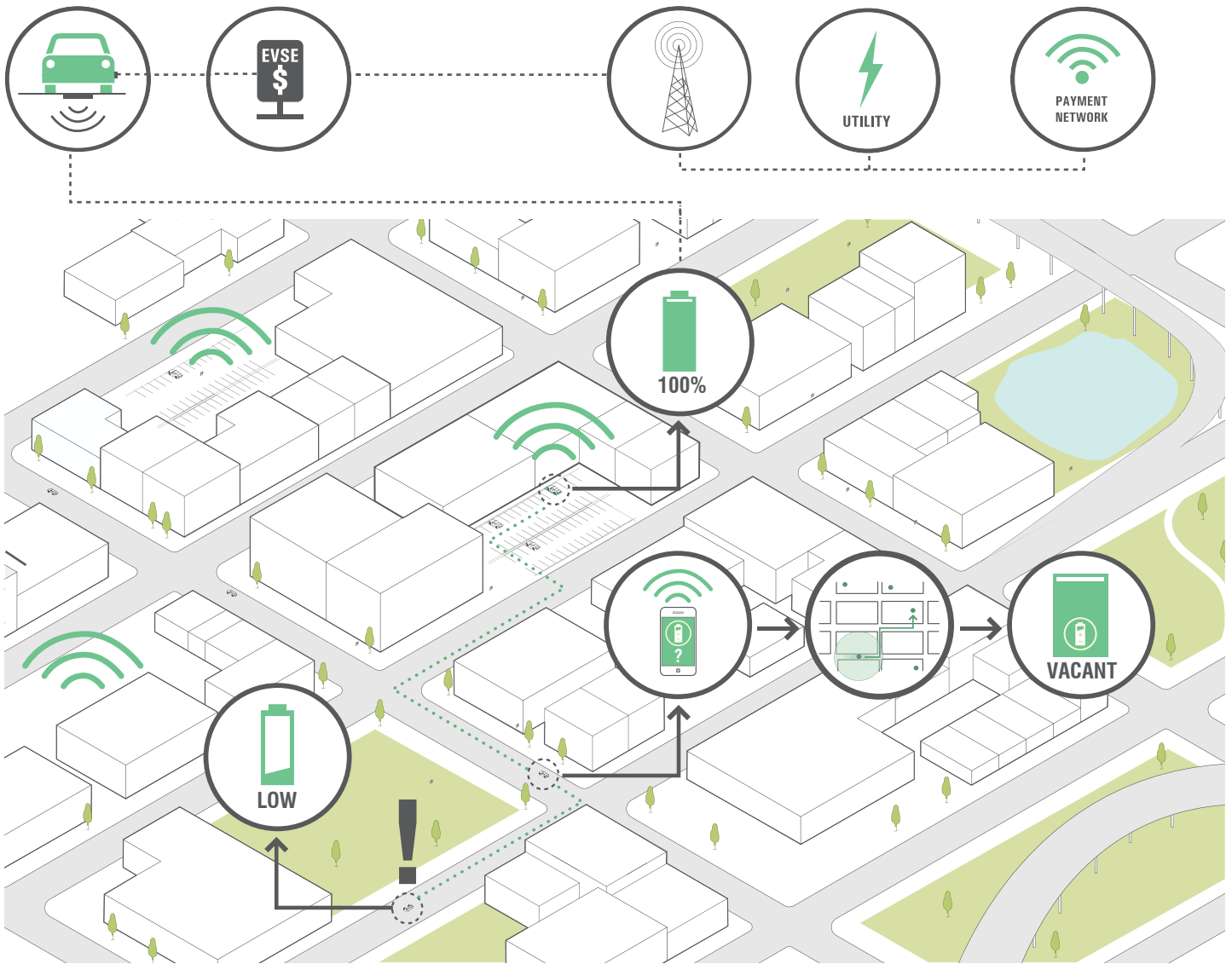


ASSESSMENT OF CURRENT EVSE AND EV DEPLOYMENT

ELECTRIC VEHICLE SUPPLY EQUIPMENT SUPPORT STUDY



Prepared for:
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and
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**Clean
Cities**
U. S. Department of Energy

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

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LIST OF ABBREVIATIONS AND TERMS

ACS	U.S. Census Bureau's American Community Survey
AFDC	Alternative Fuels Data Center
AFV	Alternative fuel vehicle
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BEV	Battery electric vehicle
DC	Direct current
DMV	Department of motor vehicles (state)
DVRPC	Delaware Valley Regional Planning Commission
EPA	U.S. Environmental Protection Agency
EREV	Extended range electric vehicle
EV	Electric vehicle
EV Community	Community (ZIP code) with EV ownership
EVSE	Electric vehicle supply equipment (charger)
GHG	Greenhouse gas
GW	Gigawatt
HEV	Hybrid electric vehicle
ICE	Internal combustion engine
MPG	Miles per gallon
MSRP	Manufacturer's suggested retail price
NEV	Neighborhood electric vehicles
PHEV	Plug-in hybrid electric vehicle
PV	Photovoltaic
TCI	Transportation and Climate Initiative
TEPCO	Tokyo Electric Power Company

EXECUTIVE SUMMARY

Overview

The purpose of this report is to analyze the patterns of current electric vehicle (EV) ownership and electric vehicle supply equipment (EVSE) installations based on a range of geographic, demographic and policy-based concerns across the Transportation and Climate Initiative (TCI) region, which includes 11 Mid-Atlantic and Northeast states and Washington, DC. The findings of this analysis highlight the greatest concentrations of EV ownership, the potential influences on EV ownership, the trends in EVSE locations, recommendations to maximize the impacts of EVSE installations on EV usage and recommendations for further areas of study.

This report, which provides a regional analysis, is a complement to the TCI *EVSE Cluster Analysis* report that seeks to define, through prototypes, the kinds of places that offer strong opportunities for enhanced EV usage and the related benefits.

Objectives and Approach

In order for public- and private-sector organizations to work toward an EV-ready environment, it is important to understand where the greatest current opportunities are for enhancing EV usage based on an analysis of EV ownership and EVSE locations across the 11 Mid-Atlantic and Northeast states and Washington, DC. This report seeks to accomplish the following:

- Map EV ownership concentrations across the TCI region
- Analyze the relationship between EV ownership concentrations and the existing demographic, geographic, and policy contexts
- Map the locations of EVSE across the TCI region
- Analyze the trends in current EVSE installation, including where it is being installed and who (e.g., government, EV

dealerships, institutions or commercial entities) is performing the installations

- Describe the correlation/lack of correlation between the current EVSE installation and current EV ownership patterns
- Highlight additional factors influencing current and future EV ownership

While the report uses selected secondary sources to support some assessments, the analysis is based on primary source information. Primary source information includes data on EV ownership by zip code for all states except Connecticut and comes from state departments of motor vehicles and various state agencies. This information was provided to the project team through Clean Cities coalitions across the TCI region in coordination with the Georgetown Climate Center.

The report has been greatly supported by the results of the 2010 Census and American Community Survey. Data on EVSE locations across the TCI region was gathered from the U.S. Department of Energy's Alternative Fuels Data Center to generate a TCI regional EVSE map. Additional secondary sources have been used to create maps that may have a bearing on future EVSE locations, such as air quality non-attainment areas and solar photovoltaic installations.

Using the geocoded zip code information on EV ownership, this report has been able to conduct a Geographic Information Systems analysis of the relationship between communities with EV ownership and the demographic, geographic and policy contexts. This cross-tabulation of information carries over to the analysis of EVSE locations and other additional issues, such as air quality non-attainment areas.

Findings and Initial Recommendations

The report analysis is divided into two areas of findings: observations on the development of EV ownership across the TCI region and conclusions regarding the locations of EVSE locations across the TCI region. This is followed by initial recommendations. Following are summaries of some of these findings and recommendations:

Findings

- Communities with EV ownership are significantly less dense than communities without EVs, with nearly all EV ownership located outside of urban cores. Whether driven by more straightforward EVSE installation, more suitable automotive trips or other factors, these communities contain more single-family homes and fewer multifamily structures than communities with no EV ownership.
- Communities with EV ownership tend to be more educated and wealthier than communities without EVs. Greater incidence of EV ownership correlates with higher income and more graduate degree attainment.
- Greater access to EV dealerships and EVSE relates to greater numbers of EVs in communities.
- EVSE should be targeted toward a set of appropriate destinations that are within driving range of EV communities. Many of these targeted destinations are examined in greater detail in the TCI companion report, *EVSE Cluster Analysis*.
- The current focus of EV ownership in lower-density, single-family-home communities highlights a challenge in getting communities with multifamily units to become more EV oriented. Accommodating EV ownership in this setting will require a careful consideration of the methods to encourage EVSE deployment.
- EVs represent a real opportunity to combat air quality concerns. Drawing support for EVs from communities affected by auto pollution—especially from trucks—should be an additional priority.

Recommendations

- EV promotion efforts should continue within communities with the highest rates of EV ownership because these places are likely to have EV purchasers who fit EV owner profiles, provide sufficient soft infrastructure (e.g., dealerships and EVSE installers) and have social networks that encourage potential EV owners.

1. CURRENT ELECTRIC VEHICLE OWNERSHIP

1.1. Electric Vehicle Background

The first component of the electric vehicle (EV) ecosystem is the EV itself. As detailed in Figure 1.1, EVs have a long history, yet for most of the narrative on the automobile, EVs have only been mentioned as niche products or curiosities. Now, several automakers have produced or are planning EV models and some, such as Nissan, are betting their futures on an automobile market with a significant EV component, if not an eventual majority.

Three categories of EVs able to utilize standard electric vehicle supply equipment (EVSE) to recharge onboard batteries exist: (1) battery electric vehicles (BEVs), (2) extended range electric vehicles (EREVs) and (3) plug-in hybrid electric vehicles (PHEVs).¹ For the purposes of this report, all are considered EVs, except where necessary to differentiate between BEV and PHEV or EREV.

1.2. EV Market

The market for EVs is growing, with 7,034 sold nationwide in October 2012, up from 1,974 sold in October 2011. Through October, 38,133 EVs have been sold in the U.S. for 2012, which is 10% of the combined sales for hybrid electric and EVs, but still only 0.3% of all vehicle sales. In total, 56,213 EVs have sold from December 2010 to October 2012, including 36,794 PHEVs and EREVs

¹ BEVs are powered exclusively by electricity stored in batteries. Currently this is the only EV type that can accept DC fast charging. BEV purchasers have different battery sizes options, meaning there is a trade-off of distance versus cost and extra weight. PHEVs and EREVs are hybrid electric vehicles with the added capability to charge the battery directly from the grid. They can be powered by either electricity or gasoline. EREVs use electricity to power the wheels at all times and have a larger battery pack which can be replenished by an onboard generator fueled by gasoline when the battery when it reaches a minimum charge level.

and 19,419 BEVs.² According to data gathered from individual states, at least 3,625 EVs have been sold in the TCI region, though the actual total is likely higher, because the data is not uniformly received, nor is data from Connecticut included.

Only seven light-duty EV models are currently available at dealerships in the TCI region.³ These are listed below, along with their electric-only range and base manufacturer's suggested retail price (MSRP) after federal tax credit.⁴

Table 1.1. EV models currently available in the TCI region⁵

Vehicle	Type	Electric Range (miles)	MSRP ⁶
Chevrolet Volt	EREV	35	\$31,465
Fisker Karma	EREV	33	\$94,500
Ford Focus Electric	BEV	76	\$32,495
Mitsubishi i	BEV	62	\$21,625
Nissan Leaf	BEV	73	\$27,700
Tesla Model S ⁷	BEV	160	\$49,900
Toyota Prius Plug-In	PHEV	11	\$30,260

2012 sales show PHEVs and EREVs outselling BEVs more than three-to-one, suggesting that people generally appreciate the safety net a gasoline motor provides against range anxiety.

² "Electric drive vehicle sales figures (U.S. Market) - EV sales," Electric Drive Transportation Association, accessed November 28, 2012, <http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952>.

³ Several production EV models are not yet available in the TCI region, including the CODA, Honda Fit EV and Toyota RAV4 EV. BMW's ActiveE is a demonstration BEV found in the New York City metropolitan region, available on a limited trial basis to participants meeting specified criteria.

⁴ A federal tax credit, dependent on battery size, is available for all models listed. For all models except the Prius Plug-in, the credit is equal to \$7,500. The credit is \$2,500 for the Prius.

⁵ Office of Energy Efficiency and Renewable Energy, Fueleconomy.gov home page, <http://www.fueleconomy.gov>, accessed November 28, 2012; and EV manufacturer sites.

⁶ MSRPs are taken from manufacturers' websites.

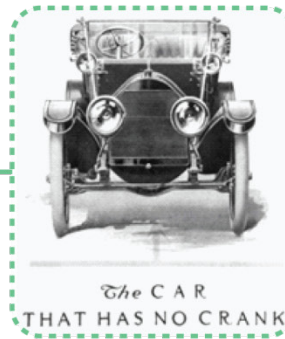
⁷ The Tesla Model S's base model, with the smallest battery option (40kWh), will not be available for purchase until the end of 2012. The range is the manufacturer's because EPA-certified ranges have not been produced.

1897-1912

Electric vehicles are popular in the early years of automobiles because of short trips, zero emissions, greater reliability and easier starting and gear changing. EVs are the predominant propulsion in 1900 and production peaks in 1912.



1911-Present



Following the development of the electric starter, consumers are persuaded by gasoline-powered automobiles' longer range, lower price and ability to better take advantage of the country's growing intra-city road network.

1930s-Present



EVs persist in certain contexts prioritizing quiet and pollution-free operation such as indoors or at resort communities.

1973-1980



The 1973 oil crisis and the corresponding gasoline price spikes and shortages lead to the quick production of a handful of EVs such as the Sebring-Vanguard Citicar and the Elcar.

