STATE OF MAINE
GOVERNOR'S ENERGY OFFICE

RESPONSE COVER PAGE

RFI#201608160

<u>DEPLOYMENT OF QUEBEC-MAINE ELECTRIC VEHICLE CHARGING CORRIDOR</u>

Lead Point of Contact for Response – Name/Title: **Barry Woods**	
Respondent's Organization Name (if applicable): **Plug In America**	
Tel: **(503) 504-6492**	Fax:
E-Mail: **bwoods@emne.net**	Website (if applicable): **http://www.pluginamerica.org**
Street Address: **6380 Wilshire Boulevard #1010**	
City/State/Zip: **Los Angeles, CA 90048**	

Table of Contents
Deployment of Quebec-Maine Electric Vehicle Charging Corridor

Section I. Organization

Plug In America is a non-profit, supporter-driven advocacy group with national headquarters at 6380 Wilshire Boulevard, #1010, Los Angeles, CA 90048. See also https://pluginamerica.org. For purposes of this project and RFI, Barry Woods, one of our Directors and principal at Electric Mobility NE, will be acting as the lead contractor in coordinating our efforts in Maine.

Plug In America is the voice of plug-in vehicle drivers across the country. Our mission is to drive change to accelerate the shift to plug-in vehicles powered by clean, affordable, domestic electricity to reduce our nation's dependence on petroleum, improve air quality and reduce greenhouse gas emissions. We are a registered 501 (c)(3) non-profit since 2008. We currently employ eight staff, including our Executive Director Joel Levin. We help consumers, policy-makers, auto manufacturers and others to understand the powerful benefits of driving electric. We provide practical, objective information to help consumers select the best plug-in vehicle for their lifestyles and needs. Plug In America founded National Drive Electric Week, the world's largest celebration of the plug-in vehicle, which welcomed over 130,000 attendees across 196 events in 2015 (its fifth year), spanning 41 states and 7 Canadian provinces. Our organization has assisted in framing policy at federal and state levels to better incentivize adoption, locate and manage public charging stations and provide consumer education. We have previously worked with Hawaii, California, and Massachusetts to further their vehicle adoption and charging station implementation plans, and we were recently awarded a $500,000 grant (DE-FOA-0001384) from the US Department of Energy to work with Connecticut, Rhode Island, Vermont and Massachusetts to promote and showcase electric vehicles.

Barry Woods has been involved in the electric vehicle industry since 2009, working in a variety of roles, including, counsel to ECOtality on the Oregon Public Utility Commission's EV docket, founding board member of Drive Oregon, manufacturer's representative for ClipperCreek, Inc, a US manufacturer of level one and level two charging stations, Administrator of Central Maine Power's Phase 2 EV Grant Program, co-founder of Drive Electric Maine and principal author of the Massachusetts Drive Clean Workplace Charging Guide. Barry has broad experience in drafting Electric Vehicle related policy and working with a variety of clients (residential, commercial, workplace) to purchase, design and install charging station infrastructure. Most recently he has worked with NissanNA and EVgo to successfully partner with Maine-based Hannaford Brothers/Delhaize supermarket chain in creating Maine's first privately owned DC Fast charge network.

Section II. Response to Information Sought

1) Are the specifications described above sufficient to meet the EV Task Force goals of interoperability, accessibility, and reliability? If not, what changes should be made (e.g., distance between stations, proximity to corridor; choice of DCFC technology)? Should there be minimum requirements in the infrastructure to ensure interoperability?

To get maximum utilization, this network must have all three attributes (interoperability, accessibility and reliability) at its core. There should also be distinctions made in this proposal between interregional mobility goals (long distance travelers and low utilization) and community mobility goals (commuter/local use and high utilization). For locations outside urban areas, where concentrations of drivers are low and private investment in infrastructure will lag, state/public financial commitment will need to be greater. While collecting EV driver payment to cover electricity costs and generate some form of revenue may be a feature of this system depending on the business model, we urge the State to remain open-minded in adapting the business model to match the particular host site. There may be inadequate traffic volume at remote interregional rural locations to create significant revenue from direct electricity sales, but adequate indirect benefits to local businesses to create interest in helping to subsidize the cost of the electricity, for example, by advertising. The core goals of this project can only be met if a viable business model is identified for each host site- and each host site may have different needs.

In addition, besides focusing on the functional attributes necessary for a successful charging corridor, we urge the state to think more broadly about defining success for this project in the context of an early market and a more developed market. The goal of this project should be viewed not only as supporting tourism (which is important for the interregional hosts), but also moving the state away from dependence on fossil fuel and capturing the many social, economic, and environmental benefits associated with electric vehicles. Reinforcing this broader message will assist the state and its partners in marketing this project and attracting additional investment. While tourism is an element of this equation, charging at workplaces, commercial venues, and public charging in (community host sites) are more significant day to day elements of the consumer experience and drive adoption of the technology. These all impact the corridor specifications by directing resources a bit differently. For example, in high use, more populated locations, it would be appropriate to allocate resources toward preparing the host site for expansion of the charging cluster and added electrical service.

To begin our effort we should also undertake an existing inventory of charging resources in the state, focusing on level 2 and DC charging and their locations, existing ownership and operational responsibilities, sources of funding for capital and operating expenses, fee structures for EV charging services and method of collection, and estimate current usage of the existing network. Our efforts should include more exhaustive review of other states with existing DCFC corridors, particularly California, Oregon and Washington. Existing data will help better inform our placement, design and business model. For an example of this type of study see Response to Question 10, Attachment F.

Below are responses to some of the stated specifications:

In remote locations, where connectivity to cellular, wifi or other communications is limited, the challenge will be to make this system function seamlessly notwithstanding telecommunication issues. More rural locations may require technology choices that have limited or no communication with a broader charging network and greater emphasis on reliability. Energy data collection can still occur, even at sites where telecommunication issues arise, if different technology is used. Data collection is important, however, reliability should be considered a primary technology goal for all host locations. These rural sites also must have significant redundancy built in to allow multiple charging opportunities. In the event one station is not operating, drivers must have additional options. This could be initially accomplished by placement of several level 2 chargers as back-up to the DCFC unit(s). Level 2 chargers are cheaper to install and maintain and do not need network connectivity. Placement of two DCFCers in one location may be a solution, however, this creates significant added cost and power outage or other site risks could render both offline at the same time. Accordingly, where appropriate such as rural locations, placement of basic level 2 chargers would help address the reliability issues at minimal upfront and ongoing operational costs.

At minimum all technology choices must be UL listed and, if they have smart charging functionality, use Open Charge Point Protocol ("OCPP") to allow different network providers access to the network in the event that a different operator is needed later.

Adequate cold weather hardiness specifications are particularly important. Some DCFC hardware has experienced heat and cold related performance issues. Choosing a DCFC manufacturer with adequate field testing in outdoor environments, including manufacturer experience operating below zero degrees F is an important attribute of ALL hardware.

All units should have NEMA 4x indoor/outdoor ratings to show adequate testing for heat, cold, and water intrusion has occurred. In select locations, building overhead shelters could be considered as an additional means to protect the equipment and also shield drivers/vehicles from snow, ice and other inclement weather while connecting and disconnecting. Evidence shows that offering protection in particular to DCFC hardware improves its performance and lengthens its lifespan.

The distances between chargers for the proposed route are reasonable, except the segment between Jackman to Bingham. The length of this part of the route can be at the outermost edge of available battery range (49 miles) for most current battery electric vehicles (BEVs) depending on the driving conditions. The variable impacts of weather/outdoor temperature/speed/driving conditions can trim thirty or more percent from the current generation of BEV's battery. For example we would anticipate a possible 30 percent reduction (or more) in range during freezing temperatures such that a typical BEV (like a 2013 Nissan LEAF) using a 24 kWh battery could have 50 miles of range MAXIMUM available. More conservative spacing between DCFC hardware would be appropriate for this leg of the corridor. Alternatively, providing robust presence of level two chargers along this route, while not ideal because of the travel delay, would help to get driver's across this gap; level two chargers provide 20 miles of range in one hour of charge. The harshness of winter conditions in this region suggest drivers should also have access to facilities during charging. We do anticipate the next generation of vehicles to have sufficient battery size to handle this gap with ease. Therefore another threshold question is the degree to which this charging network will be built for current vehicles or be built to anticipate higher range vehicles by incorporating greater distances (and project cost savings) between DCFC units. More robust use of level two chargers along this 50 mile stretch may offer a reasonable compromise to allow current vehicles access to the route, while strategically creating a DCFC system that will operate more efficiently for longer range BEVs as they become available over the next 1-3 years.

Assisting drivers in finding available charging resources is often an underappreciated issue, this is particularly true in urban locations with cluttered visual environments and large multi-level parking garages. Often adequate signage starts miles from the final charging destination. The entire charging corridor should have a distinctive logo and also use standard EV charging signage and charging space designs to make the driver experience consistent along its route.

While the Americans with Disabilities Act does not currently require charging spaces to conform to its design protocols, all charging installations should allow handicapped access and be constructed to be ADA compliant. Usually this requires the site host provide two parking spaces. While ample design information is available, the specifications for ADA compliant installations generally include to:

-Make sure parking space dimensions are consistent with current handicapped parking dimensions;

-Measure the parking slope in both directions. ADA mandates a 2% or less slope in either direction.

-DCFC cannot be installed on a surface that is higher than 8" above finished grade. (Finished grade is defined as the area where the EV driver will be when accessing the charger.)

-Side reach must be 10" or less; ask yourself if a person in a wheelchair can access the DCFC and if parallel to the charger if side reach is limited to 10" or less.

2) Should the Department seek a vendor to oversee the entire project, including selection and installation of system components, or simply provide cost-share for any company installing electric vehicle charging infrastructure along this corridor? Could there be a combination of both options?

A:. Please also note that in our view questions 2, 6 and 7 are interrelated.

While a single vendor might promise a consistent solution, given the variety of host sites along this proposed corridor, a single vendor business model may not be capable of universally addressing the variety of locations/hosts comprising this project. For example, Hannaford Brothers/Delhaize and EVgo currently have partnered on the successful installation and O&M of five DCFC stations located in Southern and Mid-coast Maine. They have expressed an interest in assisting the state by providing additional host sites (Waterville, Skowhegan, Bingham) along the proposed Route 201 corridor. Given their experience with the technology and desire to build upon their existing network, the state should consider the advantages of collaborating with them for these locations rather than choosing a new network provider to oversee the entire project. Hannaford Brother's offer to provide a suitable host site at these locations overcomes a significant obstacle many electric corridor projects encounter- finding, educating and negotiating with multiple hosts while dealing with a variety of property ownership dynamics.

Charging infrastructure along this route includes both level two chargers paired with DCFC hardware as well as installations of level two chargers by other commercial entities to attract drivers along the route. A cost-share arrangement for level two chargers, rather than DCFCers, seems like a more successful strategy to enhance charging opportunities along this route given their competitive pricing and lower O&M costs. Getting private partners to assume a large share of the burden of the DCFC costs is less likely and financing needs to be approached differently.

The initial hardware cost and installation will be hefty; the ongoing O&M will be less so, particularly as revenue from charging events increases. The likely candidates to cost share in DCFC'ers include the utilities, state agencies, charging network providers and Original Equipment Manufacturers ("OEMs") like automakers, who all stand to receive direct benefits by driving vehicle purchasing and electricity consumption.

Indeed a core issue which must be addressed is what type of business model (public/private or a combination) should be involved in installation, operation and maintenance of some or all of the host sites. The success of this project depends upon its future physical and fiscal maintenance and capacity to create direct and indirect revenue to pay for this. There also should be a fallback or succession plan in the event that the existing private owner of the network fails to meet their obligations. There are currently many projects being undertaken nationally but there has not yet emerged a definitive model. As but one example of financing models, Tesla has created a supercharger network to promote its vehicle sales by providing free charging to its customers; this is essentially a marketing program now being copied by Nissan and BMW nationwide, including in Maine.

The viability of a private business model depends on usage frequency for a particular host site; as discussed earlier DCFC host sites can be distinguished as urban stations (community mobility) v. en route stations (interregional mobility). It is doubtful that at this early stage of deployment usage will capable of supporting the costs of operation and maintenance (O&M), even in host sites located in the more concentrated Maine population centers. Rural locations or en route stations, which are a critical linchpin for the success of this project, will likely not have significant use during this early technology deployment phase. Even when EV concentrations increase, winter usage on some of these routes (Jackman and Route 201) will likely never be substantial. Getting private investment to cover hardware, installation, and O&M, even through cost sharing, will be very problematic for those remote locations. Accordingly the ownership model should be flexible depending on the host site location, with greater financial responsibility falling to the state for rural locations and to private ownership for more populous ones. The worst case scenario would be to enlist a private provider to handle the entire network only to have them go bankrupt and jettison responsibility (e.g. ECOtality).

One economic study performed by the Center for Climate and Energy Solutions ("C2ES") of the financing of public charging stations done for the state of Washington in 2014 determined that business models based solely on direct revenues from EV charging services are not currently feasible. See Response to Question 10, Attachment D. Washington had 9000 registered EV drivers at the time. In order to finance public charging networks, given the high up front cost and low initial usage, more private investment that captured those receiving indirect benefits was necessary. The biggest benefit from this project, given the low current state of deployment, is in the form of indirect benefits to governments, utilities, retailers, workplaces and OEMs, and these diverse beneficiaries should all be expected to assist in financing deployment. They should assist in financing the upfront cost of hardware and share a portion of the indirect revenue from EV charging use with the EVSE owner/operator. Indirect benefits include, sale of products and services at businesses located near chargers, increased tourism business, employee engagement and retention, increased sales of EVs, sales of advertising at EV stations, and clean energy marketing and brand-strengthening opportunities. In fact, the study concluded that it would likely take a combination of public sector interventions, such as low interest loans, grants, and proactive EV adoption policy, in order to make business models viable in the near term.

With respect to C2ES's approach, they first identified three basic "private" business models for funding EV DCFC highway:

1. Business Model 1: Large Business Funding Partners for Charging Network Development along Major Roadways (Appears to be working quite well on a nationwide basis for Tesla Motors and more hit and miss at Nissan, Kia and Mitsubishi dealerships at least in the Pacific NW.)

2. Business Model 2: Local Business Funding Pools for Charging Networks that Enable EV Travel to Tourism Destinations (To a significant extent, this model worked with public assistance for the DCFC portion of the Stevens Pass Scenic EV Highway network [Seattle -- Wenatchee: the Apple Capital of the World] resulting numerous local businesses making additional investments in Level 2 EVSEs [Primarily Sun Country] in support of eco-friendly EV Tourism.)

3. Business Model 3: Large Funding Partner and Local Business Funding Pools for Charging Networks that Enable EV Travel to Tourism and Employment Regions

C2ES's conclusion was that "[u]nder current market conditions, the three (private) business models analyzed in Chapter 2 are not financially viable without public interventions if the owner-operator requires a payback of five years or less."

The consultant's creative financing approach to the problem was to add public intervention to the equation.

Washington EV advocate legislators armed with C2ES's study were able to pass a bill which preloaded a $1 million into a new, dedicated EV Charging Infrastructure Bank, albeit, to be paid back by a new $50 annual fee in addition to the existing $100 EV annual license renewal fee already being paid by EV owners when renewing their EV registrations each year. The Infrastructure Bank is being administered by the WA DOT's office of Public/Private Partnerships (3P) which is in the process of completing the required rulemaking and currently has plans to develop criteria and grant applications prior to requesting project proposals during the fall.

The bottom line is that we need to wait and see if this WA model for funding an EV DCFC network is feasible.

The difficulty of solving the financing for DCFC stations is particularly clear. Several states (notably California) have utility proposals (PG&E, SoCalEd, San Diego Gas & Electric) pending before their Public Utilities Commissions designed to facilitate utility investment in hardware ownership through rate basing these costs- including the costs of purchase and installation of hardware and the cost of operation and maintenance subcontracted out to a network provider.

Utilities ought to have a role in early deployment of charging infrastructure given their knowledge of their distribution system and grid impacts, their ability to analyze long term benefits to their ratepayers and ability to leverage smart grid investments to address transportation's growth as a new form of electrical load. We urge Maine's utilities to look at emerging national public utility regulatory trends designed to hasten adoption of electric vehicles and initiate a policy debate and analysis surrounding the cost/benefit of electrifying Maine's transportation system.

3) What should the Department and Task Force take into consideration when determining individual sites (e.g., cost, ownership, visibility, accessibility)? Should this initiative try to leverage potential hosts to purchase electric vehicles for use by their organization or others? Should that be a factor in the evaluation between competing host sites?

Host sites are a critical element to this project's success. From a driver's perspective, the more a host site fits within typical driving experience, the better. Distances between stops are often dictated by food and restroom needs as much as battery state of charge! Any charger needs to be co-located with some form of amenity and be close to the intended travel route (preferably within a mile). Any charger placement should be visible in the parking lot from the road, dedicated to plug in vehicle use and be open to public access at all hours. There also should be policies that prevent price gouging of EV drivers for their cost of electricity; pricing for charging events must be competitive and consistent throughout the route.

Site selection criteria could include:

a) Creation of a viable business plan that works for the host and/or community;
    a. Will site host/community provide any financial contribution toward the hardware and installation?
    b. Will site host/community provide any financial support for ongoing O&M?
b) Proximity/visibility to major travel corridor(s)- the closer the better;
c) Accessibility to amenities that can be used while charging (food, bathroom, wifi, shopping);
d) Single owner sites (where business and property owner are the same) help minimize lease issues and site related negotiation;
e) Availability of three-phase power and utility service levels to insure adequate electric service for expansion;
f) Analysis of utility demand charge applicability;
g) Proximity of utility transformer to proposed charging space;
h) Willingness to provided dedicated charging spaces with appropriate signage and striping to prevent use by other vehicles and adequate room for physical expansion of charging spaces; and
i) Overhead lighting/safety of site location at night and in poor weather.

The delay and complexity of host site agreements and expectations make identifying suitable host sites daunting. How long a lease will the host site owner be expected to sign? Five years? Ten years? Who bears the cost of removal? Will the lease be conditioned on the site having room for expansion? Who will own, operate and manage the site? Will there be a charging revenue sharing element? We are unaware of any current criteria that provides site selection advantages to hosts who purchase EVs for their fleets, although such enthusiasm toward adoption should be rewarded.

4) What should be the minimum/ideal technological specifications, such as DCFC, level 2, or both; number of chargers per station; reliability and speed of technology?

Interoperability, accessibility and reliability are critical qualities for DCFC installations. Given the lack of a standard connector, all DCFC hardware must incorporate a dual connector standard, which means each unit should have both a CHAdeMo and SAE Combo connector. Unlike many charging scenarios (workplace/home/fleet), DC Fast Charging addresses the critical fueling need of long range EV driver; it is necessity charging. If the station is down, the trip is aborted and the reputation of the network is immediately challenged. Disrupting travel plans defeats a key purpose of the link between Maine and Quebec. Therefore, especially for more remote locations, monitoring of functionality and the availability of the DCFC to charge is critical. Currently, 50 kW DCFC are the norm. However OEMs are already discussing deployment of even larger electrical resources for DC fast charging, with 200kW or greater becoming available. While the State should consider whether to anticipate addressing these higher voltages in its planning, from a safety and reliability standpoint, it should require hardware that has undergone UL listing or its equivalent. It could consider providing additional investment in larger conduit size to anticipate larger electrical service and expansion of the number of chargers for specific locations. Any planning effort is well advised to consider how to deal with rapidly changing technology landscape, including longer range vehicles coupled with the need for more powerful charging infrastructure.

We recommend ANY DCFC be paired with one or more higher amperage level two chargers. Level two chargers are economical, reliable and compatible with ALL current plug in electric vehicle types. As the demand for DC Fast Charging grows, and vehicles who arrive at a charging destination find the resource occupied, their ability to immediately connect with a level two while they wait for the DCFC to become open will speed the charging process generally and help limit driver frustration. It will also provide an opportunity for drivers to leave their vehicles and take advantage of the host site’s amenities.

While 40A level two units are reasonable, we suggest that the state consider having 100A level two units installed to provide charging up to 20kW s. Current BEV vehicles charge between 6.6 kW and 20kW, with continued faster charging capabilities for newer models a near certainty. Providing faster level two chargers is cost-effective and will help future proof these sites for the next generation vehicles. All vehicles use the level two standard connector and so these chargers are highly interoperable and reliable.

5) What are the pros and cons of the various hardware options and operational/maintenance models and technologies?

As with most products, the tradeoff with enhanced functionality is greater hardware and O&M related costs.

The use of DCFC'ers necessarily involves purchase of a smart charger that is part of a larger network. Level two chargers, alternatively, may or may not need to be part of a larger network or have enhanced functionality. Investment in DCFC'ers will require resources for ongoing operation and maintenance, both remotely and in the field. Drivers experiencing trouble must be able to connect with a live human being via phone to report and address issues so there must be adequate back office support.

Any network provider should provide regular inspections of the units, preventative maintenance, corrective maintenance, and software maintenance. These elements should all be part of a regular maintenance schedule to ensure each site's function and cleanliness. Adequate hardware warranties should be provided. DCFC hardware should have the capability of communicating service related issues and whether they are accessible to drivers.

Level two chargers offer more choice in terms of options and costs, and while they can have networked communication capability, the extra O&M cost burden is significant. Level two chargers can also be accessorized economically based on the the unique attributes and functional needs of their respective host. For example, they can have non-networked energy data collection sub-meter added, simple access or activation control through mechanical (key switch) or other means, and even load regulation that allows them to work with limited amperage/circuits to maximize charging of one or more vehicles. One size need not fit all host sites.

Other options to consider, given the Maine climate, include connector holsters to keep the connector away from vehicle tires, ruggedized commercial grade features for the connector and cord itself, and availability of 25 foot cord set lengths to allow a single charging station to service multiple charging spaces. Stainless steel pedestals also provide durability where snow removal and salt treatments are common. The state should consider the advantages of placing more reliable, less costly level two units in rural locations where usage will be low and reliability needs are high.

6) What are the various ownership models being used in other locations, and what are the pros and cons of each?

Please also see our earlier response to question 2 with respect to DCFC business models.

For examples of various smart charger network ownership models, EVgo, Aerovironment, Chargepoint, Car Charging Group (f/k/a ECOtality) offer broad perspectives on these types of larger scale charging corridors. Most offer some form of subscriber-fee and credit card payment system. These network-based charging companies have recently created an non-profit industry trade group called ROEV ("Roaming for EV Charging"); http://roev.org/. To our knowledge, none of them have yet created a viable, long-term revenue stream solely from DCFC. The cost of DCFC far exceeds that of any other form of charging infrastructure and its revenue projections are speculative at this stage of market deployment, making them challenging to finance. This is why Maine must act cautiously in constructing a public and privately financed arrangement with an eye toward the overcoming the financial challenges of early market deployment. To the extent that it relies solely on one outside provider, the state is at risk of having the charging corridor succumb to these financial challenges.

Many alternative models exist for shared financing for level two chargers, however. Level two chargers are much less expensive to purchase, install and maintain.

Examples of existing models for publicly placed level two chargers include:

Municipal ownership- several communities in Maine operate level two chargers by providing free public charging to their staff and public. They have paid for charger hardware, installation and O&M themselves (e.g. South Portland) or procured financing through grants (e.g. Falmouth). These allow municipalities to charge their own fleets as well as provide a public service. The drawbacks include sometimes less than optimal placement (hidden, remote parking locations) and taxpayers pay for electricity consumption until a different model emerges.

California's Adopt-A-Charger Program model provides grant based hardware purchase and installation for level two chargers followed by procuring local sponsorship to cover O&M for 3 year periods. This might work well for level two in rural locations, however it requires buy in from local businesses or sponsorship in order to maintain the chargers for sufficiently long periods. See Question 10 Response- Attachment F.

Private ownership/Advertising Income model- Volta charger provides level two charging using an advertising promotion business model at large urban parking locations. This models requires frequency of use at a level not yet common in Maine. http://voltacharging.com

Iron Ranger- Many state parks use the "Iron Ranger" model where drivers voluntarily place money in a pay envelope and tear off a paid for parking notice which is placed on the dashboard. This model can be adapted to charger use and cover electricity cost without significant staffing overhead. The honor system can, however, be abused.

Bathroom Key Model- Level two chargers can be equipped with a physical key for activation, such that a host site who purchase the hardware and installs it can recoup some of this capital expense and electricity consumption costs by requiring a modest fee for use of the key. This is a low tech payment system that fits many situations and allows control by owner- but it also requires someone to be present to give out the key.

7) Are there organizations/municipalities/businesses who would be interested in partnering with the state on this project? What might that partnership look like? Examples include, but are not limited to, additional infrastructure at charging locations; promotion of corridor; ongoing operations and maintenance; private or municipal ownership once completed. The form of local participation may be the subject of a future RFP.

There are a number of allies that the state should seek to partner with including existing charging station host sites and networks, which include many local cities and towns! In particular, the State should continue to engage with Drive Electric Maine to assist in partnering on this project. Drive Electric Maine is an informal consortium of public/private stakeholders that convenes regularly and can provide resources to develop further interest in EVs and charging infrastructure with complementary trade groups and businesses. A key element of Drive Electric Maine is to generate impactful projects to drive increased EV-related economic development for Maine's tourism sector and businesses. Members include Greater Portland Council of Governments, Clean Communities, utilities, large employers, Auto Dealers, electrical trades, tourism and hospitality industry members, clean energy companies, state agencies, and environmental groups. These partnerships could contribute financially, provide charging site hosts, assist in marketing, provide media outreach, and present EV-related workshops.

In addition Plug In America often assists states by tailoring programs that create public outreach and education to help the state meet its EV-related goals. We have a sophisticated social media presence that broadcasts state-based activity as well as prowess at getting federal grant and private foundation-based resources. For example, we partnered with the John Merck Fund and the state of Massachusetts to hold a series of ride and drives throughout the state, focusing on large employer workplaces and public universities. This effort has now expanded to Connecticut and Rhode Island.

As stated previously, Maine's investor owned utilities (CMP/Emera Maine) are particularly critical partners for the state to engage. California's Public Utility Commission is currently engaged in decision making to allow utilities (PG&E, San Diego Gas & Electric, and SoCalEdison) to ratebase some of the costs of adding public charging infrastructure within their service territories. The need to accelerate the deployment of charging infrastructure is great and the early market economics have made this transition slower then expected. Electric utilities are uniquely positioned to benefit from the creation of a new source of electric load through existing T & D and leveraging smart grid investments already made. The state should work with utilities to better understand the grid benefits and ratepayer benefits of electrifying transportation and help create suitable utility regulation and policies to take advantage of these benefits.

8) How have other similar projects successfully promoted the existence and use of the facilities once installed?

The are many channels for broadcasting the presence of charging networks. Auto dealers should be provided notice of these resources to assist them in marketing the vehicles. States like Oregon have very engaged Offices of Tourism which create website presence that highlights EV travel and showcases hospitality industry host sites (wineries, hotels, state parks). See http://industry.traveloregon.com/industry-resources/sustainable-tourism-development/sustainable-transportation-development/electric-vehicles/

The online and phone-based app PlugShare keeps an updated tally of all public charging resources and most EV drivers use this as a source of information when traveling and looking for chargers.

The Alternative Fuels Data Center also provides a real-time map of charging infrastructure nationwide. See http://www.afdc.energy.gov/fuels/electricity.html

State and local politicians have taken extended roadtrips with the media to highlight the construction of these travel corridors (E.g. Senator Jeff Merkely, D-OR, traveled the length of the state using the West Coast Electric Highway). See http://www.gazettetimes.com/news/local/merkley-trip-touts-electric-cars/article_bb5cfc3e-c4af-11e1-833d-001a4bcf887a.html

9) Should data on the usage of the future charging infrastructure be collected? Are there privacy concerns related to the collection of data?

Data informs us about use and accuracy of assessing host site placement, the need for expansion of charging, the viability of the existing business model and, most importantly, whether service or maintenance is needed. Data therefore contributes not only to the state's ongoing experience about its charging network usage but also helps inform future planning as this technology continues to grow. Hosts should be educated about the utilization of their charging resources and its impact on their business as way of validating their decision. Data can be shared with educational and research institutions to help reach broader conclusions about behavior and electrified transportation. To date we are not aware of any privacy-based concerns relating to public charging and data collection derived from usage.

10) Please provide any additional information that may guide optimal design, purchase, installation, operation, maintenance, and ultimate use of the facilities.

This plan should be integrated or otherwise mesh with additional corridor planning and construction. We urge the state to create other DCFC'er routes to help grow tourism and local charging resources, including constructing corridors to the western mountains (Bethel- Route 26) and to Acadia National Park (Bangor-Bar Harbor). The state should move quickly to label these as alternative fuel corridors in accordance with Section 151 of the Fixing America's Surface Transportation (FAST) Act, 23 U.S.C. s. 151, which calls for state designation of electric vehicle charging corridors by December 2016.

To assist the state's consideration of this project and provide an overview of lessons learned from other DCFC and infrastructure projects, please see the following Attachments:

Attachment A- Expanding the Fast Charging Network, Jeff Allen, Executive Director of Drive Oregon, June, 2016.

Attachment B- DC Fast Charger Usage in the Pacific Northwest, Idaho National Laboratory, February 2015.

Attachment C- Sacramento Municipal Utility District DC Fast Charging Deployment Status and Lessons Learned, Bill Boyce, April 25, 2016.

EVS29 Symposium
Montréal, Québec, Canada, June 19-22, 2016

Expanding the Fast Charging Network

Jeff Allen

Executive Director at Drive Oregon, 1732 NW Quimby Street, Suite 240

Portland, OR 97209 USA, jeff.allen@driveoregon.org

Oregon has more DC Fast Chargers (DCFC) for electric vehicles per capita than any other US region. This network has played a major role in making Oregon one of the strongest markets for electric vehicle sales in the US, despite the lack of a state purchase incentive. This paper summarizes Oregon's experience with fast charging, evaluates the impact of this network, proposes new ways of defining network "success," and makes recommendations for cost effectively expanding the network. These findings and recommendations should help inform other regions that are just beginning to build out their fast charging networks.

Keywords: fast charge, infrastructure, state government, policy, United States of America

---

1 Fast Charging in Oregon

Interstate 5 is the major freeway connection running over 2,000 km from the U.S. border with Canada, through Washington, Oregon, and California, to the U.S. border with Mexico. Oregon officials, working with other west coast jurisdictions through the Pacific Coast Collaborative[1], originally conceived the idea of the "West Coast Green Highway" (WCEH) stretching from Baja California to British Columbia as early as the 1990s, and focused specifically on the WCEH shortly after 2010. With creative use of recovery act funding and a USDOT TIGER grant, Oregon completed its portion by Summer 2015. The WCEH today is an extensive network of DC fast charging stations located every 40 to 80 km along Interstate 5 and other major roadways in the Pacific Northwest.[2] These stations have also been branded with a common logo and "look and feel," providing greater visibility and driver confidence. (See Figure 1.)

Figure 1. Author using a West Coast Electric Highway charger

As outlined in Figure 2, this network now covers most of the region's major transportation corridors. California recently provided funding for installations between Ashland, Oregon and Sacramento, which will close the last gap in this charging corridor.[3]

Figure 2. West Coast Electric Highway Map

Oregon was also a participant in the EV Project, and the major Willamette Valley cities of Portland, Salem, Corvallis, and Eugene were all included (See Figure 3 below.) The Idaho National Laboratory has developed extensive fact sheets, technical reports, and presentations summarizing the results of this project.[4] After the bankruptcy of Ecotality, Car Charging Group now operates the charging stations built through the Project.[5]

Figure 3. EV Project Locations[6]

Oregon has also been a leader in providing fast charging in the urban core via its "Electric Avenue" project. Electric Avenue was launched in 2011 as a test bed for vehicle charging equipment. Electric Avenue solicited charging equipment from several different companies and placed it side by side to evaluate its technical characteristics, its reliability in use, and the consumer experience of charging. This deployment yielded many lessons about technology and the user experience, which have been summarized elsewhere.[7] This charging oasis had to be relocated due to construction at Portland State University, and was re-created at Portland General Electric's downtown Portland headquarters in 2015. (See Figure 4)

Figure 4. Electric Avenue "2.0" in Downtown Portland

As a result of these coordinated efforts, Oregon now has the most robust state-wide network of DC Fast Chargers in the nation, with about 120 stations in operation and more being added monthly, to serve a population of 4 million and a fleet of over 9,000 electric cars. This network now covers most of the region's major transportation corridors.

2 Defining "Success"

Measuring "success" in building the DCFC network is not simple.[8] Some analysts have focused on the number of charging sessions per day or per week. By that measure, very few fast charging locations are "successful" or profitable so far – which has prompted many negative media stories about money that was "wasted" building out charging stations. However, this is a grossly simplistic measure of success, akin to measuring the 'success' of your house's wiring by measuring how often you had something plugged into each outlet. The truth is you want an outlet conveniently located wherever you may need it, even if you don't use it very often. The same is true with a vehicle charging network. Ultimately, the number of uses per day will be one significant financial driver – but it's grossly inadequate as the sole or primary measure of success, particularly in these early years of the market.

One key measure of success is access: simply put, the degree to which drivers can travel the state, going about their regular business, without worrying about their ability to charge. This is the rationale that leads public agencies to provide rest areas, street lighting, sidewalks, electricity to rural homes, and other basic infrastructure. This was the approach taken in Oregon: create enough "stepping stones" so that EV drivers could travel major corridors and reach popular travel destinations around the state.[9] Many locations are absolutely necessary to get to popular destinations, such as the coast, but are unlikely to have heavy use for many years. Oregonians can now readily travel by electric vehicle to the coast, between our major cities, and to many popular destinations. In fact, Oregon has built on this network to develop one of the world's first and largest EV Tourism programs, including the first fast charger at a ski resort[10], statewide Electric Byways[11], and a "Plug In and Pinot" wine country tour.[12]

Another measure of success is whether the DCFC network provides a foundation of consumer confidence that drives increasing sales of electric vehicles and an increasing number of electric vehicle miles travelled (e-VMT.) Oregon has committed to accelerate sales of electric vehicles by opting in to the Zero Emission Vehicle (ZEV) mandate, and has also joined the International ZEV Alliance, committing to a goal that all new cars sold in Oregon will be electric by 2050. Oregon must get from just over 9,000 registered electric vehicles today to about 130,000 cars by 2025 to meet the ZEV mandate; to meet its global warming goals it must reach 300,000 cars by 2020 and over 1.5 million electric cars by 2050. Since Oregon only sells about

130,000 new cars per year, these goals require sales ramping up to between 15% and 50% of new car sales very quickly. This creates a responsibility for the state to also ensure the fundamental conditions that encourage and support electric vehicle sales and use. Evidence from the EV project does suggest that DCFC does lead to more e-VMT, and anecdotal evidence certainly suggests that ready availability of DCFC increases drivers' confidence and willingness to buy electric vehicles. However, this is an area that is also ripe for further quantitative research.

Third, and lastly, should come charging usage. Ultimately, if DCFC is going to pay for itself through fees for the use of chargers there must be enough charging activity to provide a financial return to the system operator. While there are many variables, one rough 'rule of thumb' is that a DCFC needs to be used at least 10 times per day to break even. The chargers on Oregon's West Coast Electric Highway are used far less often – from a high of ~5 uses per day to a low of ~1 use per month in some locations and some months.[13] While chargers on Portland's Electric Avenue downtown are more heavily used, they are currently free of charge, which makes direct comparisons difficult. Overall, it is not at all clear that DCFC can, or should, pay for themselves simply through usage fees in the next few years.

3 Next Steps for Oregon

Although Oregon has an extremely robust fast charging network compared to other regions, we believe it will need to be dramatically expanded to support the state's goals for electric vehicle deployment over the coming years. Stakeholders in Oregon recommend the following specific next steps in expanding and improving the DCFC network.

3.1 Densify the network in metro areas

Drivers don't just use DCFC for long trips between cities. They use this equipment to travel across metropolitan areas in a single day, as a "safety net" for unexpected trips during the day, and as an option for drivers without home garages or workplace charging. These chargers should installed in highly visible groupings with multiple DCFC and L2 chargers, modelled on Portland's Electric Avenue project, to maximize marketing value and minimize the waiting time for drivers queuing to use stations.

3.2 Add SAE combo to key corridors

When the WCEH was constructed, only CHAdeMO vehicles were available. Now that increasing numbers of manufacturers are selling vehicles with SAE Combo DCFC capability, we should ensure that they can also travel freely. Ideally, these should be new chargers co-located with existing WCEH chargers, in order to also help alleviate congestion issues.

3.3 Ensure that key destinations outside metro areas are within reach

Experience shows that drivers are not simply using electric cars as urban runabouts. They want to be able to drive on electricity to the coast, to the mountains, etc. Some of these routes have long stretches where three-phase power is not available. Battery backup systems or single phase DCFC will be needed in these locations, possibly increasing installation costs. These locations will also be the least likely to "pencil" based strictly on usage payments – but just as we extended electricity to rural homes to create universal access, we need to move toward ensuring universal access for EV drivers as well.

4 Lessons Learned and Recommendations

Based on Oregon's experience as an early test bed for fast charging technology, we believe a number of clear lessons have emerged that can help other regions now looking to develop and expand fast charging corridors and networks. These recommendations are targeted especially at public policy makers and planners, but we hope they are also helpful to private network developers and automotive planners as well. Private companies may place DCFC where they wish, but for the public to put time, effort, and scarce resources into providing DCFC, we need to be as efficient and strategic as possible. It's important to note that this paper sets aside the rather unique, vertically integrated Tesla Supercharger network.

4.1 Fast Charging Corridors are Great Marketing

As Oregon has seen, installing an initial “backbone” of DCFC along key travel corridors can generate positive media stories, and send a strong message to drivers that “you can drive all the way across the state in your electric car.” This kind of messaging helps inspire driver confidence and sales. In this regard, Section 1413 of the FAST ACT, which requires designation of Alternative Fuel corridors along major highways by December 2016, is very constructive.[14] Investments by major automakers to help build out fast charging corridors, such as the partnership between BMW, VW, and ChargePoint, are also very helpful.[15]

However, in practice and with current vehicle technology, only exceptionally dedicated drivers are going to make trips of over 150 km by electric vehicle. Rather, drivers will tend to make slightly longer trips, using one or two fast chargers to enable an “out and back” trip or a slightly longer journey. Drivers should be able to access key destinations by electric vehicle, but planners and policymakers should not be drawn into thinking of long distance DCFC corridors too literally. With the emergence of 300+ km cars like the Chevy Bolt, and faster DCFC protocols, longer trips should certainly become more common and feasible – but for now, trips of 100-150 km are going to be much more common.

4.2 However: Focus First Where the Drivers Are

All electric vehicle drivers benefit from fast charging, not just those contemplating long trips between cities. Drivers use this equipment to travel across large metropolitan areas in a single day, as a “safety net” for unexpected trips during the day, and as an option for “garage orphans” without home or workplace charging options. In fact, some drivers simply prefer the certainty and convenience of fast charging even when level 2 charging is also widely available. Planners should ensure that fast charging is readily available where electric vehicles and their drivers are already located, and where sales are expected to be highest in the next few years.

These chargers should be installed in extremely high visibility locations to maximize their marketing value. They should also be placed where drivers have easy access – in urban areas, ideally in the public right of way or on the street level. Nearby amenities are helpful, though in practice, many drivers are likely to check email or talk on the phone, remaining in their car for 20 minutes while charging. Furthermore, as noted below, these chargers should be installed in pods or hubs with multiple DCFC and L2 chargers to increase visibility and usability.

