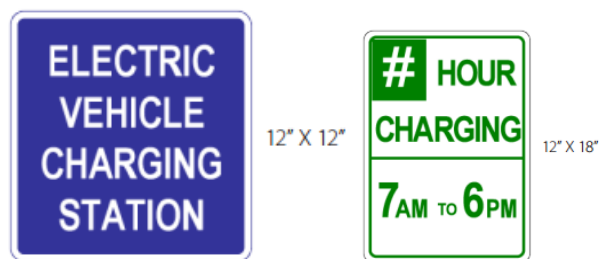
Figure 16. Michigan Model Regulatory Signage



Source: Michigan Clean Energy Coalition, 2013.

PSRC has also suggested using signs in combination to identify and regulate parking spaces reserved for EV charging (see Figure 17).

Figure 17. Model Regulatory Signage from PSRC



Source: Puget Sound Regional Council, "Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State," 2010.

Without local parking ordinances, regulatory signs are largely informational and rely on public cooperation. It is important for southeastern Pennsylvania municipalities to enact regionally consistent EV parking ordinances before installing regulatory EVSE signs. Otherwise, municipalities face the risk of people realizing the sign is not enforceable and ignoring it. See Section 7.4 for more information about parking rules.

7.6 Procurement Policies

Procurement policies establish the process and requirements that organizations must follow when acquiring goods and services. This section describes how government procurement policies can influence EV and EVSE deployment and provides examples of cases in which government procurement policies have addressed EVs.

7.6.1 Role of Procurement Policies in EV and EVSE Deployment

Government purchases have the potential to stimulate the market for a given type of vehicle or fuel for several reasons. First, private consumers are often exposed to fleet vehicles, increasing

consumer familiarity with the product. In addition, fleet procurement can help lower vehicle costs through economies of scale and, by providing proof of demand, can help overcome the barrier to entry for vehicle dealers who are uncertain about the demand for a given vehicle.

As a simple first step, local governments can include EV models on local purchasing lists.²²⁶ As a next step, local governments can prioritize EVs in their purchasing policies. Many communities have already adopted policies to prioritize procurement of low emission vehicles (LEVs) or AFVs, such as setting a target for the percentage of its fleet that consists of LEVs or AFVs. Others have chosen to allow or require consideration of environmental criteria in the procurement process or have determined that any vehicle replacements must be LEVs or AFVs, if appropriate models are available. Communities may consider amending policies that have been used to support LEVs or AFVs in the past and tailor them to promote EVs. Alternatively, communities might consider creating new policies that include EV procurement requirements. Municipalities might also consider joint procurement as a way to magnify the benefits of the procurement policy, including increasing vehicle exposure and lowering the purchase cost. Joint procurement refers to combining the purchasing power of several public authorities in a single purchasing effort to achieve economies of scale. A joint procurement pools the knowledge and skills of the participating agencies and reduces duplicative research and administrative effort. It can also help participating agencies demonstrate to their constituents or others in the organization that sustainable procurement can work for the agency, with less risk for each participant.

7.6.2 Vehicle Procurement in Southeastern Pennsylvania

The Pennsylvania Department of General Services' Green Procurement Policy states that analysis is required during the bid process for each material and service to determine if any green options exist. The Green Procurement Policy does not specifically address vehicle procurement. Rather, it focuses on increasing recycled-content purchases.²²⁷

The City of Philadelphia's procurement policy, however, does address clean vehicles. It specifies that the city's Procurement Department must purchase AFVs or HEVs when the price is reasonably competitive.²²⁸

7.6.3 Procurement Policy Resources

States and municipalities across the United States have adopted clean vehicle procurement policies, which can provide a model for EV procurement in southeastern Pennsylvania.

Jersey City, New Jersey

The City of Jersey City passed an ordinance in 2009 to amend the city code to include a requirement for the purchase of green vehicles.²²⁹ The requirement states that the purchasing

²²⁶ TCI, "Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools."

²²⁷ Pennsylvania Department of General Services, "Green Procurement," accessed June 2013, http://www.portal.state.pa.us/portal/server.pt/community/green_procurement/5247.

²²⁸ City of Philadelphia, "The Philadelphia Code: Title 17: Chapter 17-600. Procurement Price Preferences," accessed June 2013.

²²⁹ City of Jersey City, New Jersey, "Ordinance of Jersey City, N.J.: City Ordinance 09-004," accessed June 2013, http://www.cityofjerseycity.com/uploadedFiles/JC_Green/Green%20Vehicles%20Ordinance%2009-004.pdf.

agent must purchase or lease only AFVs or HEVs, when such vehicles are available, unless significant concerns exist regarding safety, performance, health, suitability, or cost.

State of Hawaii

The State of Hawaii revised the Hawaii Government Vehicle Purchase Guidelines to include requirements that county and state agencies purchase or lease light-duty motor vehicles that reduce dependence on petroleum for transportation energy. The law establishes a hierarchy of preferred vehicles, which identifies EVs or PHEVs as the preferred vehicle type, followed by hydrogen or FCVs, AFVs, HEVs, and fuel-efficient vehicles.²³⁰

²³⁰ Hawaii State Energy Office, "Vehicle Purchasing Guidelines," accessed June 2013, <http://energy.hawaii.gov/programs/achieving-efficiency/lead-by-example/programsachieving-efficiencylead-by-examplevehicle-purchasing-guidelines>.

8 Education, Outreach, and Marketing Plan for Southeastern Pennsylvania

Successful EV deployment in southeastern Pennsylvania will depend on a comprehensive, well-planned education, outreach, and marketing effort. Education, outreach, and marketing can occur through a variety of formats and settings, including electronic media, printed informational materials, and face-to-face meetings. Many resources are available to help local and regional agencies develop an EV strategy.

This section presents examples of existing education and outreach (E&O) efforts designed to engage and inform the full spectrum of stakeholders, including EV consumers (individuals, businesses, and fleet operators), vehicle dealerships, technicians, local officials, utilities, first responders, and property managers and parking garage operators. E&O initiatives can educate stakeholders about EV and EVSE benefits, best practices for use, financing options, regulations, and emergency response. The section also outlines a plan for training local government staff and provides recommendations for developing an education, outreach, and marketing campaign to increase demand for EVs in the region and position southeastern Pennsylvania as a leader in EV deployment.

8.1 Examples of E&O for Consumers

The introduction of any new technology typically requires significant outreach to consumers. This is particularly true for EVs, where misinformation and misperception are common aspects of the public conversation. City CarShare, ICF, and TrueNorth Research conducted a survey in July 2012 of consumers in the Bay Area in California. Even in a region with a relatively high level of EV deployment, the survey identified gaps in consumer knowledge. Most (84 percent) respondents indicated that they were slightly, somewhat, or very familiar with EVs, but when asked to identify an EV, more than 20 percent of survey respondents identified vehicles that were not EVs, such as HEVs or small, fuel-efficient vehicles. Local and regional agencies in southeastern Pennsylvania can promote EV deployment by providing consistent, high-level messages to highlight the availability and benefits of and mitigate concerns about EV and EVSE. Successful initiatives from other regions can serve as models for future initiatives in southeastern Pennsylvania.

8.1.1 Efforts in Southeastern Pennsylvania

Several stakeholders have already initiated consumer E&O efforts to encourage EV deployment in southeastern Pennsylvania.

DVRPC

DVRPC has developed a Microsoft Excel-based tool to calculate the total cost of ownership for EVs (see Section 5.5). The tool produces a customized report that summarizes the costs associated with acquiring, operating, and maintaining an EV compared to a comparable conventional vehicle, based on the consumer's driving habits and access to charging

infrastructure. The report also presents the net savings or costs of owning an EV over the period of vehicle ownership. The simple user interface makes it easy for users to vary their inputs (e.g., altering driving behavior, purchasing a different vehicle, and investing in different charging infrastructure) and evaluate the cost implications of these changes. DVRPC plans to make this calculator tool available to consumers through an online EV clearinghouse.

GPCC

GPCC, an officially designated DOE Clean Cities Coalition, has provided EV and EVSE presentations for a variety of consumer audiences. In partnership with PECO, GPCC hosts an annual EV workshop each summer, called “The Only Smoke in the Air BBQ.” This workshop includes presentations for EV end users, as well as an EV ride and drive, with consumer vehicles like the Chevrolet Volt and the Mitsubishi MiEV, as well as fleet vehicles like the Smith Electric Newton. The event draws hundreds of participants. In addition to the annual workshop and BBQ, GPCC and PennFuture plan to host EV workshops at three major universities in Philadelphia in 2013.

GPCC has also developed EV fleet education programs based on research with fleet managers, including face-to-face meetings and phone interviews. The research provided information that GPCC will use to tailor its future E&O efforts. For example, it concluded that fleet managers generally accept EVs as a viable vehicle in their fleets and they perceive EVs as helping to achieve overall sustainability goals. The main concerns associated with use of EVs in fleets include cost, vehicle size, and charge time. GPCC is working with the industry to provide E&O to address these concerns and reduce these barriers to EV deployment. GPCC has supported ECOtality's The EV Project (see below).

PECO

As the region's largest electricity utility, PECO uses its website to provide information about EVs and encourage consumers to notify PECO about EV purchases and EVSE installations. PECO also developed an EVSE installation checklist to guide consumers through the process.²³¹

ECOtality

Through the DOE-funded The EV Project, ECOtality has promoted EVs and EVSE installation in Greater Philadelphia since August 2012. DVRPC serves on The EV Project's Greater Philadelphia Steering Committee. Although The EV Project has reached completion, the relationships it has built will continue to serve as an organizational basis for EV and EVSE E&O.

EVX Team

The EVX Team is a West Philadelphia high school program that builds and runs AFVs, including EVs, to promote energy efficiency. This group competes nationally and is a valuable resource to help raise awareness of EVs within southeastern Pennsylvania.

²³¹ PECO, “Your Resource for Everything.”

8.1.2 National Efforts

At the national level, several organizations provide informational resources for EV consumers, including the following.

DOE

DOE implements Clean Cities, an alternative transportation vehicle deployment initiative that conducts E&O directed at consumers and provides information and resources to advance use of alternative fuels.²³² As part of Clean Cities, DOE has developed a series of educational materials, including a Vehicle Cost Calculator, which allows users to calculate the purchase price, fuel costs, repair and maintenance costs, available tax incentives, and cost and emissions savings of EVs compared conventional ICE costs.²³³

Electric Auto Association (EAA)

EAA provides information on EV technology developments and sponsors public exhibits and events to educate its members and the public on the progress and benefits of EV technology. EAA hosts regularly scheduled member meetings open to members and the general public.²³⁴

EDTA

EDTA is an industry association dedicated to advancing electric drive as a foundation for sustainable transportation. The association membership includes major vehicle manufacturers; utilities; battery, charging, and component suppliers; trade associations; universities and research institutions; government agencies; nonprofit organizations; fleet-users; retail outlets; and consumers. EDTA's website serves as an "information hub for plug-in electric vehicles."²³⁵

EPRI

EPRI conducts research and development related to the generation, delivery, and use of electricity. EPRI has developed information materials on EVs, such as installation guidelines, grid interface requirements, and life-cycle cost analysis to educate consumers and other EV industry stakeholders.²³⁶

Plug In America

Plug In America is a consumer-oriented organization promoting EV use and effective policy at the local, state and federal levels. The organization provides a range of expert assistance related to the widespread adoption of electric vehicles and conducts consumer outreach and awareness through individual events and online campaigns. Along with EAA and the Sierra Club, Plug In America organizes the National Plug-In Day and maintains a consumer-focused website that provides extensive resources, including an annual guide to new EV products.²³⁷

²³² DOE, "Clean Cities Publications," accessed June 2013, <http://www1.eere.energy.gov/cleancities/publications.html>.

²³³ DOE, "Vehicle Cost Calculator," accessed June 2013, <http://www.afdc.energy.gov/afdc/calc/>.

²³⁴ EAA, "Home," accessed June 2013, <http://www.electrcauto.org/>.

²³⁵ EDTA, "The Future Is Electric," accessed June 2013, <http://www.goelectricdrive.com/>.

²³⁶ EPRI, "Home Page," accessed June 2013, <http://www.epri.com/Pages/Default.aspx>.

²³⁷ Plug In America, "Home Page," accessed June 2013, <http://www.pluginamerica.org/>.

8.1.3 Other Local and Regional Efforts

Across the country, local and regional stakeholders, including both public and private entities, are collaborating to provide information and encourage EV and EVSE deployment. This list provides some illustrative examples of local and regional E&O efforts. These examples can serve as models for future initiatives in southeastern Pennsylvania.

Project Fostering EV Expansion in the Rockies (FEVER)

Project FEVER is an effort by the Denver Metro Clean Cities Coalition and the American Lung Association in Colorado to reduce petroleum consumption in the Colorado transportation sector. Project FEVER will result in a readiness and implementation plan to increase EV and EVSE adoption across the state. The project's website offers an engaging and informative resource for consumers.²³⁸

Bay Area PEV Ready

The Bay Area Air Quality Management District (BAAQMD) conducts E&O to promote EVs as a viable option for regional residents, as well as businesses. BAAQMD maintains a website with information about EV-related events, training, and incentives, as well as updates on the development of the regional EV deployment plan.²³⁹

8.2 Examples of E&O for Other Stakeholders

Effective E&O for entities that can influence the behavior of EV consumers and the availability and functioning of EVSE will prove essential to facilitating EV deployment. For example, training electricians on EVSE installation is important to ensure that EVSE is properly, safely, and efficiently installed and that enough qualified electricians are available to maintain competition and keep costs low for the consumer. As another example, training inspectors would help expedite the permitting and inspection process. In Pennsylvania, inspection companies must be third-party entities so E&O efforts in Pennsylvania might include private firms and inspectors.²⁴⁰

A number of existing initiatives develop curriculum for other EV stakeholders, including vehicle dealerships, technicians, local officials, utilities, first responders, and property managers and parking garage operators. These initiatives might provide useful information to incorporate in E&O programs in southeastern Pennsylvania.

8.2.1 Efforts in Southeastern Pennsylvania

Greater Philadelphia Clean Cities GPCC conducts numerous E&O initiatives to build general knowledge about EVs among regional stakeholders. As described in Section 8.1, GPCC hosts an annual EV workshop called "The Only Smoke in the Air BBQ." Beyond just addressing consumer concerns, the workshop covers all parts of the EV chain, with information for a variety of other EV stakeholders, from utilities to OEMs. In addition, regional leaders speak at the event, explaining short- and long-term goals for EV deployment in the region.

²³⁸ Denver Metro Clean Cities Coalition and the American Lung Association in Colorado, "The Electric Ride," accessed June 2013, <http://www.electricridecolorado.com/>.

²³⁹ BAAQMD, "Bay Area PEV Ready," accessed June 2013, <http://www.bayareapevready.org/>.

²⁴⁰ TCI, "Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools."

8.2.2 National Efforts

Although national E&O efforts cannot be easily replicated at the regional scale, they can provide helpful guidance for regional stakeholders, including technicians, local governments, and utilities. National E&O initiatives may also provide a source of informational materials that regional stakeholders can use in their own E&O efforts.

DOE

DOE's Clean Cities program has developed training materials for electrical contractors and public EVSE hosts, which it offers on its website.²⁴¹ As one example, the program has developed a 30-minute online presentation for electrical contractors and inspectors regarding residential EVSE installations.²⁴²

DOE also launched the Workplace Charging Challenge in 2013 with the goal of achieving a tenfold increase in the number of U.S. employers offering workplace charging in the next five years. Workplace Charging Challenge "Partners" commit to assessing employee charging demand and developing a plan to install charging stations. They then implement this plan and share progress and lessons learned. In return, DOE provides technical assistance and other nonfinancial resources to facilitate EVSE installation.

EVITP

EVITP provides a 24-hour course that trains and certifies electricians to install residential and commercial EVSE. It collaborates with the industry to develop the curriculum, which includes best practices for EVSE installation, commissioning, and maintenance. Community colleges and training centers throughout the United States provide the courses.²⁴³

National Alternative Fuels Training Consortium (NAFTC)

NAFTC develops curricula and disseminates training about alternative fuels, AFVs, and advanced technology vehicle education. NAFTC provides courses and workshops for a range of stakeholders, including first responders and fleet managers, as well as the general public. NAFTC sells textbooks, manuals, and workbooks and compiles free resources, such as presentations and fact sheets, on its website.²⁴⁴

8.2.3 Other Local and Regional Efforts

Southeastern Pennsylvania can consider implementing E&O initiatives for local and regional stakeholders based on existing efforts in other areas across the country. The following list identifies several examples of local and regional E&O efforts for EV stakeholders.

Northeast Electric Vehicle Network

TCI, a consortium of transportation, energy, and environmental agencies from 11 northeastern and mid-Atlantic states and the District of Columbia, created the Northeast Electric Vehicle

²⁴¹ DOE, "Clean Cities Publications."

²⁴² DOE, "Clean Cities TV: Natural gas Minibuses Help New Jersey Recover From Hurricane Sandy," accessed June 2013, <http://www.cleancities.tv/FeaturedContent/Training/EVSEResidentialChargingInstallation.aspx>.

²⁴³ DOE, "Electric Vehicle Infrastructure Training Program," accessed June 2013, <http://www1.eere.energy.gov/cleancities/evitp.html>.

²⁴⁴ NAFTC, "Home Page," accessed June 2013, <http://www.naftc.wvu.edu/>.

Network in October 2011 to support the rollout of EVs in the region. The network, funded by a grant from DOE Clean Cities, trains key stakeholders and promotes public awareness of the benefits of EVs. The Northeast Electric Vehicle Network has developed documents on EVs and EVSE for a variety of stakeholder groups, including consumers, property owners, employers, local governments, and utilities. These documents are all available to download via www.northeastevs.org.^{245, 246}

NYSERDA

NYSERDA develops PPPs with businesses, municipalities, residents, and other energy stakeholders to advance innovative energy solutions in the state. In partnership with TCI and 16 Clean Cities Coalitions, NYSERDA conducts E&O to engage consumers and policymakers and educate them about the benefits of EVs. The partnership has facilitated regional dialogues; conducted a literature review to assess market barriers, electrical grid impacts, plans for EV rollouts, and other issues specific to the Northeast; and created siting and design guidelines, model permits, building codes, and ordinances for EV infrastructure.²⁴⁷

Advanced Transportation Technology and Energy Initiative

The Advanced Transportation Technology and Energy Initiative provides technical education on advanced transportation and energy technologies in California. Community colleges throughout the state provide eight- to 16-hour courses on topics related to EVs, such as Hybrid Electric, Electric, and Gaseous Fuels Vehicle Identification; Vehicle Components; and First Responder Procedures for Police, Firefighters, and other Emergency Personnel.²⁴⁸

PSRC

PSRC collaborates with the Washington State Department of Commerce, local governments, and the EV industry to ensure that EV charging stations and other infrastructure are accessible and ready to go. PSRC prepared a guidance document, *Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State*, to assist local governments in meeting the requirements of Washington's new electric vehicle infrastructure law. PSRC provides model ordinances, regulations, and guidance for local governments related to EV infrastructure and batteries.²⁴⁹

Calstart EV Employer Initiative

The goal of this program is to identify best practices for EVSE installation, recommend EVSE deployment strategies, and communicate the EV value proposition for businesses. The initiative

²⁴⁵ TCI, "Northeast Electric Vehicle Network Documents," accessed June 2013, <http://www.georgetownclimate.org/state-action/transportation-and-climate-initiative/ev-documents>.

²⁴⁶ TCI, "Northeast Electric Vehicle Network," accessed June 2013, <http://www.transportationandclimate.org/content/northeast-electric-vehicle-network>.

²⁴⁷ NYSERDA, "Home Page," accessed June 2013, <http://www.nyserda.ny.gov/>.

²⁴⁸ Economic & Workforce Development, "Advanced Transportation Technology and Energy Initiative," accessed June 2013, <http://www.attcolleges.org/>.

²⁴⁹ PSRC, "Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State."

organizes monthly meetings and provides an informative website as forums for information sharing among employers.²⁵⁰

8.3 Plan to Develop an EV Training Program

This section outlines steps for a plan to train EV stakeholders in southeastern Pennsylvania, including the general public, fleet managers, vehicle dealerships, electricians and inspectors, local governments, utilities, first responders, and property managers and parking garage operators.

8.3.1 Identify roles and responsibilities

The first step in structuring a training plan is to determine who will be involved in developing and providing the training, and determine the responsibilities of each contributor. Table 24 presents one possibility for stakeholders and their corresponding roles for an EV training program in southeastern Pennsylvania.

Table 24. Recommended Roles and Responsibilities of Stakeholders Engaged in Stakeholder Education and Outreach

Stakeholder/Agency	Role/Responsibility
Greater Philadelphia Clean Cities and DVRPC	<ul style="list-style-type: none"> • Identify key audiences; • Engage potential partners; and • Host workshops (i.e., organize venues, coordinate instruction, conduct outreach/advertising/marketing, and coordinate day-of logistics).
U.S. Department of Energy and PECO	<ul style="list-style-type: none"> • Provide cofunding and logistical support; and • Conduct outreach/advertising/marketing to promote events.
NAFTC and Local Training Organizations	<ul style="list-style-type: none"> • Provide instruction.

Source: DVRPC, 2013.

8.3.2 Determine scope of training

Each training session could last for a portion of a day or a whole day. The training content would be tailored to the target audience. Table 25 includes recommendations for training content for key stakeholder groups. It may be appropriate to combine training for two or more of these groups (e.g., invite electricians and inspectors when holding a permitting workshop for local government).

²⁵⁰ Calstart, "Employer EV Initiative," accessed June 2013, <http://www.evworkplace.org/index.html>.

Table 25. Recommended Training Content by Audience

Audience	Recommended Content	Example Informational Materials
General Public	<ul style="list-style-type: none"> • Overview of EV and EVSE technology (focus on personal vehicles and home charging); • Costs and benefits of EVs; • Financing options and incentives for EVs and EVSE; • Availability of public EVSE; and • Residential EVSE permitting and installation. 	<ul style="list-style-type: none"> • <i>Handbook</i>: Plug-In Electric Vehicle Handbook for Consumers, by NREL; and²⁵¹ • <i>Handout</i>: Electric Vehicles and Charging: An Overview for New EV Owners, by Garfield Clean Energy.²⁵²
Fleet Managers	<ul style="list-style-type: none"> • Overview of EV and EVSE technology (focus on fleet vehicles and commercial charging); • Costs and benefits of EVs; • Financing options and incentives for EVs and EVSE; • Commercial EVSE permitting and installation; and • Goal-setting and progress measurement (e.g., baselines and benchmarks). 	<ul style="list-style-type: none"> • <i>Presentation, handbook, and handout</i>: Electric Drive: Fleet Applications, by NAFTC;²⁵³ • <i>Handbook</i>: Plug-In Electric Vehicle Handbook for Fleet Managers, by NREL; and²⁵⁴ • <i>Handbook</i>: How to Responsibly Green Your Fleet, by fleetcarma.²⁵⁵
Vehicle Dealerships	<ul style="list-style-type: none"> • Overview of EV and EVSE technology; • Costs and benefits of EVs; • Financing options and incentives for EVs and EVSE; • Residential EVSE permitting and installation; and • Technical requirements for EV use. 	<ul style="list-style-type: none"> • <i>Presentation</i>: EV Infrastructure Overview, by Clipper Creek, Inc.²⁵⁶ • <i>Presentation, handbook, and handout</i>: The Importance of Electric Drive: Awareness and Outreach, by NAFTC; and²⁵⁷ • <i>Handout</i>: Plugging In: A Consumer's Guide to the Electric Vehicle, by EPRI.²⁵⁸
Electricians and Inspectors	<ul style="list-style-type: none"> • Overview of EVSE technology; • EVSE market opportunities for contractors; and • EVSE permitting, installation, and inspection. 	<ul style="list-style-type: none"> • <i>Presentation</i>: Managing Electric Vehicle Supply Equipment (EVSE) Installations, by the National Electrical Contractors Association;²⁵⁹ • <i>Handbook</i>: Charging Station Installation Handbook for Electrical Contractors and Inspectors, by Advanced Energy;²⁶⁰ • <i>Handbook</i>: Installation Guide for Electric Vehicle Supply Equipment (EVSE), by the Massachusetts Department of Energy Resources; and²⁶¹ • <i>Video</i>: Training for Installing Residential Electric Vehicle Supply Equipment, by the DOE Clean Cities program.²⁶²

²⁵¹ Available at: <http://www.afdc.energy.gov/pdfs/51226.pdf>.

²⁵² Available at: <http://www.garfieldcleanenergy.org/pdf/transportation/Electric%20Vehicles/CLEER%20-%20EV%20Charging%20Fact%20Sheet%20-%20Vehicle%20Owners.pdf>.

²⁵³ Available at: <http://www.naftc.wvu.edu/cleancitieslearningprogram/petroleumreduction/electric-drive>.

²⁵⁴ Available at: http://www.afdc.energy.gov/pdfs/pev_handbook.pdf.

²⁵⁵ Available at: <http://www.fleetcarma.com/Resources/how-to-responsibly-green-your-fleet-ebook>.

²⁵⁶ Available at: <http://www.dvrpc.org/energyclimate>.

²⁵⁷ Available at: <http://www.naftc.wvu.edu/cleancitieslearningprogram/petroleumreduction/electric-drive>.

²⁵⁸ Available at: <http://www.epri.com/abstracts/pages/productabstract.aspx?ProductID=000000000001023161>.

²⁵⁹ Available at: <http://iaei-western.org/Files/2011/Programs/NECA%20EVSE%20Presentation%20NECA%20SD%202011%20Western%20IAEI%20Section.pdf>.

²⁶⁰ Available at: http://www.advancedenergy.org/transportation/evse/charging_station_installation_handbook.php.

²⁶¹ Available at: <http://www.mass.gov/eea/docs/doer/alternative-fuels/ev-manual-mass-32011.pdf>.

²⁶² Available at: <http://www.youtube.com/watch?v=4h5plqg5Puo&list=PLTTHf6mU88syVztERNF6iw088IWHZ11k4>.

Audience	Recommended Content	Example Informational Materials
Local Governments	<ul style="list-style-type: none"> • Best practices for regulations and incentives to support EV and EVSE deployment; • Codes and standards applicable in the region, including safety, accessibility, and signage standards (discussed in Section 7); and • EVSE permitting process, including site assessments, electric load calculations, and utility notification. 	<ul style="list-style-type: none"> • <i>Handbook</i>: Community Planning Guide for Plug-In Electric Vehicles, by the North Carolina Advanced Energy Corporation,²⁶³ • <i>Handout</i>: Be Part of the Solution: Join States and Communities Throughout the Northeast and Mid-Atlantic that Are Becoming “EV Ready,” by TCI; and²⁶⁴ • <i>Handout</i>: Permit for Charging Equipment Installation: Electric Vehicle Supply Equipment (EVSE), by DOE.²⁶⁵
Utilities	<ul style="list-style-type: none"> • Potential EV grid impacts and mitigation techniques; • Best practices for special EV rates and consumer outreach; and • EV-smart grid integration technology. 	<ul style="list-style-type: none"> • <i>Presentation</i>: PECO Perspective, by PECO,²⁶⁶ • <i>Handbook</i>: The Utility Guide to Plug-in Electric Vehicle Readiness, by EEI; and²⁶⁷ • <i>Handout</i>: Be Part of the Solution: Working Together to Get Ready for Electric Vehicles, by TCI.²⁶⁸
First Responders	<ul style="list-style-type: none"> • EV characteristics, components, and identification; • First responder standard operating procedures; and • Response to media inquiries regarding EV incidents. 	<ul style="list-style-type: none"> • <i>Handout</i>: Clean Cities Learning Program: First Responder Safety: Electric Drive Vehicles, by NAFTA;²⁶⁹ and • <i>Handbook</i>: The Emergency Response Guide to Alternative Fuel Vehicles, Chapter III. Electric Vehicles, by the California Department of Forestry and Fire Protection.²⁷⁰
Property Managers and Parking Garage Operators	<ul style="list-style-type: none"> • Overview of EVSE technology; • Codes and standards applicable in the region, including safety, accessibility, and signage standards (discussed in Section 7); • Siting, financing, and management options for communal EVSE; • EVSE permitting and installation; and • Benefits of offering EVSE, including green branding and diverse customer appeal. 	<ul style="list-style-type: none"> • <i>Handbook</i>: Plug-In Electric Vehicle Handbook for Public Charging Station Hosts, by NREL,²⁷¹ • <i>Handbook</i>: Siting and Design Guidelines for Electric Vehicle Supply Equipment, by TCI; and²⁷² • <i>Handout</i>: Be Part of the Solution: Install Electric Vehicle Charging Stations in Multi-Unit Dwellings, by TCI.²⁷³

Source: DVRPC, 2013.

²⁶³ Available at: <http://www.advancedenergy.org/transportation/resources/Community%20Planning%20Guide.pdf>.
²⁶⁴ Available at: <http://www.georgetownclimate.org/sites/default/files/EV%20Information%20for%20Local%20Governments.pdf>.
²⁶⁵ Available at: http://www.afdc.energy.gov/afdc/pdfs/EV_charging_template.pdf.
²⁶⁶ Available at: <http://www.dvrpc.org/EnergyClimate>.
²⁶⁷ Available at: http://www.eei.org/ourissues/EnergyEfficiency/Documents/EVReadinessGuide_web_final.pdf.
²⁶⁸ Available at: <http://www.georgetownclimate.org/sites/default/files/EV%20Information%20for%20Utilities.pdf>.
²⁶⁹ Available at: <http://assets.slate.wvu.edu/resources/527/1287695093.pdf>.
²⁷⁰ Available at: <http://osfm.fire.ca.gov/training/pdf/alternativefuelvehicles/Altfuelvehicles.pdf>.
²⁷¹ Available at: <http://www.afdc.energy.gov/pdfs/51227.pdf>.
²⁷² Available at: <http://www.georgetownclimate.org/siting-and-design-guidelines-for-electric-vehicle-supply-equipment>.
²⁷³ Available at: <http://www.georgetownclimate.org/sites/default/files/EV%20Information%20for%20Multi-Unit%20Housing.pdf>.

8.3.3 Devise a Training Schedule

Establish a date by which to complete training, based on the expectations for EV adoption in the region (see Section 5 for regional EV deployment estimates). As an example, trainings could be scheduled around new EV releases in coordination with manufacturers or hosted in coordination with other scheduled meetings.

To determine how many training sessions to hold, make an assumption about the number of individuals that will require training and the number of participants in each training session. Divide the estimated number of individuals that should receive training by the number of participants per session.

Based on the goal date to complete training and the number of training sessions needed, determine the frequency of training sessions required (e.g., one session every quarter).

