TRANSPORTATION & CLIMATE INITIATIVE
Of the Northeast and Mid-Atlantic States

# LESSONS FROM EARLY DEPLOYMENTS OF ELECTRIC VEHICLE CHARGING STATIONS

## Case Studies from the Northeast and Mid-Atlantic Regions

Prepared by Logios for the Transportation and Climate Initiative

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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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Cover photograph: Chevy Volt recharging at a public charging station at the Boston City Hall (2013). © Logios.

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## Introduction

As of this report's completion, 5,548 installations of plug-in electric vehicle charging stations, also known as electric vehicle supply equipment (EVSE), have been recorded in the United States.[1] These installations include a total of 16,256 connectors, which gives the maximum number of vehicles that could be charging at any given moment.[2] These data suggests that each installation includes, on average, 3.6 connectors. Fifteen percent of these stations and fourteen percent of these connectors are located in the District of Columbia and Northeast and Mid-Atlantic states participating in the Transportation and Climate Initiative (TCI; Table 1).

**Table 1. Charging stations in the Northeast and Mid Atlantic states**

| State | Number of charging stations | Number of connectors |
|---|---|---|
| Connecticut | 79 | 172 |
| Delaware | 7 | 105 |
| District of Columbia | 31 | 15 |
| Maine | 13 | 23 |
| Maryland | 164 | 447 |
| Massachusetts | 160 | 452 |
| New Jersey | 62 | 197 |
| New Hampshire | 13 | 42 |
| New York | 174 | 497 |
| Pennsylvania | 102 | 246 |
| Rhode Island | 9 | 41 |
| Vermont | 14 | 38 |
| **Total** | **628** | **2275** |

The goals of this study are to document real cases of charging infrastructure installations in the Northeast and Mid-Atlantic regions and uncover some of the related challenges and opportunities. Unlike earlier documents, the focus of this study is not on how installations should be done but rather on how they have been done.

The installations reported in this study were done prior to or simultaneously with the development of installation guidance documents in their region. Thus, host site owners, installers, and other stakeholders involved in the process of the installations did not have access to guidance documentation that was formally developed for their region. The earliest guidance documents of this type in the United States were created by a stakeholder process in the State of Washington in

[1] U.S. Department of Energy, Alternative Fuels Data Center. Accessed on the Web at http://www.afdc.energy.gov/ on March 10, 2013
[2] U.S. Department of Energy, Alternative Fuels Data Center. Accessed on the Web at http://www.afdc.energy.gov/fuels/stations_counts.html on March 24, 2013

2010.[3] Guidance documents were created in the Northeast and Mid Atlantic regions more recently through the TCI.[4,5] The limited access to guidance documents or specific building codes explains in part some of the choices made regarding elements such as charging station signage and disable accessibility to charging spaces.

Methodologically, the authors carried out a number of case studies and systematically explored questions related to the various aspects of charging station deployment, from procurement to installation and usage. The study does not attempt to produce detailed reports of every step in the process. Rather, the focus is on interesting or salient aspects that contribute to a cohesive body of information that facilitates the identification of potential challenges, recurrent issues, and opportunities for future installations.

As part of the data collection process, the authors spoke with and obtained information from individuals who took a leading role in the installation of the featured charging stations. The authors conducted site visits for most of the case studies. Personal communications and site visits were the two main sources of information used in the case studies.

Cases studies were selected to represent installations in a variety of geographic areas and site types, such as workplace, multi-dwelling units, sidewalk right of way, recreation, and others. The report was not structured around these site characteristics, however, as some cases might fit more than one description.

The objectives of this study were:

- To provide stakeholders with actionable information that they can use to support the deployment of electric vehicle charging infrastructure; and
- To show prospective owners of electric vehicle charging infrastructure installation stories that they can relate to and help them understand some of the issues that they may encounter and opportunities that they may benefit from.

The main body of the report contains the case studies. The final section integrates findings into lessons and opportunities that could inform future work toward supporting charging infrastructure deployment.

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[3] Puget Sound Regional Council and Washington State Department of Commerce (2010) *Electric Vehicle Infrastructure: Guidance for Local Governments in Washington State*. July. Available on the web at www.psrc.org/transportation/ev/.

[4] Sustainable Transportation Solutions (2012) *Site Design for Electric Vehicle Charging Stations*. Prepared for the New York State Research and Development Authority. Available on the web at www.hrccc.org.

[5] WXY Architecture + Urban Design (2012) Siting and Design Guidelines for Electric Vehicle Supply Equipment. Prepared for the New York State Research and Development Authority and the Transportation and Climate Initiative. November. Available on the web at www.northeastevs.org.

## Brief Technical Overview

The authors believe that it is generally helpful to specify language that refers to the charging equipment and to the combination of charging equipment and the parking space served by the equipment. In this regard, the approach first taken by the State of Washington is adopted, and references to *battery charging station*, equivalent to *electric vehicle supply equipment* (EVSE), mean the "electrical component assembly or cluster of component assemblies designed specifically to charge batteries within electric vehicles", while references to *electric vehicle charging station* (EV charging station) mean a "public or private parking space that is served by battery charging station equipment that has as its primary purpose the transfer of electric energy (by conductive or inductive means) to a battery or other energy storage device in an electric vehicle."[6]

Electric vehicle supply equipment is generally categorized in terms of its level, a term that refers to the range of current or voltage at which the equipment is designed to support the charging of the vehicle. AC level 1 EVSE supports conductive charging at current levels up to 16 amperes (A), at voltage levels of 120 alternating current volts (VAC), common in standard outlets. AC level 2 EVSE supports conductive charging at current levels between 12 and 80 A, using 208 to 240 VAC circuits. Electricity flows from the equipment to the car through a cord ending on a connector, which hooks up into the receptacle in the car. The Society of Automotive Engineers adopted a standard (J1772) for the connector, which is now found in all level 1 and level 2 charging equipment. There is a third type or level of equipment, known as DC fast charge (sometimes referred to as DC level 3). This type of equipment enables charging at much higher current and requires a different connector, for which a standard has not been yet agreed upon in the United States.

The installations described in this report involved only EVSE of levels 1 and 2. EVSE manufacturers offer a variety of configurations to meet different customer needs. The equipment may include one or two connectors, often referred to as "single" and "dual" connector EVSE, respectively. Structurally, two main varieties are found: wall mount and bollard. The former is smaller and is designed to be installed on a wall, while the latter is standing on its own pedestal and is designed to be installed on the ground. Wall mount EVSE is typically chosen for residential installations and bollard EVSE is typically chosen for on-street installations. Both types are used for installations in parking lots and parking garages.

It is generally recommended that licensed electricians be in charge of EVSE installations. Prior to interconnecting the equipment, an analysis of the electrical system is conducted to make sure that it can support the operation of the equipment. This process includes assessing whether the electrical panel has sufficient capacity (amperage), and sufficient number of breakers with the necessary rating to supply

[6] Puget Sound Regional Council and Washington State Department of Commerce (2010). *Electric Vehicle Infrastructure: Guidance for Local Governments in Washington State*. July.

the EVSE. In level 2 charging, the maximum current level is determined by the rated power of the battery charger on board of the vehicle. For most electric vehicles in the market today, these chargers are rated at between 3.3 and 6.6 kilowatt (kW). Typically, 40 A circuit breakers are used to support level 2 equipment. Per the specifications described in the preceding paragraph, level 2 EVSE is designed to operate at up to 80 A, which may occur with 19.2 kW onboard chargers.

Approved practices for all electrical aspects EVSE installations are described in the National Electrical Code. Other aspects of installations are generally grouped under the label of "site design", and include items such as signage, EV charging station dimensions, and accessibility. Requirements for site design would typically be adopted as part of building codes at the local or state levels. As of the date of completing this report, the authors are aware of no site design requirements that have been adopted within the TCI area, although TCI has recently completed EV guidance documents with recommendations for siting.

Most advanced charging stations in the market today are capable of collecting and transmitting data. Data is often collected on variables such as time, duration, and amount of energy consumed for each charging event. Although they have not yet been used for this purpose, these data will be invaluable to inform future strategy and planning and support of EVSE deployments. Data transmission is generally implemented using cellular technology although Wi-Fi and Ethernet are also common. In situations where data transmission relies on wireless signals and signal reception is not adequate, measures need to be adopted to improve its quality. One such method is the use of mesh technology, which is particularly applicable when multiple charging stations are located at the same facility. Another method is the use of repeaters. In general, the use of signal enhancing methods will have an impact on the cost of the installation and should, whenever possible, be avoided.

## Case Studies

This section includes 10 case studies of electric vehicle charging station installations in the TCI region, as well as three brief installation snapshots. In a report recently prepared for TCI, charging station host sites were classified into a number of "clusters".[7] These clusters are the downtown cluster, retail cluster, workplace cluster, higher education cluster, fleet and freight cluster, leisure destination cluster, regional transit cluster, medical campus cluster, and multifamily housing cluster. In this report, the title of each case study will indicate the type of cluster to which it most closely relates.

Case studies are organized by cluster in this report. Each study includes an introductory segment, followed by five topical segments: site preparation and equipment installation, station operation, financials, challenges, and lessons and opportunities. The authors tried to include thorough information for each subsection, although at times the complexity of the study set limits on the amount of information that could be provided.

[7] WXY Architecture + Urban Design (2012) *EVSE Cluster Analysis: Electric Vehicle Supply Equipment Support Study*. Prepared for the New York State Research and Development Authority and the Transportation and Climate Initiative. November. Available on the web at www.northeastevs.org. In the context of this reference, clusters are not to be confused with the groups obtained through numerical techniques in statistical cluster analysis. The term cluster was "used to represent typologies where (characteristics typical of EV owners) interrelate to create a place of likely EV usage with a demand for EVSE."

## The Fitzgerald Building, Baltimore, Maryland (Multifamily Housing)

The Fitzgerald is a three-year-old mixed-use development located at 1201 W. Mount Royal Ave., Baltimore, Maryland (Figure 1). Developed by the Bozzuto Group, it consists of a high-density multi-unit dwelling, with a few shops on the street level. It is located a few minutes' walk from Baltimore's Penn Station, an important transportation hub for commuters in the Baltimore-Washington, DC corridor.

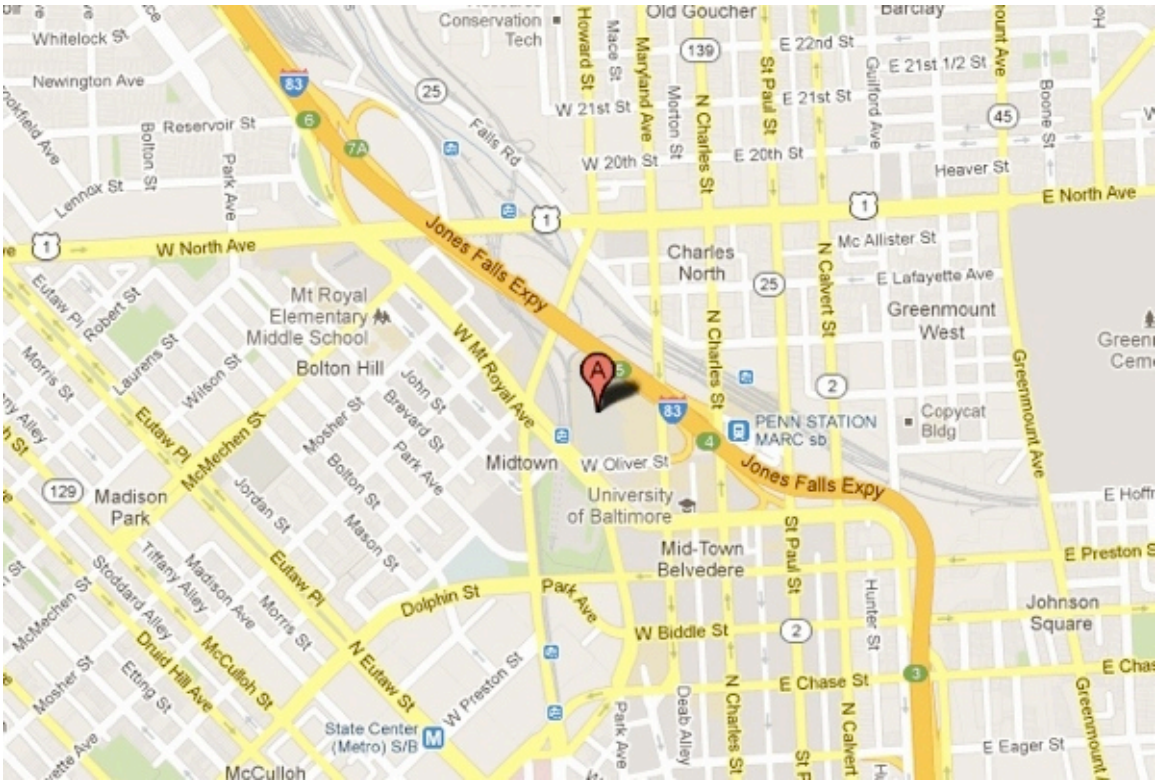



Figure 1. Location of the Fitzgerald (Source: Google Maps)

The decision to install charging infrastructure at the Fitzgerald came about as the result of discussions with stakeholders around opportunities to support electric vehicle-friendly environments. The final decision resulted from internal discussions within the Bozzuto Group and the shared desire of management to be forward-looking.