For this reason, too, even when corridor chargers are being installed, they should generally not be located directly on the highway or in a “rest area” model. They certainly need to be fairly close to the highway, but they should also be located where regional drivers can readily access them, and where amenities (snacks, bathrooms, Wi-Fi, etc.) are readily available. This will maximize their value as both “corridor” chargers and “regional” chargers, maximize their use, and help ensure that they maximize both revenue generation and electric vehicle sales.

Rest areas on Oregon’s freeways give away free coffee to motorists – but only those who are truly in need will stop to take advantage of the offer. By contrast, Oregonians will line up to pay for coffee at one of our “destination roasters.” By the same token, fast charging installations should strive to be preferred destinations and charging locations of choice – not chargers of last resort for the desperate.

4.3 Fast Chargers Must be Completely Reliable

Wherever they are located, fast chargers are critical infrastructure for electric vehicle drivers – much like gas stations are in remote rural communities. Fast chargers must be exceptionally reliable, and should measure downtime in terms of minutes per year, rather than days – similar to utility reliability measures. This is a significant challenge for public infrastructure with substantial electronics. After some initial hiccups, currently available fast chargers seem to be up to the challenge – but as pressure grows for these machines to get cheaper and faster, we need to be vigilant to insure they remain reliable as well.

Beyond engineering reliability, however, fast charging installations should also be resistant to business troubles or the vagaries of site hosts. Oregon experienced a major scare when Ecotality declared bankruptcy. If its Blink fast chargers had gone ‘dark’ the state’s electric vehicle drivers would have been in serious trouble. Similarly, the current fast charging network in Oregon relies heavily on AeroVironment, the company that installed the West Coast Electric Highway and operates it under contract. When that contract ends in a few years, it is not clear what may become of this network. One of the best ways to make the system more resilient is to require or incentivize systems that do not rely on proprietary software networks, but rather use open source software and communications such as the Open Charge Point Protocol.[16] This will help ensure that a new operator can step in to operate a charging network, and that site hosts can switch network providers, without having to replace expensive hardware.

4.4 Install Chargers in "Pods"

Because Oregon was operating with a very constrained budget, and wanted to create as long a corridor as possible, the state initially installed just one charger at each location. However, this means that if the fast charger is down for some reason, there is limited backup (although each location also has a Level 2 charger, this is a poor substitute for a driver on a schedule.) Furthermore, as some charging locations become more popular, having just one charger inevitably leads to queuing problems and waits. Basic queuing theory suggests that having two or three chargers will dramatically reduce the likelihood of a driver having to wait. Therefore, chargers should be installed in larger clusters or "pods" wherever possible.

Another reason for the "pod" approach to charging has become clear at Electric Avenue. Electric Avenue hosts four dual standard DC fast chargers as well as two level 2 chargers in a highly visible on street location. Electric Avenue has emerged as a major magnet for public charging, as drivers know they are always likely to find an open fast charger. It has also become a major focus for broader electric vehicle activity, from meetings of the Oregon Electric Vehicle Association of drivers and enthusiasts to launches of new car models. This approach will also help facilitate use of electric vehicles in car-sharing systems, such as BMW's ReachNow service, by providing an easy place to drop off and rent vehicles. Just as Portland's food cart pods have become popular destinations for diners, fast charging pods will become popular destinations for EV drivers.

While this "pod" approach is ideal from a driver's point of view, demand charges (discussed below) and other factors can be barriers. If it is only possible to install a single DCFC, planners should at least aim to include a secondary Level 2 charger.

4.5 Deal With Demand Charges

Utilities impose demand charges based on the peak power used during a billing cycle, regardless of how much energy is drawn at that rate. These charges are triggered by maximum power draw, not total energy use, and are not cumulative. They are designed in part to allocate system upgrade costs to specific high-power energy uses.

As many other authors have noted, utility demand charges can be a major barrier to widespread fast charging availability.[17] The West Coast Electric Highway, for example, includes chargers in 21 different utility service territories in Oregon and Washington. Demand charges at these virtually identical installations range from zero to over $350 monthly, or from zero to over $7/kW, leading to effective costs per kWh dispensed ranging from 5 cents all the way to 33 cents. Demand charges in other utility service territories around the country can be much, much higher, and can constitute 80-90% of a location's power bill.[18] Obviously, demand charges have a much larger impact at installations that are used only infrequently. If a fast charger is only used a few times per day – or per month – demand charges are virtually impossible to recover from drivers. At least one fast charger in Oregon has been "cranked down" to 30 kW to avoid demand charges, resulting in reduced service to drivers.

There are a number of strategies to address demand charges for fast chargers. Some utilities simply waive them as a matter of policy. Others, such as Portland General Electric, offer a slightly higher time of use rate for chargers that waives fixed demand charges.[19] Adding energy storage to buffer the initial power draw, or using smart energy management software, can also reduce peak loads. Whatever combination of technology, policy, and pricing strategy is used, however, it is important that planners address this issue early and directly - before widespread fast charging is installed.

4.6 Make Chargers Dual Standard

The West Coast Electric Highway was originally built only with CHAdeMO chargers, because only CHAdeMO vehicles were available. Now that increasing numbers of manufacturers are selling vehicles with SAE Combo DCFC capability, Oregon needs to overlay the network with SAE chargers. Other regions should ensure that fast charging installations are always dual-standard from the beginning (with the possible exceptions of automotive dealerships or similarly proprietary locations.) Several manufacturers make single units with dual cords, which lowers the cost of dual-standard charging even further. In locations, such as Oregon, where CHAdeMO chargers are working well, it may be best to add a second charging unit with SAE or dual cord sets to also reduce congestion. The availability of converters also makes these stations available to Tesla drivers as well.

4.7 Cooperate and Co-locate

Increasingly, the greatest expense to installing DCFC is not the charging unit itself, but the power and installation costs. Planners should work closely with utilities to select suitable locations that also have nearby power, but co-location of chargers can also dramatically lower costs. For example, at least one site in Oregon houses both Tesla Superchargers and a West Coast Electric Highway charging installation. Coordination, co-location, and pooling of resources from multiple sources (vehicle OEMs, EVSE providers, site hosts, government agencies, etc.) will dramatically lower costs. Cooperation and co-location also improves the driver experience, making chargers easier to find and increasing the likelihood of finding and open charging unit.

4.8 Ensure an Excellent Driver Experience

Fast charging should be an easy, pleasant, convenient experience that gives drivers confidence to make longer trips and drive more electric miles. The first step in this process is ensuring that DCFC stations are easy to locate. As part of Oregon's work on the West Coast Electric Highway, Oregon developed consistent signage to direct drivers to EV charging stations along the freeway and placed these signs alongside existing "gas-food-lodging" signage. This signage (Figure 5) has since been granted interim approval by the Federal Highway Administration for nationwide use.[20]

Figure 5. EV charging sign

Most EV drivers find charging stations using in-vehicle telematics or software applications such as Plugshare, Blink, or ChargePoint. However, highly visible freeway signage serves the dual purpose of helping EV drivers while also sending a marketing message to potential future EV drivers.

Once off the freeway at the charger, there needs to be an easy way for drivers to use the charger without having to carry a proprietary key fob or card. Again, these systems are being rapidly developed. Over time, we look forward to these systems being expanded and upgraded with features like the ability to reserve charging sessions.

4.9 Develop Creative Solutions for Remote Locations

Much of the United States, particularly in rural areas, does not have 480-volt 3-Phase power installed, creating a need for fast charging solutions that do not require it. At least one company, EV4 Oregon, currently provides a battery-driven fast charger that meets this need[21], and other products with integrated storage are in development. Another potential solution in some applications could be a slightly slower (25 kW or less) fast charger.

4.10 Plan for More and Faster Charging

Drivers are impatient, and are accustomed to instant gratification. Drivers will continue to push for a faster charging experience – and even as vehicle batteries get larger, and vehicles get greater ranges, drivers will be reluctant to wait beyond the 20-30 minutes they are currently waiting to charge. Therefore, planners should expect that overall demand for fast charging will continue to increase significantly, and that "fast" will need to get faster. Audi has already announced plans for a nationwide 150 kW fast charging network by 2018[22], and CHAdeMO has announced plans to roll out 150 kW fast chargers by 2017.[23] The future is likely to include a lot more fast charging – at a much higher level – for many years to come.

References

[1] Pacific Coast Collaborative, http://www.pacificcoastcollaborative.org/Pages/Welcome.aspx, accessed on 2016-06-13.
[2] Washington State DOT, 2014, http://www.westcoastgreenhighway.com/electrichighway.htm, accessed on 2016-06-13.
[3] Green Car Reports, http://www.greencarreports.com/news/1102523_west-coast-electric-highway-to-fill-in-california-fast-charging-stations, accessed on 2016-06-13.
[4] Idaho National Labs, 2014, http://avt.inel.gov/evproject.shtml, accessed on 2016-06-13.
[5] Car Charging Group, October 17, 2013, http://www.carcharging.com/about/news/all/carcharging-completes-3-335-million-purchase-of-ecotalitys-blink-assets-and-the-blink-network/, accessed on 2016-06-13.
[6] EV Project, 2014, http://www.theevproject.com/overview.php, accessed on 2016-06-13.
[7] Forbes, March 27, 2013 http://www.forbes.com/sites/justingerdes/2012/03/27/10-ev-charging-lessons-learned-from-portlands-electric-avenue/ and Portland State University, http://www.pdx.edu/electricavenue/sites/www.pdx.edu.electricavenue/files/ElectricAveLessonsV1.pdf , accessed on 2016-06-13.
[8] Oregon DOT, http://public.tableau.com/profile/pk2504#!/vizhome/EVHighwayVersion3/Story1, accessed on 2016-06-13.
[9] Travel Oregon, https://www.youtube.com/watch?v=kmAhczHj0WI, accessed on 2016-06-13.
[10] Travel Oregon, http://industry.traveloregon.com/industry-resources/sustainable-tourism-development/sustainable-transportation-development/electric-vehicles/, accessed on 2016-06-13.
[11] Plug in and Pinot, http://www.plugandpinot.com, accessed on 2016-06-13.
[12] Oregon DOT, http://public.tableau.com/profile/pk2504#!/vizhome/EVHighwayVersion3/Story1, accessed on 2016-06-13.
[13] Federal Highway Administration, http://www.fhwa.dot.gov/environment/climate_change/mitigation/webinars/may_12_2016/presentation.pdf, accessed on 2016-06-13.
[14] Green Car Reports, http://www.greencarreports.com/news/1096446_bmw-vw-and-chargepoint-to-build-100-ccs-fast-charging-sites-for-electric-cars, accessed on 2016-06-13.
[15] Open Charge Alliance, http://www.openchargealliance.org, accessed on 2016-06-13.
[16] Charged, https://chargedevs.com/features/utility-demand-charges-and-electric-vehicle-supply-equipment/, accessed on 2016-06-13.
[17] NYSERDA, https://www.nyserda.ny.gov/-/media/Files/Publications/Research/Transportation/Electricity-Rate-Tariff-Options.pdf, accessed on 2016-06-13.
[18] Edison Electric Institute, http://www.eei.org/resourcesandmedia/magazine/Documents/2013-05-01-LIFTMOVEPUSH.pdf, accessed on 2016-06-13.
[19] FHWA, http://mutcd.fhwa.dot.gov/resources/interim_approval/ia13/, accessed on 2016-06-13.
[20] EV 4 Oregon, http://ev4.website, accessed on 2016-06-13.
[21] Audi, https://www.audiusa.com/newsroom/topics/2015/electric-mobility-audi-e-tron , accessed on 2016-06-13.
[22] Green Car Reports, http://www.greencarreports.com/news/1104346_chademo-dc-fast-charging-to-run-at-up-to-150-kilowatts-starting-in-2017, accessed on 2016-06-13.

Author

Jeff Allen is Executive Director of Drive Oregon, a state-supported initiative to accelerate the growth of Oregon's electric vehicle industry and promote electric mobility. He holds a Master's Degree in Public Policy from the University of California, Berkeley and graduated Phi Beta Kappa from the University of Michigan. Drive Oregon is funded in part with Oregon State Lottery Funds administered by Business Oregon, the state's economic development agency.

DC Fast Charger Usage in the Pacific Northwest

February 2015

Key Conclusions

- The West Coast Electric Highway Project established a network of direct current fast chargers (DCFC) in the states of Oregon and Washington. In addition, The EV Project installed a dozen DCFCs in metropolitan areas throughout the region. Data from these two networks were analyzed to determine how often the DCFCs were used between September 1, 2012, and December 31, 2013. The most highly used DCFCs were located in the Seattle, Washington, metropolitan area. Other highly used DCFCs were found in Portland and Salem, Oregon, and along Interstate 5 (I-5) north from Salem to Vancouver, British Columbia. Usage generally decreased as distance from I-5 increased.
- When Nissan Leafs in The EV Project based in Washington and Oregon used DCFCs located inside Seattle and Portland, they tended to use them during round-trip outings of less than 75 miles. This is less than the range of the Leaf on a single charge.
- Leaf drivers used DCFCs located outside city boundaries to support longer travel, often driving 150 miles or more before returning home. For these drivers, the West Coast Electric Highway successfully enabled significant range extension.

Introduction

The deployment of DCFCs is a major topic of discussion within the electric vehicle (EV) community. DCFCs are a type of electric vehicle supply equipment (EVSE) that charge EVs by providing DC power directly to the EV's battery pack. Generally, DCFCs can charge vehicles at 50 kW or higher (compared to charge rates of 1 to 7 kW when vehicles charge using alternating current Level 1 and Level 2 EVSE), allowing vehicles to be charged quickly. For example, under the right conditions, the Nissan Leaf can charge its battery pack from near full depletion to around 80% state of charge in 30 minutes or less using a DCFC [1]. For this reason, many believe that DCFCs should have a major role in public EV charging infrastructure.

Most EV models currently on the market typically require recharging after driving less than 100 miles. Most EVs offer a driving range sufficient to meet the needs of most drivers most of the time. However, if drivers of these EVs want to take long trips, even infrequently, they need a convenient way to charge during the trip. One concept to overcome EV range limitation is to install DCFCs along transportation corridors to provide EV drivers opportunities to recharge quickly along their journey. This paper describes the use of DCFCs that have been installed for this purpose along major highways in the Pacific Northwest of the United States to determine whether they enable long distance travel in EVs.

What was Studied?

The West Coast Electric Highway Project was launched in 2011 to provide a widespread charging network of AeroVironment brand DCFCs located along highways to enable EV drivers to travel along the western coast of the United States. Also in 2011, The EV Project was launched to install a network of Blink brand EVSE in metropolitan areas of the Pacific Northwest, among other regions. In the states of Washington and Oregon, a total of 56 AeroVironment and 12 Blink DCFCs were installed within 1 mile of Interstate 5 and other highways as a result of these two projects. The DCFC were spaced 25 to 50 miles apart [2].

Idaho National Laboratory received charging data from 45 AeroVironment brand DCFCs and 12 Blink brand DCFCs along highways in Oregon and Washington. These data were analyzed, along with data from 1,063 privately-owned Nissan Leafs enrolled in The EV Project in Oregon and Washington. Analysis determined how often each DCFC was used and how far vehicles were driven on journeys during which they were charged at the DCFCs.

The period of study for this paper was September 1, 2012, through December 31, 2013. During the study period period, the 57 corridor DCFCs reporting data were used 36,846 times by 2,515 distinct EVs. Of the 1,063 Nissan Leafs whose data were analyzed, 319 Leafs were charged at least once using any of the 57 DCFCs in this study. These 319 vehicles performed 3,325 total charging events at these DCFCs during the study period.

All of the DCFCs had CHAdeMO connectors during the study period. Any CHAdeMO-compatible EV could have used these DCFCs, regardless of whether they were participants in The EV Project.

Weekly Usage of DC Fast Chargers on the West Coast Electric Highway

The usage frequency of each DCFC was determined using the data logged by the DCFC themselves. Figure 1 shows a histogram of usage frequency, in terms of the average number of charging events performed at each DCFC per week.

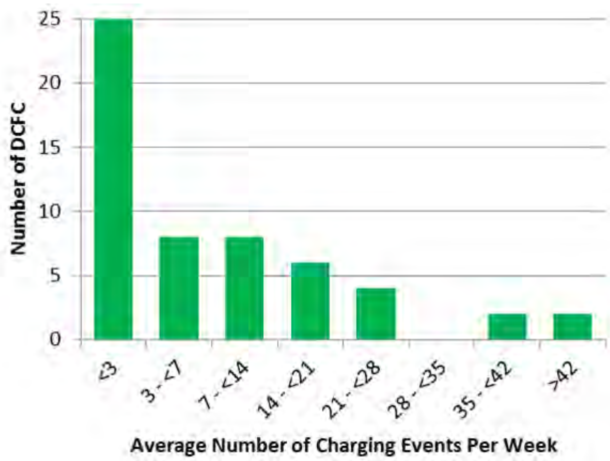


Figure 1. Distribution of usage frequency of DCFCs on the West Coast Electric Highway.

There was a wide range in the usage of DCFCs. The majority were used less than seven times per week, or once per day. However, four were used 35 or more times per week, or 5 or more times per day. A map was created to show how usage frequency varied geographically. This map is shown in Figure 2.

The figure shows a trend in DCFC usage related to its location. Generally, the DCFC that are closer to large cities were used more frequently than those in more sparsely populated areas. The DCFCs directly between the larger cities (i.e., Portland, Seattle, and Vancouver, British Columbia) also had high usage. DCFCs installed farther from large cities, especially to the east and west of I-5 and south of Eugene, were generally used less than 7 times per week. This low usage may not create high value for DCFC owners if they are counting on charger usage to produce revenue or bring in customers to their businesses. However, each individual charge may have been highly valued by the EV driver. It is important to note that the sites of the West Coast Electric Highway DCFC were not necessarily chosen based on projected usage; more important was to allow EV drivers to take longer trips and to raise awareness and visibility of EVs and charging infrastructure [3].

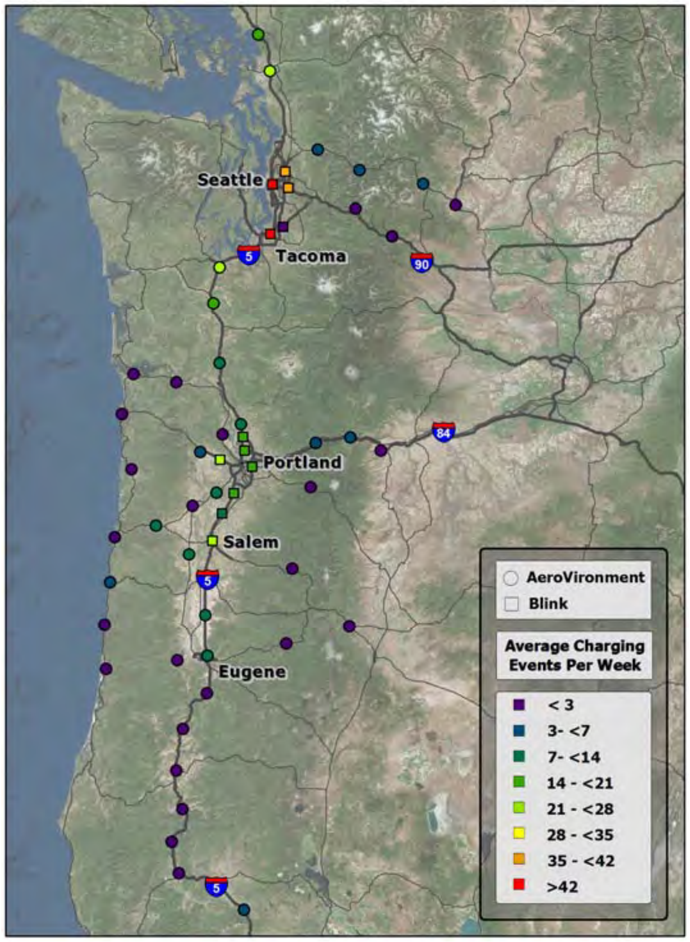


Figure 2. Usage frequency of DCFCs on the West Coast Electric Highway. The color of each symbol represents usage frequency. Symbol shape denotes the DCFC brand.

How have Electric Vehicle Drivers Used DC Fast Chargers?

To understand the usefulness to EV drivers of DCFCs located along highways, it is important to know how drivers incorporated the DCFCs into their travel. Were they using the DCFCs because they happened to be located where the drivers normally spent time or did they use them truly to enable long-distance travel along a highway corridor? To answer this question, data from Nissan Leafs in The EV Project that used the DCFC in this study were analyzed. Data from each vehicle were broken up into outings. An outing, which is sometimes also referred to as a journey or tour, represents all driving done from when a driver leaves home to when they return home. Outings can span multiple days and include numerous charges or they can be a single drive around the block.

A map was produced to show all of the places where EV Project Leafs parked when away from home during outings.

This map is shown in Figure 3. Light blue points denote where parking occurred during outings when, at some point during the outing, a DCFC was used. Parking locations were shown as black points if DCFCs were not used during the outing. For reference, the regions within which EV Project participants lived were shaded in light gray.

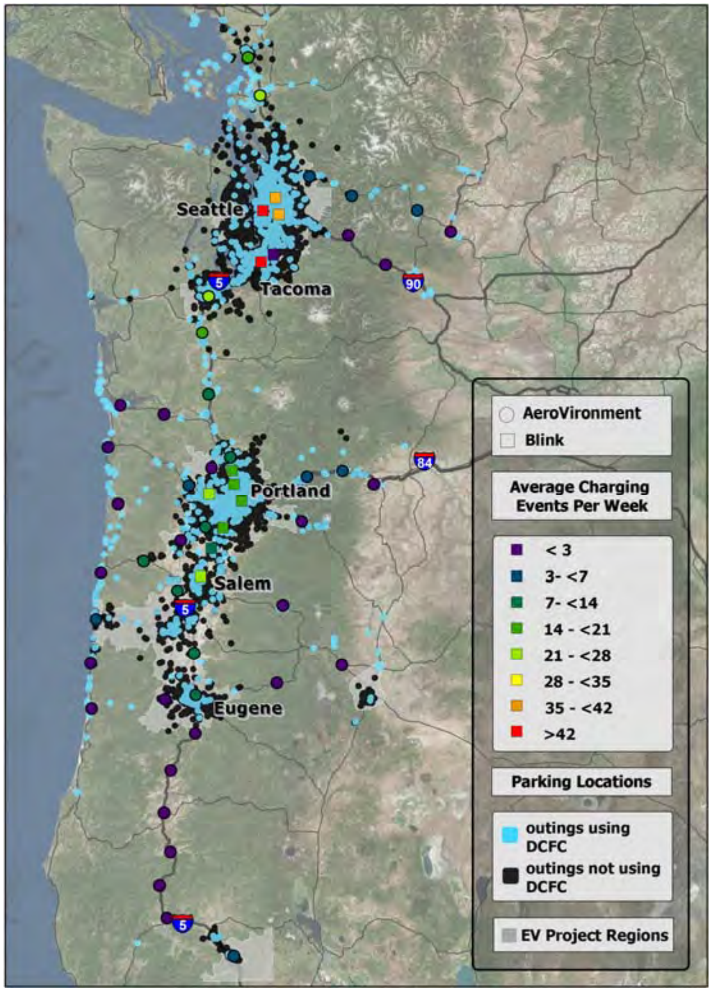


Figure 3. Away-from-home Nissan Leaf parking locations during outings were added to the map showing DCFC usage frequency. The color of the parking location points indicates whether a DCFC was used during the outing.

This map shows that when DCFCs were used, drivers covered a much larger geographic area than they did on outings without fast charging. During outings when DCFCs were not used, drivers rarely parked outside EV Project regions. From Figure 3, it is obvious that the West Coast Electric Highway DCFCs allowed drivers to cover more ground, but it is also important to quantify how far vehicles were driven before and after using these DCFCs.

For each outing during which a DCFC was used, the total distance driven in that outing was calculated. If a vehicle used a certain DCFC in multiple outings, those outing distances were averaged to remove any skewing effects that may arise from a single vehicle using a DCFC more than other vehicles. For each DCFC, this analysis produced a list of every vehicle that used it and each vehicle's average outing distance when they used the DCFC. The median of vehicle average outing distances for each DCFC was then used to represent the outings using that charger. The distribution of median outing distances for all DCFCs is shown as a histogram in Figure 4. To be included in this analysis, a DCFC had to be used in 30 or more outings. Many of the least frequently used DCFCs were not used enough by Leafs in The EV Project to be included in the outing analysis.

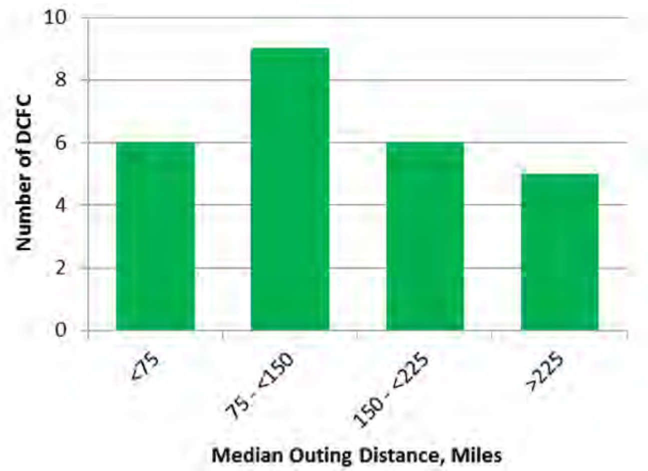


Figure 4. Histogram of median outing distance for DCFCs used during 30 or more outings by Leafs in The EV Project.

The median outing distances are fairly evenly distributed, with 75 to 150 miles being most common. The map from Figure 2 was updated to reflect the median outing distance values for each DCFC using stars of increasing size. This map can be seen in Figure 5. The symbols for the DCFCs not included in the outing analysis remain unchanged from Figure 2.

The DCFCs with the shortest median outing distances were almost all near the city centers of Seattle and Portland, which are the largest cities in Oregon and Washington. The median outing distances for these DCFCs were less than 75 miles, or less than the full charge range of the Leaf. This suggests that, in general, these DCFCs were not used to support corridor travel, but rather were used because they were in areas with high concentrations of EV Project Leafs.

Generally, the farther the DCFC was from larger cities, the higher the median outing distance was. Those that were used in the longest outings were between Portland and Seattle, on the Oregon Coast, and north of Seattle toward Vancouver, British Columbia. These DCFCs are similar in that they are not near large population centers; therefore, it is unlikely that vehicle owners lived close to them and used them for convenience.

Looking at the DCFCs on I-5 between Portland and Seattle, as well as north of Seattle, they were all used one to four times per day. All of them had median outing distances of greater than 150 miles and some were greater than 225 miles, requiring at least three full charges of the Leaf battery. These results suggest that the West Coast Electric Highway in these areas is being used by EV drivers to support a considerable amount of long distance travel. In fact, further inspection of the data found that there were 19 outings longer than 500 miles. The longest of these outings was 770 miles. To accomplish this, the driver performed 16 fast charges at nine different DCFCs throughout the region.

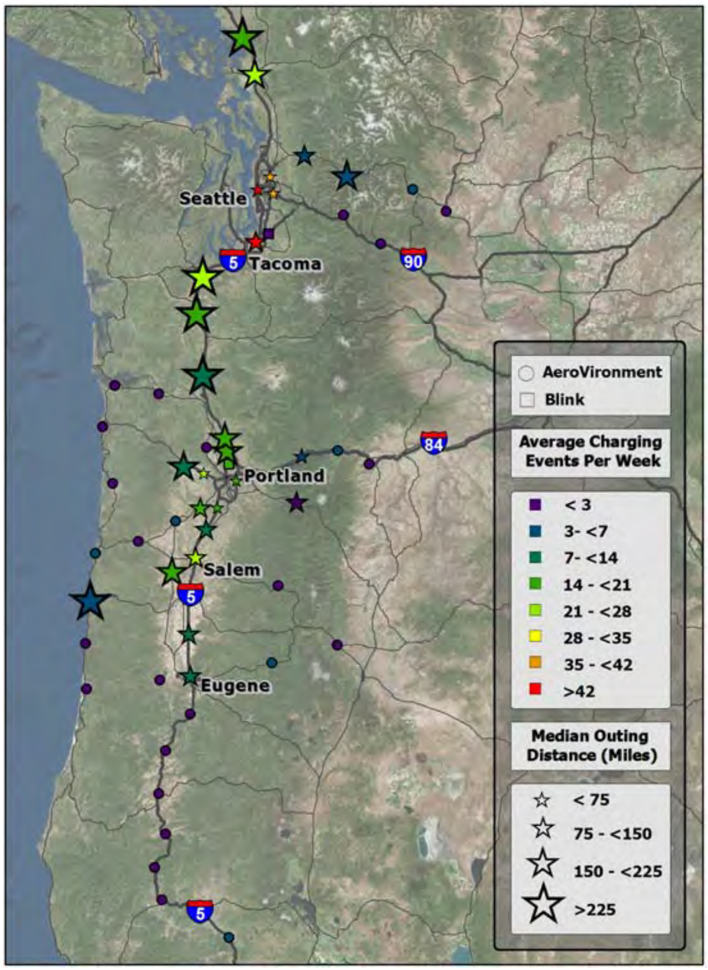


Figure 5. Stars of varying size were added to the map in Figure 2 to denote median outing distance of EV Project Leafs when using DCFCs on the West Coast Electric Highway.

About The EV Project

The EV Project was the largest plug-in electric vehicle infrastructure demonstration project in the world, equally funded by the United States Department of Energy (DOE) through the American Recovery and Reinvestment Act and private sector partners. The EV Project deployed over 12,000 alternating current Level 2 charging stations for residential and commercial use, as well as over 100 dual-port DCFCs, in 17 U.S. regions. Approximately 8,300 Nissan LEAFs™, Chevrolet Volts, and Smart ForTwo Electric Drive vehicles were enrolled in the project.

Project participants gave written consent for The EV Project researchers to collect and analyze data from their vehicles and/or charging units. Data collected from the vehicles and charging infrastructure represented almost 125 million miles of driving and 4 million charging events. The data collection phase of The EV Project ran from January 1, 2011, through December 31, 2013. Idaho National Laboratory is responsible for analyzing the data and publishing summary reports, technical papers, and lessons learned on vehicle and charging unit use.

For more information about The EV Project, visit avt.inl.gov/evproject.shtml.

About the West Coast Electric Highway

The West Coast Electric Highway is a network of 56 alternating current (AC) Level 2 EVSE and DCFC located every 25 to 50 miles along Interstate 5 and other major roadways in the Pacific Northwest (i.e., Washington and Oregon).

For more information about the West Coast Electric Highway, visit www.westcoastgreenhighway.com/electrichighway.htm.

and www.oregonelectrichighway.com.

About the AeroVironment Data

Idaho National Laboratory expresses thanks to AeroVironment for providing EVSE usage data to Idaho National Laboratory, thereby making this study possible.

For more information about AeroVironment, visit evsolutions.avinc.com.

Company Profile

Idaho National Laboratory is one of DOE's 10 multi-program national laboratories. The laboratory performs work in each of DOE's strategic goal areas: energy, national security, science, and the environment. Idaho National Laboratory is the nation's leading center for nuclear energy research and development. Day-to-day management and operation of the laboratory is the responsibility of Battelle Energy Alliance.

For more information about Idaho National Laboratory, visit www.inl.gov.

References

1. See http://www.nissanusa.com/electric-cars/leaf/owner-questions.

2. Botsford, C., “The West Coast Electric Highway,” www.energycentral.com/enduse/electricvehicles/articles/3017.

3. Powers, C., “Supporting the Plug-In Electric Vehicle Market Best Practices from State Programs,” Georgetown Climate Center, www.georgetownclimate.org/sites/GCC-Supporting-PEV-Market-December-2014.pdf.

DOCKETED

Docket Number:	15-MISC-04
Project Title:	Fuels and Transportation Merit Review
TN #:	211163
Document Title:	Presentation - Sacramento Municipal Utility District DC Fast Charging Deployment Status and Lessons Learned
Description:	N/A
Filer:	Tami Haas
Organization:	Sacramento Municipal Utility District (SMUD)
Submitter Role:	Public Agency
Submission Date:	4/20/2016 11:36:53 AM
Docketed Date:	4/20/2016

Sacramento Municipal Utility District DC Fast Charging Deployment Status and Lessons Learned

Bill Boyce

April 25, 2016

Powering forward. Together.

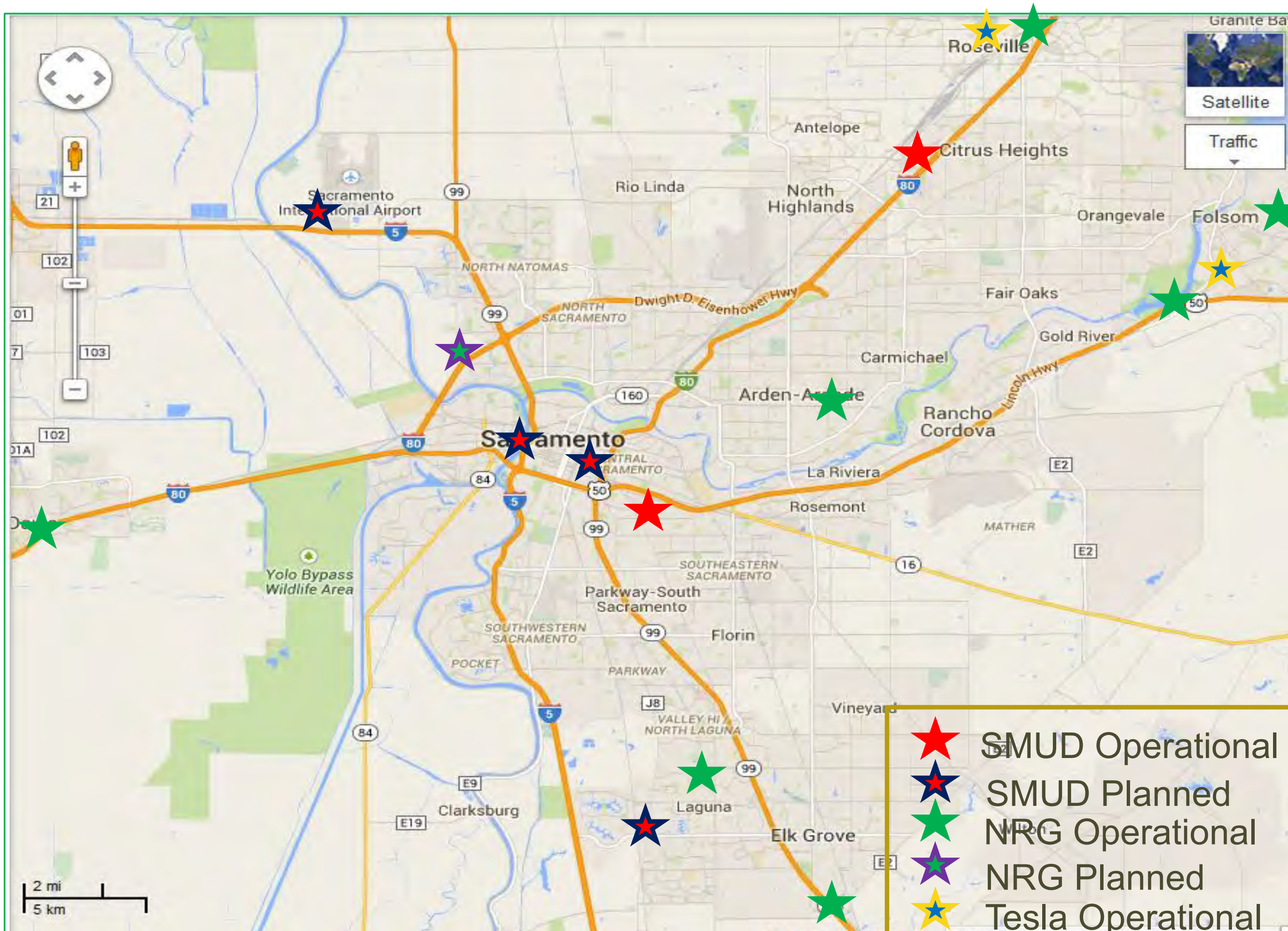
SMUD™

SMUD DC Fast Charging Activities were initiated independently back in 2013

- Originally started in response to CPUC-NRG Settlement where POU service territories were not included for DC Fast Charging deployment
- SMUD internally funded our original DC Fast Charger deployments using SMUD AB32 Credit auction revenue
- Original owner operator model chosen for maximum project learning
- CEC funding with SACOG was pursued in 2014 to add to existing plans

SMUD™

Map of Sacramento DC Fast Chargers



SMUD™

SMUD DC Fast Charger Sites

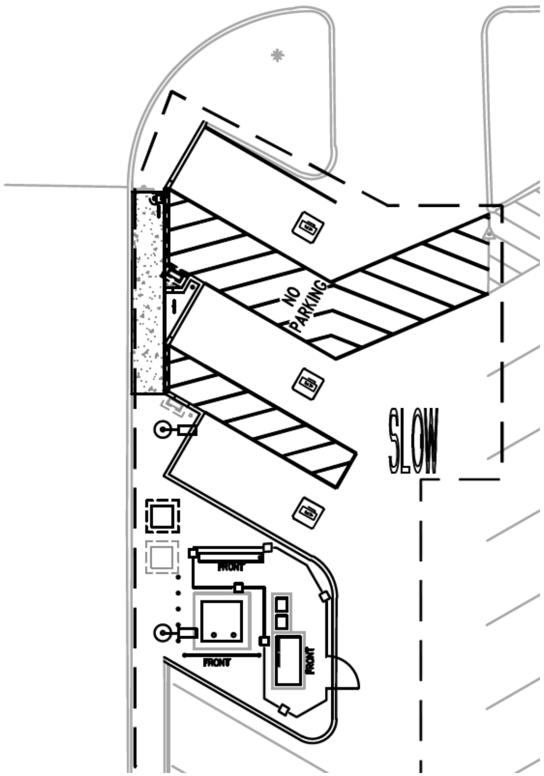
SMUD Headquarter
Operational Since March 2014

Citrus Heights Raley's
Operational since June 2015

Airport Under Construction
Cell Phone Lot (4/14/16)

Amtrak Sac Valley Station
Site Pre Construction

Standard SMUD DC Fast Charger Design / Business Model



- Stock design sized for two DC Fast Chargers and one Level 2 EVSE Units
  - Only one DCFC and 1 L2 installed at the onset
- Designs also vary by location
  - SMUD HQ designed for one standalone DCFC
  - Amtrak Sac Valley Station designed for two standalone DC Fast Chargers
- Forward looking toward ADA Compliance
- 23₵/kWh flat rate fee
  - 21₵/kWh for electricity, 2₵ City or County Tax
- Greenlots Back Office Network / Customer Interface
  - Credit Card, RFID, Cell Phone App, Pay by Phone payment capability
  - OCPP System (multiple hardware makes being used)

SMUD™

Lessons learned from our original activity went into our SACOG-SMUD CEC Proposal

- New Business Process Development
  - Outsourced customer service model
  - New EV flat commercial rate (No TOU or demand charge elements)
  - Cash flow / Information management model
  - Community tax collection for direct utility electricity sales
- Upfront Land Negotiation/Design Efforts are Laborious
  - Timelines average over a year and are equal to construction costs
  - Property owners / managers are generally unengaged/disinterested
- Disability Access trumps utility service proximity
- Hardware selection for higher temperatures was good
- Despite high reliability some operational gaps have occurred
- SMUD risk aversion / security cameras have been cost drivers