1990-2003



The California Air Resources Board mandates zero emission vehicle percentage targets for U.S. automakers. Though requirements are eventually reduced and postponed, the mandate leads to the production of several EVs: the GM EV1, Toyota RAV4-EV and Ford Ranger EV pickup truck, among others.

2006-2011



Reflecting the Prius' success, ubiquity and owner enthusiasm, a small after-market for converting the Prius to a plug-in develops; even dealerships offer to perform the conversion, which involves modifications to the software and installation of an outlet and larger battery.

2010-Present



Since the 2010 launch of the Nissan Leaf, the U.S. EV market has grown to include the BMW ActiveE, Chevy Volt, CODA, Fisker Karma, Ford Focus Electric, Honda Fit, Mitsubishi i, Tesla Model S, Toyota RAV4 EV and Prius Plug-in.

Figure 1.1. Timeline of EVs

EREVs could be considered mostly electric: according to Chevrolet, 62% of Volt driving is electric-only.⁸

Given the small number of EV purchases so far, characterizing current and potential EV owners is an important task for determining where to focus attention and investment. At the Plug-In 2012 Conference, EV automakers grouped potential owners as follows:⁹

- **Previous EV owners:** These people were part of the EV rollout attempt in the previous decade or are currently driving a vehicle conversion.
- **Tech savvy:** These people want to have the latest, coolest, and most high-tech car in the neighborhood.
- **Uber-greens:** These people are eco-conscious and most aware of their carbon footprint. They particularly appreciate the environmental and local benefits that EVs bring.
- **Energy security hawks:** These people consider reducing the nation's dependence on foreign oil to be of the utmost importance, because it supports regimes whose interests are often not aligned with those of the United States.¹⁰

1.2.1. EV Challenges

While it is important to highlight EVs' advantages, including reduced fueling costs and potentially zero emissions, EVs do face significant challenges. The U.S. Environmental Protection Agency (EPA) website *fuelconomy.gov* lists the following issues related to the battery, while reminding its audience that improvement is occurring on all of these fronts:

- **Driving range:** Most BEVs can only go about 60–100 miles before recharging,

⁸ "2013 Volt," Chevrolet, accessed November 28, 2012, <http://www.chevrolet.com/volt-electric-car.html>. The Chevy Volt's aggregate mileage numbers are updated in real-time through GM's OnStar system.

⁹ John Volecker, "Electric Car Industry Sums Up Progress, Challenges At Plug-In 2012," Green Car Reports, July 27, 2012, http://www.greencarreports.com/news/1078004_electric-car-industry-sums-up-progress-challenges-at-plug-in-2012.

¹⁰ A similar statement could be made regarding the lithium in lithium-ion batteries.

while gasoline vehicles can travel more than 300 miles before refueling.

- **Recharge time:** Fully recharging the battery pack can take 4–8 hours or more. Even a "quick charge" to 80% capacity can take 30 minutes.
- **Battery cost:** Battery packs are expensive and may also need to be replaced at a later date.
- **Bulk and weight:** Battery packs are several hundred pounds and take up considerable vehicle space, with some states removing that weight for classification.

All of these factors represent tradeoffs for EV makers, with each taking different approaches to range, cost and charge speed (see Table 1.1.). While long-term ownership costs are comparable to internal combustion engine (ICE) vehicle costs due to reduced refueling and maintenance costs, EVs have cost up to \$10,000 more than comparable ICE vehicles or even hybrid electric vehicles.¹¹

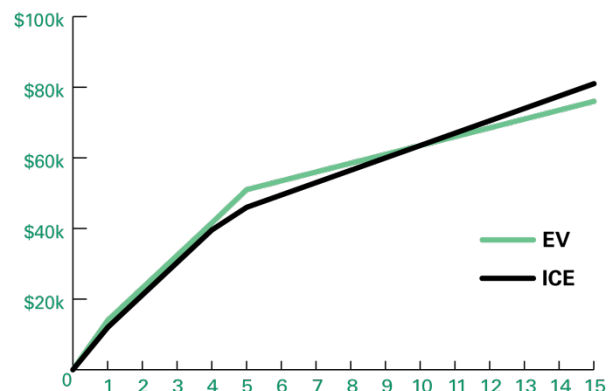


Figure 1.2. Ownership cost comparison of the Ford Focus EV with an automatic sedan (ICE) over time¹²

¹¹ This is in addition to the costs of EVSE, which may be upward of \$1,000 and potentially involve hundreds or thousands of dollars in installation costs.

¹² Results from the AFDC's Vehicle Cost Calculator (<http://www.afdc.energy.gov/calc>). The calculator's assumptions were used, including 5-year loans, except in the following instances: EV price from Table 1.1 (price for comparably equipped sedan is \$23,200); electricity and gas prices from Westchester, New York; and daily driving is assumed to be 40 miles, 40% of which is on highways. This modeling does not include potential insurance savings from EV ownership.

EV CONCENTRATION

BY ZIP CODE

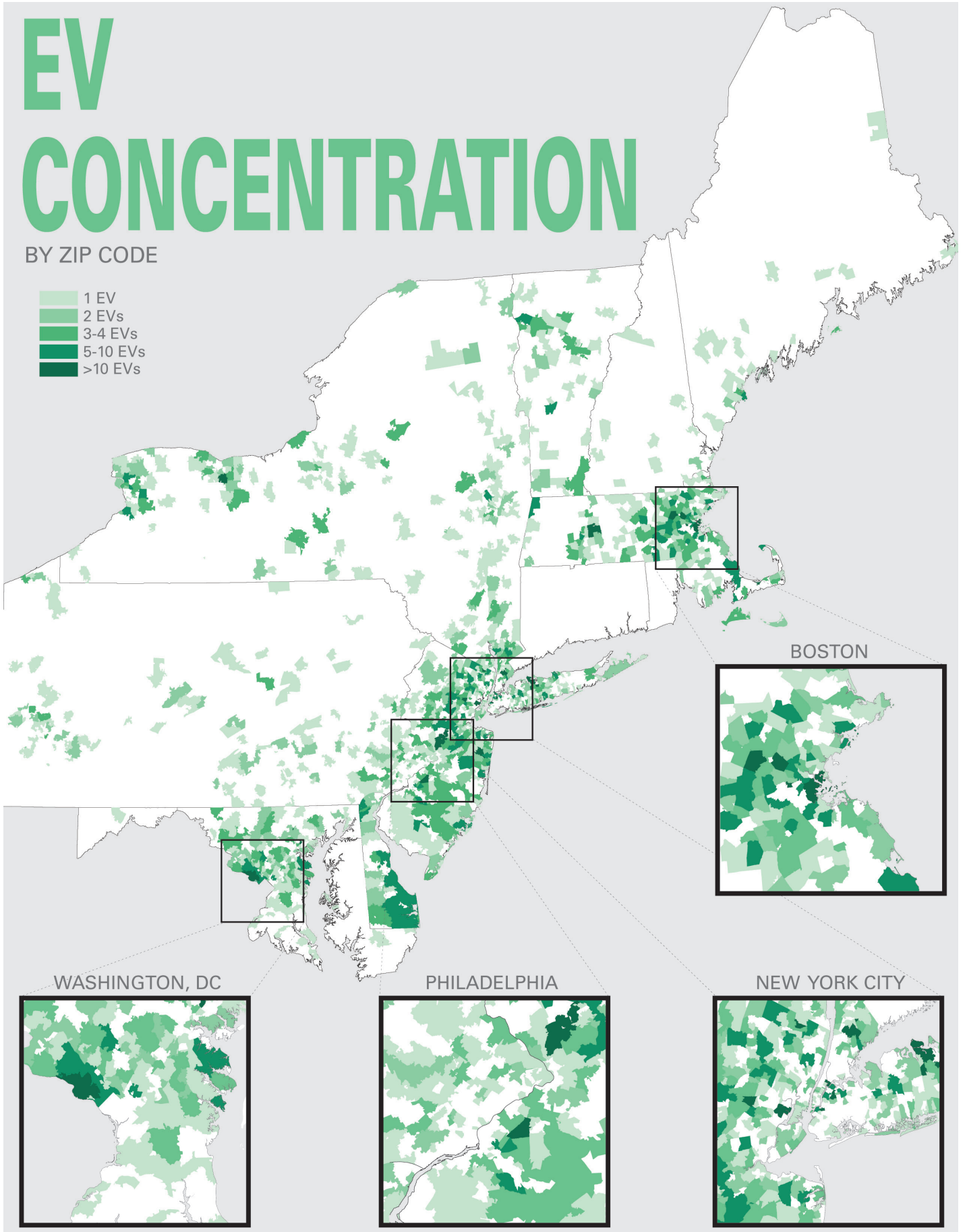
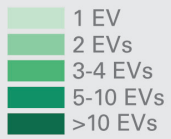


Figure 1.3. EV counts in the TCI region

Table 1.2. Comparison of counts of EVs and population in the TCI region, with data sources

Jurisdiction	Population (#, %)	EVs (#, %)	Difference (%)	As of Date	Source
Connecticut	3,572,316 (not included)	Unknown		None	None
Delaware	897,127 (1.5%)	131 (3.6%)	2.1%	7/2/2012	DMV
Maine	1,327,175 (2.3%)	43 (1.2%)	-1.1%	6/21/2012	DMV
Maryland	5,768,941 (9.8%)	389 (10.7%)	0.9%	6/20/2012	State Tax Credit Program
Massachusetts	6,538,822 (11.1%)	1,005 (27.7%)	16.6%	8/29/2012	DMV
New Hampshire	1,313,914 (2.2%)	18 (0.5%)	-1.7%	2011	Department of Environmental Services
New Jersey	8,785,400 (14.9%)	822 (22.7%)	7.8%	10/1/2012	New Jersey Department of Environmental Protection Bureau of Mobile Sources
New York	19,308,675 (32.8%)	787 (21.7%)	-11.1%	5/1/2012	DMV
Pennsylvania	12,646,409 (21.5%)	235 (6.5%)	-15.0%	4/30/2012	State Rebate Program
Rhode Island	1,051,920 (1.8%)	6 (0.2%)	-1.6%	6/1/2012	Project Get Ready Rhode Island
Vermont	625,481 (1.1%)	79 (2.2%)	1.1%	7/17/2012	Vermont Energy Investment Corp.
Washington, DC	600,725 (1.0%)	110 (3.0%)	2.0%	9/18/2012	Metropolitan Washington Council of Governments
Total	62,436,905	3,625			

1.3. Geography of EV ownership

The TCI region's 24 million households comprise approximately 60 million people. Attempts were made to obtain EV data from each jurisdiction, and, to the degree possible, the report has aggregated and unified this data for presentation.

The region-wide data indicates a total of 3,625 light-duty EVs for the TCI region, representing 0.01% of the nearly 28 million private vehicles registered.¹³ The actual regional number of EVs is assumed to be greater than this, given that the EV market is developing quickly and each month of omitted data represents a significant proportion of total sales: nationwide, over 30% of all EVs in the U.S. (sales from December 2010 to October 2012) were sold in the last 3 months.

1.3.1. Data Gathering Process

Counts of EVs from nearly all of the jurisdictions in the TCI region were gathered by the Georgetown

¹³ Federal Highways Administration, "Highway Statistics Series," U.S. Department of Transportation, December 2011, <http://www.fhwa.dot.gov/policyinformation/statistics/2010/mv1.cfm>.

Climate Center through local Clean Cities coalitions, TCI staff and others over several months. Each jurisdiction required a different data collection process, usually through the appropriate department of motor vehicles (DMV), though often through intermediate or other agencies. The complications in obtaining this data mirror the experiences of automakers, utilities and other researchers.

Some states were able to provide anonymized address-level data, while others were presumably limited by the federal Driver's Privacy Protection Act, which has been legally interpreted to prohibit involuntary disclosure of address information by DMVs.¹⁴ In those cases, DMVs provided ZIP code or community-level data, while other states were able to provide information from tax credit and rebate programs. For these states, the EV data was standardized and aggregated or interpolated to the ZIP code level. In the cases of Washington, DC, and Rhode Island, the EV counts are jurisdiction-wide only.

¹⁴ Bryan Dressler, *Making the Grid: Electric Vehicle Utility Notification*, Georgetown Law, May 15, 2012. Unpublished paper.

The EV data received is furthermore of different quality and scope; tax credit and rebate data only provide details from private purchases of current models (listed in Table 1.2), and are further hampered by the possible gap of purchasers not taking advantage of the incentives. Though it sometimes includes registrations from out-of-state addresses, DMV data oftentimes differentiates between neighborhood electric vehicles (NEVs),¹⁵ motorcycles, government and commercial fleet vehicles, vehicle conversions and even collectors' EVs such as a 1976 Sebring-Vanguard CitiCar.

Where possible, data on NEV locations has been excluded from mapping and analysis under the presumption that these likely operate under different use cases and are better considered under a separate analysis. All other EVs have been included.

1.3.2. EV Ownership Focal Points

In 2010, the EV automaker TH!NK announced the U.S. EV-Ready Cities Index for the latest incarnation of the TH!NK City car. The index is based on existing purchase and usage incentives for EVs, as well as market fit, which includes the following factors:

- Hybrid sales
- Traffic congestion
- EPA non-attainment zone status (air quality)
- Low-carbon energy sources for vehicle recharging

Five cities in the TCI region were among the top 15 scores, and the regional EV ownership maps at the start of this section reveal that the suburban areas of these five cities have particularly high concentrations of EV ownership. Not surprisingly, these also happen to be the major population centers of the TCI region.