8.3.4 Estimate total costs

Identify the cost elements for a training session. Costs will likely include venue rental, instruction, refreshments (if provided), and materials.

Costs for particular training sessions will depend on a variety of factors. For example, a large number of attendees could increase the costs associated with renting a venue, providing refreshments, and producing take-away informational materials. As another example, the choice of informational materials could affect the cost. If the host chooses to design new materials, this could increase the cost, compared to using existing materials. In addition, some materials cost more to produce, such as handbooks or videos. With respect to instruction, a training that requires specialized subject matter expertise might impose additional costs to hire an expert instructor.

Accordingly, the cost of training will vary depending on the training audience. For example, the general public might not need highly sophisticated informational materials but might benefit from more dynamic, entertaining presentations and would need a larger venue. In comparison, training for electricians or local government staff would need more specialized training content but could take place during preexisting training sessions, meetings, or other regular gatherings, minimizing costs for the venue and refreshments (if provided). Table 26 presents estimates for training costs by audience.

Table 26. Training Costs by Audience

Training Cost Components	General Public	Fleet Managers	Vehicle Dealerships	Electricians and Inspectors	Local Government	Utilities	First Responders	Property Managers and Parking Garage Operators
Number of attendees per training session	30 to 100	5 to 20	5 to 20	15 to 30	15 to 30	1 to 5	5 to 20	5 to 20
Venue <i>Rent a venue to accommodate all attendees²⁷⁴</i>	\$500 to 1,500	\$100 to 500	\$100 to 500	\$0 to 750	\$0 to 750	\$0 to 100	\$100 to 500	\$100 to 500
Instruction <i>Hire one instructor, including travel expenses²⁷⁵</i>	\$500	\$500	\$500	\$500 to 1,500	\$500	\$500	\$1,000 to 3,000	\$500
Refreshments (if provided) <i>May include breakfast and/or lunch for attendees²⁷⁶</i>	\$550 to 1,700	\$100 to 350	\$100 to 350	\$300 to 550	\$300 to 550	\$50 to 100	\$100 to 350	\$100 to 350
Materials <i>Provide a take-way (e.g., handout), notebook, and pen to all attendees²⁷⁷</i>	\$150 to 500	\$50 to 100	\$50 to 100	\$100 to 500	\$100 to 150	\$25 to 50	\$50 to 1,000	\$50 to 100
Total	\$1,700 to 4,200	\$750 to 1,450	\$750 to 1,450	\$900 to 3,300	\$900 to 1,950	\$575 to 675	\$1,250 to 4,850	\$750 to 1,450

Source: DVRPC, 2013.

²⁷⁴ Assumes that venue space costs approximately \$15 to 20 per person.

²⁷⁵ Assumes GPC could provide an instructor for most courses at a cost of approximately \$500 per session, except for courses that require specialty knowledge, for which instruction costs would be higher.

²⁷⁶ Assumes breakfast and lunch foods cost approximately \$5 and \$12 per person, respectively.

²⁷⁷ Assumes that materials cost approximately \$5 to 10 per person, except for courses that require specialty knowledge, for which materials costs would be higher.

Note that these cost estimates are conservative. Training costs could be reduced further in a variety of ways:

- Use donated space and refreshments;
- Engage volunteer instructors;
- Distribute existing informational materials, rather than developing custom materials; and
- Incorporate the EV and EVSE curriculum into preexisting training or meetings.

To cover the remaining costs, investigate whether other funding sources, such as state or federal grants, are available to support training assessments and training programs.

Conducting a training program requires substantial investment, but the return on investment includes numerous benefits. DVRPC and its project partners can collaborate to realize such a training program for stakeholders in southeastern Pennsylvania.

8.3.5 Conduct outreach to promote training

To maximize the benefit of the training program, reach out to potential participants to make them aware of the training opportunity. Low-cost ways to conduct this outreach include requesting that existing organizations (e.g., electrical unions, business groups, and government associations) promote the training to their constituents or presenting a brief “teaser” message at existing meetings or other regular gatherings (e.g., county meetings). The brief presentation could include a video clip and a handout with information about the training program.

GPCC may create an EV-focused speakers bureau, which would contact regional organizations and request that the organizations include a presentation by an EV or EVSE expert on their regular meeting agenda. The expert could provide an introductory presentation and then direct interested individuals to the training program for further information.

8.4 Plan for Developing an EV Education, Outreach, and Marketing Campaign

Various stakeholders in southeastern Pennsylvania have already engaged in EV and EVSE deployment, including public- and private-sector participants. A well-coordinated EV education, outreach, and marketing campaign can help to increase the appeal and adoption of EVs in the region. DVRPC and its project partners can use this section as a guide to develop such a campaign.

8.4.1 Clarify Campaign Mission and Objectives

Mission

The mission of the campaign would be to build awareness and demand for EVs in southeastern Pennsylvania and position southeastern Pennsylvania as a leader in EV deployment.

Objectives

The campaign objectives would include the following:

- Communicate EV benefits, including the potential to save consumers money, create a progressive image, stimulate the local economy, reduce GHG and criteria pollutant emissions, improve public health, and further energy independence.
- Educate southeastern Pennsylvania stakeholders about EV and EVSE operation, EV financing options, permitting, installation, and inspection of EVSE, EVSE availability, and such actions as preferred parking.
- Increase exposure to EVs for the general public and fleets through targeted outreach (e.g., ride and drive and other demonstration events) and provision of public EVs (e.g., through carsharing programs). Engaging current EV owners/drivers in demonstration events will provide potential consumers with the opportunity to ask questions and hear about the EV ownership experience.
- Demonstrate the business case for EV deployment in fleets, including presentation of environmental stewardship best practices.
- Identify prominent individuals or organizations to deliver campaign messages, such as civic and business leaders, EV-related companies, municipal governments, and regional agencies.
- Promote southeastern Pennsylvania as a progressive, vibrant, high-tech region.

8.4.2 Conduct Research

Over a span of several months, review existing EV campaigns, as well as research on potential EV consumers and their knowledge and interest in EVs (such as the information in Section 5). As needed, use survey tools, stakeholder interviews, and online research to develop an improved understanding of the current regional discourse on EVs. For example, review social media platforms to identify where the most robust conversations are already taking place and how key actors are using digital technology to communicate.

Also, assess the strengths and weaknesses of existing communication efforts to identify opportunities for the campaign moving forward. Local governments that have engaged in EV and EVSE deployment can inform this process, providing feedback that they receive directly, which may not be reflected in the survey of information sharing on websites and social media.

8.4.3 Identify the Target Audience and Engage Potential Partners

Based on the research conducted in the previous step, consider which audience(s) will be the primary target(s) for the campaign strategy. One option is to focus on potential early- and midadopter consumers, including individuals and fleet managers. Another option is to focus on the entities that support EV and EVSE deployment. Alternatively, the region might consider conducting an all-inclusive campaign, which would reach out to every segment of the EV chain. (A comprehensive list of potential audiences is included in Table 25 in Section 8.3.)

Based on the research conducted in the previous step and the target audience selected, identify and engage potential campaign partners. For example, identify proactive local governments who expressed interest in promoting EVs during stakeholder interviews. As another example,

stakeholder groups associated with the target audience (e.g., electrical unions) could help increase campaign exposure among their members. Community colleges can also act as partners by providing educational programs to the community. The local electric utility, PECO, could continue to conduct outreach as a campaign partner. TCI considers partnerships with local utilities to be an important step toward EV readiness.²⁷⁸ Partnerships can help maximize limited funds and broaden the reach of campaign efforts. Identify opportunities for partnerships both before implementing the campaign and throughout its course.

8.4.4 Develop a Brand Story

Building upon the preceding steps (i.e., conducting research and identifying a target audience), develop the initial brand story language. The brand story should include a compelling rationale for EV deployment, supported with concise, coherent talking points. For example, identify a sample EV success story that supports the campaign goals.

Based on the brand story, develop consistent campaign materials. Options for campaign materials include the following:

- A website with the mission statement, information for each target audience (see Section 8.3 for suggested content), and descriptions of current EV deployment activities in the region. DVRPC has begun developing an online clearinghouse of EV-related information that could serve this purpose;
- One-page handouts or brochures tailored to specific stakeholders groups. For an example, see the Northeast Electric Vehicle Network's "Be Part of the Solution" series;²⁷⁹
- Videos with EV deployment information for each target audience. NAFTC has developed a series of short training videos on EVs and EVSE that southeastern Pennsylvania could use to educate regional stakeholders.²⁸⁰ Alternatively, the region could create its own videos that use region-specific marketing messages and EV deployment information;
- Billboard posters with key campaign messages; and
- Collateral campaign materials, such as pens, EVSE installation checklists, or key contact information cards to provide stakeholders with handy information to help them deploy EVs and EVSE.

Using a variety of media for campaign materials can increase the interest level for the targeted audience.

8.4.5 Test Message Content

Conduct informal focus groups to test the effect of the campaign message content. Focus groups provide a useful tool to ensure that the outreach and communication strategies resonate with various audiences. The focus groups are also a convenient way to test more granular

²⁷⁸ TCI, "EV-Ready Codes for the Built Environment: Electrical Vehicle Supply Equipment Support Study."

²⁷⁹ TCI, "Northeast Electric Vehicle Network Documents," accessed June 2013, <http://www.georgetownclimate.org/state-action/transportation-and-climate-initiative/ev-documents>.

²⁸⁰ For an example video from the NAFTC channel, see: <http://www.youtube.com/watch?v=pqRXJTCPaeA&feature=youtu.be>. Contact NAFTC for more information about its video resources.

aspects of the campaign, including campaign language and mock materials. During the focus groups, request feedback on the language and materials. Ask whether the group members find them engaging and informative. Also, ask if they have any outstanding questions that the campaign materials could address.

8.4.6 Prepare Full Campaign Plan

After six months of mission development, research, and strategy development and testing, establish a full campaign plan, including the following:

- Specific, measureable campaign goals;
- An updated audience profile;
- Strategies and recommendations on the organizing structure of the campaign; and
- A master brand story with rationale, talking points, and recommendations for campaign materials.

A full campaign plan that is based on a thoughtfully designed mission statement and objectives and that has been developed using research and testing will help build confidence among regional stakeholders that the campaign will fulfill the need for a centralized resource for consumers in southeastern Pennsylvania.

8.4.7 Seek Plan Approval and Implement the Plan

Seek approval for the completed campaign plan from the host organization. After approval, implement the campaign plan over 12 to 18 months in conjunction with regional partners, including proactive local governments and businesses. Consider using PPPs to leverage resources, engage a spectrum of stakeholders, and demonstrate regional commitment to EV deployment.

9 Best Practices for Incentives & Programs to Enhance Demand for EVs and EVSE

Federal, state, regional, and local agencies can implement a range of incentives to enhance consumer demand for EVs and EVSE, including both monetary incentives (e.g., tax incentives and direct funding) and nonmonetary incentives (e.g., exemptions from requirements or fees and special privileges). Private entities, such as utilities and insurance companies, can also implement incentives to encourage EV and EVSE deployment. DOE's Alternative Fuels Data Center's Laws and Incentives website provides information on existing state and federal incentives, as well as laws and regulations in place throughout the United States.

Monetary incentives that defray upfront vehicle costs have helped convince consumers to purchase alternative fuel and advanced technology vehicles like EVs (and HEVs before that). Although purchase incentives have proven successful, the capital outlays that they require generally fall beyond the financial resources of local and regional agencies. Thus, entities with fewer financial resources might choose to offer nonmonetary incentives. When combined, these incentives can make a significant difference to consumers.

Despite financial and practical limitations, local and regional agencies can still implement many incentives to facilitate or accelerate the adoption of EVs. This section aims to help local and regional agencies develop and implement policies to increase demand for EVs in the study area. This guidance provides information to support adoption of incentives programs by local governments and authorities, as well as recommendations for incentives that are most appropriately provided at the state and federal level.

9.1 Types of Incentives and Programs

States, regions, and municipalities can implement a variety of incentives to encourage EV adoption and infrastructure deployment. Many of these incentives can be used to promote a range of AFVs, or they can be tailored specifically to address EVs and EVSE. Incentives can target various aspects of EV deployment, from infrastructure development to vehicle purchase, charging, and use.

Incentives can also be designed to target specific audiences. For example, tax incentives benefit entities with tax liability or who own property (e.g., property tax abatement for EVSE installation promotes deployment by property owners and developers). Grant funding can benefit both entities with tax liability and tax-exempt entities. Rebates create a point-of-sale incentive that consumers and fleets can realize immediately. Nonmonetary incentives, supplemented by targeted outreach, can also be effective for certain individuals and organizations.

This section describes four incentive types: tax incentives, direct funding, exemptions, and privileges. See Appendix K for examples of each incentive type. This section also briefly

describes other ways to promote EV deployment, including disseminating information and building a supportive regulatory framework.

9.1.1 Tax Incentives

Tax incentives provide a benefit to individuals or businesses and may include:

- Tax credits for EV or EVSE purchases;
- Reduced sales tax or sales tax exemption for EVs or EVSE purchases;
- Reduced vehicle license tax;
- Reduced personal property tax paid on EVs; and
- Reduced industrial property tax or other tax credits related to EV or EVSE research, development, or manufacturing.

The Internal Revenue Service (IRS) administers tax credits for qualified EV and EVSE purchases (see Section 1.4 for more information). There are numerous examples at the state level. For instance, the Colorado Department of Revenue provides an income tax credit to vehicle owners that title and register an AFV or HEV in the state. New Jersey exempts ZEVs purchased in the state, including AEVs, from state sales and use tax. Virginia law permits local governments to reduce personal property taxes paid on AFVs, specifically vehicles that operate using electricity, natural gas, liquefied petroleum gas (propane), or hydrogen. Michigan grants a property tax exemption for industrial property that is used for high-technology activities, including those related to advanced vehicle technologies, such as all-electric, hybrid electric, or AFVs and their components. As a final example, Georgia provides a job-creation tax credit for each qualified, full-time job generated by businesses that manufacture certain AFV components.²⁸¹

Tax incentives are most commonly implemented at the federal or state level. However, as in the Virginia example mentioned above, regional and local governments can also identify opportunities to spur EV deployment through local tax structures. Municipalities can also publicize state incentives and help residents and businesses take advantage of available state programs to promote development in their jurisdictions.

9.1.2 Direct Funding

Direct funding to make EV adoption and EVSE deployment more attractive can take several forms, including:

- Rebates and vouchers for EV or EVSE purchases;
- Grants for vehicles, equipment, or related projects; and
- Loans for EVSE installation.

²⁸¹ DOE, "Alternative Fuels Data Center," accessed June 2013, <http://www.afdc.energy.gov/>.

Funding can be provided to residential, commercial, or institutional customers. Regional and local governments can both provide funding themselves and pursue funding from state or federal grant programs to support regional EV and EVSE development projects.

Numerous states have promoted EVs through direct funding. Pennsylvania supports EV adoption through the AFV Rebates of the AFIG program, which assists eligible residents with the purchase cost of a new qualified AFV, including EVs (see Section 1.4 for more information).²⁸² California's Clean Vehicle Rebate Project provides \$2,500 rebates for the purchase or lease of light-duty EVs that CARB has approved or certified.²⁸³

Other government entities, such as air-quality districts and municipal utilities, have also administered funding. The San Joaquin Valley Air Pollution Control District administers the Public Benefit Grant Program, which provides funding to cities, counties, special districts, and public educational institutions to purchase new AFVs and EVSE and funds alternative fueling infrastructure projects, as well as advanced transportation and transit projects.²⁸⁴ The Los Angeles Department of Water and Power initiated a pilot program that includes a residential EVSE rebate and a TOU rate that provides a \$0.025 per kW discount for electricity used to charge EVs during off-peak hours.²⁸⁵

Although this document focuses on government incentives, EV consumers can also take advantage of funding from private sources. For example, some insurance companies and investor-owned utilities provide rebates or discounted rates to EV owners. For example, Farmers Insurance provides a discount of up to 10 percent on all major insurance coverage for HEV and AFV owners in Pennsylvania and other states.²⁸⁶ Dominion offers two special residential electricity rates to qualified EV owners in Virginia that provide a lower price during off-peak hours.²⁸⁷

9.1.3 Exemptions

In addition to tax benefits and direct funding, state, regional, and local governments can encourage EV adoption and EVSE deployment by exempting the vehicles, equipment, and electricity providers from requirements and fees. Exemption-based incentive programs are already in place across the United States and include exemptions from:

- Regulation of electricity rates, terms, and conditions (for entities that provide electricity for public charging);
- HOV lane passenger and time-of-day/day-of-week driving restrictions;
- Parking fees (e.g., at parking meters);

²⁸² PA DEP, "Alternative Fuels Incentive Grant Program: Alternative Fuel Vehicle (AFV) Rebates."

²⁸³ DOE, "Alternative Fuels Data Center."

²⁸⁴ DOE, "Alternative Fuels Data Center."

²⁸⁵ DOE, "Alternative Fuels Data Center."

²⁸⁶ Farmers Insurance, "Pennsylvania Insurance Discounts For Your Car and Home," accessed June 2013, http://www.farmers.com/pennsylvania_insurance_discounts.html.

²⁸⁷ Dominion, "Helping You Get Plug-In Ready," accessed June 2013, <https://www.dom.com/about/environment/pdf/electric-vehicle-brochure.pdf>.

- Registration fees;
- Vehicle inspection and maintenance requirements; and
- Taxicab operational life limits.

One of the most publicized exemption incentives has been HOV lane access for EV (and other qualified vehicle) drivers. The sales of GM's Volt experienced a significant increase in February and March 2012, after engineering modifications to the vehicle made it eligible for HOV lane access in California.²⁸⁸

As another example, the District of Columbia exempts EVs and other certified clean fuel vehicles from time-of-day and day-of-week driving restrictions and commercial vehicle bans.²⁸⁹ Nevada exempts HEV taxicabs from the operational life limit that applies to conventional vehicles, allowing HEV taxicabs to operate for an additional 24 months.²⁹⁰ The City of New Haven, Connecticut, waives city parking fees for registered AFVs that display a pass certifying a fuel economy of at least 35 miles per gallon.²⁹¹

At the time of publication, southeastern Pennsylvania does not have HOV lanes or driving restrictions that could render a similar driving access incentive feasible. However, the region could consider offering EV drivers exemptions from other applicable requirements and/or fees.

9.1.4 Privileges

Offering exclusive privileges for EVs can encourage their adoption. Privilege incentives include those that make driving EVs more convenient than driving conventional vehicles, such as priority parking. A single-occupant AFV in Arizona may park without penalty in parking areas designated for carpool operators.²⁹²

Another example is the "head of the line" incentive program at the Dallas Love Field airport. The City of Dallas, Texas, amended the Dallas City Code in 2010 to allow CNG taxicabs to advance in front of other taxicabs at airport holding or dispatch areas.²⁹³ The San Francisco Airport has a similar incentive program, which grants certain AFV taxi drivers one "front of the line" trip per shift.²⁹⁴ Although the incentive programs at Dallas Love Field and the San Francisco Airport support CNG and all AFV vehicles, respectively, similar programs could target EVs in particular.

9.1.5 Other Initiatives to Support EV Deployment

Beyond the four types of incentives described above, governments can take additional action to encourage EV adoption and infrastructure development. In particular, public education and regulatory initiatives can work to minimize barriers to widespread EV deployment.

²⁸⁸ Peter Valdes-Dapena, "Volt sales surge in California thanks to car-pool access," CNN Money, accessed June 2013, http://money.cnn.com/2012/06/06/autos/volt_california_sales/index.htm.

²⁸⁹ District of Columbia, "50-702 and 50-714," accessed June 2013, <http://www.lexisnexis.com/hottopics/dccode/>.

²⁹⁰ DOE, "Alternative Fuels Data Center."

²⁹¹ City of New Haven, Connecticut, "Hybrid Parking Permits," accessed June 2013, <http://www.cityofnewhaven.com/TrafficParking/hybridparking.asp>.

²⁹² DOE, "Alternative Fuels Data Center."

²⁹³ City of Dallas, Texas, "Ordinance No. 27831," accessed June 2013, <http://www.greendallas.net/pdfs/TaxisOrdinance.pdf>.

²⁹⁴ Association of Bay Area Governments et al., "Ready, Set, Charge, California!"

With respect to public education, governments can disseminate information about EVs, EVSE, and relevant incentive programs using a variety of formats. Websites, guidebooks, labeling, signage, marketing campaigns, and educational/training programs all provide useful methods to increase public familiarity with EVs. In addition to education initiatives for the general public, numerous workforce development programs target specific user groups, such as first responders or technicians. For example, NAFTC has developed a curriculum, funded by DOE, meant to train emergency personnel to respond to an accident involving EVs.²⁹⁵ In California, the Certified Electric Vehicle Technician Training Program funds EV technician training.²⁹⁶

In addition to promoting EV education, governments can also develop a regulatory framework that facilitates EV deployment. The following is a list of regulations that could enable or drive EV deployment (Section 7 covers some of these regulatory mechanisms in greater depth):²⁹⁷

- Definitions that specify the criteria for an “electricity provider” and “electric vehicle;”
- Procurement mandates that set goals for EVs as a share of government or commercial fleets;
- Zoning regulations that permit EVSE siting and installation (e.g., permit EVSE at MUDs);
- Parking requirements that outline the number of necessary EV-exclusive parking spaces;
- Fuel-economy standards and mandates that require production of EVs as a share of total production;
- Industry requirements to standardize EV and EVSE components;
- Certification requirements for EVSE installers;
- Construction standards that require the installation of EVSE or electrical conduit for use in possible future EVSE installations;
- Insurance regulations that protect EV owners from additional insurance charges and allow insurance companies to provide rebates or discounts to EV owners;
- Appointment of a council or individual to conduct research and provide recommendations for the development of EVSE and supportive policies; and
- Establishment of PPPs to install EVSE or supply EVs.

Public education and regulatory initiatives are not mutually exclusive. They often work hand in hand. For example, state law requires that the California Energy Commission develop and maintain a website with links to electrical corporations, local electric utilities, and other sources of information about EVs.²⁹⁸ As another example, an Arizona law requires that motor vehicle dealers provide the public with information about AFVs, including available purchase and lease incentives.²⁹⁹ Finally, to accompany streamlined permitting regulations, the City of Raleigh,

²⁹⁵ NAFTC, “First Responder Safety Training,” accessed June 2013, <http://afvsafetytraining.com/>.

²⁹⁶ Clean Tech Institute, “Certified Electric Vehicle Technician (CEVT) Training Program,” accessed June 2013, <http://www.cleantechinstitute.org/Training/CEVT.html>.

²⁹⁷ DOE, “Alternative Fuels Data Center.”

²⁹⁸ DOE, “Alternative Fuels Data Center.”

²⁹⁹ DOE, “Alternative Fuels Data Center.”

North Carolina, is collaborating with a local community college to develop training programs related to EVSE installation. The city is designing the training programs for electrical contractors and inspectors and will connect the trained professionals with local EV dealers.³⁰⁰ The program will ensure that well-trained installation professionals are available for interested EV consumers.

9.2 Best Practices for Incentives and Programs

Sharing and implementing best practices can improve the success of an incentive program. Fortunately, numerous initiatives exist to promote AFV or EV deployment, providing a foundation of best practices to guide future programs. This section presents some best practices for incentives and programs.

9.2.1 Demonstrate Leadership

Programs and resources such as the Rocky Mountain Institute's "Project Get Ready" and the City of Atlanta's "Electric Vehicle Deployment: Municipal Best Practices Study" highlight the value of government leadership in EV deployment initiatives. Demonstrating leadership involves gathering a group of stakeholders to identify regulatory, commercial, and community interests and appointing a council or individual to champion government EV deployment efforts.³⁰¹ Making it clear that the government will lead deployment initiatives with the input of stakeholders creates a climate in which businesses and residents can be confident in EV and EVSE investments.

For example, the governor of Oregon established the Transportation Electrification Executive Council to set priorities and lead EV deployment efforts. The council consists of private, public, and nonprofit representatives.³⁰² This action ensures that deployment efforts are coordinated and aligned with regional goals. It also indicates to consumers that EV deployment is a priority for Oregon.

9.2.2 Gather Information

Governments can conduct research to project and characterize EV demand. For example, governments can consult with stakeholders through meetings or surveys. They can generate consumer demand maps based on demographic indicators and other data. Having specific information about local demand can help identify candidate locations for EVSE installation, engage local businesses in cost sharing, and minimize barriers to adoption for local consumers.³⁰³

³⁰⁰ City of Atlanta, Georgia, "Electric Vehicle Deployment: Municipal Best Practices Study," accessed June 2013, <http://www.rmi.org/Content/Files/Atlanta%20EV%20Readiness%20Study%20.pdf>.

³⁰¹ City of Atlanta, Georgia, "Electric Vehicle Deployment: Municipal Best Practices Study."

³⁰² Organization for Economic Cooperation and Development, "EV City Casebook," accessed June 2013, <http://www.iea.org/evi/EVCityCasebook.pdf>.

³⁰³ City of Atlanta, Georgia, "Electric Vehicle Deployment: Municipal Best Practices Study."

Using demographic and travel data, Houston, Texas, and Seattle, Washington, developed maps of locations where potential EV owners live and work. Collaborating with stakeholders, the cities used these maps to identify areas of greatest EVSE demand.³⁰⁴

New York City contracted McKinsey & Company in 2010 to conduct an EV adoption study, which indicated that the city has high potential for early adoption, although lack of consumer education inhibits demand. This study informed city officials that a critical step for EV deployment will be increasing consumer demand through public education and outreach. This information will allow the city to invest its resources more wisely.³⁰⁵

DVPRC has conducted extensive research and analysis of EV demand in southeastern Pennsylvania (for example, see DVPRC's EV demand projection maps in Section 5). DVPRC can use the results of its analysis to help local stakeholders, including businesses and consumers, make informed decisions as they invest in EVs and EVSE.

9.2.3 Focus on Consumer Priorities and Concerns

Because both individual and commercial vehicle owners are influenced by a range of factors in their vehicle purchase decisions, and because they have different limitations that dictate purchase decisions, governments need to design incentive programs to carefully target the key factors identified. "One size fits all" programs are not likely to be effective. Individual consumers tend to weigh initial purchase price more heavily than the total cost of ownership when choosing a vehicle.³⁰⁶ Thus, incentives that reduce the initial purchase price of an EV, such as a purchase rebate, will be more effective to encourage consumer adoption than incentives that provide future savings. Ideally, these incentives will be applied at the point of sale so that the consumer realizes the benefit immediately. Other consumer concerns, such as limited range or safety issues, are amplified by unfamiliarity with EVs and a lack of EV-specific regulations. Thus, government efforts to increase consumer understanding of EV technology, and to standardize EVSE installation codes, will improve the likelihood of adoption.³⁰⁷ To mitigate concerns that result from lack of understanding of EV technology, the City of Los Angeles, California collaborated with industry stakeholders to develop a series of EV 101 workshops for municipalities and residents.³⁰⁸

Governments providing incentives for EVSE deployment should consider challenges facing residents in MUDs and other common interest developments in which vehicle owners cannot access a garage. EV deployment at MUDs presents significant challenges, including questions about EVSE ownership and cost allocation, which could be addressed in part by targeted incentives, such as tax credits for property managers that install EVSE for tenant use.

³⁰⁴ City of Atlanta, Georgia, "Electric Vehicle Deployment: Municipal Best Practices Study."

³⁰⁵ Organization for Economic Cooperation and Development, "EV City Casebook."

³⁰⁶ DOE, "One Million Electric Vehicles by 2015," accessed June 2013,

http://www.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.pdf.

³⁰⁷ RAND Europe, "Bringing the electric vehicle to the mass market," accessed June 2013,

http://www.rand.org/content/dam/rand/pubs/working_papers/2012/RAND_WR775.pdf.

³⁰⁸ Organization for Economic Cooperation and Development, "EV City Casebook."

Fleet owners are more likely than individual consumers to consider the total cost of vehicle ownership.³⁰⁹ Thus, fleet buyers may respond more positively than individual consumers to initiatives that lower costs over an extended period of time (e.g., discounted utility rates). However, because fleets require numerous vehicles, upfront costs still present a significant barrier. Incentives that lower the purchase cost, especially rebates, vouchers, and other incentives that take effect at the point of sale, can enhance fleet EV deployment. Financing options, such as Nebraska's low-cost loans for vehicle infrastructure, are also attractive to fleet owners.³¹⁰

The Illinois Alternative Fuels Rebate Program is an example of an incentive program aligned with fleet priorities. The program provides a rebate for 80 percent of the incremental cost of purchasing or converting to an AFV. It is part of the Illinois Green Fleets Program, which provides benefits to organizations, businesses, and nonfederal government units, as well as residents.³¹¹

As another example of a fleet-focused incentive, Oregon's Commercial Electric Truck Incentive Program provides voucher-based reimbursements for qualified commercial zero-emission truck purchases. By providing funding to both public and private fleets, the program aims to replace 200 high-polluting medium-sized urban diesel vehicles. This is a good example of coupling purchase incentives with incentives for vehicle retirement in order to encourage fleet EV adoption.³¹²

Not all consumers can take advantage of every incentive type. For example, only entities with tax liability can benefit from tax incentives. Thus, tax credits do not appeal to municipal fleets. On the other hand, funding programs might limit funding to particular types of consumers. Other incentives, however, are generally open to a broad range of beneficiaries. Considering the applicability of incentives to the target audience can help governments select an incentive profile with the greatest impact.

Implementing incentive programs can also raise equity issues, particularly as they relate to privileges. For example, although the Dallas Love Field taxicab incentive mentioned above sends a clear message that Dallas will reward investment in alternative fuels, the program sparked controversy among drivers who cannot afford to invest in new vehicles or vehicle conversions. Trying to anticipate perception issues among affected entities before implementing an incentive program can help to avoid these concerns.

9.2.4 Partner with Businesses

PPPs can help to minimize barriers to EV deployment by coordinated leverage of public and private resources. PPPs can focus on EVSE installation, vehicle provision, or other services,

³⁰⁹ RAND Europe, "Bringing the electric vehicle to the mass market."

³¹⁰ Nebraska Government, "Dollar and Energy Saving Loans," accessed June 2013, <http://www.neo.ne.gov/loan/index.html>.

³¹¹ DOE, "Alternative Fuels Data Center."

³¹² Oregon Department of Transportation, "Commercial Electric Truck Incentive Program (CETIP)," accessed June 2013, <http://cms.oregon.gov/ODOT/HWY/OIPP/docs/cetiproadmap5.pdf>.

such as EV carsharing. A RAND research study indicated that the use of PPPs to develop charging infrastructure will be critical to move EVs from the niche market to the mass market.³¹³

For example, The EV Project has deployed the largest number of EVSE installations in history in the United States through a large public-private venture. The Project installed X chargers in the Philadelphia area. These chargers will collect valuable information on how EV owners use both public and private chargers.