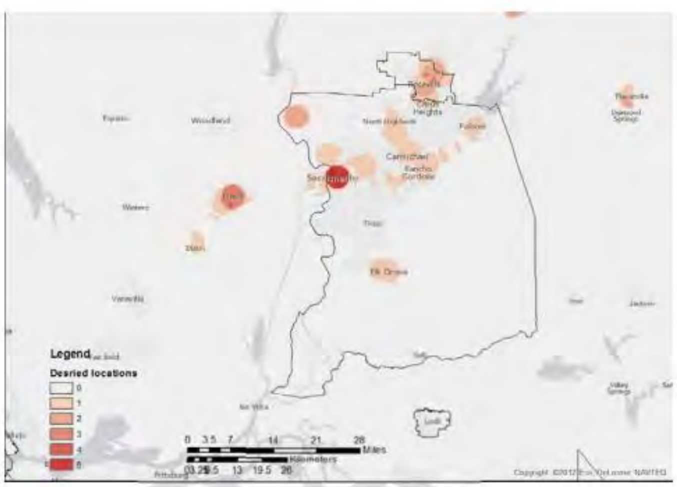
SMUD™

SACOG led the local team for the CEC Proposal

TAKECHARGE
ELECTRIC VEHICLES IN THE SACRAMENTO REGION

*TAKE*CHARGE II: Infrastructure Roadmap

TakeChargeSac.org



Regional DC Fast Charger Desired Locations

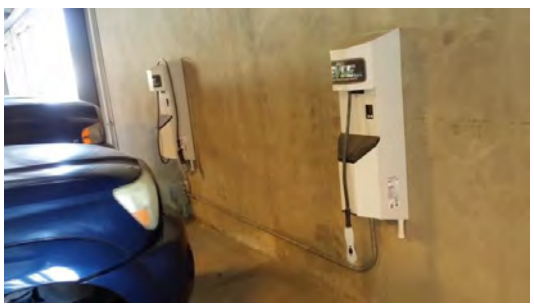
- Sites tied into SACOG Take Charge Sac EV Readiness Plan
- Siting analysis performed by UC Davis
- SACOG brought in other community partners
  - Sacramento Food Coop
  - Nugget Markets
- SMUD is the major subrecipient under the effort

SMUD™

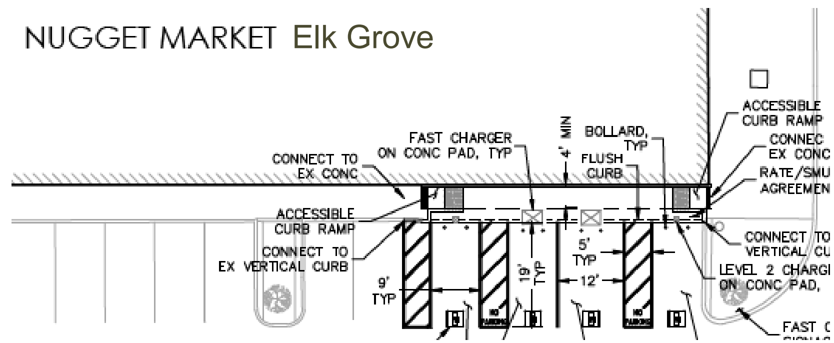
Status on existing SACOG CEC Effort

- Original Scope for 3 new stations truncated to 2
  - Property negotiation for the third site discontinued after 2 years
    - Assessment of two other adjacent sites came to no fruition

- 2 New Sites include the Sacramento Food Coop and Elk Grove Nugget Market



Sac Food Coop Level 2's Installed



- Sacramento Food Coop built into existing facility remodeling
  - Construction Ongoing
- Elk Grove Nugget site recently completed property agreement and construction will start late Q2 2016

SMUD™

Additional Lessons Learned from current effort

- Earlier SMUD activity had already solved a lot of organization issues
  - Business approach and processes, Rates, Taxes
  - Hardware selection

- Property negotiation screening process needs to be improved
  - Strategic agreements with large multi-site property owners
  - Better screening processes needed
  - Take it or leave it negotiation screening tactics
  - Figure out a revenue stream for the property owner

- Focus siting activities on utility property or with single entity owners
  - Utility property requires no negotiations
  - Multi-entity property ownership complicates/slows negotiations
  - Weingarten's and Simon Properties are better models
  - Best model is where a business and property owner are one in the same

- Incorporating charging into new building / remodeling construction can be equally slow
  - Dependent on the rest of the construction activities
  - Less overall headaches and lower cost

SMUD™

Summary

- SMUD has supported Public DC Fast Charging since 2012
- Basic DC Fast Charging emerging for Sacramento
- Business approach and lessons learned shared with many entities
- Property negotiations approaches need improvement
- Drivers seem willing to pay for DC Fast Charging and Level 2 if costs are reasonable

SMUD™

BUSINESS

BUSINESS MODELS FOR FINANCIALLY SUSTAINABLE EV CHARGING NETWORKS

CENTER FOR CLIMATE
AND ENERGY SOLUTIONS

Report Authors

Nick Nigro
Matt Frades
Center for Climate and Energy Solutions

March 2015

BUSINESS MODELS FOR FINANCIALLY SUSTAINABLE EV CHARGING NETWORKS

Report Authors

Nick Nigro
Matt Frades
Center for Climate and Energy Solutions

March 2015

Contact at the Washington State Legislature's Joint Transportation Committee
Mary Fleckenstein
Committee Coordinator
Mary.Fleckenstein@leg.wa.gov
360-786-7312

Contact at the Center for Climate and Energy Solutions (C2ES)
Nick Nigro
Senior Manager, Transportation Initiatives
nigron@c2es.org
703-516-4146

The Center for Climate and Energy Solutions (C2ES) is an independent, nonprofit, nonpartisan organization promoting strong policy and action to address the twin challenges of energy and climate change. Launched in November 2011, C2ES is the successor to the Pew Center on Global Climate Change. Learn more at www.C2ES.org.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The Center for Climate and Energy Solutions (C2ES) would like to thank the Washington State Legislature's Joint Transportation Committee for contracting with C2ES to conduct this study. C2ES would also like to thank the following for their substantial input: Representative Judy Clibborn, Representative Ed Orcutt, Representative Jake Fey, Representative Drew MacEwen, Representative Chad Magendanz, Senator Mark Mullet, Representative Dick Muri, Wayne Amondson, Scott DeWees, Ben Farrow, Stephen Johnsen, Ron Johnston-Rodriguez, Charles Knutson, Dan O'Shea, David Peterson, Sandra Pinto de Bader, Colleen Quinn, Glen Stancil, Nick Bowman, Tonia Buell, Alyson Cummings, Jeff Doyle, Debbie Driver, Mary Fleckenstein, Kim Johnson, Jerry Long, Jackson Maynard, Peter Moulton, Sonia Plasencia, Dana Quam, Beth Redfield, and Andrew Russell.

C2ES would also like to thank Philip Quebe of Cadmus Group for developing the EV Charging Financial Analysis Tool and assisting with the business model analysis.

C2ES would like to thank Linda Bluestein of the U.S. Department of Energy Clean Cities Program; Jim Francfort, John Smart, and Brion Bennett of Idaho National Laboratory; and Colleen Quinn and Jeremy Hall of ChargePoint for sharing charging use data.

EXECUTIVE SUMMARY

Electric vehicles (EVs) are a small, but rapidly growing part of the passenger vehicle market in the United States, with almost 300,000 EVs purchased since late 2010. In the state of Washington, EVs have been more popular than in other markets, in part because of action by the state government to lower the upfront cost of EVs to consumers and to facilitate the deployment of publicly available charging infrastructure.

While state and federal governments have played a central role in providing EV charging infrastructure to date, greater private investment will be needed to ensure adequate access to publicly available charging stations to continue to advance EV adoption.

In May 2014, the Washington State Legislature's Joint Transportation Committee commissioned a study to develop new business models that will foster private sector commercialization of publicly available EV charging services and expand the role of private sector investment in EV charging throughout the state.

The results of this new study demonstrate that, with continued public support and EV market growth in the near term, it is reasonable to expect the private sector to be able to be the predominant source of funding for publicly available commercial charging stations within approximately five years.

What is a Business Model?

In this study, a business model refers to the method by which a business or group of businesses offers one or more products or services. The business model is composed of the value a customer receives in exchange for payment or value-transfer (value proposition), the target market, and cost and revenue streams.

This report documents the analyses and findings of this study, which consisted of three phases. The first phase assessed the state of EV charging in Washington. The second identified and evaluated innovative business models for EV charging in Washington. The final phase developed recommendations on the role of the public sector in supporting those business models to maximize private sector investment in EV charging.

STATE OF PUBLICLY AVAILABLE EV CHARGING NETWORK IN WASHINGTON

While in the rest of the country, plug-in hybrid vehicles (PHEVs are powered by batteries and gasoline) outnumber battery electric vehicles (BEVs are powered solely by batteries) by a wide margin, the opposite is true in Washington. Washington drivers have purchased more than twice as many BEVs as PHEVs. This fact is important to consider in evaluating Washington's EV charging network. BEV drivers rely on the publicly available charging network to travel distances beyond the range provided by a single battery charge. As a result, any gaps in the state's existing publicly available network limits travel for BEV drivers.

EV owners and publicly available charging stations tend to be found in the same regions of the state. The vast majority of EVs and charging stations are in the state's most populous region around Puget Sound, with most in King County. However, outside of this major population center, publicly available charging stations are comparatively sparse, with the exception of the Vancouver, Washington, area near Portland, Oregon. See **Figure ES-1** for a statewide map of the EVs and direct current (DC) fast charging locations.

Box 1. EV Business Models Study Participants and Process

The Washington State Legislature's Joint Transportation Committee selected C2ES to develop new business models that will foster private sector commercialization of public EV charging services.

An advisory panel of state legislators and EV experts was assembled to guide the direction of the study, provide input, and be an information resource to C2ES. The advisory panel met three times in person and twice via webinar.

In addition to the advisory panel, a workgroup of staffers from the State Legislature and state agencies provided guidance to C2ES throughout the project. The staff workgroup met frequently via conference call and in person ahead of each advisory panel meeting.

The first phase of the study was to assess the state of EV charging in Washington and create useful products for the state to perform similar assessments as the market evolves. The second phase was to evaluate business models for EV charging in Washington. A key part of this step was an all-day workshop to assess the effectiveness of various business concepts for financing publicly available charging infrastructure in the state of Washington. The workshop participants included the Washington State Legislators, their staff, and members of the advisory panel assembled for this study. The final phase was to develop recommendations on the role of the public sector in supporting those business models in order to maximize private sector investment in EV charging.

See Appendix A for more details of the study process.

EVALUATE CURRENT STATUS OF EV CHARGING IN WASHINGTON

Construct Public Charging Network Database

Create interactive maps for charging suitability assessment

Provide insights into role of public charging networks in encouraging EVs

Summarize findings

May – August 2014

DEVELOP BUSINESS MODELS

Leverage C2ES's AFV Finance Initiative

Conduct Business Model Workshop

Create three business model summaries

July – November 2014

IDENTIFY PUBLIC & PRIVATE ROLES

Execute financial analysis on business model viability

Identify public sector role in addressing barriers to private investment

October – December 2014

Because of this, many travel destinations are inaccessible to BEV drivers, confining most travel to the Interstate 5 (I-5) corridor, King County, and the Vancouver region. See **Figure ES-2** for an overview of the travel routes analyzed in this study. The travel route analysis identified three charging infrastructure gaps:

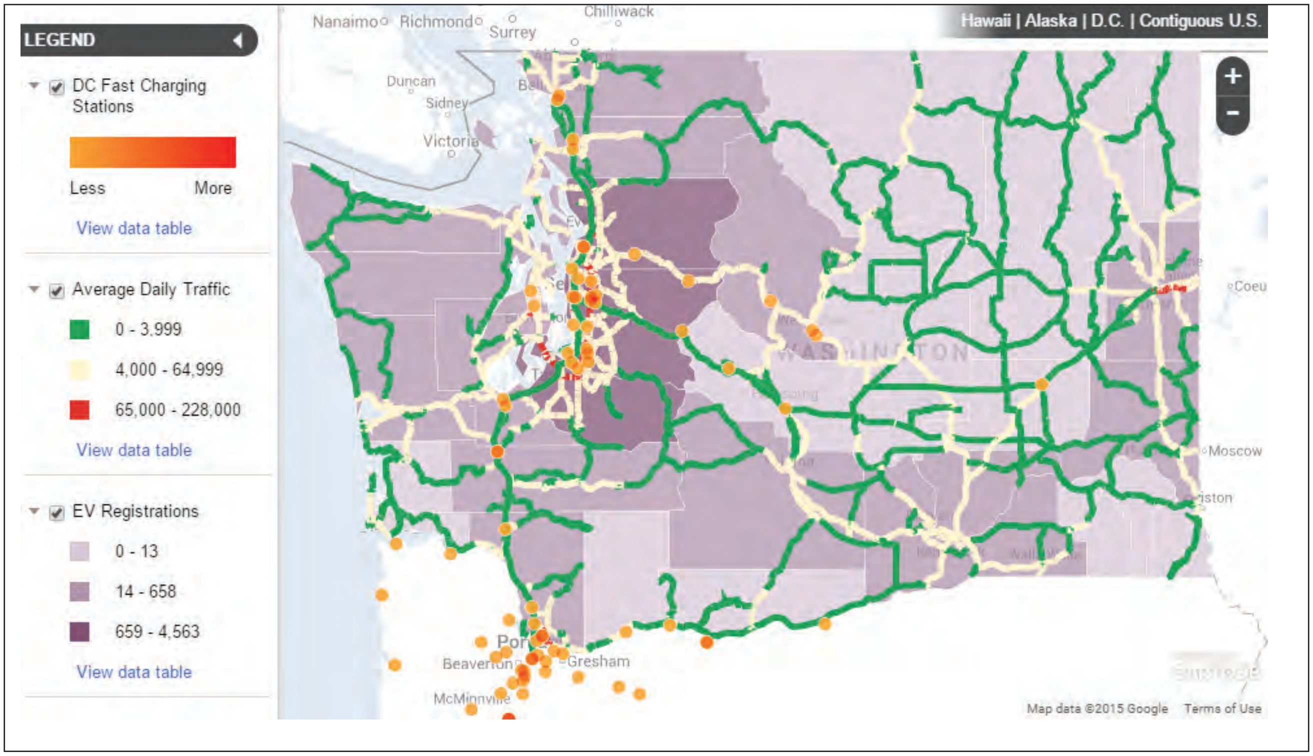
- **I-90 Charging Gap:** Travel from the Puget Sound Region to Spokane along Interstate 90 (I-90).
- **Ocean Shores Charging Gap:** Travel from the Puget Sound Region to the Pacific Coast.
- **Tri-Cities/Walla Walla Charging Gap:** Travel from the eastern and western part of the state along I-90 to the Tri-Cities and Walla Walla region.

NEW BUSINESS MODELS TO ADDRESS CHARGING GAPS

It is currently challenging to construct a profitable business case for publicly available EV charging investments for several reasons. These include high initial investment costs, low and uncertain near-term demand for publicly available charging, and commercial charging competing with home charging.

FIGURE ES-1: DC Fast Charging Network Intensity Map as of June 2014

This map shows that large segments of many major roadways do not have any publicly available DC fast charging. DC fast charging stations are shown in orange, while major roadways are shown in green, yellow, or red depending on average daily traffic.



Source: C2ES, DC Fast Charging Network in Washington State, September 2014. http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/maps/wa-dc-fast-charging-network.

For this reason, charging station business models that rely solely on direct revenue from EV charging services currently are not financially feasible. The analyses completed for this study focused on DC fast charging stations, capable of charging a Nissan LEAF to 80 percent in less than 30 minutes, and alternating current (AC) Level 2 charging stations, which can fully charge a Nissan LEAF in 3.5 to 7 hours. The analyses show that investment in a single DC fast charging station results in a net loss of more than $44,000 for a private project developer over a 10-year period. Similarly, investment in a charging site with five slower, lower powered, and lower cost alternating current (AC) Level 2 charging stations results in a net loss of more than $26,000 for a private project developer over the same 10-year period.

To build a business case that will attract capital and convince the private sector to invest in EV charging, total revenues must be greater than the project's total cost, and an acceptable level of profit is necessary. There are four general ways to improve the financial performance of charging station projects: increase revenues, decrease capital costs, decrease operating costs, and/or decrease the cost of funds for the project.

One promising opportunity to improve the financial performance of charging station investments is to develop business models that, through private partnerships and joint investment strategies, capture other types of business value in addition to selling electricity. This might include tourist revenue for retailers and tourism businesses that get more sales from EV drivers when located near EV charging stations; automakers selling more EVs; and "clean energy" marketing and brand-strengthening opportunities for businesses visibly involved in EV charging deployment projects.

This study identified three business models aimed at capturing these sources of value, and analyzed the financial viability of each business model by applying them to address an infrastructure gap in the state:

- **Business Model 1:** A large business that benefits from EV sales and use (such as an automaker or a battery supplier) or seeks to gain a marketing advantage (such as a retail or restaurant chain) contributes funding to subsidize the deployment of a DC fast charging network for interregional EV travel. This model was applied to the I-90 Charging Gap. At least six new DC fast charging stations are needed to enable BEV travel between Seattle and Spokane along I-90. In the application of the model, an automaker provided an upfront cash transfer to the charging owner-operator in the amount of $7,000 for each DC fast charging station.
- **Business Model 2:** A group of local businesses contributes annually to a funding pool that subsidizes the cost of deploying a charging network for EV travel to and within the region. These businesses may be tourism businesses and retailers aiming to sell products and services to EV drivers. This model was applied to the Ocean Shores Charging Gap. Travel to and within Ocean Shores—a tourist destination—requires many more charging stations to enable BEV travel from the Puget Sound region, Olympia, and Longview. At least 3 DC fast charging stations and 25 Level 2 charging stations are needed to address this gap. In the application of the model, the local businesses shared 10 percent of their revenue from new business related to EV charging use each year for 10 years with the charging owner-operator.
- **Business Model 3:** This model combines Business Models 1 and 2, providing the charging station project with subsidies from both a large business and a funding pool financed by local businesses. This model was applied

FIGURE ES-2: Travel Routes Analyzed

Travel simulations were conducted for battery electric vehicles along routes highlighted in green below. These simulations identified charging infrastructure gaps along I-90 from Seattle to Spokane and the Tri-Cities/Walla Walla region, and from the Puget Sound region to the Pacific Coast.

to the Tri-Cities/Walla Walla Charging Gap. Travel to and within the Tri-Cities and Walla Walla region—Washington's wine country—from Seattle and Spokane requires at least 10 DC fast charging stations and 50 Level 2 charging stations to address this charging gap. These stations could be hosted by local wineries who would contribute 10 percent of their new EV tourist revenue each year for 10 years. In the application of the model, an automaker provided an upfront cash transfer to the charging owner-operator in the amount of $7,000 for each DC fast charging station and $500 for each Level 2 charging station. In addition, the local businesses shared 10 percent of their revenue from new business related to EV charging use with the charging owner-operator each year for 10 years.

The EV Charging Financial Analysis Tool created for this study was developed to analyze the expected financial performance of each of these business models as applied to their EV charging infrastructure gaps. The initial analysis included only private sector funds; no public sector contributions were considered.

Results of analysis with no public subsidies. The financial analyses demonstrate that each business model can materially improve the financial performance of EV charging projects. The models do this by capturing the value of EV charging services to other businesses, thereby increasing private sector investment in the EV charging network. However, the analyses also show that it is unlikely that the private sector will implement these business models in the near term. Investors would likely view the financial performance of these charging station investments as unfavorable

TABLE ES-1: Summary of Application of Three Business Models with No Public Sector Interventions

This table summarizes the application of each business model to a real-world EV charging infrastructure gap. The results show that the owner-operator of the charging stations does not achieve profitability, or would achieve profitability in 9 years—a timeframe that is unlikely to attract private investors.

	BUSINESS MODEL 1	BUSINESS MODEL 2	BUSINESS MODEL 3
Private Sector Partner Funding Contributions to Implement Business Model	$42,000 upfront cash transfer from automaker to owner-operator ($7,000 for each DC fast charging station)	Owner-operator receives between $28,000 and $84,125 annually from the funding pool financed by local businesses	$95,000 cash transfer from automaker to owner-operator ($7,000 for each DC fast charging station and $500 for each Level 2 charging station) Owner-operator receives between $56,000 and $168,250 annually from funding pool financed by local businesses.
EV Infrastructure Gap	Interregional travel on I-90 between Seattle and Spokane	Travel to Ocean Shores (from Longview and the Puget Sound region) and within the destination region	Travel to Tri-Cities and Walla Walla (from Spokane and the Puget Sound region) and within the destination regions
Charging Equipment	6 DC fast charging stations	3 DC fast charging stations 25 Level 2 stations	10 DC fast charging stations 50 Level 2 stations
Station Deployment Cost	$561,600	$501,500	$1,384,100
Owner-Operator Net Present Value	–$118,207	+$49,439	+$54,166
Owner-Operator Payback	No payback	9 years	9 years

under current market conditions. Many private investors are only interested in projects that can achieve payback within five years, a threshold that none of the business models is currently estimated to meet. **Table ES-1** summarizes the application of these business models to real-world EV charging infrastructure gaps identified in this study.

ROLE OF GOVERNMENT IN FACILITATING BUSINESS MODELS IN THE NEAR TERM

Under current market conditions, the three business models were not financially viable without public interventions if the owner-operator requires a payback of five years or less.

Rationale for public sector subsidies or interventions are numerous, and could include promoting local economic development (e.g., from retail sales), ensuring a sufficiently dense network that keeps EV drivers from getting stranded, fostering clean energy deployment; and reducing transportation emissions, among others.

The study analyzed a variety of roles that the public sector can play to help expand private investment in EV charging infrastructure. The public roles are referred to as interventions because they are intended to deliberately influence the financial performance of a charging station project. The range of interventions analyzed included:

- Low-interest loans;
- Grants;
- Extending the BEV sales tax exemption;
- Participation in California's Zero Emission Vehicle (ZEV) Program;
- Adopting EV-ready building codes; and
- Sharing local and state fleet EV charging stations with the public.

Results of analysis with public subsidies and interventions. A variety of public sector interventions were tested to identify what it would take to make the business models profitable and sustainable, with a goal of investor payback within five years. Three public interventions were selected for analysis: low-interest loans, one-time grants, and a five-year extension of the BEV sales tax exemption. The analyses show that a combination of these interventions could achieve the five-year payback objective. The details of the combinations of interventions that meet the goal for each business model and charging gap are provided below.

- Business Model 1 applied to the I-90 Charging Gap became profitable and achieved a five-year payback with a $110,000 loan at 5.4 percent interest, a one-time grant of $220,000, and the continuation of the BEV sales tax exemption.
- Business Model 2 applied to the Ocean Shores Charging Gap became profitable and achieved a five-year payback with a $150,000 loan at 5.4 percent interest, a one-time grant of $85,000, and the continuation of the BEV sales tax exemption.
- Business Model 3 applied to the Tri-Cities/Walla Walla Charging Gap became profitable and achieved a five-year payback with a $415,000 loan at 5.4 percent interest, a one-time grant of $240,000, and the continuation of the BEV sales tax exemption.

These combinations demonstrate the level of public sector intervention that is needed to meet the five-year payback goal. Alternative combinations of public sector interventions could also meet this goal.

Public subsidies may only be needed for five years. A key finding of the study is that the use of subsidies and interventions for five years can help the EV market to develop to the point where, after five years, no further public sector intervention will likely be needed to make EV charging business models profitable and sustainable.

This key finding assumes significant growth in the number of EVs on the road (and therefore increased charging station utilization), and a decreased cost of DC fast charging station equipment. Without public subsidies and interventions, Washington could have nearly 22,000 EVs on the road by 2020. With public subsidies and interventions, more than 29,000 EVs could be on the road by 2020. These additional EVs, plus the lower cost for charging equipment, make the business models profitable and sustainable.

A range of potential revenue sources was identified to fund the public sector interventions, including a special annual fee for EVs, limiting the BEV sales tax exemption to vehicles below a certain price, and state and federal transportation funds.

CONCLUSION AND NEXT STEPS

The analyses performed for this study show that both private and public sector participation will likely be required to ensure the sustained development of EV infrastructure in the state. Private sector entities that gain indirect value from EV charging station deployment can play a critical role in improving the financial performance of EV charging station investments. In the near term as the EV market develops, public interventions can help make charging station investments more financially attractive to investors. Finally, with sustained EV market development, public sector interventions may no longer be needed to attract private investment in charging stations after five years.

There is growing evidence that a key finding of this report—that diverse businesses may be willing to help fund charging station deployment because of the indirect benefits they receive—is gaining traction in the United States. In January 2015, automakers including BMW, Volkswagen, and Nissan announced major investments in publicly available charging infrastructure that aim to install more than 1,000 charging stations in key markets in Oregon, California, the Northeast, and elsewhere.

Building off the momentum created by these newly announced projects, Washington could demonstrate the business models presented in this study through a new pilot program. One way to structure such a pilot program would be for the state to call for private sector partners to apply for grants or low-interest loans to lower the cost of funds for a charging project. The state could fund the program through a combination of increased fees on EV drivers, general revenue, and/or other sources.

Under such a pilot program, applicants would need to demonstrate that their proposed project addresses a specific charging infrastructure gap in the state, similar to those identified in this study. The project could address travel to a specific region, within a targeted area, or a combination of both. Applications would be expected to present a clear case for the value proposition of filling the charging gap and provide evidence that the project would be profitable and sustainable for the charging network owner-operator and any private sector partner. The EV Charging Financial Analysis Tool created for this study could be used to help evaluate the viability of potential projects for this pilot program.

INTRODUCTION

Electric vehicles (EVs) are a small, but rapidly growing part of the passenger vehicle market in the United States. In the state of Washington, EVs have been more popular than in other markets, in part because of action by the state government to build out publicly available charging infrastructure and provide a sales tax exemption for battery electric vehicles (BEVs). The Washington State Legislature is interested in exploring government's role in fostering new business models that will expand private sector commercialization of EV charging services. This report is the final deliverable of a study on expanding the role of private sector investment in publicly available EV charging throughout Washington.

What is a Business Model?

In this study, a business model refers to the method by which a business or group of businesses offers one or more products or services. The business model is composed of the value a customer receives in exchange for payment or value-transfer (value proposition), the target market, and cost and revenue streams.

The goal of this study is to identify sustainable business models that the private sector can execute to address EV charging infrastructure gaps in Washington state. In general, a business model is a description of the ways a business makes money by offering a product or service. The key component of a business model is its value proposition—the value a customer receives in exchange for payment or value-transfer. In addition to the value proposition, a business model consists of the target market for a product or service, the cost and revenue streams to demonstrate the concept's viability, guidance on implementing or demonstrating the concept, and methods to test the concept's success or failure.

This study investigates a range of business models to identify promising opportunities for Washington. The study first evaluated a simple business model under which a private entity acting alone receives revenue only from the direct sale of charging services. Then the study evaluated how other businesses might value charging services and how capturing this value could improve the business case for offering charging services.

The report consists of three chapters:

1. **Assessing the existing EV publicly available charging network in Washington**. The chapter evaluates the current state of charging infrastructure in the state and identifies locations where additional infrastructure may be needed. The assessment next investigates specific travel corridors where private investment could increase EV adoption and identifies and describes three illustrative charging infrastructure gaps. The chapter summary offers conclusions on the state of the publicly available charging network.
2. **Identifying new business models for EV charging that capture business value in addition to selling electricity**. The chapter first identifies the challenges of ensuring adequate access to EV charging infrastructure and the barriers to increasing the private sector role in expanding charging access. Next, it quantifies the indirect value of EV charging services to different private sector partners. The chapter identifies three business models that leverage the indirect value of EV charging services. Finally, it presents a financial analysis on the application of each model to real-world EV infrastructure gaps identified in Chapter 1.
3. **Identifying the role of government in facilitating business models in the near term**. The chapter identifies several public sector interventions and presents an analysis on the effect of each intervention on the business models analyzed in Chapter 2. A second analysis using a combination of public sector interventions then shows how the three business models can achieve payback within five years or less. A third analysis shows the financial performance of these business models five years out, to demonstrate the feasibility of the business models without public sector interventions in the near future. Finally, the chapter explores a range of funding options for these public interventions.

EV charging stations in Washington and elsewhere have not attracted significant private investment so far because the owner-operators of these stations have been unable to make a profit based on payments for EV charging services alone. To explore how private sector partnerships could help boost the profitability of these stations, the business models explored in this study are aimed at capturing additional indirect sources of value that EV charging stations may generate, such as:

- Increased sales of other products and services at businesses located near EV charging stations;
- Increased tourism business from EV travel to popular destinations;
- Increased sales of EVs;
- Sales of advertising at EV charging stations; and
- "Clean energy" marketing and brand-strengthening opportunities.

Each model focuses on the private sector, identifying people, groups, or organizations that have an interest or concern and the value they can expect to receive in return for their investment. Each model identifies the target market for charging services, evaluates the expected financial performance, and identifies criteria to evaluate success and failure. Finally, each model allows for a range of state and local government roles.

While the business models identified in this study improve the financial performance of charging station projects, the private sector is unlikely to implement these models in the near term because the financial performance is not favorable enough to attract investors under current market conditions. As a result, public sector interventions are also explored in this study. These interventions could play a strong role in advancing the EV market in Washington resulting in more favorable conditions for the business models to be implemented without public intervention in the near future.

1. ASSESSMENT OF THE PUBLICLY AVAILABLE EV CHARGING NETWORK IN WASHINGTON

1.1. SUMMARY OF FINDINGS

Washington drivers prefer battery electric vehicles (BEVs) to plug-in hybrid vehicles (PHEVs) by a more than 2-to-1 margin. Because BEVs generally need recharging more often than PHEVs, the distribution of charging stations in the state's publicly available network limits travel for the state's BEV drivers.

The distribution of charging stations and EVs throughout the state is similar. The vast majority of both EVs and charging stations are in the state's most populous region around Puget Sound, with most in King County. Publicly available charging stations around the rest of the state are comparatively sparse, with the exception of the Vancouver, Washington area near Portland, Oregon.

Because of this, many travel destinations are inaccessible to BEV drivers, confining most travel to the Interstate 5 (I-5) corridor, King County, and the Vancouver region. Additional charging infrastructure is needed to facilitate travel to the Pacific Coast, between the eastern and western part of the state along Interstate 90 (I-90), and to the Tri-Cities and Walla Walla region.

1.2 INTRODUCTION

Chapter 1 describes an assessment of the publicly available EV charging network in Washington state as of September, 2014. Included in this chapter are the following:

- The challenges of ensuring adequate access to EV charging infrastructure and the barriers to increasing the private sector role in expanding charging access;
- The current state of charging infrastructure in Washington and locations where additional infrastructure may be needed;
- Description of specific travel corridors where private investment could increase EV adoption; and
- Summary and conclusions on the state of the publicly available charging network.

1.3 THE WASHINGTON EV MARKET

This section provides an overview of the EV market in Washington. It focuses on why BEVs, or vehicles that can only be powered by batteries, have been more popular than PHEVs, which contain a battery pack and a gasoline engine (see **Box 2**). This section also describes a potential relationship between the concentration of EVs and charging locations at the county level.

EV Adoption over Time and the Ratio of BEVs to PHEVs

Washington has not followed the national trend of PHEV sales outpacing BEV sales. Nationally, 27 percent more PHEVs have been sold than BEVs from December 2010 to June 2014 (see **Figure 1**). In contrast, there are currently more than two BEVs for every PHEV on the road in Washington. As of June 2014, there were almost 9,400 EVs registered in the state, with BEV registrations totaling about 6,500 and PHEV registrations totaling fewer than 2,900. BEVs have outsold PHEVs since EV sales began in Washington in late 2010. **Figure 2** shows original registrations of EVs in Washington over time.

One possible explanation for the popularity of BEVs over PHEVs in Washington is the presence of state sales tax exemption for BEV purchases that is not available for PHEV purchases. This BEV sales tax exemption amounts to a $3,000 or more "discount" for a BEV compared to a PHEV. Automakers have said that taking $1,000 or more off the price of a vehicle can spur sales.[1] A similar trend in BEV purchases is seen in Georgia, where a $5,000 income tax credit and high-occupancy vehicle lane access are both available only to BEVs. These incentives have helped make Atlanta the top market for the all-electric Nissan LEAF for many months.[2]

Because BEVs outnumber PHEVs by 130 percent in Washington, charging infrastructure needs in Washington may differ from those in other markets. BEVs do not have the option to run on gasoline to increase range as PHEVs do, so Washington EV drivers

Box 2. Defining the Types of EVs

BEVs are EVs that can only be powered by the vehicle's battery pack while EREVs and PHEVs contain a battery pack and a gasoline engine. For the purpose of this study, EREVs and PHEVs are considered equivalent and are referred to collectively as PHEVs.

Many BEVs currently available can only travel 100 miles or less on a single charge. As a result, BEVs require a robust fast charging network to enable long distance travel. The flexibility offered by a PHEV's gasoline engine enables it to travel more easily without the need to stop and recharge the vehicle's battery. On the other hand, PHEVs typically have less than 40 miles of all-electric range, so their share of electric miles traveled decreases on longer trips unless the batteries are recharged.

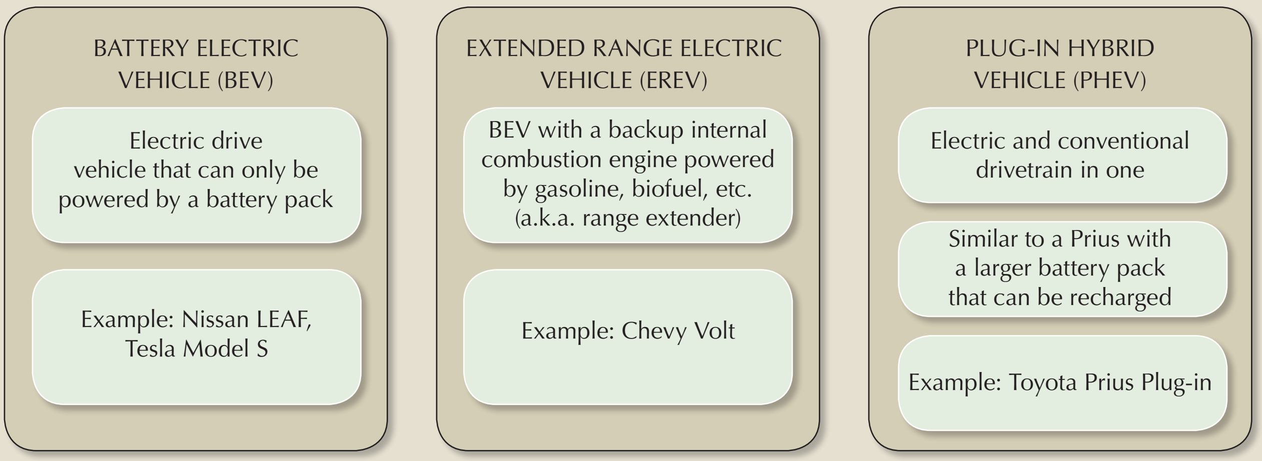
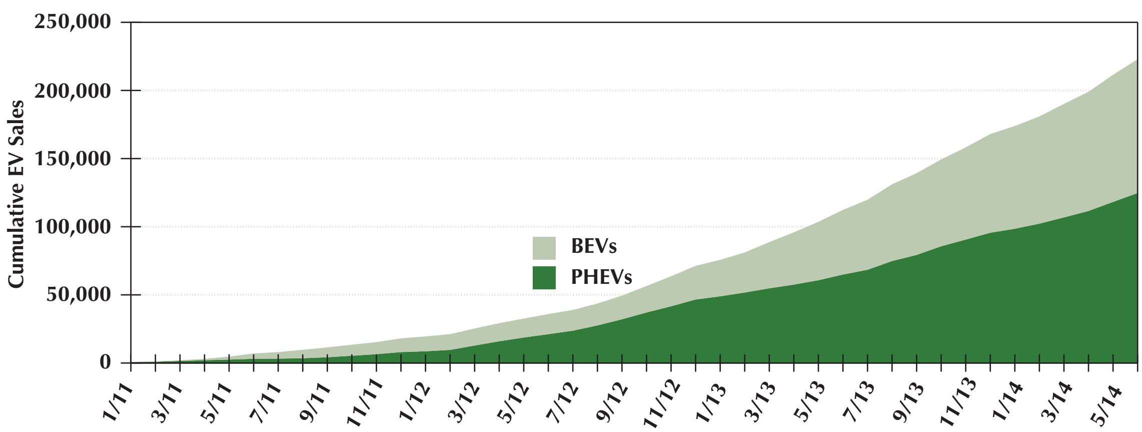


FIGURE 1: PHEVs Have Outsold BEVs in the United States by More Than 25 Percent

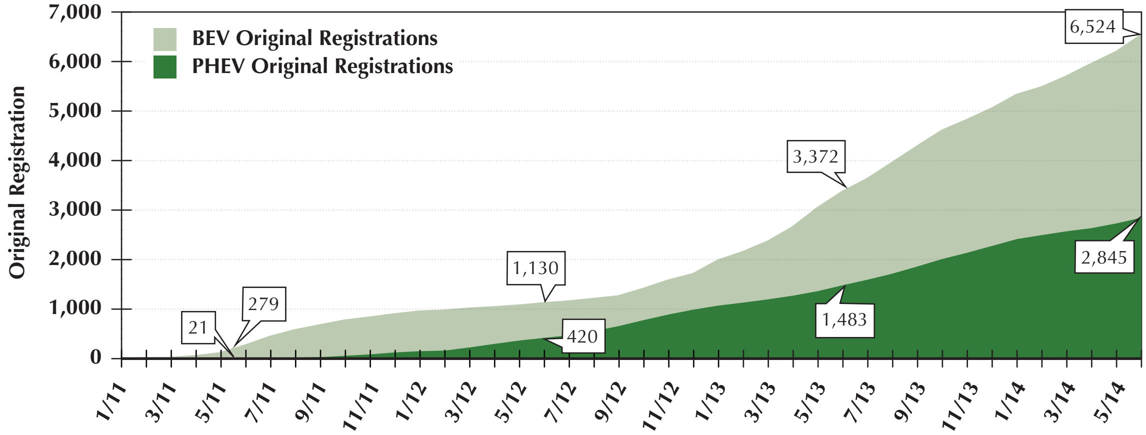
124,718 PHEVs and 98,267 BEVs have been sold in the United States through June 2014. PHEVs have consistently outsold BEVs on a monthly basis since early 2011.



Source: Hybridcars.com. 2014. Hybrid Market Dashboard. July. Accessed September 21, 2014. http://www.hybridcars.com/market-dDashboard.html.

FIGURE 2: BEVs Have Outsold PHEVs in Washington by 130 Percent

This figure shows cumulative registrations for BEVs and PHEVs from January 2011 to June 2014. An original registration occurs when a vehicle owner first registers the vehicle in Washington. The figure shows new and used vehicles as they were first registered. Washington differs from the national EV market because BEVs have outsold PHEVs by a large margin. The actual number of vehicles on the road will differ from the total vehicles shown below at any given time because it does not include the existing vehicle stock.



Source: Washington Department of Licensing.

may need greater access to high-powered charging to meet their travel needs than drivers in other states.