Table 1.3. TH!NK's U.S. EV-Ready Cities Index (2010)

City	Purchase/Usage Incentives	Market Fit	Overall Score
Los Angeles	5.75	3.75	9.50
San Francisco	5.75	3.25	9.00
Chicago (tie)	5.75	2.15	7.90
New York (tie)	5.75	2.15	7.90
San Diego	5.75	2.00	7.75
Portland	5.55	1.95	7.50
Sacramento	5.75	1.50	7.25
Newark	4.85	2.15	7.00
Seattle	3.30	3.25	6.55
Atlanta	4.85	1.20	6.05
Denver	4.65	0.80	5.45
Boston	2.40	1.90	4.30
Philadelphia	2.40	1.70	4.10
Washington, DC	0.80	3.05	3.85
Phoenix	1.70	1.90	3.60

¹⁵ NEVs are BEVs limited to streets of certain speed limits, classified as low-speed vehicles by the U.S. Department of Transportation.

1.3.3. Urban, Suburban and Exurban Areas

Table 1.4. Top 10 metropolitan areas' EV counts

Metropolitan Area	EVs (%)		Population (%)	
New York—Newark, NY—NJ—CT	1,085	(30.9%)	18,613,833	(31.6%)
Boston, MA—NH—RI	684	(19.5%)	4,397,189	(7.5%)
Washington, DC—VA—MD	256	(7.1%)	2,276,340	(3.9%)
Philadelphia, PA—NJ—DE—MD	226	(6.4%)	5,690,996	(9.7%)
Baltimore, MD	159	(4.5%)	2,355,902	(4.0%)
Worcester, MA—CT	112	(3.2%)	595,450	(1.0%)
Springfield, MA—CT	81	(2.3%)	590,551	(1.0%)
Buffalo, NY	67	(1.9%)	1,064,518	(1.8%)
Pittsburgh, PA	51	(1.5%)	1,922,054	(3.3%)
Rochester, NY	50	(1.4%)	721,728	(1.2%)
Total	2,771	(75.8%)	38,228,561	(65.0%)

Most EV models have been introduced in and around urban centers, as detailed in Section 1.4.2.¹⁶ This is an understandable strategy, especially in the TCI region, because the 2010 census shows it to be more urban-centered than the nation, with 85% of the population living in metropolitan areas compared to 81% nationally. EV ownership is even more skewed toward metropolitan areas, with 89% of EV owners living in areas associated with cities of populations of 50,000 or greater.

The 10 most populous metropolitan areas contain 76% of all EVs in the TCI region, accounting for more than the population distribution would predict. EV ownership is not equally dispersed among metropolises, with those in

Massachusetts containing more EVs than expected, while those in Pennsylvania containing fewer, matching the state-by-state data from Table 1.2. However, as shown in Table 1.4 and Figure 1.4, EV ownership is concentrated in the less-dense, suburban and exurban portions of metropolitan areas. Data shows that 75% of EV owners live in areas with population densities of fewer than 5,000 people per square mile, whereas 50% of the general TCI region population lives in these less-dense regions. The concentration in these areas suggests that most use cases comprise single-family home ownership with regular commuting to an urban core.

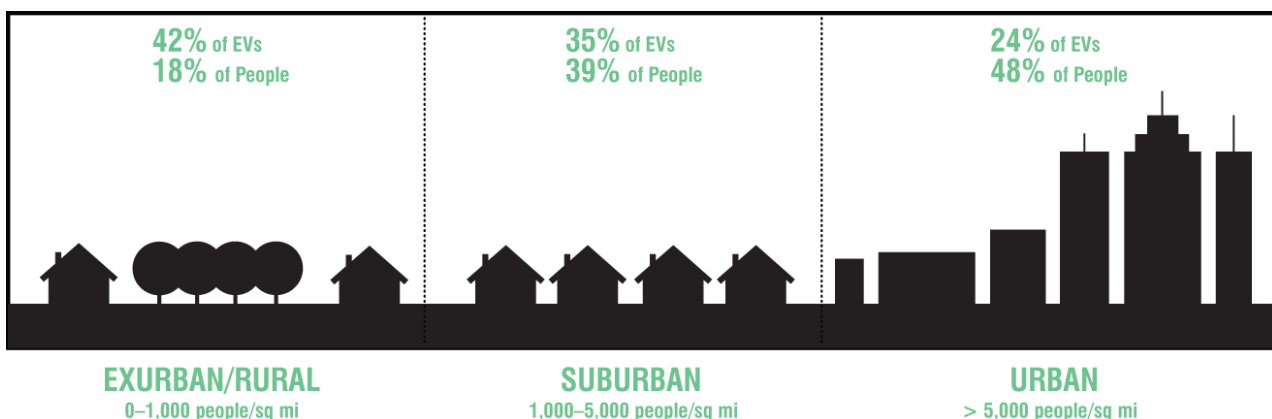


Figure 1.4. EV ownership versus population density (individuals per square mile)

¹⁶ This is evident in the rollouts of the Ford Focus EV and the Tesla Model S, which each featured only a handful of dealerships selling the EVs.

DEMOGRAPHICS*

The typical EV community is **YOUNGER**, more **EDUCATED**, **WEALTHIER**, **PROFESSIONAL** and low-density **EXURBAN & SUBURBAN**

All the above characteristics are greater in communities with **THREE OR MORE EVs**

- **YOUNGER**, tech-savvy and eco-conscious

6% larger under 45 population

1.5 Years younger median age

- **WEALTHIER** and desiring to show off the latest eco-purchase

38% higher median household incomes

47% more households with income greater than or equal to \$200,000

- **Highly EDUCATED** and more concerned with energy security

31% more bachelor's degrees

47% more graduate degrees

- **SUBURBAN & EXURBAN DWELLERS** living in stable households

40% higher home values

38% more homes with four or more bedrooms

- Diverse occupation base with high percent in **MANAGERIAL** positions

21% more management, business, science and arts roles

23% more in professional and scientific industries

*For ZIP codes and census tracts, based on 2010 Census and American Community Survey data

Figure 1.5. Demographics summary of EV communities (source: 2010 Census and American Community Survey)

1.4. Demographics

Several qualitative descriptions for EV owners are given in Section 1, but their characteristics are difficult to measure. Many automakers and organizations planning for EVs have made more quantitative assumptions regarding the characteristics of potential EV owners, mostly in terms of income. Ford pegs the typical household income for EV owners between \$120,000 and \$140,000, and sees a high correlation with current hybrid ownership. BMW suggests that its ActiveE customers (Electronauts) “are affluent, mostly urban individuals who put a high value on social responsibility and environmental friendliness,” presumably similar to other BMW owners.¹⁷ The Delaware Valley Regional Planning Commission (DVRPC), in scoring areas for EV ownership potential, gives the highest scores to census block groups with household incomes of more than \$150,000, along with current hybrid or EV ownership.¹⁸

Many factors may influence EV ownership in a particular locality, and those demographics that show significant divergence between localities with and without EVs are explored in this and subsequent sections of the report. Many of these factors may be correlated. For instance, household income and number of cars, but this report does not presume to list primary or secondary causes of EV ownership.

1.4.1. Socio-Economics

Without having demographics for individual EV owners, this report relies on community-level data to discern EV owner characteristics, and the

results should not be interpreted as a survey of EV owners. The primary sources of community socio-economic and demographic data for the TCI region are the U.S. Census Bureau’s Profile of General Population and Housing Characteristics: 2010 and its American Community Survey (ACS) 2010 5-year estimates.¹⁹ Using the EV ownership data mentioned previously in conjunction with Census data, region-wide demographic analysis was performed for a majority of the TCI member states—Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania and Vermont.^{20, 21}

¹⁹ These three tables are Selected Social Characteristics in the United States, Selected Economic Characteristics and Select Housing Characteristics.

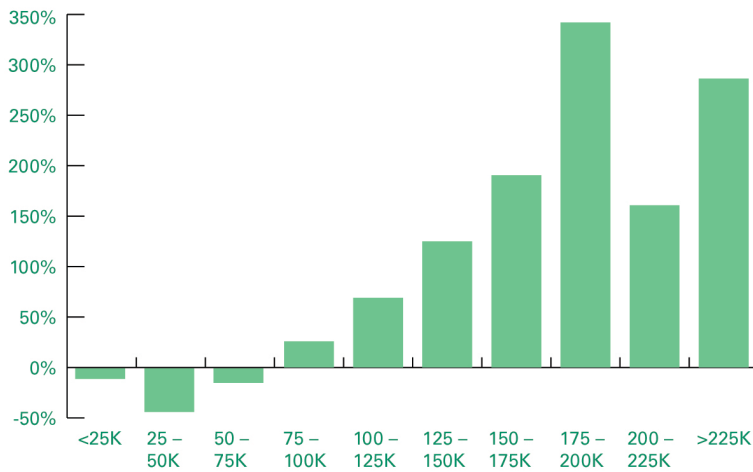
²⁰ NEV counts were removed from the analysis where possible. Localized analysis for Rhode Island and Washington, DC, was not possible because only total EV ownership was obtained. No Connecticut EV data was obtained.

²¹ As discussed, the EV data was received at various scales, predominantly as ZIP code summaries, but also as individual street addresses and community totals. Where only addresses were given, these were aggregated at the ZIP code level, while totals by community were evenly distributed among constituent ZIP codes. The most finely grained data from the ACS is only available for census tracts, which have little relation to ZIP code boundaries. ZIP code data was converted to census tracts using the Missouri Data Center’s Geographic Correspondence Engine, found at <http://mcdc1.missouri.edu/MableGeocorr/geocorr2010.html>. Census tracts were matched with their greatest overlapping ZIP codes, with a minimum threshold of 10% overlap. In Delaware and Pennsylvania, where address-level data was available, those data were matched with census tracts directly using ArcGIS. A separate analysis of ACS data was performed for Delaware and Pennsylvania to verify the conversion methodology and to check whether intra-state comparisons would produce more pronounced results because the TCI region is demographically diverse, causing local trends to be lost. Similarly, additional analyses were performed for communities with three or more EVs to determine if these stronger EV communities were further distinguished from non-EV communities. The results from all of these analyses largely aligned, though in some cases trends were more pronounced locally and in 3+ EV communities. These cases are highlighted in the following sections.

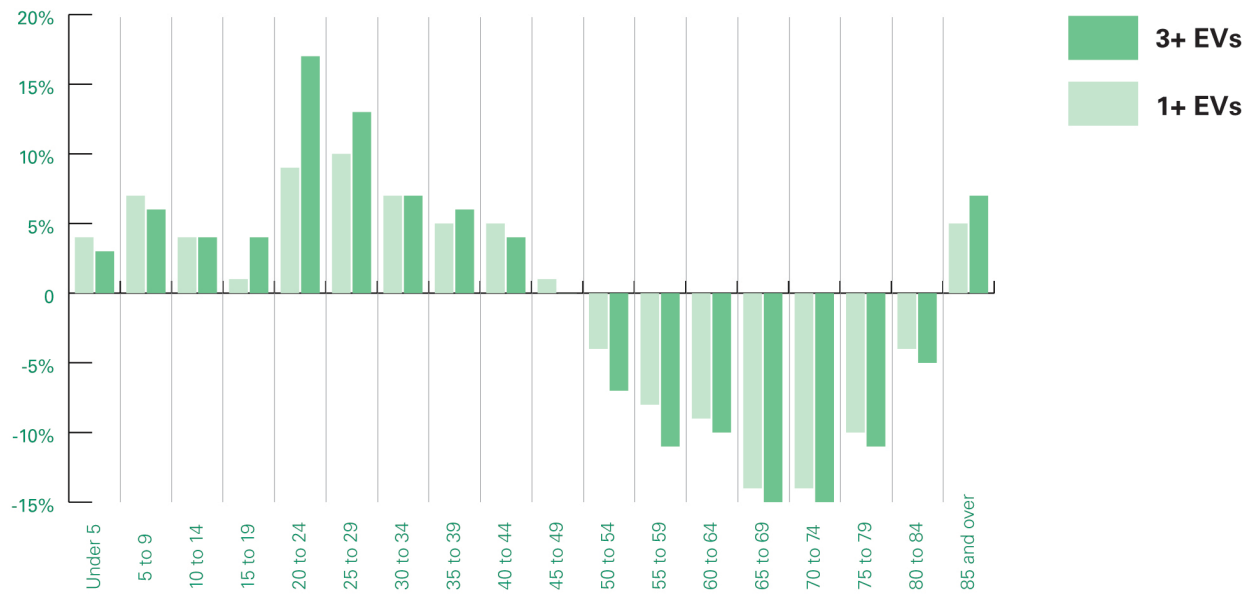
¹⁷ “Will BMW’s Solar-Wind Package Tap a New Target Car Market?” Greentechmedia, accessed November 28, 2012, <http://www.greentechmedia.com/articles/read/will-bmws-solar-wind-package-tap-a-new-target-car-market/>.

¹⁸ Meanwhile, Honda’s EV Readiness Assessment (<http://automobiles.honda.com/fit-ev/ev-readiness-assessment.aspx>) is more logistically focused, defining the ideal factors for EV ownership as: locations in select, urban markets; commutes of less than 50 miles and a private garage accommodating Level 2 EVSE. Delaware Valley Regional Planning Commission, *Southeastern Pennsylvania Preliminary Electric Vehicle (EV) Grid and Transportation Network Analysis*, July 10, 2012.