As another example, the City of Portland, Oregon, partnered with Portland General Electric and Portland State University to develop “Electric Avenue” in downtown Portland. The corridor integrates EVSE, transit, and public greenway space and offers reserved parking spaces for charging EVs.³¹⁴ This project sends a clear message that the city is invested in EV deployment and will partner with local entities to support further progress.

9.2.5 Pursue Funding Opportunities

Numerous national and state programs provide funding for local alternative fuel and advanced vehicle deployment initiatives; some may target EV deployment projects specifically. Local governments can take advantage of these opportunities to fund EVSE installation, which can encourage consumer EV adoption.

The City of Philadelphia provides a model for successful efforts to promote EVSE and EV deployment using this strategy. In partnership with PhillyCarShare, the City of Philadelphia pursued funding from Pennsylvania's AFIG program to purchase and install EVSE in Philadelphia. The city secured the funding in 2010 and installed the chargers at nine different sites. To build off of this successful EVSE deployment effort, PhillyCarShare added 20 Chevrolet Volts to its fleet in 2012 for use by Philadelphia residents.³¹⁵

9.2.6 Develop a Plan for Periodic Review

Before implementing any incentive program, local governments might consider developing a manual or guidelines document that clearly states the requirements, responsibilities, timeline, and other important considerations for the program. In addition, they can establish benchmarks to measure progress and create a plan to periodically evaluate progress toward program goals.

9.3 Current Federal, State, Local, and Private Incentives in Southeastern Pennsylvania

This section summarizes existing incentives and programs in southeastern Pennsylvania, including those offered by federal, state, local, and private entities.

9.3.1 Tax Incentives

EV owners in southeastern Pennsylvania may qualify for vehicle and infrastructure tax credits from the IRS. First made available in 2009, the federal qualified plug-in electric vehicle tax credit

³¹³ RAND Europe, “Bringing the electric vehicle to the mass market.”

³¹⁴ Portland State University, “Electric Avenue,” accessed June 2013, <http://pdx.edu/electricavenue/>.

³¹⁵ See Appendix D.

supports the purchase of new, qualified EVs and ranges from \$2,500 up to \$7,500. The amount of the credit is based on the vehicle's traction battery capacity and the gross vehicle weight rating. The minimum credit of \$2,500 applies to vehicles with a battery capacity of at least four kWh. The tax credit increases by \$417 for every kWh of battery capacity in excess of five kWh, for the maximum credit of \$7,500. The Chevrolet Volt (16 kWh battery) and the Nissan LEAF (24 kWh battery) both qualify for the maximum credit. The 2012 Prius Plug-In (4.4 kWh battery) qualifies for a \$2,500 tax credit.³¹⁶ The credit applies to vehicles acquired after December 31, 2009, and it phases out as manufacturers reach a limit of 200,000 eligible EVs sold.³¹⁷ For a breakdown of the tax credit, see Appendix A.

Consumers and businesses may also claim a tax credit for 30 percent of the cost of qualified EVSE installed before the end of 2013. Residential EVSE is eligible for up to \$1,000, and nonresidential charging equipment may receive a credit of up to \$30,000. This tax credit expired on December 31, 2011 but was reinstated by the American Taxpayer Relief Act of 2012 (Public Law 112-240).³¹⁸

9.3.2 Direct Funding

EV owners in southeastern Pennsylvania can take advantage of direct funding from the Commonwealth of Pennsylvania and from two private entities: PECO and ECotality.

PA DEP provides AFV Rebates on a first-come, first-serve basis to Pennsylvania residents for the purchase of new AFVs through its AFIG Program.³¹⁹ The first 500 qualified EV applicants receive rebates of \$3,500 for an EV with a battery capacity equal to or greater than 10 kWh; the next 500 receive rebates of \$3,000. The program provides rebates of \$1,000 for other qualified EVs (with a battery capacity less than 10 kWh), as well as NGVs, FCVs, and propane vehicles. Rebates of \$500 are available for electric motorcycles and scooters.³²⁰ As of March 2013, all of the \$3,500 rebates have been distributed and most of the \$3,000 rebates remain.

In June 2012, PECO began providing a Smart Driver Rebate of \$50 to residential customers who purchase a new, qualified EV by December 31, 2013. For government, institutional, and nonprofit customers, PECO provides a rebate of \$1,000 per unit for installing up to two Level 2 public EVSE. In each county that PECO serves, PECO will pay counties up to \$3,000 to install Level 2 public EVSE. PECO set the deadline for submission of rebate forms for March 1, 2014.³²¹

ECotality covers up to \$400 of the cost of EVSE installation for owners of qualified EVs in the Philadelphia metropolitan area through The EV Project, which is a deployment project run by ECotality in partnership with DOE. All participants in The EV Project incentive program must

³¹⁶ IRS, "Qualified Vehicles Acquired after 12-31-2009: Qualified Plug-In Electric Drive Motor Vehicles (IRC 30D)," accessed June 2013, <http://www.irs.gov/Businesses/Qualified-Vehicles-Acquired-after-12-31-2009>.

³¹⁷ IRS, "Plug-In Electric Vehicle Credit (IRC 30 and IRC 30D)," accessed June 2013, <http://www.irs.gov/businesses/article/0,,id=214841,00.html>.

³¹⁸ DOE, "Alternative Fuels Data Center."

³¹⁹ PA DEP, "Alternative Fuels Incentive Grant Program: Alternative Fuel Vehicle (AFV) Rebates."

³²⁰ PA DEP, "Alternative Fuels Incentive Grant Program: Alternative Fuel Vehicle (AFV) Rebates."

³²¹ PECO, "PECO Smart Driver Rebate."

agree to anonymous data collection after installation. The project began in Philadelphia in August 2012 and is no longer accepting applications as of the date of publication.^{322, 323}

9.3.3 Privileges/Other Incentives

The City of Philadelphia has amended its code by adding a new section (Section 12-1131: Electric Vehicle Parking) to facilitate reserved on-street parking for EV. The city is also revising an existing section (Section 12-2809: Civil Penalties and Costs) to institute penalties for illegally parking a non-EV in a designated EV parking space. The new code language allows city residents who own an EV to reserve an on-street parking spot in front of their property for EV charging.^{324, 325}

³²² ECOtality, "The EV Project."

³²³ ECOtality, "EV Project offers Free Blink® Chargers to EV Drivers and Commercial Host Sites in Philadelphia."

³²⁴ City of Philadelphia, "The Philadelphia Code: Title 12. Traffic Code," accessed June 2013, <http://legislation.phila.gov/attachments/4385.pdf>.

³²⁵ City of Philadelphia, "Bill No. 070788: An Ordinance."

10 Utility Policies and Plans to Accommodate EVs

Widespread EV deployment presents an opportunity for greater revenue for electric utilities. At the same time, it has the potential to increase strain on the distribution grid. The degree of the impact on the grid will depend on the level of EV market penetration, the current condition of distribution infrastructure, and the load management strategies used by the local utility. EV charging during peak load periods may place some additional strains on electric distribution infrastructure, while charging during off-peak hours would tend to flatten load curves, resulting in more efficient use of existing infrastructure. To prepare for the impacts of EV deployment, utilities across the country are working to better understand consumer usage patterns and load management options, such as charging time incentives and technology solutions.

TOU tariff structures, which charge higher rates during peak hours and lower rates during off-peak hours to more closely reflect the actual cost of power, are one tool that some utilities use to encourage customers to use electricity during off-peak hours to prevent high utility bills. Some utilities offer dynamic pricing to customers, which differ from conventional TOU tariffs in that the price of electricity is determined in real-time based on actual market conditions. With proper notification protocols and access to tools, customers are able to adjust their energy consumption to avoid price spikes and achieve cost savings.

Technology solutions to reduce grid impacts and minimize costs for EV-owning customers include smart charging technologies, which track daily usage patterns and restrict charging to periods when electricity demand is not at peak.³²⁶ Utilities have actively engaged in developing smart charging equipment as a tool to educate EV owners about TOU or dynamic pricing signals. Additionally, utilities have initiated pilot programs to encourage EV deployment and test strategies to minimize negative grid impacts associated with that deployment. Table 27 presents a sample list of utility pilot programs that offer EVSE incentives and/or special EV charging rates.

³²⁶ Charles Zhu and Nick Nigro, "Plug-in Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review," 10.

Table 27. Utility Pilot Programs with Special EV Rates and/or EVSE Incentives

Utility Location	Pilot Program Name	Incentive Type	EVSE Included	EV Rate
Austin Energy – Austin, TX	Plug-in Everywhere	Rebate up to \$1,500 for purchase and installation of Level 2 EVSE	Level 2 EVSE installed by preapproved contractor	None
Consumers Energy - Michigan	EV Incentive Program	Rebate up to \$2,500 for purchase and installation of Level 2 EVSE; limited to first 2,500 participants	No	Option 1 - no additional meter - combines EV and household usage; Option 2 - requires second meter - TOU rate; Option 3 - requires second meter - Flat rate for EV only (based on usage up to 300 kWh per month) and limited to 250 participants
Dominion - Virginia	EV Rates Pilot	EV-specific pricing rates; each rate plan limited to first 750 participants	No	EV Pricing Plan requires installation of second meter to be supplied by Dominion; Off-peak 8-hour window; in EV + Home Pricing Plan meter is replaced by interval meter, which allows Dominion to read in 30-second increments
DTE Energy - Michigan	Plug-in Ready Option 1	Rebate up to \$2,500 for installation of a separately metered Level 2 EVSE; limited to first 2,500 customers participants	Level 2 EVSE provided and installed by SPX; DTE installs second meter	D1.9 (EV TOU Rate); \$40 Monthly Flat Rate available to the first 250 customers
Duke Energy – North and South Carolina	Charge Carolinas	Rebate up to \$1,000 of installation costs for residential customers	Level 2 EVSE provided with maintenance for the duration of the pilot program; customer can purchase the EVSE for \$250 at the end of the pilot	None

Utility Location	Pilot Program Name	Incentive Type	EVSE Included	EV Rate
Duke Energy - Indiana	Project Plug-IN	Rebate up to \$1,000 of installation costs for residential customers and \$1,500 for commercial customers	Level 2 EVSE provided with maintenance for the duration of the pilot program	None
Hawaiian Electric Company - Hawaii	EV Pilot Rates	Participants receive new TOU meters free of charge; limited to first 1,000 participants on Oahu, first 300 in Maui, and first 300 on the Island of Hawaii	No; load control and load monitoring devices will be installed free of charge	Customers enrolling on the TOU-EV or Schedule EV-R rates will have a new meter installed exclusive for EV charging. The rate EV-R customer's existing load will remain on the existing meter and account
Los Angeles Department of Water and Power- Los Angeles, CA	Charge Up LA!	Rebate up to \$2,000 for purchase and installation of Level 2 EVSE; limited to first 1,000 participants	No	EV TOU rate available and requires separate meter; EV discount of 2.5 cents per kWh during off-peak, nighttime hours and on weekends

Source: Austin Energy, 2013; Consumers Energy, 2013; Dominion, 2013; DTE Energy, 2013; Duke Energy, 2013; Hawaii Electric Company, 2013; Los Angeles Department of Water and Power, 2013. This list was developed by PECO and ICF based on broad outreach efforts to utilities, an assessment of pilot programs, and the potential applicability of projects to the southeastern Pennsylvania region. Other utilities around the country provide TOU rates specific to EVs, EVSE purchase and installation incentives, and even EV purchase incentives. For more information, see the AFDC Laws & Incentives Database.

Like their counterparts across the country, Pennsylvania utilities have begun to plan for EV deployment. The following sections provide context on the electricity market in Pennsylvania, introduce PECO, describe PECO's support of EV deployment in the region, review existing research on the potential grid impacts of EV deployment, and discuss PECO's plan to minimize grid impacts from EV charging in the region.

10.1 Pennsylvania Electricity Market and PECO

Pennsylvania's electricity market is one of the most mature deregulated retail electricity markets in the United States. Because Pennsylvania is a deregulated state, third-party electricity generation suppliers (EGSs) can competitively price electricity and use the PECO transmission and distribution systems. Competitive retail electric suppliers serve approximately 50 percent of the electric load in Pennsylvania. These suppliers interface directly with retail customers. In southeastern Pennsylvania, PECO, a subsidiary of Exelon Corporation (Exelon), provides default service to the remainder (i.e., customers who have not chosen a competitive retail

electric supplier) with power purchased from wholesale suppliers through competitive procurements.

PECO provides electric distribution service in southeastern Pennsylvania, including the City of Philadelphia, as well as Bucks, Chester, Delaware, and Montgomery counties. It manages 500 power substations and 29,000 miles of distribution and transmission lines, and serves approximately 1.6 million electric customers. Approximately 90 percent of PECO's customers are residential.³²⁷ PECO's load distribution is approximately 33 percent residential, 22 percent small commercial and industrial, and 45 percent large commercial and industrial.

10.2 PECO's Involvement in EV Deployment in Southeastern Pennsylvania

PECO has partnered with DVRPC to support the deployment of EVs and EVSE in the region. The utility has launched a comprehensive corporate initiative to ensure that its business processes and regulatory policies and programs support customer adoption of EVs in southeastern Pennsylvania. PECO's executive team engages directly with local government leaders on a broad array of issues and has directed the utility's alternative vehicle strategy team to engage with these leaders to identify opportunities to support EV deployment in the region. At the executive team's request, PECO formed a multidisciplinary team in 2009 to look specifically at the potential system impacts and issues that could arise from adoption of EVs in its territory. The team includes representatives of the company's Operations, Fleet, Rates and Regulatory Affairs, Economic Development, Marketing, Communications, and Governmental and External Affairs departments. The team provides quarterly briefings to PECO's CEO and executive leadership teams, including updates on consumer EV adoption, usage patterns, PECO pilot programs, external partnership activities, and presentations by outside experts. Throughout the development of the DRVPC *Ready to Roll!* report, PECO has provided data and feedback to project partners and engaged with national, state, and local governments and organizations to advance early adoption of EVSE and EVs in southeastern Pennsylvania.

In addition to these EV deployment initiatives, PECO has taken steps to understand consumer electricity usage patterns and load management options as they relate to EV deployment. As part of its advanced grid investments program included in its DOE Smart Grid Investment Grant (SGIG), PECO has:

- Installed disturbance monitoring equipment at all 31 substations;
- Completed the intelligent substation project in November 2012 and modified 10 intelligent substations;
- Completed installation of 368 miles of fiber optic cable and 168 SONET Multiplexors required for critical communications infrastructure;
- Completed installation of the full scope of 100 reclosers on the distribution automation project;

³²⁷ PECO, "About Us," accessed June 2013, <https://www.peco.com/AboutUs/WhoWeAre/Pages/default.aspx>.

- Completed the Tier 2 wireless backhaul, including 18 Tier II microwave paths, 24 base station radios, and 123 subscriber radios;
- Deployed the Advanced Metering Infrastructure (AMI) Geographic Information System (GIS) Interfaces with Phase 1 delivery completion in December 2012; and
- Completed AMI Connectivity and IP Enablement projects (included migration of 519 circuits and router installations) in December 2012.

The following sections describe research conducted by PECO and other entities regarding potential grid impacts from EV deployment. They also discuss PECO's plans to minimize grid impacts, including infrastructure upgrades, dynamic pricing, and smart grid deployment.

10.3 Research on Grid Impacts from EV Deployment

A variety of studies have evaluated the impact of EV deployment on regional electric grids. This section summarizes these grid impact studies, reviews the market penetration assumptions that were used, and synthesizes the grid impact results.

10.3.1 Grid Impact Studies

Analyses conducted by EPRI, Exelon, PECO, and DVRPC have addressed potential impacts on electric grids, in general and on their respective regional systems.

EPRI Study³²⁸

The largest electric utility in Illinois, Commonwealth Edison (ComEd), commissioned EPRI to study the potential impact of EV deployment on two of its circuits: Highland Park and Oak Park. EPRI used data from the 2001 National Household Travel Survey to conduct three types of analyses (asset-level deterministic, system-level deterministic, and stochastic). EPRI estimated ComEd's available asset capacity; predicted the system response to EV charging; and evaluated the impacts of EV loading, factoring in where and when EVs are expected to charge. Focusing on currently available EV technologies and residential customers, EPRI analyzed impacts like thermal overload, low voltage, losses, and voltage imbalances in the near term (i.e., one to five years). It did not reference a specific time period to allow interpretation of the results even as market conditions change.

Exelon Study³²⁹

Exelon is the parent company of both ComEd and PECO. Exelon assessed the current status of EV technology, including its stage of commercialization, economics, and consumer view. It also forecast EV market penetration through 2020 and identified key policy drivers and hurdles for EV adoption. Although the Exelon study did not focus on electric grid impacts, it did estimate the load growth effects of various levels of EV deployment in the United States and, more specifically, in the ComEd and PECO service territories. Exelon included both PHEVs and AEVs in its forecasts.

³²⁸ EPRI, "Commonwealth Edison PEV Distribution Impact Study," August 2010.

³²⁹ Exelon, "Exelon Technology Council: Grid-Enabled Vehicles," January 2011.

PECO Study³³⁰

PECO interpreted the results of the EPRI and Exelon studies, taking into account the unique characteristics of electric infrastructure in Philadelphia and surrounding areas to analyze its capacity to support EV adoption and to identify potential grid impacts in its service territory. It considered potential grid impacts like circuit and equipment overloads, low voltage, losses, and voltage imbalances. It also proposed solutions to address these issues in its service area. PECO's analysis focused on residential customer charging with Level 2 chargers (240V, 15 or 30A) during peak hours. Like the EPRI study, it considered only currently available EV technologies.

DVRPC Study of the Impact of EV Development on the Electric Grid

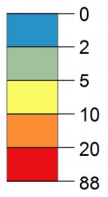
DVRPC identified areas of potential grid impact in southeastern Pennsylvania. DVRPC evaluated the EV purchasing potential for 2,979 census block groups in southeastern Pennsylvania, based on income data from the 2006 to 2010 ACS and vehicle ownership data, including ownership of AEVs, HEVs and PHEVs, from PennDOT. It produced maps that show the locations where EV owners are most likely to live. DVRPC staff also identified the areas with the highest potential for installation of public and workplace EVSE. These areas were identified using spatial data on employment, roadway and interchange volume, and major destinations. DVRPC developed maps to show these locations, along with locations of current or planned EV charging stations (see Section 5.3 for additional detail on these analyses).

Through internal modeling and analysis and review of detailed locational modeling and adoption scenarios developed by DVRPC, PECO does not anticipate any systemic detrimental impacts to its distribution grid as a result of EV adoption and EVSE deployment. Figure 18 illustrates the projected number of EVs in 2020 using the geography used by PECO to evaluate its grid infrastructure. While isolated issues may arise in the future, PECO's successful efforts to establish a vehicle registration and tracking system and partner with OEMs, local auto dealers, and entities installing charging stations should assist PECO in managing EV adoption under reasonable projected adoption scenarios. Additionally, in response to forecast models developed as part of *Ready to Roll!* PECO will be prepared to continue to monitor potential EV clustering with a focus on areas in Center City Philadelphia, and older, first-ring suburbs where the potential for localized impacts is greatest.

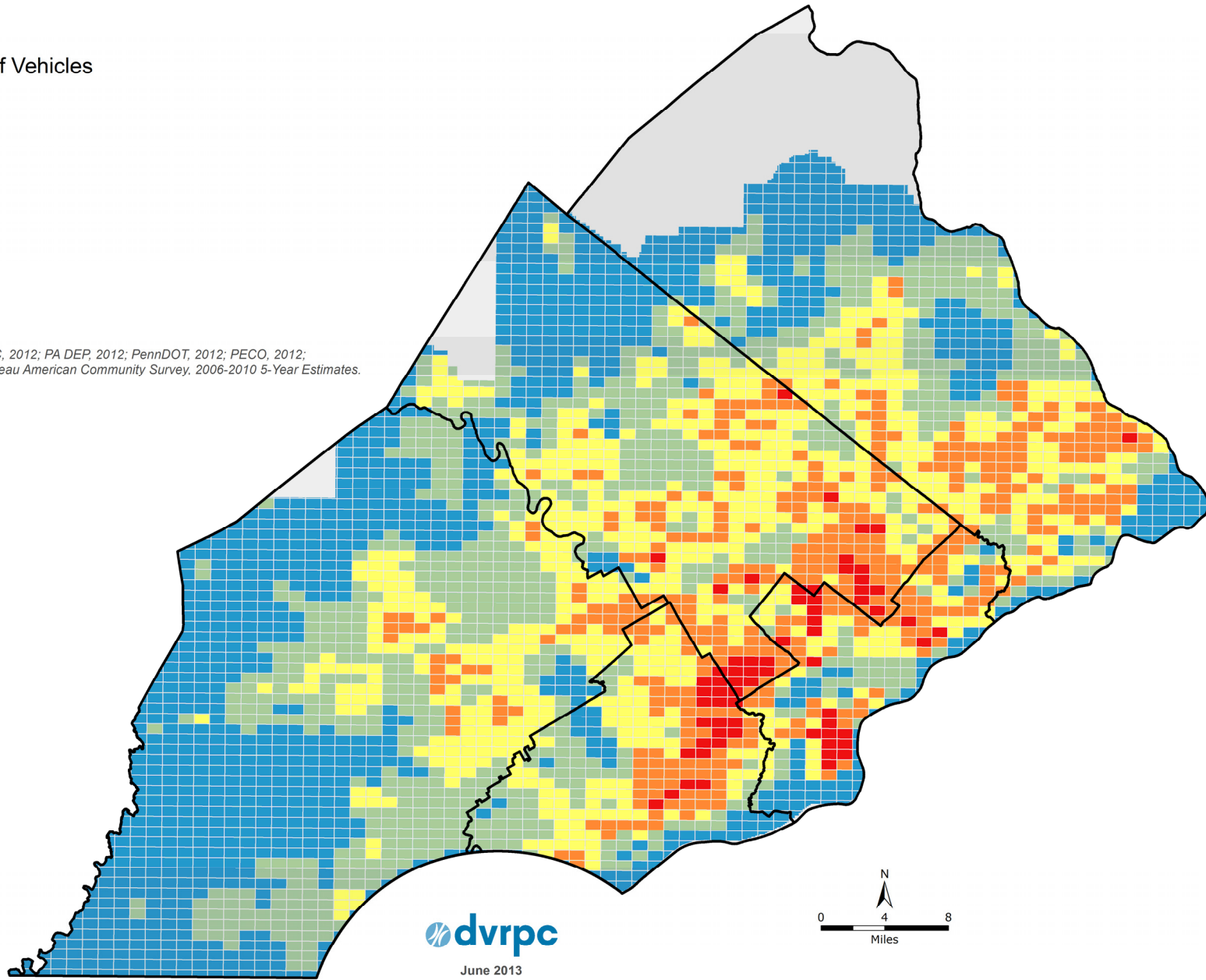
³³⁰ Kyle Copeland, "Electric Vehicle Impact at PECO," PECO, March 11, 2011.

Figure 18. Projected EVs by PECO Major Index Grid Areas

Number of Vehicles



Sources: DVRPC, 2012; PA DEP, 2012; PennDOT, 2012; PECO, 2012;
U.S. Census Bureau American Community Survey, 2006-2010 5-Year Estimates.



10.3.2 Market Penetration Assumptions

EPRI, Exelon, and PECO developed assumptions for future EV market penetration. Based on these rates, the studies estimated the impact of EV deployment on the electric grid.

EPRI estimated that EVs would reach a low to medium (two to four percent) market penetration rate. It also considered impacts under high penetration levels (20 to 30 percent), although these were not considered realistic scenarios. EPRI did not provide a specific timeframe for its estimates.

Exelon assumed that the adoption rate for EVs would be similar to the adoption rate for HEVs in the past. Thus, Exelon forecast that 150,000 to 800,000 EVs would be on U.S. roads by 2015, increasing to 1.25 to 5 million by 2020. This represents up to three percent and 10 percent of new vehicle sales in 2015 and 2020, respectively. Exelon estimated that the corresponding EV market penetration rate would be low (0.5 to two percent) by 2020.

Based on Exelon's analysis, PECO assumed that EVs would account for two percent of vehicles owned by 2020; PECO does not expect high market penetration rates in its service territory.

The three studies align in terms of their assumptions about the future EV market penetration rate. All three forecast a low market penetration rate of around two percent. EPRI proposed a potential medium market penetration rate of four percent. All three studies agreed that the 20 to 30 percent market penetration rate was high and unrealistic.

10.3.3 EV Grid Impacts Results

The EPRI, Exelon, and PECO studies analyzed the potential grid impacts due to EV deployment at various penetration levels; they considered peak demand increase, load growth, thermal overload, low voltage, losses, voltage imbalances, and shortened transformer life expectancy. Table 28 presents the results, which are described in more detail below.

Table 28. Results from Existing EV Grid Impact Studies

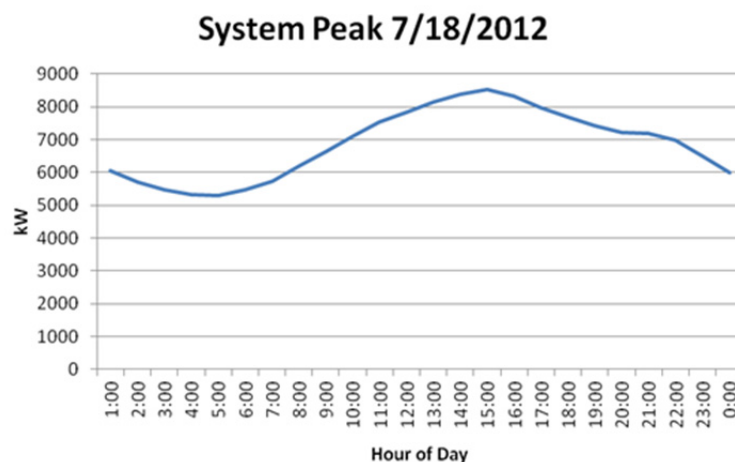
	EPRI	Exelon	PECO
Peak Demand Increase	0.5-0.8%	-	-
Load Growth	-	0.5% (US); 0.78% (ComEd service territory); 0.73% (PECO service territory)	0.73%
Thermal Overload	Largest effect on service transformers; minimal effect on substation transformers and feeder conductors; minimal effect on circuit	-	Small risk of equipment overload due to EV clustering, especially in Philadelphia; minimal effect on circuit, unless already in need of load relief
Low Voltage	Largest effect on secondary terminals of service transformers with Level 2 charging during peak hours; minimal effects with Level 1 charging	-	Largest effect on secondary terminals of service transformers with Level 2 charging during peak hours; minimal effects with Level 1 charging
Losses	Negligible impacts	-	Negligible impacts
Voltage Imbalances	Negligible impacts	-	Negligible impacts
Shortened Transformer Life Expectancy	Decrease in transformer life expectancy associated with thermal overload	-	-

Source: EPRI, 2010; Exelon, 2011; PECO, 2011.

Peak Demand Increase

Demand refers to the rate of electricity use (usually expressed in kW), or the amount of electricity consumption in a given amount of time. Peak demand in the PECO territory occurs around 3 p.m. in summer, as shown in Figure 19.

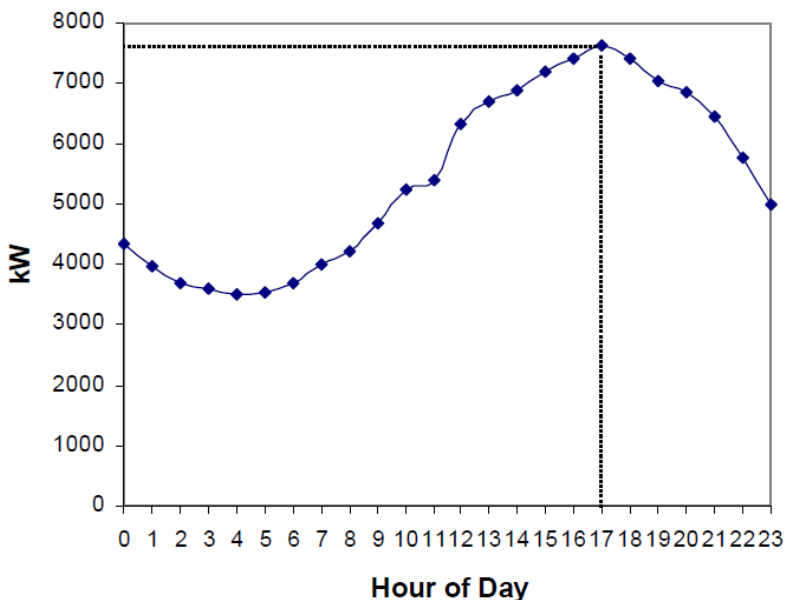
Figure 19. PECO Summer Peak Load Profile



Source: PECO Energy, 2013.

According to EPRI's analysis, peak demand for the ComEd circuits occurs at 5 p.m. in summer, as presented in Figure 20.

Figure 20. Peak Day Load for the Oak Park Circuit

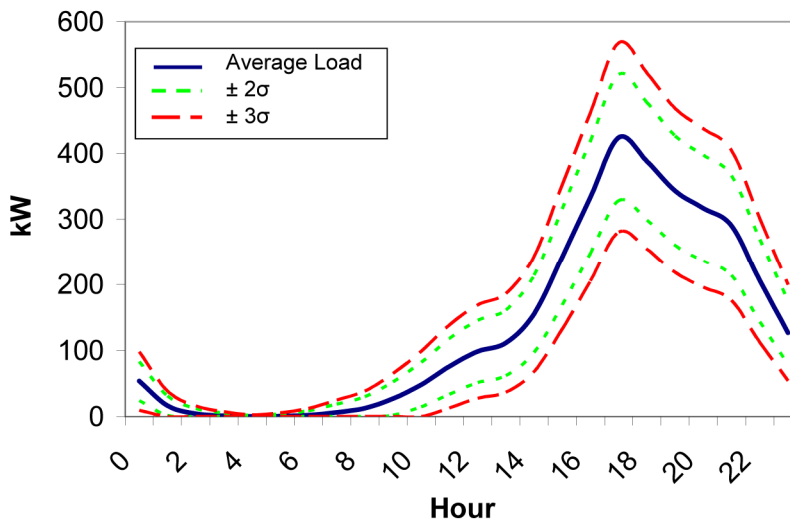


Source: EPRI, 2010.