**Site preparation and equipment installation**: Two single-connector level-2 stations were installed in the Fitzgerald parking garage. As shown in Figure 2, the charging equipment is mounted on the wall and each piece serves one parking space, which are reserved exclusively for the use of plug-in electric vehicles that use the charging equipment. To give a sense of the space needed for the installations, the

units installed in this particular case measure about 22 inches long by five inches wide.

The charging stations are located in two contiguous prime parking spots close to the entrances to the garage and to the building. When deciding where to locate the stations, Bozzuto gave consideration to several factors. They were aware that the stations would likely see limited use, at least at the beginning, but Bozzuto decided that using prime, highly visible spaces rather than remote spaces was more in line with their company's goals, and would encourage retail customers to drive electric. This decision was also consistent with the intention to serve the general public, enabling easy spotting of the stations by EV drivers and also marketing the forward-looking vision of the Bozzuto Group. As seen in Figure 3, the location of the charging stations can be easily identified from the entrance of the garage, both because of their prime location and because of the design of the charging sites.


Figure 2. Charging stations at the Fitzgerald

**Station operation:** The units installed, like most advanced products in the competitive market of charging stations, come with a variety of smart functionalities. Important considerations to prospective charging station owners are those related to the access to and payment for the use of the equipment. The stations in the Fitzgerald can read debit and credit cards, which make them accessible to the general public without any membership or subscription requirement. The stations also feature a card reader, which would enable the charging station owner, for example, to restrict access to charging only to certain registered users. The owner is also able to set rules for the price of using the equipment, such as time-of-use pricing. The use of the stations in the Fitzgerald is currently priced according to the duration of the charge.

**Financials:** A spokesman for the Bozzuto Group reported that the costs associated with these installations were covered out of pocket, using no grant funding, and were roughly divided into $3,000 for each piece of equipment and $2,000 for the actual installation. Though Bozzuto Group did not benefit directly from any tax benefits related to the purchase or installation of charging equipment, businesses in Maryland are entitled to an income tax credit equal to 20% of the cost of up to 30 pieces of qualified charging equipment, as set forth in the Internal Revenue Code.

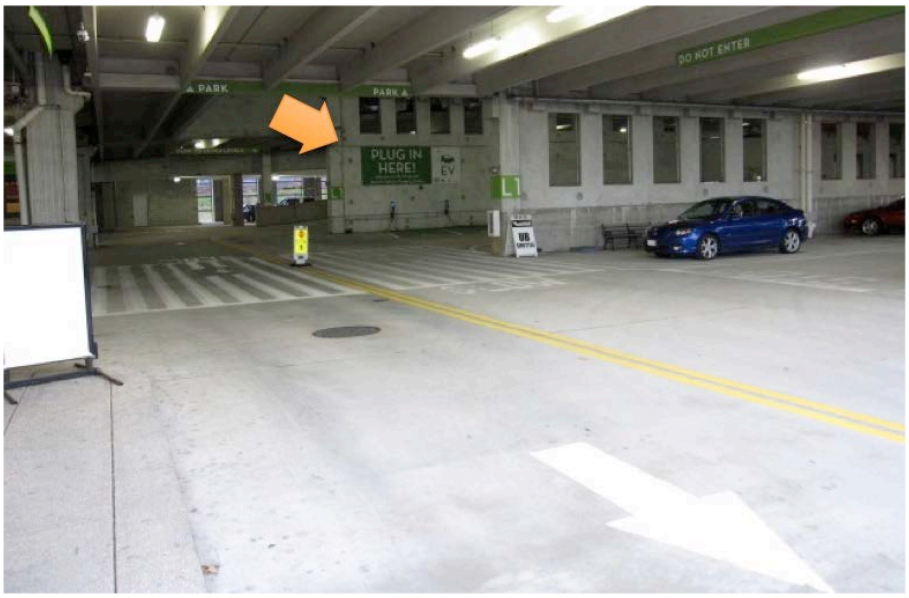



**Figure 3. View of the Fitzgerald's charging stations from the entrance of the garage. The orange arrow points at the location of the charging stations.**

The site design was developed specifically for this installation. The visually striking design, combined with the location, obviates the need for directional (wayfinding) signage within the parking facility. The design includes one charging station with ADA[8]-compatible loading space, which should typically be at least 5 feet (Figure 2). In this case, the equipment is mounted not on the center but toward the driver's side of the parking space, to make it easier to reach. The site does not formally feature an ADA access corridor between the wall and the vehicle for vehicle models in which the on board connector is located on the front of the vehicle. Guidance on ADA-compatible charging station site design has been recently developed by TCI.[9]

In the absence of common guidance on charging site design, such as EV and EVSE signage standards and charging station development regulations, installation designs are often unique to the site, and this is the case for all case studies discussed

[8] American with Disabilities Act
[9] WXY Architecture + Urban Design (2012) Siting and Design Guidelines for Electric Vehicle Supply Equipment. Prepared for the New York State Research and Development Authority and the Transportation and Climate Initiative. November. Available on the web at www.georgetownclimate.org.

here. Also common to all case studies, the authors found no regional directional signage in the vicinity of or entrance to the building. Informal signage was placed at the sidewalk to indicate that parking was available for attendees to a nearby event (see Figure 4).

**Lessons and opportunities:** For future installations in the Fitzgerald or other properties, Bozzuto is considering choosing level 1 instead of level 2 equipment. They believe that this choice may be more consistent with the current state of development of the EV market and may enable a better return on investment.

**Figure 4. Street access to the garage in the Fitzgerald. A video showing the urban landscape around the Fitzgerald can be seen at the website of the Transportation and Climate Initiative.[10]**

The targeted end users of these stations were the residents of the Fitzgerald and customers of the shops in the first floor of the development. In this sense, the Fitzgerald is an example of charging infrastructure serving a mixed-use development. Further, property management staffers reported having observed increased use of the stations when events take place at the Modell Performing Arts Center, located across the street from the Fitzgerald. Though unplanned, the charging infrastructure at the Fitzgerald is an example of integration between the host site and neighboring trip attractors— referred to as "zonal integration." The potential for zonal integration is an opportunity that can be considered in the planning of future charging infrastructure. Zonal integration is possible when the charging infrastructure is accessible to the general public, but becomes less practical as EV owners move in and need exclusive access to charging stations (see the case study of the Vonardo building).

[10] www.transportationandclimate.org

## Vornado Realty Trust, Arlington, Virginia[11] (Multifamily Housing)

Vornado Realty Trust has implemented a number of initiatives to support energy efficiency, ranging from distributed generation (including solar and combined heat and power) to resident education. Vornado expanded its sustainability program with the installation of 10 charging stations at several of its properties in the Washington metropolitan region. One of the installations, located at 220 20th Street, in Arlington (Figure 5), was completed on January 8, 2012.

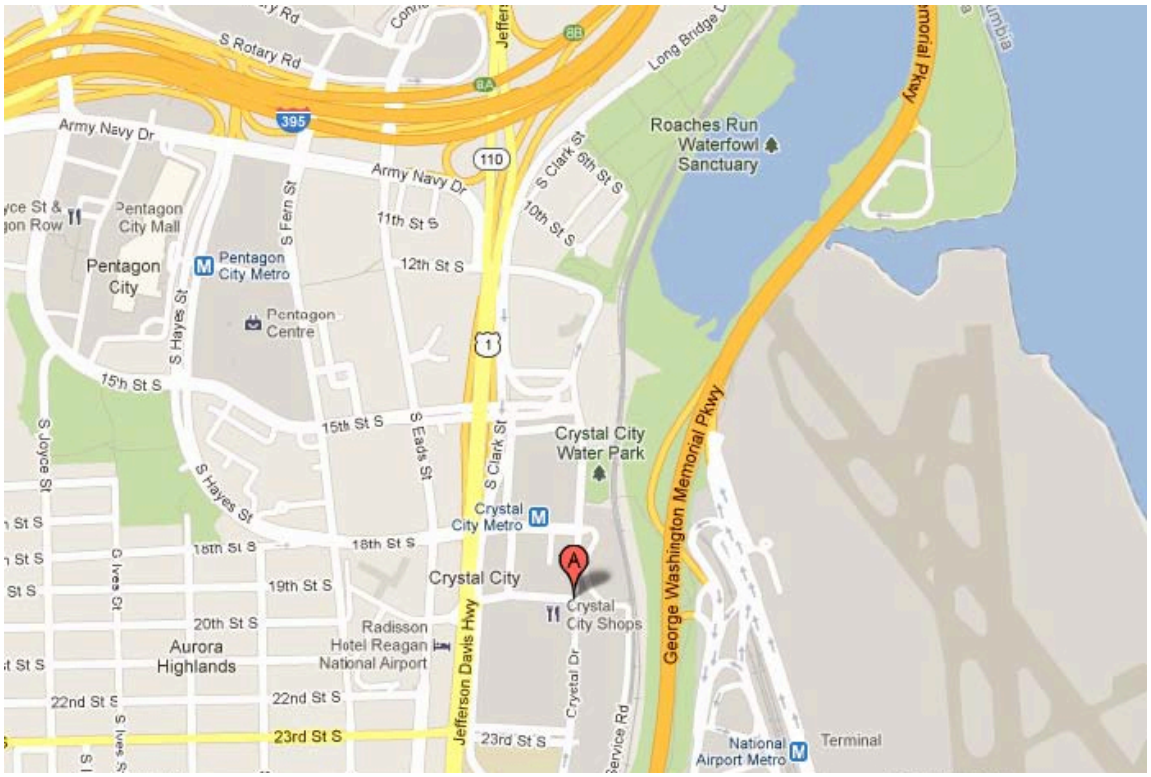



Figure 5. Location of the Vornado property (Source: Google Maps)

**Site preparation and equipment installation**: The charging station is located in the parking garage directly below the building. Vornado conducted due diligence prior to selecting the site of the charging station, and a contractor was hired to install and commission the device.

220 20th St achieved LEED Silver certification for its design and construction and incorporated many sustainable elements, including reserving priority parking for high-efficiency vehicles. The location chosen for the charging station straddles two of those reserved spaces, which allows two cars to charge simultaneously—one with Level 1voltage and the second with Level 2 voltage. Currently, only one of the spaces is reserved exclusively for plug-in vehicles. As the EV market grows, Vornado has

[11] The State of Virginia is not a member of TCI but Arlington can be considered part of the Washington, D.C., metropolitan area.

the potential to reserve a second space for EV parking that utilizes the same station. Additionally, during the installation of the charging station, Vornado prepared for future EV market growth by installing a supplemental electric panel and extra electrical conduit with the capacity for future charging stations.