Correlation of communities' median household income with EV ownership



Age composition of EV communities compared to non-EV communities



Education attainment of EV communities compared to non-EV communities

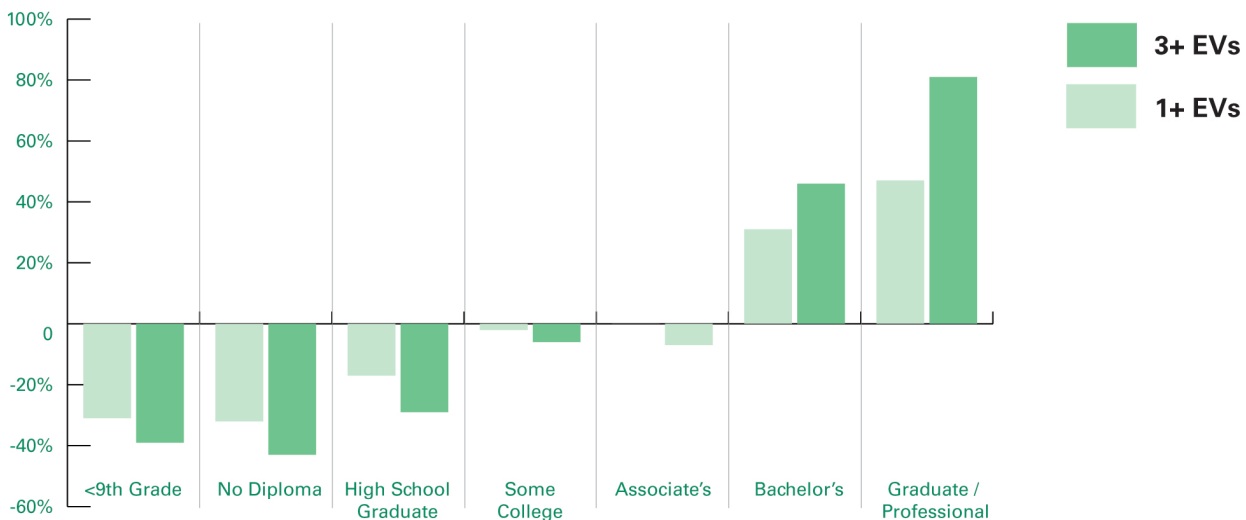


Figure 1.6 Socio-economic trends for EV communities (source: 2010 Census and American Community Survey)

Income and Occupations

High income is cited as a common attribute of EV owners, as mentioned previously. The theoretical tech-savvy enthusiast who demands the latest and greatest and the uber-green, perhaps desiring to show off the latest eco-purchase, are presumably more likely to be found in higher-income areas, where cost considerations are less acute. Census ACS data supports this assumption when comparing EVs areas to non-EV areas in the TCI region, finding substantially higher income in communities with EVs, specifically the following:

- **38%** higher median household incomes
- **98%** more households with incomes of \$200,000 or more

This income EV ownership trend is even stronger for communities with three or more EVs, which show:

- **52%** higher median incomes
- **150%** more households of \$200,000 or more

Analysis of EV communities in Delaware and Pennsylvania points to an even stronger relationship to income; those states show **three times** as many \$200,000 households in communities with EVs, compared to those without. This suggests the regional variation in incomes may be masking an even stronger local correlation between income and EV ownership.

The first chart of Figure 1.6 shows the relation of EV ownership to income by comparing the proportion of EVs to the proportion of the population for each income bracket. For example, the percentage of total EVs in communities in the \$200,000–\$225,000 bracket is 160% greater than the region's population living in that same bracket. As evidenced by the chart, increasing income is highly correlated with greater EV ownership, until it plateaus at \$175,000+. This suggests a threshold over which income is not the deciding factor in increasing EV ownership.²²

²² Much research has gone into the social aspects of EV and HEV purchasing, which may be one explanation for differences in EV ownership among areas with similar demographics. John Aksen and Kenneth S. Kurani *Reflexive Layers of Influence: A Model of Social Influence, Vehicle Purchase Behavior, and Pro-Societal Values* (Davis: CA, University of California, Davis, July

Beyond income numbers, inhabitants of EV communities also work in different occupations and industries, with 21% more people in management, business, science and arts roles and 16% more in information roles; 23% more in professional and scientific industries and 17% more in the finance, insurance and real estate industries. In addition, EV communities find 14% more people who are able to work from home. All of these distinctions are greater in communities with three or more EVs.

Age

As expected from tech savvy and eco-conscious demographics, the populations of EV communities skew younger than communities without EVs in the TCI region. Overall, communities with EVs have a median age that is 1.5 years younger and an under-45 population that is 6% larger. Figure 1.4 gives a more detailed breakdown of the difference in age composition of communities with and without EVs, showing significantly greater numbers of 20- to 35-year-olds and fewer 55- to 75-year olds in communities with EVs. These trends are even more pronounced for communities with three or more EVs

Educational Attainment

Higher income is usually correlated with greater educational attainment, and the more educated are likely to be more technology-savvy and eco-conscious. Currently, EV marketing mainly highlights the vehicles' green features, specifically the potential for lower or even zero emissions, which is most likely to resonate with those with higher levels of education. The association between EVs and education looks to be strong: EV communities have 31% more bachelor's degrees and 47% more graduate degrees than non-EV ones, with communities with three or more EVs having 46% and 81% more bachelor's and graduate degrees, respectively. These differences with non-EV communities are charted more clearly in Figure 1.6.

30, 2010), http://publications.its.ucdavis.edu/publication_detail.php?id=1411; Steven E. Sexton and Alison L. Sexton *Conspicuous Conservation: The Prius Halo and Willingness to Pay for Environmental Bona Fides* (Davis, CA: University of California, Davis, November 2011), http://www.uce3.berkeley.edu/WP_029.pdf.

Housing

Housing value is understandably related to income, and homes in EV communities in the TCI region are larger and more expensive than in non-EV communities. In EV communities, median home values are 40% greater, and 93% more homes are valued at \$1 million or more. The comparison in Delaware and Pennsylvania is even starker; home values are 69% greater and there are four times as many \$1 million homes. Using the number of rooms as a proxy for house size, EV communities in the TCI region have homes with 7% more rooms and 38% more homes with four or more bedrooms.

The Census data suggests EV communities are more stable, on average having a 22% lower housing vacancy rate, 15% more owner-occupied housing units and 20% fewer rental units. These communities also have 21% more homes headed by a married couple.

A preliminary study of EVs in San Diego by researchers from the University of California, Davis shows EV owners have more garage space.²³ ACS data also implies greater EV readiness, with 20% more single-family detached homes and 29% more housing structures built since 1990. Whether these favorable conditions induce more EV purchases or simply reflect greater income is unclear. Housing age varies a great degree across the region; nonetheless, at the more local level of Delaware and Pennsylvania, EV communities have more than twice as many homes built since 1990.

²³ Gil Tal et al., *Plug-In Vehicles in the San-Diego Region: A Spatial Analysis of the Demand for Plug-In Vehicles*, presentation, Electric Vehicle Symposium 26, May 11, 2012.

ACCESSIBILITY TO DEALERSHIPS

Number of EV models from Table 1.1
available within driving distance

- Up to 1
- Up to 2
- Up to 3
- Up to 4
- Up to 5
- Up to 6
- Up to 7
- EV Dealership

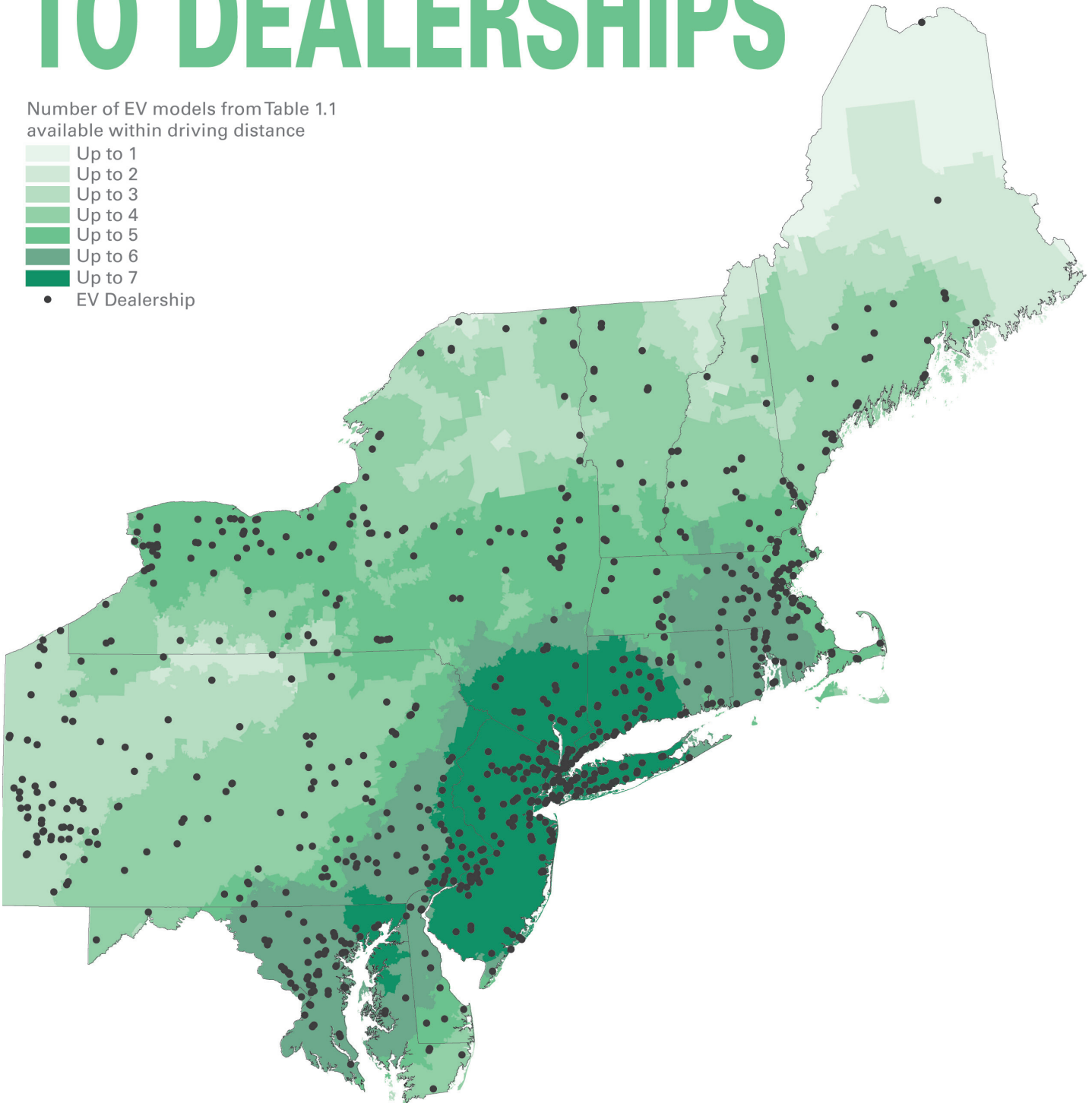


Figure 1.7. EV dealerships (source: Georgetown Climate Center)

1.4.2. Automobile Market

Related to the demographics discussed in the previous section, EV communities contain more cars and more automobile commuting than non-EV communities. In communities with EVs, 12% more commuters drive to work alone and 44% fewer use public transportation. Sixty-four percent of households in EV communities have two or more vehicles, a rate 23% greater than seen in non-EV communities. Two-car households suggest a market opportunity for a primary (battery) EV for commuting and the second car for other trips. Communities with EVs are shown to have 46% fewer vehicle-less households.

EV Dealerships

Mass-market EV models have only been on sale since late 2010, with the introduction of the Nissan Leaf. Rollouts of BEVs and PHEVs have so far begun around the major cities of the TCI region, especially New York City and Washington, DC.

Access to dealerships selling EV models is not evenly spread across the TCI region, and dealership proximity is particularly important for purchasing BEVs because of their range limitations.²⁴ To measure EV dealership accessibility, dealership data was manually obtained from automobile company website listings, and distances to each dealership type were calculated for each community for all models available in the TCI region. These distances were then compared to each model's electric-only range.²⁵ Dealership proximities for the region are shown on the map on the previous page.

Table 1.5 divides the region by accessibility to dealerships of the EV models from Table 1.1, up to seven. As evidenced from the data, a majority of the TCI region's population has access to most

of the vehicle models, yet the areas with five or fewer dealerships contain a lower number of EVs than the population proportion would dictate.

Table 1.5. EVs and populations' accessibility to dealerships, by number of available EV models

Available EV Models	EV Count (#, %)	Population (#, %)
1	1 (0.0%)	43,202 (0.1%)
2	1 (0.0%)	130,730 (0.2%)
3	20 (0.6%)	1,026,545 (1.8%)
4	241 (6.7%)	6,976,232 (12.1%)
5	440 (12.2%)	8,486,432 (14.7%)
6	1,080 (29.8%)	10,221,007 (17.7%)
7	1,838 (50.8%)	30,919,116 (53.5%)

These results may reflect the EV makers' recognition of demographics described previously, or the transition process required for training sales staff and generally accommodating EVs. According to presenters at the Plug-In 2012 conference, an EV may take up to four times as long to sell as an ICE vehicle. Anecdotal reports indicate that sales staff can be uninformed, or simply prefer the simpler, more familiar process of selling a gasoline car.²⁶

²⁴ This inconvenience was measured firsthand by Consumer Reports when trying to review the Ford Focus: <http://news.consumerreports.org/cars/2012/07/our-new-ford-focus-electric-exposes-a-challenge-in-buying-an-ev.html>. Every community in the TCI region except Eastport, Maine, has accessibility to at least one EV dealership.

²⁵ EREVs and PHEVs do not suffer from the same range limitations as BEVs, but for most owners, maintenance is likely to occur at the dealership. Therefore for EREVs and PHEVs, accessibility to a dealership is calculated using double the vehicle's electric range.

²⁶ There are reports of sales staff attempting to talk buyers out of the EVs they intend to buy. In response, one maker is considering different compensation schemes for EV salespeople, reflecting the added effort and time required for the education and charging station components of a plug-in sale.

