CHARGING FORWARD

lessons learned from the first six months at Electric Avenue
PLUG-IN ELECTRIC VEHICLE

100 MILES PER CHARGE
acknowledgments

The authors would like to thank all of those that have helped to gather information and take time to discuss the development, building, and operation of Electric Avenue. Many thanks to Portland General Electric, the City of Portland, and Portland State University for offering insight, resources, and time. Special thanks to Charlie Allcock, George Beard, Alex Bejarano, Rani Boyle, Jeremy Dalton, Katja Dillmann, Rick Durst, Dale Garcia, Erin Flynn, Stan Sittser, Lee Sumner, and many more who have personally helped capture the early story of Electric Avenue.

We would also like to thank our charging station partners for collaborating with us on this innovative project.

This report was prepared by John MacArthur and Colin Rowan of the Oregon Transportation Research and Education Consortium at Portland State University.

host partners

- Portland State University
- Portland General Electric
- City of Portland

equipment partners

- Eaton
- ECOtality
- General Electric
- Kanematsu USA
- NorthWrite
- OpConnect
- Shorepower
- SPX

special thanks

OTREC
Oregon Transportation Research and Education Consortium

v1. June 2012
# Our Electric Future

- The EV Challenge
- What is Electric Avenue?
- Electric Avenue at a Glance

# The Road to Electric Avenue

- Planning + Design
- Construction
- Pre-Launch: Lessons Learned

# Navigating the Unexpected

- Operations + Management
- Functionality
- Signage + Wayfinding
- Unauthorized Use
- Vandals, Graffiti + Birds??
- Post-Launch: Lessons Learned

# Looking to the Horizon

- The Road Ahead
- Questions > Answers > Questions

# Appendix

- A: EV Supply Equipment
- B: City of Portland Parking Code
With more research and incentives, we can break our dependence on oil with biofuels, and become the first country to have a million electric vehicles on the road by 2015.

— President Barack Obama, 2011 State of the Union

This challenge was issued by President Obama in his 2011 State of the Union address, to help break the nation’s dependence on oil and fundamentally change the way we travel. Electrification of our cars, trucks, buses, trains, bikes and motorcycles allows us to leverage renewable energy resources and advanced smart grid technologies to achieve a lower-impact transportation system.

The acceptance of Electric Vehicles (EVs) as a viable transportation choice will require convenient, fast, and reliable access to charging stations. While overnight home charging is expected to meet most charging needs in the future, the security and convenience of a widespread network of charging stations in public places expands range, provides access to users without garages and alleviates driver “range anxiety” about being stuck without enough power to get home.

During 2011-2012, approximately 800 EV charging stations will be installed in public locations throughout Portland, Salem, Corvallis, and Eugene as part of the federal funded “EV Project.” In October 2009, ECOtality was granted $99.8 million in U.S. Department of Energy stimulus funding to install 15,000 EV chargers in five states, including Oregon. This project is being carried out in partnership with Nissan North America, which is deploying over 5,000 electric LEAF vehicles throughout these regions. Many charging stations will be located in parking garages and parking lots. However, the siting of some stations in highly visible locations will generate enthusiasm about electric vehicles while demonstrating reliable access to charging infrastructure.

Adding to Oregon’s charging infrastructure is “Electric Avenue,” a block of seven EV charging stations on the Portland State University campus. This report outlines the lessons learned in the design, planning, construction and implementation of Electric Avenue, and attempts to identify lessons that might serve other cities around the country. Supplemental information is provided about the technical aspects of the site and of the equipment utilized. The audience for this report is other cities and communities looking to install similar electric vehicle charging infrastructure.

1  www.theevproject.com
what is Electric Avenue?

On August 16, 2011, the unique partnership between the City of Portland, Portland General Electric (PGE) and Portland State University (PSU) led to the creation of Electric Avenue, a first of its kind electric vehicle charging infrastructure pilot project. Built along an entire block-face at the PSU campus in the heart of downtown Portland, Electric Avenue uses 100% renewable energy from PGE, and offers electric vehicle (EV) charging priced at standard city parking rates. The site is comprised of eight on street parking spaces with seven available charging stations. Ongoing use and effectiveness data is being collected to explore the future implementation of charging infrastructure and consumer behavior.