EPRI evaluated the increase in electricity demand associated with EV charging at different EV market penetration levels. Its analysis factored in variables like state of battery charge, home arrival time, and EV location. At two percent penetration, peak demand increased by 0.5 percent and 0.8 percent on the Highland Park and Oak Park circuits, respectively. At high (30 percent) penetration, peak demand increased by 7.5 to 12.0 percent. Figure 21 presents EPRI's demand analysis for ComEd's Highland Park circuit under the high (30 percent) penetration scenario. The chart shows how much additional load is expected at each time of day due to EV charging,

with the blue line representing the average increase. According to this figure, the greatest increase in demand due to EV charging is expected around 5 p.m.

Figure 21. Additional Hourly Demand at Highland Park Substation Transformer



Source: EPRI, 2010.

Load Growth

Electric load refers to the overall amount of electricity consumption (in kWh). Exelon estimated that, at a two percent EV market penetration rate, electric consumption in the United States would increase by 0.5 percent by 2020. Exelon’s study also estimated the load growth in the ComEd and PECO service territories. It determined that, at two percent penetration, electric consumption in the ComEd and PECO service territories would increase by 0.78 percent and 0.73 percent, respectively. Based on the Exelon estimates, PECO estimated that, at 0.5 to two percent market penetration, its regional electric load might increase by 0.19 to 0.73 percent by 2020 as a result of EV deployment.

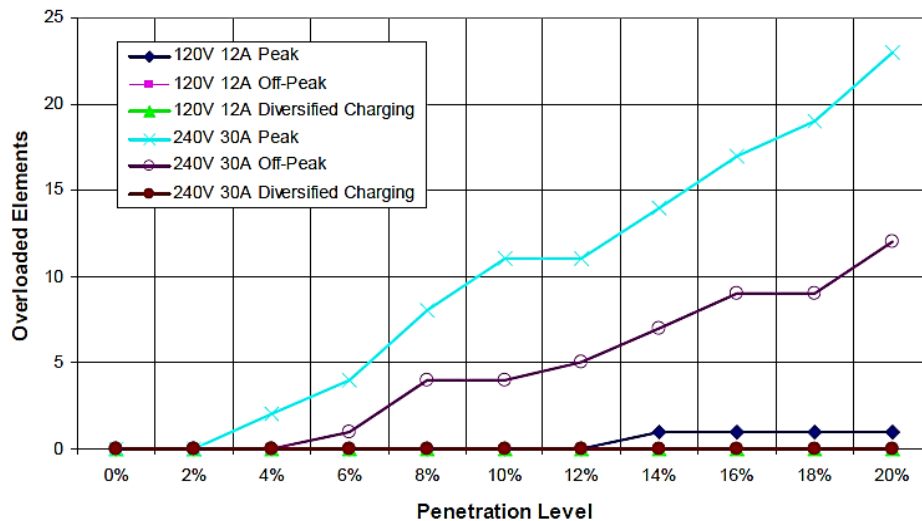
Thermal Overload

Thermal overload is a technical issue that can result from peak demand increase and load growth. Thermal overload refers to situations when circuit lines or equipment overheat because they exceed their capacity (i.e., do more work than they were designed to do).

EPRI identified the potential for some negative impacts related to thermal overload. EPRI identified circuit loading as an issue at higher penetration levels. In addition to circuit loading, EPRI noted some potential for equipment overload, particularly at service transformers. Figure 22 below illustrates the potential for thermal overload at service transformers as a result of different types of EV charging at various penetration levels. At low to medium penetration levels, Level 2 charging during peak hours resulted in equipment overload. At higher penetration levels, Level 2 charging during peak and off-peak hours resulted in significant equipment overload and Level 1 charging during peak hours resulted in minor equipment overload. However, diversified charging and Level 1 charging during off-peak hours did not cause equipment overload, even

with high penetration. Moreover, EPRI determined that there would be negligible impacts related to thermal overload on substation transformers and feeder conductors.

Figure 22. Highland Park Circuit Service Transformers Experiencing Overload



Source: EPRI, 2010.

PECO does not expect additional electricity demand from EVs to overload its system. During a typical year, PECO's load grows approximately one percent.³³¹ Thus, the estimated load growth of 0.73 percent by 2020 will likely have a minimal impact on its system.

With respect to individual pieces of equipment (e.g., service transformers), PECO noted some factors that could increase the likelihood of overload. For example, EV clustering can increase the chance of equipment overload. EV clusters occur when more than one vehicle is connected to the grid in a concentrated area. EPRI noted that the closer a circuit component is to its load, the more susceptible it will be to EV clustering. Although clustering can happen at a two percent penetration level, it is more likely at larger penetration rates.

PECO does not anticipate high risk of equipment overload in its service territory for several reasons. First, PECO will soon replace the smaller transformers in the areas surrounding the city because they were installed over 40 years ago and are nearing the end of life. Also, because of demographic characteristics and lack of available dedicated parking, PECO does not expect a high volume of early EV adopters in the City of Philadelphia and its older, first-ring suburban areas. Early EV adopters are more likely to live in suburban neighborhoods, which generally have greater transformer capacity per customer. Furthermore, most underground facilities for residential developments built since 1970 were sized for air conditioning load and have larger transformers. Thus, PECO does not consider equipment overload due to EV charging will present a significant concern in its service territory.

³³¹ This growth is before the required Act 129 energy reductions and any significant co-generation. If the energy reduction efforts were not occurring, EV impacts at the circuit level would still be minimal. A circuit would have to be on the edge of requiring a load relief project for the small increase in load due to EVs to move any project forward, even for a year.

However, PECO has determined that proximity to the City of Philadelphia could increase the likelihood of equipment overload due to EV charging. Transformers in the city and surrounding areas have less available capacity per customer. The forecast models developed as part of *Ready to Roll!* indicate that PECO should continue to monitor potential EV clustering with a focus on areas in Center City Philadelphia and older, first-ring suburbs, where the potential for localized impacts is greatest.

Low Voltage

According to EPRI's analysis, low voltage also presented a potential issue when EV drivers charged their vehicles with Level 2 EVSE during peak hours. Low voltage primarily occurred at secondary terminals of service transformers.

PECO applied EPRI's findings to evaluate the potential for low voltage issues in its service territory. PECO reported that customers who are already near the lower tariff limit could experience low voltage during EV charging. Level 1 charging does not cause a low voltage concern.

Circuit Losses and Voltage Imbalances

EPRI estimated a slight increase in system losses as EV penetration increased, mostly during peak hours with Level 2 charging, but considered the impacts to be minor. Similarly, the maximum voltage imbalance increased only slightly under the high penetration scenario. Thus, EPRI concluded that circuit losses and voltage imbalances would be negligibly affected by EV deployment. Based on the results of the EPRI study, PECO also expects that impacts on losses and voltage imbalance will be negligible.

Shortened Transformer Life Expectancy

Because transformers age depending on their load, EPRI concluded that thermal overload decreases transformer life expectancy. EPRI noted that the type of EV and the number of EVs can affect the increase in load and the resulting decrease in transformer life expectancy.

10.4 Plans to Minimize Grid Impacts from EV Deployment

EPRI and PECO presented options to minimize thermal overload and low voltage impacts resulting from EV charging. EPRI noted that, for an asset to become less susceptible to overload, the available capacity must increase and/or the number of customers must decrease. Along those lines, PECO identified solutions that would either increase capacity or reduce the demand at any given time. In this section, we discuss options to minimize grid impacts from EV charging in southeastern Pennsylvania and describe PECO's current or planned initiatives.

10.4.1 Infrastructure Upgrades and Installations

PECO suggested that, depending on the location of a problem, it could upgrade an existing transformer with the next largest size or install an additional transformer to add capacity. For equipment located along the street, both an upgrade and a new installation could be completed with relative ease. Even upgrading an underground transformer could be completed in a reasonably short amount of time.

PECO acknowledged that upgrades and installations to certain types of facilities could be more challenging. Facilities located in rear property or underground require more complicated fixes. These facilities can be difficult to access because of homeowners' fences, sheds, and trees. In addition, cables might need to be rerouted. These jobs can require detailed evaluations, design, and civil excavations. PECO also identified row houses in Philadelphia as a unique challenge because large transformers (167 kilovolt-amperes) sometimes feed houses along several blocks. Correcting overloads or low voltage in these areas could require new equipment, which can be costly, and finding an existing pole, or space to install a new pole, can be challenging. PECO expects that upgrading facilities in the heavy underground districts of the city would be the most costly because expanding capacity into these areas can require installing a manhole, ducts, switch module, new transformer, and underground secondary conductors. Because these areas generally lack dedicated, off-street parking and are less likely to experience significant early EV deployment, PECO anticipates limited impact, with the possible exception of parking garages in the Center City central business district.

10.4.2 Charging Time Incentives

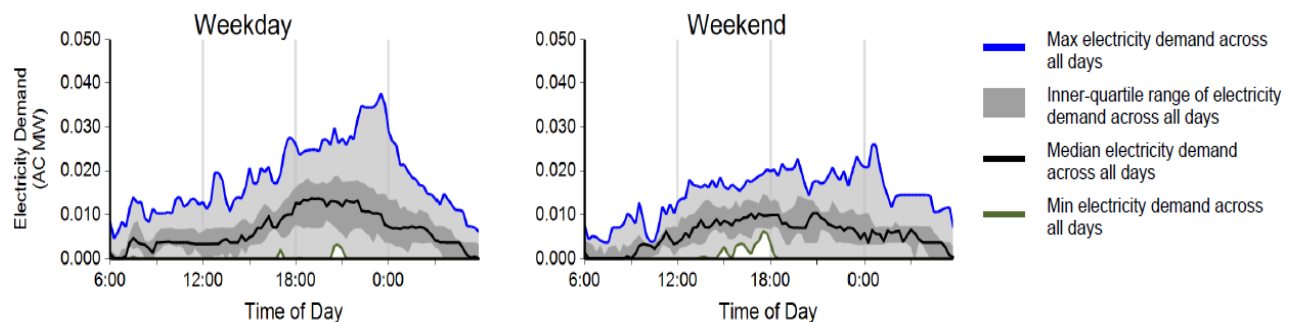
As mentioned above, to minimize the thermal overload and low voltage impacts of EVs, utilities can use charging time incentives, such as TOU tariffs or dynamic pricing, to encourage customers to shift EV charging to periods of low demand. Some utilities use TOU tariff structures that charge higher rates during peak hours and lower rates during off-peak hours.³³² While both TOU tariff structures and dynamic pricing rates can incentivize consumers to shift consumption to periods of lower demand, dynamic pricing differs from conventional TOU rates in that the price of electricity is determined in real-time based on actual market conditions, as opposed to being set at predetermined rates.

Benefits of Charging Time Incentives

Currently, electricity demand due to EV charging in the Philadelphia area peaks around midnight on weekdays and weekends, as shown in Figure 23, minimizing any potential impact to normal peak demand, which as shown in previous sections, occurs normally around 3 p.m.

³³² Charles Zhu and Nick Nigro, "Plug-in Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review," 12.

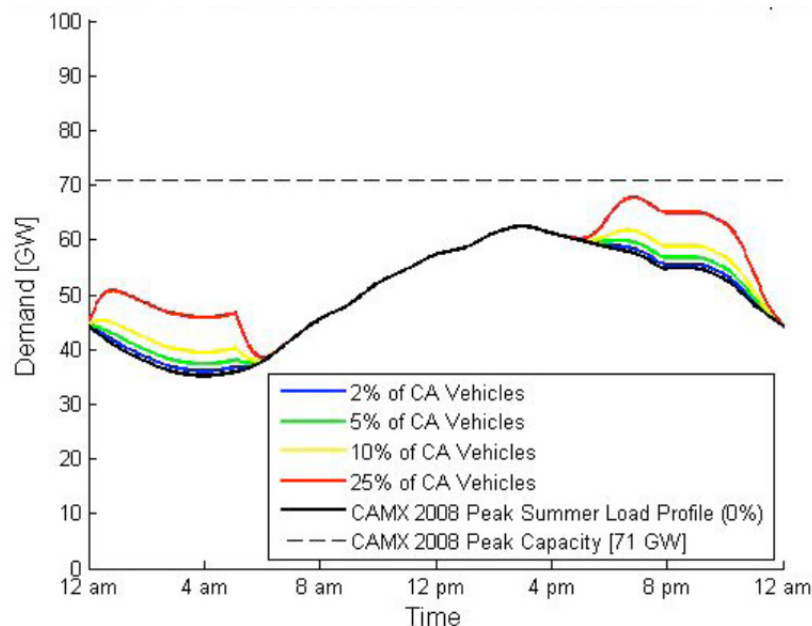
Figure 23. ECotality Data: Electricity Demand due to EV Charging in Philadelphia



Source: : ECotality, "Q4 2012 Report: The EV Project," accessed June 2013, <http://www.theevproject.com/downloads/documents/Q4%202012%20EVP%20Report.pdf>.

Both the EPRI and PECO analyses indicated that EV charging during off-peak hours would not cause overload or low voltage concerns. Thus, creating an incentive to maintain charging during off-peak hours could eliminate the need for any equipment upgrades or installations. As an additional benefit, EV charging during off-peak hours could help fill in the "valleys" of the circuit load profile, as demonstrated in Figure 24.

Figure 24. Summer Peak Load Profile for California

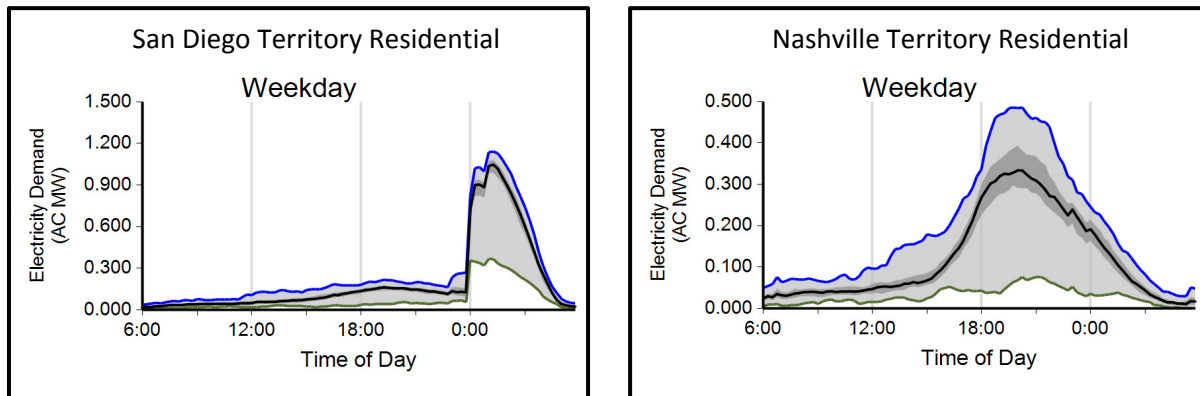


Source: DeForest, N., et al. "Impact of Widespread Electric Vehicle Adoption on the Electrical Utility Business – Threats and Opportunities." Center for Entrepreneurship & Technology, UC Berkeley, 2009.

Data from The EV Project indicate that charging time incentives are effective in influencing EV owners to shift their charging patterns to off-peak hours. Figure 25 shows the electricity demand of EV owners in San Diego, where there is a TOU rate, compared to Nashville, where there is no TOU rate. Figure 25 shows that EV owners in San Diego waited to charge their vehicles until off-peak hours to take advantage of the lower rate. Note that delaying charging does not require

delaying connecting the EV to the EVSE—all commercial EVs are able to be programmed to delay charging until a time specified by the owner.

Figure 25. ECOTality Data: 2012 Quarter 4 Weekday Residential Charging Demand in San Diego and Nashville



Source: ECOTality, 2013.

In addition to improving grid reliability, charging time incentives could save utilities money by leveling the demand profile and avoiding the need to purchase supplemental electricity at high rates from third-party providers during demand spikes.

Furthermore, charging time incentives, such as dynamic pricing, could enable certain consumers to reduce electricity costs, as described in the following exercise. In 2012, PECO's default service residential rate, including the customer charge, generation charge, transmission charge, and variable distribution charge, averaged about \$0.17 per kWh. Applying the 2012 rate to demand curves generated by The EV Project³³³ indicates that the average EV driver will spend approximately \$575 per year to charge an EV, using a default service residential rate. In comparison, PECO's dynamic pricing rate (described later in this section) would result in an estimated bill of \$300 per year for EV charging, saving EV drivers almost \$300. EV customers with AMI meters ("smart meters") may want to select a dynamic pricing rate to benefit from the cost savings (if their lifestyles do not require them to use a significant amount of energy during the peak periods, which could negate the benefit of the off-peak rates).

Development of Charging Time Incentives

Utilities have just begun developing demand management strategies involving charging-time incentives. As utilities gain experience with these strategies, additional tariff structures and pricing plans will evolve. Table 29 presents some of the time-variant structures that currently exist. PECO and ICF also conducted broad outreach to utilities on existing pilot programs with charging-time incentives. Utilities around the country have implemented pilot programs to test and assess special EV charging rates. Table 30 presents a sample list of these programs.

³³³ Demand curves provided to ICF were based on charging times in the San Francisco Bay area.

Table 29. Summary of Time-variant Utility Rate Structures

Types of Time-Variant Structures	Description	Advantages	Disadvantages
Whole-house Time-of-Use	Same rates Electricity for EVs has same price as electricity for the entire house.	Avoids establishing any rate structure precedent that customers could come to expect, especially if the rate structure has unknown and potentially damaging effects; does not require installation of second meter.	Does not encourage EV electricity use in off-peak periods as much as high differential rates do.
	EV high differential rates Electricity for EVs and for the entire house has same whole-house EV-only rate for EV adopters – usually a high differential price with especially high peak rate and low off-peak rate.	Simple and cheap for utility and customer to operate if impacts on the electrical grid will be negligible; does not require installation of second meter.	Widespread adoption creates a new peak at lower rate; necessary peak electricity use (e.g., for cooking stoves and ovens) becomes expensive.
Fixed fee/fixed fee off-peak	EV owners pay a flat fee per month for access to unlimited charging. One potential hybrid model is to charge a flat fee only for off-peak charging.	Simple to use; does not necessarily require an additional meter.	Does not discourage EV use in on-peak periods.
Two-meter house with high-differential pricing	Off-peak rates are especially low, while peak rates are especially high.	Encourages off-peak charging and helps grid stability.	Must install a second meter, which may be expensive.
Sub-metering off EV charging circuit with high-differential pricing	Same as two-meter house structure, except the EV charging circuit is submetered and simply subtracted from main meter use.	Appropriate for MUDs; cheaper for utilities; allows for differential pricing.	Master meters are owned and maintained by utility, but submeters are owned and operated by user – less incentive to install submeter from leased buildings.
Demand response (can be combined with options above)	Utility enters contract with user to control power flow to EV; during high demand period, power is diverted.	Especially useful for local grids that may be near 100% capacity.	Can inconvenience EV drivers if battery is not charged when needed.

Source: Charles Zhu and Nick Nigro, "Plug-in Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review," 67.

Table 30. Utility Pilot Programs with Special EV Rates

Utility/Location	Pilot Program Name	Incentive Type	EVSE Included	EV Rate
Consumers Energy - Michigan	EV Incentive Program	Rebate up to \$2,500 for purchase and installation of Level 2 EVSE; limited to first 2,500 participants	No	Option 1 - no additional meter - combines EV and household usage; Option 2 - requires second meter - TOU rate; Option 3 - requires second meter - Flat rate for EV only (based on usage up to 300 kWh per month) and limited to 250 participants
Dominion - Virginia	EV Rates Pilot	EV-specific pricing rates; each rate plan limited to first 750 participants	No	EV Pricing Plan requires installation of second meter to be supplied by Dominion; Off-peak eight-hour window; in EV + Home Pricing Plan meter is replaced by interval meter which allows Dominion to read in 30 second increments
DTE Energy - Michigan	Plug-in Ready Option 1	Rebate up to \$2,500 for installation of a separately metered Level 2 EVSE; limited to first 2,500 customers participants	Level 2 EVSE provided and installed by SPX; DTE installs second meter	D1.9 (EV TOU Rate); \$40 Monthly Flat Rate available to the first 250 customers
Hawaiian Electric Company - Hawaii	EV Pilot Rates	Participants receive new TOU meters free of charge; limited to first 1,000 participants on Oahu, first 300 in Maui, and first 300 on the Island of Hawaii	No; load control and load monitoring devices will be installed free of charge	Customers enrolling on the TOU-EV or Schedule EV-R rates will have a new meter installed exclusive for EV charging. The rate EV-R customer's existing load will remain on the existing meter and account
Los Angeles Department of Water and Power - California	Charge Up LA!	Rebate up to \$2,000 for purchase and installation of Level 2 EVSE; limited to first 1,000 participants	No	EV TOU rate available and requires separate meter; EV discount of 2.5 cents per kWh during off-peak, nighttime hours, and on weekends

Source: Consumers Energy, 2013; Dominion, 2013; DTE Energy, 2013; Hawaiian Electric Company, 2013; Los Angeles Department of Water and Power, 2013.

Charging Time Incentives in Southeastern Pennsylvania

PECO has four primary types of tariffs: Rate R for Residential Service, Rate GS for General Service, Rate PD for Primary-Distribution Power, and Rate HT for High Tension Power. The rates most applicable to EVs are Rate R and Rate GS.

As a regulated utility, PECO must have all of its rates approved on a regular basis by PA PUC. In 2011, PA PUC ordered PECO to phase out its discounted heating rates, referred to as RH, and its off-peak heating rate for water heaters by the end of 2012.

In September 2012, PA PUC approved PECO's dynamic pricing plan as part of the new AMI program. PECO plans to make the Dynamic Pricing Plan available to a limited number of residential customers with new AMI meters installed at their homes. A third-party EGS (proposed to be Reliant Energy Northeast LLC) will provide the commodity and will offer a reduced TOU rate on PECO's behalf. PECO chose to work with a third-party EGS so that the plan could eventually lead to competitive off-peak rate offerings from the EGS community that will encourage off-peak EV charging.

10.4.3 EV-Smart Grid Integration

A smart grid is an electric grid that uses digital technology to collect data and act automatically to address grid performance issues. A smart grid monitors the supply and consumption of electricity with AMI metering. The key features of AMI metering are the ability to provide interval usage data (typically in increments of one hour or less), transmit these data to customers through electronic communications interfaces, and communicate on a bidirectional basis with customers. The smart grid can use AMI data to take independent actions that improve grid performance and reduce costs. In addition to making automatic corrections, the smart grid conveys data back to customers and service providers who can analyze the information and change their behavior accordingly. Smart grid technology has potential to minimize grid impacts from EV charging.

Benefits of Smart Grid Deployment and EV-Smart Grid Integration

Smart grid technology can provide a variety of benefits. First, smart grid technology can make automatic corrections to protect grid integrity. For example, a smart grid might turn off an appliance when demand is high to prevent an overload. In the context of EVs, a smart grid might stop charging an EV when demand is high or use the stored energy in the vehicle battery to prevent an overload to the system, using V2G technology.

V2G technology (also discussed in Section 2) is a smart grid technology that enables an EV to provide services to the electric grid, including load leveling, quick-response energy supply, and energy storage. V2G technology can automatically slow charging during periods of high demand (unidirectional power flow) or store electricity and supply it back to the grid during periods of high demand (bidirectional power flow). Use of V2G technologies could minimize grid impacts from EV charging. It could also save utilities money by avoiding the need to purchase

supplemental electricity at high rates from third-party providers during demand spikes; the estimated value to utilities is up to \$4,000 per year per vehicle.³³⁴ Finally, the potential to store energy in EVs could also allow electric utilities to use more renewable energy, which is generally produced intermittently rather than simultaneously with demand. Utilities might consider installing and using smart grid technologies, taking advantage of opportunities to gather granular data on EVSE and vehicle usage patterns, and integrate with future V2G technology opportunities.

Second, AMI data can help utilities and consumers better manage electricity consumption. Utilities can use real-time AMI data to implement dynamic pricing to encourage customers to shift consumption to periods of low demand. Likewise, customers can use AMI data to assess when they use electricity and how to shift their use patterns to take advantage of lower rates and more reliable service. For example, AMI data could help utilities and customers identify alternative times for EV charging. Coupled with charging time incentives, like favorable off-peak electricity rates, information from the smart grid could help EV owners decide when to charge to avoid impacts like thermal overload or low voltage (and high electricity bills). Shifting consumption to off-peak hours can improve utility asset utilization, minimize grid disturbances, and reduce costs.

Third, utilities can use AMI data to track EV charging locations, anticipate potential grid issues, like overloads or low voltage, and target vulnerable areas for infrastructure upgrades. PECO discussed smart grid technology as an option to mitigate grid impacts associated with EV deployment. PECO could establish a Transformer Load Management program, which would use AMI data to identify overloaded transformers. This would allow PECO to prevent overload issues by upgrading the equipment or installing new equipment.

Barriers to Smart Grid Deployment and EV-Smart Grid Integration

Two current barriers to smart grid deployment include the initial capital expenditures and risks associated with cyber security. However, federal programs have helped some utilities overcome the costs of smart grid deployment and begin to address cyber security risks. For example, PECO has developed a plan to protect against cyber threats.³³⁵

For V2G technology specifically, PECO has identified several barriers to deployment:

- Commercially available vehicles are not equipped with V2G capability, and vehicle manufacturers do not appear to consider this technology a priority, given existing challenges of cost, range, and battery life;
- Given the substantial cost of EV batteries, vehicle owners may be reluctant to potentially

³³⁴ John Addison, "Will Google Charge Your Electric Car?" Clean Fleet Report, accessed June 2013, <http://www.cleanfleetreport.com/google-energy-v2g/>; Messenger, "V2G Generates Electricity and Cash," accessed June 2013, <http://www.udel.edu/PR/Messenger/07/01/V2G.html>.

³³⁵ DOE, "Smart Grid Investment Grant Program: Progress Report," accessed June 2013, <http://energy.gov/sites/prod/files/Smart%20Grid%20Investment%20Grant%20Program%20-%20Progress%20Report%20July%202012.pdf>.

degrade their batteries or shorten their useful lives by exercising V2G options;

- PECO's distribution infrastructure is not currently configured to support power flows from vehicles into the distribution grid; and
- Available studies on EV charging patterns indicate that there may be significant overlap between utility peak system usage periods and EV charging needs.

Technology and rate structures may mitigate these concerns in the future, and PECO will continue to monitor developments in the V2G technology field.

EV-Smart Grid Integration Technology is currently under development despite the absence of V2G capable vehicles in the United States.³³⁶ However, as of 2011, Mitsubishi was considering putting a V2G system on a crossover PHEV to be sold on the American market, depending on consumer interest. Nissan was investigating the marketability and feasibility of introducing V2G technology in North America.³³⁷

Moreover, EV and EVSE manufacturers, utilities, academic institutions, and other interested entities have partnered to evaluate vehicle storage and communication capabilities and to implement V2G demonstration projects.

- In Detroit, a nonprofit corporation, NextEnergy, has partnered with Chrysler, A123 Systems, and REV Technologies to develop EVSE that will let EVs return power to the grid. The V2G technology will be based on a microgrid technology developed by NextEnergy for the U.S. Department of Defense, which is interested in V2G technology for its potential to store and supply energy for military bases.³³⁸
- ECOTALITY has demonstrated V2G technology and studied the impact of V2G activity on EV batteries.³³⁹
- The National Renewable Energy Laboratory has demonstrated V2G capabilities, using a bidirectional battery converter developed by Ideal Power Converters.³⁴⁰
- The University of Delaware (UD) has also been active in developing V2G technology. In a 2010 presentation, UD's Dr. Willett Kempton presented a V2G demonstration project, which involved creating, permitting, and testing a grid-integrated vehicle. He reported that UD has signed a license for its vehicle smart link equipment.³⁴¹ UD began a joint V2G development and demonstration project called eV2g with NRG Energy, an electricity

³³⁶ Idaho National Laboratory (INL), "Vehicle-to-Grid (V2G) Power Flow," accessed June 2013, <http://avt.inel.gov/pdf/evse/V2GPowerFlowRpt.pdf>.

³³⁷ Jim Motavalli, "In a Blackout, Nissan, Mitsubishi and Toyota EVs Could Function as Generators," accessed June 2013, <http://wheels.blogs.nytimes.com/2011/09/01/in-a-blackout-nissan-mitsubishi-and-toyota-e-v-s-could-function-as-generators/>.

³³⁸ Sarah Schmid, "Detroit Leading U.S. Development of New Vehicle-to-Grid Technology," accessed June 2013, <http://www.xconomy.com/detroit/2012/09/25/whos-leading-u-s-development-of-vehicle-to-grid-technology-believe-it-or-not-detroit/>.

³³⁹ INL, "Vehicle-to-Grid (V2G) Power Flow."

³⁴⁰ Philippe Crowe, "Vehicle-To-Grid Possibilities Moves One Step Forward," accessed June 2013, <http://www.hybridcars.com/news/vehicle-grid-possibilities-moves-one-step-forward-54862.html>.

³⁴¹ Willett Kempton, "Vehicle to Grid Demonstration Project," accessed June 2013, <http://energy.gov/sites/prod/files/SG%202010%20Peer%20Review%20-%20Vehicle%20to%20Grid%20Demonstration%20-%20Willett%20Kempton.%20U.%20Delaware.pdf>.

company with operations in the northeastern United States, Texas, and California.³⁴²

- In early 2012, IBM, Honda, and Pacific Gas & Electric announced a joint pilot project to demonstrate EV-grid integration.³⁴³
- Internationally, Nuvve, a Danish company co-founded by UD's Dr. Willett Kempton, developed a server to connect EVs to the grid operator. As of October 2011, Nuvve was deploying V2G technology in a pilot of about 30 cars in Denmark.³⁴⁴
- In Japan, Mitsubishi Corporation, Mitsubishi Motors Corporation, and Mitsubishi Electric Corporation began a smart grid demonstration system that uses EV batteries for load leveling at its factory facilities.³⁴⁵
- The City of Hangzhou in China agreed to purchase 20,000 EVs with V2G capabilities for a pilot EV leasing program.³⁴⁶
- Nissan, Mitsubishi, and Toyota are planning to release vehicle with V2G capabilities to the Japanese market.³⁴⁷

Forecasts for V2G commercialization in the United States vary. In 2010, Federal Energy Regulatory Commission Chairman, Jon Wellinghoff, predicted that V2G technology would be available within three to five years.³⁴⁸ However, in 2012, Gary Gauthier, the director of business development for NextEnergy, estimated that V2G commercialization was at least five years away.³⁴⁹ UD's Dr. Kempton said that though utilities might be interested in buying small amounts of electricity from groups of EV vehicles beginning in 2012, commercialization could reach a larger multimegawatt scale in 2014 or 2015.³⁵⁰

Issues that will need to be addressed to deploy V2G technology include potential reduction in battery life associated with bidirectional power flow, customer questions about utility compensation and effects on EV charge levels, and development of policies and standards for V2G technology.³⁵¹ With respect to standards, the Pacific Northwest National Laboratory is working with the Society of Automobile Engineers to develop standards for V2G communication technology. Project partners include the EPRI, Argonne National Laboratory, and communication technology manufacturers Maxim, TI, and Ariane Controls.³⁵² V2G deployment

³⁴² Scott Fisher, "V2G Business Models," accessed June 2013,

http://www.pevcollaborative.org/sites/all/themes/pev/files/docs/Fisher_PEVC%20Collaborative%20V2G%20Panelv2_120411.pdf.