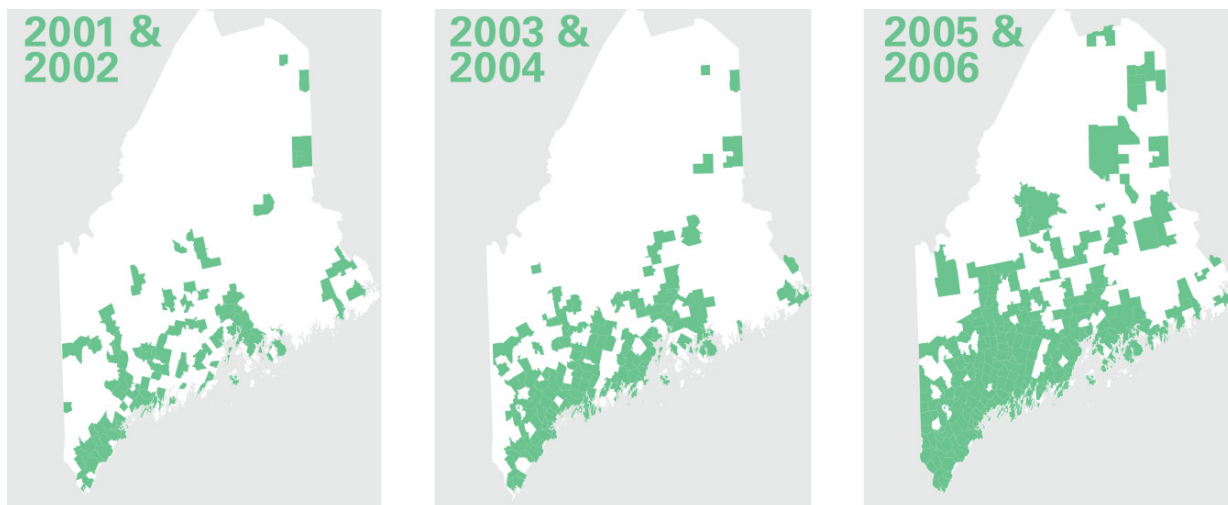


Figure 1.8. Prius adoption in Maine

Hybrid Ownership

Hybrid electric vehicles (HEVs) could be considered mainstream, currently making up 3% of total vehicle sales.²⁷ The Prius in particular, was the world’s third best-selling car line in the first quarter of 2012.²⁸ HEVs are assumed to appeal to the same markets of eco-conscious, tech savvy and energy-security-conscious consumers, and therefore HEV ownership, in particular the early adopter purchases—prior to 2007—is expected to correlate with current EV adoption.²⁹

As part of the EV data collection process, several jurisdictions also provided HEV data, again of varying quality and scale: Maine; Massachusetts; New Hampshire;³⁰ New York; Pennsylvania and

the metropolitan planning organization for the Philadelphia area, the DVRPC.³¹ Analyses of these locations were performed in an attempt to correlate EV and HEV ownership. First, Maine data, which consisted of Priuses only, was filtered to test for early adopter purchases (2001–2006). Correlations between the current total number of EVs and HEV registrations between 2001 and 2006 in Maine communities are not strong, though it is unclear whether HEV data includes all purchases or only currently registered vehicles. According to this comparison, the town of Waterford, Maine, has one EV but zero HEVs, which may suggest the data is incomplete or that HEV and EV markets may not overlap entirely as anticipated. For New York, Pennsylvania and the DVRPC, total HEVs were compared with total EVs, and higher correlations were found in the first two, though lower in the DVRPC.³² For Massachusetts, the percentage of EVs and HEVs in each town were compared to eliminate the

²⁷ “Electric Drive Vehicle Sales Figures (U.S Market) – EV Sales,” Electric Drive Transportation Association, accessed November 28, 2012, <http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952>.

²⁸ Alan Ohnsman and Yuki Hagiwara, “Toyota Prius Escapes Niche to Surge into Global Top Three,” Bloomberg, May 29, 2012, <http://www.bloomberg.com/news/2012-05-29/toyota-prius-escapes-niche-to-surge-into-global-top-three.html>.

²⁹ A yet-to-be-published study finds that 68% of California EV purchasers surveyed either currently own or owned a hybrid vehicle. This study also found a close spatial correlation between the location of hybrid owners and EV owners, reinforcing the concept of social influence in the spread of HEV purchases. Gil Tal et al., “Plug-In Vehicles in the San-Diego Region: A Spatial Analysis of the Demand for Plug-In Vehicles,” presentation, Electric Vehicle Symposium 26, May 11, 2012.

³⁰ Given the small number of EVs in New Hampshire (18), and even smaller proportion of current model EVs

(three) (according to the data source), New Hampshire’s EVs and HEVs were not compared.

³¹ Below are the states and sources (current as of date listed):

Maine, DMV, Toyota Prius only (6/21/12); Massachusetts, DMV (10/3/12); New Hampshire, Department of Environmental Services (2011); New York, DMV, (9/1/12); Pennsylvania, HEV rebate program, 2004–2010 (April 2011); Delaware Valley Regional Planning Commission (6/21/12).

³² The Pearson’s *r* correlations for Maine, New York, Pennsylvania and the DVRPC are 0.36, 0.56, 0.50 and 0.22, respectively.

effect of population size on correlation, and the correlation is not strong.³³

1.4.3. Incentives and Policy

Government support for EVs is a strong lever for increasing EV purchases. Currently, the federal government has enacted a tax rebate worth up to \$7,500 (dependent on battery size), to help close the cost gap between EVs and ICE vehicles. Several states have enacted additional financial incentives to further convince potential EV purchasers, including tax credits or exemptions and rebates at time of purchase. Others have provided accessibility incentives such as high-occupancy vehicle (HOV) lane eligibility or reduced tolls.

Table 1.6 displays a summary of the benefits provided in each jurisdiction. Private market incentives for EVSE are also included, as are jurisdictions pursuing EV purchases themselves to serve as role models in proving the viability of EVs. Comparing these incentives against the numbers of EVs in Table 1.2 suggests a correlation between the two.

³³ The Pearson's r correlation for Massachusetts by town is 0.87, but when calculated as a ratio to total cars, the correlation is 0.47.

Table 1.6. EV adoption incentives by jurisdiction³⁴

Jurisdiction	Access Benefits	Tax Exempt.	Credits/ Rebates	Private EVSE Subsidy	Fleet Requirements (for government vehicles unless specified otherwise)
Connecticut					Must be 100% alternative fuel vehicle (AFV), HEV or EV
Delaware			None		
Maine			None		
Maryland	HOV access		\$2,000 tax credit; 20% income tax credit for EVSE	EV Project (DC), ChargePoint America (Baltimore)	
Massachusetts				ChargePoint America (Boston)	Must be 50% HEV or AFV by 2018. Seventy-five percent of non-excluded vehicles shall be the cleanest AFVs available, with 10% zero-emission vehicles
New Hampshire					Seventy-five percent of new purchases must be AFVs, and state agencies must adhere to the state's Clean Fleets Program
New Jersey		Sales tax		EV Project (Phil.), ChargePoint America (NYC)	
New York	Reduced tolls and HOV access		\$500 rebate ³⁵	ChargePoint America (NYC)	
Pennsylvania			\$3,500 rebate	EV Project (Phil.)	
Rhode Island					Must be at least 75% AFVs; the remaining 25% must be HEV to the greatest extent possible
Vermont					AFV must be considered
Washington, DC		Excise tax		EV Project, ChargePoint America	Commercial fleets of at least 10 vehicles must be at least 70% AFV

Potential incentives are further explored in the report *The EVSE Toolkit: Administrative and Planning Strategies for Local Jurisdictions*.

³⁴ TCI region Clean Cities Coordinators.

³⁵ Through the Long Island Power Authority.

2. EVSE LOCATIONS

This section considers EVSE locations, which, as a critical piece of the EV ecosystem, are an important counterpart to EV ownership.

Siting EVSE effectively, so it is most useful for current and future EV owners, requires prioritizing EVSE locations in certain contexts. The Puget Sound Regional Council's 2010 *Electric Vehicle Infrastructure Regional Station Siting Analysis* analyzed the origin and destination of commuters in its region and reached the following conclusions regarding the use of EVSE by future EV owners:³⁶

- A single battery charge can easily accommodate typical automobile tours. This includes *all* of the trips made while away from home, such as to work and errands along the way.
- EV owners will likely be more concerned about non-typical travel, giving importance to "safety-net" charging sites.
- Public charging will largely involve "topping off" the battery.
- Level 2 chargers may serve a purpose at sites where typical dwell time exceeds 2 hours.

These findings align with most installation studies and efforts, though organizations having rolled out EVSE networks such as the Tokyo Electric Power Company (TEPCO) and The EV Project have uncovered additional trends:

- The 2009 TEPCO EV Study, which analyzed driver behavior before and after the installation of a citywide network of direct current (DC) fast charge stations, found that these EVSE installations increased drivers' willingness to more fully use their EV batteries, rather than increase EVSE usage.³⁷

³⁶ Puget Sound Regional Council, "Electric Vehicle Infrastructure Regional Station Siting Analysis," presentation, July 2010.
http://psrc.org/assets/4144/Station_siting_July2010.pdf.

³⁷ Martin Hale, "EV Charging Infrastructure Rapid Charge Solutions," presentation, EV Investor Club, December 8, 2011,

- The EV Project, which has installed Level 2 EVSE in select markets across the United States, found a 25% increase in use of public charging facilities between July and September of 2012, as well as a 20% increase in average charge times, suggesting EV trip distances are growing.³⁸

These trends show that providing public EVSE does in fact benefit EV owners. Therefore, to fully benefit the EV ecosystem, EVSE installations should be focused near current and projected EV ownership. A focus should also be made to locate public EVSE in high visibility places, increasing usage by current EV owners and persuading potential owners that there are sufficient public opportunities, even if the owners may not use the EVSE in question.

EVSE is being installed at a rate of more than two units per day in the TCI region.³⁹

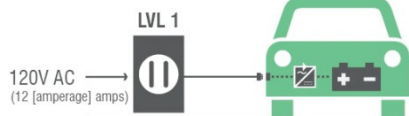
http://www.cleantechinvestor.com/events/docs/EV_dec11_abb.pdf.

³⁸ Jon Guerester, "Guest Post: Back-Up Generators—How Much are they Worth," Greentechmedia, November 28, 2012, <http://www.greentechmedia.com/articles/read/crunching-the-big-data-of-ev-charging>.

³⁹ Alternative Fuels Data Center download: http://www.afdc.energy.gov/data_download.

LEVELS OF CHARGE: DIAGRAMS AND ATTRIBUTES

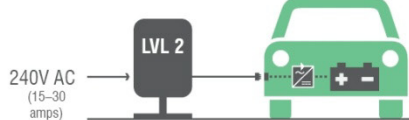
LEVEL 1



ATTRIBUTES:

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

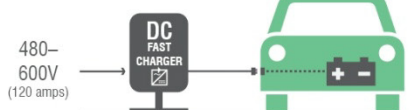
LEVEL 2



ATTRIBUTES:

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

DC FAST CHARGE



ATTRIBUTES

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

Figure 2.1. EVSE charging levels

Table 2.1. Existing and planned EVSE locations in the TCI region (excluding EVSE in private homes)

Jurisdiction	Existing	Planned	Level 1 (charge points)	Level 2 (charge points)	DC Fast Charge	Publicly Accessible (% of total)	On a Network
Connecticut	74	6	12 (33)	76 (109)		44 (59%)	9
Delaware	9		1 (2)	8 (10)		6 (67%)	2
Maine	4		1 (1)	3 (4)		3 (75%)	
Maryland	182	5	56 (86)	183 (285)		145 (80%)	133
Massachusetts	163	2	28 (47)	161 (310)		132 (81%)	91
New Hampshire	23		3 (13)	20 (23)		11 (48%)	2
New Jersey	76		20 (42)	74 (114)	1	48 (63%)	27
New York	217	1	87 (122)	213 (314)		153 (71%)	108
Pennsylvania	109	2	4 (12)	109 (150)	1	70 (64%)	22
Rhode Island	7	1	3 (12)	8 (26)		6 (86%)	1
Vermont	7	1	5 (6)	6 (8)		6 (86%)	5
Washington, DC	39		26 (38)	39 (61)		33 (85%)	35
Total	910	18	246 (414)	900 (1414)	2	657 (72%)	435

2.1. Geography of EVSE Installations

EVSE is being installed in the TCI region at a rapid pace. During the production of this report, the number of EVSE locations in the region increased by more than 25%, as shown in Figure 2.3. A state-by-state summary of the existing and planned EVSE locations as of September 5, 2012, is shown in Table 2.1.

The EVSE location data is taken exclusively from the Alternative Fuels Data Center (AFDC),⁴⁰ a resource of the U.S. Department of Energy's Clean Cities program, which has the stated goal of helping to find ways to reduce petroleum consumption through the use of alternative and renewable fuels, advanced vehicles and other fuel-saving measures.⁴¹ AFDC is considered the

⁴⁰ As of September 5, 2012, Alternative Fuels Data Center, "Data Downloads," U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, accessed November 30, 2012, http://www.afdc.energy.gov/data_download.

⁴¹ EVSE locations may include multiple charging categories, so the sum of existing and planned will not equal the sum of level 1, level 2 and DC fast charger. These EVSE and alternative fuel station locations are gathered by the National Renewable Energy Laboratory (NREL) from trade media, Clean Cities coordinators, submissions to the AFDC website and collaborations with infrastructure equipment providers. EVSE data is updated twice a month. NREL also compares its station data with those of other relevant trade organizations

most comprehensive resource for EVSE installations outside of private homes, and it serves as the source data for several EVSE-locator applications. A segment of private home installations can be found on websites such as PlugShare and CarStations.⁴²

Nearly all of the 910 locations contain Level 2 charging, but many also include outlets for Level 1 charging, providing a backup opportunity for charging in case the Level 2 connection is occupied. Also, while more than 70% of EVSE in the TCI region is publicly accessible, it may be located in paid lots. Two-thirds of publicly accessible EVSE is part of a billing and reservation network, with ChargePoint holding a dominant position among that EVSE, representing more than 75% of the market. Together with the SemaCharge and Blink networks, these account for more than 98% of networked installations in the region. These EVSE networks may see first-mover advantages over potential future entrants into the public EVSE space.

and websites, http://www.afdc.energy.gov/fuels/data_methods_stations.html.