Local guidance documents were not available to Vornado for site design when they selected the charging site. Vornado assigned the station prime parking spaces, close to the access to the building and next to a disabled parking space (Figure 6). They developed branded on-site signage (Figure 7). No directional signage was installed but the location of the charging station is communicated to all building residents. Information about the charging station is also integrated into leasing materials.

By carefully selecting the location for the charging station, Vornado avoided the need for repeaters. Vornado reported that the need for repeaters, because of their cost, precluded them to install a station at another of their buildings.

A video showing a panoramic view of the Vornado charging site can be seen at the website of the Transportation and Climate Initiative.[12]


**Figure 6. Location of the charging space in the garage**

[12] www.transportationandclimate.org

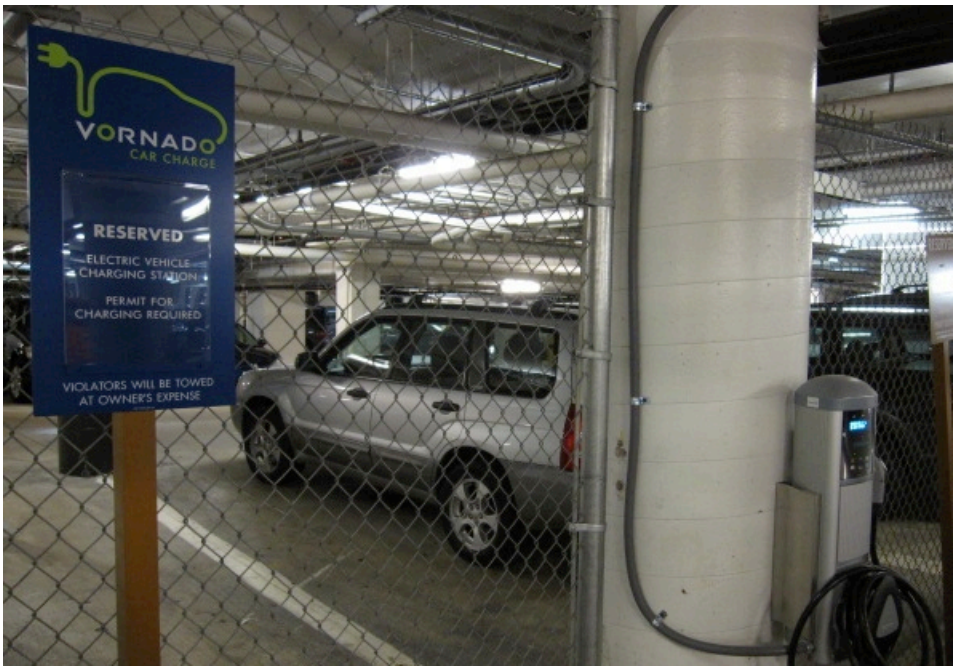



Figure 7. On-site signage at the Vornado building

**Station operation**: The charging equipment has two connectors, one level 1 and one level 2. The station is for the exclusive use of residents of the building and can also be used for Vornado's fleet of two plug-in electric Chevy Volts.

This particular station has only been used once since its installation. For comparison, a station installed at another of Vornado's residential properties in Arlington has seen much higher rates of usage. As shown by historical data maintained by the equipment manufacturer, that station was not used for the first six months after its installation and since then, about 60 charging events have been recorded with a cumulative energy delivery of over 350 kWh.

**Financials**: Vornado received the EV charging equipment through a DOE grant. Vornado paid only for the costs of site preparation and equipment installation. The equipment is owned and maintained by Vornado.

**Challenges**: The charging station installed at 220 20th St was not used for over a year after it was first installed. Unlike most commercial office buildings, multifamily buildings usually do not offer public parking and therefore EV owners in the neighborhood who need to charge their cars do not have access to many multifamily stations.

**Lessons and opportunities**: The EV market continues to expand, both in terms of the types of EV vehicles available and the quantity of vehicles sold. While the charging station at 220 20th Street is not used often, it only takes one resident with a plug-in vehicle to effectively bring the unit to full capacity, delivering electricity on a daily basis.

## Windham Mountain, Windham, New York (Recreational Destination)

The installation of charging infrastructure at ski resorts was first promoted by the Washington State Department of Commerce in 2011, in the context of planning the EV-friendly Scenic Byway across the Cascades. Stevens Pass in Washington State became the first ski resort to host charging infrastructure. After that other resorts around the country followed.

The management team of the Windham Mountain (WM) ski resort in Greene County, New York (Figure 8), felt that installing charging stations was well aligned with the values supported by the resort and those of their clients. They believe that supporting clean transportation to access the resort is a means to help preserve natural resources. They also envisioned that installing charging infrastructure would create a competitive advantage by being the only ski resort in the region that offered this amenity.

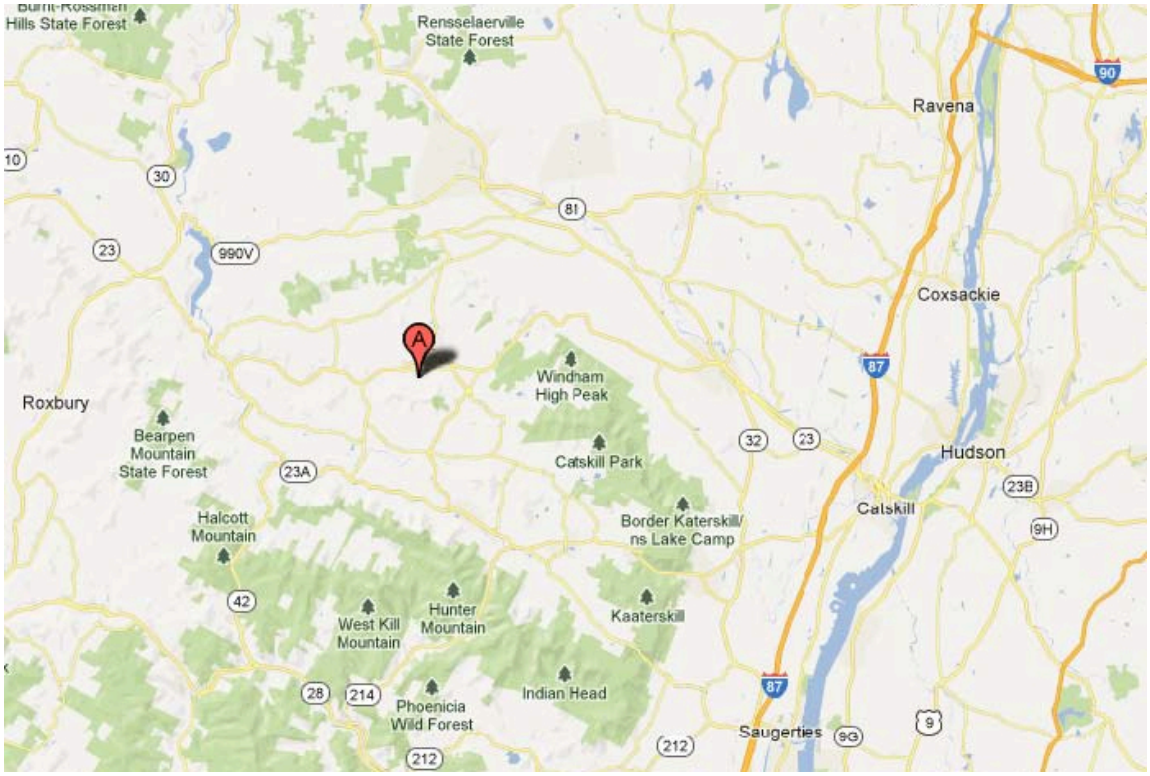



Figure 8. Location of the Windham Mountain ski resort (Source: Google Maps)

**Site preparation and equipment installation**: WM installed one pedestal-mounted charging station with dual level 2 connectors. WM had the charging station installed in their open parking lot. Their parking lots will undergo remodeling soon and WM will continue working on the design of the charging site once the remodeling work is complete. Their plan is to paint the parking spaces in green and to install improved directional and on-site signage. The signs currently installed

were adopted from signs WM found on the Internet. As with all the other cases studied, WM was not aware of guidance documents available for site design and were pleased to learn that the Transportation and Climate Initiative has developed such documents. As WM completes their work on site design, they may become one of the first sites to adopt the guidance just developed for the region.

**Station operation**: The equipment is owned and operated by WM. The use of the equipment is offered as a courtesy to the general public. Having received the equipment free of cost from New York State Energy Research and Development Authority (NYSERDA), they entered an agreement with the equipment supplier not to charge for its use for at least four years. However, vehicles parked at the charging spaces are required to be charging. Vehicles violating this requirement will receive a notification and could be towed away.

As expected, the charging equipment sees more use during weekends. WM reported since its installation, the equipment has delivered 128 kWh during 20 charge events.

WM reported that the charging station has been used on multiple occasions. Specifically, they reported having seen Model S Teslas (Figure 9) and C-Max Energi Fords. The former is a pure electric model with a long range afforded by a large onboard battery. The latter is a plug-in hybrid model that does not depend exclusively on the battery to supply motive energy.

Figure 9. Electric vehicle charging at Windham Mountain

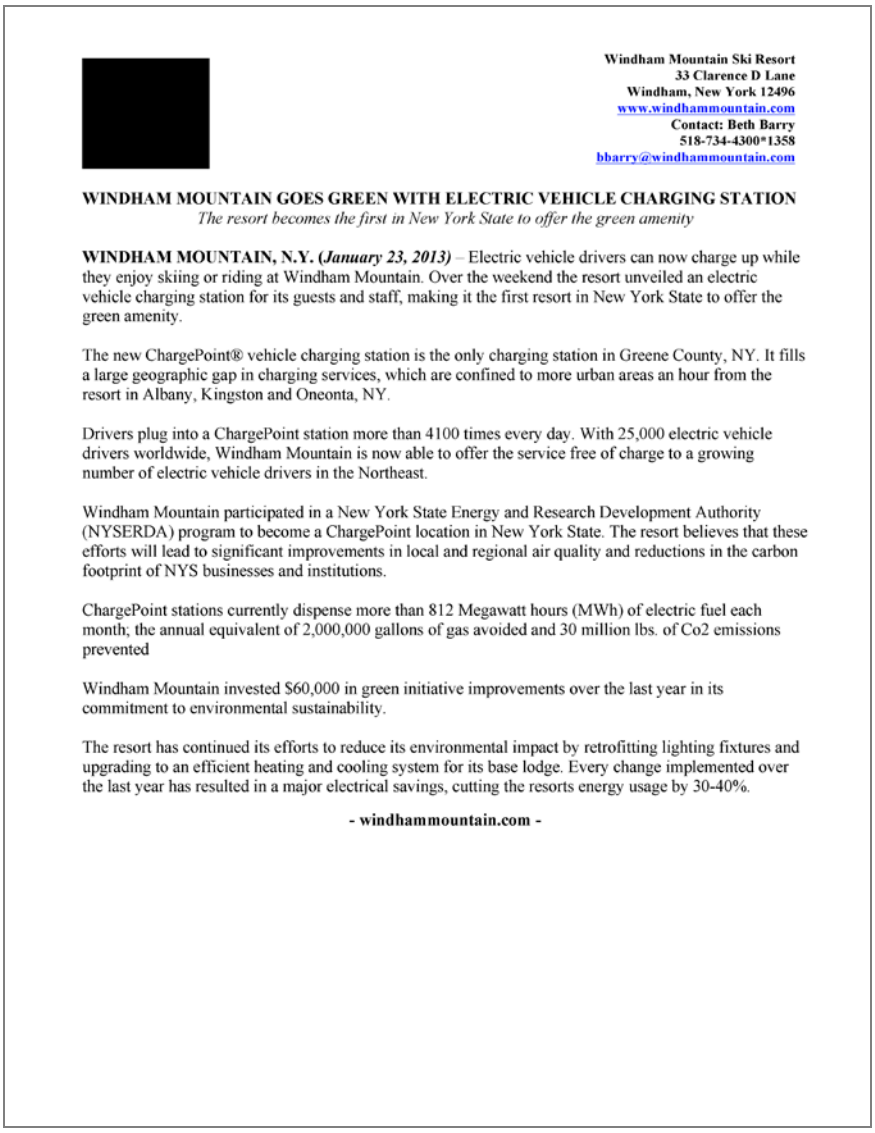
**Financials**: A charging infrastructure company approached WM about the possibility of installing charging equipment at their resort. NYSERDA had awarded the charging infrastructure company a grant that would cover the cost of the equipment, and this company asked WM to cover the costs of site preparation and installation as part of the required cost share. The cost of site preparation was about $1,500 and installation, which took two days and included some repairs of the surface, cost about $3,500.