³⁴³ Nicholas Zart, "IBM, Honda and Pacific Gas and Electric Company Team Up For A Smart Grid," accessed June 2013,

<http://www.torquenews.com/1079/ibm-honda-and-pacific-gas-and-electric-company-team-smart-grid>.

³⁴⁴ Maria Gallucci, "Vehicle-to-Grid Charging for Electric Cars Gets Lift from Major U.S. Utility," accessed June 2013,

<http://insideclimatenews.org/news/20111012/vehicle-to-grid-v2g-technology-electric-vehicles-charging-nrg-energy?page=2>.

³⁴⁵ Mitsubishi Corporation, Mitsubishi Motors Corporation, and Mitsubishi Electric Corporation, "EV-Smart Grid Demonstration Project," accessed June 2013, <http://www.mitsubishicorp.com/jp/en/pr/archive/2012/html/0000014509.html>.

³⁴⁶ Tom Konrad, "Kandi Technologies Bags Largest Single Electric Vehicle Order Ever," accessed June 2013,

<http://www.forbes.com/sites/tomkonrad/2012/07/11/kandi-technologies-bags-largest-single-electric-vehicle-order-ever/>.

³⁴⁷ Jim Motavalli, "In a Blackout, Nissan, Mitsubishi and Toyota E.V.'s Could Function as Generators."

³⁴⁸ Martin LaMonica, "FERC chairman: Let EV owners sell juice to grid," accessed June 2013, http://news.cnet.com/8301-11128_3-20017160-54.html.

³⁴⁹ Sarah Schmid, "Detroit Leading U.S. Development of New Vehicle-to-Grid Technology."

³⁵⁰ Jim Motavalli, "In a Blackout, Nissan, Mitsubishi and Toyota E.V.'s Could Function as Generators."

³⁵¹ INL, "Vehicle-to-Grid (V2G) Power Flow."

³⁵² Pacific Northwest National Laboratory, "Vehicle to Grid Communication Standards Development Support," accessed June 2013, http://www1.eere.energy.gov/vehiclesandfuels/pdfs/merit_review_2012/veh_sys_sim/vss055_gowri_2012_p.pdf.

will require collaborative efforts by regulators, utilities, and EV, battery, and EVSE manufacturers, as well as demand from informed consumers.

Substantial work remains to identify communications and data storage requirements to achieve full interface of EVs with the smart grid. PECO will be working with AMI and EVSE technology developers to establish communications and data storage requirements that are compatible with its AMI technology, including V2G technologies.

EV-Smart Grid Integration in Southeastern Pennsylvania

PECO is implementing a \$200 million grant from the DOE SGIG program to deploy an automated metering and grid infrastructure upgrade (or smart grid) program. The project launched in 2010, with project activities expected to conclude in April 2014. At the end of 2012, PECO's SGIG project, "Smart Future Greater Philadelphia," was approximately 80 percent complete. Grant activities include:

- Working with DVRPC to analyze potential high impact EV demand corridors and evaluate the impact of implied electricity use on these areas' electricity generation, transmission, and distribution infrastructure, particularly with respect to the challenges and opportunities of integrating EVs into its smart grid planning program;
- Deploying 600,000 AMI meters with bidirectional communications capabilities and interval recording capabilities. PECO has filed with the Pennsylvania PUC to deploy AMI meters to the remainder of its customers (approximately 1.7 million in total) by the end of 2014;
- Testing the smart grid capabilities to effectively communicate with EV equipment to continually refine any future demand reduction programs through its AMI test center;
- Leasing two EVs to test performance, charging, and utility usage applications;
- Installing EVSE at its AMI technology testing center in Berwyn, Pennsylvania, its facility in Conshohocken, Pennsylvania, and the PECO Main Office Building in Center City Philadelphia to test communications and information technology infrastructure solutions to leverage the smart grid; and
- Offering a range of incentives to customers in the PECO service territory to encourage EV registration in the service territory and installation of advanced EVSE capable of reporting interval charging data. Additionally, PECO coordinated with The EV Project to offer enhanced incentives to governmental and nonprofit institutions to encourage installation of 20 EVSE throughout the service territory.

PECO's smart grid infrastructure includes a communications network and smart meters, among other components. PECO's communications network uses Flexnet infrastructure designed by

Sensus, PECO's lead contractor for the project.³⁵³ As of February 2013, PECO installed more than 363,000 of 600,000 smart meters.³⁵⁴

PECO's smart grid deployment program will establish the systems required for EV integration. PECO has plans to establish three EV charging stations at strategic locations throughout southeastern Pennsylvania, one of which will serve as an AMI test facility to enable PECO to develop and test strategies to integrate EVs with the smart grid. At its AMI test center, PECO will test the capability of the smart grid to communicate with EV equipment. As of July 2012, it had installed two AMI-compatible EV charging stations.³⁵⁵ PECO also collaborated with DVRPC to identify potential EV demand corridors for integration into its smart grid planning program. DVRPC delivered its preliminary census code block scale mapping of anticipated high-impact EV charging locations and corridors to PECO in the second quarter of 2012 (see Figure 18).³⁵⁶

10.5 Summary of Potential Grid Impacts and Plans to Accommodate EVs in Southeastern Pennsylvania

EV deployment represents an opportunity for load growth for PECO. The company's analysis determined that it has adequate system capacity to support all forecast EV adoption scenarios. At two percent penetration, system-wide issues are unlikely in southeastern Pennsylvania, but the potential for load pockets does exist. Potential challenges include circuit or equipment thermal overload and low voltage.

However, with proactive management and appropriate policy tools, PECO can minimize or eliminate negative effects on the electric distribution system, while adding to base electric consumption. For example, upgrading infrastructure and providing incentives to encourage EV charging during off-peak hours can help to prevent operational issues. In addition, EV-smart grid integration presents a range of opportunities to go beyond mitigating grid impacts to actually improving grid performance and providing financial benefits to utilities and their customers. EV-smart grid integration would allow utilities like PECO to track the location of EV charging and anticipate needs for new or upgraded infrastructure. It would also allow utilities like PECO to determine how best to structure charging time incentives, like dynamic pricing, based on AMI data. Furthermore, it would allow EV owners to dictate to their vehicles how and when to charge to achieve the most competitive electricity rates. Finally, it could pave the way to eventually allow EVs to contribute electricity back to the grid.

³⁵³ Andrew Maykuth, "PECO to resume smart-meter installations with new manufacturer," accessed June 2013, http://articles.philly.com/2012-10-11/news/34364508_1_sensus-meters-landis-gyr-ag-smart-meters.

³⁵⁴ PECO, email message to author, February 18, 2013.

³⁵⁵ Recovery.gov, "PECO Energy Company," accessed June 2013,

<http://www.recovery.gov/Transparency/RecipientReportedData/pages/RecipientProjectSummary508.aspx?AwardIdSur=80623>.

³⁵⁶ Recovery.gov, "PECO Energy Company."

Glossary of Terms, Abbreviations, and Acronyms

A: Amperes (also known as amps). The International System of Units base unit of electric current.

AC: Alternating Current. Electric current that changes direction with a regular frequency. Standard wall outlets in the United States supply AC current.

ACS: American Community Survey. An ongoing statistical survey conducted by the U.S. Census Bureau that samples a small percentage of the population every year.

ADA: Americans with Disabilities Act. Congress passed ADA in 1990 and amended ADA in 2008. ADA is a civil rights law that prohibits discrimination based on disability, defined as "...a physical or mental impairment that substantially limits a major life activity."

AEV: All-Electric Vehicle. An AEV is a subcategory of electric vehicle (see EV definition below) and is any vehicle that operates exclusively on electrical energy stored in the vehicle's battery and produces zero tailpipe emissions or pollution when stationary or operating. AEV batteries are charged using an external source of electricity. Also known as a battery electric vehicle (BEV).³⁵⁷

AFIG: Alternative Fuels Incentive Grant. A grant program established in 1992 and administered by the Pennsylvania Department of Environmental Protection to help create new markets for alternative fuels in Pennsylvania, including the deployment of alternative fuel vehicles, fleets, and technologies.

AFV: Alternative Fuel Vehicle. A dedicated, flexible fuel, bi-fuel (or dual-fuel) vehicle designed to operate on at least one alternative fuel (e.g., biodiesel, natural gas, propane, electricity, or ethanol).

AMI: Advanced Metering Infrastructure. Systems consisting of electronic hardware and software that gather real-time data and enable two-way communication between the customer site and the service provider.

ARRA: American Recovery and Reinvestment Act. Congress passed ARRA in 2009 in direct response to the economic crisis with the goal of saving existing and creating new jobs, spurring long-term economic growth, and fostering accountability in government spending. ARRA provided nearly \$8 billion in tax reductions and funding for entitlement programs, grants, and loans.

³⁵⁷ In a presentation given on May 7, 2012, at EVS26 in Los Angeles, CA, David Sandalow, Assistant Secretary for Policy & International Affairs, DOE, requested that the term AEV be used instead of the term BEV.

BAAQMD: Bay Area Air Quality Management District. A public agency that regulates the stationary sources of air pollution in California's San Francisco Bay Area.

Battery exchange station: A facility that enables an electric vehicle with a swappable battery pack to exchange a depleted battery pack for a fully charged battery pack, generally through an automated process. Other terms for a battery exchange station include battery switch station and battery swap station.

C2ES: Center for Climate and Energy Solutions. An independent, nonprofit organization working to advance policy and action to address energy and climate change.

CAFE: Corporate Average Fuel Economy. Fuel economy standards developed by the U.S. Environmental Protection Agency based on a vehicle's footprint.

CAR: Center for Automotive Research. A nonprofit organization that conducts research, forecasts trends, develops new methodologies, and advises on public policy related to automobiles.

CARB: California Air Resources Board. A department established in 1967 within the California Environmental Protection Agency. CARB seeks to attain and maintain healthy air quality, protect the public from exposure to toxic air contaminants, and provide innovative approaches for complying with air pollution rules and regulations.

Charger: An electrical component assembly or cluster of component assemblies designed specifically to charge batteries or other energy storage devices within electric vehicles. Chargers include standardized indicators of electrical force, or voltage (see Charging levels definition below), and may charge batteries by conductive or inductive means.

Charging: Term referring to the act of inserting a charger connector into an electric vehicle inlet in order to transfer electrical power to recharge the batteries on board the vehicle.

Charging levels: Standardized indicators of electrical force, or voltage, at which an electric vehicle's battery is recharged. They are referred to as Level 1, Level 2, and Level 3 (or DC/AC Fast Charging).

Circuit breaker: A device that automatically interrupts the flow of current in an overloaded electric circuit.

CNG: Compressed Natural Gas. A fossil fuel generally considered a cleaner and safer alternative to conventional fuels, like gasoline, diesel fuel, and propane. CNG is used in traditional internal combustion engine vehicles that have been converted into bi-fuel vehicles (i.e., gasoline and CNG).

CO₂: Carbon Dioxide. A greenhouse gas produced by burning carbon-based fuels.

Consumer: An individual or organization that purchases, rents, or drives an electric vehicle.

Current: The flow of electricity (commonly measured in amperes).

DC: Direct Current. Electric current that moves in one direction from negative to positive. Batteries in electric vehicles provide direct current.

DOE: U.S. Department of Energy.

DOT: U.S. Department of Transportation.

DVRPC: Delaware Valley Regional Planning Commission.

E&O: Education and Outreach.

EAA: Electric Auto Association. A nonprofit educational organization based in San Jose, California to promote adoption of electric vehicles.

Early adopters: Consumers who embrace new technology before the rest of the market. Early adopters are expected to make up the majority of electric vehicle purchases in southeastern Pennsylvania for the next several years.

EDISON: Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks. A project to create software and hardware for smart grid-electric vehicle integration, developed by a consortium of utilities, corporations, the Danish Technical University, and the Danish Energy Association.

EDTA: Electric Drive Transportation Association. An industry association dedicated to promoting electric drive to achieve efficient and clean use of secure energy in the U.S. transportation sector.

EEI: Edison Electric Institute. An association of shareholder-owned electric companies.

EIA: U.S. Energy Information Administration.

Electric vehicle charging station: The space serviced by a charger, including all signs, information, pavement surfaces, surface markings, and protective equipment, in which the transfer of electric energy occurs by conductive or inductive means between the charger and the battery or other energy storage device in a stationary electric vehicle.

EPA: U.S. Environmental Protection Agency.

EPRI: Electric Power Research Institute. A utility-industry-based research group.

EREV: Extended Range Electric Vehicle. An alternate term for a plug-in hybrid electric vehicle, specifically referring to one designed to run in all-electric mode until the battery is depleted. It is considered by some industry observers to be a marketing term.

EV: Electric Vehicle. Any motor vehicle for on-road use that is capable of operating solely on the power of a rechargeable battery or battery pack (or other storage device that receives electricity

from an external source, such as a charger) and meets the applicable federal motor vehicle safety standards and state registration requirements. Electric vehicles include, but are not limited to: all-electric vehicles, plug-in hybrid electric vehicles, neighborhood electric vehicles, and electric motorcycles. Also known as a plug-in electric vehicle (PEV).

EVITP: Electric Vehicle Infrastructure Training Program. A voluntary collaboration of electrical industry organizations that provides training and certification for people installing EV supply equipment.

EVSE: Electric Vehicle Supply Equipment. Inclusive of all of the components for electric vehicle charging stations, including: the conductors; the ungrounded, grounded, and equipment grounding conductors; electric vehicle connectors; attachment plugs, and; all other fittings, devices, power outlets, or apparatus installed specifically for the purpose of delivering energy from the grid to an electric vehicle.

FCV: Fuel Cell Vehicle. A type of vehicle that uses a fuel cell to produce electricity from hydrogen and oxygen to power an onboard electric motor.

FEVER: Fostering EV Expansion in the Rockies. A project by the Denver Metro Clean Cities Coalition and the American Lung Association in Colorado to reduce petroleum consumption in the Colorado transportation sector by increasing EV and EVSE adoption in Colorado.

FHWA: U.S. Federal Highway Administration. FHWA is a division of DOT that specializes in highway transportation.

GDI: Gasoline Direct Injection. A variant of fuel injection in internal combustion engines that involves injecting pressurized gasoline directly into the combustion chamber of each cylinder (as opposed to conventional multi-point fuel injection that happens in the cylinder port).

GHG: Greenhouse Gas. Any of the gases (e.g., carbon dioxide, methane, ozone, nitrous oxide, and fluorocarbons) that contribute to the greenhouse effect by absorbing solar radiation once in the atmosphere. The dominant GHG is carbon dioxide, a primary product of the combustion of fossil fuel.

GM: General Motors. A manufacturer of EVs.

GPCC: Greater Philadelphia Clean Cities.

GPS: Global Positioning System. A satellite navigation system that provides location and time information anywhere on or near Earth.

HEV: Hybrid Electric Vehicle. A motor vehicle that is powered by both an electric propulsion system with a conventional internal combustion propulsion system and meets the applicable federal motor vehicle safety standards and state registration requirements. An HEV does not plug into an off-board electrical source.

HOA: Homeowner Association. A corporation formed by a real estate developer for the purpose of marketing, managing, and selling of homes and lots in a residential subdivision.

HOV: High-Occupancy Vehicle. A vehicle with a driver and one or more passengers, including carpools, vanpools, and transit buses. A standard minimum occupancy level is two or three occupants.

IBC: International Building Code. A model building code developed by the International Code Council.

ICC: International Code Council. A member-focused association dedicated to developing model codes and standards used for structural design, construction, and compliance.

ICE: Internal Combustion Engine. An engine that uses the explosive power of combusting fuel inside a chamber as a means of delivering power.

INL: Idaho National Laboratory. A federal research facility established in 1949.

IRC: International Residential Code. A comprehensive residential code that sets minimum regulations for one- and two-family dwellings of three stories or less, including building, plumbing, mechanical, fuel gas, energy and electrical provisions.

IRS: Internal Revenue Service.

J1772: Industry-wide standard EV connector for Level 2 charging.

kg: Kilogram. A unit of mass the International System of Units equal to 1,000 grams.

kW: Kilowatt. A unit of power equal to 1,000 watts.

kWh: Kilowatt-hour. A unit of energy, equal to one kW delivered per hour, commonly used for measuring the energy capacity of a battery. This is the normal quantity used for metering and billing electricity customers.

LDV: Light-Duty Vehicle. A passenger car or passenger car derivative capable of seating 12 passengers or less.

LEED: Leadership in Energy and Environmental Design. A rating system for the design, construction, and operation of high performance green buildings, homes, and neighborhoods.

LEV: Low Emission Vehicle. A vehicle that emits relatively low levels of tailpipe emissions from the onboard power source.

Li-ion: Lithium-ion. The chemical technology used in a majority of electric vehicle batteries at the time of this document's publication. Lithium-ion batteries are lighter in weight and have higher energy density than the batteries they replaced.

Likely adopters: Consumers who typically embrace new technology but may start investing in the technology after early adopters have proven its success.

LNG: Liquefied Natural Gas. Natural gas that has been converted to liquid form for ease of storage or transport. LNG achieves a higher reduction in volume than CNG, although LPG has a relatively high cost of production and requires storage in expensive cryogenic tanks.

MPG: Miles Per Gallon.

MSRP: Manufacturer's Suggested Retail Price.

MUD: Multiunit Dwelling. Housing in a single building with more than one discrete housing unit (e.g., an apartment building or duplex house). MUDs are also referred to as multifamily dwellings (MFDs) or multidwelling units (MDUs).

MUTCD: Manual on Uniform Traffic Control Devices. A document issued by FHWA of DOT to specify the standards by which traffic signs, road surface markings, and signals are designed, installed, and used.

MY: Model Year. A number used to describe approximately when a product is produced.

NAFTC: National Alternative Fuels Training Consortium. A nationwide AFV and advanced technology vehicle training organization.

NEC: National Electric Code. A standard for the safe installation of electrical wiring and equipment in the United States. This code is sponsored and regularly updated by the National Fire Protection Association.

NEV: Neighborhood Electric Vehicle. An EV typically restricted to low-speed roads and powered solely by electricity. Also known as a low-speed vehicle.

NFPA: National Fire Protection Agency. An international nonprofit established in 1896 to provide and advocate consensus codes and standards, research, training, and education for fire prevention.

NGO: Nongovernmental Organization. A legally constituted corporation that operates independently from any form of government.

NGV: Natural Gas Vehicle. An AFV that uses CNG or LNG as a cleaner alternative to other fossil fuels.

NHTSA: National Highway Traffic Safety Administration. An division of DOT that focuses on reducing fatalities and injuries from vehicle-related crashes.

NiMH: Nickel metal hydride. The chemical technology for a battery type often used for HEVs.

NOx: Nitrogen Oxide. A compound or mixture of compounds of oxygen and nitrogen, including NO and NO₂, which are produced during combustion. NOx acts as a precursor for tropospheric ozone and is harmful to human health.

NREL: National Renewable Energy Laboratory. A laboratory for renewable energy and energy efficiency research and development funded through DOE.

NYSERDA: New York State Energy Research and Development Authority. A public benefit corporation established in 1975 that provides information and analysis, programs, technical expertise, and funding to help reduce energy consumption and greenhouse gas emissions in New York State.

OEM: Original Equipment Manufacturer. For purposes of this report, OEM refers to EV manufacturers. Examples include GM and Nissan.

ORNL: Oak Ridge National Laboratory. A multiprogram science and technology laboratory in the DOE system.

PA DEP: Pennsylvania Department of Environmental Protection.

PA PUC: Pennsylvania Public Utility Commission.

PennDOT: Pennsylvania Department of Transportation.

PEV: Plug-In Electric Vehicle. Another common term for electric vehicle (see EV definition above).

Phase: Classification of an AC circuit; circuits are usually single-phase (two-, three-, or four-wire) or three-phase (three- or four-wire).

PHEV: Plug-in Hybrid Electric Vehicle. A type of electric vehicle (see EV definition above) that is powered by an ICE, as well as an electric motor, and is capable of being powered solely by electricity. PHEV batteries are primarily charged by connecting to the grid or another off-board electrical source but may also be able to sustain battery charge using an on-board internal-combustion-driven generator.

Possible adopters: Consumers who invest in technology only after it has been proven by early and likely adopters.

PPP: Public-Private Partnership. A government service or private business venture which is funded and operated through a partnership of government and one or more private sector companies

PSRC: Puget Sound Regional Council. A regional planning organization that develops policies about transportation and economic development in the Seattle metropolitan area.

PUC: Public Utility Commission. A state regulatory agency that governs retail utility rates and practices. Also known as Public Service Commission in some states.

SAE: SAE International, formerly the Society of Automotive Engineers. SAE International develops standards to create consistency in the design of EVs and the associated charging equipment.

SGIG: Smart Grid Investment Grant. A \$3.4 million grant program that is part of ARRA and administered by DOE to stimulate the deployment and integration of advanced digital technology needed to modernize the electric grid.

Tcf: Trillion Cubic Feet. A nonmetric unit of volume, used in the United States and the United Kingdom, defined as the one trillion cubic feet, where a cubic foot equals the volume of a cube with sides of one foot in length.

TCI: Transportation and Climate Initiative. A regional collaboration of 12 Northeast and Mid-Atlantic jurisdictions that seeks to develop the clean energy economy and reduce GHG emissions in the transportation sector.

TOU: Time-of-Use. An electricity billing method with rates based upon the time of usage during the day.

UCC: Uniform Construction Code. Pennsylvania's statewide building code.

UD: University of Delaware. A U.S. university active in research on vehicle-to-grid technology.

UL: Underwriters Laboratories. An independent, nonprofit product safety testing and certification organization.

UPS: United Parcel Service. A global package delivery company.

V: Volt. A measure of electrical potential difference or pressure. One volt is defined as the electrical potential required to produce a current of one ampere across a one ohm resistance.

V2G: Vehicle-to-Grid. The concept of using EVs as energy storage devices for the electric grid.

VMT: Vehicle Miles Traveled. An indicator of the level of travel on roadways by motor vehicles.

W: Watt. A unit of power, defined as one joule per second, which measures the rate of energy transfer.

Wh: Watt-hour. A unit of energy, defined as one watt (1 W) of power expended for one hour of time.

ZEV: Zero Emissions Vehicle. A vehicle that emits no tailpipe pollutants from the onboard source of power.

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www.pikeresearch.com/research/energy-environment-consumer-survey.

A report on a consumer survey that measures the favorability of a variety of clean energy and clean environment concepts.

Vyas, Charul, Dave Hurst, and John Gartner. *Executive Summary: Electric Vehicle Consumer Survey Consumer Attitudes, Preferences, and Price Sensitivity for Plug-in Electric Vehicles and EV Charging Stations*, Pike Research, 2011. www.pikeresearch.com/wordpress/wp-content/uploads/2011/12/EVCS-11-Executive-Summary.pdf.

An executive summary of a research report that analyzes the results of a web-based survey of 1,051 U.S. consumers in the fall of 2011.

Technology

Boston Consulting Group. *Batteries for Electric Cars: Challenges, Opportunities, and the Outlook for 2020*, 2010. www.bcg.com/documents/file36615.pdf.

A report on battery technologies, which features cost models and forecasts based on production levels.

Birnie, Dunbar, III. "Solar-to-Vehicle (S2V) Systems for Powering Commuters of the Future," *Journal of Power Sources*, October 2008.

www.sciencedirect.com/science/article/pii/S0378775308018946.

A journal article that discusses the use of photovoltaic-equipped parking lot shade structures to charge commuter EVs.

Bruninga, Robert, P.E.. *Overlooking L1 Charging At-Work in the Rush for Public Charging Speed*. www.aprs.org/Energy/Charging/IEEEpaper.pdf.

A report opining that Level 1 charging can meet most EV users' needs.

Cunningham, Brian. "Automotive Li-Ion Battery Cooling Requirements," U.S. Department of Energy, 2012.

www1.eere.energy.gov/vehiclesandfuels/pdfs/thermoelectrics_app_2012/wednesday/cunningham.pdf.

A presentation that discusses the impact of ambient temperature on battery life.

ECOtality North America. *Technologies Required to Fully Integrate Electric Vehicles and the Smart Grid*, 2011. www.theevproject.com/downloads/documents/Smart%20Grid.pdf.

A presentation describing technological and technical precursors to full use of smart-grid technology by EVs.

Element Energy Limited. *Cost and Performance of EV Batteries*, 2012. www.element-energy.co.uk/wordpress/wp-content/uploads/2012/04/CCC-battery-cost-Element-Energy-report-March2012-Public.pdf.

A report to the United Kingdom Committee on Climate Change, which outlines current and expected EV battery technology, as well as associated barriers and opportunities.

Gopalakrishnan, Duleep, and others. *Assessment of Electric Vehicle and Battery Technology*, ICF International and Ecologic Institute, 2011.

A report that provides an overview of the ongoing and expected developments in EV and battery technology.

Hensley, Russell, John Newman, and Matt Rogers. "Battery Technology Charges Ahead," *McKinsey Quarterly*, July 2012. europe.autonews.com/assets/PDF/CA80553711.PDF.

A periodical article that forecasts battery technology trends with a focus on battery cost.

Keyser, Matt, and others. *Energy Storage R&D: Battery Thermal Modeling and Testing*, National Renewable Energy Laboratory, 2011.

www1.eere.energy.gov/vehiclesandfuels/pdfs/merit_review_2011/electrochemical_storage/es110_smith_2011_p.pdf.

A presentation that discusses the impact of ambient temperature on battery life and charging characteristics.

Nicholas, Michael, and others. *Fast Charging Network Dynamics in California: Modeling Travel Diary Data and Surveys*, University of California, Davis, Institute of Transportation Studies, Plug-In Hybrid and Electric Vehicle Research Center, 2012.

A poster presentation of findings regarding the need for DC fast-charging EVSE.

Toyota Motor Sales, USA, Inc. "Toyota Prius Plug-In Hybrid Demonstration Program." <http://www.slideshare.net/accessio/toyota-pluginprius-demonstration-program>.

A website that contains data on time-of-day driving, EV mode versus HEV mode use, trip mileage, EV miles per trip, mpg by trip distance, energy per charge, charge start time, and charge events per day for 112 of the vehicles that participated in a 2009 Toyota demonstration program.

Turrentine, Tom and others. *The UC Davis MINI E Consumer Study*, University of California, Davis, Institute of Transportation Studies, Plug-In Hybrid and Electric Vehicle Research Center, 2011. pubs.its.ucdavis.edu/publication_detail.php?id=1470.

A report that provides the findings of a field study of BMW Mini E use.

Effects and Outcomes

Anair, Don, and Amine Mahmassani. *State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings Across the United States*, Union of Concerned Scientists,

2012. www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf.

A report that compares the emissions of EVs to ICE-propelled vehicles.

Axsen, Jonn, and Kenneth Kurania. "Anticipating Plug-in Hybrid Vehicle Energy Impacts in California: Constructing Consumer-Informed Recharge Profiles," *Transportation Research*, Part D, 15 (2010): 212-219. escholarship.org/uc/item/3h69n0cs.

A report that estimates the electricity and gasoline use of PHEVs under three recharging scenarios and uses these estimates to provide policy recommendations.

Electric Power Research Institute. *Transportation Electrification in New York State*, 2011. [www.nyserda.ny.gov/en/Publications/Research-and-Development/~media/Files/Publications/Research/Transportation/epri-phev.ashx](http://www.nyserda.ny.gov/en/Publications/Research-and-Development/~/media/Files/Publications/Research/Transportation/epri-phev.ashx).

A study that seeks to determine the energy, economic, environmental, and electricity distribution impacts of EV deployment in New York.

Hadley, Stanton, and Alexandra Tsvetkova. *Potential Impacts of Plug-in Hybrid Electric Vehicles on Regional Power Generation*, Oak Ridge National Laboratory, 2008. ornl.gov/info/ornlreview/v41_1_08/regional_phev_analysis.pdf.

A report that predicts the grid impacts of PHEVs and estimates the need for new generation capacity by region given a 25 percent market share of PHEVs.

McCarthy, Ryan, and Christopher Yang. "Determining Marginal Electricity for Near-Term Plug-in and Fuel Cell Vehicle Demands in California: Impacts on Vehicle Greenhouse Gas Emissions," *Journal of Power Sources*, 2009. www.researchgate.net/publication/222550525_Determining_marginal_electricity_for_near-term_plug-in_and_fuel_cell_vehicle_demands_in_California_Impacts_on_vehicle_greenhouse_gas_emissions.

An analysis that uses an hourly electric dispatch model to investigate the operation of the current California grid and its response to added EV charging demand in the near term.

Recker, W.W., and J.E. Kang. *An Activity-Based Assessment of the Potential Impacts of Plug-In Hybrid Electric Vehicles on Energy and Emissions Using One-Day Travel Data*, University of California, Irvine, Institute of Transportation Studies, 2010. www.escholarship.org/uc/item/71k7k533.

A report that uses one-day travel patterns and various charging scenarios to estimate the grid impacts of PHEV substitution for ICE vehicles.

Song, C.C. *Electric Vehicles: Who's Left Stranded*, The Greenlining Institute, 2011. stage.greenlining.org/resources/pdfs/ElectricVehiclesReport.pdf.

A report that describes the benefits of EVs, with an emphasis on the fact that these benefits may not be fully realized until EVs become an option for lower-income communities.

Stenquist, Paul. "How Green Are Electric Cars? Depends on Where You Plug In," *The New York Times*, 2012. www.nytimes.com/2012/04/15/automobiles/how-green-are-electric-cars-depends-on-where-you-plug-in.html?_r=1.

A periodical article that describes the conclusions of a Union of Concerned Scientists report, which analyzes the emissions of EVs and compares them to the emissions of ICE-propelled vehicles and HEVs.

Yang, Christopher, and Ryan McCarthy. "Electricity Grid: Impacts of Plug-in Electric Vehicle Charging," Air & Waste Management Association, *EM*, 2009. www.escholarship.org/uc/item/3d5219kx.

An article that provides an overview of barriers and opportunities related to EV deployment, as well as associated grid impacts and energy use.

Emergency Response and Safety

CalFire. *The Emergency Response Guide to Alternative Fuel Vehicles*, 2009. osfm.fire.ca.gov/training/pdf/alternativefuelvehicles/Altfuelintroduction.pdf.

A guide on emergency response best practices for incidents involving AFVs.