The planning and design of Electric Avenue presented a unique opportunity for collaboration and learning. The principal partners, PSU, the City of Portland, and PGE, were supported by a large group of associate partners that included the original charging station manufacturers: Eaton, ECOtality, General Electric, OpConnect, Shorepower, and SPX. Additional supporting partnerships have been created with Drive Oregon, the Oregon Electric Vehicle Association (OEVA), the International Brotherhood of Electrical Workers (IBEW) union, the Oregon Transportation Research and Education Consortium (OTREC), Northwrite, Inc., Toyota, Nissan North America, Mitsubishi North America, Ford Motor Company, General Motors, and the Piaggio Group. Each partner has been able to add the knowledge and perspective to help the project to succeed.

The University District provided an ideal location for creating a signature project for public EV charging infrastructure. The district is a vital regional transportation hub where the busiest transit stops in the metro area are coupled with hundreds of people arriving by bike each day. By selecting a site for on-street EV charging stations where bus, light-rail, streetcar, bike, and pedestrian traffic converge, the City of Portland has an opportunity to illustrate how EV infrastructure fits into the range of low-carbon travel options available in the region.

A number of street segments within the University District were evaluated as potential sites for Electric Avenue. Through collaborative evaluation by the project partners, other potential sites were eliminated from consideration and SW Montgomery Street between SW Broadway and SW 6th Avenue was identified as the ideal location for creating a pilot project. This section of SW Montgomery Street connects the Smith Memorial Student Union with the Urban Plaza, generating high volumes of pedestrian activity and is in the immediate vicinity of bus, light-rail, streetcar, and bike facilities.

The two-way traffic segment on Montgomery was converted into a single eastbound travel lane and angled parking was installed on the south of the street replacing parallel parking located on both sides of the street. The use of angled parking accommodates electric vehicles with charging connections located on the front or side of the vehicle.
The current electric vehicle supply equipment (EVSE) vendors onsite include Eaton, Shorepower, OpConnect, General Electric, SPX, and JFE Radipas (Appendix A). Two DC Quick Chargers can charge a vehicle within 30 minutes, while five Level 2 stations can charge vehicles in 2-4 hours. Some Level 2 chargers are equipped with Level 1 outlets, allowing them to accommodate plug-in hybrids and EV conversions in addition to fully electric vehicles. One Level 2 station provided by OpConnect can charge two vehicles simultaneously.

The inclusion of multiple types and brands of charging stations meets a variety of needs and allows for the comparison of charging stations. Drivers making brief visits may choose the DC quick chargers, which provide significant recharging in a short amount of time, while those visiting the district for longer periods of time are able to choose from a variety of Level 2 chargers. Drivers pay regular rates for parking but electricity is currently provided by PSU complementary. Spaces with charging stations are restricted to vehicles in the process of charging.

The location of charging stations in the public right-of-way raises many unique challenges, requiring extensive collaboration among the project partners. The successful installation of charging stations on SW Montgomery St will hopefully provide a model for additional installations in Portland and elsewhere. Occupancy and electricity usage is being studied, and will inform long-term decisions about pricing, partner roles, and the role of EVSE in the public right-of-way. All partners are committed to extensive monitoring and documentation of the pilot program, to facilitate replication in Portland and elsewhere.

By June of 2012, Electric Avenue had supplied 18,000 kWh of renewable energy to EVs, equal to 54,000 miles of tailpipe-emissions-free electric driving.
Electric Avenue is located on the campus of Portland State University along SW Montgomery Street between SW Broadway and SW 6th Avenue.

- The location is a public street with charging equipment located in the public right-of-way.
- Charging equipment is placed between the sidewalk and the curb.
- Parking spaces are reserved for only electric vehicles. A bike rack with a charger for electric bikes and scooters is located in the center of the facility. There is a motorcycle-only bank in front of the bicycle racks.
- The DC quick charger spaces have a one-hour parking limit.
- All Level 1 and Level 2 parking spaces have an eleven-hour parking limit.
- Intended to serve all electric vehicles: passenger vehicles, neighborhood electric vehicles (NEVs), motorcycles, bicycles, urban freight, service, and fleet vehicles.
- Location is along the central axis of PSU and routes to the downtown core located seven blocks away at Pioneer Courthouse Square.
- PSU is Oregon’s largest university with 29,000 students.
- Location is convenient to out-of-town visitors and commuters. Electric Avenue is close to Interstate 405, Interstate 5, Oregon Highway 99W, and US Highway 26.
The debut of Electric Avenue was one in a series of events celebrating electric mobility in Portland.