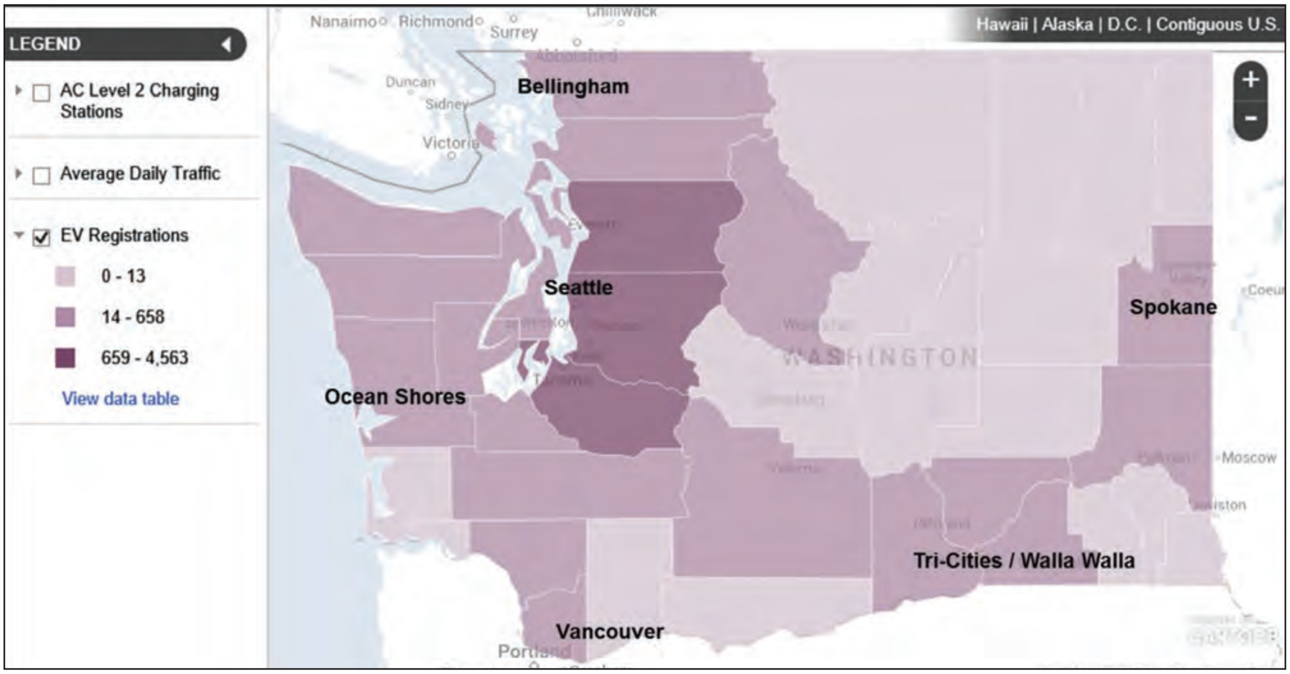
Geographic Distribution of EVs

EVs are heavily concentrated in the Puget Sound region. In most Washington counties, the distribution of EVs is roughly proportional to that of regular passenger vehicles. However, 85 percent of the state's EVs are registered in Clark, King, Kitsap, Pierce, and Snohomish counties, while only 64 percent of total passenger vehicles are registered in those counties.

A relationship may exist between the number of EVs and the number of publicly available charging locations in a county. EVs are particularly concentrated in King County, home to 56 percent of EVs registered in the state, compared with 30 percent of total passenger vehicles. King County also contains 57 percent of the alternating current (AC) Level 2 charging locations and 39 percent of direct current (DC) fast charging locations. Considering that Level 2 charging stations are often intended to accommodate average daily travel needs, a given county should have a similar share of Level 2 charging locations and EV registrations, as is the case with King County. On the other hand, the number of DC fast charging stations in a county does not need to match its EV registration level. This is because DC fast charging is often used for traveling long distances, so drivers are more likely to plug into a DC fast charging station on the way to a distant destination, not close to home. See **Table 1** for a summary of EVs and charging infrastructure for the top five counties in Washington, which constitutes 85 percent of the EV market in the state.

FIGURE 3: Registered EVs in Washington by County through December 2013

This figure shows that the vast majority of EVs in Washington are registered in the Puget Sound region. Many counties have very few EVs registered, denoted by the lightest purple color.



Source: C2ES. 2014. AC Level 2 Charging Network in Washington State. August. Accessed September 21, 2014. http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/maps/wa-ac-level-2-charging-network.

TABLE 1: Top 5 Counties for Total EV Registrations (December 2013)

This table shows that Clark, King, Kitsap, Pierce, and Snohomish counties have 85 percent of Washington's total EV registrations. Percentages in this table are a share of state totals.

COUNTY	BEVs REGISTERED	PHEVs REGISTERED	EVs REGISTERED	POPULATION (%)	BEV (%)	PHEV (%)	EV (%)	DC FAST CHARGING LOCATIONS (%)	LEVEL 2 CHARGING LOCATIONS (%)
Clark	278	157	435	6.3%	5%	6%	5%	15%	3%
King	3,433	1130	4,563	28.8%	61%	45%	56%	43%	60%
Kitsap	264	107	371	3.7%	5%	4%	5%	5%	3%
Pierce	399	260	659	11.8%	7%	10%	8%	5%	11%
Snohomish	569	272	841	10.6%	10%	11%	10%	8%	8%

Source: Washington State Department of Licensing; U.S. Census Bureau, U.S. Department of Energy

1.4 CHARGING NETWORK ASSESSMENT OVERVIEW

This section assesses the ability of the existing publicly available charging network to enable travel throughout Washington. It begins with a description of vehicle and charging technologies and assumptions about those technologies that form the basis for the analysis. The section then describes how the DC fast charging and Level 2 charging networks in Washington meet the needs of different EV technologies and travel distances. Although each network was assessed separately, DC fast charging and Level 2 charging can complement each other to accommodate average daily driving needs and the occasional long-distance trip.

Washington had 423 publicly available charging locations as of June 2014, giving it the fourth highest per capita publicly available charging network in the country.[3] The cost of acquiring and installing many stations in the state was funded by federal government grants, but all stations are owned and operated by private businesses. These charging stations are primarily concentrated in the state's most populous region around Puget Sound. Publicly available charging stations are rather sparse in the rest of the state, with the exception of the Vancouver area near Portland, Oregon.

There are three publicly available commercial charging networks in the state: AeroVironment, Blink, and ChargePoint. Tesla's fast charging network is only available to Tesla vehicles and was not considered in this study.

Vehicle and Charging Technologies Considered and Assumptions

The following section describes the vehicle and charging technologies considered in the network assessment and any assumptions used in the analysis. An EV can recharge at three power levels in increasing order: AC Level 1, AC Level 2, and DC fast charging. Level 1 chargers are typically located in homes and have power levels up to 1.4 kW, and are not considered in this study.

Level 2 charging have power levels up to 19.2 kW, but more typically offer charging at 3.3 kW or 6.6 kW. Level 2 stations are often located where drivers are expected to spend several hours, such as retail outlets, public parks, recreational areas, public parking lots, and sports stadiums. Recharging a typical EV can take 3.5 to 7 hours. Charging equipment and installation vary widely, but can cost about $6,500 in public or less than $2,000 at home.

DC fast charging has power levels up to 90 kW, though stations typically only provide power at a rate up to 50 kW. It provides rapid battery recharging in a somewhat similar timeframe as refueling a conventional gasoline powered vehicle. It is intended to enable long distance EV travel and accommodate EV owners without access to convenient, daily charging at home or the workplace. These charging stations are often located where drivers are expected to spend less than 30 minutes, such as along the roadway, similar to a gasoline station. Charging equipment and installation can cost more than $90,000.

All EVs can accept a Level 2 charge because they are currently equipped with a common connector, the Society of Automotive Engineers (SAE) J1772, which will fit a plug from a Level 2 charging station. However, DC fast chargers will not work with all EVs because of competing technology among equipment manufacturers. There are three different types of DC fast chargers, each with a unique plug designed for a different make of EV.

- CHAdeMO: developed by an association of Japanese companies and used by Nissan and Mitsubishi. As of June 2014, all of the DC fast chargers in Washington were CHAdeMO except for the Tesla Superchargers.
- SAE J1772 Combo: developed and adopted by the Society of Automotive Engineers in conjunction with the J1772 connector standard used for Level 2 charging and used by most American and European automakers. There were no SAE J1772 Combo charging stations in Washington as of June 2014.
- Tesla: a proprietary technology developed by Tesla Motors that is currently only compatible with Tesla vehicles.

This study makes several assumptions about EV driving ranges and charging capabilities for this study. For example, an EV can be expected to travel 3.5 miles with each kilowatt-hour (kWh) of energy delivered to its batteries, equivalent to charging the vehicle at 1 kilowatt (kW) for an hour. Charging a vehicle at 30 kW for 30 minutes provides about 50 miles of range. Thus, the higher the power the charging station provides to the vehicle, the faster the vehicle's batteries can recharge.

The study used maps to analyze the expected travel range of vehicles as they left a particular charging location, and the expected risk that vehicles will not be able to access that charging location because it had no additional use capacity or was otherwise unavailable. Circles were drawn around each charging location to provide an estimate of electric miles traveled after recharging the vehicle's battery.

FIGURE 4: Charging Levels Explained

There are three kinds of EV charging: AC Level 1, AC Level 2, and DC Level 2. This study considered only AC Level 2 and DC Level 2. Throughout this study, AC Level 2 is referred to as Level 2 and DC Level 2 is referred to as DC fast charging.

Low—AC 120V "AC" LEVEL 1	Medium—AC 240V "AC" LEVEL 2	High—DC Fast Charge "DC" LEVEL 2
• Uses standard outlet • Power requirements similar to a toaster • Up to 1.4 kilowatts • Adapter comes with the car • Accommodates average daily driving needs • Very low cost installation, often free • Fully charge a Nissan LEAF: 17 hours	• Requires high-voltage circuit • Power requirements similar to an electric clothes dryer • Up to 19.2 kilowatts • Equipment & installation costs vary widely (~$6,500 in public and ~$2,000 at home) • Fully charge a Nissan LEAF in 3.5–7 hours	• Requires very high voltage circuit & 3-phase power • Power requirements are up to max power for 15 homes • Up to 90 kilowatts • No common standard for electric vehicles (CHAdeMO, SAE, Tesla) • Very high equipment & installation cost (~$90,000) • Equipment costs vary widely • 80% charge a Nissan LEAF less than 30 minutes

Source: SAE. 2011. SAE Charging Configurations and Ratings Terminology. Accessed September 21, 2014. http://www.sae.org/smartgrid/chargingspeeds.pdf.

- For DC fast charging, circles are calculated assuming 30 minutes of charging at a conservative 30 kW. This results in a circle with a radius of 40 miles.
- For Level 2 charging, circles are calculated assuming 90 minutes of charging at 6.6 kW. This results in a circle with a radius of 28 miles.

The circles drawn along a travel corridor provide a means of assessing charging location density and travel risk. That is, the darker the circles, the more charging locations in an area, resulting in reduced risk of individual station outages or unexpected wait times. In assessing the viability of the charging network, redundancy and reduced risk are keys to overcoming consumers' fear of exhausting the vehicle's battery energy either during the course of a trip or in additional driving required to find a station. Station outages are an important consideration in Washington, as it has experienced issues with the reliability of the Blink Network stations.[4] EV drivers could be discouraged from traveling far outside their home if they experience station outages on a consistent basis. See **Figure 5** for an example map of assessing EV travel.

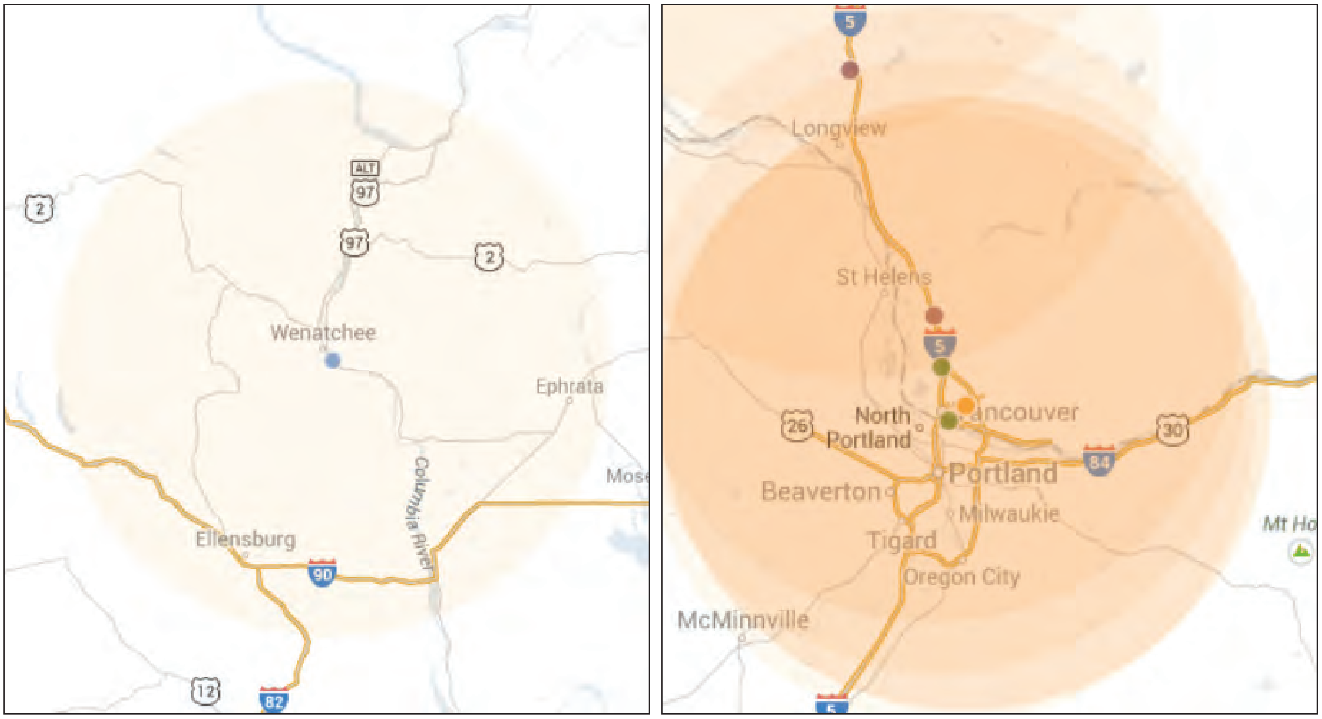
One measure of the effectiveness of station siting and the need for additional stations is the utilization of a charging station—the share of time a station is charging a vehicle. As the use of charging stations increases and charging congestion becomes an issue, drivers will face greater risk of extended overall trip times as they wait to charge their vehicle. If a station has a low utilization, it is possible that an additional station in that location will be unnecessary.

Utilization is not the only metric to evaluate effective charging siting and, depending on the stakeholder's point of view, it may not be the most important metric. For example, some stations will not be used frequently because they are intended to facilitate travel to rural parts of the state.

However, utilization can help assess the business case for charging stations when the business model's success depends on delivering energy at an expected frequency (e.g., a pay-per-use station). For those business models to be effective, the station utilization must meet the expectations the business defined to its investors before the station was installed.

FIGURE 5: Expected Travel Range of a Charging Location

The circles in these images show the expected range of travel from a charging location at a glance. The image on the left shows there are no other charging stations within a 40-mile radius of a single charging location (blue dot) in Wenatchee. The image on the right shows five charging locations around Vancouver, Washington, each with a circle showing a of 40-mile radius. The circles around each charging station overlap, indicating that there are multiple stations within the specified radius, and demonstrating a greater likelihood that one or more charging locations will be available in that area.



Source: C2ES

For this study, the following formula was used to separately calculate Level 2 and DC fast charging station utilization in the analyses presented in Chapters 2 and 3:

$$\text{Utilization\_Percent} = \frac{\text{Time\_Charging\_Vehicle}}{\text{Days\_in\_Month} \times \text{Expected\_Hours\_in\_Operation} \times \text{Charging\_Count}}$$

Where

- *Time_Charging_Vehicle* is the number of hours the charging station is delivering power to the vehicle in a month in a ZIP code.
- *Expected_Hours_in_Operation* is eight, the number of hours a charging station could be expected to be in use in a 24-hour period, assuming it is sited at a typical public location.
- *Charging_Count* is the total number of charging locations (DC fast charging) or ports (Level 2) that provided energy in a month in a ZIP code.

For example, five charging stations in Longview charged vehicles for 128 hours in May and 186 hours in June. Using the formula above, Longview had a utilization rate of 10.3 percent in May and 15 percent in June.

The level of utilization required to meet the expectations of investors depends on the price of the charging services and the cost of installation and operation of the charging equipment. Although investors would not expect a station to have near-100 percent utilization, a station may need to be used multiple times a day in order to be profitable. In Chapters 2 and 3, ranges of utilization and their effects on the profitability of a charging project are explored in detail.

1.5 DC FAST CHARGING NETWORK ASSESSMENT

The DC fast charging network in Washington provides access to charging along much of the I-5 corridor and in King County, but DC fast charging is unavailable in much of the state. Drivers dependent on the DC fast charging network will not be able to travel east of Ellensburg and Wenatchee on I-90 and U.S. 2. Other areas inaccessible to drivers dependent on DC fast charging include the Pacific coast, Spokane, and Walla Walla. This means that segments of I-90, U.S. 395, I-82, and Route 12, which have moderate daily traffic, also have an insufficient number of DC fast charging locations.

There were 40 DC fast charging locations in Washington as of June 2014.[5] Charging locations are concentrated where EVs are registered and where vehicle traffic is heaviest, with the exception of segments of I-5 and U.S. 2. See **Figure 6** for a map of all DC fast charging locations, EV registrations, and daily traffic.

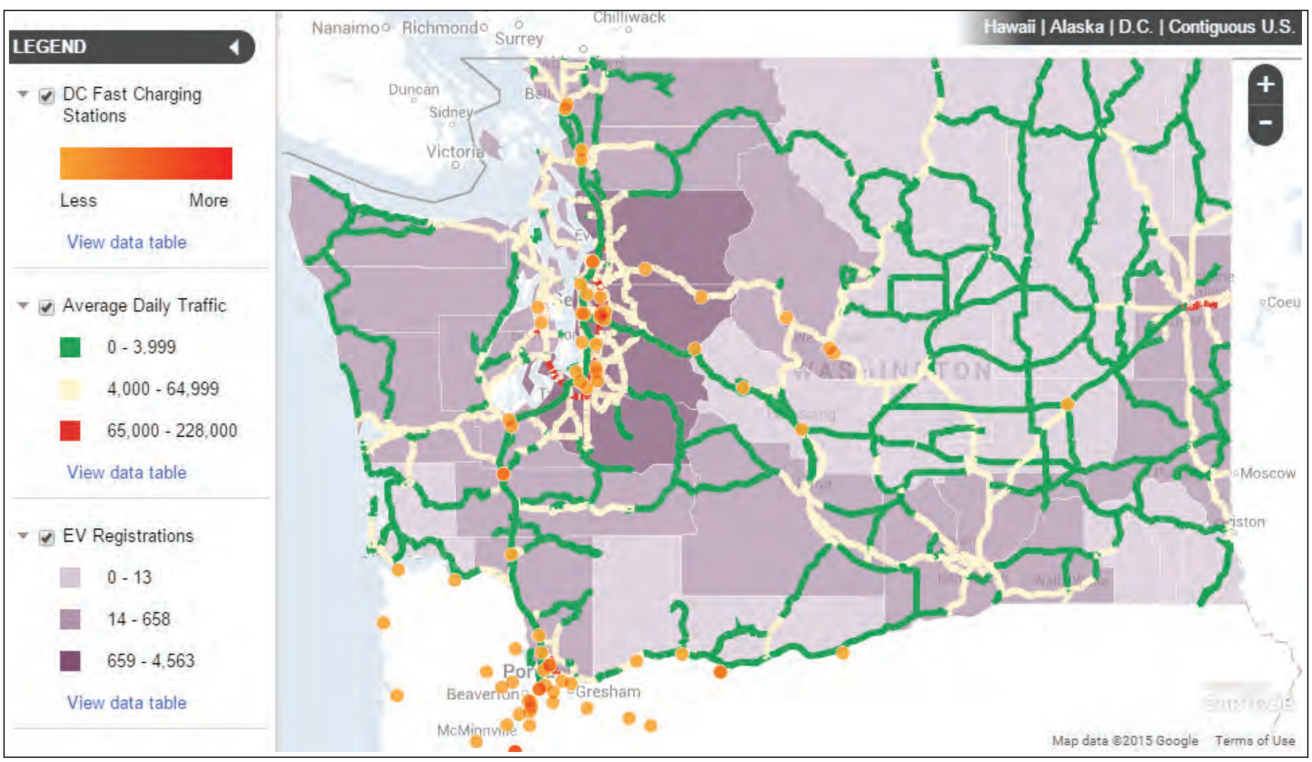
Although many locations include more than one DC fast charging port, only Tesla enables more than one vehicle to charge at a time.[6] For other providers, charging is limited to the number of locations rather than the number of charging ports. This means that drivers looking to “charge and go” run the risk of having to wait for an extended period if a charging port is occupied. Additionally, in cases where only one port or station is found within a county, drivers run the additional risk of finding themselves stranded without power if the station is out of service.

The Washington State Department of Transportation and Department of Commerce funded the installation of charging locations operated by the AeroVironment Network primarily with federal funds. The locations for the AeroVironment stations were picked to complement other planned DC fast charging locations around Puget Sound (operating on the Blink Network) to enable travel to more destinations in the state. Publicly available

---

FIGURE 6: DC Fast Charging Network Intensity Map as of June 2014

In Figure 6, DC fast charging stations are shown in orange, while major roadways are shown in green, yellow, or red depending on average daily traffic. Large segments of many major roadways do not have any publicly available DC fast charging.



Source: C2ES. 2014. DC Fast Charging Network in Washington State. August. Accessed September 21, 2014. http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/maps/wa-dc-fast-charging-network.

charging locations include private retail locations such as shopping malls, restaurants, and fueling stations in addition to two "gateway" safety rest areas along I-5.[7]

The Blink Network was funded in part by a federal grant through the American Recovery and Reinvestment Act. As with AeroVironment charging stations, stations on the Blink Network currently support only the CHAdeMO fast charging standard. Charging locations operating on the Tesla Network can only be accessed with Tesla EVs presently.

AeroVironment and Blink make up 65 percent of the DC fast charging locations. Blink Network stations are concentrated in King County while AeroVironment Network stations are spread throughout 10 counties (see **Table 2**).

King County (Seattle) has the largest concentration of stations with 30 percent of total locations and 28 percent of total charging ports. The Blink Network operates 9 of 12 locations in King County, while three are operated by Nissan dealerships.

DC fast charging is very accessible in King County. There is significant redundancy in charging locations within the expected range of a DC fast charging station. As a result, drivers will likely have more confidence that DC fast charging station in and around King County will be available when needed, though the large number of EVs in King County could lead to wait times.

The publicly funded charging locations along the I-5, U.S. 2, and I-90 corridors were intended to enable travel from Bellingham to Vancouver (north to south along I-5), Everett to Wenatchee (west to east along U.S. 2), and Seattle to Ellensburg (west to east along I-90). When traveling away from King County along I-5, I-90, and U.S. 2, however, the network becomes less dense, with only a single charging location connecting some portions of the roadway. The lack of redundant charging in these areas could discourage some drivers from making trips, or could prolong trips due to station outages or excessive wait times. As one travels toward the Oregon border along I-5 the density of DC fast charging locations

TABLE 2: DC Fast Charging Network Summary

This table shows the number of charging locations in each county. Values in parentheses are the total number of charging ports at these locations.

COUNTY	AEROVIRONMENT NETWORK	BLINK NETWORK	CHARGEPOINT NETWORK	OTHER OR NONE	TESLA NETWORK	TOTAL LOCATIONS (PORTS)
Chelan	2 (2)					2 (2)
Clark	1 (1)	2 (4)	1 (1)	1 (1)		5 (7)
Cowlitz	1 (1)					1 (1)
Douglas			1 (1)			1 (1)
King	1 (1)	9 (18)	1 (1)	1 (1)		12 (21)
Kitsap		2 (4)				2 (4)
Kittitas	2 (2)				1 (5)	3 (7)
Lewis	1 (1)				1 (10)	2 (11)
Pierce		1 (2)	1 (1)			2 (3)
Skagit	1 (1)				1 (8)	2 (9)
Snohomish	1 (1)		1 (1)	2 (2)		4 (4)
Thurston	1 (1)		1 (1)			2 (2)
Whatcom	1 (1)			1 (1)		2 (2)
Total Locations (Ports)	**12 (12)**	**14 (28)**	**6 (6)**	**5 (5)**	**3 (23)**	**40 (74)**

Source: U.S. Department of Energy (DOE). 2014. Alternative Fuels Data Center. http://www.afdc.energy.gov.

increases again; DC fast charging stations are accessible in and around Vancouver.

Notably, there is very little connectivity for the DC fast charging network outside of I-5 and parts of U.S. 2 and I-90. Although these areas are less traveled than the roadways around Seattle on average, access to these parts of the state is an essential component to an adequate DC fast charging network. No DC fast charging exists east of Ellensburg and Wenatchee on U.S. 2 and I-90, meaning east-west travel across the entire state for most BEVs is not possible using DC fast charging stations. There are also no DC fast charging stations in or around Spokane. Access to the Pacific coast is also severely limited due to a lack of DC fast charging stations west of Centralia and Olympia. In addition, segments of I-90, U.S. 395, I-82, and Route 12 have moderate daily traffic, ranging from 6,000 to more than 20,000 vehicles, but have few or no DC fast charging locations.[8] See **Figure 7** for a map that informed the assessment of DC fast charging access.

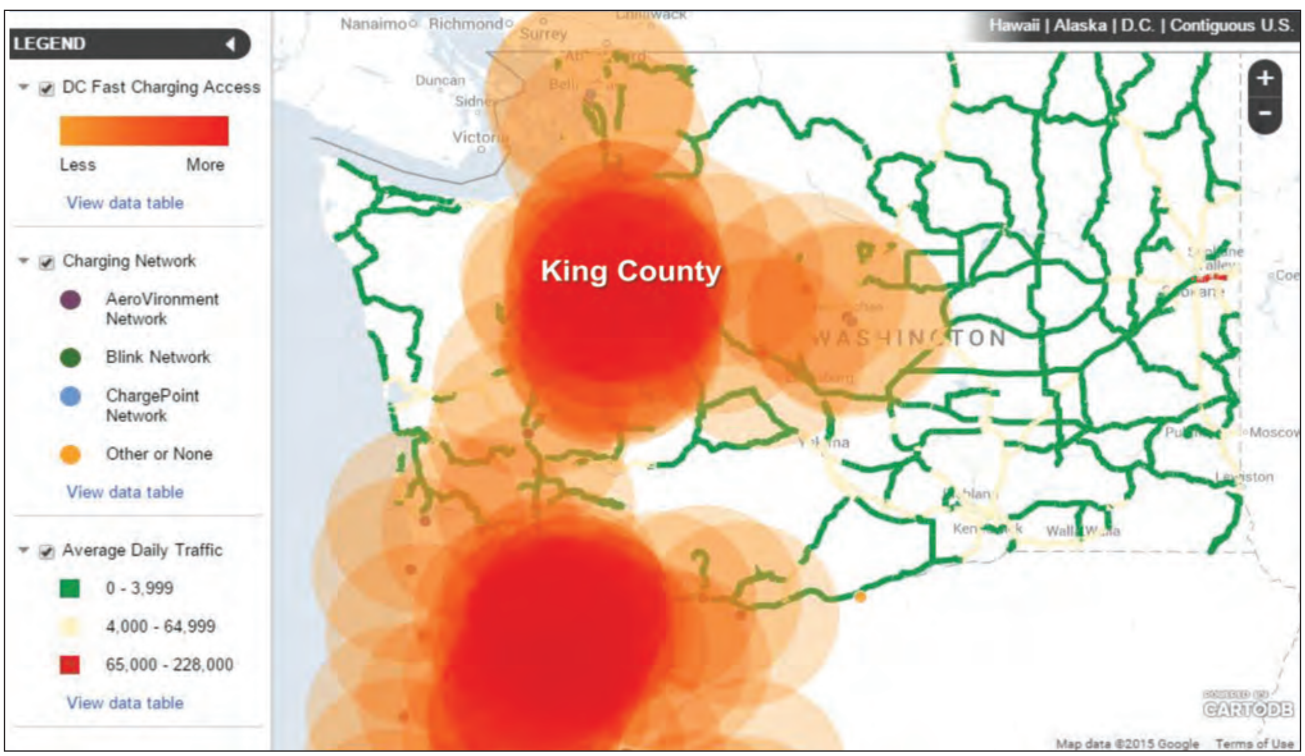
1.6 LEVEL 2 CHARGING NETWORK ASSESSMENT

The Level 2 charging network in Washington provides EV charging access in King County, but does not provide access in much of the rest of the state outside of Vancouver. Seventy-four percent of ZIP codes in the state, covering 44 percent of the population, have no Level 2 charging stations. As a result, many possible destinations for drivers may be inaccessible to BEVs.

> ***Despite having one of the most extensive Level 2 charging networks in the United States, Washington's Level 2 charging network may not be enough to accommodate its current EV fleet. Studies have suggested one Level 2 charging port is needed for every 2.5 EVs. Washington has 11 EVs for every Level 2 charging port.***

FIGURE 7: DC Fast Charging Access as of June 2014

This figure shows that DC fast charging is very accessible in King County. The dark orange circles indicate significant redundancy in charging locations within the expected range of a DC fast charging station. As a result, drivers have greater choice and confidence in the availability of DC fast charging in and around King County.



Source: C2ES. 2014.

Although Level 2 and DC fast charging complement each other, the assessment below assumes that Level 2 charging stations power all miles traveled by both BEVs and PHEVs.

Level 2 charging can play an integral role at trip destinations because it provides energy to an EV at a rate that requires several hours to fully recharge. Drivers are unlikely to use Level 2 charging stations to travel along highway corridors because of these long charging times. Instead, these charging stations are typically located in places where drivers are expected to charge for longer than an hour (e.g., shopping malls and other retail outlets, workplaces, and public parking garages). For example, Plug-in North Central Washington has a program to promote EV tourism by facilitating the installation of Level 2 charging stations at businesses throughout the region.[9]

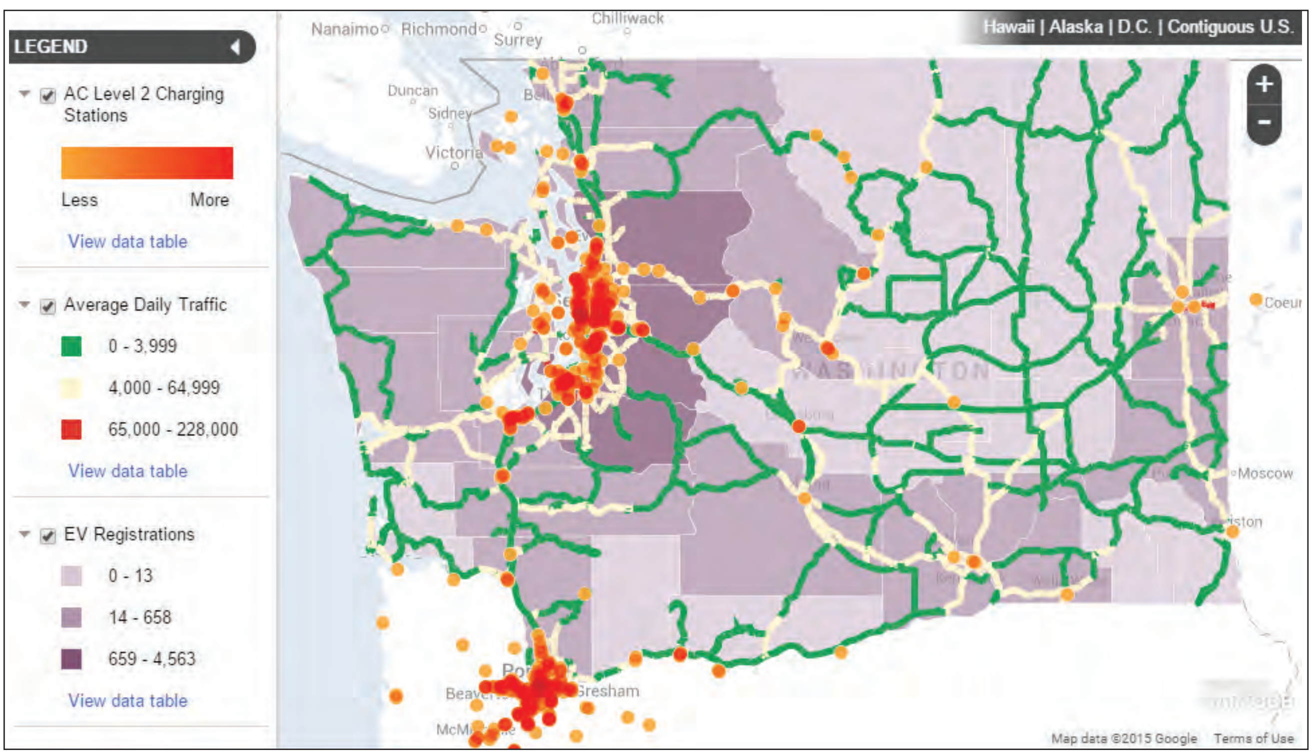
Even though Washington has one of the most extensive Level 2 charging networks in the United States, it may not be enough to accommodate the current EV fleet in the state. There are 414 Level 2 charging locations with 891 charging ports. See **Figure 8** for a map of all Level 2 charging locations, EV registrations, and daily traffic.

Unlike DC fast charging stations, most Level 2 locations can charge more than one vehicle at a time. There are 23 EVs for every Level 2 publicly available charging location or 11 EVs for every Level 2 charging port. These ratios indicate far less publicly available charging is available than studies have suggested would be necessary to provide adequate publicly available charging. For example, the National Research Council's 2013 report Transitions to Alternative Vehicles and Fuels assumed one Level 2 charging port would be needed for 2.5 EVs.[10]

The Blink and ChargePoint networks have nearly the same number of charging locations and ports, each making up 36 and 35 percent of the network,

FIGURE 8: Level 2 Charging Network Intensity Map as of June 2014

This figure shows Washington's Level 2 charging network is concentrated in the Puget Sound Region and in the Vancouver, Washington, area. Large segments of many major roadways do not have any publicly available Level 2 charging. Major roadways are denoted by green, yellow, and red colors depending on the average daily traffic.



Source: C2ES. 2014.

respectively. AeroVironment only has 15 charging locations, which complement the DC fast charging stations installed in partnership with the Washington State Department of Transportation.

King County contains 57 percent of the Level 2 locations, but only 29 percent of total population. This is likely the result of King County having 54 percent of the registered EVs in the state. Similar to the DC fast charging network, drivers in King County have access to numerous Level 2 charging stations. The existence of redundant charging locations in the same area improve the likelihood a driver can access a publicly available charging station. However, drivers may be required to wait to charge if utilization at these stations is high. See **Figure 9** for a map that informed the assessment of Level 2 charging access.

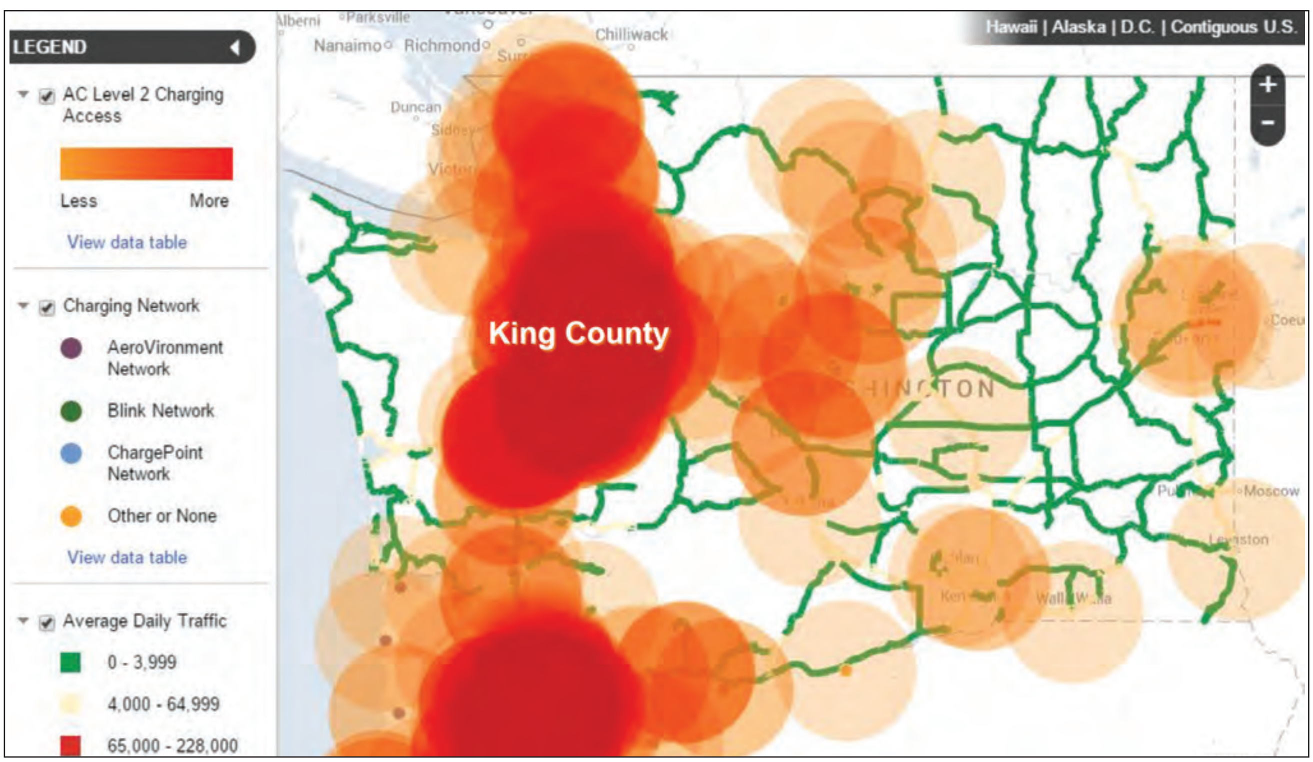
Level 2 charging stations are typically located in places where drivers are expected to spend longer than an hour. On a daily basis, drivers typically stay close to where they live, so locating publicly available charging near where EVs are registered is sensible to extend daily travel beyond what home charging can provide.

Of the ZIP codes in Washington with an EV registered, 59 percent do not have a Level 2 charging station. In fact, there are eight ZIP codes in the Seattle area with more than 50 EVs registered and no Level 2 charging stations (see **Table 3**). **Figure 10** highlights the relevant ZIP codes around Seattle.

Many locations throughout the state have no Level 2 charging stations. In counties constituting 25 percent of Washington's population, there are less than five Level 2 charging ports. EV drivers may be unable to travel to these locations.

FIGURE 9: Level 2 Charging Access as of June 2014

This figure shows drivers in King County have access to numerous Level 2 charging stations. The deep orange color indicates there are redundant charging locations in the same area, increasing driver choice and improving the likelihood a driver can access a publicly available charging station.



Source: C2ES. 2014.