Clean Cities Coachella Valley Region. "Train the Trainer: First Responder Safety Training," National Alternative Fuels Training Consortium, 2011. www.cleancities.tv/FeaturedContent/Training/VehicleSafety.aspx.

A video presentation of a first responders training course offered at the College of the Desert in Palm Desert, California.

ECOTality North America. *EV Project: First Responder Training*, 2011. www.theevproject.com/downloads/documents/EV%20Project%20-%20%20First%20Responder%20Training.pdf.

A lessons learned report published as part of The EV Project that discusses first responder training for EVs.

Ford Motor Company. *2012 Focus Electric Emergency Response Guide*. www.motorcraftservice.com/vdirs/quickref/2012-Focus-Electric-ERG.pdf.

A guide for emergency responders responding to an incident involving a 2012 Ford Focus Electric.

Grant, Casey, P.E. *Fire Fighter Safety and Emergency Response for Electric Drive and Hybrid Electric Vehicles*, Fire Protection Research Foundation, 2010.

A report funded by a U.S. Department of Homeland Security Assistance to Firefighters Grants Fire Prevention & Safety Grant that seeks to assemble and disseminate best practices about the proper handling of EVs in emergency situations.

National Fire Protection Association. "Electric Vehicle Safety Training." evsafetytraining.org/.

A website on EV safety training for first responders.

Plans and Guidance Documents

Advanced Energy. *Residential Charging Station Installation Handbook for Single- and Multi-Family Homeowners and Renters, Version 1.0*, 2012.

www.advancedenergy.org/transportation/resources/MUD%20Handbook%20FINAL%20Web.pdf

A handbook that provides basic information about residential equipment and charging EVs in various residential settings.

Association of Bay Area Governments and others. *Ready, Set, Charge California!*, 2011. www.baclimate.org/images/stories/actionareas/ev/guidelines/readysetcharge_evguidelines.pdf.

A set of guidelines and recommendations to prepare communities for EVs.

Balmin, Judith, Greg Bonett, and Megan Kirkeby. *Increasing Electric Vehicle Charging Access in Multi-Unit Dwellings in Los Angeles*, University of California, Los Angeles, Luskin School of Public Affairs, Luskin Center for Innovation, 2012.

luskin.ucla.edu/sites/default/files/EV%20Charging%20in%20LA%20MUDs.pdf.

A report containing policy recommendations to increase EVSE availability and facilitate installation in MUDs.

California Plug-in Electric Vehicle Collaborative. *Streamlining the Permitting and Inspection Process for Plug-in Electric Vehicle Home Charger Installations*, 2012.

www.pevcollaborative.org/sites/all/themes/pev/files/EV_Permitting_120827.pdf.

A report that provides an overview of EVSE permitting processes and recommendations for improvement.

County of Sonoma General Services Department. *Electric Vehicle Charging Station Program and Installation Guidelines*, 2011. www.sonoma-county.org/prmd/docs/misc/ev_prog_guidelines.pdf.

A plan and guidelines for installation of EVSE in Sonoma County, California.

Electrification Coalition. *Electrification Roadmap: Revolutionizing Transportation and Achieving Energy Security*, 2009. www.electrificationcoalition.org/sites/default/files/SAF_1213_EC-Roadmap_v12_Online.pdf.

An industry-led document that makes the case for EVs, identifies challenges and opportunities to EV and EVSE deployment, and recommends a strategic approach to deployment focusing first on demonstration projects and then on wider adoption.

Metropolitan Washington Council of Governments. *Charged Up: Making Metropolitan Washington Electric Vehicle Ready*, 2012. www.mwcog.org/uploads/committee-documents/bF1dWVpc20120718132507.pdf.

The Washington, D.C. metropolitan area EV planning document.

Plug-in Hybrid & Electric Vehicle Research Center. *Taking Charge: Establishing California Leadership in the Plug-in Electric Vehicle Marketplace*, California Plug-in Electric Vehicle Collaborative, 2010. publications.its.ucdavis.edu/publication_detail.php?id=1436.

A plan that establishes goals, a vision, and recommendations for EV deployment in California.

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

A plan that identifies and develops strategies to overcome the barriers to EV and EVSE deployment in Virginia.

Washington Department of Commerce and Puget Sound Regional Council. *Electric Vehicle Infrastructure: A Guide for Local Governments in Washington State*, 2010. www.psrc.org/assets/4325/EVI_full_report.pdf.

A document that contains a model ordinance, model development regulations, and other guidance related to EVs and EVSE.

Appendices

Appendix A. EV Cost Model - Universal Inputs

Net Present Value Inputs	
Current year	2013
Acquisition and Ownership Inputs	
Pennsylvania state sales tax	6.0%
Length of ownership	10 years
Estimated lifetime VMT	154,270 miles
Recreational VMT per year	2,000 miles
Share of Recreational VMT assumed electric	30%
Federal EVSE tax credit (through 2013)	30%
Fuel Inputs	
Current year electricity price	\$0.17/kWh
Electricity case	Reference
Current year gasoline price	\$3.69/gal
Gasoline case	Reference
EVSE Cost Inputs (Level 1 in Garage)	
Hardware	\$200
Installation	\$500
Permitting	\$100
EVSE Cost Inputs (Level 2 in Garage)	
Hardware	\$500
Installation	\$1,000
Permitting	\$100
PHEV Maintenance Cost Inputs ³⁵⁸	
Routine maintenance	\$0.024/mi
Oil change	\$0.010/mi
AEV Maintenance Cost Inputs	
Routine maintenance	\$0.020/mi
Oil change	\$0.000/mi
ICE Maintenance Costs Inputs	
Routine maintenance	\$0.030/mi
Oil change	\$0.015/mi

³⁵⁸ Per-mile maintenance costs calculated by dividing lifetime maintenance costs in Appendix B by estimated lifetime VMT in Appendix A.

Federal Tax Credit Inputs (by battery capacity in kWh)	
<= 5	\$2,500
>5 to 6	\$2,917
>6 to 7	\$3,333
>7 to 8	\$3,750
>8 to 9	\$4,167
>9 to 10	\$4,583
>10 to 11	\$5,000
>11 to 12	\$5,417
>12 to 13	\$5,833
>13 to 14	\$6,250
>14 to 15	\$6,667
>15 to 16	\$7,083
>16 to 17	\$7,500

Source: DVRPC, 2013.

Appendix B. EV Cost Model: Maintenance Cost Assumptions (For Vehicle Lifetime)

These values are a combination of research and data from a study for DOE prepared by the Oak Ridge National Laboratory (ORNL) entitled “Plug-In Hybrid Electric Vehicle Value Proposition Study.”

	PHEV	AEV	ICE
Oil Changes			
Lifetime Oil Changes	19	0	29
Oil and Filter Costs per Oil Change	\$32.25	\$0.00	\$36.25
Labor Cost per Oil Change	\$45.33	\$0.00	\$45.33
Total Oil Change Lifetime Cost	\$1,474.02	\$0.00	\$2,365.82
Air Filter Replacements			
Lifetime Air Filter Replacements	2	0	4
Filter Cost per Replacement	\$21.25	\$21.25	\$21.25
Labor Cost per Replacement	\$39.95	\$39.95	\$25.50
Total Air Filter Lifetime Cost	\$122.40	\$0.00	\$187.00
Spark Plug Replacements			
Lifetime Spark Plug Replacements	0	0	1
Plug Cost per Replacement	\$12.00	\$12.00	\$18.00
Labor Cost per Replacement	\$62.33	\$62.33	\$204.00
Total Spark Plug Lifetime Cost	\$0.00	\$0.00	\$222.00
Timing Chain Adjustments			
Lifetime Timing Chain Adjustments	0	0	1
Chain Cost per Adjustment	\$0.00	\$0.00	\$0.00
Labor Cost per Adjustment	\$168.00	\$168.00	\$168.00
Total Timing Chain Lifetime Cost	\$0.00	\$0.00	\$168.00
Brake Replacements			
Lifetime Brake Replacements	2	1	3
Brake Cost per Replacement	\$290.00	\$290.00	\$290.00
Labor Cost per Replacement	\$170.00	\$170.00	\$170.00
Total Brake Lifetime Cost	\$920.00	\$460.00	\$1,380.00
Other Scheduled Maintenance			
Total Other Maintenance Lifetime Cost ³⁵⁹	\$2,634.66	\$2,634.66	\$2,634.66
Total Routine Maintenance Costs (excluding oil changes)	\$3,677.06	\$3,094.66	\$4,591.66
Total Routine Maintenance Costs (including oil changes)	\$5,151.08	\$3,094.66	\$6,957.48

Source: Oak Ridge National Laboratory, “Plug-In Hybrid Electric Vehicle Value Proposition Study,” 2010; DVRPC, 2013.

³⁵⁹ The ORNL study indicates that these costs represent additional maintenance items that ICE vehicles, HEVs, and PHEVs all undergo. The value is the difference between the sum of lifetime maintenance costs and the sum of individual maintenance cost elements listed in the table.

Appendix C. EV Cost Model: EV and ICE Equivalent Models

EV Model	ICE Equivalent Model
2013 Chevrolet Volt	2013 Chevrolet Cruze ECO
2013 Fiat 500 Electric	2013 Fiat 500 Abarth
2013 Ford Focus EV	2013 Ford Focus Titanium 5-Door
2013 Honda Fit EV	2013 Honda Fit Sport
2013 Mitsubishi iMiEV ES TRIM	2013 Smart ForTwo Passion Cabriolet
2013 Nissan LEAF SV	2013 Nissan Versa SV
2013 Smart ForTwo Electric	2013 Smart ForTwo Passion Cabriolet
2013 Tesla Model S (40 kWh)	2013 Audi A4/BMW 3 Series/Mercedes C Class (Basic models)
2013 Tesla Model S (60 kWh)	2013 Audi A4/BMW 3 Series/Mercedes C Class (Mid-range models)
2013 Tesla Model S (85 kWh)	2013 Audi A4/BMW 3 Series/Mercedes C Class (High-end Models)
2013 Toyota Prius PHEV	2013 Toyota Prius v Five
2013 Toyota RAV4 EV	2013 Toyota RAV4 Limited (AWD)
2013 Chevrolet Volt	2013 Chevrolet Cruze ECO

Source: DVRPC, 2013.

Appendix D. “Garage-Free” Electric Vehicle Summit 2012: Meeting Proceedings

“Garage-Free” Electric Vehicle Summit
February 29, 2012

10:00 a.m. – 3:00 p.m.

Delaware Valley Regional Planning Commission
190 N. Independence Mall West, 8th Floor

Philadelphia, PA 19106

ATTENDEES:

Baltimore

Jill A. T. Sorensen	Baltimore Electric Vehicle Initiative, Inc.
John Murach	Baltimore Gas & Electric
William Doane	City of Baltimore Energy Office
Paul Skorochood	City of Baltimore Energy Office
Herbert Chee	Constellation Energy
Elizabeth Entwisle	Maryland Department of the Environment
Tiffany James	Parking Authority of Baltimore City

Boston/Cambridge

Bronwyn Cooke (on phone)	City of Cambridge
Stephanie Groll (on phone)	City of Cambridge
Rachel Szakmary (on phone)	City of Boston Transportation Department
Steve Russell	Massachusetts Dept. of Energy Resources/Massachusetts Clean Cities
Watson Collins	Northeast Utilities

New York City/Lower Hudson Valley

Ari Kahn	City of New York
Mark Simon	City of New York Department of Transportation
John Shipman	Consolidated Edison Company of New York, Inc.
Christina Ficicchia	New York City and Lower Hudson Valley Clean Communities, Inc.

Greater Philadelphia

Tony Bandiero	GPCC
Thomas Bonner	PECO
Heather Cowley	PA DEP
Sarah Wu	Philadelphia Mayor's Office of Sustainability

Washington, D.C.

Emil King	District of Columbia Department of the Environment
Daniel White	District of Columbia Department of the Environment
Claude Willis	Greater Washington Region Clean Cities Coalition

Other

Nick Nigro	C2ES
Colleen Quinn	Coulomb Technologies, Inc.
Stephen Schey	ECotality North America
Karen Paci	Enterprise Holdings (PhillyCarShare)
Britta Gross (on phone)	GM
Adam Ruder	NYSERDA/TCI
David Peterson (on phone)	Nissan North America, Inc.
Mark Perry (on phone)	Nissan North America, Inc.
Tracy Woodard (on phone)	Nissan North America, Inc.
Cassie Powers	TCI/Georgetown Climate Center
Daniel Witt	Tesla Motors
Peter Bruvik	Zipcar

Staff

Barry Seymour	DVRPC
Elizabeth Compitello	DVRPC
Robert Graff	DVRPC
Shawn Megill Legendre	DVRPC
Amy Miller	DVRPC
Sarah Alexander	ICF
Erika Myers	ICF

I. Welcome

Mr. Barry Seymour, Executive Director of DVRPC, welcomed the attendees to the meeting and provided introductory remarks. Mr. Seymour explained the intent of the meeting and the importance of EV deployment in the City of Philadelphia. He then introduced his colleague, Mr. Robert Graff.

II. Overview and Introductions

Mr. Graff, the Manager of the Office of Energy and Climate Change Initiative at DVRPC, introduced himself and his role in the EV deployment effort and thanked everyone for their participation. He emphasized the importance of having a joint discussion about the mechanics of implementing new vehicle technologies into a city with a shortage of dedicated off-street parking. Mr. Graff highlighted that DVRPC is one of 16 recipients of funding through DOE's

Clean Cities Program Grant Program, *Electric Vehicle Communities Readiness Projects*.³⁶⁰ The intent of the grant award is to prepare regionally coordinated plans to address the introduction of EVs and EVSE into southeastern Pennsylvania. The goal of the “Garage-Free” Electric Vehicle Summit was to identify barriers and develop solutions for potential EV owners with limited home access to EVSE as part of *Ready to Roll!*. After the summit, DVRPC plans to have additional discussions with stakeholders and will reach out to the attendees as necessary. Mr. Graff briefly reviewed the agenda and asked for brief introductions from each of the attendees (listed above). He then introduced the next speaker, Mr. Nick Nigro.

III. Framing Presentation

Mr. Nigro is the Manager of Transportation Initiatives at C2ES³⁶¹ and reports to the Vice President for Technology and Innovation. He is responsible for research, analysis, and communication of transportation technology and policy solutions for reducing greenhouse gases. Mr. Nigro received his Masters of Public Policy with a focus on Energy Policy from the University of California, Berkeley's Goldman School of Public Policy. He also holds a Bachelor of Science in Electrical and Computer Engineering from Worcester Polytechnic Institute. Nick has worked at the federal, state, and local levels to assess impacts of energy issues on the economy. Prior to attending University of California, Berkeley, Nick was a key member of one of New England's fastest-growing startup companies, Oasis Semiconductor. Mr. Nigro provided a presentation titled, “The EV Dialogue Group's Action Plan with a focus on Multi-unit Dwellings.”

Mr. Nigro spearheaded a multiyear program at C2ES to encourage EV and EVSE deployment and coordinated the activities of the Plug-In Electric Vehicle Dialogue Group (Group), which released two white papers in July 2011.³⁶² The group comprised key stakeholders representing leaders from the public and private sectors, including nongovernmental organizations (NGOs), to develop a series of recommendations to accelerate EV deployment.

The group will release an action plan in conjunction with the Natural Resources Defense Council³⁶³ and Project Get Ready³⁶⁴ on March 13, 2012. Mr. Nigro's presentation represented an preview of the report and its recommendations.

Relating specifically to MUDs, the report emphasized the lack of research available in this area and determined that the issue would need to be developed and customized over time. The report encouraged clarity from state and local government in regards to legal issues and recommended that local governments require new or refurbished buildings to accommodate EVSE installation.

Mr. Nigro also discussed charging infrastructure needs for the rollout of EVs. At a minimum, home and workplace charging should be available, with some public charging to address range

³⁶⁰ http://www1.eere.energy.gov/cleancities/electric_vehicle_projects.html

³⁶¹ <http://www.c2es.org/>

³⁶² <http://www.c2es.org/publications/plug-in-electric-vehicles>

³⁶³ <http://www.nrdc.org/>

³⁶⁴ <http://projectgetready.com/>

anxiety. Alternatively, if a local government wanted to maximize the availability of EVSE, it would also be installed at major retail outlets, curbside spots, public parking lots, and major destinations. Past demonstration projects have shown that extensive public infrastructure is not necessary. However, the needs and concerns (i.e., range anxiety) of early adopters may not be comparable to the general public.

MUD residents could represent a significant portion of EV consumers but will need to overcome obstacles presented by the landlord/tenant constraints, HOAs, retrofitting historic buildings, legal restrictions, physical limitations, and deeded vs. shared parking. These residents will therefore be dependent on publicly accessible EVSE.

Key questions generated by the report related to MUDs included two potential scenarios for access:

- Dedicated parking:
 - Who pays for EVSE (i.e., capital costs, electricity costs, and maintenance)? What happens if EV owners move? Who owns the EVSE and who can use it? How does installation process scale?
- Nondedicated parking:
 - If people rely on publicly accessible EVSE, how do cities ensure that the EVSE is convenient to the MUDs? Can a city support on-street charging stations and balance equity concerns? What charging level is needed to accommodate travel needs (some neighborhoods may only need Level 1)? How many residents will utilize city-owned parking garages? Can the city limit EVSE access to residents for overnight charging?

Mr. Nigro and Mr. Graff then opened the floor for questions and discussions.

Ms. Colleen Quinn stated that a national roadmap for investment in infrastructure was necessary. With over 3,000 utilities and four states with legislation like California's to standardize utility regulations on EVSE, she asked Mr. Nigro if it would be possible to have national legislation. Mr. Nigro responded that despite bipartisan support for EVs and EVSE, the likelihood of federal action in the near term is uncertain. For this reason, the report did not evaluate Congressional action, and Mr. Nigro welcomed ideas from Coulomb Technologies about national implementation.

Ms. Quinn followed up with a statement about integrating EVSE into the smart grid. She mentioned the appearance of Secretary Chu's advisor at a recent National Association of Regulatory Utility Commissioners³⁶⁵ meeting in Washington, D.C., and efforts at the American Association of State Highway and Transportation Officials³⁶⁶ and the National Association of State Energy Officials³⁶⁷ to create a national EVSE vision.

³⁶⁵ <http://www.naruc.org>

³⁶⁶ <http://www.transportation.org>

³⁶⁷ <http://www.naseo.org>

Ms. Jill Sorenson added that uncertainty may be a good thing because industry standards still needed to be developed.

Ms. Christina Ficicchia suggested integrating EVSE standards into building codes for MUDs. She stated that EVSE installation could be a metric for green buildings, though such a metric was recently removed from LEED certification standards. Could there be an opportunity for reinstating that metric within LEED and other building standards? She also asked Mr. Nigro if the EV Dialogue Group had evaluated what customers were willing to pay for at-home vs. public EVSE.

Mr. Watson Collins stated that in Philadelphia, the Green Parking Council³⁶⁸ was utilizing LEED as an avenue to encourage EVSE installation and had evaluated options for time-sharing EVSE. He asked Mr. Nigro if the EV dialogue group had evaluated time sharing and cooperatives.

Mr. Dave Peterson discussed the NRG Energy³⁶⁹ project in Dallas and Houston as an example of a networked approach to shared EVSE.

Ms. Rachel Szakmary mentioned that the City of Boston was considering partnering with a company similar to Parkmobile,³⁷⁰ which would link the EVSE to a smart phone. She suggested a potential for network membership to be linked to neighborhood permitting so an individual could receive an access code to EVSE in the area when s/he paid for a parking permit.

Ms. Quinn agreed that the City of Boston's suggestion could be a good project model that would provide valuable information in conjunction with Nissan data. She also emphasized that real-time information should be available to the drivers, for example through reservation systems. She also stated that Coulomb Technologies, Inc. has begun exploring opportunities to combine real-time data to a reservation system to allow customers easier access to infrastructure.

Ms. Tiffany James stated that the Baltimore Parking Authority has taken information about parking meters, Zipcar³⁷¹ usage, and residential permitting and combined the concepts to sell EVSE parking space permits in order to assign curbside parking. Ms. James also asked whether there might be a way to remove the battery from the car and charge it at home or by swapping the battery.

Mr. Mark Perry with Nissan has a partnership with Better Place³⁷² to explore battery-swapping opportunities in Israel and Denmark.³⁷³ To date, there is no application in the United States. Mr. Perry also suggested that DVRPC consider opportunities for workplace charging within urban areas because it is the second longest time that a car is parked.

³⁶⁸ <http://www.greenparkingcouncil.org/>

³⁶⁹ <http://www.nrgenergy.com/econrg/electric-vehicles.html>

³⁷⁰ <http://us.parkmobile.com/members/>

³⁷¹ <http://www.zipcar.com>

³⁷² <http://www.betterplace.com>

³⁷³ <http://www.betterplace.com/global/progress/Denmark>

Mr. Graff agreed and mentioned that workplace chargers could also be made available to local residents during nonbusiness hours. He also mentioned the possibility of instituting a program comparable to a neighborhood transit score for EVSE. ECOtality³⁷⁴ estimates that EVSE must be located within a one-quarter mile walking radius of area in order to optimize availability.

Mr. Claude Willis asked if any feasibility analysis had been done on mobile charging stations. Mr. Watson agreed that it was a good concept and that many types of fleets have mobile fueling stations. Mr. Graff explained that mobile charging units are currently very expensive and perhaps most applicable for emergency applications. Mr. Ari Kahn agreed that the economics were tough for mobile charging stations, but he could put Mr. Willis in touch with Green Charge Networks³⁷⁵ in Brooklyn, New York, which makes an EVSE mobile charger for AAA. Mr. Kahn suggested that even though Level 1 charging may not be as attractive to potential EV owners, it could be sufficient for the majority of users. He added that New York City is currently developing a map of plugs accessible to EV owners that could be used for Level 1 charging. The majority of these locations are in parking garages. He also suggested developing a cooperative model for EVSE installation and utilization.

Ms. Britta Gross stressed that the one major advantage for EVs currently is the inexpensive cost of refueling compared to petroleum. Any labor intensive solution, such as battery swapping or mobile EVSE, only adds to the complication and cost of charging. She suggested focusing on reducing complications for early adopters and providing inexpensive ways to charge, such as free electricity.

Mr. Graff then closed the floor for questions and began discussion on the next agenda item.

IV. Round Robin Identification of Issues

Mr. Graff started the Round Robin with a brief presentation developed by SF Environment,³⁷⁶ titled “EV Chargers in Multifamily Buildings.”

A large percentage of residents in the County of San Francisco and neighboring suburbs live in MUDs. The MUDs in the region vary widely in terms of the number of units and parking availability. Major factors impacting EVSE in this area are the physical challenges of installation, the cost of installation and operation, and the codes, covenants, and legalities restricting access. Mr. Graff briefly went through the slides and discussed some of the nuances associated with deploying EVSE in MUDs.

Mr. Graff provided a handout for the group called, “Priming the Pump: Issues and Questions,” which was developed from suggestions submitted by participants before the summit. Mr. Graff explained the rules of the Round Robin and asked that participants expand upon the list of issues addressed in the handout. Attendees raised the following additional issues:

³⁷⁴ <http://www.ecotality.com/>

³⁷⁵ <http://greenchargenet.com/>

³⁷⁶ <http://www.sfenvironment.org/>

Big Questions

- Workplace charging? Use during off-hours? What mix of home, workplace, etc. charging is needed?
- What is the role of the public sector in providing EVSE and fuel to EVs?
- How does Philadelphia get EVs out to the public? Is there a way to speed up OEM deployment?
- What is the best way to measure demand? Particularly with regard to choosing locations for EVSE?

Economics/Funding

- What is the “Break Even” point for MUD renters and owners?
- “Time-sharing” approaches?
- Can energy contracting play a role?
- “Cooperative” solutions? Neighborhood-based?
- Commercial fleet opportunities for EVSE and EV deployment?
- If free EVSE is offered now, who will pay for the energy when usage increases? If a municipality did charge, where would the payments go? A Use Fee or General Fund?
- How could private industry work with OEMs to invest in urban infrastructure?
- What are the differential costs of installation based on the location of the EVSE site?

Permits and Regulations

- Role of green building codes and incentive programs?
- Marrying parking permits with EV permits?
- How do we harmonize the middle through state regulation, local zoning, and use permitting?

Importance of Standards

- Should there be a standardization of chargers?

Technology Questions

- Should there be an ability to create a “reservation” system for potential users?
- What is the feasibility of removable battery technologies?
- What is the role of Mobile EVSE and smart plugs, instead of stationary EVSE?
- Could curbside utility or light poles be utilized for EVSE as a way to reduce costs?
- How conscious should EVSE developers be of “load pockets” for new EVSE installation and potential grid impacts?
- Could EV OEMs install or could owners retrofit vehicles with on-board meters?
- What happens during a power outage? Does the utility prioritize charging?

Strategic Questions

- A major issue is how to get vehicles to market and engage the private sector. Similar to the green building movement, organizers should educate the building community about the benefits of EVSE as an energy efficiency solution. How do we get to the point where EVSE is viewed as another appliance?
- Should a municipality provide incentives to owners of MUDs to promote EVSE deployment?
- Is there a way to limit liability costs to property owners deploying EVSE? Is there a business case for deploying EVSE?

Information Needed/Offered

- How does a municipality educate Landlord Associations?

Other Issues

- How could EVs and EVSE apply to car sharing in low-income communities?
- What is the role of integrating EVSE with renewable energy? Is there some way to better monetize renewable energy infrastructure development?
- Can we learn from past EVSE experiences—for example, Santa Monica had a number of curbside EVSE in the 1990s for the first generation of EVs. How does a municipality evaluate whether or not to allow curbside EVSE based on past experiences?
- Significant research on EVSE access and utilization has already been performed. Nissan has collected data from 11,000 LEAF customers (over 20 million miles), including driving and charging habits. Can Nissan share the information as aggregate data?
- Should there be separate preferred parking? Could it frustrate other drivers and create questions about equity?

V. Discussion of Issues

Following the lunch break, DVRPC and its project partners developed three major issues to discuss with attendees. The information provided should be delineated between curbside, shared, and dedicated parking. The three issues included: how to use existing infrastructure for vehicle charging, feasibility of neighborhood EVSE hubs, and EVSE success stories. The goal of the exercise was to highlight the major discussion points for each issue, including potential solutions. Discussion points for each of the issues were as follows:

1) How do you capture the value of existing infrastructure?

- How to get electricity to the street level?
- Must resolve other issues (e.g., safety and vandalism). Vandalism could occur to steal copper from the EVSE cables.
- PECO would envision working with another party that owns, maintains, or sells EVSE; they are not in a position to act independently without the request of a customer. PA PUC would not be supportive of PECO acting as an EVSE provider.

- There may be a pilot project between National Grid³⁷⁷ and Coulomb Technologies to deploy EVSE on existing utility poles, currently assessing the costs and potential issues. Coulomb Technologies has also completed a project in the City of San Jose using light poles for EV charging.
- Utilities warn against assuming that there is sufficient power available on utility poles for EVSE.
- If customers were to express interest in using specific infrastructure for vehicle charging, the utility would assess the ability to meet this demand through meter analysis and an application process based on the particular area. Important to begin the process of review with the utilities early in the exploration phase.
- Municipality may need to charge the customer for electricity (e.g., City of San Jose), or otherwise it would be considered a “gift of public funds.”
- There are different franchises and franchising rules that will need to be considered. For any curbside EVSE installed on public property, a municipality may need to evaluate franchising options.
- Need to balance the needs of the community. If the municipality were to provide dedicated parking spots for EVs, it could anger other drivers, but lack of dedicated EV parking could lead to low usage of the EVSE.
- Curbside EVSE typically has a much higher installation cost. The EV Project³⁷⁸ focused on locations where infrastructure costs would be lower.
- There could be concerns about ADA accessibility with curbside parking. Some parking lots may have set asides, but according to some municipal interpretation, curbside parking should always be ADA compliant.
- There are opportunity costs of setting aside spots. Municipalities could lose revenue from those dedicated spaces, impacting businesses that depend on the parking supply.
- Need to be aware of tariffs for the location.
- Individual street lights are not metered, so what is a fair way to assign costs? Equipment doesn't exist for limited-access outlets or mobile metering. Do utilities charge for electricity no matter the use?
- In Boston, a vender is offering a payment system on mobile charging equipment.
- Baltimore has found that there are 11 different combinations of ownership/leasing of street lights, making EVSE integration very complicated.
- Use special business improvement districts as a way to finance EVSE.
- Enforcement issues - how does a municipality enforce dedicated EV spaces?
- How do municipalities structure ordinances to ensure fairness?
- Curbside parking should be a lower priority for densely packed urban areas. Minimally

³⁷⁷ <https://www1.nationalgridus.com/CorporateHub>

³⁷⁸ <http://www.theevproject.com/>

used surface lots may be a better option for EVSE. Also, may be able to use existing resources, such as EZ Pay Stations, and add EVSE charges to the parking fee.

- The Zipcar model is an example of found revenue because it utilized spaces that were not previously metered and created revenue for municipalities. Could do something comparable with EVSE and reinvest the funds into the neighborhoods for an added incentive and buy-in from the community.
- Licenses to purchase energy credits for EVSE could help to create good will among neighbors for unregulated Level 1 charging points, for example, PlugShare.³⁷⁹
- Need to anticipate the future needs of EVs as long-range batteries become more common. Level 1 charging may not work for every vehicle. For example, PHEVs charging needs differ significantly from long-range AEVs. Additionally, new technologies are becoming available, such as advanced flow batteries.
- For whom/what are you providing electricity? Daily drivers? Emergency needs?
- Infrastructure should be driven by demand. Level 1 may work for short distance needs, but what about long distance? Does DC fast charging play a role?
- Suggest that DVRPC perform a customer survey among existing EV owners to get a better feel for EVSE needs. University of California, Davis, has performed some research on behavioral studies, due to be released in September 2012.
- How much EVSE availability makes a difference for consumers?
- If owners of garages know they can make money, will they deploy EVSE? Will there be daytime and evening rates?
- PhillyCarShare³⁸⁰ currently owns 20 Chevrolet Volts and has access to public EVSE. The EVSE logistically could not be available to the public given the needs of the vehicles.
- Carshare programs even run into problems curbside irrespective of EVs.
- Philadelphia passed a law in 2007 to allow EV owners to obtain a dedicated spot, similar to an ADA request. However, it only reserves access to an individual spot. It does not necessarily facilitate the charging. No one has successfully installed EVSE in those spaces, though several people use the 110 volt plugs on their homes. Requests to install EVSE at the dedicated spaces would need to go through the planning division in the streets department; however, there is not a formal process to date. If the EV owner utilizes a standard extension cord to provide power across a walkway, it may cause pedestrian safety concerns.
- Virtual net metering may provide a good example of how to resolve billing issues at a location beyond the home meter. A third-party may own a system and allow people to buy shares. Those shares would in turn be billed to a home account. May also add charges directly onto a utility bill.
- Ports on vehicle could provide information about the distance to the EVSE.