Mar 2009: The pre-production Nissan Leaf prototype debuts in Portland
May 2010: Toyota kicks off the Plug-in Prius demonstration program at PSU
Aug 2010: Ford picks Portland to launch a 14-city electric vehicle tour
Aug 2011: Official Launch of Electric Avenue
Oct 2011: Mitsubishi introduces iMiEV to America
Oct 2011: National Plug-in Day at Electric Avenue
Nov 2011: The all-electric Coda sedan debuts at EV Roadmap 4
What if...

The idea for Electric Avenue started with a hastily scribbled diagram and the words “what if” written on a napkin. But for it to become a reality, the three principal partners needed to play their role. PSU provided project and site management, maintenance, ongoing research, and location enhancements including sidewalk improvements. The City of Portland provided technical assistance related to codes, parking infrastructure, and permitting, and made changes to the right-of-way, including shifting the road from two-way traffic to a one-way alignment and re-orientating the parking from parallel parking on both sides to angled pull-in parking on one side. Finally, PGE provided technical assistance related to energy delivery, installation of the electrical infrastructure such as conduit, plumbing, and charging equipment, and continues to provide ongoing energy data information essential to interpreting user behavior and changes over time.

As an urban research university, Portland State takes its mission, “Let knowledge serve the city” to heart. Electric Avenue represented a unique opportunity to create a “living laboratory” for EVs on campus, and to promote PSU’s leadership in urban mobility and transportation electrification. The City of Portland is committed to advancing vehicle electrification, the development of an EV manufacturer base, and sustainable transportation solutions. Electric Avenue provided an opportunity to showcase this potential in a visible, public location. To PGE, Electric Avenue provided a showcase venue where representatives could demo a host of chargers in a single, attractive, centrally located place, learn about impacts on system grid, and learn about charging usage patterns.

Based on criteria outlined in the Electric Avenue Plan, three possible locations were identified: Southwest Tenth Avenue between Mill and Market streets, Southwest Park Avenue between Jackson and College streets, and the chosen location at Southwest Montgomery Street between Sixth Avenue and Broadway. Additional planning was performed in order to assess revenue neutrality, including an audit of underused load zones and commercial and “car share” spaces. The identified spaces throughout the parking district provided more potential revenue than the spaces “lost” to electric vehicles.
As a first-of-its-kind project Electric Avenue presented a number of unique challenges. For example, the city had a particular interest in the precedent that such a project in the public right-of-way would set. Without existing city code each action had to be carefully considered. The site needed to minimize visual and physical clutter, had to be in full compliance with Americans with Disabilities Act (ADA) requirements, and needed a functional business model that would support the continued maintenance of the infrastructure without relying on advertising revenue. Any action, procedural or otherwise, could be interpreted as precedent for future projects.

The State of Oregon’s freedom-of-speech protections demand that there be no discrimination in advertisers, meaning there could be no preference or censorship of advertising content on Electric Avenue, including on the charging units in the public right away. While EVSE companies with business models that rely on advertising may not be best suited for such a project in Oregon, other states may not face the same issues around advertising discrimination and can confidently pursue contracts if advertising is desired in the public right-of-way.

Based on lessons learned from the performance of the various EVSEs, the city will be in a better position to develop franchising agreements for additional infrastructure installed in the public right-of-way. An easy to use, well-designed, and thoughtfully implemented charger that does not have a business plan tied to membership is more likely to win the city’s franchising support.

PSU produced the Electric Avenue Plan in February 2011, which provided the configuration and long-term plans for Southwest Montgomery Street, including green street functions such as vegetated stormwater bioswales, a “curbless street,” and one-way, single-lane streetscape with limited automobile access. This document helped establish the following planning criteria:

- Capacity to accommodate angled parking and one-way traffic
- Develop partnerships with multiple charger manufacturers
- PGE power availability was within reasonable distance
- Low traffic volume on the street but high visibility
- No/minimal conflict with rail infrastructure and operations
- Construction would not adversely affect local residents or businesses
- Revenue neutral for the City
- Proximity to PSU property
The construction phase of the project started in June 2011. Because of the thorough work during the planning process, there were few delays during construction: permitting came in a timely fashion, contractors performed high quality work, and it was only the delivery of the changing equipment and the lack of standardized instructions that caused minor delays in the installation.