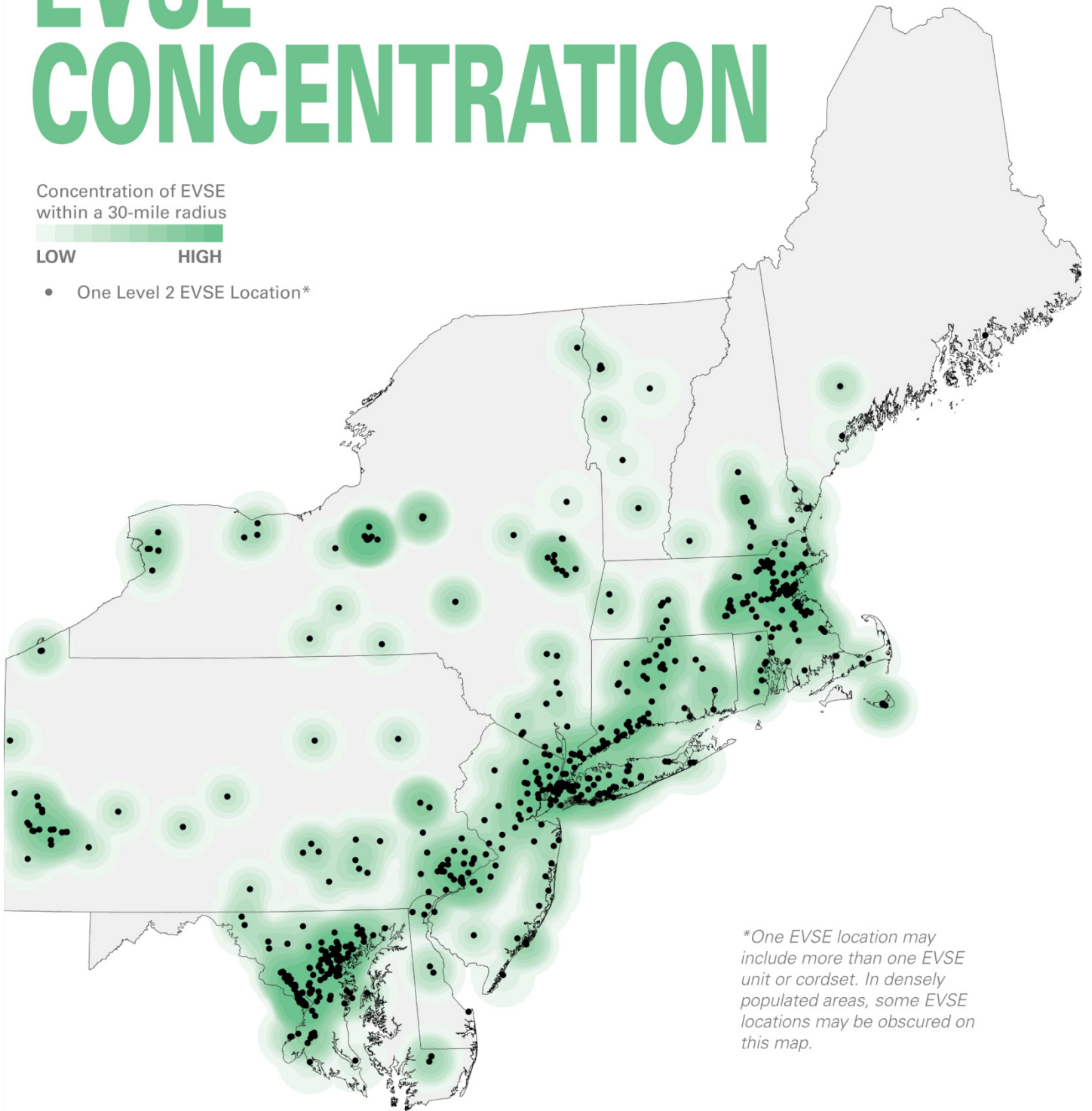
⁴² Plug Share homepage, accessed November 28, 2012, <http://www.plugshare.com/>; Car Stations homepage, accessed November 28, 2012, <http://carstations.com/>.

EVSE CONCENTRATION

Concentration of EVSE
within a 30-mile radius

LOW HIGH

• One Level 2 EVSE Location*



**One EVSE location may include more than one EVSE unit or cordset. In densely populated areas, some EVSE locations may be obscured on this map.*

Figure 2.2. Level 2 EVSE in the TCI region and density (source: Alternative Fuels Data Center, <http://www.afdc.energy.gov>)

Overall EVSE counts and proximities for the region may be deceiving. Not all EVSE is equally accessible, with many units located in private facilities (28% of all EVSE locations) or in non-free lots. Furthermore, a large percentage of EVSE is located at automobile dealerships and service stations, which are non-ideal destinations for extended dwell times or for combining with other trips.

Co-Location of EVSE and EVs

A basic premise of EV readiness is that an infrastructure build out of EVSE is required for widespread adoption of EVs, so comparing the current numbers for each will provide a snapshot of the current EV ecosystem. Geographically, much of the TCI region does not have access to public EVSE locations, but nearly all communities with EVs do. Ninety-nine percent of these communities have at least one within 30 miles, and 85% have one within 5 miles. In fact, the median distance to the closest public EVSE for EV communities is only 1.7 miles, and an average EV community is within a 5-mile range of 7 EVSE locations and a 30-mile range of 70 EVSE locations.

Statistically, the number of EVs in a community is most strongly associated with the count of EVSE facilities within five miles, and it is slightly negatively correlated with the distance to the nearest EVSE facility.⁴³ This suggests that, at present, *providing EVSE at destinations in the vicinity of potential EV owners is more important than installing them in their home communities.* This suggestion is consistent with the assumption that most EV owners charge at home.

As of September 2012, the TCI region had 1,830 potential charging points (which includes multiple charging spots at the 910 EVSE locations but does not include home locations), which compares to 3,625 EVs in the region. This number establishes a ratio of one charging spot to every two EVs (1:2) in the TCI region.

This ratio is significantly greater than the existing ratio between stations and gasoline vehicles, which is approximately 1:200.⁴⁴ However, EV

⁴³ EV Count and EVSE proximity have a Pearson's *r* correlation of -0.16 and EV Count and EVSEs within five miles have a Pearson's *r* correlation of 0.33.

⁴⁴ Fueleconomy.gov (<http://www.fueleconomy.gov/>) shows 168,000 (2004) stations, and the Federal

charging is a fundamentally different experience than gasoline refueling; perhaps the ratio of parking spaces to cars—cited as between two and eight parking spaces per car, nationwide—is a better measure.⁴⁵ It is unclear what the ratio in a mature market should be, though ECOtality suggested it should approach 1:1.⁴⁶ This implies that many more EVSE units will need to be installed with a greater EV market share.

Highway Administration shows 130 million personal vehicles, assuming four pumps per gas station.

⁴⁵ Michael Kimmelman, "Paved, But Still Alive," *The New York Times*, January 6, 2012, <http://www.nytimes.com/2012/01/08/arts/design/taking-parking-lots-seriously-as-public-spaces.html>.

⁴⁶ ECOtality North America, "Long Range EV Charging Infrastructure Plan for Western Washington," draft version 2.0, (Phoenix, AZ: ECOtality North America, June 2010), http://psrc.org/assets/4123/Western_WA_EV_LR_Plan_V_2_0_Excerpt_June10.pdf.

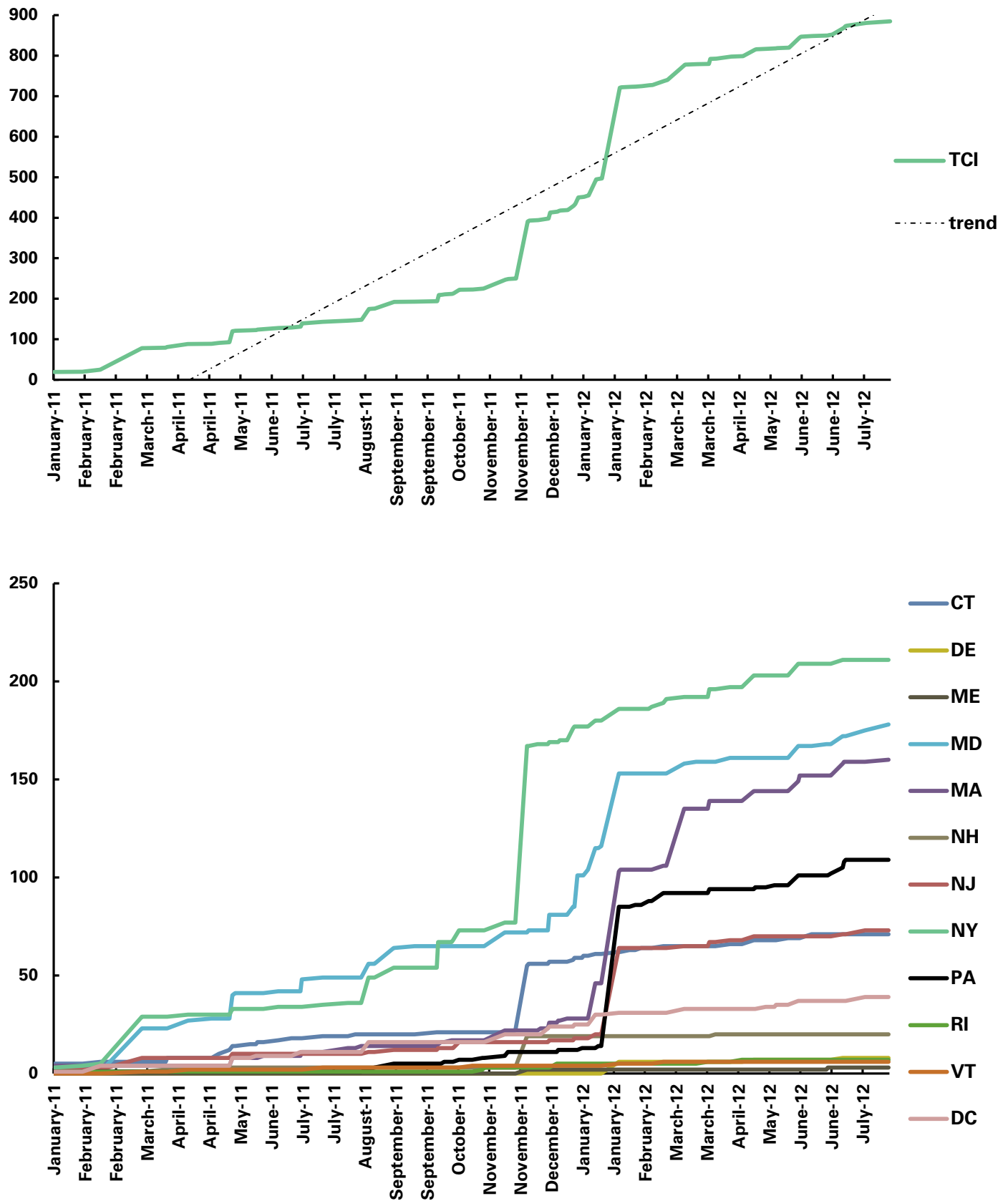


Figure 2.3. Total Level 2 EVSE installations over time and by jurisdiction (source: Alternative Fuels Data Center, <http://www.afdc.energy.gov>)

Climate Affecting EVSE Installation

While climate has not been shown to affect EV purchases,⁴⁷ precipitation and temperature considerations may affect EVSE location decisions. Much of these decisions are design considerations, and these issues along with other considerations are included in the TCI guidance document: *Siting and Design Guidelines for Electric Vehicle Supply Equipment (EVSE)*.⁴⁸

Generally humid and damp locations should be avoided, as should any specific locations that are prone to floods or susceptible to ponding. Freezing temperatures are also a major consideration for EVSE use because of the potential for cords and couplers to stick to pavement or the EVSE itself, and in extreme cases for the cord wiring to become brittle and break. Furthermore, EVSE must be protected from snow in particular, both directly and in terms of snow plowing management.⁴⁹ Therefore, EVSE installations in colder climates are likely to be more difficult and expensive, perhaps explaining the deficit of EVSE in the northern reaches of the TCI region, which can also be attributed to those areas' lower income and population density.

Based on the analysis of EVSE, the number of EVSE locations in the TCI region's colder areas is not disproportionately less than in the warmer areas.

2.2. EVSE Location Typologies

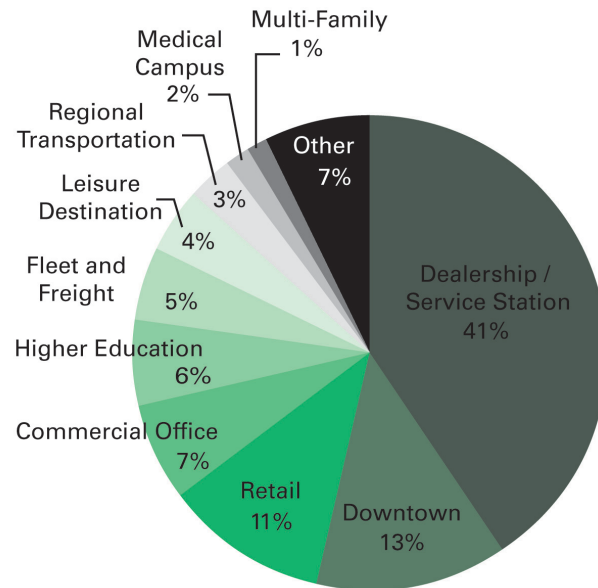


Figure 2.4. EVSE deployment by location type

EVSE in the TCI region can be found in several location contexts in different numbers. This section discusses the top five location types by current EVSE deployment. The supplemental TCI report *EVSE Cluster Analysis* looks further at all of these typologies and analyzes their viability across a range of categories.