³⁷⁹ <http://www.plugshare.com>

³⁸⁰ <http://www.phillycarshare.org/>

2) Neighborhood hubs: financing, ownership issues, on/off street

- The most expensive part of the infrastructure is underground, so installing multiple chargers at a “hub” makes sense. The same infrastructure may eventually be retrofitted with updated equipment if and when standards change.
- There could be a significant role for fleet solutions as part of regular charging patterns.
- Dedicated “real estate” is a possibility as demanded by residents; for example, spaces in Baltimore garages in Fells Point and Federal Hill were based on citizen requests.
- Community-based solar could be a model for EVSE ‘hubs.’ Additionally, EVSE could be added to existing solar infrastructure (e.g., solar canopies). Similar to solar infrastructure, how much infrastructure would you need to install in order to get a return on investment?
- Advertise existing units to residents through green cooperative groups or neighborhood associations and provide presentations to community groups.
- Educate or compel HOAs to consider EVSE options. When presented with HOA challenges, consider modeling state or local programs on:
 - A California law that prohibits HOA restrictions on EV owners (S.B. 209).³⁸¹
 - Proposed Illinois law requiring HOAs to provide responses to EVSE requests within 120 days.
 - State solar access laws could also be a good example of how to handle HOA issues.
- Massachusetts’ Green Communities Act³⁸² requires communities to evaluate options and opportunities to address a litany of issues, including the transportation concerns. Boston hosted a number of educational EVSE workshops targeting parking garage owners.
- Train garage attendants and valets about how to use EVSE. There may be business models that allow parking garage attendants to move around vehicles on individual chargers over the course of the night (also dedicated hotel valets).
- Beam Charging LLC³⁸³ is a third-party company based in New York City using Coulomb Technology EVSE and coordinating deployment with garage owners.
- There may be near-term opportunities for neighborhood hubs, but policy makers should also consider long-term opportunities related to redevelopment and master planning. Would there be a way to incorporate EVSE into infrastructure requirements, such as vacant lots? Important to keep in mind that early adopters who can afford expensive vehicles are not necessarily located near vacant lots.
- Public health benefits are a major reason for pushing EV deployment into community standards and could be used to justify the development of tax benefits for installing EVSE. EVSE installation tax benefits could act similarly to tax credits currently offered for redevelopment of existing buildings, which are a good way to incentive developers.

³⁸¹ <http://ca.opengovernment.org/sessions/20112012/bills/sb-209>

³⁸² <http://www.malegislature.gov/Laws/SessionLaws/Acts/2008/Chapter169>

³⁸³ <http://www.beamcharging.com>

Property tax abatement would be another option to incentivize property owners.

- How do you maintain density issues with dedicated hubs?
- The Baltimore City Master Plan³⁸⁴ is incorporating a certain number of bike parking spots for each group of vehicle spots; planners could also require new developments to install conduit/wire for each new park space (or a certain number of spaces per group of vehicle spots). Even just requiring the appropriate electrical infrastructure and conduit would cover a significant portion of the cost of retrofitting.
- Should Pennsylvania consider deploying special EV plates for identification, particularly to help emergency responders (e.g., Massachusetts plates and Maryland tags)?
- Based on GM's experience, potential EV drivers include HEV and luxury vehicle buyers.

3) Success stories of EVSE

- Coulomb Smart Phone App provides real-time information about EVSE availability and allows for better charging management.
- Street visibility is a great way to help neighbors know where EVSE is located.
- SemaConnect³⁸⁵ in Maryland has a business model targeting MUDs. It started with 58 EVSE and has been very successful.
- Baltimore Parking Authority has made EVSE available to the public. Despite limited availability, the units are being utilized. The city plans to add additional stations depending on demand and several neighborhoods have already requested curbside units.
- Massachusetts Clean Cities has received funding for 142 EVSE units throughout the state and is leveraging the dollars with private investment. Massachusetts Clean Cities is primarily targeting curbside and high visibility parking lots to attract more attention to the infrastructure.
- NYSERDA utilized Congestion Mitigation and Air Quality funds to perform a pilot project at commuter rail train stations.
- In Syracuse, New York, city and county officials developed ordinances related to EVSE accessibility.
- NYSERDA will shortly release an announcement about EVSE installations around the state as part of grant awards, many of which will target MUDs.
- In Maryland, SunTrust Bank³⁸⁶ in Bethesda installed EVSE charged by solar energy developed through collaboration with three separate vendors. GM dealerships in Maryland are also installing solar EVSE. Need to be mindful when incorporating renewable energy to consider the net metering and interconnection needs.
- MultiCharge SF³⁸⁷ is a fully funded program to be targeted at MUDs in San Francisco. EVSE is subsidized through a grant from the California Energy Commission. The program

³⁸⁴ <http://www.baltimorecity.gov/Government/AgenciesDepartments/Planning/ComprehensiveMasterPlan.aspx>

³⁸⁵ <http://www.semaconnect.com/>

³⁸⁶ <http://carstations.com/13485>

³⁸⁷ http://www.sfenvironment.org/downloads/library/Application-Draft_11-22.pdf

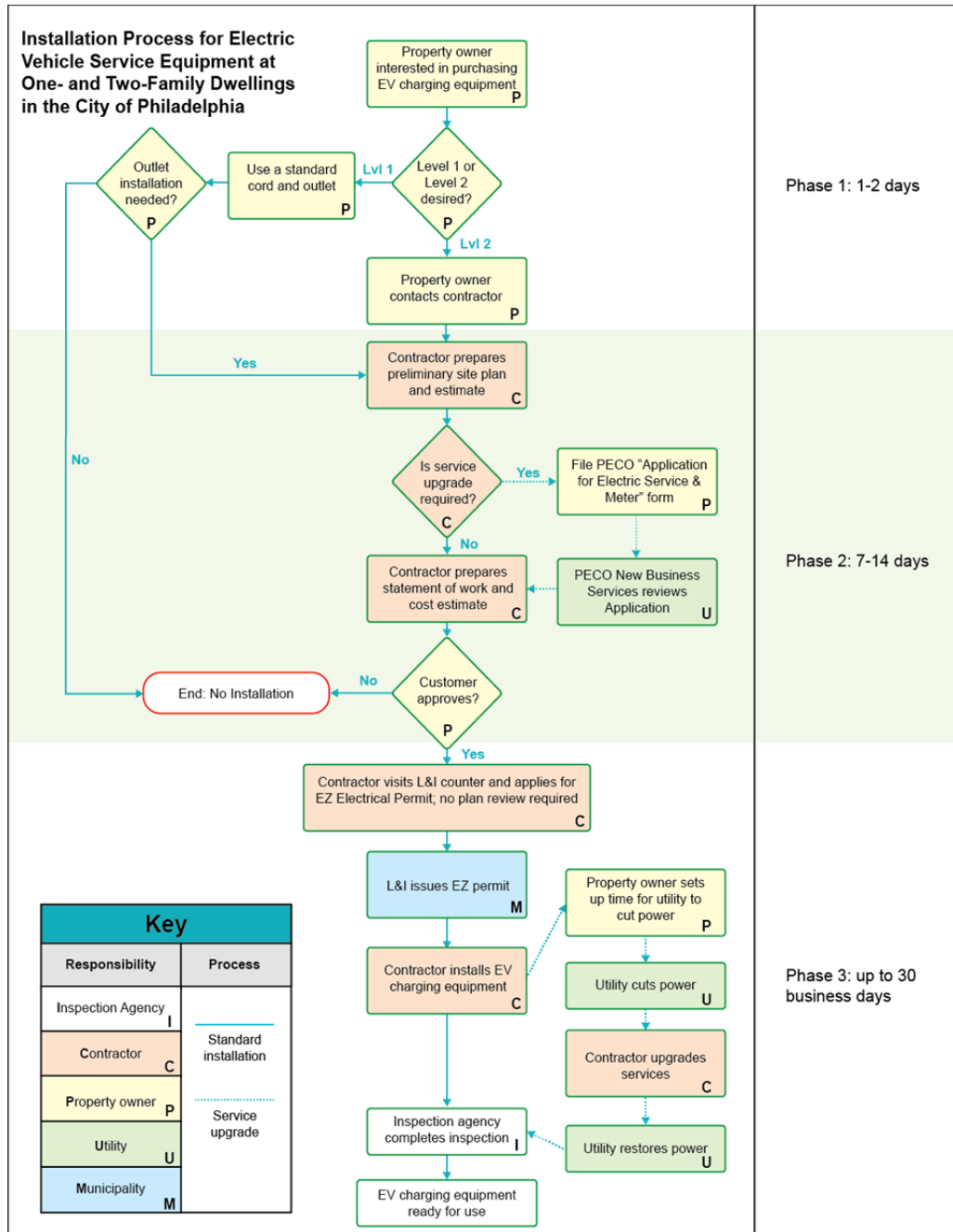
hosted workshops designed to educate property owners and business managers about the EVSE needs, and over 150 individuals attended the sessions. So far there have been 60 applications for the infrastructure. MultiCharge SF will be collecting data through 2013.

- In White Plains, New York, EV owners may obtain priority on a parking garage waiting list near a public transit station.
- Demonstration projects, no matter how small, are very useful to addressing local barriers and concerns regarding EVSE deployment. For example, the first eight stations in Baltimore City were extremely educational.
- Northeast utilities should help educate consumers about prioritizing their charging needs overnight.
- In cooperation with NRG Energy, the Washington Redskins installed 10 EVSE at the National Football League field, which are highly visible to the public.
- Washington, D.C., has found that the first adopters of solar energy are also first adopters of EVs.
- PhillyCarShare's Chevy Volts have been highly utilized and aid in educating mainstream drivers about the technology. The vehicles were also highlighted in conjunction with Philadelphia Clean Cities on MotorWeek.

VI. Follow-Up and Next Steps

Mr. Graff informed attendees that additional information about the meeting and follow-up action items would be circulated in the following weeks. Mr. Graff thanked the attendees for their participation and Mr. Nigro for his presentation. The meeting was adjourned at 3:00 p.m.

Appendix E. Philadelphia June 2012 Draft Residential Permitting Process Overview



Source: Sarah Wu (Philadelphia Mayor's Office of Sustainability), e-mail message to author, August 6, 2012.

City of Philadelphia Permit Application Process for Residential EVSE Installation

If you plan to install 240-V electrical outlets for Level 2 EVSE, coordinate with a licensed electric contractor and the provider of your EV charging equipment to avoid delay.

ONE- AND TWO-FAMILY DWELLINGS LEVEL 2 EVSE PERMITTING PROCESS

- Property owner contacts licensed electrical contractor to estimate cost of EVSE installation and prepare a site plan.
- Electrical contractor applies for EZ Electrical Permit from City of Philadelphia Licenses & Inspections and pays fees at time of submission.
- City of Philadelphia Licenses & Inspections reviews issues permit EZ permit.
- Contractor installs EVSE.
- Licensed electrical inspection agency inspects property.

To view the City of Philadelphia Licenses & Inspections Application for Electrical Permit, visit www.phila.gov/li or go directly to business.phila.gov/Documents/Permits/electricalPermit.pdf.

Applications for electrical permits must be submitted in person at one of the following locations:

Municipal Services Building – Concourse Level
1401 John F. Kennedy Boulevard
Philadelphia, PA 19102
(215) 686-8686 or 311

Northeast Philadelphia
Rising Sun Ave. & Benner St.
Philadelphia, PA
(215) 685-0581

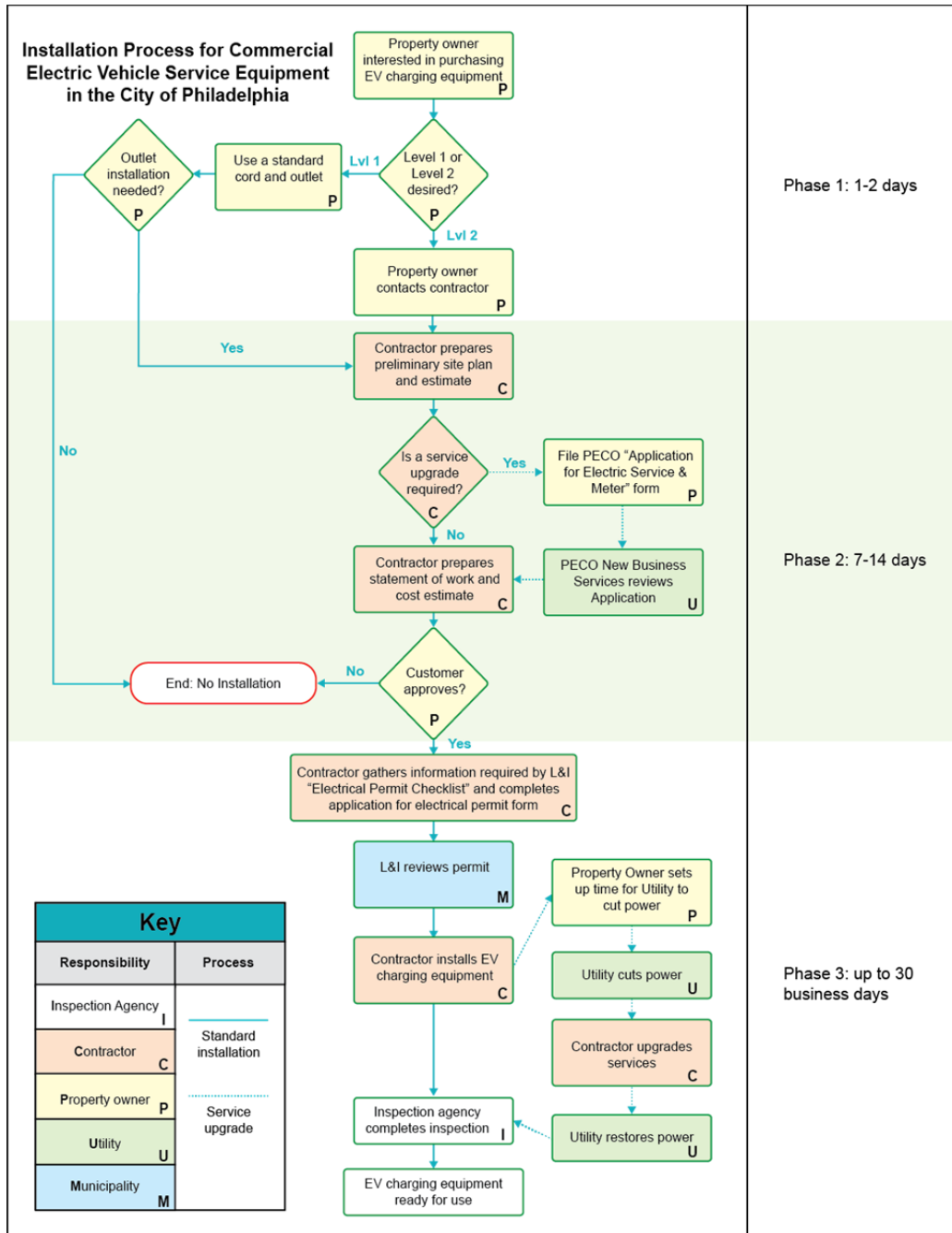
Central Philadelphia
990 Spring Garden St., 7th Floor
Philadelphia, PA 19123
(215) 685-3787

South Philadelphia
11th & Wharton Streets, 2nd Floor
Philadelphia, PA 19147
(215) 685-1576

North Philadelphia
217 E. Rittenhouse St.
Philadelphia, PA 19144
(215) 685- 2276

West Philadelphia
43rd & Market Streets
Philadelphia, PA 19104
(215) 685-7681

Appendix F. Philadelphia June 2012 Draft Commercial Permitting Process Overview



Source: Sarah Wu (Philadelphia Mayor's Office of Sustainability), e-mail message to author, August 6, 2012.

City of Philadelphia Permit Application Process for Commercial EVSE Installation

If you plan to install 240-V electrical outlets for Level 2 EVSE, coordinate with a licensed electric contractor and the provider of your EV charging equipment to avoid delay.

COMMERCIAL LEVEL 2 EVSE PERMITTING PROCESS

- Property owner contacts licensed electrical contractor to estimate cost of EVSE installation and prepare a site plan.
- Electrical contractor completes City of Philadelphia Application for Electrical Permit.
- Contractor submits application to Licenses & Inspections and pays fees at time of submission.
- City of Philadelphia Licenses & Inspections reviews application and issues permit or returns application with questions.
- Contractor installs EVSE.
- Licensed electrical inspection agency inspects property.

To view the City of Philadelphia Licenses & Inspections Application for Electrical Permit, visit www.phila.gov/li or go directly to business.phila.gov/Documents/Permits/electricalPermit.pdf.

Applications for electrical permits must be submitted in person at one of the following locations:

Municipal Services Building – Concourse Level
1401 John F. Kennedy Boulevard
Philadelphia, PA 19102
(215) 686-8686 or 311

Northeast Philadelphia
Rising Sun Ave. & Benner St.
Philadelphia, PA
(215) 685-0581

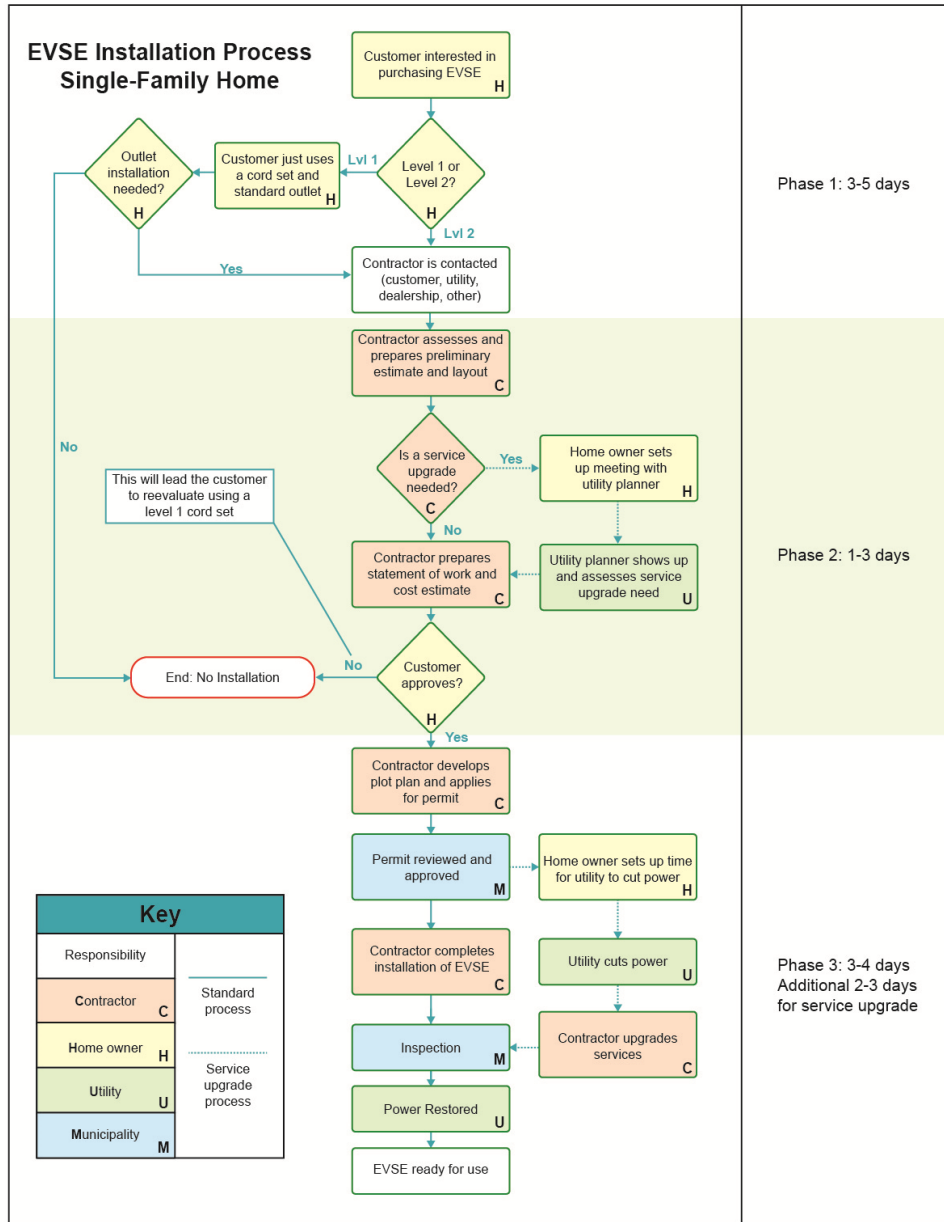
Central Philadelphia
990 Spring Garden St., 7th Floor
Philadelphia, PA 19123
(215) 685-3787

South Philadelphia
11th & Wharton Streets, 2nd Floor
Philadelphia, PA 19147
(215) 685-1576

North Philadelphia
217 E. Rittenhouse St.
Philadelphia, PA 19144
(215) 685- 2276

West Philadelphia
43rd & Market Streets
Philadelphia, PA 19104
(215) 685-7681

Appendix G. Raleigh Residential EVSE Installation Process



Source: City of Raleigh, North Carolina, "EVSE Installation Process," accessed June 2013, http://www.raleighnc.gov/content/AdminServSustain/Documents/EVSE_Install_Process.pdf.

Important Information

The Homeowner is Key

The Homeowner will make the decision as to whether they want a Level 2 EVSE or if Level 1 will be sufficient. The Homeowner also makes the approval for any work to take place.

The Homeowner will need to be home for any work being done, including service upgrade and inspection. It is important that the homeowner is informed of this as early as possible.

The Homeowner has to make appointments with the utility planner to assess the need for a service upgrade as well as to perform the upgrade.

The homeowner may be able to set a preference with their utility to allow the contractor to make these appointments.

Avoid Major Time Delays

Time delays occur primarily in the transfer of task ownership. Strong communications are required to expedite the process. The longest potential delays occur at the following steps:

Contractor is contacted: The period of time between the interest in EVSE purchase and actual arrival of the contractor on site can vary widely depending on the contractor's availability. Most Dealerships will have recommended EVSE manufacturers and installation networks which will be able to provide solutions to a new customer. For homeowners who opt to install different EVSE or are buying a used plug-in vehicle, utilities also have contractor networks that will benefit the overall process.

Homeowner sets up meeting with utility planner: When a service upgrade is needed, the homeowner will need to contact their utility planner to assess the need for a service upgrade. It may take two days for the utility planner to visit the site. At this point, the homeowner may elect to allow their contractor to schedule this appointment (if possible through the utility). Note that there may be additional time needed if service conductors or transformers need to be upgraded.

Homeowner sets up time for utility to cut power: Time must be coordinated with homeowner, contractor and utility to drop power if a service upgrade is required. Inspection must also take place before power is restored by Utility.

Know Who to Contact

Progress Energy Carolinas Customer Support: 1-800-452-2777

City of Raleigh Permits:

Litchford Customer Service Center

8320-130 Litchford Road
Raleigh, NC 27615
919-713-4200

Downtown Customer Service Center

One Exchange Plaza Suite 404
Raleigh, NC 27601
919-516-2495

City of Raleigh Permits: 919-516-2500 or 919-857-4412

Appendix H. Regulation Governing the Establishment of EV Parking Spaces Pursuant to Section 12-1131 of The Philadelphia Code

CITY OF PHILADELPHIA
Department of Streets

Regulation Governing the Establishment of Electric Vehicle Parking Spaces Pursuant to Section 12-1131 of The Philadelphia Code

§ 1. General.

(1) This Regulation is issued pursuant to § 12-1131 of The Philadelphia Code, which provides for reserved parking for electric vehicles.

(2) The Department of Streets hereby delegates to the Philadelphia Parking Authority, to the extent not expressly reserved to the Department of Streets or another agency by this Regulation, the authority to administer the granting, establishing, and administration of Electric Vehicle Parking Spaces.

(3) Definitions. The definitions set forth in § 12-1131(1) shall apply to this Regulation, and, further, the following terms shall have the following meanings:

EVC. Electric Vehicle Charger, as defined by § 12-1131(1).

EVPS. Electric Vehicle Parking Space, as defined by § 12-1131(1).

NEC. National Electrical Code (NFPA 70), published by the National Fire Protection Association, as in effect in the City of Philadelphia at the time of installation.

PennDOT. The Pennsylvania Department of Transportation.

PPA. The Philadelphia Parking Authority.

§ 2. Application Process.

(1) Applicants shall provide all of the following to PPA:

- (a) A PennDOT vehicle registration indicating that the electric vehicle is owned or leased by an individual who is a resident of the address at which the reserved parking space is sought.
- (b) A copy of the applicant's current driver's license identifying the applicant and showing the applicant's current address. A copy of an amending document, issued by the same agency that issued the driver's license, showing an updated address, shall be acceptable proof of address when accompanied by a copy of the original driver's license.
- (c) Proof that the owner of the property at which the reserved parking space is sought, if such person is not the applicant, consents to the placement of an EVPS in front of the property.
- (d) Where the proposed parking space would encroach on the frontage of any neighboring property, written consent from the owners of all such properties.
- (e) A clear photograph showing the entire area in which the EVPS would be located, and the front of all property abutting the proposed EVPS.
- (f) A scale plan of the right of way in front of property for 20 feet on either side of property, showing the entire width of the street, with labels indicating directions of travel, and the entire width of the sidewalk abutting the property. Where the electric vehicle requires a space larger than 20 feet on the longest side, a description of vehicle from the manufacturer showing the vehicle length shall also be included.
- (g) If the applicant seeks Department of Streets approval for less than five feet of passable sidewalk space under § 3(1)(d), such request shall be made with the application, and PPA shall forward the request to the Department of Streets for review.
- (h) A \$50 application fee.
- (i) Following approval of the EVPS by PPA, a copy of the application to the Department of Licenses and Inspection for an electrical permit to install an EVC at the EVPS.

§ 3. Approval of Proposed EVPS by PPA.

(1) Upon the filing of an application with PPA pursuant to § 2, the PPA shall investigate the proposed EVPS location to determine whether it is practical and feasible with respect to traffic operations. A proposed EVPS shall be deemed practical and feasible with respect to traffic operations if it is consistent with public safety and convenience pursuant to the following criteria:

- (a) The proposed EVPS meets traffic safety requirements, as follows:
 - (i) The proposed EVPS must be no more than 20 feet in length, unless a greater length is necessary, based on the size of the vehicle.

(ii) The proposed EVPS shall not be in any location where parking is currently prohibited by state or local law.

(iii) The proposed EVPS is otherwise consistent with traffic safety.

(b) No garage, driveway, or other location not in the right of way is available to the applicant for parking of the Electric Vehicle.

(c) The number of reserved on-street parking spaces, of any kind, on a blockface, does not exceed:

(i) on blocks with single-side parking – three (3);

(ii) on blocks shorter than 500 feet in length, with parking on both sides – four (4);

(iii) on blocks that are 500 feet or longer in length, with parking on both sides – five (5).

(d) The proposed EVC shall not interfere with pedestrian movement on the sidewalk, and shall leave at least five feet of passable space between the EVC and the edge of the sidewalk farthest from the street. Where the total space required under this subsection (1)(d) is insufficient to allow five feet of passable space between the EVC and the edge of the sidewalk farthest from the street, an applicant may, pursuant to § 2(1)(g), request a smaller width of passable space that permits free passage of pedestrians and conforms to law, but in no event shall such width be less than three feet. The EVC shall be placed at least two feet, but not more than three feet, from the point where the curb abuts the street.

(2) PPA shall not approve an EVPS where the applicant is liable for any delinquent fines or penalties under § 12-2809(2) of the Code.

§ 4. Approval by the Department of Licenses and Inspections and Installation of Electric Vehicle Charger.

(1) Following approval by PPA pursuant to § 3 of this Regulation, the applicant shall apply for an electrical permit from the Department of Licenses and Inspections for the installation of an EVC. Installations shall conform to the NEC, including provisions of the NEC specific to Electric Vehicle Charging Systems, and be performed by a licensed electrical contractor pursuant to an electrical permit from the Department of Licenses and Inspections. The following additional criteria shall govern such installation as a condition of placing it in the sidewalk, unless otherwise specified by the Department of Licenses and Inspections, or the NEC imposes a more stringent requirement:

(a) The EVC must be located on a dedicated branch circuit with ground fault circuit protection at the main panel.

(b) A shut-off switch for the EVC must be installed inside the applicant's residence at the point of ingress and egress nearest the EVPS.

(c) The receptacle at which the Electric Vehicle is connected to the EVC must be secured by an outdoor weatherproof, lockable, NEC-compliant enclosure that will prevent tampering and unintentional contact with any portion of the EVC that is or may be electrified.

(d) The receptacle at which the Electric Vehicle is connected to the EVC must be no higher than 48 inches from the ground.

(e) There shall be no commercial use associated with the EVC.

(2) The electrical permit required by this § 4 shall be obtained prior to the installation of the EVC, or the commencement of any work thereon.

§ 5. Establishment of EVPS.

(1) An EVPS, once approved by PPA, shall not be established unless installation of the EVC is complete, and complies with § 4 of this Regulation .

(2) Upon installation of a properly functioning EVC, the PPA or the Department of Streets shall:

(a) Post the required signs designating the EVPS; and

(b) Mark the pavement to designate the EVPS. The Department of Streets may, in the alternative, provide the applicant with a permit to so mark the pavement, subject to such requirements as the Department of Streets may impose.

§ 6. Fee.

(1) The fee for an EVPS shall be in the same amount and determined in the same manner as the fee for a curb loading zone pursuant to § 12-905 of the Code.

(2) The fee shall initially be due upon approval by the Department of Licenses and Inspections of an electrical permit for the installation of an EVC.

(3) An EVPS may be revoked, and the EVPS and EVC may be removed by the Department of Streets or the PPA if such yearly renewal fee as required under § 12-905 is not timely paid in accordance therewith.

§ 7. Other Matters.

(1) The person to whom an EVPS has been issued shall immediately notify the PPA, and the EVPS may be immediately revoked, if any of the following events occur:

(a) The registration or license plate is transferred to a Non-Electric Vehicle;

(b) The Electric Vehicle is transferred to another owner who does not reside at the address for which the EVPS was established;

(c) The owner of the Electric Vehicle ceases to reside at the address for which the EVPS was established.

(2) An EVPS may be revoked under any of the following circumstances:

(a) Any condition necessary for the grant of the EVPS under this Regulation ceases to be met.

(b) The EVC or its associated wiring is not maintained in good repair or presents a hazard due to deterioration, malfunction, or improper use.