TABLE 3: ZIP Codes with More than 50 EVs and No Public Level 2 Charging Stations

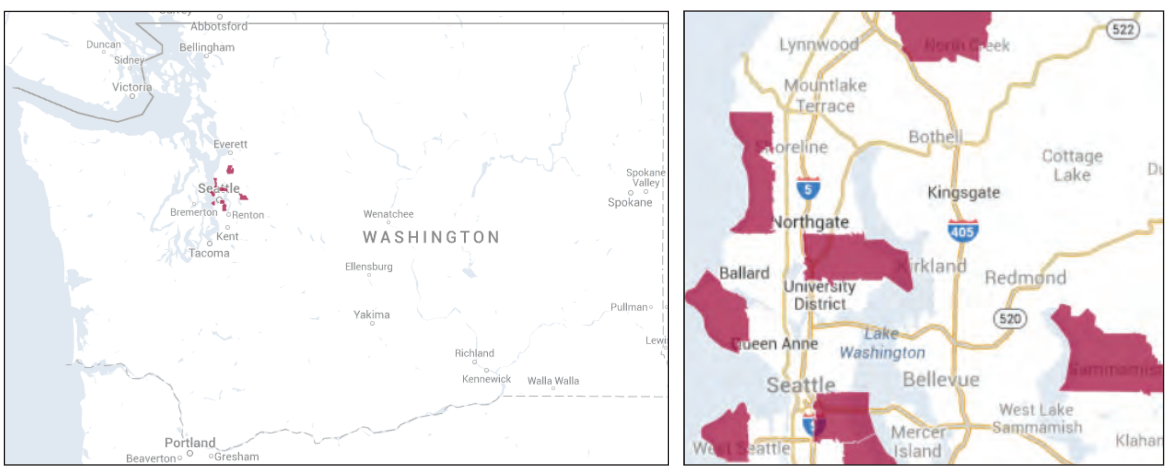
The ZIP codes below have no publicly available Level 2 charging station as of June 2014. The vehicle counts in this table are through December 2013.

ZIP CODE	PRIMARY CITY	COUNTY	BEVs REGISTERED	PHEVs REGIS-TERED	EVs REGISTERED
98012	Bothell	Snohomish	63	38	101
98074	Sammamish	King	118	18	136
98115	Seattle	King	122	35	157
98116	Seattle	King	41	20	61
98118	Seattle	King	38	13	51
98144	Seattle	King	44	18	62
98177	Seattle	King	52	19	71
98199	Seattle	King	45	14	59

Source: Washington State Department of Licensing, U.S. DOE. 2014.

FIGURE 10: ZIP Codes around Seattle with More than 50 EVs and No Public Level 2 Charging Stations

The image on the left shows ZIP codes with 50 or more EVs registered as of June 2014 and no Level 2 charging stations. The image on the right is zoomed in to show the ZIP code location in more detail.



Source: Washington State Department of Licensing, U.S. DOE. 2014.

1.7 BEV TRAVEL ALONG KEY WASHINGTON STATE CORRIDORS

This section simulates travel for BEVs in six key traffic corridors in Washington, including five simulations along heavily traveled Interstates 5 and 90, and one simulation from the state's capital, Olympia, to the Pacific Coast. The purpose of these simulations is to evaluate an EV driver's ability to travel using the existing publicly available charging network.

Drivers in the United States generally drive less than 30 miles per day.[11] As such, daily driving needs for EV drivers can often be met with a single charge at home or at work. However, longer trips from home require publicly available charging infrastructure to extend the travel range of EVs and to reduce EV drivers' "range anxiety," which is the fear of running out of power and being stranded along the road. Adequate charging infrastructure serves to mitigate range anxiety concerns.

EV travel throughout Washington is contingent on EV battery capacity and the availability of publicly available charging stations along key travel corridors. EVs with longer electric-only ranges are more likely to complete trips with the current charging infrastructure. Other than the Tesla Model S, no BEVs on the road today can travel more than one hundred miles on a single charge. For many of the travel simulations, BEVs with shorter ranges could not complete the trip. These trips include traveling to the Pacific Coast from the Puget Sound region, traveling to Spokane along I-90, and traveling to the Tri-Cities and Walla Walla region from either Seattle or Spokane. And even when trips were possible, such as along I-5 from Seattle to Portland, Oregon the travel time is longer for a BEV than a gasoline vehicle because of the time required to recharge the vehicle.

Overview of Travel Simulation

Evaluations on EV travel were completed using Google Maps and the U.S. Department of Energy's Alternative Fuel Data Center listing of publicly available charging stations (accessed June 2014). Travel was simulated along six routes in Washington to gauge coverage of existing publicly available charging stations for BEVs. The simulations identified:

- Whether travel was possible along these routes, using the Level 2 charging network or the DC fast charging network;
- Areas with high charging station density, low charging station density; and
- Noticeable coverage gaps that would be critical to completing travel along the preferred routes.

The simulations examined travel along the following routes:

- I-5 between Seattle and Portland, I-5 between Seattle and Bellingham;
- I-90 between Seattle and Spokane;
- I-90 and I-82 between Seattle and Walla Walla, I-90, US-395, and US-12 between Spokane and Walla Walla; and
- State Route 8 and US-12 between Olympia and Ocean Shores.

Each route is analyzed in three segments, in order to assess publicly available charging station density along each segment of the route, and to identify noticeable coverage gaps along the route.

Travel Simulation Assumptions

The simulations used three examples of BEVs: a BEV-40 with a range up to 40 miles, a BEV-80 with a range up to 80 miles, and a BEV-200 with a range up to 200 miles. These BEVs are meant to be illustrative and are not intended to reflect current options in the marketplace. Importantly, only Tesla Motors offers a BEV with a range of 200 miles or more at the time of this study, so conclusions drawn in the simulations do not reflect experiences of most BEV drivers in Washington.

PHEV are not included in these simulations because they do not have the same range issues as a BEV. Since PHEVs have both a battery and a gasoline-powered internal combustion engine, they do not depend as much on publicly available charging infrastructure as BEVs. The analysis also focused on BEVs because they are so prevalent in Washington, with nearly two BEVs for every PHEV.

For travel along these routes, the BEVs were assumed to start the trip with a full charge and follow the speed limit. In most instances in the simulations, a BEV stopped to recharge the battery before it reached a 20 percent state of charge. The 20 percent state of charge was used to account for range anxiety and other external factors, such as elevation changes and the use of air-conditioning and heating in the vehicle. At each charging station, the BEVs charged only enough to make it to the next charging stop or final destination in order to minimize charge time. BEVs reached the final destination with a 20 percent state of charge.

Under these simulations, BEVs made exclusive use of either the DC fast charging network or the Level 2 charging network to recharge. In some instances, the BEV charged above 80 percent battery capacity (the state of charge when a DC fast charging station begins to charge more slowly) or the BEV battery dropped below a 20 percent state of charge to travel to the next charging station. The simulations assumed DC fast charging stations had a power output of 30 kW and Level 2 charging stations had a power output of 6.6 kW.

For each route and vehicle type, the simulations determined the actual distance of the trip, the number of charging station stops, the minimum charge time based on the number of charging stops, and total drive time under normal traffic conditions. The total trip time was calculated as the sum of driving time and charge time.

The publicly available charging infrastructure along any route was considered adequate as long as a BEV driver could complete travel along the route relying only on the publicly available charging network.

Simulation 1: Travel between Seattle and Portland along I-5

The route along I-5 between Seattle, Washington and Portland, Oregon was divided into three parts. The northern segment connected Seattle and Olympia, the middle segment connected Olympia and Ridgefield, and the southern segment connected Ridgefield and Portland.

Publicly available charging infrastructure is in place to complete travel between Seattle, Washington and Portland, Oregon in all simulations. The total trip time along the preferred route was longer for BEVs than a gasoline-powered vehicle because of the time required to charge the vehicle (see **Table 4**). A gasoline-powered vehicle took 2.8 hours to travel 173 miles on I-5 between Seattle and Portland. The total trip time for BEVs using the DC fast charging network ranged from 3.2 to 4.5 hours, and the charge time ranged from 4 to 31 percent of total time. Trips using the DC fast charging network were 22 minutes to 1.6 hours longer than a trip made with a gasoline-powered vehicle.

The total trip time for EVs using the Level 2 charging network ranged from 3.7 to 9.5 hours, and the charge time ranged from 17 percent to 67 percent of total drive time. The total trip was 51 minutes to 6.7 hours longer than a trip made with a gasoline-powered vehicle.

The high concentration of publicly available charging locations along the northern and southern segments of the route enables BEVs to travel along these segments

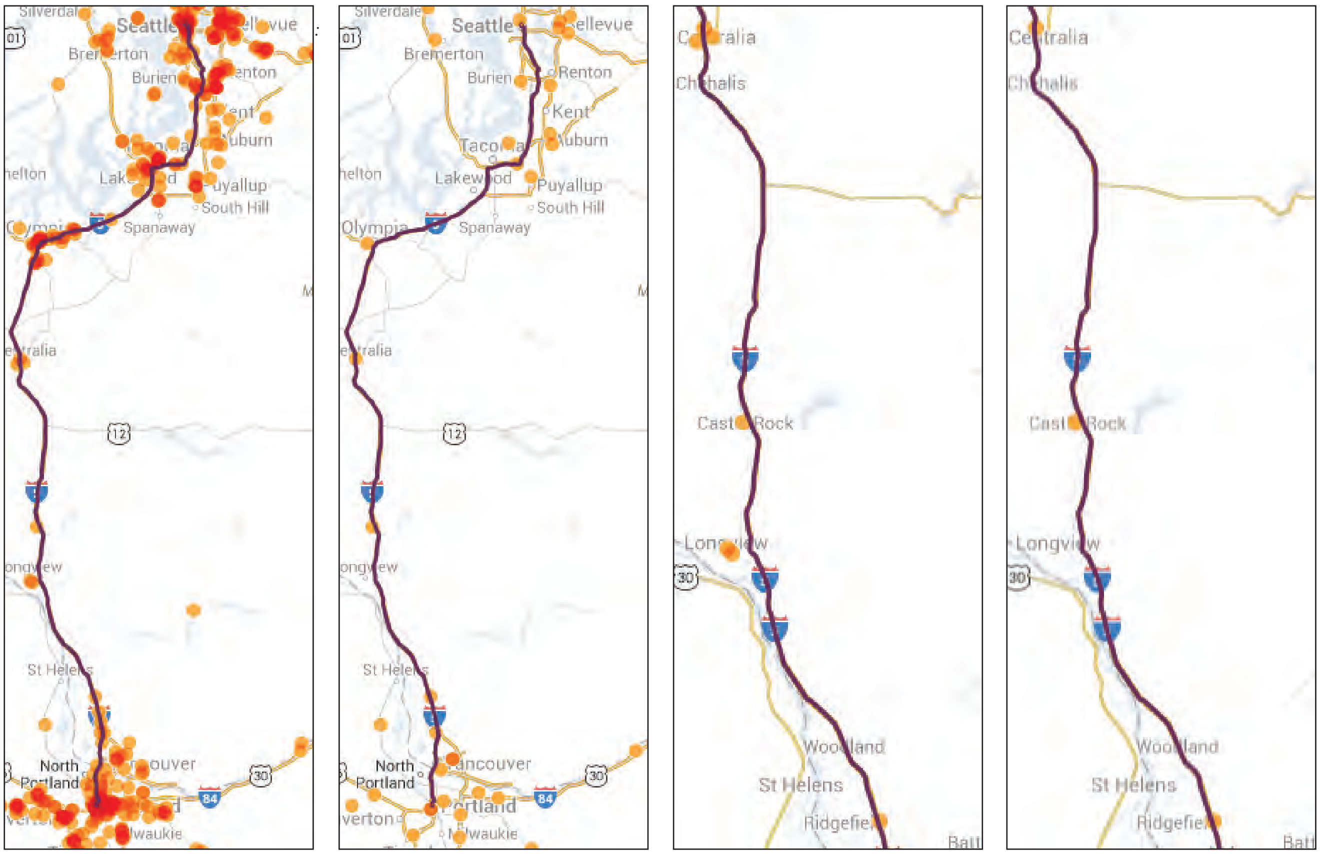
TABLE 4: Travel between Seattle, Washington and Portland, Oregon

This table shows travel time for four types of vehicles: gasoline-powered vehicles and BEVs with 40, 80, and 200 mile ranges. Total trip time was longer for BEVs than gasoline-powered vehicles because of charging time. BEVs with a larger battery capacity had to make fewer charging stops and generally spent less time charging. All BEVs simulated were able to complete travel between Seattle and Portland.

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	173	N/A	170	N/A	170
DC Fast Charging	BEV-40	178	5	184	83	267
DC Fast Charging	BEV-80	175	2	184	64	248
DC Fast Charging	BEV-200	174	1	184	8	192
Level 2	BEV-40	179	4	188	381	569
Level 2	BEV-80	178	2	178	288	466
Level 2	BEV-200	174	1	184	37	221

FIGURE 11: Charging Locations between Seattle and Portland and between Centralia and Ridgefield

The figures on the left show existing Level 2 and DC fast charging locations, respectively, between Seattle and Portland. The figures on the right shows existing Level 2 and DC fast charging locations, respectively, along one segment of the trip, between Centralia and Ridgefield. View this map online at https://www.c2es.org/maps/wa-simulation-1.



of the route. There are 12 DC fast charging locations and 207 Level 2 charging locations in and around Seattle, and there are 5 DC fast charging locations and 20 Level 2 charging locations in and around Vancouver. All BEVs in the simulations were able to travel the upper and lower segments of the route without the vehicles' batteries dropping below a 20 percent state of charge.

The low number of publicly available charging locations in the middle segment of the route makes existing publicly available charging locations critical to completing the trip. There are 2 DC fast charging locations and 6 Level 2 charging locations along the middle segment of the route. As such, travel along this route for the BEV-40 and the BEV-80 was dependent on charging locations located in Castle Rock and Ridgefield.

Travel between Castle Rock and Ridgefield resulted in the BEV-40 dropping to a 10 percent state of charge. Installing additional charging locations between these two locations would allow the BEV-40 to travel this segment of the route and not drop below a 20 percent charge level. There is one DC fast charging station between Centralia and Ridgefield—located in Castle Rock—that was a critical stop for the BEV-80 to complete the trip. Installing additional DC fast charging locations between Centralia and Ridgefield would alleviate dependency on the one Castle Rock publicly available charging station for BEV-80 travel. The BEV-200 only needed to make one charging stop and is not reliant on publicly available charging locations in the southern segment of the route.

Simulation 2: Travel between Seattle and Bellingham along I-5

The route along I-5 between Seattle and Bellingham was divided into three parts. The northern segment connected Bellingham and Burlington, the middle segment connected Burlington and Everett, and the southern segment connected Seattle and Everett.

Publicly available charging infrastructure is in place to complete travel between Seattle and Bellingham in all but one scenario. The total trip time along the preferred route was longer for BEVs than a gasoline-powered vehicle because of the time required to charge the vehicle (see **Table 5**). A gasoline-powered vehicle took 1.5 hours to travel 90 miles on I-5 between Seattle and Bellingham.

The BEV-200 did not need to recharge on this trip. The BEV-80 completed the trip along the preferred route using the existing DC fast charging network. The total trip time for the BEV-80 was 1.7 hours. The charge time was 14 percent of the total drive time or 14 minutes longer than a trip made with a gasoline-powered vehicle. The BEV-40 could not complete the trip along the preferred route using the existing DC fast charging network.

The total trip time for the BEV-80 using the Level 2 network was 2.7 hours and the charge time was 42 percent of the total drive time. The total trip time for the BEV-40 was 4.1 hours and the charge time was 62 percent of total drive time. The trip was 1.2 to 2.6 hours longer than a trip made with a gasoline-powered vehicle for the BEV-80 and BEV-40, respectively.

The high concentration of publicly available charging locations in the southern segment of the route enables BEVs to travel along this segment of the route. There are 12 DC fast charging locations and 210 Level 2 charging locations in and around Seattle, and there are 2 DC fast charging locations and 2 Level 2 charging locations in and around Burlington. All BEVs in the simulations were able to travel the lower segment of the route without the battery dropping below a 20 percent state of charge.

The low number of publicly available charging locations located in the middle and northern segment of the route makes the charging stations located in the southern segment of the route critical to completing the trip. There are 2 DC fast charging stations and 5 Level 2 charging stations along the middle and northern segment of the route. The BEV-80 was able to complete this trip using the DC fast charging network as long as it charges between Burlington and Seattle. Conversely, the BEV-40 was unable to complete the trip because the distance between the Burlington and Everett DC fast charging station was greater than the vehicle's range. Installing additional DC fast charging locations between these two locations would allow the BEV-40 to complete travel along this route. There are an adequate number of Level 2 charging locations for the BEV-40 and BEV-80 to complete travel. However, installing additional charging locations between Burlington and Everett would allow the BEV-40 to make one less charging stop along this route. The BEV-200 would not need to make a charging stop when traveling the preferred route.

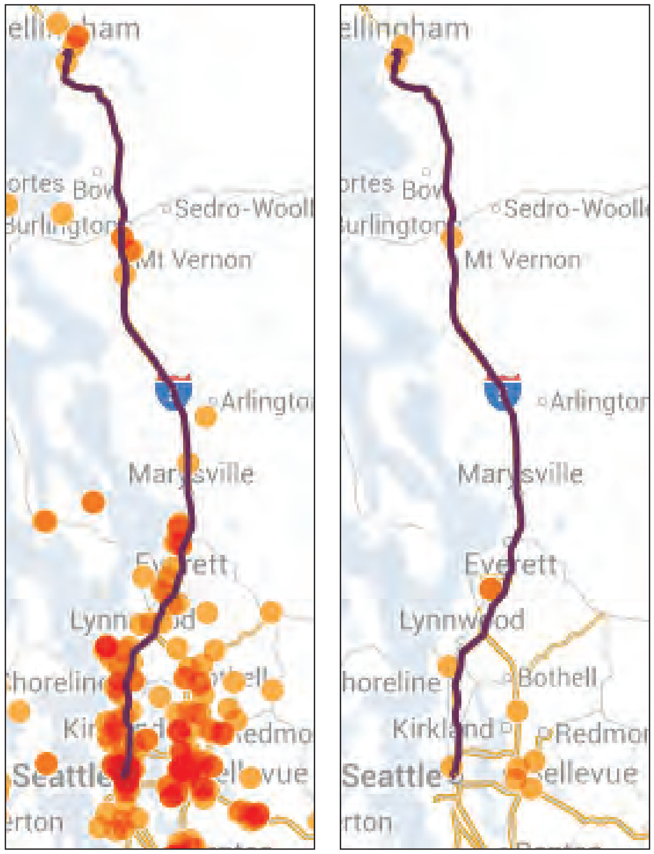
TABLE 5: Travel between Seattle and Bellingham

This table shows travel time for four types of vehicles: gasoline-powered and BEVs with 40, 80, and 200 mile ranges. Total trip time was longer for the BEV-40 and BEV-80 than for gasoline-powered vehicles because of charging time. All trip simulations were successful except the BEV-40 using the DC fast charging network, which is denoted with an "X."

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	89	N/A	90	N/A	90
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	89	1	89	14	103
DC Fast Charging	BEV-200	89	0	90	0	90
Level 2	BEV-40	90	3	94	152	246
Level 2	BEV-80	90	1	93	68	161
Level 2	BEV-200	89	0	90	0	90

FIGURE 12: Publicly Available Charging Locations between Seattle and Bellingham

The figure on the left shows existing Level 2 charging locations while the figure on the right shows existing DC fast charging locations between Seattle and Bellingham. View this map online at https://www.c2es.org/maps/wa-simulation-2.



Simulation 3: Travel between Seattle and Spokane along I-90

The route along I-90 between Seattle and Spokane was divided into three parts. The western segment connected Seattle and Cle Elum, the middle segment connected Cle Elum and Moses Lake, and the eastern segment connected Moses Lake and Spokane.

Existing publicly available charging infrastructure allows only a BEV-200 to complete travel between Seattle and Spokane. A gasoline-powered vehicle would take 4.2 hours to travel 279 miles on I-90 between Seattle and Spokane (see **Table 6**). The BEV-40 and the BEV-80 were unable to complete the trip between these two locations using the Level 2 charging network or DC fast charging network. The BEV-200 was able to complete the trip between Seattle and Spokane using the DC fast charging network, but it had to travel an additional 40 miles out of its way to charge at Wenatchee. It completed the trip with a 15 percent battery state of charge. The BEV-200 could not make a return trip from Spokane using the DC fast charging network, however, due to a lack of publicly available charging infrastructure.

The total trip time along the preferred route is longer for the BEV-200 than a gasoline-powered vehicle because of the time required to charge the vehicle and the additional travel to a charging station. For DC fast charging, the total trip time for the BEV-200 was 6.5 hours, and the charge time was 22 percent of the total drive time. The trip time was about 2.2 hours longer than a trip made with a gasoline powered vehicle. For Level 2 charging, the total trip time for the BEV-200 was 9.5 hours, and the charge time was 55 percent of the total drive time. The trip time was 5.3 hours longer than a trip made with a gasoline-powered vehicle.

TABLE 6: Travel between Seattle and Spokane

The BEV-200 was able to complete travel along this route. Total trip time was longer for the BEV-200 versus a gasoline-powered vehicle because of charging time and the additional travel to a charging station. The BEV-40 and BEV-80 were unable to complete travel between Seattle and Spokane due to a lack of publicly available charging locations, and is denoted with an “X.”

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	279	N/A	254	N/A	254
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	X	X	X	X	X
DC Fast Charging	BEV-200	318	2	302	85	387
Level 2	BEV-40	X	X	X	X	X
Level 2	BEV-80	X	X	X	X	X
Level 2	BEV-200	282	2	254	316	570

FIGURE 13: Publicly Available Charging Locations between Seattle and Spokane

The figure on the top shows existing Level 2 charging locations while the figure on the bottom shows existing DC fast charging locations between Seattle and Spokane. View this map online at https://www.c2es.org/maps/wa-simulation-3.

The high concentration of publicly available charging locations along the western segment of the route enables easy BEV travel. There are 12 DC fast charging locations and 210 Level 2 charging locations in and around Seattle. All BEVs in the simulations were able to travel the western segment of the route without the vehicles' battery reaching a 20 percent state of charge.

The low number of publicly available charging locations in the middle and eastern segment of the route prevents the BEV-40 and BEV-80 from completing the trip. There are 2 DC fast charging locations and 6 Level 2 charging locations along the middle and eastern segment of the route. There are no DC fast charging locations between Cle Elum and Spokane, and there are no Level 2 charging locations between Moses Lake and Spokane. Installing at least 6 DC fast charging locations and 6 Level 2 charging locations between Cle Elum and Spokane would allow the BEV-40, BEV-80, and BEV-200 to travel between Seattle and Spokane and not drop below a 20 percent charge level.

Simulation 4: Travel between Olympia and Ocean Shores along State Route 8 and U.S. 12

The route along State Route 8 and US 12 between Olympia and Ocean Shores was divided into three parts. The eastern segment connected Olympia and Elma, the middle segment connected Elma and Aberdeen, and the western segment connected Aberdeen and Ocean Shores.

Existing publicly available charging infrastructure hinders the BEV-40 from traveling between Olympia and Ocean Shores. The BEV-40 was unable to complete travel between these two locations using the Level 2 charging network or DC fast charging network (see **Table 7**). In addition, Ocean Shores lacks publicly available charging infrastructure, which could prohibit a return trip from Ocean Shores to Olympia.

The BEV-200 and BEV-80 were able to complete the trip between Olympia and Ocean Shores without having to use publicly available charging infrastructure. The total trip time along the preferred route was 1.5 hours and was equivalent to a gasoline-powered vehicle because the vehicles did not have to charge along the preferred route. However, the BEV-80 would reduce the battery state of charge to 7.5 percent versus the 20 percent used in other travel simulations.

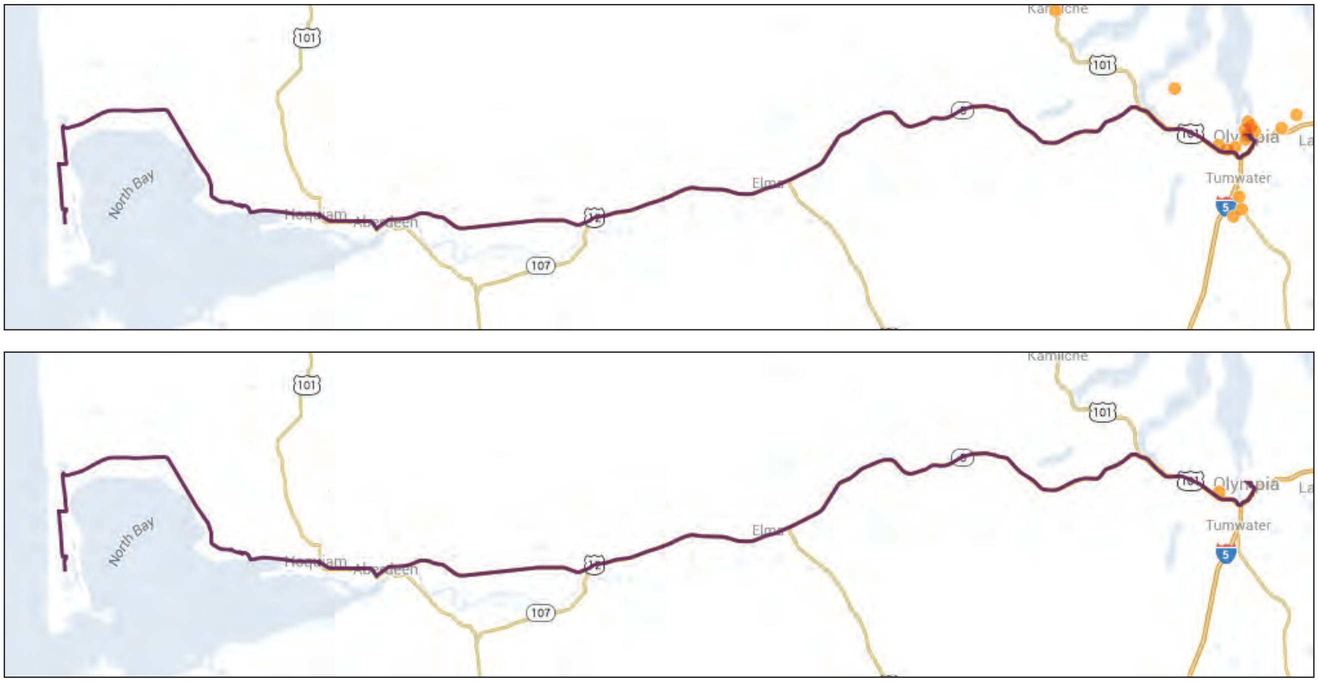
TABLE 7: Travel between Olympia and Ocean Shores

The BEV-200 was able to complete travel along this route. Total trip time was the same for the BEV-200 versus a gasoline-powered vehicle because it did not have to charge. The BEV-80 has the range to travel between these two locations, which will require the vehicle to go below the 20 percent state of charge threshold used in other simulations. The BEV-40 was unable to complete travel between Olympia and Ocean Shores due to a lack of publicly available charging locations, and is denoted with an "X."

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	75	N/A	88	N/A	88
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	75	0	88	0	88
DC Fast Charging	BEV-200	75	0	88	0	88
Level 2	BEV-40	X	X	X	X	X
Level 2	BEV-80	75	0	88	0	88
Level 2	BEV-200	75	0	88	0	88

FIGURE 14: Publicly Available Charging Locations between Olympia and Ocean Shores

The figure on the top shows existing Level 2 charging locations while the figure on the bottom shows existing DC fast charging locations between Olympia and Ocean Shores. View this map online at https://www.c2es.org/maps/wa-simulation-4.



Publicly available charging locations are concentrated in and around Olympia. There are two DC fast charging locations and 30 Level 2 charging locations in and around Olympia, and there are no DC fast charging locations nor Level 2 charging locations between Elma and Ocean Shores.

Additional charging locations are needed along this route for a BEV-40 and BEV-80 to complete round trip travel between Olympia and Ocean Shore. Installing at least two DC fast charging locations and two Level 2 charging locations between Elma and Ocean Shores would allow the BEV-40 and BEV-80 to travel between Olympia and Ocean Shores and not drop below a 20 percent charge level.

Simulation 5: Travel between Seattle and Walla Walla along I-90 and I-82

The route along I-90, I-82, and US-12 between Seattle and Walla Walla was divided into three parts. The western segment connected Seattle and Cle Elum; the middle segment connected Cle Elum and Grandview; and the eastern segment connected Grandview and Walla Walla.

Existing publicly available charging infrastructure only allows the BEV-200 to complete travel from Seattle to Walla Walla. The BEV-40 and the BEV-80 were unable to complete travel between these two locations using the Level 2 charging network or the DC fast charging network (see **Table 8**). The BEV-200 was able to complete travel between Seattle and Walla Walla using either network, but could not travel from Walla Walla to Seattle using the DC fast charging network.

The total trip time along the preferred route is longer for the BEV-200 than a gasoline-powered vehicle because of the time required to charge the vehicle. A gasoline-powered vehicle would take 4.2 hours to travel

TABLE 8: Travel between Seattle and Walla Walla

The BEV-200 traveling from Seattle to Walla Walla was able to complete travel along this route. Total trip time was longer for the BEV-200 versus a gasoline-powered vehicle because of charging time. The BEV-40 and BEV-80 were unable to complete travel between Seattle and Walla Walla due to a lack of publicly available charging locations, and is denoted with an "X."

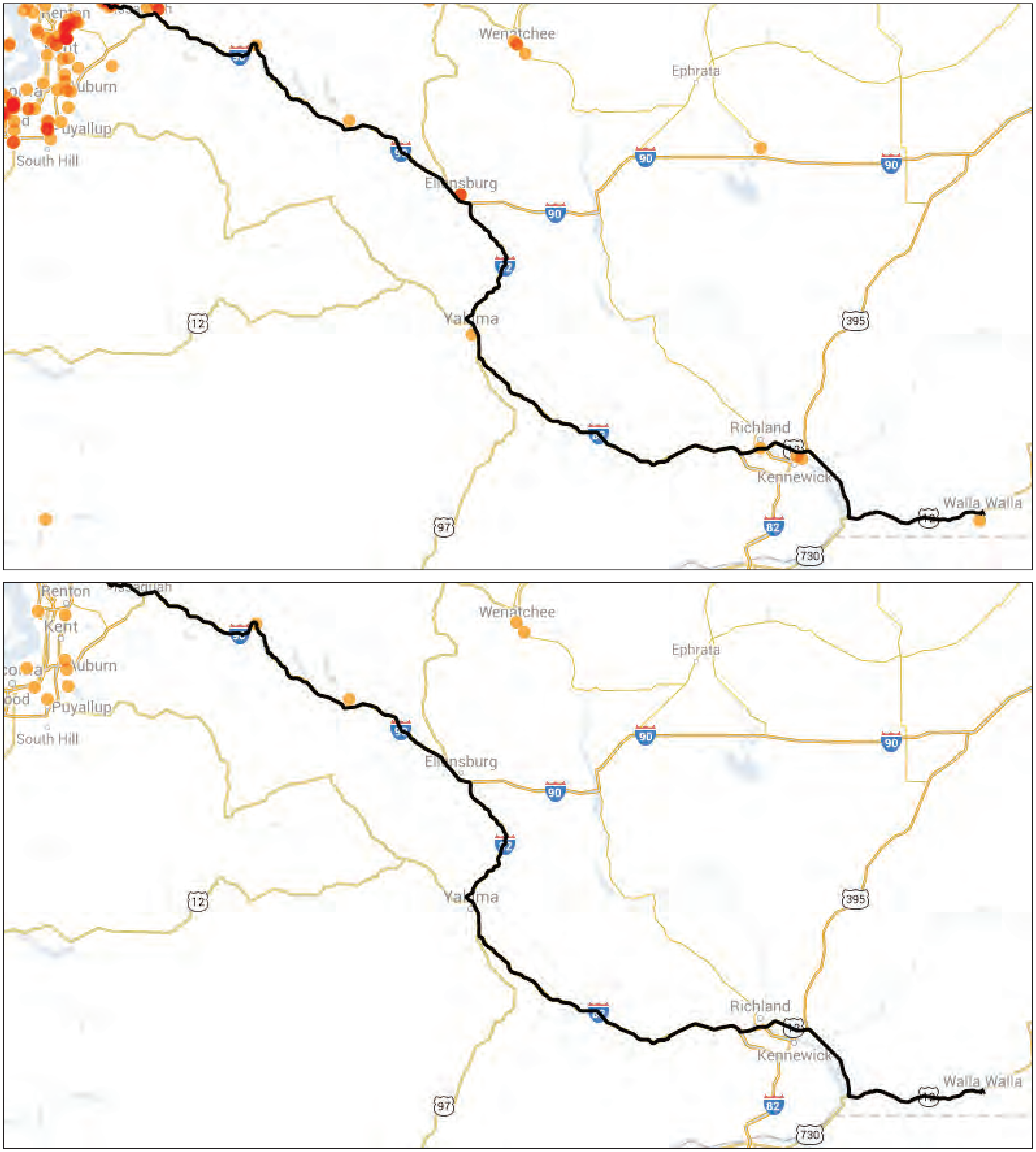
CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	272	N/A	243	N/A	254
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	X	X	X	X	X
DC Fast Charging	BEV-200	275	1	263	58	321
Level 2	BEV-40	X	X	X	X	X
Level 2	BEV-80	X	X	X	X	X
Level 2	BEV-200	273	1	255	280	535

272 miles on I-90 and I-82 between Seattle and Walla Walla. The total trip time from Seattle to Walla Walla for the BEV-200 using the DC fast charging network was 5.4 hours, and the charge time was 18 percent of the total drive time. The trip time was 1.1 hours longer than a trip made with a gasoline-powered vehicle. The total trip time between Seattle and Walla Walla for the BEV-200 using the Level 2 charging network was nearly 9 hours, and the charge time was about 52 percent of the total drive time. The trip time was 4.7 hours longer than a trip made with a gasoline-powered vehicle.

The low number of publicly available charging locations in the middle and eastern segment of the route prevents the BEV-40 and BEV-80 from completing the trip. There is one DC fast charging location and five Level 2 charging locations along the middle and eastern segment of the route. There are four DC charging locations and more than 80 Level 2 charging locations in the western segment of the route. Installing at least eight DC fast charging locations and four Level 2 charging stations between Ellensburg and Walla Walla would allow the BEV-40 and BEV-80 to travel between Seattle and Walla Walla and not drop below a 20 percent charge level.

FIGURE 15: Publicly Available Charging Locations between Seattle and Walla Walla

The figure on the top shows existing Level 2 charging locations while the figure on the bottom shows existing DC fast charging locations between Seattle and Walla Walla. View this map online at https://www.c2es.org/maps/wa-simulation-5.



Simulation 6: Travel between Spokane and Walla Walla along I-90, US-395, and US-12

The route along I-90, I-82, and US-12 between Spokane and Walla Walla was divided into two parts. The northern segment connected Spokane and Ritzville and the southern segment connected Ritzville and Walla Walla.

Existing publicly available charging infrastructure allows only the BEV-200 to complete travel from Spokane to Walla Walla. A gasoline-powered vehicle would take 2.7 hours to travel 180 miles on I-90, I-82, and US-12 between Spokane and Walla Walla (see **Table 9**). The BEV-40 and the BEV-80 were unable to complete travel between these two locations using the Level 2 charging network or the DC fast charging network. The BEV-200 has the vehicle range to travel 180 miles between Spokane and Walla Walla without having to use publicly available charging infrastructure. However, doing so would reduce the battery state of charge to 10 percent versus the 20 percent used in other travel simulations. The BEV-200 could not make the return trip from Walla Walla to Spokane using the DC fast charging network due to a lack of publicly available charging infrastructure in Walla Walla.

The low number of publicly available charging locations along the route prevents most BEVs from completing the trip. There are five Level 2 charging locations and no DC fast charging locations along this route. An additional DC fast charging station and Level 2 charging station in the northern segment along with two to three charging stations in the southern segment are required for the BEV-40 and BEV-80 to complete the trip.

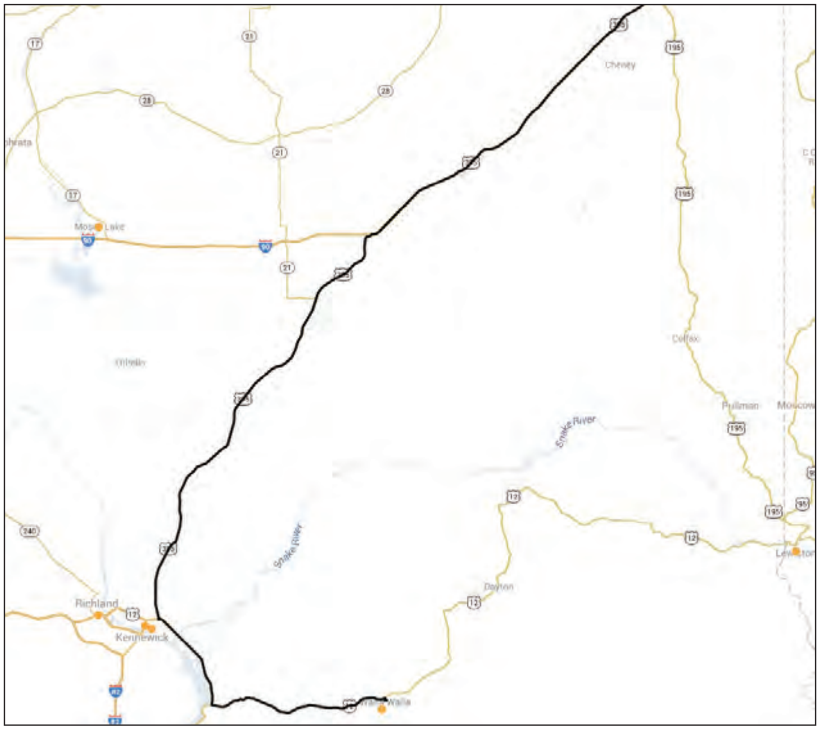
TABLE 9: Travel between Spokane and Walla Walla

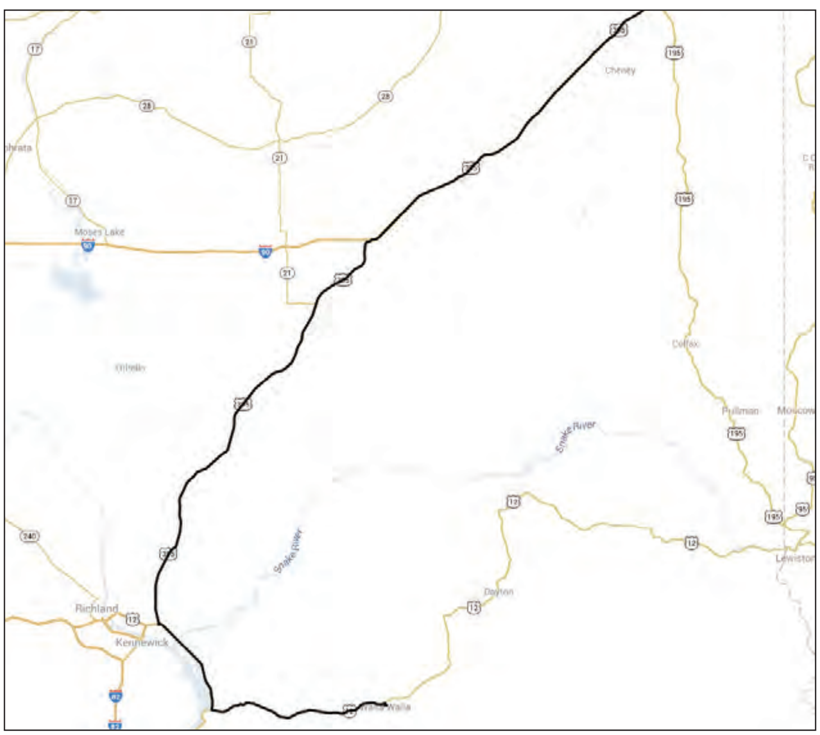
The BEV-200 was only able to complete travel along this route by traveling from Spokane to Walla Walla. The BEV-80 and BEV-40 were unable to complete travel between Spokane and Walla Walla due to a lack of publicly available charging locations, and is denoted with an "X."