Dealerships and Service Stations

Of the 910 Level 2 EVSE installations in the TCI region, more than one-third are located at Nissan dealerships. Each of those dealerships houses two EVSE installations: one public, and one for the service station. These service station EVSE installations account for two-thirds of private installations in the region, while Nissan's public EVSE installations account for one-quarter of all public EVSE units and two-thirds of non-networked public EVSE installations.

For dealerships, publicly displaying EVSE is as much about introducing the public to EVs as it is about gaining goodwill from existing EV owners. These installations are generally not great public EVSE locations, because they are unlikely to be located near other destinations. As such, dealerships and service stations were not included in *EVSE Cluster Analysis*.

⁴⁷ An analysis of EV ownership by climate zone, from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), does not show any meaningful correlation with EV ownership. "ASHRAE Climate Zones Map," Green Zone, accessed November 28, 2012, http://www.greenzone.com/general.php?section_url=12.

⁴⁸ This report can be found on the website of the Northeast Electric Vehicle Network, a TCI project, found here: <http://northeastevs.org>.

⁴⁹ David Eppstein, Vice President for Operations. Medical Academic and Scientific Community Organization, Inc., interview, July 13, 2012.

Downtown

This category includes both municipal and private lots. Municipal lots are government sponsored, and EVSE installation therefore reflects policy. These lots are located at town centers and serve public facilities. Meanwhile, in private lots, EVSE acts as service differentiators, drawing customers for extended periods of time. EVSE was often installed because of memoranda of understanding with government, and an overwhelming percentage of private lot EVSE is located in New York City.

Retail

For retailers, EVSE represent a marketing opportunity, either by drawing in potential customers or extending their stay because of charging requirements. These locations are particularly appealing to PHEV or EREV owners, allowing them to top-off their battery and avoid using their gasoline engine.⁵⁰ In the TCI region, half of retail EVSE is located at Walgreens, and a quarter is at restaurants or grocery stores.

Commercial Offices

EVSE installations in office locations are driven by internal mission, employee demands or developer marketing. Where paired with EV-owning employees, these are prime secondary or even primary charging locations because of consistent patterns and long dwell time. Nationally, efforts are being made to lobby and train employers in the benefits of incorporating EVs and installing EVSE.⁵¹

Higher Education

Given the strong connection between EV ownership and educational attainment, colleges and universities are worthwhile EVSE locations. Installations at these major employment centers can serve professors and employees, as well as distinguish a school's sustainability policies. Many of these installations are occurring at public universities, which may also be driven by government policies.

⁵⁰ This phenomenon has been named "gas anxiety" and ECOtality has found that it drives PHEV/EREV owners to plug in more frequently than BEV owners. Diane Cardwell, "For Hybrid Drivers, A gas Pump Allergy," *The New York Times*, October 18, 2012, <http://green.blogs.nytimes.com/2012/10/18/for-hybrid-drivers-a-gas-pump-allergy/>.

⁵¹ See <http://www.evworkplace.org/>, a CALSTART partnership with Google.

3. ENERGY AND EMISSIONS INFLUENCING FUTURE EV USAGE

3.1. Energy and Emissions

EVs shift the energy generation model away from the petroleum products on the vehicle itself and to electricity generated at power plants, interfaced through a utility. Utilities are well aware of the opportunities and challenges EVs present, with many recognizing the benefits of having a large number of EV batteries as part of a smart grid to increase the reliability of their electricity service as well as enable higher penetration of renewable generation sources such as wind and solar power. Several utilities provide incentives for EVs, including rebates, financial and logistical support for EVSE installation and reduced electricity rates. These are described in more detail in the TCI report *The EVSE Toolkit: Administrative and Planning Strategies for Local Jurisdictions*.

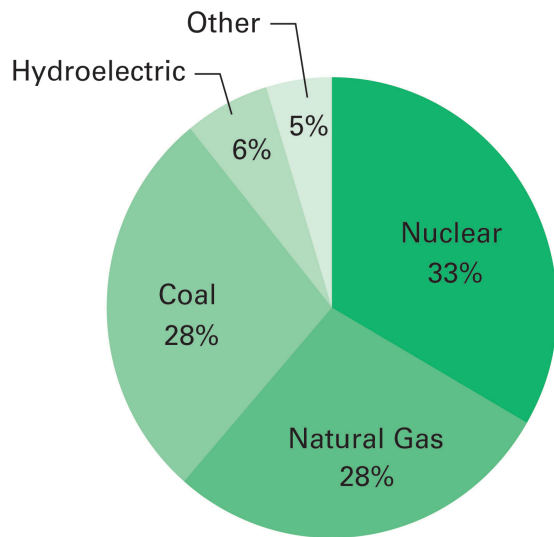


Figure 3.1 Electricity generation mix for TCI region⁵²

⁵² Other includes: biomass, petroleum, solar and wind. From U.S. Energy Information Administration, "Electricity Generation by State by Type of Producer by Energy Source," Data.gov, May 29, 2012, <https://explore.data.gov/Energy-and-Utilities/Electricity-Generation-by-State-by-Type-of-Producer/rhyi-ndfk>

There are, however, few efforts to highlight EVs' local air pollution benefits, though most EV marketing prioritizes the connection to "green living" and, as discussed in Section 1.4.2, public eco-consciousness is a strong social motivator for purchase. The TCI region's combination of clean energy generation, shown in Figure 3.1, and air pollutant concentration make it an ideal location for such marketing efforts.

3.1.1. Air Pollution

Transportation is the largest single source of air pollution in the United States, in the form of particulates, greenhouse gases (GHGs), carbon monoxide and ingredients for smog formation.⁵³ Most of these are emitted through car tailpipes and are therefore experienced locally. EVs benefit from emission-less propulsion and more efficient energy generation,⁵⁴ so that in nearly all cases—even with the dirtiest of fuel sources for electricity—they produce less pollution.

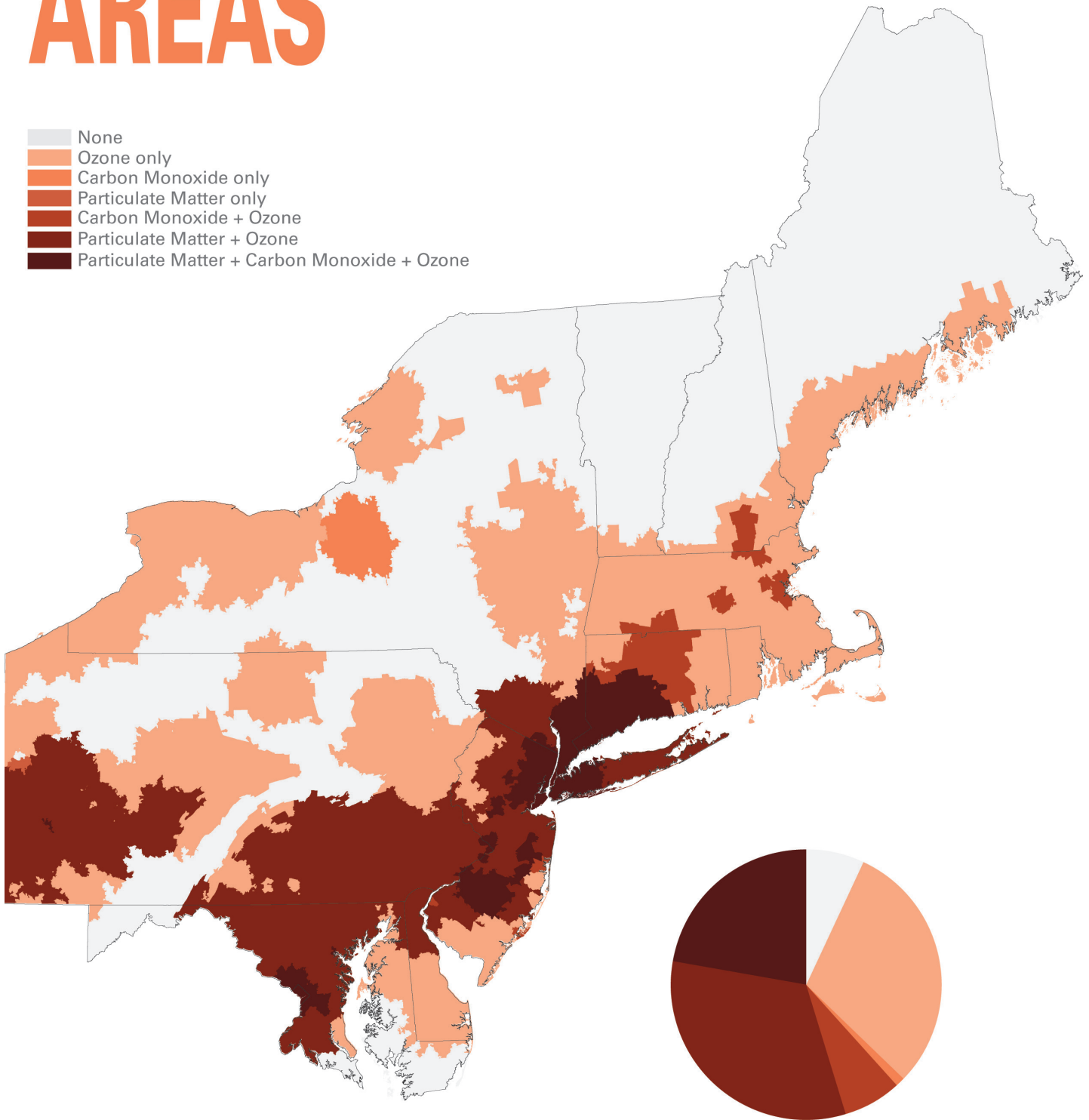
EV driving does move pollution to the point of electricity generation, which can affect different communities and in some cases may introduce other categories of pollutants. The Union of Concerned Scientists' report *State of Charge*⁵⁵ attempts to qualify which regions in the United States will benefit most from EV usage, specifically in terms of GHG emissions, assigning values of *good*, *better* and *best*. Nearly all of the TCI region lies in the *best* region, including 92% of current EV ownership, meaning ICE vehicles would need to achieve at least 50 miles per gallon to achieve a GHG emission level equivalent to that of a BEV. In Buffalo, New York, because of a high reliance on hydroelectric power, ICE vehicles would need to achieve 115 MPG to match the GHG emissions of a BEV.

⁵³ "Cars, Trucks, & Air Pollution," Union of Concerned Scientists, accessed November 28, 2012, http://www.ucsusa.org/clean_vehicles/why-clean-cars/air-pollution-and-health/cars-trucks-air-pollution.html.

⁵⁴ As evidenced by EVs' superior scores under the EPA's MPG-equivalent rating, representing the number of miles a vehicle can go using a quantity of fuel with the same energy content as a gallon of gasoline.

⁵⁵ Anair and Mahmassani, *State of Charge: Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States*, (Union of Concerned Scientists, April 2012), http://www.ucsusa.org/assets/documents/clean_vehicles/electric-car-global-warming-emissions-report.pdf.

NON ATTAINMENT AREAS



Non-attainment for ZIP codes with EVs

Figure 3.2. Non-attainment areas by type, for TCI region and EV communities (source: Research and Innovation Technology Administration "Geospatial Information," Bureau of Transportation Statistics, accessed November 28, 2012, http://www.bts.gov/programs/geographic_information_services/)

Non-Attainment Areas

As part of the National Ambient Air Quality Standards enforceable under the Clean Air Act of 1990, the EPA specifies limits for those pollutants deemed hazardous to public health and the environment (not including GHG emissions).⁵⁶

Regions not in conformity with those standards are considered non-attainment areas, and the EPA requires non-attaining jurisdictions to devise plans to meet those standards. The Indiana utility NIPSCO's emission plan resulting from Clean Air Act violations is discussed in the TCI report *Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools*.⁵⁷

Seventy-four percent of the TCI region is in non-attainment for one or more pollutant,⁵⁸ representing a significant portion of non-attainment in the United States. ZIP codes containing EVs are even worse off, because 92% of those in the TCI region are in non-attainment areas, and 64% of those communities are non-attaining for two or more pollutants, as shown in Figure 3.2. This makes clear how much communities in the TCI region stand to benefit from continued and increased EV adoption.

Mandates for Low- to Zero-Emission Vehicles

Whether because of Clean Air Act violations or general interest in air pollution reduction, several jurisdictions have taken the step of mandating or recommending zero- or low-emission for certain categories of vehicles.

Most famously, the California Air Resources Board in 1990 mandated that the largest vehicle manufacturers include increasing percentages of zero-emission vehicle models as part of their marketed offerings. At the time, EVs were the only alternative fuel vehicle (AFV) to achieve zero emissions, so this led to the production of General Motors' EV1, Toyota's RAV4-EV and Ford's

⁵⁶ "National Ambient Air Quality Standards (NAAQS)," U.S. Environmental Protection Agency, accessed November 28, 2012, <http://www.epa.gov/air/criteria.html>.

⁵⁷ This report can be found in on the TCI website located at <http://www.transportationandclimate.org/>.

⁵⁸ Non-attainment areas include 93% of the TCI region's population. Parts of the TCI region were previously non-conforming to carbon monoxide, though all are now under "maintenance."