The City of Portland engaged in a new permitting process during the construction of Electric Avenue. Because the city codebook does not address any use similar to electric vehicle charging, new configurations and interpretations had to be established in a timely manner. Above all, the City wanted a safe facility that did not jeopardize citizens’ right to the public right-of-way. The one area hampered by the code and permitting was the issues of signage, which will be discussed in the operations section.

While construction was relatively smooth, there were still a few service delays and disruptions with minor impacts. Traffic was rerouted at various times in order for work to progress. The sidewalk was dug up in order to allow trenching. Electrical service disruptions affected the nearby a restaurant, requiring that a back-up generator be provided during the service distributions. Fortunately, daytime construction noise impact was limited because few students were on campus during the summer sessions and few people live nearby the site.

Once the trenching, conduit, and wires were in place, the site was ready for EVSE installation. Some chargers arrived without manuals, some manuals did not properly instruct installation, and some mounting brackets were not built to design specifications. While these issues did not cause significant delays, they demonstrate the need for established design standards within the EVSE industry. Even so, thanks to the ingenuity and hard work of the PGE-led crew - including building a custom mounting plate with drilled anchor points for one charger - Electric Avenue was up and running on schedule.
There are many transferable lessons that jurisdictions considering similar projects should study. While every locality provides unique challenges and difficulties, careful reading of the following lessons may provide helpful insight and a smoother road.

1. **Forge strong partnerships** – Strong partnerships allow for much needed flexibility and creativity and provide maneuverability around otherwise insurmountable obstacles. They foster greater accountability, credit sharing, and communication, particularly during a pilot project, where new permitting, code variances, and fee structures are required. Strong partnerships often take political will and support from organizational leadership to maintain. Mayor Sam Adams of Portland was a vocal proponent of vehicle electrification and was able to reach a broad constituency of support. Together with PSU President Wim Wiewel and PGE President and CEO Jim Piro, Electric Avenue had the necessary support and leadership to make it a reality.

2. **Consistent representation is important** – Designating a single primary contact for each project partner leads to increased efficiency, clearer communication, and better results. Preliminary meetings discussing the feasibility of Electric Avenue involved a rotation of representatives from each partner organization, sometimes resulting in confusion and misunderstanding. Having consistent representation from the beginning allows for the forging of personal relationships and continuity of conversations.

3. **Location, location, location** – For a project of this nature, location is everything. The venue needs to be both highly visible and convenient, both demonstrative and functional. The Electric Avenue site is located in the public right-of-way, near access points to both downtown freeways; adjacent to bus, light rail, and streetcar stops; and within a block of PSU’s transportation office, food, coffee, classrooms, and a recreation center. The location sends a clear message that vehicle electrification is an integrated and important component of the transportation network.

4. **Form and format** – It is important for the leading municipal partner to have a simple, uniform permitting and design review process. Setting good precedent was a major concern for the City of Portland. The project needed to be replicable at other locations around the city, with different criteria and partners.
5. **Know what you are getting yourself into** – From the very beginning, identify the wide range of needs and possible challenges the project presents for the different partners. The Electric Avenue project partners knew there would be difficulties with public space, energy provisions, and business models. Wherever possible, such issues must be identified early and addressed cooperatively. Questions of who should control, clean, police, and maintain the space need to be answered during the planning stages, including consideration for potential hidden costs and concerns.

6. **Look for hidden costs** – Anticipate who will pay for any unforeseen costs related to the various components (electrical transformer, trenching, conduit, and sidewalk) if anything goes awry. For example, PSU is legally responsible for the sidewalks in the area and therefore paid for the concrete work, a cost that proved to be substantially higher than anticipated.

7. **Design decisions need to be made** – A number of questions will need to be answered during the planning and design phase: what will be the long-term capacity needs? Should all conduits run wires for DC quick charge compatibility? Should communication wires be integrated? Should pedestals be placed in the middle of the parking spaces or to the sides? Should spaces be angled for front-in charging? These are vital considerations for permanent infrastructure projects.