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	180	N/A	159	N/A	159
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	X	X	X	X	X
DC Fast Charging	BEV-200	180	0	159	0	159
Level 2	BEV-40	X	X	X	X	X
Level 2	BEV-80	X	X	X	X	X
Level 2	BEV-200	180	0	159	0	159

FIGURE 16: Publicly Available Charging Locations between Spokane and Walla Walla

The figure on the top shows existing Level 2 charging locations while the figure on the bottom shows existing DC fast charging locations. View this map online at https://www.c2es.org/maps/wa-simulation-6.





1.8 THREE EXAMPLE CHARGING INFRASTRUCTURE GAPS

This section summarizes three charging infrastructure gaps identified in the travel simulations. These gaps illustrate the gaps in the current charging network and demonstrate that travel to parts of the state are currently impossible for BEV drivers who rely on publicly available charging infrastructure.

For each gap along major roadways, charging locations were spaced 40 miles apart to fill the gap. In addition, charging locations spaced 20 miles apart were also identified for a denser deployment scenario. Locating charging stations near commercial centers was prioritized. Commercial centers are the primary target sites because they are (1) convenient charging sites for EV drivers; (2) likely to have site hosts with incentive to participate in charging deployment projects; and (3) likely to have access to three-phase power on site (necessary for DC fast charging stations), which reduces project costs.

Where necessary charging stations could not be located near commercial centers, these sites were noted as challenging. Remote sites may be more challenging for several reasons:

- Stations may be more costly to deploy, in part because access to existing three-phase power may not be available;
- Stations may be less convenient for EV drivers to use;
- Sites without nearby commercial centers present fewer opportunities to capture indirect revenue; and
- Federal law prohibits the commercialization of interstates in Washington, which includes EV charging stations at rest areas.[12]

The three gaps selected were based on the travel simulations completed in the previous section. The analyses completed in subsequent sections of this report could be applied to analyze other gaps as well. For example, two other gaps identified by the assessment of the existing publicly available charging network are:

- The need for additional Level 2 chargers in urban areas, especially where EV owners do not have access to a garage for home charging, such as in Seattle; and
- The need for additional charging stations on I-5 outside of the Seattle and Vancouver area, where coverage is currently sparse, to reduce travel times and the risk of EV drivers running out of power if stations are crowded or out of service.

Enabling Interregional BEV Travel on I-90

I-90, between Seattle to Spokane, is a critical east-west corridor in the state. DC fast charging station availability is insufficient to enable east-west travel of BEVs between Seattle and Spokane along I-90, as shown in **Figure 17**.

In order to fill this charging infrastructure gap with stations 40 miles apart, at least six DC fast charging stations are needed. A denser deployment scenario, siting stations only 20 miles apart, would require 18 additional DC fast charging stations. See **Figure 18** for a map of the minimum and denser deployment scenarios and **Table 10** for a description of the charging stations needed to address the infrastructure gap.

FIGURE 17: DC Fast Charging Stations and Infrastructure Gaps between Seattle and Spokane along I-90

Tan circles (●) indicate locations of existing DC fast charging stations. Lengths of road highlighted in cyan (▬) indicate sections along the route where BEV travel is currently possible using existing publicly accessible DC fast charging stations. Lengths of road highlighted in magenta (▬) indicate sections along the route where BEV travel is currently not possible using existing publicly accessible DC fast charging stations.

FIGURE 18: Candidate Locations of DC Fast Charging Stations to Enable BEV Travel along I-90

Orange circles (●) indicate candidate locations of new DC fast charging stations spaced 40 miles apart. Red circles (●) indicate additional locations of DC fast charging stations under a denser deployment scenario, assuming spacing 20 miles apart. Circles marked with a grey square (▣) indicate stations that were necessarily sited in rural areas (far from existing commercial locations), which may be more costly to deploy, less convenient to use, and present fewer opportunities to capture indirect revenue. Tan circles (●) indicate locations of existing DC fast charging stations.

TABLE 10: Charging Stations Deployed to Enable BEV Travel between Seattle and Spokane along I-90, under Two Scenarios

STATION TYPE	MINIMUM DEPLOYMENT SCENARIO (40-MILE SPACING)	DENSER DEPLOYMENT SCENARIO (20-MILE SPACING)
DC Fast Charging Stations	6 total stations (6 sited near commercial locations, 0 sited in rural, non-business locations)	18 total stations (13 sited near commercial locations, 5 sited in rural, non-business locations)

Enabling EV Travel to and within Ocean Shores

DC fast charging station availability is insufficient to enable BEV travel along major roadways to and from tourism destinations in Ocean Shores from inland, populated areas—such as the Puget Sound region, Olympia, and Longview—as shown in **Figure 19**. Also, there are no publicly available DC fast charging or Level 2 charging stations available to enable BEV travel within the Ocean Shores area.

Demand for EV charging services can be expected to be moderately high along roadways from Puget Sound, Olympia, and Longview to Ocean Shores, and within the region because Ocean Shores is a popular destination due to its coastal tourism, convention centers, casino, and other attractions, and may be a likely destination for BEV travelers.

FIGURE 19: DC Fast Charging Stations between Seattle and Ocean Shores and Between Longview and Ocean Shores

Tan circles (●) indicate locations of existing DC fast charging stations. Lengths of road highlighted in cyan (▬) indicate sections along the route where BEV travel is currently possible using existing publicly accessible DC fast charging stations at 40 miles apart. Lengths of road highlighted in magenta (▬) indicate sections along the route where BEV travel is currently not possible using existing publicly accessible DC fast charging stations.

Two additional DC fast charging stations are needed along the route to enable travel to Ocean Shores. If stations were sited 20 miles apart, then eight additional DC fast charging stations would be needed. To enable travel within the Ocean Shores area, it was estimated that 25 additional Level 2 stations and one additional DC fast charging station would be needed. See **Figure 20** for a map of the minimum and denser deployment scenarios and **Table 11** for a description of the charging stations needed to address the infrastructure gap.

FIGURE 20: Candidate Locations of DC Fast Charging Stations Deployed to Enable BEV Travel to Ocean Shores

Orange circles (●) indicate locations of new DC fast charging stations at 40 mile spacing. Red circles (●) indicate additional candidate locations of DC fast charging stations under a denser deployment scenario at 20 mile spacing. All of the stations can be sited near existing commercial locations. Tan circles (●) indicate locations of existing DC fast charging stations. Not shown in the figure are 25 Level 2 stations, five at five sites in Ocean Shores.

TABLE 11: Charging Stations Deployed to Enable BEV Travel to, from, and within Ocean Shores, under Two Scenarios

STATION TYPE	MINIMUM DEPLOYMENT SCENARIO (40-MILE SPACING)	DENSER DEPLOYMENT SCENARIO (20-MILE SPACING)
DC Fast Charging Stations	3 total stations (2 sited along major roadways near commercial locations, 0 sited along major roadways in rural, non-business locations, and 1 sited in Ocean Shores)	9 total stations (8 sited along major roadways near commercial locations, 0 sited along major roadways in rural, non-business locations, and 1 sited in Ocean Shores)
Level 2 Charging Stations	25 total stations (5 stations each at 5 sites in Ocean Shores)	25 total stations (5 stations each at 5 sites in Ocean Shores)

Enabling EV Travel to and within Tri-Cities and Walla Walla

DC fast charging station availability is insufficient to enable BEV travel along major roadways to and from tourism destinations in the Tri-Cities and Walla Walla areas from populated areas, such as Spokane and the Puget Sound region, as shown in **Figure 21**. Also, Level 2 stations are relatively sparse within the destination region, with two publicly available Level 2 stations in the Tri-Cities area and one in Walla Walla.

Demand for EV charging services can be expected to be relatively high along these routes and at these destinations for two reasons. First, the Tri-Cities region is an energy sector employment center, where employees at workplaces such as the Columbia Generation Station, the Hanford Site, and the Pacific Northwest National Laboratory may be likely to demand EV charging services. Second, Walla Walla and the Tri-Cities are popular tourism destinations, with more than 300 wineries, and may be a likely destination for BEV travelers.

FIGURE 21: DC Fast Charging Stations along Major Roadways to Walla Walla and Tri-Cities from Seattle and Spokane

Tan circles (●) indicate locations of existing DC fast charging stations. Lengths of road highlighted in cyan (▬) indicate sections along the route where BEV travel is currently possible using existing publicly accessible DC fast charging stations. Lengths of road highlighted in magenta (▬) of road indicate sections along the route where BEV travel is currently not possible using existing publicly accessible DC fast charging stations.

For BEV drivers to reach Tri-Cities and Walla Walla, an additional eight DC fast charging stations will be needed. If stations are cited 20 miles apart, then 17 DC fast charging stations will need to be installed. To better enable travel within the Tri-Cities and Walla Walla region, 50 Level 2 stations and two DC fast charging stations would be needed. See **Figure 22** for a map of the minimum and denser deployment scenarios and **Table 12** for a description of the charging stations needed to address the infrastructure gap.

FIGURE 22: Candidate Locations of Additional DC Fast Charging Stations Deployed to Enable BEV Travel along Major Roadways to Walla Walla and Tri-Cities from Seattle and Spokane

Orange circles (●) indicate candidate locations of new DC fast charging stations based on stations situated 40 mile apart. Red circles (●) indicate additional candidate locations of DC fast charging stations at 20 mile spacing. Circles marked with a grey square (●) indicate stations that were necessarily sited in rural areas (far from existing commercial locations), which may be more costly to deploy, less convenient to use, and present fewer opportunities to capture indirect revenue. Tan circles (●) indicate locations of existing DC fast charging stations. Not shown in the figure are 50 Level 2 stations, five stations each at ten total sites in the Tri-Cities and Walla Walla areas.

TABLE 12: Charging Stations Deployed to Enable BEV Travel to Walla Walla and Tri-Cities from Seattle and Spokane, under Two Scenarios

STATION TYPE	MINIMUM DEPLOYMENT SCENARIO (40-MILE SPACING)	DENSER DEPLOYMENT SCENARIO (20-MILE SPACING)
DC Fast Charging Stations	10 (8 sited along major roadways in commercial locations, 0 sited along major roadways in rural, non-business locations, 1 sited in the Tri-Cities area, and 1 sited in Walla Walla)	26 (17 sited along major roadways in commercial locations, 7 sited along major roadways in rural non-business locations, 1 sited in the Tri-Cities area, and 1 sited in Walla Walla)
Level 2 Charging Stations	50 (5 stations each at 10 total sites in the Tri-Cities and Walla Walla areas)	50 (5 stations each at 10 total sites in the Tri-Cities and Walla Walla areas)

1.9 SUMMARY OF THE PUBLICLY AVAILABLE CHARGING NETWORK ASSESSMENT

Widespread adoption of EVs depends in part on a robust publicly available charging network. Access to charging that enables EV drivers to travel desired destinations in a reasonable amount of time is essential for EVs to compete with gasoline-powered vehicles on a mass scale. Although Washington's EV network is ahead of most other states in the United States, many parts of the state remain inaccessible to EV drivers who rely on publicly available charging locations.

Washington has a disproportionate number of BEVs compared to PHEVs relative to the rest of the United States, indicating the state's charging network may be more dependent on high-powered charging to meet drivers' travel needs. The largest concentration of EVs is in King County, which corresponds well with the density of charging locations.

Washington's network of EV charging consists of DC fast charging and Level 2 charging locations. These charging technologies can complement each other to enable EV drivers to complete daily travel needs along with occasional trips that require charging along the way.

Quantifying the success of charging station siting can be difficult because the motivation for a charging station may be to enable access to distant locations rather than delivering a significant amount of energy to EVs. At the same time, some business models for publicly available charging rely on frequent use in order to be profitable.

DC fast charging is concentrated along the I-5 corridor with little connectivity to other major roadways. Level 2 charging is mostly located in King County and near Vancouver, Washington. More publicly available charging is needed outside these regions to enable access to popular destinations, like the Pacific Coast, and to link major traffic corridors of the state, like I-90.

The following three charging infrastructure gaps identified in the travel simulations demonstrates that travel to parts of the state are currently impossible for BEV drivers who rely on publicly available charging infrastructure.

1. Most BEV drivers cannot travel between Seattle and Spokane along I-90.
2. Travel to the Pacific Coast is also not possible for most BEV drivers reliant on the existing publicly available network.
3. Travel to Tri-Cities and Walla Walla region from either Spokane or Seattle is not possible for most BEV drivers.

The next chapter of this report describes and assesses the degree to which new business models could be deployed to fill the kinds of charging gaps identified in the charging network assessment.

2. USING NEW BUSINESS MODELS TO ADDRESS CHARGING GAPS

2.1 SUMMARY OF FINDINGS

It is currently challenging to construct a profitable business case for EV charging investments for several reasons. These include high initial investment costs, low and uncertain near-term demand for publicly available charging, and the limited ability and willingness for consumers to substitute commercial charging for affordable home charging (or gasoline use for PHEVs).

For this reason, charging station business models that rely solely on direct revenue from EV charging services are currently not financially feasible. The analyses completed for this study show that investment in a single DC fast charging station results in a net loss of more than $44,000 for a private project developer over a 10-year period. Similarly, investing in a charging site with five slower, lower powered, and lower cost Level 2 charging stations results in a net loss of more than $26,000 for a private project developer over the same 10-year period.

In order to build a business case that will attract capital and convince the private sector to invest in EV charging, total revenues must be greater than the project's total cost, and an acceptable level of profit is necessary. There are four general ways to improve the financial performance of charging station projects: increase revenues, decrease capital costs, decrease operating costs, and/or decrease the cost of funds for the project.

One promising opportunity to improve the financial performance of charging station investments is to develop business models that, through private partnerships and joint investment strategies, capture other types of business value in addition to selling electricity. This might include EV tourist revenue for retailers and tourism businesses that have increased sales when located near EV charging stations; automakers selling more EVs; and "clean energy" marketing and brand-strengthening opportunities for businesses visibly involved in EV charging deployment projects. This study identified three business models aimed at capturing these sources of value, and analyzed the financial viability of each business model by applying them to an applicable infrastructure gap in the state:

- **Business Model 1**: A large business that benefits from EV sales and use (such as an automaker or a battery supplier) or seeks to gain a marketing advantage (such as a retail or restaurant chain) contributes funding to subsidize the deployment a DC fast charging network for interregional EV travel. This model was applied to interregional travel along I-90, where gaps in existing infrastructure have been identified. At least six new DC fast charging stations are needed to enable BEV travel between Seattle and Spokane along I-90. In the application of the model, an automaker provided an upfront cash transfer to the charging network owner-operator in amount of $7,000 for each DC fast charging station.
- **Business Model 2**: A group of local businesses contributes annually to a funding pool that subsidizes the cost of deploying a charging network for EV travel to and within the region. These businesses may be tourism businesses and retailers aiming to sell products and services to EV drivers. This model was applied to travel to and within Ocean Shores—a tourist destination—where many more charging stations are needed to enable BEV travel from the Puget Sound region, Olympia, and Longview. At least 3 DC fast charging stations and 25 Level 2 charging stations are needed to address this gap. In the application of the model, six local businesses shared 10 percent of their revenue from new EV tourist revenue each year for 10 years with the charging network owner-operator.
- **Business Model 3**: This model combines Business Models 1 and 2, providing the charging network owner-operator with upfront and annual subsidies from a large business and a group of local businesses. This model was applied to travel to and within the Tri-Cities and Walla Walla region—Washington's wine country—from Seattle and Spokane. At least 10 DC fast charging stations and 50 Level 2 charging stations are needed to address this charging gap. These stations could be hosted by local wineries that would contribute 10 percent of

their new EV tourist revenue each year for 10 years. In the application of the model, an automaker provided an upfront cash transfer to the charging network owner-operator in the amount of $7,000 for each DC fast charging station and $500 for each Level 2 charging station. In addition, the local businesses shared 10 percent of their new EV tourist revenue with the charging network owner-operator each year for 10 years.

The EV Charging Financial Analysis Tool was developed to analyze the expected financial performance of each of these business models as applied to their EV charging infrastructure gaps. The initial analysis included only private sector funds; no public sector contributions were considered.

Conclusion: The financial analyses demonstrate that each business model can materially improve the financial performance of EV charging projects. The models do this by capturing the value of EV charging services to other businesses, thereby increasing private sector investment in the EV charging network. However, they also show that it is unlikely that the private sector will implement these business models in the near term. Investors would likely view the financial performance of these charging station investments as unfavorable under current market conditions. Many private investors are only interested in projects that can achieve payback within five years, a threshold that none of the business models is currently estimated to meet.

2.2 INTRODUCTION

This chapter explores the opportunities and challenges of expanding the private sector role in offering EV charging services.

First, the chapter explores general questions of who could provide EV charging services and why it is challenging to construct a profitable business case for EV charging investments.

Next, the value of EV charging stations to various businesses—beyond the value of simply selling electricity to EV drivers—is considered and estimated. For example, automakers can expect more EV sales with the increased availability of charging stations, which allows EV drivers to travel further and have more confidence in the technology.

Finally, three business models are identified and evaluated. These business models improve the financial performance of charging station investments by capturing other types of business value in addition to selling electricity. Through private partnerships and joint investment strategies, these models can increase private sector investment in EV charging. The EV Charging Financial Analysis Tool created for this study was used to evaluate the financial performance of these business models. Appendix B provides instructions on how to use the EV Charging Financial Analysis Tool and information about the default assumptions used in the analyses presented in this chapter.

2.3 THE CHALLENGE OF EXPANDING THE PRIVATE SECTOR ROLE IN OFFERING EV CHARGING SERVICES

While state and federal governments have played a central role in providing EV charging infrastructure to date, greater private investment will be needed to further build-out the publicly available charging network. However, it is currently challenging to construct a profitable business case for EV charging investments for several reasons.

> ***At a minimum, a promising EV charging project must show that the charging station owner-operator will receive direct and indirect revenues that are sufficiently greater than the total project cost to generate profit. Furthermore, investors must receive a return on investment from a project that is equal to or greater than alternative investment opportunities. Improving the profitability of EV charging business models could be achieved through some combination of increased revenue, decreased capital cost, decreased operating cost, or decreased cost of funds.***

Barriers faced by EV charging business models include high capital costs for new infrastructure and the associated financing costs, and high operating costs. Deploying a publicly available charging station requires an upfront capital investment for equipment and installation, which costs about $6,500 for a Level 2 charging station or more than $90,000 for a DC fast charging station. **Box 4** shows the cost assumptions used in this study and how some of these costs have declined in recent years.[13] Access to public or private financial capital needed for these investments may present an additional barrier. Charging station hosts

Box 4. EV Charging Installation Cost Assumptions for this Study

One of the main barriers to deploying DC fast charging stations is the high cost of installation. Over time, equipment costs have declined; providing a high-powered connection to the electrical grid (three-phase power) now constitutes much of the installation cost.[14]

The table below shows the equipment and installation costs of the West Coast Electric Highway project in Washington from 2012, along with cost assumptions used in this study. This study uses similar installation costs as the West Coast Electric Highway project, but incorporates more recent DC fast charging equipment cost data.

COMPONENT	COST (2012)	COST (STUDY)
DC Fast Charging Equipment	$58,000 per unit	$35,000 per unit
Level 2 Charging Station Co-Located with DC Fast Charging Station	$2,500 per unit	$2,500 per unit
Equipment Installation (Labor and Electric-Panel Upgrade)	$26,000 per location	$26,000 per location
Host-Site Identification, Analysis, and Screening	$5,000 per location	$5,000 per location
Negotiation, Legal Review, and Execution of Lease	$6,000 per location	$6,000 per location
Utility Interconnection	$12,500 to $25,000 per location	$20,000 per location
Total	$109,500 to $122,000	$94,500

Source: Washington State Department of Transportation, ABB, Plug-In America[15]

or service providers may also bear substantial operating costs, including electricity distribution costs associated with powering DC fast charging stations or sites with multiple Level 2 charging stations.

On the revenue side, charging station investors face challenges on both the quantity of demand for services and the price they can charge for those services. Near-term demand for publicly available charging services is low and uncertain, and consumer willingness to pay for charging services is limited due to competition with relatively inexpensive home charging. In Washington, residential electricity prices averaged only $0.08 per kilowatt-hour in April 2014, with prices as low as $0.03 per kilowatt-hour.[16] In addition, the potential for charging stations to capture indirect revenue—such as increased retail sales near publicly available charging locations—from charging stations is uncertain and not well recognized.

A summary of the key cost and revenue components of EV charging business models is presented in **Figure 23**.

The formula below illustrates the basic requirement for the profitable operation of an EV charging network. For the private market to consider investing in a charging station or network of stations, the direct and indirect revenue must be greater than the costs of the station(s).

Direct & Indirect Revenue [R] > Capital Costs [C] + Operating Costs [O] + Cost of Funds [F]

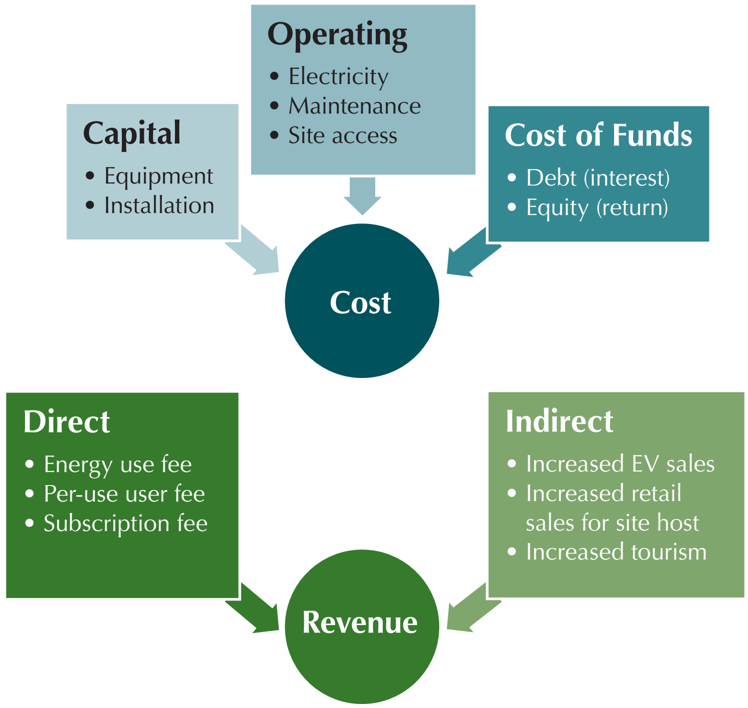
Where:

- *Capital Costs* are the costs of equipment and installation.
- *Operating Costs* are the ongoing costs to maintain and run the station.
- *Cost of Funds* are the cost of paying interest on debt and investor returns on equity.
- *Direct Revenue* are funds attributable to direct use of a charging station (e.g., per-use fee).
- *Indirect Revenue* are funds that are realized through sales of other products but could be attributed to the charging station.

Financial models were constructed for this study to quantify the financial performance of a simple 'pay-per-unit-of-energy' model for two simple deployment cases: a single DC fast charging station and a Level 2 charging station site with five stations. In these models, the owner-operator of the charging equipment collects revenue

FIGURE 23: Cost and Revenue Components of EV Charging Business Models

These figures show private, market-based costs and returns. While most if not all of the costs must be paid by the owner-operator, some of the revenues (particularly the indirect revenues) are received by other businesses.



only from the sale of electricity to users of the charging station. The fee for use was assumed to be $0.25 per kilowatt-hour for Level 2 (three times the cost of retail electricity) and $0.50 per kilowatt-hour for DC fast charging (equivalent to $3.50 per gallon of gasoline). No other forms of direct or indirect revenue were included in this model. The calculations assumed a 10-year project period—a generally-accepted estimate of the useful life of EV charging equipment. In these analyses, the cost of funds was represented as the weighted average of interest on debt and return on investor equity, which was assumed to be 15 percent.[17] The cost of funds was applied as the 'discount factor' of future cash flows.

These analyses show that the business model of offering charging services and relying solely on revenue from the sale of electricity is not financially sustainable for private sector entities for either DC fast charging or Level 2 charging. For DC fast charging, investment in a single station results in a net loss of $44,589 for a private project developer over 10 years. For Level 2 charging, investment in a charging site with five Level 2 charging stations results in a net loss of $26,076 for a private project developer over the same period. The cash flows for analysis are depicted in **Figure 24**.

In order to build a business case that will attract capital and convince the private sector to consider investing in EV charging, direct and indirect revenues must be greater than the project's total cost, and the project must generate an acceptable level of profit. There are four general ways to improve the financial performance of charging station projects: increase revenues, decrease capital costs, decrease operating costs, and/or decrease the cost of funds for the project.

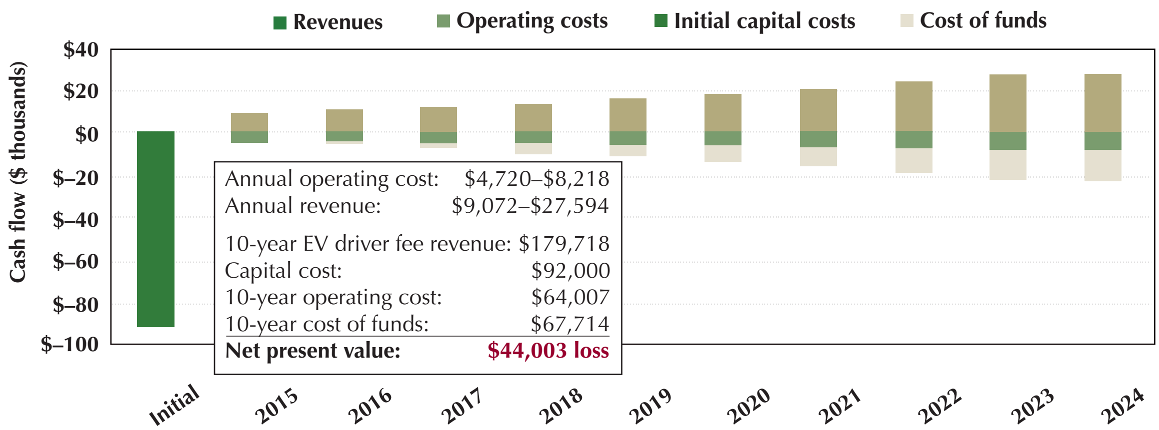
2.4 EV CHARGING DEPLOYMENT MODELS AND ROLES FOR PUBLIC AND PRIVATE ENTITIES

Public and private entities could employ a variety of models to deploy and manage EV charging infrastructure. The following four questions explore the range of possible models and enable the comparison and evaluation of these models described later in this chapter.

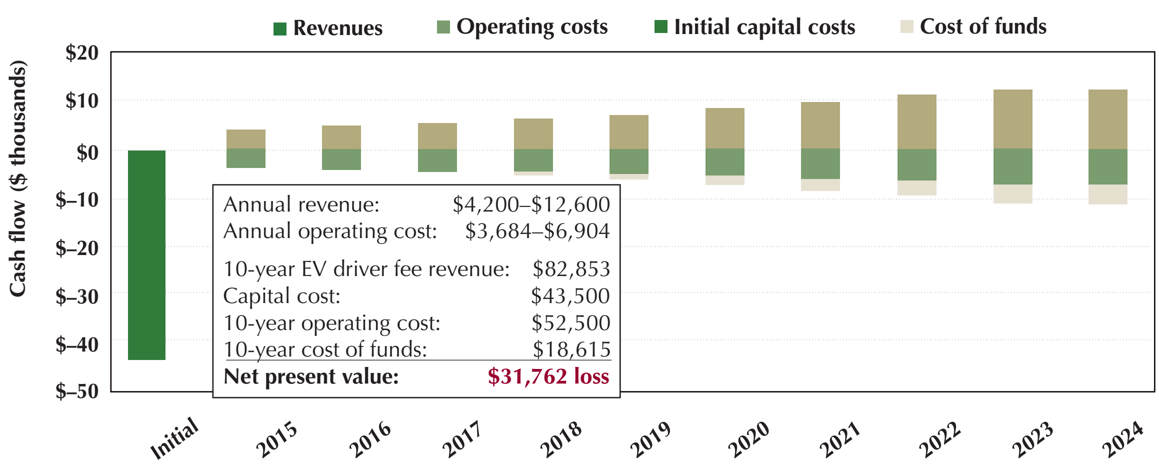
FIGURE 24: Investments in Charging Stations (DC Fast Charging and Level 2) Lose Money over Project Lifetime

These two charts illustrate the challenge of paying back large initial capital cost investments in charging stations. Projects for DC fast charging stations and Level 2 charging sites both lose money over their lifetime. In both cases, annual revenues from EV drivers exceed operating costs and revenues are small compared to initial capital costs.

DC Fast Charging Station



Level 2 Charging Site



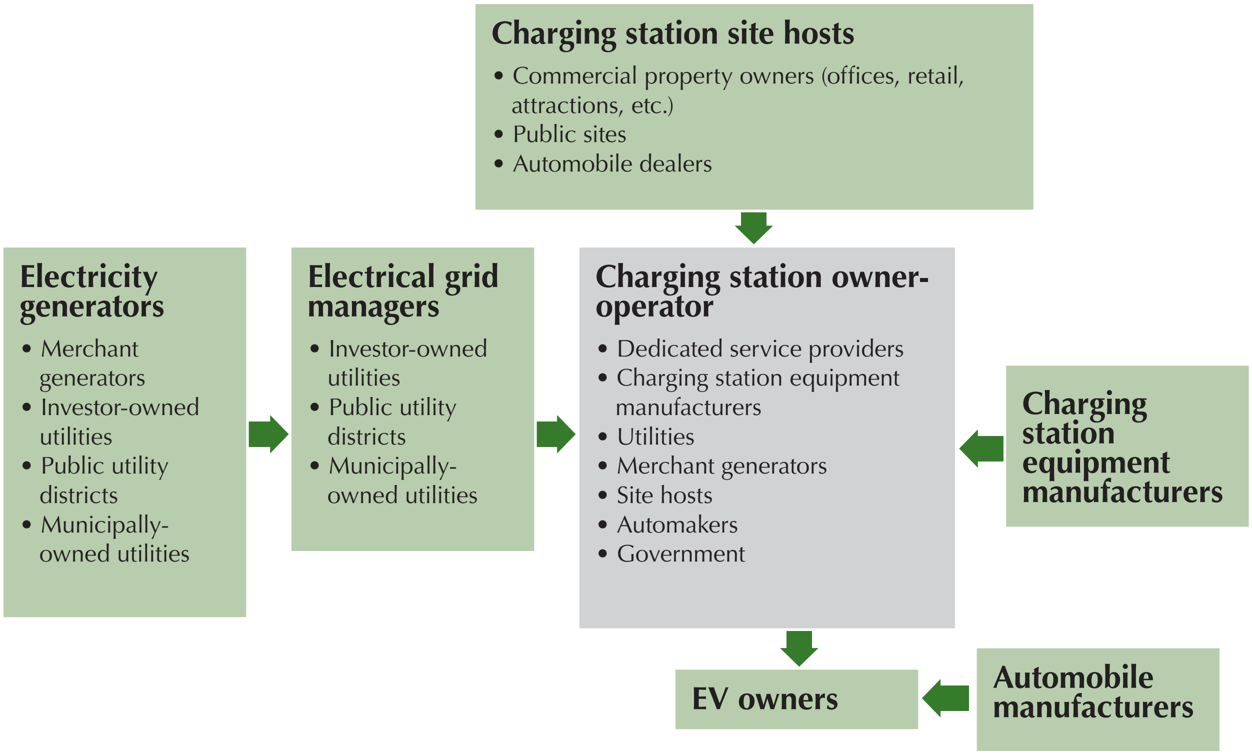
What are the critical components of an EV charging network?

An EV charging network requires a number of products and services to support it, including the following:

- Installation sites must be developed to host EV charging stations;
- Electricity must be generated, transmitted, and distributed to supply electricity to EV charging sites;
- Charging station equipment must be manufactured and purchased by an EV charging service provider; and
- EVs must be manufactured and purchased.

Each of these components is essential to providing charging services, and several of them can be carried out by multiple types of business and government entities, listed in **Figure 25**.

FIGURE 25: Public EV Charging Network Roles (in bold), Stakeholders that Could Play Each Role (bullets), and Flows of Products and Services (arrows)



Which entities are positioned to provide EV charging services?

There are many entities involved in installing and operating charging equipment, including charging site hosts, electricity generators, electric grid managers, equipment manufacturers, EV owners, auto manufacturers, and EV charging service providers. As shown in Figure 25, the function of the EV charging station owner-operator could be played by many alternative entities, including dedicated charging service companies, charging equipment manufacturers, property owners acting as site hosts, automakers, electric utilities, electricity generators, and state and local governments.

These stakeholders differ in their potential interests in and concerns about EV charging deployment. For example, automakers receive the most direct benefits from increased EV sales, while public and private electric utilities and government would likely be concerned with the effects of high-powered charging equipment on electrical grid reliability. Some interests may be shared, such as vehicle-to-building (V2B) and vehicle-to-grid (V2G) power services that generate additional revenues or cost savings for many different entities. The opportunities and challenges from each entity's perspective are presented in **Table 13** and **Table 14**, respectively. Notably, these entities face many of these benefits and concerns whether or not they directly assume the role of EV charging station owner-operator.

How would these entities derive value from providing EV charging services?

In order for any of these entities to consider investing in EV charging, they will need to expect that the project will generate value that is greater than its total cost. For commercial entities, the monetary value of EV charging projects is of primary concern. For government entities, the social benefits of EV charging deployment may also be considered.

The monetary value of providing EV charging services is dependent on the total revenue these services generate. The most straightforward sources of revenue are station user fees. User fees may be collected at the time of charging, through a flat fee per charging session, a fee based on the time spent parked or connected to the

TABLE 13: Opportunities from the Deployment of EV Charging from Stakeholders' Perspective

This table presents the opportunities that are within each stakeholder's scope of interest. Opportunities are shown as general categories that illustrate the stakeholders' primary motivations.

	PUBLIC/GOVERNMENT	PUBLIC UTILITY DISTRICTS AND MUNICIPALLY-OWNED UTILITIES	INVESTOR-OWNED ELECTRIC UTILITIES	MERCHANT ELECTRICITY GENERATORS	DEDICATED CHARGING SERVICE PROVIDERS	CHARGING EQUIPMENT MANUFACTURERS	AUTOMAKERS	CHARGING SITE PROPERTY OWNER
Vehicle Fuel Cost Savings	x							
Reduced Environmental and Public Health Costs	x	x						
Economic Development from EV and Charging Station Use	x	x						x
Increased Electricity Use		x	x	x				
More Efficient Use of off-Peak Generation Capacity	x	x	x	x				
Long-Term Prospect of Vehicle-To-Building and Vehicle-To-Grid Benefits	x	x	x	x	x	x	x	x
Greater EV Sales							x	
Sales of EV Charging Equipment						x		
Increased Retail Sales from Offering Charging On-Site								x
Sales of Charging Network Support Services		x	x		x			x

Source: C2ES

charging station, or a fee based on the amount of energy used. Alternatively, user fees may be collected through subscriptions, membership fees, or permits.

In addition to user fees, EV charging stations may also generate other types of indirect revenue streams for businesses. Because these revenue streams are not captured by the charging station itself, operators may ignore them. However, some businesses may choose to bear the costs of offering charging services based on the value of these indirect revenue streams and other benefits. For example, offering EV charging at retail locations may increase sales revenue by drawing EV drivers to the destination and by increasing the time customers spend parked at these locations. EV charging infrastructure deployment may accelerate sales of EVs, potentially increasing expected revenues for automakers as they work to drive down costs for these advanced technology vehicles. Offering EV charging stations may also provide other sources of value for businesses that are not tied to specific revenue streams, such as employee engagement and retention benefits or marketing and brand-strengthening opportunities of offering EV charging. And, over a longer time frame, technology and infrastructure development may enable EVs to provide V2B and V2G power services. Any of these businesses may invest in charging infrastructure to realize these benefits.

In addition to the monetary value of charging services, state and local governments, companies interested in promoting clean energy to increase their sales, and public utilities may consider the social benefits associated with increased EV deployment, including:

- Keeping EV drivers from getting stranded;
- Fostering clean energy deployment;

TABLE 14: Challenges from EV Charging Deployment from Stakeholders' Perspective

This table presents the challenges from each stakeholder's perspective. Challenges are shown as general categories that illustrate stakeholders' primary concerns.

	PUBLIC/ GOVERNMENT	PUBLIC UTILITY DISTRICTS AND MUNICIPALLY-OWNED UTILITIES	INVESTOR-OWNED ELECTRIC UTILITIES	MERCHANT ELECTRICITY GENERATORS	DEDICATED CHARGING SERVICE PROVIDERS	CHARGING EQUIPMENT MANUFACTURERS	AUTOMAKERS	CHARGING SITE PROPERTY OWNER
Cost to Public of Charging Investment and Subsidies/ Equity Concerns	x	x	x					
High-Power Charging Impacts on Grid Reliability/Need for Distribution Upgrades	x	x	x					
Vehicle-to-Building Technology Could Reduce Demand for Grid Electricity		x	x	x				
Financial Sustainability of Charging Station Investment	x	x	x	x	x			x
Rate of Return of Charging Station Investment				x	x			
Uncertain Impacts of Charging Station Deployment on EV Adoption	x						x	
Lack of Interest in Owning and Operating Charging Infrastructure	x	x	x				x	

Source: C2ES

- Reducing transportation emissions; and
- Promoting local economic development (e.g., from retail sales).[18]

However, the value of some of these benefits that could be directly attributed to a particular EV charging infrastructure project is relatively uncertain and difficult to quantify.

What sources of financial capital are available to fund station deployment?

Any business entity seeking to deploy EV charging infrastructure will need financial capital to fund upfront equipment and installation costs. Upfront capital costs could be funded in several ways, including:

- Private financing through commercial loans or leases;
- Capital from third-party investment partners;
- Commercial entities' available cash-on-hand; and
- Investor-owned electric utility shareholder funds.[19]

The public sector may contribute funds to EV charging deployment projects, either by owning and operating stations themselves, by subsidizing commercially managed deployments, or through electric utility ratepayer fees. Funding for public investment in charging stations could come from tax or fee revenues. Charging station subsidies could take the form of grants, tax exemptions, or low-cost lending programs. Notably, such programs in Washington must be designed to ensure compliance with constitutional limitations on public subsidies, including extending credit to private entities.

Taken together, these four questions—what is a charging network, who can provide it, how is value captured, and how is it funded—frame the challenges of and opportunities for ensuring adequate access to publicly available charging infrastructure and expanding the private sector role in this effort.

2.5 QUANTIFYING SOURCES OF VALUE FOR PRIVATE SECTOR PARTNERS

This section provides estimates of the indirect value received by automakers, investor-owned utilities, and retailers and the effect on the charging station business case of investing all or a portion of this value in an owner-operator's charging station project.