**Challenges**: The process of installation, as reported by WM's staff, went smoothly and without any complications. One of the challenging parts was to decide on the best place to install the equipment. The staff feels that access to a good source of information about EVSE installations would have been useful in the process of site selection and preparation.

**Lessons and Opportunities**: WM management saw EVSE as an opportunity to further their commitment to natural resources protection and simultaneously appeal to the values of an important segment of their client base (Figure 10). While in retrospect WM looks at the installation of charging infrastructure as a success story, they see how similar organizations may hesitate to follow their steps if they had to pay for the equipment out of pocket. In view of their own experience, WM does encourage other recreational resorts to consider installing EVSE, though they recognize concerns about current levels of demand.

As WM further develops their EV program, the resort could look into the experience of Stevens Pass. Compared with Stevens Pass at 4,000 feet, Windham Mountain is located at an elevation of only 1,500 feet. The lower elevation makes WM more accessible to clients with electric vehicles.

WM's management reported some anecdotal evidence that they have been able to attract customers from other resorts who want to drive electric. Overall, management feels that the installation of charging stations has been a success story, by providing significant public relations returns on investment in addition to adding a value proposition that can help support a segment of their customer base now and in the future.



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**WINDHAM MOUNTAIN GOES GREEN WITH ELECTRIC VEHICLE CHARGING STATION**

*The resort becomes the first in New York State to offer the green amenity*

**WINDHAM MOUNTAIN, N.Y. (*January 23, 2013*)** – Electric vehicle drivers can now charge up while they enjoy skiing or riding at Windham Mountain. Over the weekend the resort unveiled an electric vehicle charging station for its guests and staff, making it the first resort in New York State to offer the green amenity.

The new ChargePoint® vehicle charging station is the only charging station in Greene County, NY. It fills a large geographic gap in charging services, which are confined to more urban areas an hour from the resort in Albany, Kingston and Oneonta, NY.

Drivers plug into a ChargePoint station more than 4100 times every day. With 25,000 electric vehicle drivers worldwide, Windham Mountain is now able to offer the service free of charge to a growing number of electric vehicle drivers in the Northeast.

Windham Mountain participated in a New York State Energy and Research Development Authority (NYSERDA) program to become a ChargePoint location in New York State. The resort believes that these efforts will lead to significant improvements in local and regional air quality and reductions in the carbon footprint of NYS businesses and institutions.

ChargePoint stations currently dispense more than 812 Megawatt hours (MWh) of electric fuel each month; the annual equivalent of 2,000,000 gallons of gas avoided and 30 million lbs. of Co2 emissions prevented

Windham Mountain invested $60,000 in green initiative improvements over the last year in its commitment to environmental sustainability.

The resort has continued its efforts to reduce its environmental impact by retrofitting lighting fixtures and upgrading to an efficient heating and cooling system for its base lodge. Every change implemented over the last year has resulted in a major electrical savings, cutting the resorts energy usage by 30-40%.

**- windhammountain.com -**

**Figure 10. Press release that accompanied the opening of the charging station at Windham Mountain**

## Linganore Winecellars, Mt. Airy, Maryland (Recreational Destination)

Linganore Winecellars is a family-run winery in western Maryland that opened in 1971. In 2011, the Baltimore Business Journal awarded Linganore Winecellars the Green Business of the Year in the small to midsize business category, rewarding the winery's efforts to maximize its intake of wind power for its energy needs. That same year, while traveling in Florence, Italy, Linganore's President, Anthony Aellen, noticed a structure on the sidewalk that he could not recognize at first. On a closer look, he noticed that the box contained a number of wall sockets. At that moment, a man riding a scooter parked on the curbside right next to it, and pulling a cord from the compartment under the scooter's seat, he proceeded to connect it to one of the sockets in the structure.

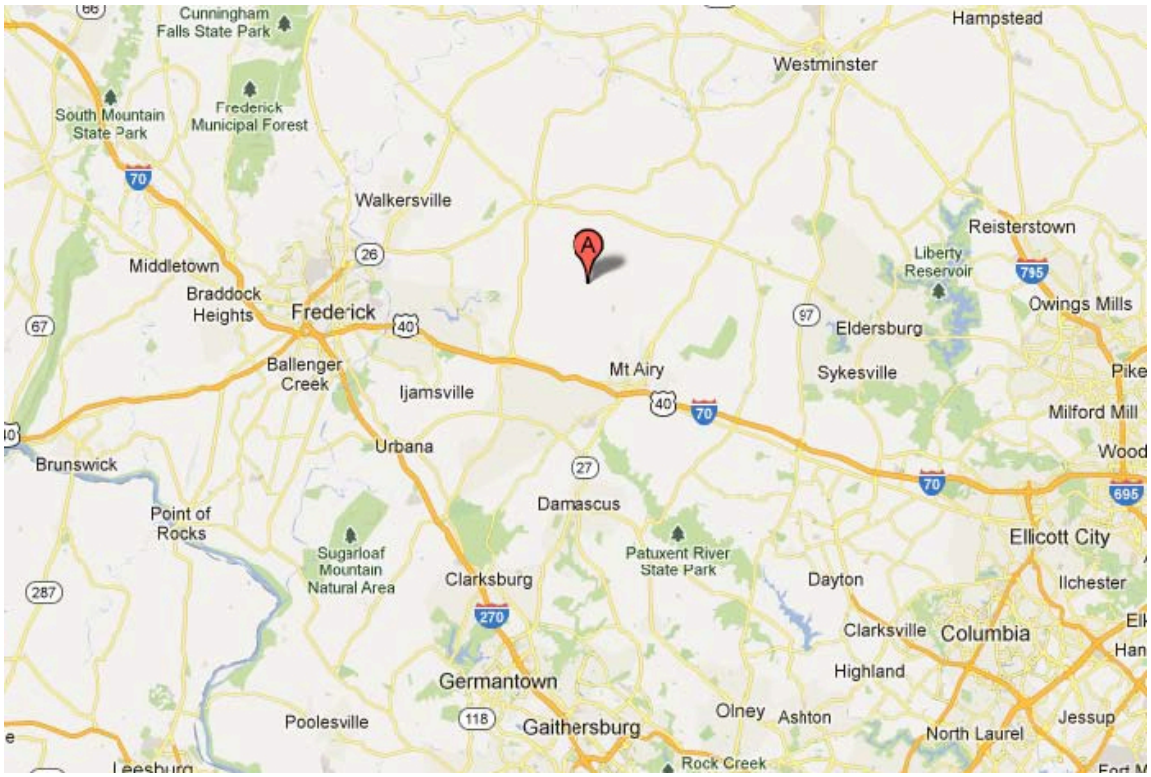



**Figure 11. Location of Linganore Winecellars (Source: Google Maps)**

The structure was one of the electric scooter charging stations that abound in the streets of Florence. Anthony learned that Florence supported electric transportation as a strategy to combat air pollution, and that the electricity from the public scooter charging stations was free to the public. This experience inspired Linganore Winecellars to install electric vehicle charging stations to support clean transportation at home.

**Site preparation and equipment installation**: Linganore approached the Baltimore Electric Vehicle Initiative (BEVI) and learned that they were administering a grant to install charging infrastructure in Maryland. BEVI offered two charging stations, which Linganore accepted and installed at its visitors' parking lot (Figure 12). Linganore also obtained on-site signage from BEVI, with the same template that was employed in other installations in Maryland under the grant (see signage at Johns Hopkins installation; Figure 27.)


Figure 12. Nissan Leaf recharging at Linganore Winecellars

To offer EV visitors the cleanest possible charge, Linganore connected the charging stations to a solar tracker that it had recently installed at the winery (Figure 13). A standard net metering arrangement was implemented whereby power is drawn from the panels and whenever solar generation is not sufficient the balance is drawn from the grid.

**Station Operation**: Consistent with its intention to bring home the ideas its president discovered in Florence, Linganore made its stations available to the general public and free of charge. Like all standard commercial level 2 charging equipment, the cord has a J1772 connector that hooks directly in the receptacle in the car (Figure 12).


Figure 13. Charging station and solar tracker at Linganore

**Financials**: As noted above, the equipment was given to Linganore as part of the federal grant administered by BEVI. Linganore spent approximately $2,000 toward installation. As described above, the winery decided to cover the costs of operation as well.

**Challenges**: Linganore found the process of procurement and installation straightforward and without complications. In general, installations on the owner's property can be expected to be simpler as the number of stakeholders, permits and requirements are significantly reduced. However, Linganore recognizes that similar businesses may hesitate to install charging equipment that they have to pay for out of pocket, given that plug-in vehicles are not yet found in large numbers.

**Lessons and Opportunities**: Linganore is very pleased to offer electric vehicle charging amenities at its facilities. The charging stations, coupled with the solar tracker, have drawn much attention and interest from visitors. Above all, the stations are a reflection of the winery's commitment to clean energy. While costs can still be relatively high, Linganore believes that the growth of new clean technologies depends on early adopters willing to pay a little extra.

## Canal Park, Washington, D.C. (Downtown)

Canal Park is an urban recreational area in the neighborhood of the Navy Yard Metro station and the Nationals' stadium in Washington, D.C. The park features an ice rink and a multitude of sustainable elements. The main pavilion next to the rink holds a gold LEED certification for its adoption of geothermal heating, the recycling of storm water to provide for most of the water needs of the park, and other features.


Figure 14. Dual level 2 charging station at Canal Park

The installation of two dual level 2 charging stations (Figure 14) was completed at 1000 2nd Place SE (Figure 15), on the east side of Canal Park, on November 4, 2012. These stations are located on the public right of way and they serve four curbside parking spaces.

The installation of charging infrastructure at Canal Park took the form of a public-private partnership. The developer of the park contacted the District of Columbia Department of Transportation (DDOT) to seek guidance on how to install equipment on the public right of way. The developers took it upon themselves to lay out the entire conduit, while the District of Columbia paid for the installation and provided overall support. DDOT is committed to promoting sustainable travel practices and central to this vision is improving energy efficiency and modern mobility.