8. **Plumb for the future** – While it is unknown what the standard power supply of the future will be, in the near-term it is likely that more DC quick chargers will be in demand. The concrete costs alone of tearing up the sidewalks in the future to upgrade the wiring could be cost prohibitive. By building a project with additional capacity to be retrofitted to a DC quick charger the site has greater longevity and adaptability to uncertain standards and demands.

9. **Standardization is needed immediately** – The mounting patterns of the pedestals are sometimes very different, which made each install unique. If EVSE vendors could use one in-ground mount and preset the location of the conduit entry into the station base, this would increase the ease of installation and reduce cost. Other municipalities or organizations can reduce this issue by using fewer vendors.

10. **Plan for disruptions** – Service disruption comes in a number of forms, from detouring vehicle traffic to necessary power service outages. If installation of the transformer and chargers affects a large institution or office building contingency planning may be necessary. It may not be possible to disrupt service at an institution such as a hospital. Build the time costs into the plan and expect to give affected groups ample notice (perhaps months).
Electric Avenue went live on August 16, 2011. A grand opening and ribbon cutting included a flash mob dance and speeches by Portland Mayor Sam Adams, PSU President Wim Wiewel, and PGE President and CEO Jim Piro. The site received widespread media coverage, with over 200 stories from outlets including the New York Times, Wired, and the Huffington Post.

Public reaction to Electric Avenue has been mostly positive. PSU staff are capturing user experiences through surveys, email communications, and field observations. A number of positive emails including pictures of people charging their vehicles have been sent to electric@pdx.edu and Electric Avenue continues to receive kudos from users, community members, news agencies, and other cities around the country. Since launch, an increasing volume of EVs have been seen using the facility including Nissan LEAFs, Chevy Volts, Mitsubishi iMIEVs, Toyota Prius PHEVs, and conversions. The utilization of the facility by conversions indicates the importance of maintaining Level 1 chargers since many conversions and neighborhood EVs lack the capability to use Level 2 or DC Quick chargers.

As a pilot project, Electric Avenue is in a way a solicitation for issues and problems that have yet been uncovered. Customers have voiced concerns ranging from unclear signage (“Can I park here?”) to functionality (“How much is the cost to charge per hour?”, “I can’t get the quick charger to work!”). While this section focuses on the issues that still face Electric Avenue, it is important to recognize that the site is functioning well, generating revenue for the City and data for PGE and PSU, while serving as an excellent test bed and showcase.
Electric Avenue provided the opportunity to test the real-world performance of charging equipment and their compatibility with different EVs. While each charger features the same J-1772 connector, some chargers had difficulty ‘hand-shaking’ with certain vehicles. Some chargers initially wouldn’t charge the Chevy Volt, while others caused the Toyota Plug-in Prius to trigger a fault light. Such issues might have remained hidden without the Electric Avenue implementation, and their discovery has been helpful to both EVSE and EV manufacturers.

Real-world testing also helped uncover a design flaw in the charging-cord pin-clip on some of EVSE models. The Yazaki connector on one of the DC quick chargers was too brittle and broke within a few days of installation. After being replaced and broken twice more, the clip design was determined to be too unfamiliar and difficult for users. As with the hand-shaking issues, this feedback proved to be helpful to the manufacturers as subsequent designs have been altered to address this problem. The DC quick charger at Electric Avenue has been updated as well and has had no issues since.

**to card or not to card?**

Some chargers at Electric Avenue require the use of an access card to operate. Membership cards are free and provide a helpful communication channel between users and EVSE providers, but the user will need to have already requested and received their card before visiting the charging station. We have found that this has caused a great deal of confusion and frustration for some users at Electric Avenue.
signage + wayfinding

A lack of clear and consistent signage has proven to be one of the biggest challenges facing Electric Avenue. Drivers of internal combustion engine (ICE) vehicles are frequently seen parking at the facility, rendering those spaces unavailable for EVs and, perhaps unintentionally, encouraging other ICE drivers to park there. This behavior is likely due in part to the overabundance of signs on site, that send mixed messages about whether or not Electric Avenue is safe to park on. There are “No Parking” signs with small “electric vehicle only” signs below them. There are no signs indicating that the electricity is provided with the cost of parking, but there are signs pointing where to pay for parking in a fashion identical to a regular city parking spot. The Eaton DC quick charger does not clearly state that it is a one-hour parking space. While many of the signs make sense to experienced EV users, they appear confusing to the general public and newer EV drivers.