(c) Any excavation of the right of way for installation or maintenance of the EVC or associated wiring is not properly restored.

(3) The owner of an Electric Vehicle with respect to which an EVPS has been granted shall notify PPA of the registration of any other Electric Vehicle that such person intends to park in the EVPS regularly.

(4) An EVC shall be removed within 30 days of the revocation of an EVPS.

(5) No person shall acquire any ownership interest or exclusive parking rights in an EVPS. PPA may eliminate an EVPS at any time if the EVPS or the owner of the Electric Vehicle ceases to conform to the requirements of § 12-1131 or this Regulation.

Appendix I. Example State and Municipal Regulations

California

Regulatory Environment: Electrical contractors are licensed by the state³⁸⁸ and they must employ only state certified electricians.³⁸⁹ Renewal requirements for electricians consist of 32 hours of continuing education every three years. California has implemented a statewide mandatory California Green Building Standards or CALGreen.³⁹⁰ CARB is charged with implementing Assembly Bill 32, The Global Warming Solutions Act, to reduce greenhouse gas emissions³⁹¹ supported by a decoupled electric utility marketplace.

State of California

The Department of Fair Housing and Community Development adopted CALGreen modifications to require all new construction of single-family and multiunit dwellings to preinstall a dedicated branch circuits for Level 2 EVSE.³⁹²

Assembly Bill No. 475 (2011)³⁹³

Summary: Amends Section 22511 of the California Vehicle Code to read: "A local authority, by ordinance or resolution, and a person in lawful possession of an off-street parking facility may designate stalls or spaces in an off-street parking facility owned or operated by that local authority or person for the exclusive purpose of charging and parking a vehicle that is connected for electric charging purposes."

City of Los Angeles

Electrical Permit Application (2011)³⁹⁴

Summary: The Department of Building and Safety handles EVSE permitting. The Department of Water and Power initiated a stakeholder group to discuss, among other issues, ways to adapt local codes and standards that encourage deployment of EVs. The city recently approved a new online application for Electric Vehicle Charger to process permits within 24 hours.

City of Riverside

EV Charger Installation Guidelines (2011)³⁹⁵

³⁸⁸ State of California Contractors State License Board, "Home Page," accessed June 2013, <http://www.cslb.ca.gov/>.

³⁸⁹ State of California Department of Industrial Relations, "Division of Apprenticeship Standards," accessed June 2013, <http://www.dir.ca.gov/das/ElectricalTrade.htm>.

³⁹⁰ California Building Standards Commission, "California Green Building Standards Code," accessed June 2013, http://www.documents.dgs.ca.gov/bsc/calgreen/2010_ca_green_bldg.pdf.

³⁹¹ CARB, "Assembly Bill 32: Global Warming Solutions Act," accessed June 2013, <http://www.arb.ca.gov/cc/ab32/ab32.htm>.

³⁹² California Department of Housing and Community Development, "Final Express Terms for Proposed Building Standards of the Department of Housing and Community Development," accessed June 2013, http://www.hcd.ca.gov/codes/sh/ET_CALGreen_FINAL_REV%207-20-11.pdf.

³⁹³ California General Assembly, "Bill No. 475," accessed June 2013, http://www.leginfo.ca.gov/pub/11-12/bill/asm/ab_0451-0500/ab_475_bill_20110907_chaptered.pdf.

³⁹⁴ Los Angeles, California, Department of Building and Safety, "Application for Electrical Permit," accessed June 2013, <http://ladbs.org/LADBSWeb/forms.jsf>.

Summary: The purpose of this guideline is to assist homeowners and contractors in streamlining the permitting and installation process for home EVSE. The Riverside Public Utilities provides electricity to residents.

City of Sunnyvale

*Ordinance 2964-11 (2011)*³⁹⁶

Summary: Amends Chapter 16.43 (Green Building Code) of Title 16 (Building and Construction) of the Sunnyvale Municipal Code, by requiring prewiring for EVSE in new construction to accommodate Level 2 EVSE in all garages or carports accessory to single-family dwelling, residential developments with attached individual garages or carports, and 12.5 percent of the total required parking spaces in residential developments with common shared parking.

Hawaii

Regulatory Environment: Electrical contractors are licensed by the state and journeymen electricians are tested and certified by the state with a continuing education requirement for certification renewal.³⁹⁷ Hawaii Building Codes Commission approved adoption of 2008 NEC, as no statewide electric code exists.

State of Hawaii

*Act 291 (1997)*³⁹⁸

Summary: Revised statutes to the Hawaii Department of Transportation code to issue special EV license plates, which permit free parking at state and county facilities for EVs and allow EV access to HOV lanes with only a single occupant.

*Act 156 (2011)*³⁹⁹

Summary: Requires large parking facilities to designate one percent of parking for EV charging and up to two percent once 5,000 EVs are registered in the state.

*Act 186 (2010)*⁴⁰⁰

Summary: Permits an individual to install EVSE on or near the parking stall of any multifamily residential dwelling or townhouse owned by that person and permits private entities to adopt rules reasonably restricting the placement and use of EVSE provided that those restrictions do not prohibit the placement or use of the EVSE altogether.

³⁹⁵ City of Riverside, California, Building and Safety Division, "Electric Vehicle Charger Installation Guidelines," accessed June 2013, <http://www.riversideca.gov/building/pdf/handouts/EV-Charger-Guidelines.pdf>.

³⁹⁶ City of Sunnyvale, California, "Ordinance No. 2964-11," accessed June 2013, <http://qcode.us/codes/sunnyvale/revisions/2964-11.pdf>.

³⁹⁷ Hawaii Department of Commerce & Consumer Affairs, "Licensing Area: Electrician and Plumber," accessed June 2013, <http://hawaii.gov/dcca/pvl/boards/electrician/>.

³⁹⁸ Hawaii State General Assembly, "Act 290," accessed June 2013, <http://energy.hawaii.gov/wp-content/uploads/2011/09/Act-2902.pdf>.

³⁹⁹ Hawaii State General Assembly, "Hawaii Revised Statutes 0291, Part IV. Miscellaneous," accessed June 2013, http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0291/HRS_0291-0071.htm.

⁴⁰⁰ Hawaii State General Assembly, "Hawaii Revised Statutes 0196, section 196-7.5," accessed June 2013, http://capitol.hawaii.gov/hrscurrent/Vol03_Ch0121-0200D/HRS0196/HRS_0196-0007_0005.htm

Oregon

Regulatory Environment: An electrical contractor license is a specialized license allowing a company to engage in the business of making electrical installations. This license is required in addition to licensing and bonding required by the Construction Contractors Board.⁴⁰¹ Electrical contractors must employ at least one electrical supervisor. Additionally, the state certifies journeymen electricians, who are required to attend 24 hours of continuing education every three years to maintain their certification.⁴⁰² Oregon has a statewide Energy Efficiency Specialty Code, which all cities and counties must meet and may exceed.⁴⁰³

City of Portland

*Resolution No. 36749 - Implementation of Policies and Programs to Reduce Local Emissions of Greenhouse Gases (2009)*⁴⁰⁴

Summary: The Bureau of Transportation developed standards for permitting EVSE in the right of way, seeks further funding and develops partnerships to promote EVs and EVSE as a clean alternative.

Texas

Regulatory Environment: Anyone who performs electrical work in the State of Texas must be licensed (some states use the term "certification").⁴⁰⁵ Electrical contractors must be licensed master electricians or employ master electricians. Four hours of continuing education need to be completed every 18 months for license renewal.

City of Houston

*Electrical Permitting*⁴⁰⁶

Summary: The city has incorporated EV permitting into its existing online express permitting process. The Code Enforcement Group can issue permits within one day.

Washington

Regulatory Environment: Electrical contractors (electrical administrators) and electricians must be licensed by the Washington Department of Labor and Industries. State law prohibits city or county electrical licensing or certification. Electrical administrators, electricians, and master electricians must take 24 hours of continuing education courses for renewing their certificates.⁴⁰⁷

⁴⁰¹ State of Oregon, "Licenses, Permits and Registrations," accessed June 2013, http://licenseinfo.oregon.gov/index.cfm?fuseaction=license_seng&link_item_id=1536.

⁴⁰² State of Oregon, "Licenses, Permits and Registrations."

⁴⁰³ ICC, "Oregon Codes," accessed June 2013, http://ecodes.biz/ecodes_support/free_resources/Oregon/10_Energy/10_OREnergy_main.html.

⁴⁰⁴ Office of the City Auditor, "Implementation of Policies and Programs to Reduce Local Emissions of Greenhouse Gases," accessed June 2013, <http://www.portlandonline.com/auditor/index.cfm?a=287960&c=29151>.

⁴⁰⁵ Texas Department of Licensing and Regulation, "Electrical Safety and Licensing Frequently Asked Questions," accessed June 2013, <http://www.license.state.tx.us/electricians/elecfaq.htm>.

⁴⁰⁶ DOE, "Houston's Plug-In Vehicle Activities and Progress."

⁴⁰⁷ Washington Department of Labor and Industries, "Electrical," accessed June 2013, <http://www.lni.wa.gov/tradeslicensing/electrical/>.

Regional Transportation Organizations: Any regional transportation planning organization containing a county with a population greater than one million must collaborate with state and local governments to promote EV use, invest in EVSE, and seek federal or private funding for these efforts. Collaborative planning efforts may include: 1) developing short- and long-term plans outlining how state, regional, and local governments may construct EV charging locations and ensure that the infrastructure can be electrically supported; 2) supporting public education and training programs on EVs; 3) developing an implementation plan for counties with a population greater than 500,000 to have 10 percent of public and private parking spaces ready for EV charging by December 31, 2018; and 4) developing model ordinances and guidance for local governments for site assessment and installing EV infrastructure.⁴⁰⁸

In Washington, the state's EV law (HB 1481) requires that all local governments in the state allow EVSE in most of their zoning categories. Recognizing that this would create the need to address a number of issues beyond zoning, HB 1481 also required PSRC to develop "model ordinances and guidance for local governments related to the siting and installation for electric vehicle infrastructure."⁴⁰⁹

PSRC

*Model Ordinance*⁴¹⁰

Summary: PSRC has provided sample ordinance language per the requirements of HB 1481, which jurisdictions may utilize for their adopting ordinances. In the State of Washington, the language from the model ordinance can be used unchanged or modified to suit local government needs. The model ordinance can easily be tailored to communities outside of Washington, and includes text and "whereas" findings that jurisdictions may choose to provide regarding regional and state coordination, where such coordination exists (e.g., countywide planning policies and development regulations that implement these policies).⁴¹¹ Broadly, the Electric Vehicle Infrastructure Sections contain the following categories of sample language:

- Definitions;
- Vehicles and Traffic;
- Zoning;
- Streets, Sidewalks, and Public Places;
- State Environmental Policy Act compliance; and
- State Battery, Building, and Electrical Provisions.

King County

⁴⁰⁸ Washington State Legislature, "Regional Transportation Planning Organization," accessed June 2013, <http://apps.leg.wa.gov/rcw/default.aspx?cite=47.80>.

⁴⁰⁹ Washington State Legislature, "HB 1481 – 2009-2010: Regarding Electric Vehicles," accessed June 2013, <http://apps.leg.wa.gov/billinfo/summary.aspx?year=2009&bill=1481>.

⁴¹⁰ PSRC, "Electric Vehicle Infrastructure: A guide for local governments in Washington State," 11-14, accessed June 2013, www.psrc.org/assets/4325/EVI_full_report.pdf.

⁴¹¹ PSRC, "Section 1. Model Ordinance Regarding Electric Vehicle Infrastructure and Batteries," accessed June 2013, http://psrc.org/assets/4328/EVI_report_Sec1_Ordinance.pdf.

*Ordinance 2009-0631 (2010)*⁴¹²

Summary: Establishes demonstration program for EVSE at county facilities, sets criteria for deciding where to locate the charging stations, and defines policies for the operation of the program.

City of Bellevue

*Resolution No. 515*⁴¹³

Summary: Approved City Council Ordinance 5989, which amends the Bellevue Land Use Code allowing EVSE and related infrastructure in all land use districts.

*Ordinance 5989*⁴¹⁴

Summary: Amends the current Land Use Code to allow EVSE and related infrastructure. Provides glossary definitions and requires battery exchange stations to be an ancillary use only to auto repair and washing services and are permitted as a component of that use.

*Title 20 Land Use Code, 20.10.010*⁴¹⁵

Summary: Allows EVSE and related infrastructure in all land use districts where accessory parking, auto parking, park and rides, street and highway rights-of-way parking, gasoline service stations, auto repair, or vehicle maintenance is allowed.

City of Everett

Ordinance 3210-11 (2011)^{416 417}

Summary: Amends Ordinance sections 19.04.020, 19.05, and Table 5.2; incorporates revised EVSE and related infrastructure definitions to the City of Everett Zoning Code.

City of Issaquah

*Ordinance 2587 (2010)*⁴¹⁸

Summary: Amends Chapter 18.02 and Section 18.06.130; incorporates provisions for EVSE and related infrastructure by adding a definition for “electric vehicle” and permitting EV infrastructure in most zoning districts in the city.

City of Mountlake Terrace

*Ordinance 2553 (2010)*⁴¹⁹

⁴¹² King County, Washington, “Development and Use of Electric Vehicle Charging Stations at King County Facilities,” accessed June 2013 http://mkcclegisearch.kingcounty.gov/LegislationDetail.aspx?ID=596851&GUID=59CDD462-DB96-4A06-A0EF-19DF496D20AE&Options=&Search_

⁴¹³ City of Bellevue, Washington, “Resolution No. 515,” accessed June 2013, <http://www.bellevuewa.gov/pdf/Community%20Council/Res-515.pdf>.

⁴¹⁴ City of Bellevue, Washington, “Ordinance No. 5989,” accessed June 2013, <http://www.bellevuewa.gov/Ordinances/Ord-5989.pdf>.

⁴¹⁵ Bellevue City Code, “Title 14: Transportation Code,” accessed June 2013, <http://www.codepublishing.com/wa/bellevue/?/Bellevue14/Bellevue14.html>.

⁴¹⁶ City of Everett, Washington, “Chapter 4: Zoning Code Definitions,” accessed June 2013, <http://www.mrsc.org/mc/everett/everet19/everet1904.html#4>.

⁴¹⁷ City of Everett, Washington, “Chapter 5: Use Tables,” accessed June 2013, <http://www.mrsc.org/mc/everett/everet19/everet1905.html#5>.

⁴¹⁸ City of Issaquah, Washington, “Ordinance No. 2587,” accessed June 2013, <http://www.mrsc.org/ords/i75o2587.pdf>.

⁴¹⁹ City of Mountlake Terrace, Washington, “Ordinance No. 2553,” accessed June 2013, <http://www.mrsc.org/ords/m67o2553.pdf>.

Summary: Amends Municipal Code 19.125.140 and Chapter 19.126; provides guidance for municipal EVSE deployment, including permitted locations, facilities where EV charging stations will be required; accessibility requirements, parking restrictions, and signing requirements.

City of SeaTac⁴²⁰

Chapter 15.40, Ordinance 12-1001 (2012)

Summary: Adopts state model ordinances in totality.

⁴²⁰ City of SeaTac, Washington, "Chapter 15.40: Electric Vehicle Infrastructure," accessed June 2013, <http://www.codepublishing.com/WA/Seatac/html/Seatac15/seatac1540.html#15.40>.

Appendix J. Summary of NEC Adoption by State

State	Adoption	Implementation		State	Adoption	Implementation	
Alabama	October 1, 2012	Local	State	Montana	May 2010	7/30/10	
Alaska	January 1, 2009 →	1/1/09		Nebraska	6/9/11	8/27/11	
Arizona	Local Adoption	See Adoption Report		Nevada	Local Adoption	See Adoption Report	
Arkansas	August 16, 2011 →	1/1/12		New Hampshire	June 2011 →	7/1/11	
California	Jan 2010	1/1/2011		New Jersey	3/30/12	5/7/12	
Colorado	Jan 24, 2011	7/1/11		New Mexico	????	11/1/11	
Connecticut	Chose to stay 2005	08 Under Review		New York	12/28/09	July 2010	
Delaware	June 9, 2009	11/11/09		North Carolina	9/1/2011	7/3/2012	
Florida	June 2009	1/1/09		North Dakota	1/1/11	9/1/11	
Georgia	November 2008	1/1/12		Ohio	May 2011	11/1/11	●
Hawaii	4/16/10	varies		Oklahoma	2011 Effective 11/1/12		
Idaho	8/15/07	7/1/08		Oregon	January 2011 →	4/1/011	
Illinois	Local Adoption →	See Adoption Report		Pennsylvania	Ref to IBC – 12/10/09	1/1/10	
Indiana	August 2009	9/26/09		Rhode Island	Adopted June 20, 2011	8/1/11	
Iowa	9/15/11	1/1/12		South Carolina	Accepted 2/25/09	9/1/09	
Kansas	Local Adoption →	See Adoption Report		South Dakota	6/7/11	7/1/11	
Kentucky	February 17, 2011	2/1/12		Tennessee	December 2008	1/28/09	
Louisiana	April 14, 2009	1/1/10		Texas	State & Local Adoption →	Local	State
Maine	Adopted July 2011	7/19/11		Utah	July 2012 (2009 IRC 1 & 2 Family Dwellings)	7/1/2012	
Maryland	Local Adoption →	See Adoption Report		Vermont	7/1/11	7/1/11	
Massachusetts	December 8, 2010	1/1/11		Virginia	1/24/11	3/1/11	
Michigan	October 2009	12/2/09		Washington		12/31/08	
Minnesota	6/17/11	8/1/11		West Virginia	7/1/10	9/1/10	
Mississippi	Local Adoption →	See Adoption Report		Wisconsin	9/1/08	3/1/09	
Missouri	Adopted 05' NEC 5/1/08	2008 NEC not until 5/11'		Wyoming	2/15/11	7/1/11	

Key	
2011 NEC – 27 States	2008 NEC – 15 States
2005 NEC – 1 States	Local Adoption – (7)

Source: National Electrical Manufacturers Association, "NEC Adoption by State," accessed June 2013, <http://www.nema.org/Technical/FieldReps/Documents/Combined-NEC-Adoption-Report-No-IRC.pdf> and <http://www.nema.org/Technical/FieldReps/Documents/NEC-Adoption-Map-PDF.pdf>.

Appendix K. Sample EV Incentives & Programs

Many incentive programs already exist for EVs and EVSE. The following table provides examples of the various types of incentive programs, organized by the four main types described in this document: tax incentives, direct funding, exemptions, and privileges. The target audience indicates how the incentive would apply if it were tailored for EVs and EVSE. Some incentive programs are more appropriate for implementation by federal or state government (e.g., tax incentives), while others can be implemented by local governments (e.g., exemptions and privileges). Local-level examples are provided below when available.

Incentive	Entity	Description	Target Audience
Tax Incentives⁴²¹			
Tax Credits	Arizona	A tax credit of up to \$75 is available to individuals for the installation of qualified EVSE in a house or housing unit that they have built.	Residential EVSE consumer
Reduced Sales Tax	Washington	The purchase or lease of a new EV before July 1, 2015, is exempt from state motor vehicle sales and use tax.	EV purchaser/lessees
Sales Tax Exemption	New Jersey	ZEVs sold, rented, or leased in the state are exempt from state sales and use tax.	EV purchaser/lessee/renter
Reduced Vehicle License Tax	Arizona	The initial annual vehicle license tax on an AFV is lower than the license tax on a conventional vehicle. The vehicle license tax on an AFV is \$4 for every \$100 in assessed value.	EV owner
Reduced Personal Property Tax	Loudon County, VA	EVs are taxed at a personal property tax rate of \$2 per \$100 of assessed value (effective January 1, 2010), which is lower than the general personal property rate of \$4.20 per \$100.	EV owner
Reduced Industrial Property Tax	Michigan	A tax exemption may apply to industrial property use for high-technology activities, including those related to advanced vehicle technologies, such as EVs and their components.	Industrial property owner

⁴²¹ Information on tax incentives comes from the following sources: Arizona State Legislature, "Title 43 – Taxation of Income: 43-1090 and 43-1176," accessed June 2013, <http://www.azleg.gov/ArizonaRevisedStatutes.asp?Title=43>; Washington State Legislature, "Revised Code of Washington Title 83 - Excise taxes: Section 82.08.809," accessed June 2013, <http://apps.leg.wa.gov/RCW/default.aspx?cite=82.08.809>; New Jersey Department of Treasury, "Sales Tax Exemption – Zero Emission Vehicle (ZEV)," accessed June 2013, <http://www.state.nj.us/treasury/taxation/zevnotice.shtml>; Arizona State Legislature, "Title 28 – Transportation: 28-5805 and 28-5801," accessed June 2013, <http://www.azleg.gov/ArizonaRevisedStatutes.asp?Title=28>; Loudoun County Government, "Vehicle Personal Property Tax - Clean Special Fuel and Electric Vehicles," accessed June 2013, http://www.loudoun.gov/faq.aspx?TID=70#a_70; Michigan Legislature, "Michigan Compiled Laws Chapter 207 – Taxation: 207.552 and 207.803," accessed June 2013, [http://www.legislature.mi.gov/\(S\(23tcqrqvqkpbpa4bpea1tbj45\)\)/mleg.aspx?page=getObject&objectName=mcl-chap207](http://www.legislature.mi.gov/(S(23tcqrqvqkpbpa4bpea1tbj45))/mleg.aspx?page=getObject&objectName=mcl-chap207).

Incentive	Entity	Description	Target Audience
Direct Funding⁴²²			
Rebates	City of Riverside, CA	City of Riverside residents and employees are eligible to receive a rebate toward the purchase of qualified natural gas or electric vehicles purchased from a City of Riverside automobile dealership. The rebate is worth up to \$2,000 for a new vehicle or \$1,000 for a used vehicle.	EV purchaser
	City of Corona, CA	Residents can receive rebates of \$2,000 for the purchase of a new qualified AFV, including EVs, or \$1,000 for a qualified used vehicle while funds last.	EV purchaser
	San Joaquin Valley Air Pollution Control District	The Public Benefit Grant Program provides funding to cities, counties, special districts, and public educational institutions for purchase of new AFVs; EVSE and alternative fueling infrastructure projects; and advanced transportation and transit projects.	EV purchaser, EVSE installer (government and public institution)
Grants	City of Dallas, TX; North Central Texas Council of Governments	The North Texas Green & Go Clean Taxi Partnership facilitates the replacement of existing taxis with low emission vehicles through a grant program to offset incremental costs and implement other nonfinancial incentives for the purchase of cleaner vehicles.	EV fleet purchaser
	New York	The New York Truck - Voucher Incentive Program will provide funding to speed the introduction of low-emitting trucks and buses, including EVs, into the transportation sector in New York.	Organizations that sell, convert, or retrofit vehicles with advanced vehicle technology
Loans	Nebraska	Low-cost loans up to \$750,000 are available to support alternative fuel projects, including replacement of conventional vehicles with AFVs; purchase of new AFVs; conversion of conventional vehicles to operate on alternative fuels; and construction or purchase of a fueling station or equipment.	EV purchaser, EV fleet operator or purchaser, EVSE installer

⁴²² Information on direct funding comes from the following sources: City of Riverside, California, "Alternative Fuel Vehicle Rebate Program," accessed June 2013, <http://www.riversideca.gov/air/alternativefuel.asp>; City of Corona, California, "Alternative Fuel Vehicle Rebate Program," accessed June 2013, <http://www.discovercorona.com/City-Departments/Public-Works/Public-Services-and-Information/Alternative-Fuel-Vehicle-Rebate-Program.aspx>; San Joaquin Valley Air Pollution Control District, "Public Benefit Grant Program," accessed June 2013, http://www.valleyair.org/Grant_Programs/GrantPrograms.htm#PublicBenefitGrantProgram; North Central Texas Council of Governments, "North Texas Green & Go Partnership," accessed June 2013, <http://www.nctcog.org/trans/air/programs/fleet/regulated/GreenTaxi.asp>; NYSERDA, "New York Truck - Voucher Incentive Program," accessed June 2013, <https://truck-vip.ny.gov/>; Nebraska Government, "Dollar and Energy Saving Loans," accessed June 2013, <http://www.neo.ne.gov/loan/index.html>.

Incentive	Entity	Description	Target Audience
Exemptions⁴²³			
Regulation of Rates, Terms, and Conditions	Florida	EV charging for the public by a nonutility is not considered a retail sale of electricity and, therefore, the rates, terms, and conditions of EV charging services are not subject to regulation.	EVSE provider
HOV Lane Passenger Requirements	Hawaii	Qualified EVs affixed with special state-issued license plates may use HOV lanes regardless of the number of passengers.	EV owner
Driving Restrictions	District of Columbia	EVs and other certified clean fuel vehicles are exempted from time-of-day and day-of-week driving restrictions and commercial vehicle bans.	EV driver
Parking Fees	City of New Haven, CT	The City of New Haven provides free parking on all city streets for HEVs and AFVs registered in New Haven that have an EPA city or highway fuel economy rating of at least 35 mpg. Vehicles owners must display a nontransferable pass from the Department of Traffic and Parking.	EV owner
	City of Cincinnati, OH	The city's All-Electric Vehicle Incentive Pilot Program offers free parking to EVs at three city-owned garages and one city-owned parking lot, as well as at all parking meters within the city limits.	EV driver
Registration Fees	New York	*Pending legislative action: New EVs, clean fuel vehicles, and vehicles that meet the clean vehicle standards would be exempt from the first year of registration fees.	EV owner
	Illinois	*Reduction, rather than full exemption: Individuals may register a EV at a discounted registration fee of no more than \$18 per year.	EV owner
Inspection and Maintenance Requirements	Nevada	AFVs are exempt from the emissions testing requirements of the Nevada Emissions Control Program. New HEVs are exempt for the first six years, after which vehicles must comply annually with emissions inspection testing requirements.	EV owner

⁴²³ Information on exemptions comes from the following sources: Florida Senate, "Florida Statutes Title 27 – Railroads and Other Regulated Utilities: 366.94," accessed June 2013, <http://www.flsenate.gov/Laws/Statutes/2012/Title27/#Title27>; Hawaii State Legislature, "Senate Bill 2746," accessed June 2013, http://www.capitol.hawaii.gov/measure_indiv.aspx?billtype=SB&billnumber=2746; District of Columbia, "50-702" and "50-714," accessed June 2013, <http://www.lexisnexis.com/hottopics/dccode/>; City of New Haven, Connecticut, "Hybrid Parking Permits," accessed June 2013, <http://www.cityofnewhaven.com/TrafficParking/hybridparking.asp>; City of Cincinnati, Ohio, "Free Parking For All-Electric Vehicles," accessed June 2013, <http://www.cincinnati-oh.gov/oeq/residential-programs/electric-vehicle-free-parking/>; New York State Senate, "Bill A4390-2011," accessed June 2013, <http://open.nysenate.gov/legislation/bill/A4390-2011>; Illinois General Assembly, Illinois Compiled Statutes 5/3-805," accessed June 2013, <http://www.ilga.gov/legislation/ilcs/ilcs.asp>; Nevada Legislature, "Nevada Revised Statutes Chapter 445B – Air Pollution: 445B.770-445B.825," accessed June 2013, <http://www.leg.state.nv.us/Division/Legal/LawLibrary/NRS/NRS-445B.html>.

Incentive	Entity	Description	Target Audience
Privileges⁴²⁴			
Priority Parking	Arizona	An individual driving an AFV may park without penalty in parking areas that are designated for carpool operators provided the vehicle is using alternative fuel.	EV driver
Front-of-Line	City of Dallas, TX	Dedicated CNG taxicabs authorized to operate at the Dallas Love Field airport receive "head of the line" privileges, which allow the eligible taxicabs to advance to the front of a taxicab holding or dispatch area ahead of all ineligible taxicabs.	EV fleet driver (taxicab)

Source: Compiled by ICF International, 2013.

⁴²⁴ Information on privileges comes from the following sources: Arizona State Legislature, "Title 28 – Transportation: 28-877," accessed June 2013, <http://www.azleg.gov/ArizonaRevisedStatutes.asp?Title=28>; City of Dallas, Texas, "Ordinance No. 27831," accessed June 2013, <http://www.greendallas.net/pdfs/TaxisOrdinance.pdf>.

Appendix L. Utility EVSE Guidance Documents

Numerous EV research studies have been conducted and are ongoing, which will be of benefit to the southeastern Pennsylvania region. For example:

- INL has conducted a wide variety of EV and EVSE research available through the Advanced Vehicle Testing Activity website.⁴²⁵ INL has been an integral partner in a wide variety of research activities and is a resource for the southeastern Pennsylvania region.
- CAR released projections about EV deployment in its report, “Deployment Rollout Estimate of Electric Vehicles: 2011-2015.”⁴²⁶ The study shows a high correlation between HEV registrations and early markets for EVs. The information provided in this study will help Philadelphia anticipate EV deployment and EVSE needs in the region.
- Over the years, Pike Research has conducted a variety of EV surveys, including the “Executive Summary: Electric Vehicle Consumer Survey.” The survey provides insight into a consumer’s motivations and willingness to purchase EVs. This survey will help decision-makers in the region understand what kind of demographic may be most likely to purchase an EV.⁴²⁷

⁴²⁵ INL, “Advanced Vehicle Testing Activity,” accessed June 2013, <http://avt.inl.gov/index.shtml>.

⁴²⁶ CAR, “Deployment Rollout Estimate of Electric Vehicles: 2011-2015,” accessed June 2013, <http://www.cargroup.org/assets/files/deployment.pdf>, 9.

⁴²⁷ Pike Research, “Executive Summary: Electric Vehicle Consumer Survey,” accessed June 2013, <http://www.pikeresearch.com/wordpress/wp-content/uploads/2011/12/EVCS-11-Executive-Summary.pdf>, 1.

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Abstract: *Ready to Roll! Southeastern Pennsylvania's Regional Electric Vehicle Action Plan* is a comprehensive, regionally coordinated approach to introducing electric vehicles (EVs) and electric vehicle supply equipment (charging facilities) into the five counties of southeastern Pennsylvania. This plan is the product of a partnership between DVRPC, the City of Philadelphia, PECO Energy Company (the region's electricity provider), and Greater Philadelphia Clean Cities. ICF International provided assistance to DVRPC with the preparation of this plan. The plan incorporates feedback from key regional stakeholders, national best practices, and research to assess the southeastern Pennsylvania EV market, identify current market barriers, and develop strategies to facilitate vehicle and infrastructure deployment.

Ready to Roll! is presented in two volumes, and is accompanied by an online information clearinghouse, containing links to additional resources. The first volume (publication number 12055A) includes the regional readiness plan. The second volume (this document) provides an in-depth analysis of a variety of EV and EVSE issues.

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