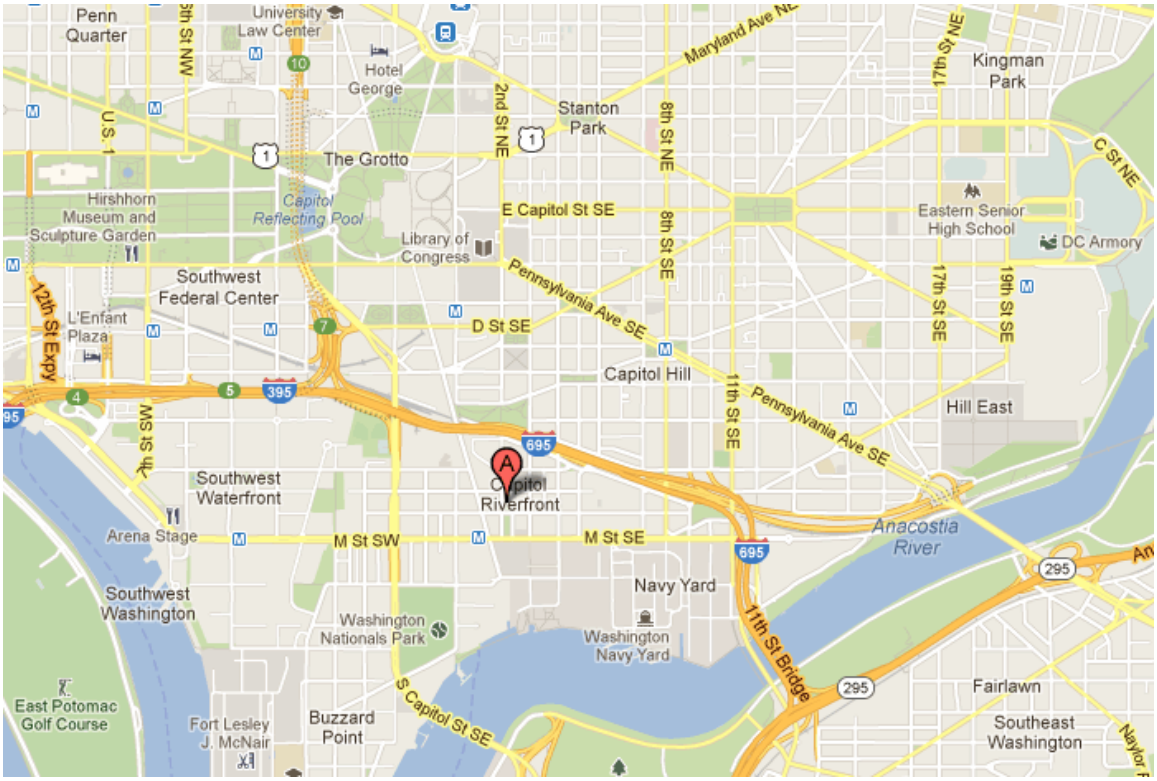



**Figure 15. Location of Canal Park stations (Source: Google Maps)**

**Site preparation and equipment installation**: The District of Columbia looked at the experience of the State of Washington for guidance on the development of signage (Figure 16). The areas reserved for each charging vehicle are marked with white lines on the pavement, and have dimensions that seem compatible with ADA requirements. It was not clear, by visual inspection of the site, whether the charging equipment would be accessible to a disabled person from the curb (Figure 17).


Figure 16. Signage at Canal Park charging site

In total, the installation of the equipment took more than one week and involved upgrades of electrical panels and relatively minor surface trenching.

A video showing a panoramic view of the Canal Park charging site can be seen at the website of the Transportation and Climate Initiative.[13]

**Station operation**: The stations are publicly available, and, for now, their use is free of charge. The District of Columbia expects that soon a charge will be applied. Current estimates are that the price of using the equipment will be $2.00 per hour during the peak hours of 7:00 am to 6:30 pm. The rest of the day, the price will be $1.00 per hour. As observed by DDOT, the stations tend to see higher use during business hours.

Even when there is no charge for the use of the charging stations, users need to connect with the operator of the charging equipment to unlock the connectors. Typically, users make a phone call to the operator, provide information on the charging station, and request that the connector be unlocked. The use of the

[13] www.transportationandclimate.org

charging spaces is reserved for the use of the equipment by plug-in vehicles. The enforcement rules are analogous to those of parking infringements.

**Financials**: The District of Columbia received the equipment free of charge from the federal government. DDOT partnered with the developers of Canal Park to finance the rest of the project costs. The developer covered the costs of the electrical design, upgrades and wiring. The District of Columbia covered the cost of site design and installation. The combined cost of upgrades, conduit, electric utility meter and other preparation work was approximately $15,000, while the cost of the two installations was $5,000 total. The cost of site design (e.g. painting and signage) was approximately $500. Some of the operation costs are covered by the equipment manufacturer, while other operation costs, such as enforcement and liabilities, are covered by the District of Columbia.

Figure 17. Charging station at Canal Park

**Challenges**: Installations that are undertaken as part of a new development are often less expensive than those undertaken in existing buildings. This is because the electrical systems in new developments are planned to accommodate the charging loads. Based on cost estimates obtained for this study, it appears that the Canal Park installation may have not been able to achieve significant savings. One of the reasons may have been related to the utility's requirement to install a separate

utility meter.[14] Such requirements may vary across utility service areas and prospective EVSE owners should ask about them as part of their planning process.

**Lessons and opportunities**: A noteworthy aspect of this case study was the close collaboration between a private sector property owner and a city planning office. This collaboration resulted in coherent integration of the project into the public right of way, with a thoughtful site design including the adoption of signage developed and tested in other regions.

[14] Precise information about the need for a new meter was not obtained, but the need for new meters is recommended after the load analysis of the electrical system.

## The Lenox Hotel, Boston, Massachusetts (Downtown)

On August 4, 2011, the Lenox Hotel completed the installation of an on-street level 2 charging station on 61 Exeter Street. The walk space where the station is located is used for parking valet services and is maintained by the Lenox. The hotel's main motivation was to be supportive of sustainable and innovative services, consistent with the hotel's goals.


Figure 18. Location of the Lenox charging station (Source: Google Maps)

**Site preparation and equipment installation**: This was the first private installation on the sidewalk right-of-way in Boston, which brought significant attention to the project. The City of Boston was very supportive particularly through the Department of Transportation. The City also was directly involved in providing guidelines for the project. The Lenox needed to appear before the Public Improvement Commission (PIC) to present on the project and return two weeks later for a vote. During that two-week period, the Lenox had to address a number of questions, such as getting approval from the Boston Water and Sewage Commission.

The Lenox met requests from the City regarding site design. For example, they painted the curb in green and modified the signage to match the design of the charging site already in place at the Boston City Hall. They worked with the City also on requirements for bollards and usage instructions at the site. Because of the trenching needed, building permits were also needed (Figure 19).

The Lenox was required to prepare a congestion management plan (CMP) before obtaining permits. The CMP had to identify impacts on vehicles, bicycles, and pedestrians and pertinent mitigation measures.

The Lenox discussed questions internally around liability for incidents related to the equipment as well as for damage to the equipment. They decided that their insurance policy already covered these areas, so no extra measures needed to be taken.

Figure 19 Site design at the Lenox

**Station operation**: The Lenox decided to make the station available to the general public, and not just to hotel guests. The general public and hotel customers are offered free charging. However, the City required that the charging space remain under valet control, so all customers are subject to valet service fees. The City made this decision to ensure that the valet service can move plug-in vehicles that are fully charged, making space for either other plug-in vehicles or valet parking. The City created a dual-use space, allowing four-hour charging for electric vehicles and a ten-minute valet lane at all other times. Meeting this request from the PIC would forgo the need to revise the Lenox's valet license. To encourage EV visitors, the Lenox has run promotions offering free valet parking and free overnight parking for select periods since installing the unit.

The Lenox noticed an increase in the use of the station after August 2012 when it was upgraded to the newer charging station model with improved software. After that, the Lenox estimates an average of five users per month. The new software in

the equipment does have a glitch related to charging Tesla vehicles, but the manufacturer has assured the Lenox that the issue will be resolved quickly.

**Financials**: The Lenox knew that revenue from the equipment would be slow at the beginning and while they do hope that it will increase, this was not their leading motivation to install the equipment. The price of the single-connector pedestal level-2 station was approximately $6,400. The installation, including trenching, wiring and other work, took two days and cost approximately $8,500. The electrical permit from the City of Boston was $245 in addition to $1,200 for other permits. About $2,500 was invested toward site preparation, including painting, signage and other items.

**Challenges**: Navigating the bureaucratic process was time consuming. The Lenox felt that working with an experienced installer and a lawyer who was familiar with PIC processes really helped them communicate and address their requirements. The Lenox understood that they were pioneering installations on the sidewalk right-of-way in Boston, which would slow down the process of approval as involved officials learned about the different aspects of EVSE installations.

**Lessons and opportunities**: One of the questions that the Lenox recommends being addressed moving forward is what happens when the parking time is longer than the charging time. They addressed this question with the use of valet services but recognize that it will not be a practical solution in many other cases.

The Lenox also shared that, depending on the location, prospective EVSE owners may want to consider completing the installation on private property to ease administrative requirements. At the same time, they feel that installations on the sidewalk may often be more comfortable to the user than those in garages. They are confident that as other organizations follow their example and do sidewalk installations, city and state officials will become more familiar with these technologies and will be able to implement smoother approval processes.

## War Memorial, Baltimore, Maryland (Downtown)

In the summer of 2013, two single-connector level 2 charging stations will be inaugurated at the War Memorial in downtown Baltimore. The stations will serve four curbside charging spaces on the southern side of E Lexington Street between N Gay Street and the Baltimore City Hall (Figure 20).

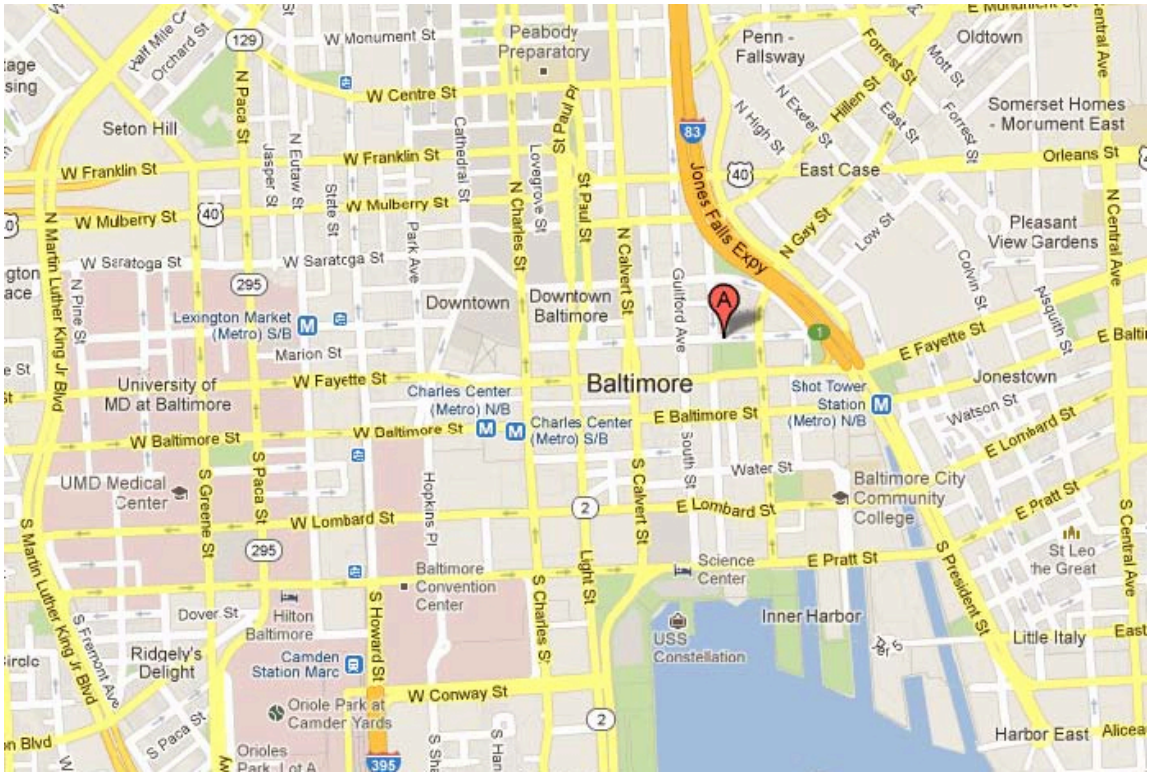



Figure 20. Location of future charging stations at the War Memorial (Source: Google Maps)

**Site preparation and equipment installation**: The installation company, BITHENERGY, the City of Baltimore Department of General Services (DGS), Maryland Department of the Environment (MDE) and the Maryland Energy Administration evaluated a number of available locations and decided on the War Memorial primarily because of its high visibility and location on public land. The site indeed offers opportunities for public education and use maximization. Baltimore City and several surrounding counties are currently in nonattainment for ozone and fine particulate matter. The installation will contribute toward demonstrating the potential that EVs have for reducing criteria air pollutants and carbon dioxide emissions from the transportation sector. The War Memorial is witness to significant pedestrian traffic every day. Situated in front of the City Hall and in the vicinity of a great number of trip attractors in downtown Baltimore, it offers opportunities to maximize the utility of the stations to EV drivers (Figure 21). The stations will be located toward the Eastern end of the block, to be closer to the main distribution panel (MDP), thus minimizing trenching work. It was already

determined that the capacity of the panels is adequate to support the charging infrastructure.