Final standardization is needed for signage on EV charging/parking spaces as well. Similar to the national Handicapped Parking symbol, a nationally unified “Electric Vehicle Only” logo would be a significant step forward. A simple sign that clearly and politely states that the parking is only for electric vehicles would significantly limit the visual clutter currently seen on Electric Avenue.

Wayfinding around the city is another concern as some EV drivers have expressed having difficulty finding Electric Avenue. While many ICE vehicle drivers have come to rely on “gas next exit” signs along the highway, there are no such signs around the Portland metro area for EV charging stations.

On April 1, 2011 the Federal Highway Administration updated the Manual on Uniform Traffic Control Devices (MUTCD) to give interim approval for the “optional use of an alternative electric vehicle charging general service symbol sign” on state highways. This approval seeks to establish an interim national standard for electric vehicle charging sites. This sign is currently not being used at the site or in any wayfinding signage. Ideally, such a sign would be standardized regionally or nationally, with an elements indicating DC quick charger and Level 1 and 2 charger availability.
The physical environment around the facility should be clean, uncluttered, safe, and easy to use. Unforeseen challenges since the launch of Electric Avenue include a roost of pigeons above the site that resulted in significant droppings around one charging station, visual clutter by way of excess signage, and occasional clutter by way of uncoiled power cords. As new designs are developed for commercial and public use it is likely that recoiling cords will become an industry standard. At this time the untidy cords do not present a significant barrier to use.

Vandalism such as graffiti and physical destruction of the equipment is also a concern. Graffiti “tags” and stickers that have been placed on the equipment, necessitating regular clean-up and removal. There have also been a series of issues around equipment user interfacing. Some operational information is not visible at night. Some chargers rely on LCD screens that are prone to sun-glare and vandalism, or are simply not user-friendly.

It is important that partners agree to the maintenance and upkeep expectations in order to avoid negligence over time. In developing a similar facility it will be important to carefully define responsibility for site management: who will clean and upkeep the site? How often will they check? How will damage be reported? What will the response time be to reported damage? In the case of Electric Avenue, the task of site management has been more intensive than what the project team had originally expected.

Since the launch of Electric Avenue on August 11 through November 14, 2011, 104 citations have been issued by parking enforcement. Of those, 66 were for ‘non-compliance’ with the electric vehicle only regulation (Appendix B). There has been a dramatic reduction in violations since, with only 25 citations for non-compliance issued from November 15-January 22. While this suggests that understanding of the facility is increasing, there is still a need for better signage and clearly marked parking spaces. One proposed solution is new road painting that would clearly denote the space as being for EV use only. The project partners continue to discuss possible designs that could be consistently implemented in other future locations.
post-launch: lessons learned

1. **Keep planning** – An operation plan to determine responsibilities for site maintenance and upkeep is an important lesson. Consideration must be given to institutional capacities to provide upkeep and to tend to financial needs that may arise.

2. **Site management** – Designing a detailed site management plan that considers ongoing upkeep and repairs is necessary to sustainably operate a charging facility with high user satisfaction. All details should be discussed and agreed upon in writing by project partners.

3. **Design standards if you please** – Charger standardization is largely out of the control of municipalities. From the installation of the chargers to the positioning of the power cords and the plugs to the cars’ computers, there is a critical lack of standardization throughout the various charger/vehicle combinations. In order for successful construction of similar projects it is necessary to have reliable equipment at all levels. It is recommended that charger manufacturers standardize certain elements of design to ensure future compatibility and ease of use.

4. **A universal handshake** – As mentioned above, it was expected that the charging equipment would be installed and it would work. That has not consistently been the case. If a city were to pay for this equipment they would likely install a single design instead of a showcase of charging designs. A city needs to carefully choose the charging equipment and have reasonable assurance of functionality and compatibility. Equipment needs standardization as soon as possible and the project partners must demand functionality and ease of use. Electric Avenue was designed and built with a functional catalog of chargers in order to be a demonstration place. As the many chargers arrived for installation the diverse design language employed by the companies, difficult installation instructions, ADA compliance, and the lack of charging cord ‘neatness’ and ease all presented challenges.