For each private sector partner, the following information is provided:

- A description of the partner's role and why the funding partner may be interested in the charging station project;
- An estimate of how much the partner may be willing to contribute to a charging station project;
- Discussion of legal or regulatory barriers to implementation; and
- Estimates of the financial performance of each applicable business model under low, medium, and high contribution scenarios.

The three charging infrastructure gaps identified in Chapter 1 were used as examples to evaluate how each project's financial performance is improved when a business gives to the owner-operator a portion of the indirect value they receive from charging infrastructure, though an upfront subsidy or annual revenue sharing. For the I-90 Charging Gap, only the upfront subsidy was analyzed. For the Ocean Shores Charging Gap, only annual revenue sharing was analyzed. For the Tri-Cities and Walla Walla Charging Gap, the analysis included both the upfront subsidy and annual revenue sharing.

The EV Charging Financial Analysis Tool created for this study was used to complete this analysis. Appendix B provides detailed information about this tool. A base case was analyzed for each example charging station project assuming an owner-operator uses a mix of debt and equity to fund charging station installation and operation. The owner-operator collects revenue through fees for the use of the charging equipment. The fee was assumed to be $0.25 per kilowatt-hour for Level 2 (three times the cost of retail electricity) and $0.50 per kilowatt-hour for DC fast charging (equivalent to $3.50 per gallon of gasoline). The other two forms of direct revenue, subscription fees and per-use fees, were not included in this analysis. The complete set of assumptions used for these analyses are detailed in Appendix B.

The base case financial results are compared with alternative scenarios that incorporate contributions from each private sector partner. The alternative scenarios illustrate the effect of capturing the indirect value on each project's financial performance. The indirect value of each partner (i.e., automaker, investor-owned utility, and retailer) was estimated and applied to each example charging project in the form of a cash transfer to the owner-operator. These cash transfers were either in the form of upfront cost subsidies or sharing of indirect revenue with the station owner-operator throughout the term of the project. These scenarios are summarized in **Table 15**.

Each partner's effect on the financial performance was evaluated separately. Three scenarios (low, medium, and high contribution levels) were analyzed for each private sector partner to convey the effects of different levels of subsidies and revenue sharing. **Table 15** defines the subsidy values and value of revenue sharing for the medium scenario. The financial performance results for each role are presented in a summary table. For each role, two financial metrics are shown:

- The net present value (NPV), which is the total profit of the project to the entity in present value dollars. The NPV indicates whether the entity will realize net profitability over the lifetime of the project. In most

TABLE 15: Summary of Private Sector Partner Roles: Benefits and Contributions

		ESTIMATED PARTNER CONTRIBUTIONS	
PRIVATE SECTOR PARTNER	PARTNER BENEFITS	UPFRONT CAPITAL EQUIPMENT SUBSIDY	ANNUAL INDIRECT REVENUE SHARING
Automaker, battery supplier	EV Sales	$7,000 for DC fast charging station; $500 for Level 2 station	N/A
Investor-owned utilities, private power generators	Charging Use	$2,000 for DC fast charging station; $450 for Level 2 station	N/A
Restaurants, hotels, etc.	Indirectly Benefits from Charging Use	N/A	10% of local business sales revenue attributed to EVs

cases, a business entity's NPV must be positive for that entity to consider involvement in the project.

- The payback period for the project, which is the period of time required for the project to generate net positive value for the entity. The payback period helps determine whether involvement in the project generates net profitability quickly enough to attract investment from the entity. Many private investors are only interested in projects that can achieve payback within three to five years.

These financial metrics are presented for the owner-operator, funding partners, and the total project perspective for each of the three scenarios (low, medium, and high).

The analyses in this section assume no role for the public sector in the charging station projects. In addition, the analyses do not address equity issues for private sector partners that may arise from free riders, who benefit but do not invest in charging projects, which are discussed in **Box 5.**

Businesses that Benefit from Increased EV Sales (Automaker Example)

Why would the businesses want to invest? There is a strong connection between deployment of publicly available charging infrastructure and EV sales. As a result, businesses that benefit from EV sales may be encouraged to invest in charging infrastructure. For example, automakers and battery suppliers may be willing to invest in order to sell more EVs and battery systems. In January 2015, BMW, Volkswagen, and Nissan announced plans to invest in 1,000 publicly available charging stations in major east and west coast markets.[20]

Medium scenario explanation: For the financial modeling, charging infrastructure was treated as a marketing tool in order to estimate the value of a

Box 5. Capturing the Indirect Value of Charging Stations: Uncertainty and Free Rider Issues

The financial analyses in this section assume that other businesses are willing to invest some of the value they get from charging stations to subsidize the cost of deployment. However, it may be challenging for charging station owner-operators to convince businesses to contribute funds for several reasons.

First, businesses that benefit from charging services may not recognize the value of charging deployment or may feel that the value is too uncertain. Businesses may choose to try out pilot partnerships where the terms of the partnership attempt to balance financial risk between owner-operators and business partners. As the EV charging market develops and successful business partnerships are forged, the wider availability of data on the value of charging services to businesses will help to reduce this uncertainty.

Second, even if a business recognizes the value of charging station deployment, it may be challenging for owner-operators to convince businesses to contribute funds due to the "free rider" issue. Some businesses will receive many of the benefits of charging station deployment whether they contribute funds or not. For instance, automakers will find it easier to sell EVs if charging infrastructure is developed, regardless of whether they themselves contribute funds.

The challenge this presents is that charging station deployment is generally not profitable without capturing these other sources of value. So, unless the "free rider" problem is addressed, EV infrastructure development will be stagnant and the value to various businesses will not be realized.

Businesses and policymakers can employ a range of strategies to help overcome the "free rider" challenge. One option is for groups of businesses to establish a funding pool in order to coordinate investments Forming a funding pool that is managed by a third party could encourage collaboration on project investments. Another option is to add extra value for funders to concentrate the benefits realized by funding partners. For instance, the owner-operator could allow the partner business to advertise or "brand" their charging stations, or could offer a discount on charging services to the partner business's customers.

charging station to an automaker. That is, the analysis assumes an automaker would not invest all of the value it receives from EV charging into infrastructure projects. Assuming an automaker is only willing to invest just over half that value, the medium scenario uses a subsidy by an automaker of $7,000 for each DC fast charging station and $500 for each Level 2 charging station.[21] This level of investment is comparable to a recent promotion by Nissan, where the company was willing subsidize the cost of a DC fast charging installation by $10,000.[22]

Legal/regulatory barriers: No known legal or regulatory barriers prevent a non-regulated business from contributing funds towards EV charging station projects in this way.

Financial performance results: The results of the financial analyses, presented in **Table 16**, show that:

- Without public sector intervention, the payback for the owner-operator is beyond the expected life of charging equipment in all cases. This means that the project is not financially viable for the owner-operator because the amount of revenue from user fees and private sector contributions was not enough to cover project costs.
- For the I-90 Charging Gap, the overall project is not profitable in any of the three scenarios. The owner-operator's NPV increased by 30 percent from the base case to the scenario with the largest equipment cost subsidy, but was still negative. The investment is profitable for an automaker so long as the subsidy is less than the value it gets from the charging station deployment. As a result, the automaker is profitable in the low and medium subsidy scenario, but not in the high subsidy scenario, where the subsidy exceeds the expected value to the automaker.
- For the Tri-Cities/Walla Walla Charging Gap, the project is not profitable in any of the three scenarios. The owner-operator's NPV increased by 25 percent from the base case to the scenario with the largest equipment cost subsidy—but was still negative. The investment is profitable for an automaker in all three subsidy scenarios, meaning their subsidy is less than the value they expect to receive from the charging network.

TABLE 16: Effects of an Automaker Subsidy on the Financial Performance of Charging Gap Projects (I-90 and Tri-Cities/Walla Walla)

This table illustrates how various levels of automaker subsidies would affect the business case for the project. The net value (the NPV) of each project is presented from two perspectives: the owner-operator and the automaker. Payback time (in years) is presented in parentheses where applicable. The table also presents the financial performance for the overall project, with all perspectives merged.

The table presents the base case, assuming no subsidies, as well as three scenarios in which an automaker subsidizes some of the charging station equipment costs at a low, medium, or high rate.

CHARGING GAP		FINANCIAL PERFORMANCE (YEARS TO PAYBACK)			
		BASE	LOW	MEDIUM	HIGH
Contribution by Automaker		No subsidy	10% equipment cost subsidy ($3,500 DC Fast Charging; $250 Level 2)	20% equipment cost subsidy ($7,000 DC fast charging; $500 Level 2)	40% equipment cost subsidy ($14,000 DC Fast Charging; $1,000 Level 2)
I-90	Project	–$82,917	–$85,347	–$87,777	–$92,637
	Owner-operator	–$139,585	–$128,896	–$118,207	–$96,829
	Automaker	+$45,570 (1)	+$32,551 (3)	+$19,532 (5)	–$6,506
Tri-Cities and Walla Walla	Project	–$257,864	–$263,360	–$268,856	–$279,849
	Owner-operator	–$384,729	–$360,551	–$336,374	–$288,018
	Automaker	+$103,075 (1)	+$73,627 (3)	+$44,179 (5)	–$14,716

Businesses that Benefit from Increased EV Charging Use (Investor-Owned Utility Example)

Why would the businesses want to invest? Investor-owned utilities (IOUs) and private power generators earn revenue through the sale of electricity. EV charging presents an opportunity for these entities to significantly increase revenue through increased electricity sales. An EV that travels 10,000 miles at 3.5 miles per kilowatt-hour consumes 2.9 megawatt-hours, an amount equal to approximately a quarter of an average household's annual electricity use.[23]

Medium scenario explanation: For the financial modeling, the medium scenario uses a value to the utility of $2,000 for a DC fast charging station (6 percent of total cost) and $450 for a Level 2 station (18 percent of total cost).[24] It was assumed that the IOU would invest all of the value it is expected to receive from charging infrastructure back into charging projects.

Legal/regulatory barriers: Washington state currently prohibits IOUs from using electricity ratepayer funds to make investments that increase electric load.[25] Private power generators that connect to regulated grids may also face this barrier. However, these businesses are allowed to invest their own profits in charging infrastructure projects.

Financial performance: The results of the financial analyses, presented in **Table 17**, show that:

- The payback is beyond the expected life of charging equipment for the owner-operator in all cases. This means the project is not financially viable for the owner-operator.
- For the I-90 Charging Gap, the project is not profitable for the owner-operator and from the total project perspective for all three scenarios. The owner-operator's NPV increased by only 9 percent from the base case to the scenario with the largest equipment cost subsidy. The project is not profitable for the IOU or power generator in either the medium or high subsidy scenarios, because the cost of subsidy equals or outweighs the expected value to the IOU or power generator.

TABLE 17: Effects of an IOU or Power Generator Subsidy on the Financial Performance of Charging Gap Projects (I-90 and Tri-Cities/Walla Walla)

This table illustrates how various levels of IOU or power generator subsidies would affect the business case for the project. The net value (the NPV) of each project is presented from two perspectives: the owner-operator and the IOU or power generator. Payback time (in years) is presented in parentheses where applicable. The table also presents the financial performance for the overall project, with all perspectives merged.

The table presents the base case, assuming no subsidies, as well as three scenarios in which an IOU or power generator subsidizes some of the charging station equipment costs at a low, medium, or high rate.

CHARGING GAP		FINANCIAL PERFORMANCE (YEARS TO PAYBACK)			
		BASE	LOW	MEDIUM	HIGH
Contribution by IOU/ Power Generator		No subsidy	Equipment cost subsidy ($1,000 DC fast charging, $225 Level 2)	Equipment cost subsidy ($2,000 DC fast charging, $450 Level 2)	Equipment cost subsidy ($4,000 DC fast charging, $900 Level 2)
I-90	Project	–$123,487	–$124,181	–$124,875	–$126,264
	Owner-operator	–$139,585	–$136,531	–$133,477	–$127,369
	IOU/Power generator	+$7,440 (1)	+$3,720 (4)	$0	–$7,439
Tri-Cities and Walla Walla	Project	–$339,497	–$341,956	–$344,415	–$349,333
	Owner-operator	–$384,729	–$373,913	–$363,096	–$341,464
	IOU/Power generator	+$26,350 (1)	+$13,176 (4)	$0	–$26,346

- Similarly, for the Tri-Cities/Walla Walla Charging Gap, the project is not profitable for the owner-operator and from the total project perspective for all three scenarios. The owner-operator's NPV increased by only 11 percent from the base case to the scenario with the largest equipment cost subsidy. The project is not profitable for the IOU or power generator in either the medium or high subsidy scenarios, because the cost of subsidy equals or outweighs the expected value to the IOU or power generator.

Businesses that Indirectly Benefit from Nearby Charging Stations (Retailer Example)

Why would the businesses want to invest? Retailers and other businesses can increase sales of their core products and services by offering EV charging services to EV tourists or shoppers. Such businesses include hotels, restaurants, shopping centers, convention centers, and tourism destinations. In this business model, each year the businesses would share a percentage of their incremental sales revenue resulting from nearby charging stations with the charging station owner-operator over the 10-year life of the charging station.

Medium scenario explanation: For the financial modeling, the medium scenario assumed that partner businesses share 10 percent of their incremental sales revenue with the owner-operator, annually totaling $3,000 to $9,125 for a DC fast charging station and $1,000 to $3,000 for a Level 2 station.[26] Despite the fact that drivers park longer when charging at Level 2 stations, DC fast charging stations are assumed to be worth more to retailers because customers turn over more quickly. The number of customers who use the parking space is more important than the parking duration because the analyses assume that there is a maximum amount that drivers will spend while parked.

Legal/regulatory barriers: No known legal or regulatory barriers prevent a non-regulated business from investing in a project that implements these interventions.

Financial performance: The results of the financial analyses, presented in **Table 18**, show that:

- For both the Ocean Shores and the Tri-Cities/Walla Walla Charging Gaps, the project is profitable for the owner-operator and the local businesses in most cases. The exception to this is the owner-operator perspective, which does not experience a positive NPV under the low scenario where the partner business shares only 5 percent of revenues. However, the payback period of 9 and 7 years in the medium and high scenarios, respectively, may be too long for most businesses.

TABLE 18: Effect of Retailer Subsidy on the Financial Performance of Charging Gap Projects (Ocean Shores and Tri-Cities/Walla Walla)

This table illustrates how various levels of retailer subsidies would affect the business case for the project. The net value (the NPV) of each project is presented from two perspectives: the owner-operator and the retailer. Payback time (in years) is presented in parentheses where applicable. The table also presents the financial performance for the overall project, with all perspectives merged.

The table presents the base case, assuming no subsidies, as well as three subsidy scenarios in which a group of retailers shares a percentage of percent of incremental revenue with owner-operator at a low, medium, or high rate.

CHARGING GAP		FINANCIAL PERFORMANCE (YEARS TO PAYBACK)			
		BASE	LOW	MEDIUM	HIGH
Contribution by Retailer		No subsidy	5% revenue sharing	10% revenue sharing	15% revenue sharing
Ocean Shores	Project	+$305,718 (6)	+$299,019 (6)	+$292,320 (6)	+$285,620 (6)
	Owner-operator	–$145,830	–$48,195	+$49,439 (9)	+$147,074 (7)
	Retailer	+$413,131 (1)	+$309,849 (1)	+$206,566 (1)	+$103,283 (1)
Tri-Cities and Walla Walla	Project	+$523,823 (7)	+$510,425 (7)	+$497,026 (7)	+$483,628 (7)
	Owner-operator	–$384,729	–$189,459	+$5,811 (10)	+$201,080 (8)
	Retailer	+$826,265 (1)	+$619,699 (1)	+$413,133 (1)	+$206,566 (1)

- The project is profitable for the small business funding partners with every level of subsidy because, from their perspective, the project generates additional revenue with no upfront investment. The local businesses simply share a fraction of their increased revenue with the owner-operator.

2.6 IDENTIFYING BUSINESS MODELS

This section describes the process of identifying three promising business models that the private sector can execute to finance EV charging infrastructure gaps in Washington state.

Business Model Workshop

On October 1, 2014, an all-day workshop was conducted in Olympia, Washington to assess the effectiveness of various business concepts for financing publicly available charging infrastructure in the state of Washington. The workshop participants included the Washington State Legislators, their staff, and members of the advisory panel assembled for this study.

The workshop began with an opening plenary session based on a simple business model for publicly available charging that Washington state had already explored. Following the plenary session, each workshop participant was assigned to one of three breakout groups. Each group explored three types of EV charging infrastructure gaps, and discussed alternative ways to finance charging stations. The charging gaps were drawn from Chapter 1 of this report.

More information on the workshop, including materials used to facilitate discussion, is available at http://leg.wa.gov/JTC/Pages/ElectricVehicleChargingStationNetworksStudy.aspx.

Description of Business Models

At the conclusion of the Business Model Workshop, three business models were identified for further analysis:

- **Business Model 1:** Large Business Funding Partners for Charging Network Development along Major Roadways
- **Business Model 2:** Local Business Funding Pools for Charging Networks that Enable EV Travel to Tourism Destinations
- **Business Model 3:** Large Funding Partner and Local Business Funding Pools for Charging Networks that Enable EV Travel to Tourism and Employment Regions

These business models are described below and are compared in **Table 19**.

Business Model 1: Large Business Funding Partners for Charging Network Development along Major Roadways

Summary: A large business that benefits from expanded access to EV charging infrastructure contributes funding that subsidizes the deployment a DC fast charging network for interregional EV travel. The business could also act as a site host. Charging stations could be owned and managed by the site hosts or by a third-party charging service provider.

Form of funding: The funding partner directly transfers funds upfront to the charging station owner-operator.

Target market for charging services: The primary target market of this business model is BEV drivers taking interregional trips that are longer than the expected range of their vehicles, although PHEV drivers that seek charging services at convenient locations along major roadways may also contribute to demand for these services in the future.[27]

Potential players and value propositions: From the perspective of the charging station owner-operator, the value proposition consists of direct revenues from charging services fees.

A range of other businesses may see value in helping to fund a network of charging stations along major roadways, including:

- Automakers, for whom DC fast charging stations along major roadways could serve as a useful marketing tool to help sell more EVs;
- Battery suppliers who also benefit from EV sales;
- Electric utilities or electricity power generators, who may wish to expand access to charging in their service territories to serve their customers; and
- Retail chains and restaurant chains, for whom on-site charging stations may provide additional sales.

For all private sector participants, support for and operation of EV charging stations may also present marketing opportunities.

Business Model 2: Local Business Funding Pools for Charging Network Development that Enables EV Travel to Tourism Destinations

Summary: A group of businesses located in a popular tourism destination contribute to a funding pool that provides an annual subsidy to the charging network owner-operator. The charging network addresses travel to and within the destination region. Members of the group commit to hosting charging sites. Charging stations could be owned and managed by the site hosts or by a third-party charging service provider.

Form of funding: Local businesses contribute to a funding pool from which funding is transferred to charging station owner-operator each year for the expected life of the equipment (10 years).

Target market for charging services: The primary target market of this business model is BEV drivers taking trips to tourism destinations. These drivers may demand charging services to travel to and from the tourism destination and/or to travel within the destination region. PHEV drivers seeking charging on trips to, from, and within the tourism destinations may also contribute to demand for these services.

Potential players and value propositions: From the perspective of the charging station owner-operator, the value proposition consists of direct revenues from charging services fees.

Businesses located in tourism destinations may see value in collectively supporting a network of charging stations that enable BEV travel to, from, and within their region. For each business, the value of contributing funds towards the deployment of these charging stations would be increased sales associated with on-site charging as well as clean energy marketing opportunities. These businesses could include:

- Hotels,
- Retailers,
- Commercial real estate owners,
- Restaurants,
- Tourist attractions

In addition to direct involvement of local businesses, local chambers of commerce could also play a role in planning, coordinating, and/or funding charging station deployment.

Business Model 3: Large Business Funding Partner and Local Business Funding Pools for Charging Network that Enables EV Travel to Tourism & Employment Regions

Summary: A combination of Business Model 1 and 2. A large business that benefits from EV charging infrastructure provides an upfront subsidy for the deployment an interregional DC fast charging network that also enables EV travel EV travel to a popular tourism destination or employment region. A group of local businesses in the destination region provides an annual subsidy as well.

Form of funding: The large business funding partner directly transfers funds to the charging station owner-operator at the beginning of project deployment. The local businesses contribute annually to a funding pool which is transferred annually to charging station owner-operator.

Target market for charging services: The target markets of this business model are BEV drivers taking interregional trips that are longer than the expected range of their vehicles as well as BEV drivers taking trips to tourism destinations. PHEV drivers that seek charging services at convenient locations along major roadways may also contribute to demand for these services.

Potential players and value propositions: At least one large business such as an automaker or battery supplier, and a group of local businesses such as hotels, wineries, restaurants, retailers, etc.

TABLE 19: Comparison of EV Charging Business Models

	BUSINESS MODEL 1	BUSINESS MODEL 2	BUSINESS MODEL 3
Brief Description	A large business that benefits from expanded access to EV charging infrastructure provides an upfront subsidy for the deployment of a network of DC fast charging stations that enables interregional EV travel.	A group of businesses located in a tourism destination contributes annually to a funding pool that is used to subsidize the cost of deploying a network of DC fast charging and Level 2 charging stations that enables EV travel to and within the region.	Both a large business (following Business Model 1) and a local business funding pool (following Business Model 2) subsidize the cost of deploying a network of DC fast charging and Level 2 charging stations that enables EV travel to and within a region.
Sources of Indirect Value	• Increased sales of EVs • "Clean energy" marketing and brand-strengthening opportunities	• Increased sales of EVs • "Clean energy" marketing and brand-strengthening opportunities	• Both Business Model 1 and Business Model 2 sources
Candidate Businesses	Large businesses, including: • Automakers • Electric utilities • Retail chains • Restaurant chains	Smaller, local businesses, including: • Hotels • Retailers • Restaurants • Tourist attractions • Commercial real estate owners	At least one large business from Business Model 1 and a group of local businesses from Business Model 2
Form of Funding	Direct upfront transfer of funds from funding partner to charging station owner-operator	Annual subsidy by local businesses transferred to charging station owner-operator	Both Business Model 1 and Business Model 2 funding sources
Infrastructure Gap Focus	• DC fast charging stations along major interregional roadways	• DC fast charging along roadways that enable travel to the destination • DC fast charging and Level 2 charging stations that enable travel within the region	• DC fast charging along major interregional roadways that also enable travel to the destination • DC fast charging and Level 2 charging stations that enable travel within the region

2.7 Financial Analyses of Business Models

The financial analysis conducted in this section estimated the performance of a charging station network project that demonstrates each of the three business models identified previously. Only private sector roles were considered because the public sector does not provide any funding in these analyses.

The EV Charging Financial Analysis Tool, developed as part of this study, was used to complete these analyses. The tool can analyze a variety of alternative EV charging investment arrangements under a wide range of market assumptions. The tool is a flexible, Microsoft Excel workbook described in detail in Appendix B.

The EV Charging Financial Analysis Tool was used to assess the financial performance of the three business models applied to an example EV charging infrastructure gap in Washington. The infrastructure gaps used as example applications of each business model are defined in detail in Chapter 1 and summarized below:

- **I-90 Charging Gap:** Business Model 1 applied to charging gap to enable interregional travel on I-90 between Seattle and Spokane
- **Ocean Shores Charging Gap:** Business Model 2 applied to charging gap to enable travel to Ocean Shores (from Longview and the Puget Sound region) and within the destination region
- **Tri-Cities/Walla Walla Charging Gap:** Business Model 3 applied to charging gap to enable travel to Tri-Cities and Walla Walla (from Spokane and the Puget Sound region) and within the destination regions

The financial analysis estimated the performance of a charging station network project from three distinct perspectives:

- Charging station project owner-operator
- Project funding partner (a single large business or a group of local businesses)
- Total project performance as a whole as if all of the entities' perspectives are combined into a single entity

For each of the business perspectives, the tool estimated total capital investment, NPV, and discounted payback period to help evaluate whether participation in the business model makes sense from each entity's perspective. Definitions of each of these financial metrics, as well as explanations of their relevance to evaluating the feasibility of the business model, are provided in **Table 20**.

Total project performance metrics are useful because a project may perform well as a whole (e.g., generate net value), but fail to perform adequately for a particular entity. In such a case, the roles of each entity may need to be adjusted to make the business model financially sustainable. Conversely, a project may perform well for one entity, but fail to generate net value as a whole, in which case the business model may not capture enough value to be worth pursuing. In such a case, additional sources of revenue may need to be identified.

While each financial analysis scenario incorporated some unique assumptions associated with the particular business model and gap analyzed, all three scenarios share some general parameters. In each scenario, the EV charging owner-operator bears the costs and receives the direct revenues from user fees ($/kilowatt-hour) associated with the network of EV charging stations. The costs include capital costs for equipment and installation; operating costs for electricity, maintenance, and site access; and financing costs for interest paid on loans and returns paid to equity investors.

A project funding partner business (or set of businesses contributing to a funding pool), provided some level of funding to the owner-operator in the form of a cash transfer without expectation of repayment. This

TABLE 20: Financial Analysis Metrics Used to Evaluate the Success of the Business Model

METRIC	DEFINITION	RELEVANCE TO FEASIBILITY OF THE BUSINESS MODEL
Total Capital Investment / Amount of Station Funding Provided	The amount of funds invested/contributed to pay for charging station deployment.	Indicates whether it is realistic for the entity to invest/contribute funds at this level, based on that entity's access to funds.
Net Present Value (NPV)	The total value (revenue) of the project to the entity, net of the costs faced by the entity, in present value dollars.	Shows whether the entity will realize net profitability over the lifetime of the project. In most cases, a business entity's NPV must be positive for that entity to consider involvement in the project.
Discounted Payback Period	The period of time required for the project to generate net positive value for the entity.	Helps determine whether involvement in the project generates net profitability quickly enough to attract investment from the entity. Many private investors are only interested in projects that can achieve payback within three to five years.

cash transfer amount was a portion of the estimated indirect value (revenue) gained by the funding partner as a result of the EV charging station project. The revenue for a project funding partner can come indirectly from one more of the following sources:

- Increased sales of EVs;
- Increased sales of other products and services at businesses located near EV charging stations;
- Increased tourism business from EV travel to popular destinations;
- Employee engagement and retention benefits of offering EV charging at the workplace; and/or
- "Clean energy" marketing and brand-strengthening opportunities

The full list of market assumptions incorporated in the model is provided in Appendix B.

Critical factors that affect the success and failure for the business funding partners and the owner-operators were identified for each business model based on a series of sensitivity analyses. For example, the expected utilization of a charging station in the first year of the project significantly affects the direct revenue for the owner-operator. In each sensitivity analysis, the change in project NPV and payback period are shown over a range of possible values for a single variable, holding all other variables constant.

Descriptions and results of each of the three financial analysis scenarios are provided below.

Applying Business Model 1 to Enable Interregional EV Travel on I-90

Business Model 1 ("Large Business Funding Partners for Charging Network Development along Major Roadways") was applied to deployment of a DC fast charging network along I-90.

Description of scenario and assumptions: In this model, an automaker that benefits from expanded access to EV charging infrastructure gives $42,000 ($7,000 per charging station) to an EV charging service provider at the beginning of the project, subsidizing 20 percent of the DC fast charging equipment costs. These funds are used to deploy a network of six DC fast charging stations along I-90.

Financial performance: The financial analysis results, presented in **Table 21**, show that:

- Station deployment costs a total of $561,600.
- The owner-operator funds the station deployment with a mix of private-sector loans and equity. The

TABLE 21: Results of Financial Analysis of Applying Business Model 1 to Enable BEV Travel between Seattle and Spokane along I-90

FINANCIAL METRIC	RESULT
Total Project Level Perspective	
Total Capital Investment (Spent on Charging Station Deployment)	$561,600
NPV	–$87,777
Payback Period	No payback
Owner-operator Perspective	
Funds Spent on Stations (Equity)	$224,640
Funds Spent on Stations (Loans)	$336,960
NPV	–$118,207
Payback Period	No payback
Automaker Perspective	
Amount of Funds Transferred to Owner-Operator	$42,000
NPV	+$19,532
Payback Period	5 years

owner-operator also receives $42,000 from the funding partner. The NPV of the project for the owner-operator is -$118,207, so the project lost money and, as a result, the business model is not sustainable from the owner-operator perspective.

- The automaker contributes $42,000 to the owner-operator in the form of an upfront cash transfer. The project is profitable for the automaker, with an NPV of +$19,532, who reaches payback in five years. As a result, the business model is sustainable from the automaker perspective.

To understand the potential for improving the business case for this charging gap, the effect of different charging utilization rates and usage fees on the project's financial performance was investigated. These sensitivity analyses showed that:

- Projects with higher utilization can generate a positive NPV for the owner-operator and for the project as a whole. Greater utilization can be achieved by increasing the number of EVs on the road, although there are limits to the number of charging sessions each station can support in a day.[28]
- Increasing the station user fee also improves the NPV for the owner-operator and the project as a whole.

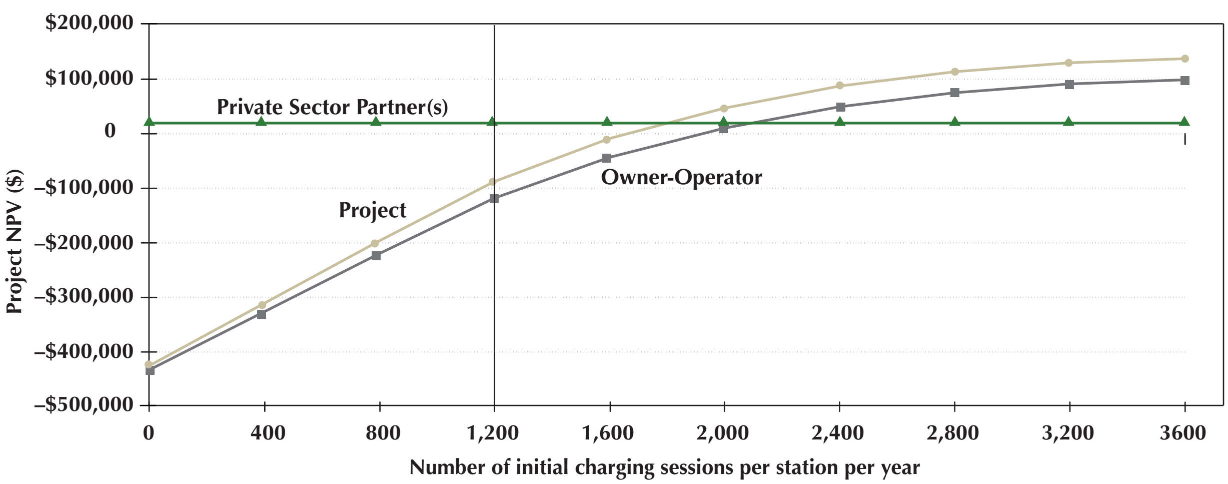
These sensitivity analyses, and others, are described in detail below.

Projects with higher station utilization can generate a positive NPV from the project and owner-operator perspective. The base case scenario assumes that each of the six new DC fast charging stations would be used 1,200 times per year (3.3 charging sessions per day) in the first year. Future EV charging station projects may experience higher initial utilization rates if more EVs are on the road. If station utilization in the first year is greater than 2,000 sessions per year (5.5 sessions per day), then the project generates a positive NPV and is financially sustainable for the owner-operator, as shown in **Figure 26**. However, the business model still may not attract owner-operator investment because the payback period for the owner-operator may be too long.

Higher station utilization can also shorten the owner-operator's payback period to five years. An initial utilization rate of at least 3,600 sessions per year is required for the

FIGURE 26: Business Model 1 Project NPV (Charging Station Utilization Sensitivity)

The project is more profitable for the owner-operator as average station utilization rises. If the I-90 charging stations are used more than 2,000 times a year initially, then the project is profitable for the owner operator. This figure shows diminishing returns from an increase in the number of charging sessions per station per year in the first year because the maximum number of sessions in a year (3,600) is reached sooner. The dark vertical line indicates the value in the base case scenario (1,200).



owner-operator to achieve payback within five years, as shown in **Figure 27**. This is very close to the assumed maximum 10 charging sessions per day. Utilization at this level initially and continuing over a sustained period is probably unrealistic given the current state of EV market development.

Increasing the user charge improves the payback period from the project and owner operator perspectives. If the user fee is increased from $0.50 to $0.70 per kilowatt-hour and the initial station utilization is at least 2,000 sessions per year, then the owner operator reaches payback within 5 years, as shown in **Figure 28**.

Funding partner interest depends on expected indirect value. Business Model 1 assumes a large business, in this case an automaker, acts as a funding partner, who expects to gain increased revenue as a result of deploying these six DC fast charging stations; the automaker expects to sell more EVs. If the expected indirect value generated by each station drops below the amount of funding it provides, then the project will not generate net value to the funding partner, in which case the funding partner is unlikely to participate in the project.

The following summarizes the application of Business Model 1 to the I-90 Charging Gap:

- Under the base case assumptions, the business model is not sustainable from the owner-operator perspective. Without significantly higher station utilization, higher user fees, or additional interventions by third parties, the owner-operator will not be profitable under this business model.
- If charging station utilization is significantly higher, (e.g., in the future if more EVs are on the road), then the business model may be sustainable for the owner-operator.
- The viability of the business model is also conditional on funding partner participation, which itself is highly dependent on the level of indirect value that the funding partner expects to gain from the charging stations.

Applying Business Model 2 to Enable EV Travel to and within Ocean Shores

Business Model 2 ("Local Business Funding Pools for Charging Network Development that Enables EV Travel to Tourism Destinations") was applied a network of EV charging stations that would enable travel to, from, and within Ocean Shores.

FIGURE 27: Business Model 1 Project Payback (Charging Station Utilization Sensitivity)

The owner-operator's payback period declines as average station utilization rises. If the I-90 stations are used 3,600 charging sessions a year initially, then the owner-operator can achieve payback in five years. This level of charging use is probably unrealistic at this time. For retail revenue levels where data is not shown, there is no payback. Dark vertical line indicates the value in the base case scenario (1,200).

Number of S&P Global 100 Companies, and Percent by Region

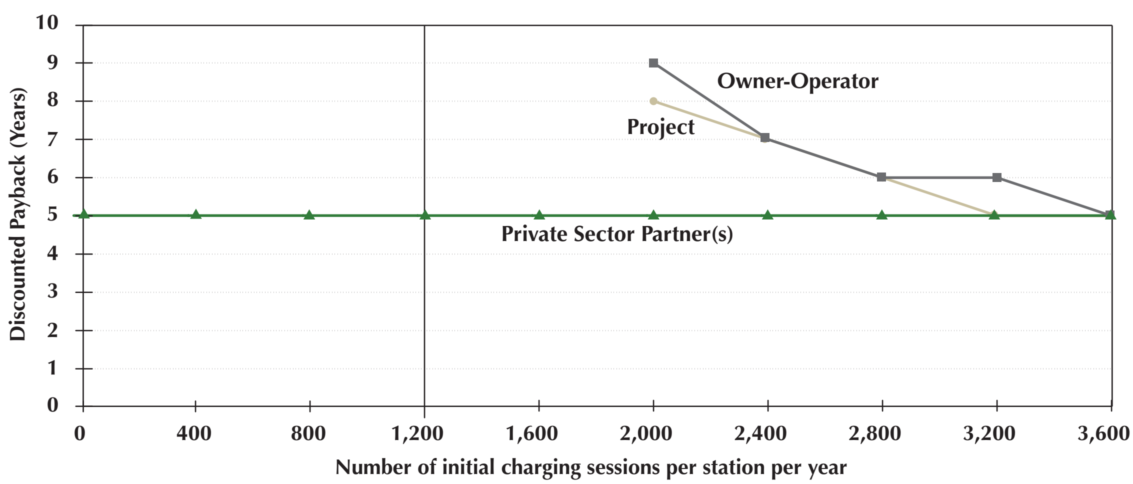
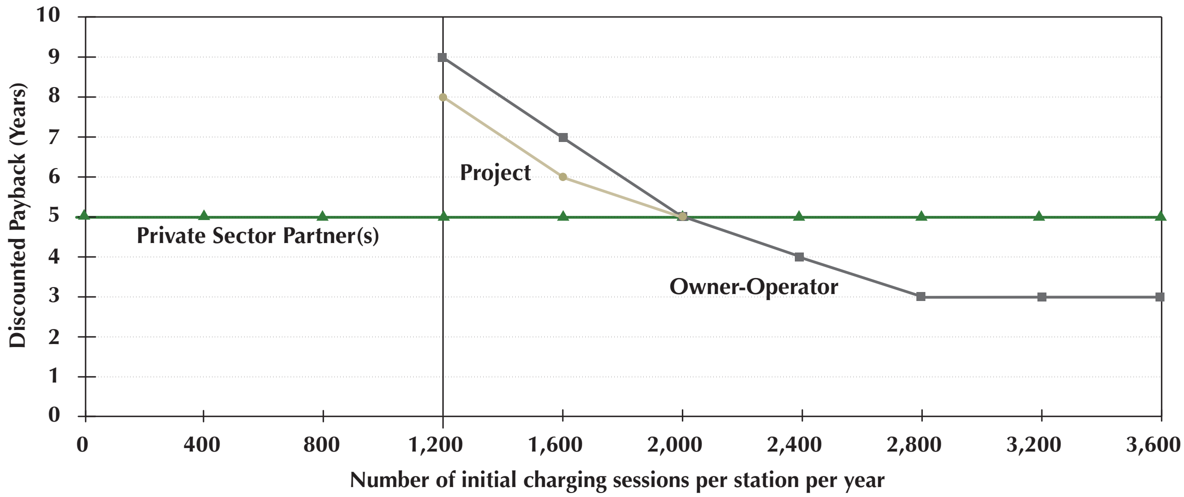


FIGURE 28: Business Model 1 Project Payback (Charging Station Utilization Sensitivity and User Fee of $0.70 per Kilowatt-Hour)

Dark vertical line indicates base case scenario assumption value, but results differ from the base case model because the user fee has also been changed from base case assumptions.



Description of scenario and assumptions: In this model, a group of six businesses located in Ocean Shores contributes to a funding pool that is used to provide an annual subsidy to the charging network owner-operator. This deployment follows the assessment of charging needs to enable EV travel to and within Ocean Shores, described in Chapter 1. Of these six businesses, five businesses each host five Level 2 charging stations and one business hosts a single DC fast-charging station. Each business expects to gain $1 in increased revenue per minute that EV drivers spend charging at their site, with a maximum expected additional revenue per charging session of $25. Each business agrees to contribute 10 percent of the revenue stream associated with the new EV tourists each year to the funding pool. Based on these assumptions, total annual contributions to the funding pool grow from $28,000 in the first year to $84,125 in the tenth year due to increase utilization of the charging station equipment.

Financial performance: The financial analysis results, presented in **Table 22**, show that:

- Station deployment costs a total of $501,500.
- The owner-operator funds the station deployment with a mix of private-sector loans and equity. The owner-operator also receives between $28,000 and $84,125 annually from the funding pool. The NPV of the project for the owner-operator is +$49,439 and the owner-operator reaches payback in 9 years. As a result, the business model makes money, and is sustainable from the owner-operator perspective. However, because a nine-year payback period may be too long for most businesses, this business model may not attract private investors.
- The local businesses collectively contribute between $28,000 and $84,125 annually into a funding pool that is provided to the owner-operator annually. The NPV of the project from the perspective of the local businesses collectively is +$206,566. The local businesses realize instant payback because they simply pay 10 percent of the estimated revenue they gain from the new EV tourists, and keep the other 90 percent of new revenue.