Figure 21. View of the War Memorial site and the City Hall

Because this is a historic site, the installation work will require special attention to preserving the granite on the sidewalk (Figure 22), and will require the oversight of the Baltimore City Commission for Historical and Architectural Preservation (CHAP). An 18-inch wide trench will be dug for conduit between the concrete blocks where the stations will be supported by the MDP. Extra conduit will be laid out in case there is a need to install additional infrastructure in the future. The site will also feature bollards to protect the equipment.

The development of the engineering plan was led by BITHENERGY and DGS. Much attention was devoted to minimize the cost of installation at this location. There are cases when the experience of the installers can be critical to move the installation along technical and bureaucratic requirements. The War Memorial is one such case. Throughout the process, DGS is working with BITHENERGY, an engineering and installation company with years of experience working in Maryland.

A video showing a panoramic view of the War Memorial charging site can be seen at the website of the Transportation and Climate Imitative.[15]

[15] www.transportationandclimate.org

Figure 22. View of the site from the War Memorial

**Station operation**: The stations will be publicly available and the charging spaces will be restricted to plug-in electric vehicles that use the equipment. The equipment that will be installed at this location will be pedestal mounted and will feature a cord management system, ideal for operation on the sidewalk right of way. The City of Baltimore will own the equipment once the project is complete. Initially both parking at the charging spaces and the use of the charging equipment will be free of charge. The City will collect and provide usage data monthly to MDE for a period of 10 years. The data will be used to facilitate planning for future charging station installations and cost recovery in the State.

**Financials**: The funding for these installations was obtained by MDE from settlement of a legal action. This funding will cover all the costs of equipment and installation. MRAS will provide two last-generation pedestal-mounted charging units.

According to BITHENERGY, the installation costs are anticipated to include $500 toward electrical permitting, $1,000 toward other permits, and $500 toward the electrical inspection.

**Challenges**: The process of selecting a site for the installation is often a balancing act. Some of the challenges in the War Memorial case are typical of first-time installations in the sidewalk right of way. The limited experience with these technologies and their installation in public areas may impose additional pressure

on permit boards and other officials involved in the approval of each facet of the project.

**Lessons and opportunities**: The Maryland Attorney General's Office, the Maryland Department of the Environment, and BITHENERGY were instrumental in developing an agreement for the funding of this infrastructure project. The State of Maryland in general and the City of Baltimore in particular have a great opportunity to learn from the installation at the War Memorial, document the process, encourage public officials to build on this experience, adopt some of the guidelines developed by the Transportation and Climate Initiative for the region (including signage and overall site design), and extrapolate lessons learned into improved installation and approval processes in public areas in the future. The project demonstrates a cooperative approach involving a number of public and private entities. The siting, initial free access to public charging, and collection of usage data to inform public infrastructure investment is consistent with the recommendations in the final report of Maryland's Electric Vehicle Infrastructure Council.

## Coolidge Corner, Brookline, Massachusetts (Downtown)

Brookline is a Massachusetts town immediately west of Boston with a population of about 60,000. The town prepared a proposal in 2011 to compete for a federal grant, administered by the state, for the installation of two electric vehicle charging stations. The grant application, led by Brookline's Department of Planning and Community Development (DPCD), resulted in the inauguration of a dual level 2 charging station in Coolidge Corner on November 12, 2011 (Figure 23).

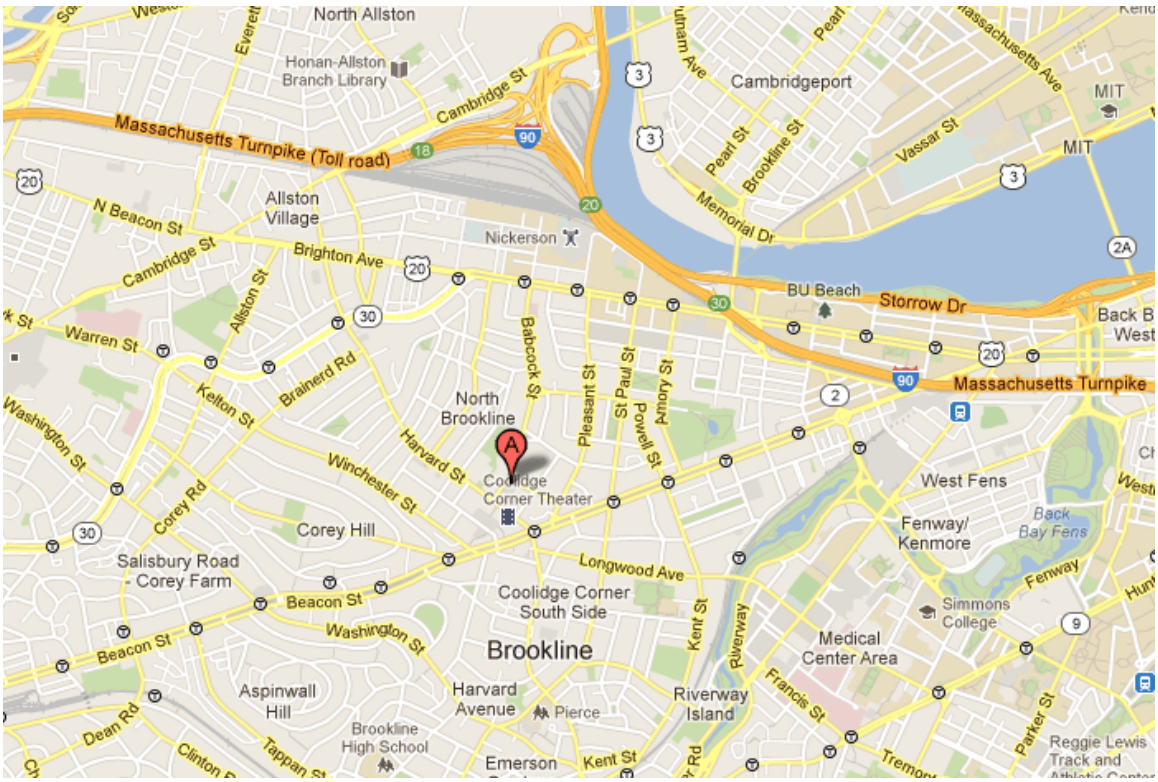



Figure 23. Location of Coolidge Corner station (Source: Google Maps)

**Site preparation and equipment installation**: Initially, the town had envisioned installing the two charging stations at the town hall. Following conversations with state stakeholders, the decision was made to install one at the town hall and one in Coolidge Corner. Coolidge Corner is a lively neighborhood around the intersection of Harvard Street and Beacon Street, hosting a plethora of restaurants, a cinema, and shops, in addition to many high-density residential buildings. The area characteristics seemed ideal to maximize use of the stations as well as visibility for the project.

In consultation with the Department of Public Works, DPCD selected the Babcock Street parking lot as the installation site. Part of the reason for this choice was that conduit was already in place, which was expected to reduce the costs of installation.

Brookline did not follow any particular guidance document for site preparation and design. DPCD was aware of guidance documents developed on the West Coast, though the site design was led by the Department of Public Works in collaboration with the equipment manufacturer. As shown in Figure 24, the charging station is situated between two parking spaces, although there is no clear signage indicating which spaces are reserved for plug-in vehicles (compare with signage indicating the space reserved for disabled drivers in Figure 25). Figure 25 shows that neither of the spaces were designed to meet ADA accessibility requirement, and that they were assigned prime locations, near the pedestrian exit and closer to the commercial area.


Figure 24. Charging station between charging spaces

**Station operation**: The station is publicly available, and currently users have to pay only for the parking. Even though there is no charge for the use of the charging stations, (similar to other cases reviewed above) users need to connect to the operator of the charging equipment to unlock the connectors. The town expects to undertake a review process to better assess the costs of operation of the stations and the possibility to charge for the use of the equipment.

Figure 25. Charging spaces design

The use of the two parking spaces served by the charging station is reserved exclusively for plug-in vehicles except for weekends and 6:00pm-11:00pm on weekdays. The enforcement rules are analogous to those of parking infringements. The photo in Figure 25 was taken on a Sunday and shows a Tesla Model S charging in the space on the right and a conventional gasoline vehicle legally occupying the charging spaces on the left. A Nissan Leaf could still park to the right of the Tesla and reach the connector to charge.

**Financials**: The Town of Brookline received the equipment free of charge from the federal government as part of a grant administered by the state. The cost of installation, initially estimated at $1,000, was about $2,500. The Building Department paid for the difference. The Town did not pay for the permitting and inspection of the installation, since the Town administers all permitting and inspection.

**Challenges**: The cost of installation was higher than initially anticipated. Part of the reason for this was that by the time that the grant came through, the conduit that was available at the parking site had already been taken for the installation of multi-space parking meters serving the parking lot. To proceed with the installation, additional conduit had to be laid out. In general, the town felt that original estimates of installation costs developed in conversations with the state were too optimistic.

The project leaders convinced key stakeholders of the benefits of installing EVSE at such a central location, although concerns were raised over losing parking space for conventional cars. Eventually an agreement was reached by negotiating the hours of restricted access to the charging spaces (described above). The town occasionally hears complaints about the spaces being unavailable for parking when no plug-in

vehicles are using them. The town also acknowledged that enforcement of restrictions for non-plug-in vehicles is an area with room for improvement. It should be noted that pressure to release restricted use of charging spaces is not at all uncommon. This is to be expected in an area like Coolidge Corner, with intense demand for parking.

**Lessons and opportunities**: As expressed by DPCD, the uncertainties around the installation of charging infrastructure can be significant for municipalities considering such projects for the first time. Questions such as the responsibilities and costs of operation, maintenance, and liabilities are sometimes not easy to resolve. The town believes municipalities might give more consideration to infrastructure installation if they had more information about questions ranging from operation to site design. Municipalities that go through the process of installing equipment will be more capable of providing informed guidance to constituents interested in installing their own stations.

## Johns Hopkins University, Baltimore, Maryland (Workplace, Higher Edu.)

On October 4, 2011, the installation of four single-connector level 2 charging stations on the main campus of Johns Hopkins University in Baltimore (Figure 26) was completed. This was the result of a collaborative process led by the Sustainability Office of the University and the Baltimore Electric Vehicle Initiative (BEVI).