5. **Standardize authentication** – Some chargers require the use of an ID or membership card before a vehicle can be charged, leaving many EV drivers with a stack of different cards for different EVSE networks. The development of a universal authentication process would greatly simplify the EV user experience.
6. **Time to rewrite some codes** – At the city level there is much that can be done to ensure standardization. Design standards can be adopted by jurisdictions to ensure easy permitting, uniformity, and ease of installation. It is an iterative process and each city will need to explore what works best within City Codes and permitting structures. If a city were able to move ahead of the installation and preempt some code changes the way would be smoother.

7. **Clear, simplified signage** – Signage needs standardization and simplification and should be regulated and uniform throughout the city and, where possible, throughout the country. A national conversation about design of site and wayfinding signage is needed, and an outreach campaign needs to be developed to educate the public about these new signs and what they mean.

8. **New business models** – Current business models employed by EVSE companies do not always match the requirements of the host site, especially in public locations. Working in a public space was a particular challenge with the revenue models of different charger manufacturers. Alternative business models should be considered that account for public organizations and jurisdictions that cannot allow advertising. Consistency practices and equipment will allow municipalities to confidently develop similar projects.

9. **Get the word out!** – The more news articles, press mentions, press releases, tweets, public outreach and general commotion the site receives the more people will think about the possibility of electric vehicles. Showcase the public space; make it a destination and a regional focal point.

---

**what about the grid?**

“*How big of a transformer did you have to upgrade to?*”

PGE engineers hear this question a lot, and the answer might surprise you. The fact is that the existing transformer has continued to serve the surrounding area and Electric Avenue without a hitch.
The lessons learned from the planning, construction, and early operations of Electric Avenue demonstrate that a similar project is viable in Portland or elsewhere. In order for vehicle electrification to take off there needs to be a reliable and comprehensive charging infrastructure in place.

This is not a How-To guide to building a similar project as each state, municipality, and neighborhood has its unique strengths and challenges. The practitioner and policy-maker will know their area best. Even so, careful consideration of all the lessons learned is encouraged. Absorbing and applying them to your unique planning environment will help uncover similar challenges and hidden costs.

Some of the key lessons identified in the first six months of operation include the ongoing importance of relationship building, the need for careful consideration of planning and operating costs, and the declaration of roles and responsibilities. New codes and sign policies may be needed for effective wayfinding. As electric vehicle adoption continues many of the mechanical issues will resolve themselves. Until that time it will be very important for a jurisdiction to consider the cross-applicability of chargers purchased. It is an exciting time for vehicle electrification and municipalities and institutions can play a vital role in facilitating adoption.

Since Electric Avenue is a two year research project, PSU will continue to work with its partners to evaluate and monitor the use of the site. During the spring and summer of 2012, PSU will survey users of the site to obtain impressions of the site and behavioral characteristics of the users.
Portland State has conducted a number of interviews and surveys around Electric Avenue. Observations are based on intercept survey responses, 35% of which were non-EV owners. Preliminary results show that, observationally:

- Most cars used the facility during the afternoon hours.
- Generally, people are happy with the user experience.
- People view PSU’s role with Electric Avenue positively.
- Gas cars (internal combustion engine cars) parking in the spaces continue to be an issue stated by users.
- Certain level of concern about reliability of equipment to be operating was expressed.

This information raises the following questions:

- How do people communicate with the site management about problems?
- How quickly do people expect to have repairs made to the equipment?
- What is the process by which PSU finds out about a problem?
- What signage will best inform drivers?

---

**EV roadmap**

Since 2009 PGE and PSU have hosted EV Roadmap, a periodic colloquium on the unique challenges and promising future of electric vehicles.

- **Nov 2009, EV Roadmap 1: Preparing Oregon for the Introduction of EVs**
- **Jun 2010, EV Roadmap 2: 6-Mo. Update on Oregon’s EV Initiative**
- **Jan 2011, EV Roadmap 3: Leading the Charge**
- **Nov 2011, EV Roadmap 4: Getting to 1 Million**
- **Jun 2012, EV Roadmap 5: From Can’t to Can**
One of the research objectives of Electric Avenue is to serve as a working demonstration showcase for various manufacturers’ electric vehicle supply equipment (EVSE), more commonly termed chargers. The following overview of the companies that have partnered on Electric Avenue is provided to give background on the essential functional characteristics of the available chargers.