Ranger EV, among others.⁵⁹ Those requirements were reduced and delayed, and production of those models ceased, but recent strengthening of those ZEV mandates has led to the limited-run production of "compliance cars" by several carmakers.⁶⁰

In the TCI region, as listed in Table 1.6, Connecticut, Massachusetts, Rhode Island and Vermont all have made requirements or recommendations for AFV procurement for government vehicles. Though these government fleets are not guaranteed to be EVs, and overall compose small percentages of total vehicles in-state, these measures accelerate adoption rates and market EVs to the public. Washington, DC, meanwhile mandates that local commercial fleets of ten or more vehicles be AFV, as long as the district remains a non-attainment area. This tactic can have a large impact on air quality because the larger and older vehicles often found in commercial fleets can cause significantly more air pollution.

Mandates for low or zero emissions can also be instituted locally, where reduced noise and air pollution are highly valued. Some resort communities and home-ownership associations, of which there are 250,000 in the United States,⁶¹ have already mandated low-speed, low-emission vehicles such as golf carts and NEVs.⁶²

Renewable Portfolio Standards and Goals

EV emissions are destined to get cleaner due to requirements for renewable electricity generation among other steps to clean up generation. All of the TCI region's jurisdictions have instituted renewable portfolio standards obligating utilities to reach target percentages of renewable energy generation for their total capacity. No two locations' programs are the same, reflecting

⁵⁹ Gary Kendall, *Plugged In: The End of the Oil Age* (Brussels: World Wide Fund for Nature, March 2008).

⁶⁰ Danny King, "These Electric Vehicles Aren't Really, Real; Just California Compliance EV," *AutoblogGreen*, May 4, 2012, <http://green.autoblog.com/2012/05/04/these-electric-vehicles-arent-really-real-just-california-com/>.

⁶¹ Alan Wienstien, "Homeowners Associations," *PlannersWeb*, April 6, 2005, <http://plannersweb.com/2005/04/homeowners-associations/>.

⁶² David Slade, "New Zoning Urged for Electric Cars," *The Post and Courier*, Charleston, SC, March 19, 2012, <http://www.postandcourier.com/article/20100908/PC1602/309089969>.

specific policy objectives and capacity to expand renewable production. Even definitions of what is considered renewable vary.⁶³ Table 3.1 lists target percentages and target years.

Table 3.1. Renewable portfolio standards for the TCI region

Jurisdiction	Target	Year	Notes
Connecticut	23%	2020	
Delaware	25%	2025	
Maine	40%	2017	10% must be new; 8 gigawatt (GW) wind by 2030
Maryland	20%	2022	
Massachusetts	15%	2020	Includes 2 GW wind goal
New Hampshire	23.8%	2025	
New Jersey	22.5%	2020	
New York	30%	2015	
Pennsylvania	18%	2020	
Rhode Island	16%	2020	
Vermont	20%	2017	Voluntary
Washington, DC	20%	2020	

3.1.2. Solar

The solar market is rapidly growing and will be poised for further expansion with greater electricity needs—a potential outcome of widespread EV adoption.⁶⁴ Many homeowners across the TCI region have already installed rooftop solar photovoltaic (PV) systems; if the panels are sized correctly, the electricity to fuel an EV can be zero-cost. Furthermore, because solar electricity generation is zero emission, the entire driving experience can be zero emission.

Because of the potential for a zero-cost, zero-emission transportation paradigm, some see the futures of EVs and solar as inextricable, while

⁶³ “Renewable Power & Energy Efficiency: Energy Efficiency Resource Standards (EERS) and Goals,” Federal Energy Regulatory Commission, September 13, 2011, <http://www.ferc.gov/market-oversight/other-mkts/renew/other-rnw-eers.pdf>.

⁶⁴ “Blistering Rate of Growth for U.S. Solar Industry,” Seeking Alpha, December 5, 2011, <http://seekingalpha.com/article/311886-blistering-rate-of-growth-for-u-s-solar-industry>.

others simply see EVs and solar PV as reaching similar markets. The DVRPC, as part of its efforts to model the EV market, mentioned in Section 1.4, requested the locations of those customers using net metering⁶⁵ from the local utility, which indicates PV panel installation. Research in other parts of the United States indicates that many EV buyers already own PV panels, or at least live near households with PVs.⁶⁶

Businesses see the connection as well. EV makers see sustainable marketing opportunities, including Tesla, with its “Supercharger” network of fast-charging EVSE stations powered by PVs, and BMW, offering what it describes as a “truly holistic approach to sustainable mobility” for ActiveE lessees by providing a 35% discount on residential solar installations.⁶⁷ Even retailers see the potential for PV canopies over EVSE as marketing tools to attract particular clientele.⁶⁸

For the TCI region, a positive relationship is apparent between EV ownership and PV installations, as seen in Figure 3.3. The strength of the relationship varies by state however; for instance, the correlation is stronger in Maryland than New Jersey, despite their similar climates. Partially this can be explained by New Jersey’s excellent financial incentives for PVs, which may skew installations away from those driven solely by eco-consciousness.⁶⁹ For the TCI region overall, ZIP codes with EVs have 4.7 times as many PV installations as non-EV zip codes

⁶⁵ Net metering allows electric customers to transfer locally generated energy (e.g., solar or wind) to the grid and offset power drawn from the grid.

⁶⁶ Gil Tal et al., “Plug-In Vehicles in the San-Diego Region: A Spatial Analysis of the Demand for Plug-In Vehicles,” presentation, Electric Vehicle Symposium 26, May 11, 2012.

⁶⁷ Devin Coldewey, “Tesla Unveils Network of Free, Solar ‘Superchargers’ for Model S,” FutureTech, accessed November 28, 2012, <http://www.nbcnews.com/technology/futureoftech/tesla-unveils-network-free-solar-superchargers-model-s-1B6095618>;

Herman K. Trabish, “Will BMW’s Solar-Wind Package Tap a New Target Car Market?” Greentechmedia, August 3, 2012, <http://www.greentechmedia.com/articles/read/will-bmws-solar-wind-package-tap-a-new-target-car-market/>.

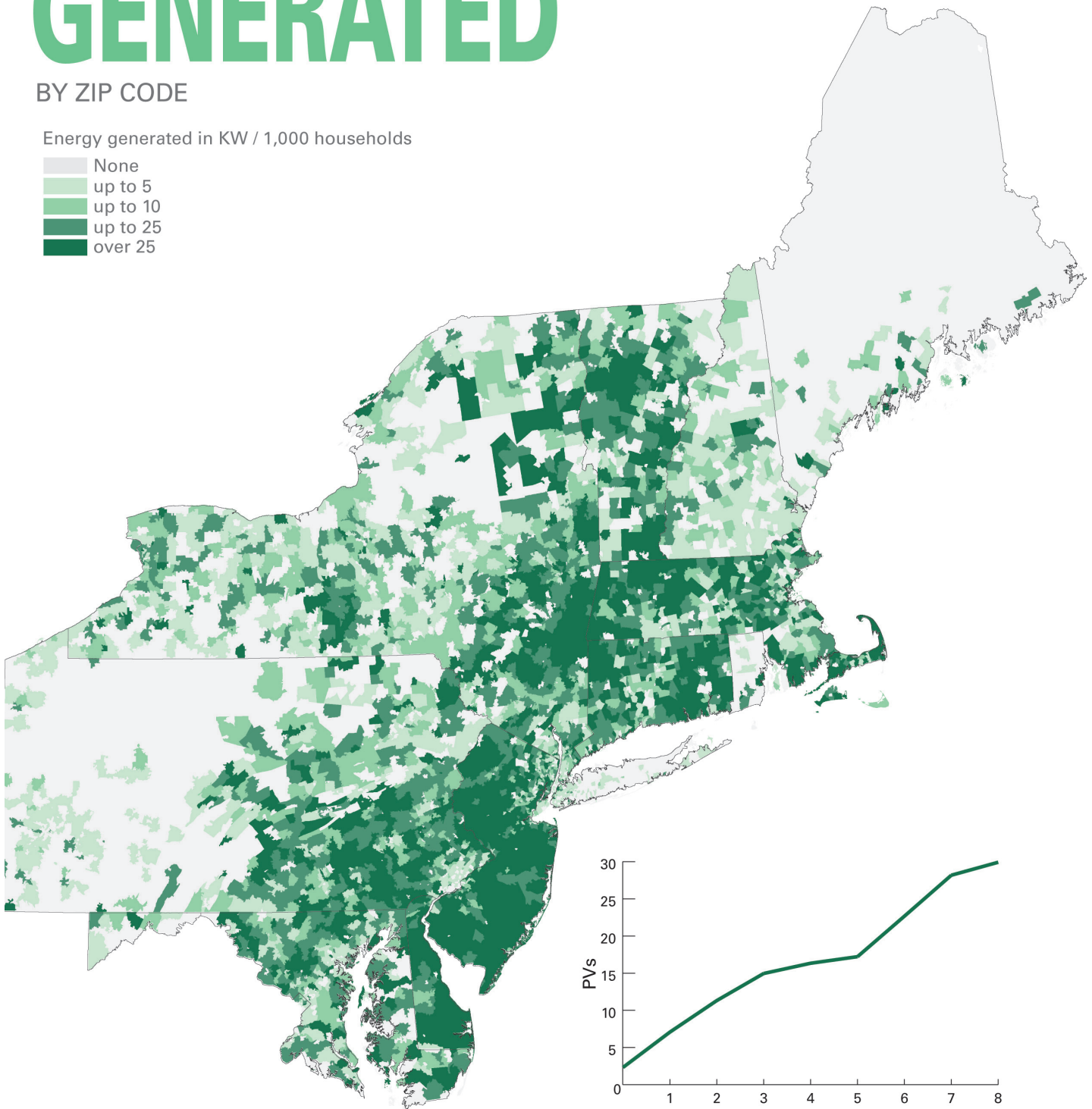
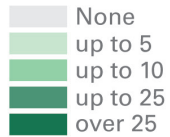
⁶⁸ Joseph Berman, Golub Corporation, interview, July 25, 2012.

⁶⁹ “SREC Registration Program,” New Jersey’s Clean Energy Program, accessed November 28, 2012, <http://www.njcleanenergy.com/srec>.

SOLAR ENERGY GENERATED

BY ZIP CODE

Energy generated in KW / 1,000 households



Average PV installation by # of EVs

Figure 3.3. Solar electricity generation, and relationship between PV installation and EV ownership (source: National Renewable Energy Laboratory's Open PV Project, <https://openpv.nrel.gov/> [as of 6/19/2012])

4. CONCLUSIONS

This report has reviewed the latest and most comprehensive information available on EV ownership and EVSE locations across the TCI region. Based on this information, analytical mapping and cross-tabulated information, the following findings and initial recommendations are put forward:

TCI Region EV Ownership Findings

- Areas of EV ownership are significantly less dense than communities without EVs, with nearly all ownership located outside of urban cores. Across the TCI region, more than 40% of EV ownership is located in exurban and less dense suburban areas, which compose only 20% of the population. These areas tend to have more single-family homes and fewer multifamily structures than communities without EVs.
- Communities with EV ownership tend to be younger than communities without EV ownership.⁷⁰ This data contrasts with the information on hybrid early adopters, which clearly emphasize a skewing toward older buyers.
- Areas with EV ownership tend to be more educated, especially in graduate-degree attainment, than communities without EVs. They are also wealthier; higher-income communities are significantly more likely to have EV ownership.
- There appears to be a positive correlation between the level of EV ownership and the variety of EV models available at EV dealerships nearby.
- There are large and significant discrepancies in EV ownership on a state-by-state basis, such as between Pennsylvania and Massachusetts.⁷¹ This discrepancy may be due to several

⁷⁰ It is important to note that the data on EV ownership is provided by ZIP code, rather than by household. As a result, this analysis considers “EV communities” rather than data based on individuals.

⁷¹ Some of this discrepancy may be due to slightly more current data from the local Clean Cities coalition, which reflects more recent EV purchases.

factors. It is important to note that the policy of providing EV purchase rebates of \$3,500 in Pennsylvania does not appear to be moving the state up the ladder of EV ownership.

TCI Region EVSE Findings

- EVSE is being installed near communities with EV ownership, but having an EVSE installation in the immediate vicinity does not appear to increase EV ownership. This may be due to the siting of many EVSE installations at *destinations* rather than close to the homes of EV owners.
- A significant portion (approximately 37%) of the region’s EVSE is located at dealerships. A good distribution of these locations is important in order to provide adequate coverage of driving ranges for EV buyers to reach home, but dealerships are not ideal charging destinations for EV owners.
- Other major types of areas where EVSE has been installed include universities, retail areas and commercial office buildings.
- Of the commercial EVSE locations, half of the installations are at tech-specific office buildings.

Initial Recommendations

- EV promotion efforts should continue within communities with the highest rates of EV ownership, because these places are likely to have EV purchasers who fit EV owner profiles, provide sufficient soft infrastructure (e.g., dealerships and EVSE installers) and have the social networks that help to encourage potential EV owners.
- Given the lack of positive correlation between EV communities and EVSE locations, this report begins to build the case that EVSE locations are predominantly based at destinations rather than close to homes. As such, the expansion of EVSE locations should be targeted toward a set of appropriate destinations that are within driving range of EV communities. Many of these targeted destinations are examined in greater detail in the companion TCI report, *EVSE Cluster Analysis*.
- The greater propensity for EV ownership in relatively low density, single-family-

home commuting communities suggests that EVSE locations at park-and-ride facilities for regional transportation may be significant opportunities. There may be concerns around developing EVSE locations at park-and-ride facilities because they do not necessarily match up with typical dwell times and thus make monetization more challenging. But, given the long dwell times of commuters, minimal installations using Level 1 EVSE may be appropriate.

- The EV ownership focus on lower-density single-family-home communities highlights a challenge in getting communities with multifamily homes to become more EV oriented. A shift toward this demographic will require a careful consideration of ways to encourage EVSE installation for home charging.
- Based on the mapping of communities with EV ownership and air quality non-attainment areas, there is a real opportunity to gather support for EVs from communities affected by auto pollution, especially trucks. Investments in government and commercial fleets are excellent candidates to connect to less-privileged communities.