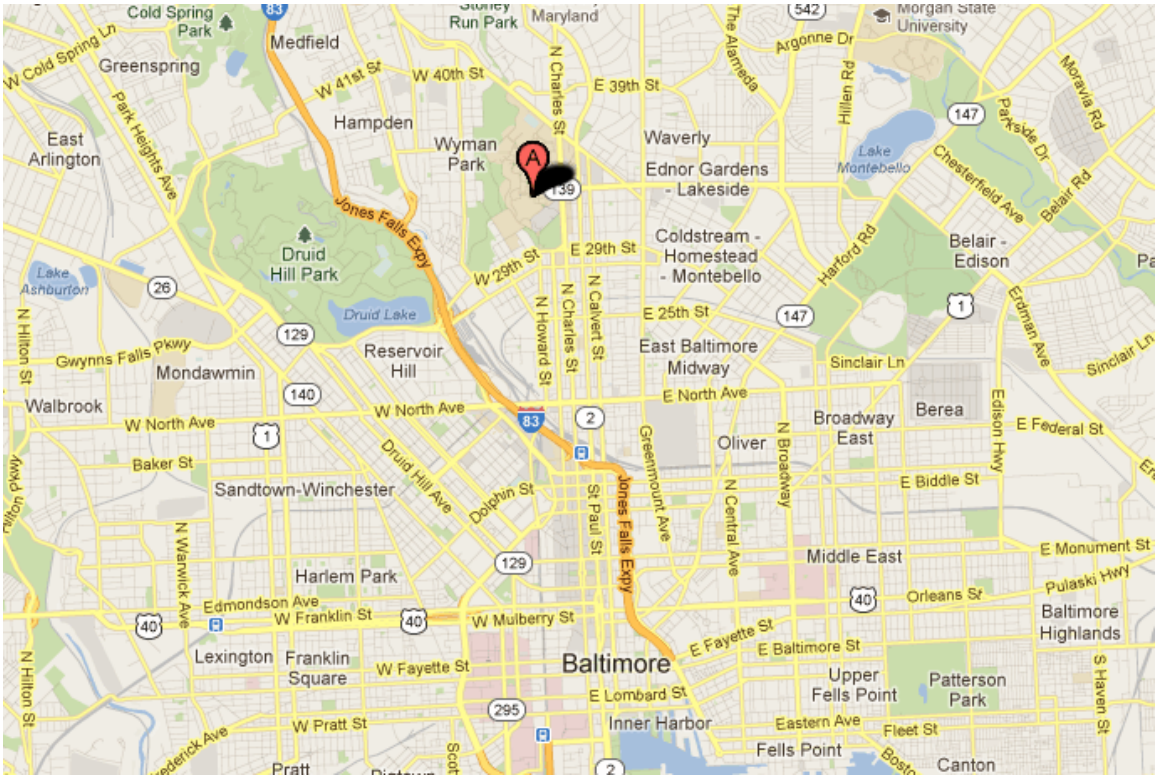



Figure 26. Location of Johns Hopkins charging stations (Source: Google Maps)

The University already owned a low-speed charging station to support neighborhood electric vehicles for campus operations (Figure 27). Faculty members who drove plug-in vehicles had expressed interest in the possibility of having access to charging infrastructure on campus. The Sustainability Office was already familiar with plug-in vehicles and was aware of latent demand for charging infrastructure.

When the University was approached by BEVI with news about a U.S. Department of Energy grant that Maryland was awarded to support charging infrastructure projects, the conditions were ideal to start a collaboration. BEVI offered Johns Hopkins charging equipment free of charge and Johns Hopkins offered parking space in their facilities to install it, and covered the cost of installation.


Figure 27. Neighborhood electric vehicle charging at Johns Hopkins

**Site preparation and equipment installation**: The site chosen for the charging stations is in the south garage on the main campus. Given the mission of the Sustainability Office, visibility was an important factor in the decision about the exact location for the stations. In collaboration with the Parking Office, a highly visible area right next to an entrance was allocated to charging spaces (Figure 28).

The installation of the equipment was completed in over a week and, as shown in Figure 28, each piece of equipment was mounted on the wall at the center of its corresponding parking space. Thus, each charging station serves one parking space. Green signs were installed to indicate that the charging spaces are reserved exclusively for plug-in vehicles. As discussed in the last section of the report, at the time of these installations there was no formal guidance yet regarding ADA accessibility adopted in the Northeast and Mid Atlantic, and the layout of the charging spaces did not formally address ADA accessibility.

**Station operation**: The stations are publicly available, and, for now, their use is free of charge. Johns Hopkins is interested in exploring alternatives to charging for the use of the equipment, including charging per amount of energy consumed.

Under conditions set by the DOE grant, the charging stations have to be publicly accessible and, until the end of March 2013, users may not be charged for their use of the stations. The charging spaces are reserved exclusively for the use of plug-in vehicles that use the charging equipment. Enforcement measures include parking tickets and potentially towing away violators.

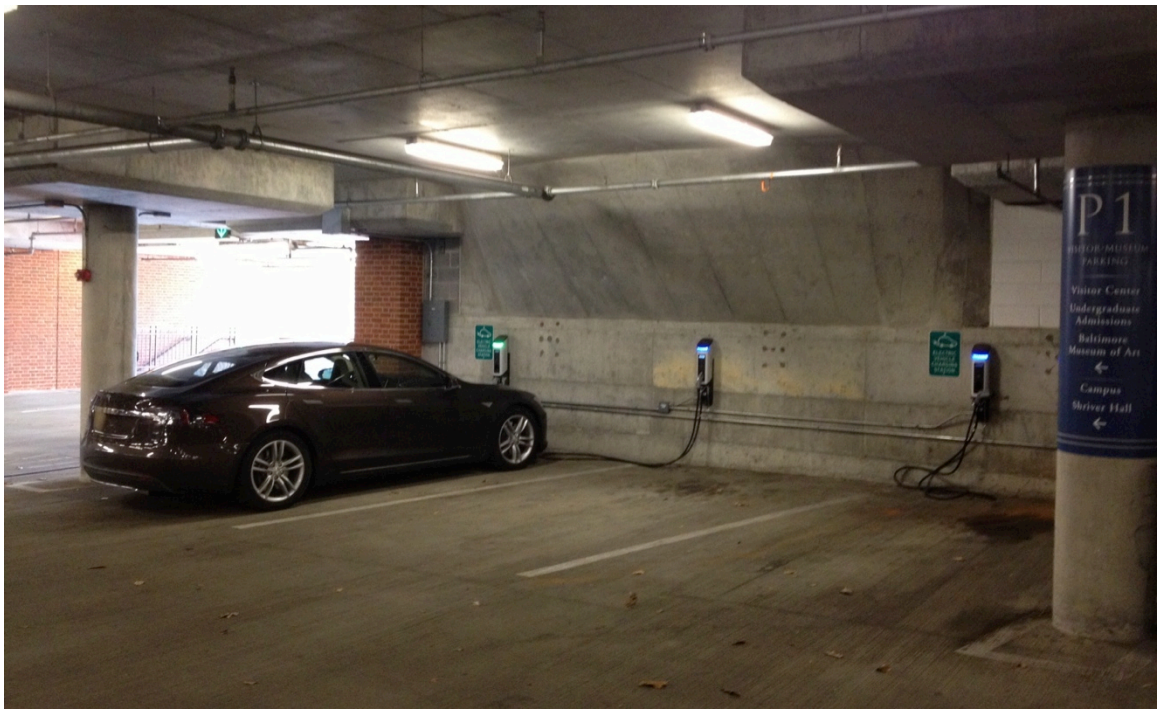



Figure 28. Charging stations next to garage entrance

**Financials**: As discussed above, Johns Hopkins expected that there would be no capital cost toward equipment. BEVI covered up to $5,000 toward the cost of each piece of equipment, but as the contractor revised their estimates, the University was asked to cover an additional $3,000 per station. Consistent with the initial agreement, Johns Hopkins contributed $3,000 toward the installation of each piece of equipment in addition to approximately $1,000 toward site preparation for each charging space. The total capital cost to Johns Hopkins was in the end $28,000, or $7,000 per station.

Johns Hopkins estimates that the maintenance of all four stations will cost $100 annually. Operation costs should also include the opportunity cost of redirecting parking space from conventional vehicles to plug-in vehicles. This may result in some degree of space underutilization in the short run, until the market share of plug-in vehicles among the university population increases sufficiently. Based on expression of interest from the campus community, Johns Hopkins is optimistic about long-term use of the stations.

**Challenges**: Negotiating the dedication of parking space to vehicle charging with parking managers is one of the difficult areas in most public-access installations. Johns Hopkins was not an exception. Negotiations were required between the Sustainability Office and the Parking Office, but both sides were willing partners and shared a vision of supporting clean transportation on campus.

Establishing an effective communication with the equipment installers proved difficult and the original cost estimates for the equipment and the installations were revised upward significantly. This problem may have been an artifact of the structure of the contract used for the grant.

**Lessons and opportunities**: Despite confusing financial communications with contractors installing the equipment, the successful installation of charging equipment at Johns Hopkins is a reflection of the University's commitment to its sustainability goals and to supporting positive choices made by the members of its community. The Sustainability Office has already observed encouraging signs, as the stations are frequently used by the Tesla shown in Figure 28, and by a Chevy Volt, a Honda Civic, and a converted van.

## Porter Square Shopping Center, Cambridge, Massachusetts (Retail Center)

Parking lots in commercial areas are one of the most promising places to install charging infrastructure. High volumes of visitors spread over many hours offer opportunities for educating the public about plug-in vehicles and for supporting EV travel without concerns about parking-longer-than-charging issues. When the City of Cambridge received a grant from the State of Massachusetts as part of a grant to the state from the U.S. Department of Energy to install public access charging stations, they approached Gravestar, the property management company that managed the shopping center in Porter Square (Figure 29). Gravestar saw the potential of charging infrastructure to support EV customers as well as other public relations benefits. The City and Gravestar developed a partnership whereby Gravestar would receive charging equipment free of charge and would contribute the costs of site preparation and installation at the shopping center. As a result, the installation of one dual level 2 charging station was completed on February 14, 2012.

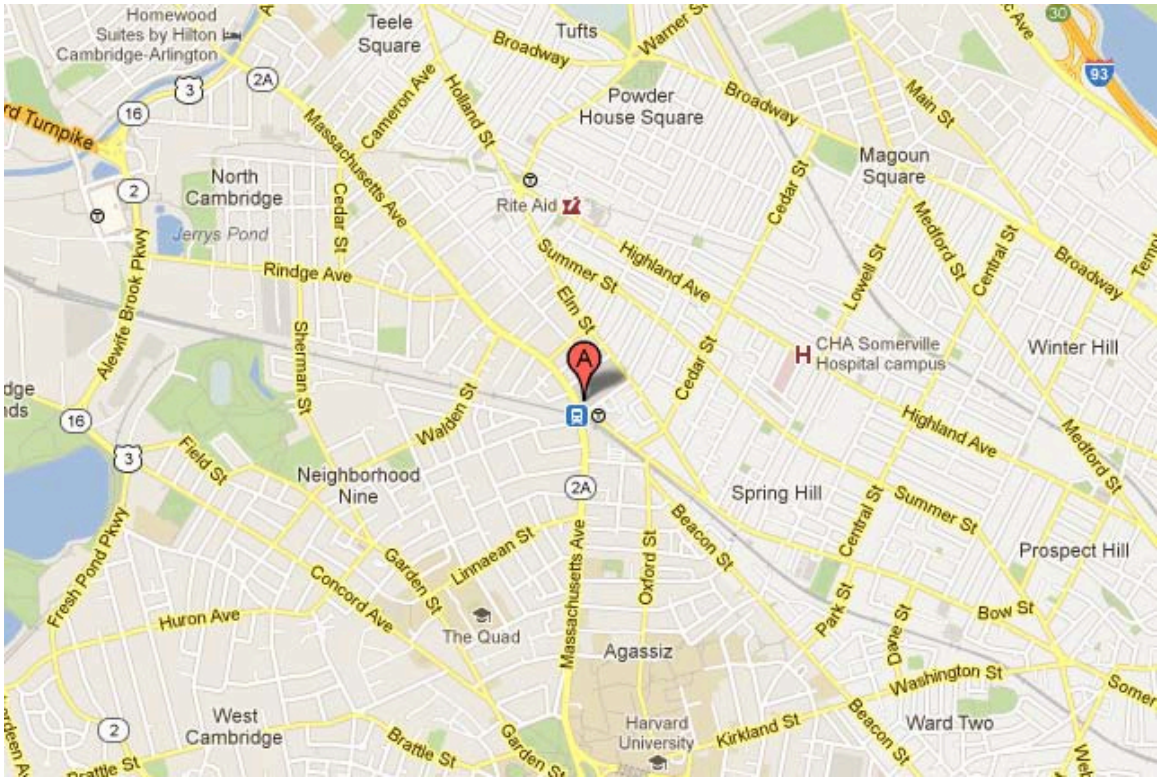



Figure 29. Location of the Porter Square Shopping Center (Source: Google Maps)

**Site preparation and equipment installation**: The City considered several factors in choosing the shopping center at Porter Square. First, they looked for a suitable commercial area in North Cambridge to improve the geographical coverage of the City's charging infrastructure. Second, they recognized the additional value of this

location in an urban area with a high density of residential buildings that may have very limited parking facilities. They hoped the charging stations would attract EV owners in the area with limited access to charging infrastructure to do their shopping in Porter Square.