Eaton has two chargers installed on Electric Avenue (Level 2 and DC Quick Charger). Eaton’s Pow-R-Station family of charging solutions includes Level 2 Charging, DC Quick Charger, residential chargers, and network management software for commercial chargers. Eaton assembles their charging stations at their Wilsonville facility.
General Electric (GE) provides a number of charging solutions, including home chargers. Double pedestal, single pedestal, pole mounted, and wall mounted chargers provide flexible installation options.

The GE Level 2 DuraStation charger installed on Electric Avenue presents users with a simple interface. The recently launched GE WattStation features a recoiling cable and an interactive touch screen.

JFE RAPIDAS

The newest addition to Electric Avenue, the JFE RAPIDAS Quick Charger launched on February 29, 2012, and is distributed in the United States by Kanematsu USA. This CHAdeMO standard charger utilizes a grid-charged storage battery that allows for additional power. Through this technology the RAPIDAS can output 50kW while only drawing 20kW from the power grid. A free membership card can be obtained at www.evcollective.com
OpConnect 1/2

The Level 1/2 charger by Portland based OpConnect is the only dual-headed unit installed on Electric Avenue. It supports both 120V and 240V charging for two parking spaces. Use of the charger requires a subscription to MyOpConnect. Users can input their email address for temporary access to the unit, while members use an RFID tag to sign in.

shorepower technologies 1/2

Shorepower is a Utica, New York based company that recognized the green energy incubator that is Portland. The company has opened a satellite office in the city, allowing a direct link and partnership building opportunities. The charging stations are produced in Portland.

At Electric Avenue a Shorepower Level 1 and 2 kiosk charger is installed, supporting both 120V and 240V charging. Visually evocative of a classic vacuum filling station pump the charger shares common branding with Electric Avenue.
A Level 2 SPX pedestal charger is located on Electric Avenue. The company’s business model has been focused on home charging equipment sales and with the Electric Avenue project they have entered the fray with a public outdoor pedestal charger. The company has partnered with Chevrolet to bundle a home charger with the Chevy Volt. Additionally, SPX has made a new partnership with Daimler AG and DTE Energy for turnkey at-home charging solutions. Currently, they are developing a DC Quick Charger for the public market.

ECOtality

NOTE: This charger was originally installed on Electric Avenue in partnership with ZipCar. However, the companies decided not to pursue the necessary city permits for a car-share space and the unit was removed in February 2012.

ECOtality is the manufacturer of the Blink Type 2 and DC Quick Charger technology. ECOtality and the Blink chargers were selected by the US Department of Energy to manage the EV Project, a $99.8 million effort to deploy 14,000 chargers in 18 major cities and metropolitan areas in six states and the District of Columbia. Oregon is one of the states partnering with ECOtality to install charger infrastructure. Though ECOtality is not part of Electric Avenue, they are still installing a charging network around Portland as part of the EV Project.
Portland City Code, Title 16 Vehicles and Traffic, includes language for EV specific parking spaces. The code language is found below:

16.10.050 Compliance Required:

*It is unlawful for a pedestrian or the operator of any vehicle to disobey the instructions of a traffic control device placed in accordance with the provisions of this title, unless otherwise directed by an authorized office.*

**ELECTRIC VEHICLE ZONE**

(16.10.050)

Non-electric vehicle not plugged in, cite for Non-Compliance - Electric Vehicle, Code #83. Only one Non-Compliance - Electric Vehicle citation may be issued to the vehicle in the same location per day.

1. No vehicle other than an electric vehicle, while charging, may park in an Electric Vehicle Zone.

2. While charging, an electric vehicle may remain in the space all day long or as posted with a valid pay receipt displayed.

3. While charging, the vehicle must pay for the space.

4. If no receipt is displayed and the vehicle is plugged into a charger, cite for No Meter Receipt, Code #95. Only one No Meter Receipt citation may be issued to the vehicle in the same location per day.

5. If a receipt is displayed but has expired, cite for Overtime Meter, Code #43.

**TOWING**

Non-electric cars: Cite and warn to tow; if still there after one hour, may tow.