Consistent with Gravestar's marketing objectives, they installed the equipment in a prime location right next to shops (Figure 30).


Figure 30. Station next to shops in Porter Square

This choice of location is even more commendable given that the shopping center sees intense demand for parking much of the time (Figure 31). Businesses struggle with the question of whether there will be sufficient demand for electric vehicles, and thus dedicating parking space to vehicle charging is generally a difficult decision.

Figure 31. Demand for parking is high at the Porter Square shopping center


Figure 32. On-site signage at Porter Square

The design of the charging site did not follow any specific guideline document. The installers decided to install bollards to protect the equipment. Templates for on-site signs were obtained from the state Department of Energy Resources, which administered the federal grant and has been a center of leadership on EV readiness in Massachusetts. As seen to some extent in Figure 32, there is no painting on the parking surface. Figure 30, however, is a reminder that in the Northeast (and regions with similar winter climate) all essential signage should remain above the surface.

A video showing a panoramic view of the Porter Square charging site can be seen at the website of the Transportation and Climate Initiative.[16]

[16] www.transportationandclimate.org

**Station operation**: The station is available to the general public and it has a card reader that accepts standard credit cards. The two charging spaces are restricted to electric vehicles that use the equipment (although the language in the signs refer to electric vehicle "*parking*"). The signs do clearly indicate the enforcement policy: non plug-in vehicles parking in these spaces will be towed away.

As reported by the City's Community Development Department, 50 to 60 charging events were recorded in the last month of October. They have further observed some overnight charging, which suggests that neighborhood residents may be using the equipment.

**Financials**: Funding for these installations was obtained by the City of Cambridge in the form of a grant from the federal government administered by the state Department of Energy Resources. The grant covered the cost of the equipment and $1,000 toward the costs of installation. The host, Gravestar, contributed approximately $5,000 to cover the rest of the installation costs as well as the preparation and design of the site. Costs related to the operation of the equipment are estimated at $170 per year.

**Challenges**: In principle, installing charging infrastructure at parking facilities with shared property rights can present challenges. Such is the case of unassigned parking spaces in multi-unit dwellings or shopping areas. The Porter Square example shows that working with the property manager, whenever possible, significantly simplifies the process.

As described by the Community Development Department, the main concerns centered on strategies to recover the cost of electricity used by the station. In the larger picture, the City expressed concerns as to whether business owners will be inclined to invest in charging infrastructure without government financial support and in the absence of clearer signals about the future market demand.

**Lessons and Opportunities**: Shopping centers have a number of attributes that make them attractive as prospective hosts of charging infrastructure. The example of Porter Square demonstrates that administratively the process does not need to be complicated when management of the parking facility is centralized. Installation costs can be relatively low, as typically there is great flexibility to locate the stations near the electrical panels. This case also shows that an underutilized parking space at night can offer opportunities to provide charging services to residents who do not have dedicated parking space.

## Case Snapshots

Equity Residential installed charging infrastructure at the West End apartment building in downtown Boston on December 2011. The infrastructure, which was privately financed, is located in the garage right under the building and is accessible to residents. The most interesting aspect of this case is its site design, led by the installation company, CarCharging.


The station is located in a lit compartment in front of spaces assigned to Zip Car vehicles and together with a tire inflation station. The charging equipment, mounted on a column, is not visible from outside the charging space. Though no standard EV signage is installed, the design on the back wall enhances visibility.

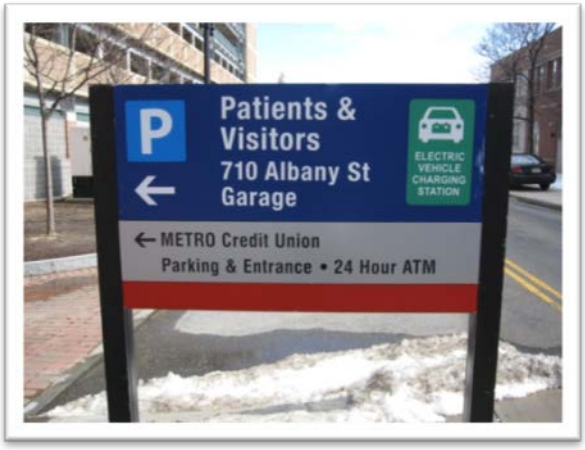
The City of Cambridge installed one level 2 charging station at the City Hall on June 2012. The single-connector station is open to the public and is often used by the City Mayor who commutes to work driving a Chevy Volt. The equipment was installed on the side of the building, instead of at the parking lot behind the building, to minimize cost of surface trenching and easier access to the electrical system.


Following a snowstorm in the winter of 2012-2013, a snowplow truck accidentally pulled the cord and damaged the equipment.

The regulatory sign at this site is unique among our case studies in that it explicitly indicates that the use of the charging space is reserved for vehicles that are using the equipment.

The Boston Medical Center (BMC), located in Boston's South End, installed two charging stations serving four parking spaces, on January 2012.

The parking spaces are reserved exclusively for plug-in electric vehicles that use the charging equipment. The design of these signs is consistent in other locations in Boston but is not consistent with signs found at locations across the broader metropolitan area (see case studies on the cities of Brookline and Cambridge).





Directional (wayfinding) signs were installed at the entrance of and within the garage, which make it easy for first time users to find the charging stations.

## Concluding Remarks

The case studies included in this report are part of the early stage of charging infrastructure deployment. These early adopters share a desire to support clean transportation and a willingness to make a financial commitment even when returns on investments are not clear. Guidance documents developed by the Transportation and Climate Initiative as part of their EVSE planning efforts were not yet available when most of these installations began. Because of limited availability of guidance, parties involved in these early installations faced a variety of uncertainties and sometimes had to make challenging decisions. Questions such as what signage should be used, what information should it contain, and where it should be displayed may become more complex when an actual installation is undertaken. Issues such as to how to navigate a certain bureaucratic process to approve an installation may also be more complex than expected .

Early adopters such as those referenced in this report helped uncover strategies that can be used for effective support of future infrastructure deployment. The following points summarize some of the key issues that may need attention when preparing such strategies.

- **New vs. Existing Buildings.** In general, preparing the charging sites as part of a new development is more cost effective than incorporating EVSE into an existing structure. Adapting an existing building or parking structure to host charging infrastructure may be costly if electric system upgrades, surface trenching, and/or parking layout modifications are necessary. The cost of upgrades also tends to increase with the age of the building. In this context, building codes that not only allow but also facilitate EVSE installations would help reduce the cost of future installations.
- **Public vs. private space.** Installations in public spaces, such as sidewalk right of way, can be administratively burdensome. Installers generally agree that education of public officials and formalizing clear procedures for permitting and approval will help expedite installations.
- **Multi-dwelling units (MDU).** This report examined MDU where the initiative to install infrastructure originated with the building owner. More complicated scenarios may appear when the interest is driven by an individual resident. While the authors have not been able to identify a case like this in the TCI region, it is important to recognize the potential challenges with this type of installation. MDU residents interested in installing charging infrastructure in the building's garage may face questions such as: Are all the units in the building served by one panel or are there individual panels for each unit? Is the homeowner association or building owner supportive? Are parking spaces assigned? Can privately owned equipment be installed in a common area?
- **The current price of charging equipment.** Most case studies pointed to the current prices of the charging equipment as one key barrier to broader

deployments. Installers generally agree that given the technical complexity of standard charging stations, prices of equipment should be expected to come down.

- **Level 1 vs. level 2.** As a corollary of the previous point, charging station hosts must choose between installing level 1 or level 2. The faster charge delivered by level 2 equipment is may be preferred by the end user. Level 1 installs, however, remain very attractive because they are much cheaper and less complicated from an electrical systems point of view.
- **Signage.** TCI documents highlight the need to develop and adopt consistent EV-related signage for the region.[17] The case studies in this report showed that a variety of different signs have been used across charging sites. Standardization of signs, both regulatory (or on-site) and directional (or wayfinding) will not only improve communication to drivers but also reduce the burden on site owners and designers.
- **Space restrictions and regulatory signage**. On-site signs in the cases studied in this report restricted use of the charging space to electric vehicle parking, though site owners and designers usually meant to restrict the use to vehicle charging. Clear signage will be helpful to the user and, whenever appropriate, to enforcement personnel.
- **Charging management and business models**. Site owners, current and prospective, often struggle with the question of return on investment on charging equipment. What happens when a vehicle is parked longer than the time it takes for a complete charge? How to assess the benefits that a charging station could bring to my business? These and others are questions that site owners ponder as they evaluate investments on charging stations.
- **Charging station cord management.** Some charging station models feature a cord management system, such a cord retraction. For many other models, cords can only be rolled in the front of or around the equipment. The authors observed cords without a management system are often left spread about on the ground and may potentially become a hazard for users or the equipment. In one case, a snowplow accidentally pulled one such loose cord and damaged the equipment.
- **Accessibility.** Discussions on electric vehicle charging station accessibility generally center on implications of the American with Disabilities Act (ADA) of 1990. The State of Washington discussed and incorporated ADA recommendations as part of a multi-stakeholder process to develop EVSE model development regulations. Given the early stage of their EVSE planning process, the Northeast and Mid Atlantic regions have not yet formally adopted guidelines or recommendations on the definition of ADA-accessible charging space and the minimum number of charging stations that need to meet that definition. The authors could not identify cases where a formal approach to

[17] WXY Architecture + Urban Design (2012) Siting and Design Guidelines for Electric Vehicle Supply Equipment. Prepared for the New York State Research and Development Authority and the Transportation and Climate Initiative. November. Available on the web at www.georgetownclimate.org.

accessibility was taken and are unable comment on this experience in the region. If states or jurisdictions within the TCI region adopt accessibility recommendations, these may be included in the building codes of the respective states and allow a more formal approach to this question in future installations and new developments that plan for the possibility of hosting charging infrastructure.

- **Selection of charging space.** While the cost of the charging equipment, in the current state of the market, does not in general vary significantly across manufacturers, the cost of installation can and, as was found as part of this study, does vary significantly. The cost of installation, relative to the cost of the equipment, may range from somewhat lower to several orders of magnitude higher. Three factors that have large effects on the cost of installation are the amount and type of construction work needed (e.g. surface trenching), the distance from the charging space to the electrical system, and the type of upgrades to the electrical system. A careful evaluation of the possible spaces where the equipment could be located and their impact on the economics of the installation should be part of the planning process before a commitment to installing the equipment is made.
- **Public-private partnerships.** Parties interested in hosting EVSE should reach out to their local and state government to inquire about opportunities to share the costs of the installation. This report described a number of partnerships in which the costs of the equipment and installation were divided among the host and government. Such partnerships help the host construct a more attractive economic case to install the equipment, while enabling government to pursue their community goals.
- **Terms of a grant.** Prospective hosts are recommended to pay close attention to any requirements that are part of grants that they may receive. Some may forbid them from billing people for using the EVSE, some may only cover installation costs or equipment costs up to a fixed cap, and some may require a cost share as a percentage of the total. Understanding the terms of the grant will help prevent surprises down the road.
- **Operation costs.** Before entering into agreements to install charging stations, prospective hosts should make sure they understand who will pay for maintenance, for electricity, and other ongoing costs after installation.