Because the payback period is likely too long to attract most private businesses, the effect of alternative revenue-sharing scenarios on the project's financial performance was investigated. These sensitivity analyses showed that:

TABLE 22: Results of Financial Analysis of Applying Business Model 2 to Enable BEV Travel to, from, and within Ocean Shores

FINANCIAL METRIC	RESULT
Total Project Level Perspective	
Total Capital Investment (Spent on Charging Station Deployment)	$501,500
NPV	+$292,320
Payback Period	6 years
Owner-Operator Perspective	
Funds Spent on Stations (Equity)	$200,600
Funds Spent on Stations (Loans)	$300,900
NPV	+$49,439
Payback Period	9 years
Collective funding pool perspective (6 businesses)	
Amount of Funds Transferred to Owner-Operator Annually	$28,000–$84,125
NPV	+$206,566
Payback Period	<1 year

- If customers spend more than the assumed $25 at the retail charging host-sites, then the owner-operator can achieve payback more quickly.
- If the local businesses shares more than 10 percent of their new EV revenue, the owner-operator's payback period is also shortened.

These sensitivity analyses, and others, are described in detail below.

Greater revenue per customer can shorten the payback period from the owner-operator perspective. If the local businesses gain more revenue from hosting charging stations, they can contribute more money to the funding pool and the owner-operator's payback period can be shortened, as shown in **Figure 29**. If the maximum amount that customers will spend in the local retail businesses per charging event is 50 percent more than estimated in the base case ($36 per charging event instead of $25) then the payback period for the owner-operator is 7 years. For the owner-operator to reach payback within five years, the maximum revenue per charging event must be greater than $60. While there are some businesses where this may be feasible, it is probably not likely in grocery stores, bait shops, and similar small businesses located in Ocean Shores.

Increasing the share of revenue from the funding pool can significantly decrease the owner-operator's payback period. The local businesses can help the owner-operator reach payback within five years if the local businesses contribute 25 percent of their new EV tourist revenues to the funding pool, as shown in **Figure 30**. However, local businesses may not be willing or able to contribute such a high fraction of revenues, depending on the profit margins of their business.

The partnership may be an attractive proposition for local businesses. The analyses show that this business model may be highly attractive to local businesses—as long as estimated revenue increases are actually realized. However, it is difficult for local businesses to reliably estimate potential revenue increases from offering EV charging on site; this may present a challenge for garnering local business participation in this business model. This uncertainty also increases the risk for an owner-operator, since shared revenue is essential for the owner-operator to achieve profitability.

The following summarizes the application of Business Model 2 to travel to and within Ocean Shores:

- Under the base case assumptions, the business model is profitable from the owner-operator

FIGURE 29: Business Model 2 Project Payback (Maximum Retail Revenue Sensitivity)

The owner-operator's payback period becomes shorter as the revenue per charging session rises. If the maximum amount that customers will spend per charging event at an Ocean Shores business hosting a charging station is $60 (data point circled on this chart), then the owner-operator of the charging network achieves payback in five years. The dotted horizontal line indicates payback within five years. For retail revenue levels where data is not shown, there is no payback. The dark vertical line indicates the value in the base case scenario ($25.00).

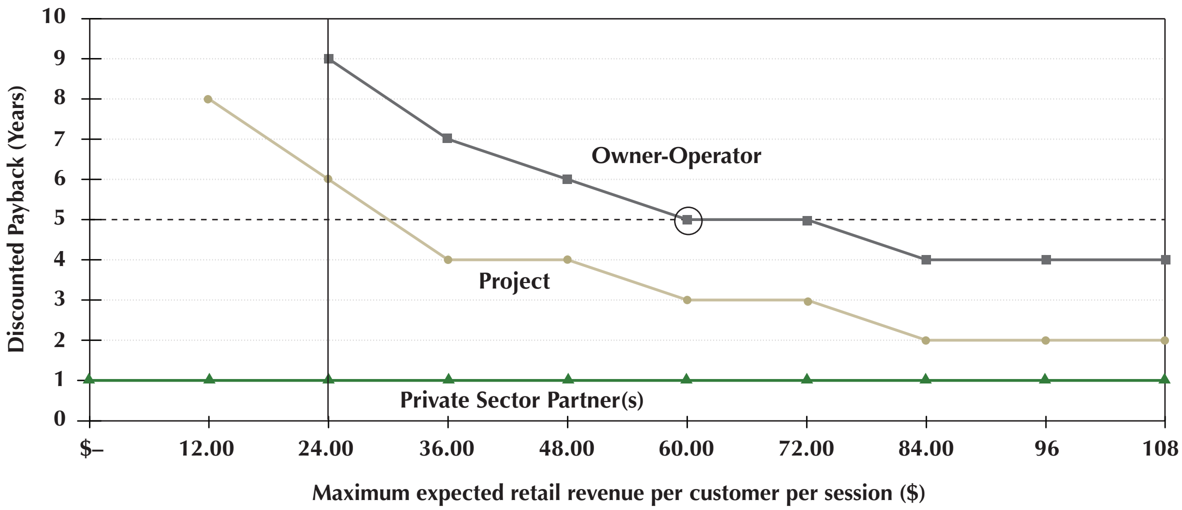
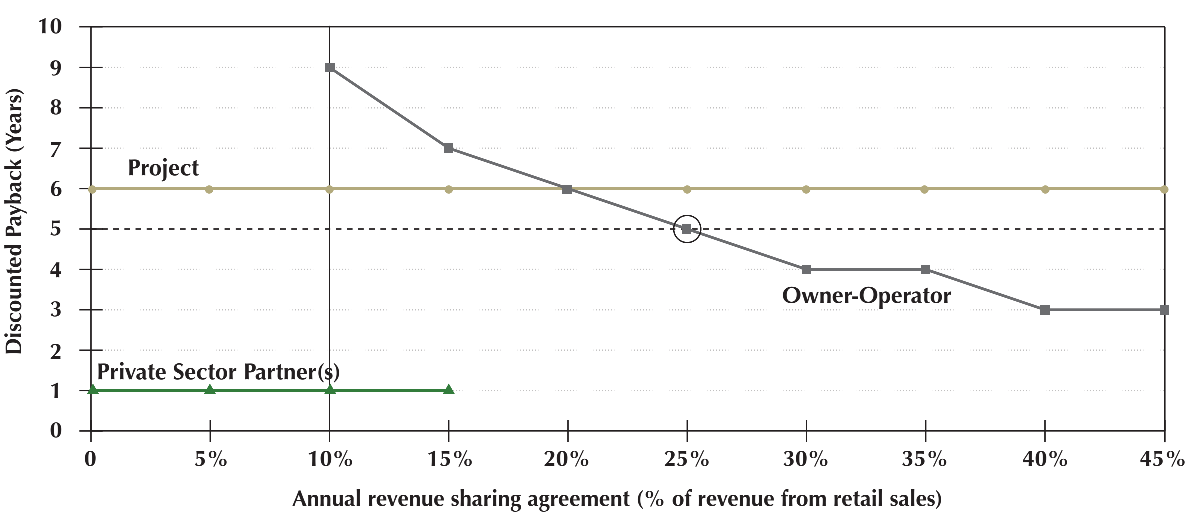


FIGURE 30: Business Model 2 Project Payback (Revenue Increase Percent Shared by Local Businesses with Station Owner-Operator Sensitivity)

The owner-operator's payback period decreases as business funding partners share a higher fraction of their incremental revenue with the owner-operator. If the local businesses contribute 25 percent of their increased revenues to the funding pool, then the owner-operator can reach payback within five years. For businesses with narrow profit margins, this level of contribution may be infeasible. The dotted horizontal line indicates payback within five years. For retail revenue levels where data is not shown, there is no payback. The dark vertical line indicates the value in the base case scenario (10 percent).



perspective, but the nine-year payback period may be too long for most investors.

- Owner-operator payback is sensitive to the amount of indirect revenues realized by local businesses and the percentage of those revenues that they share with the owner-operator. The owner-operator can reach payback within five years if the estimated maximum indirect revenue per charging event is greater than $60 (more than double the base case value of $25). On the other hand, if local business share less than 10 percent of their additional indirect revenues from on-site charging stations then, under base case assumptions, the business model becomes unsustainable for the owner-operator.
- The local businesses realize instant payback because they simply pay a percentage of their estimated annual EV tourist revenues. But if the indirect value of charging stations is low, then the local businesses do not stand to make much money from installing EV charging stations, and they may not participate in this business model.

Applying Business Model 3 to Enable EV Travel to and within Tri-Cities and Walla Walla

Business Model 3 ("Large Business Funding Partner and Local Business Funding Pools for Charging Network that Enables EV Travel to Tourism & Employment Regions") was applied to enable travel to, from, and within the Tri-Cities and Walla Walla region.

Description of scenario and assumptions: In this model, an automaker that benefits from expanded access to EV charging infrastructure contributes $95,000 of upfront funding to an EV charging service provider. The payment of $95,000 is based on the assumption that the automaker is willing to contribute $7,000 to the owner-operator for each DC fast charging station and $500 for each Level 2 charging station—20 percent of the equipment cost. The automaker expects this to be a profitable investment because more people will buy EVs as a result of the existence of these new charging stations.

In addition, a group of twelve small businesses located in the Tri-Cities and Walla Walla region (such as wineries) contribute to a funding pool that provides additional payments each year to the charging station owner-operator. Among these wineries, 10 host five Level 2 charging stations each and two host a single DC fast charging station. Each winery expects to gain $1 in increased revenue per minute that EV drivers spend charging at their site, with a maximum expected additional revenue per charging session of $25. Each winery agrees to contribute 10 percent of this new EV tourist revenue each year to the funding pool. Based on these assumptions, total annual contributions to the funding pool grow from $56,000 in the first year to $168,250 in the tenth year, as the number of EV driving visitors grows.

Together, these funds from the large and small businesses are used to subsidize the cost of deploying of a network of charging stations that enables EV travel to and within the region, following the assessment of charging needs to enable EV travel to and within the Tri-Cities and Walla Walla region.

Financial performance: The financial analysis results, presented in **Table 23**, show that:

- Station deployment costs a total of $1,384,100.
- The owner-operator funds the station deployment with a mix of private-sector loans and equity. The owner-operator also receives $95,000 from an automaker initially and between $56,000–$168,250 annually from the funding pool. The NPV of the project for the owner-operator is +$54,166 and the owner-operator reaches payback in 9 years. As a result, the business model is sustainable from the owner-operator perspective. However, the nine-year payback period may be too long for most investors, so the business model still may not attract owner-operators.
- The automaker contributes $95,000 initially to the owner-operator. The local businesses collectively contribute between $56,000 and $168,250 annually into a funding pool that is transferred to the owner-operator. The NPV of the project from the joint perspective of the automaker and the local businesses is +$457,312. The local businesses realize instant payback since they simply pay a percentage of their new EV tourist revenues and keep the bulk of that new revenue.

To understand the potential for improving the business case for this charging gap, the effect of different charging utilization rates and loan interest rates on the project's financial performance was investigated. These sensitivity analyses showed that:

- Payback for the owner-operator is sensitive to station utilization. Projects with higher utilization can generate a positive NPV for the owner-operator and for the project as a whole, but there are limits

TABLE 23: Results of Financial Analysis of Applying Business Model 3 to Enable BEV Travel to Tri-Cities and Walla Walla from Seattle and Spokane

FINANCIAL METRIC	RESULT
Total Project Level Perspective	
Total Capital Investment (Spent on Charging Station Deployment)	$1,384,100
NPV	+$595,703
Payback Period	6 years
Owner-Operator Perspective	
Funds Spent on Stations (Equity)	$553,640
Funds Spent on Stations (Loans)	$830,460
NPV	+$54,166
Payback Period	9 years
Automaker/Funding Pool Perspective	
Amount of Funds Transferred to Owner-Operator Initially	$95,000
Amount of Funds Transferred to Owner-Operator Annually	$56,000–$168,250
NPV	+$457,312
Payback Period	2 years

to the number of charging sessions each station can support in a day, and it requires an increase in the number of EVs on the road.

- Payback for the owner-operator is also sensitive to the cost of debt (the interest rate on private-sector loans). While decreasing the cost of debt alone cannot make the business model sustainable, a significantly higher cost of debt can make the business model unprofitable.

These sensitivity analyses, and others, are described in detail below.

Payback for the owner-operator is highly sensitive to station utilization. The base case financial analysis assumes that the DC fast charging stations will experience 1,200 charging sessions per year (3.3 sessions per day) in the first year. If initial station utilization is greater than 3,200 charging sessions per year (8.8 sessions per day), then the owner-operator realizes a payback within five years, as shown in **Figure 31**. However, if the initial utilization for the DC fast charging stations is below 1,200 charging sessions per year (2.7 sessions per day), the project is not financially sustainable for the owner-operator.

From the perspective of the local business funding partners, the profitability of the project is not sensitive to station utilization because the businesses make no upfront investment and they simply share a portion of the increased revenue with the owner-operator.

Payback for the owner-operator is also sensitive to the cost of debt. The base case financial analysis assumes that the cost of debt to the owner-operator is 8 percent. **Figure 32** shows that if the cost of debt is reduced to 2 percent, then the owner-operator can realize payback within 8 years. However, it is highly unlikely that private lenders would provide loans at an interest rate that low. In fact, it is more likely that private lenders would require an interest rate greater than 8 percent, because they would perceive an EV charging business venture as relatively risky. If the owner-operator cannot obtain loans at an interest rate at or below 10 percent, then the project is not financially sustainable, given the other assumptions.

The following summarizes the application of Business Model 3 to travel to and within Tri-Cities and Walla Walla:

- Under the base case assumptions, the business model is sustainable from the owner-operator

FIGURE 31: Business Model 3 Project Payback (DC Fast Charging Utilization Sensitivity)

The owner-operator's payback period declines as average station utilization rises. If the Tri-Cities and Walla Walla stations are used more than 3,200 charging sessions a year initially, then the owner-operator can achieve a five-year payback. This level of charging is probably unrealistic at this time. For retail revenue levels where data is not shown, there is no payback. The dark vertical line indicates the value in the base case scenario (1,200).

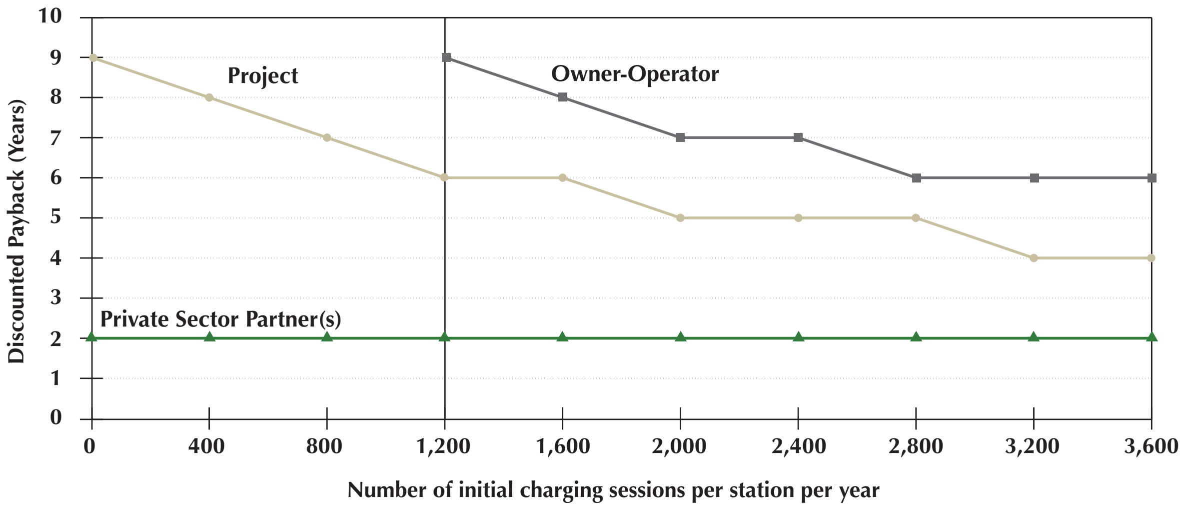
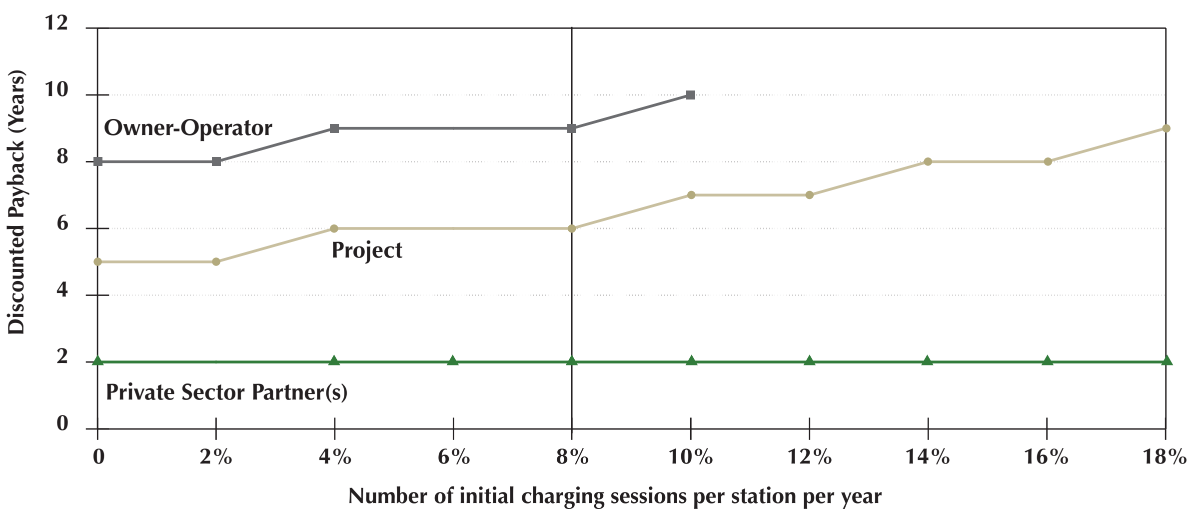


FIGURE 32: Business Model 3 Project Payback (Cost of Debt Sensitivity)

The owner-operator's payback period declines as the cost of debt decreases. If the owner-operator cannot obtain loans at an interest rate at or below 10 percent, then the project is not financially sustainable. For retail revenue levels where data is not shown, there is no payback. The dark vertical line indicates the value in the base case scenario (8 percent).



perspective, but the nine-year payback period may be too long for investment to be compelling for most investors.

- If charging station utilization is significantly higher (e.g., in the future if more EVs are on the road), then the business model may be sustainable for the owner-operator. Payback for the owner-operator is highly sensitive to station utilization. If initial station utilization for the DC fast charging stations is greater than 3,200 charging sessions per year (9 sessions per day), then the owner-operator realizes a payback within five years. However, if the initial DC fast charging station utilization is below 1,200 charging sessions per year (3 sessions per day), the project is not financially sustainable for the owner-operator.
- Payback for the owner-operator is also sensitive to the cost of debt (the interest rate on private-sector loans). The base case financial analysis assumes that the cost of debt to the owner-operator is 8 percent. If the owner-operator cannot obtain loans at an interest rate at or below 10 percent, then the project is not profitable for the owner-operator.
- The viability of the business model is also conditional on funding partner participation, which itself is highly dependent on the level of indirect value that the large business and local business funding partners expect to gain from the charging stations. If the indirect value of charging stations is perceived to be low, then these may not participate in this business model. For some high-margin businesses, such as some wineries, the prospect of revenue increases may present a strong value case.

CHAPTER 3: ROLE OF GOVERNMENT IN FACILITATING BUSINESS MODELS IN THE NEAR TERM

3.1 SUMMARY OF FINDINGS

Under current market conditions, the three business models analyzed in Chapter 2 are not financially viable without public interventions if the owner-operator requires a payback of five years or less.

A variety of public sector interventions were tested to identify what it would take to make the business models profitable and sustainable, with a goal of investor payback within five years. A combination of three public interventions was selected for analysis: low-interest loans, one-time grants, and a 5-year extension of the BEV sales tax exemption.

- Business Model 1 was applied to the I-90 Charging Gap. It became profitable and achieved a five-year payback with a $110,000 loan at 5.4 percent; a one-time grant of $220,000, and the continuation of the BEV sales tax exemption.
- Business Model 2 was applied to the Ocean Shores Charging Gap. It became profitable and achieved a five-year payback with a $150,000 loan at 5.4 percent, a one-time grant of $85,000, and the continuation of the BEV sales tax exemption.
- Business Model 3 was applied to the Tri-Cities/ Walla Walla Charging Gap. It became profitable and achieved five-year payback with a $415,000 loan at 5.4 percent, a one-time grant of $240,000, and the continuation of the BEV sales tax exemption.

A key finding of the study is that the use of subsidies and interventions would be helpful to the development of the EV market in near term. Over the next few years, as long the EV market continues to develop, it is likely that no further public sector intervention will be needed to make EV charging business models profitable and sustainable.

Potential revenue sources to offset the cost of the public sector interventions include an annual EV fee, limiting the BEV sales tax exemption to vehicles below a certain price, and state and federal transportation funds.

The analyses performed for this study show that both private and public sector participation would likely be required to ensure the sustained development of EV infrastructure in the state. Private sector entities that gain indirect value from EV charging station deployment can play a critical role in improving the financial performance of EV charging station investments. In the near term as the EV market develops, public interventions can help make charging station investments more financially attractive to the private sector. Finally, with sustained EV market development, public sector interventions may no longer be needed to attract private investment in charging stations after five years.

3.2 INTRODUCTION

The goal of this study is to identify sustainable business models that the private sector can execute to finance EV charging infrastructure gaps in Washington state. This chapter explores the roles that public sector entities can play in expanding private investment in EV charging infrastructure.

In Chapter 2, three business models were identified that capture the indirect value of EV charging stations (see **Box 6**). These business models were then evaluated based on their projected financial performance when applied to address three example charging infrastructure gaps under current, baseline market conditions with no public sector intervention. The key findings from those analyses were:

- The private sector will not adequately invest in charging infrastructure today, because EV charging station projects are likely to operate at a loss if selling electricity is the only source of revenue.
- Capturing the indirect value of EV charging services to other businesses is possible and necessary to increase private sector investment in the EV charging network.
- Business models designed to capture the indirect value of charging stations can materially improve the financial performance of EV charging projects. However, it is unlikely that the private sector will implement these business models in the near

Box 6. Three Business Models and Example Charging Gaps Analyzed in Chapters 2 and 3

- **Business Model 1:** Large Business Funding Partners for Charging Network Development along Major Roadways. This model is applied to the I-90 Charging Gap. At least six new DC fast charging stations are needed to enable BEV travel between Seattle and Spokane along I-90.
- **Business Model 2:** Funding Pools Financed by Local Businesses for Charging Network Development that Enables EV Travel to Tourism Destinations. This model is applied to the Ocean Shores Charging Gap. At least 3 DC fast charging stations and 25 Level 2 charging stations are needed to address this gap.
- **Business Model 3:** This model combines Business Model 1 and 2 and is applied to Tri-Cities/Walla Walla Charging Gap. At least 10 DC fast charging stations and 50 Level 2 charging stations are needed to address this charging gap.

term without public sector intervention because the projects' financial performance is likely not favorable enough to attract investors under current market conditions.

In this chapter, options for government intervention are considered and funding sources for these interventions are explored.

The public sector may decide that it is worth spending public dollars to help attract private investment in EV charging infrastructure due to various forms of value that EV chargers provide to society, including:

- Promoting local economic development (e.g. from retail sales).
- Keeping EV drivers from getting stranded;
- Fostering clean energy deployment;
- Reducing transportation emissions; and

The public roles are referred to as interventions because they are intended to deliberately influence the financial performance of a charging station project. The interventions consist of public policies like tax incentives, funding contributions, regulatory requirements, and other actions intended to improve the financial performance for a charging station project that implements those business models.

This chapter analyzes the effects of these public sector interventions on applications of the business models identified in Chapter 2. First, each public sector intervention is considered as a stand-alone policy. The effect of each policy on the financial performance of each of the three Business Models is estimated. There are two reasons in which a public intervention would be required to make a business model viable:

- In some cases, the net present value (NPV) of a business model is negative and an intervention by the public sector would be necessary for the model to result in a positive return for the private sector.
- In other cases, the business model yields a positive NPV, but the return on investment is not high enough or payback may not be soon enough to attract private investment, considering the risk of the project's success.

Three scenarios for each type of public sector intervention are analyzed: a low, medium, and high level of intervention. Potential barriers to implementing each intervention are also considered.

Next, an analysis is presented of example combinations of public sector interventions that would improve the expected financial performance of the three business models to allow private investors to achieve payback within five years or less, a common objective of industry. These combined public interventions demonstrate the level of public sector intervention that may be needed today in order for each business model to be viable in the marketplace. An analysis of the financial performance of these business models in five years' time without public sector interventions was also completed to demonstrate the feasibility of the business models in the near future, assuming the EV market continues to develop and the number of EVs in Washington increases.

Finally, the range of funding source options for these potential public interventions is explored.

3.3 PUBLIC SECTOR INTERVENTIONS

This section summarizes the various roles public sector partners can play in implementing the three business models. Public sector roles can improve the financial performance of a charging station project through direct funding, such as low-interest loans and grants. Regulatory or policy changes could also spur EV sales and charging station deployment. These interventions include enacting building code requirements for charging access, implementing California's ZEV program, and conducting a consumer education or outreach campaign. The effect of these interventions on the financial performance of a charging station project is difficult to quantify. In addition, there may be opportunities for public sector vehicle fleets to share charging stations with the general public, which would increase station utilization by allowing for the use of those stations to be shared between public and private EV drivers.

For each public sector intervention, the following information is provided:

- A description of the intervention and how it could improve the business case for investing in charging stations;
- An explanation of how the intervention could impact the financial performance of charging station projects;
- An overview of any potential legal or regulatory barriers to implementing the intervention; and
- The modeled financial performance of each applicable business model under a range (low, medium, and high) of levels of intervention.

The financial analyses in this section rely on the same default assumptions used to analyze the business models in Chapter 2. For example, the analyses assume that station deployment costs for each project are funded through an initial capitalization composed of 60 percent debt and 40 percent equity. As a result, a public sector intervention focused on project equity can only affect 40 percent of the total capital costs of the project.

Each public sector intervention affects the financial performance of the business model differently. For example, a low-interest loan reduces the cost of funds to the project owner-operator, thereby improving the cash flow of the project. Extending the BEV sales tax exemption would increase EV sales and therefore improve the utilization of charging stations. The effects of each of these interventions on the financial performance of charging station project are described in **Table 24**.

The Washington State Constitution prohibits the lending of state credit and the gift of public funds. Washington has developed programs to provide public grants and loans to businesses under certain circumstances, but the mechanism for doing so was not explored in this study. In the following pages, the public sector interventions are described as grants and/or loans to owner-operators of charging networks. Washington policymakers must determine the appropriate way to provide such assistance.

Low-Interest Loan

The public sector could help improve the financial performance of private-sector EV charging station investments by providing low-interest loans.

Individual loans could be issued directly to charging station owner-operators as part of a solicitation of proposals for charging station projects. Alternatively, the state could establish a dedicated revolving loan fund, designed to be as fiscally self-sustaining as possible, to offer low-interest loans to charging station owner-operators.

Medium Scenario Explanation: The public sector provides loans equal to 50 percent of total project debt (30 percent of the total project capital costs) at an interest rate of 5.4 percent with a 10-year term.[29] For comparison, without access to low-interest loans, the base case assumption is that 100 percent of total project debt is financed with private loans at an interest rate of 8 percent with a 10-year term.

Legal/Regulatory Barriers: Establishing a large, dedicated low interest loan program would require legislative action.

Financial Performance Results: The results of the financial analyses, presented in **Table 25**, show that:

- Low-interest loans can improve the financial performance for the owner-operator, but not enough to make the owner-operator profitable under any of the three business model applications.
- EV charging station projects that are unfamiliar to lenders or considered risky may have limited access to private lending or have a cost of funds that is prohibitively expensive. While these analyses indicate that the impact of low-interest loans on the financial performance for the owner-operator are not large, their importance may be greater for these projects.

TABLE 24: Summary of Public Sector Interventions

INTERVENTION	FINANCIAL PERFORMANCE IMPACT (MEDIUM SCENARIO)
Low-Interest Loan	Finance 50% of project debt (30% of the total project capital costs) at an interest rate of 5.4% with a 10-year term. This rate is 33% lower than the assumed private-sector loan interest rate of 8%.
Grant	Subsidize cost of charging station equipment by 50%.
Zero-Emission Vehicle (ZEV) Program	Increase charging station utilization growth rate from 15% to 30%.
Building Codes	Require new construction or major renovations to provide power to a fixed number of parking spots on site (i.e., EV ready). For applicable sites, the effect of this intervention is estimated to subsidize 50% of the cost of electric utility upgrades and grid interconnection for DC fast charging sites ($10,000) and 50% of the cost of construction and equipment installation ($13,000 for DC fast charging sites and $2,000 for Level 2 charging sites).
Consumer Education	Develop and implement a campaign to educate consumers about EVs, including public awareness campaigns, ride-and-drives, media engagement, and employee engagement programs. The effect of this intervention is estimated to increase charging station utilization growth rate from 15% to 18%.
Extending BEV Sales Tax Exemption	Extend the current sales tax exemption for BEVs, which is set to expire on June 30, 2015, for five years. This intervention is estimated to increase the annual growth rate of charging station utilization from 15% to 22%.
Shared Use EV Charging Stations (Publicly Available and Public Fleets)	State or municipal public fleets considering incorporating EVs in their vehicle fleets share a privately owned and managed charging station with the general public, rather than deploy a dedicated charging station with restricted access. For applicable sites, the effect of this intervention is estimated to increase initial DC fast charging station utilization by 1 session per day (a 30% increase) and the maximum charging station utilization by 1 session per day (a 10% increase).

Grant

The public sector could help improve the financial performance of private-sector EV charging station investments by providing a grant that lowers the upfront cost of a project.

By issuing a grant, a state or local government could subsidize the upfront costs of a charging station project (e.g., charging equipment) with no expectation of the funds being paid back by the charging station owner-operator.

While the lack of repayment of grants is a drawback relative to issuing low-interest loans, grants have some advantages. First, grants may be easier to implement and administer. Second, grants may be more effective than loans at spurring private investment in charging stations in the near term because the larger subsidy may be more compelling to owner-operators.

Medium Scenario Explanation: The medium scenario assumes that the public sector provides grants equal to 50 percent of the cost of charging station equipment.

Legal/Regulatory Barriers: Establishing a dedicated grant program would require legislative action.

Financial Performance Results: The results of the financial analyses, presented in **Table 26**, show that:

- Grants can dramatically improve the financial performance for the owner-operator, but not enough to achieve a five-year payback in the low and medium scenarios.
- The high scenario (equal to 75 percent of equipment costs) can make the owner-operator profitable under

TABLE 25: Effects of Low-Interest Loans on the NPV and Payback for Each Business Model

This table compares the impacts on project financial performance of the public sector providing 25, 50, or 75 percent of project debt at an interest rate of 5.4 percent with a 10-year term. Loans could be provided by state or local governments. Debt for the project is up to 60 percent of the total project capital costs. The medium scenario assumes the public sector provides loans for 50 percent of the debt for the project, or 30 percent of the total project capital costs. Where applicable, project payback in years is shown in parentheses. The NPV and payback for the public sector do not account for the social benefits of EV market development.

BUSINESS MODEL		BASE	LOW	MEDIUM	HIGH
Contribution by Private Sector Partners		As modeled in Chapter 2 (no public intervention)	25% of debt	50% of debt	75% of debt
Business Model 1 Applied to I-90 Charging Gap	Project	–$87,777	–$89,595	–$88,500	–$84,372
	Owner-Operator	–$118,207	–$112,553	–$106,899	–$101,245
	Private Sector Partner (Automaker)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)
	Public Sector	N/A	$0*	$0*	$0*
Business Model 2 Applied to Ocean Shores Charging Gap	Project	+$292,320 (6)	+$298,662 (6)	+$307,844 (6)	+$319,983 (7)
	Owner-Operator	+$49,439 (9)	+$54,488 (9)	+$59,537 (9)	+$64,586 (8)
	Private Sector Partners (Local Businesses)	+$206,566 (1)	+$206,566 (1)	+$206,566 (1)	+$206,566 (1)
	Public Sector	NA	$0*	$0*	$0*
Business Model 3 Applied to Tri-Cities/Walla Walla Charging Gap	Project	+$595,703 (6)	+$608,374 (7)	+$628,737 (7)	+$657,106 (7)
	Owner-Operator	+$54,166 (9)	+$68,101 (9)	+$82,035 (9)	+$95,970 (9)
	Private Sector Partners (Automaker, Local Businesses)	+$457,312 (2)	+$457,312 (2)	+$457,312 (2)	+$457,312 (2)
	Public Sector	N/A	$0*	$0*	$0*

* The public sector's NPV is zero because the cost of administering the loan is not included and the loans are expected to be paid back in full.

Business Model 1 and reduce the owner-operator's payback to five years for Business Models 2 or 3.

ZEV Program

The public sector could help improve the financial performance of private-sector EV charging station investments by participating in California's Zero Emission Vehicle (ZEV) Program.

The ZEV Program is an ambitious policy requiring manufacturers in participating states to produce and deliver for sale ZEVs, which include electric and hydrogen fuel cell passenger vehicles. Currently, nine states—Connecticut, Massachusetts, Maryland, Maine, New Jersey, New York, Oregon, Rhode Island, and Vermont—are participating in California's ZEV Program.

Participating in the ZEV Program could improve the financial performance of charging station investments by increasing station utilization growth as a result of requiring manufacturers to produce and deliver ZEVs.

Medium Scenario Explanation: The base case assumption for growth in station utilization (as the number of EVs on the road grows) is 15 percent per

TABLE 26: Effects of Grants on the NPV and Payback for Each Business Model

This table compares the impacts on project financial performance of the public sector providing a grant equal to 25, 50, or 75 percent of charging station equipment costs. Grants could come from state or local governments. Where applicable, project payback in years is shown in parentheses. The NPV and payback for the public sector do not account for the social benefits of EV market development.

BUSINESS MODEL		BASE	LOW	MEDIUM	HIGH
Contribution by Private Sector Partners		As modeled in Chapter 2 (no public intervention)	25% equipment cost subsidy	50% equipment cost subsidy	75% equipment cost subsidy
Business Model 1 Applied to I-90 Charging Gap	Project	–$87,777	–$87,777	–$87,777	–$87,777
	Owner-Operator	–$118,207	–$62,047	–$5,887	+$50,273 (7)
	Private Sector Partner (Automaker)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)
	Public Sector	N/A	–$56,160	–$112,320	–$168,480
Business Model 2 Applied to Ocean Shores Charging Gap	Project	+$292,320 (6)	+$292,320 (6)	+$292,320 (6)	+$292,320 (6)
	Owner-Operator	+$49,439 (9)	+$99,589 (7)	+$149,739 (6)	+$199,889 (4)
	Private Sector Partners (Local Businesses)	+$206,566 (1)	+$206,566 (1)	+$206,566 (1)	+$206,566 (1)
	Public Sector	N/A	–$50,150	–$100,300	–$150,450
Business Model 3 Applied to Tri-Cities/Walla Walla Charging Gap	Project	+$595,703 (6)	+$595,703 (6)	+$595,703 (6)	+$595,703 (6)
	Owner-Operator	+$54,166 (9)	+$192,576 (8)	+$330,986 (6)	+$469,396 (3)
	Private Sector Partners (Automaker, Local Businesses)	+$457,312 (2)	+$457,312 (2)	+$457,312 (2)	+$457,312 (2)
	Public Sector	N/A	–$138,410	–$276,820	–$415,230

year.[30] The exact effect of participation in the ZEV program on EV sales and station utilization is uncertain, but for the medium scenario, participation is assumed to increase the annual station utilization growth rate to 30 percent. This growth rate is considered reasonable since it is roughly in line with the growth rate in the number of ZEVs that would likely be sold in the state in order to comply with the ZEV Program.[31]

Legal/Regulatory Barriers: Participating in the ZEV Program would be a significant commitment for the state. In 2005, the Legislature directed the Department of Ecology to implement the California Clean Car Standards, but prohibited the Department of Ecology from adopting the ZEV program.[32]

Financial Performance Results: The results of the financial analyses, presented in **Table 27**, show that:

- For Business Model 1, participation in the ZEV Program can significantly improve the financial performance for the owner-operator. However, the owner-operator is still not profitable, even in the high scenario.
- For Business Models 2 and 3, participation in the ZEV Program can significantly improve the financial performance for the owner-operator. Although the owner-operator is able to achieve profitability, payback in less than five years is not possible under any scenario.

TABLE 27: Effects of the ZEV Program on the NPV and Payback for Each Business Model

This table compares the impacts on project financial performance of participating in the ZEV Program under three scenarios: 20, 30, and 40 percent annual increases in charging station utilization growth. Where applicable, project payback in years is shown in parentheses. The NPV and payback for the public sector do not account for the social benefits of EV market development.

BUSINESS MODEL		BASE	LOW	MEDIUM	HIGH
Contribution by Private Sector Partners		As modeled in Chapter 2 (no public intervention)	20% utilization growth rate	30% utilization growth rate	40% utilization growth rate
Business Model 1 Applied to I-90 Charging Gap	Project	–$87,777	–$47,871	–$3,694	$20,231 (9)
	Owner-Operator	–$118,207	–$80,995	–$39,167	–$16,254
	Private Sector Partner (Automaker)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)
	Public Sector	N/A	$0	$0	$0
Business Model 2 Applied to Ocean Shores Charging Gap	Project	+$292,320 (6)	+$376,614 (5)	+$468,830 (4)	+$518,701 (4)
	Owner-Operator	+$49,439 (9)	+$104,428 (7)	+$165,626 (6)	+$199,105 (6)
	Private Sector Partners (Local Businesses)	+$206,566 (1)	+$230,053 (1)	+$256,076 (1)	+$270,308 (1)
	Public Sector	N/A	$0	$0	$0
Business Model 3 Applied to Tri-Cities/Walla Walla Charging Gap	Project	+$595,703 (6)	+$790,881 (6)	+$1,004,798 (5)	+$1,120,479 (4)
	Owner-Operator	+$54,166 (9)	+$188,949 (8)	+$339,249 (7)	+$421,473 (6)
	Private Sector Partners (Automaker, Local Businesses)	+$457,312 (2)	+$504,277 (2)	+$556,333 (2)	+$584,796 (2)
	Public Sector	N/A	$0	$0	$0

Building Codes

The public sector could help improve the financial performance of private-sector EV charging station investments by adopting building codes that require new construction or major renovation projects to be "EV-ready" by providing power to a specified number of parking spots on site.

Although such building codes would add additional costs to construction projects, they present two advantages in the context of increased private sector investment in EV charging infrastructure. First, requiring pre-wiring would decrease the incremental costs of installation and grid interconnection for owner-operators considering whether or not to deploy charging stations. Second, wiring for charging stations during new construction or major renovations can significantly reduce installation costs because it avoids dedicated "trenching" for electrical conduit or upgrading preexisting electrical equipment.

While this intervention can provide installation cost savings, its ability to improve the business case for investing in charging stations in the near term is limited because it would only apply to new and renovated building projects. It will take years for enough of the building stock to "turn over," so that the resulting installation cost savings would be gained.

Medium Scenario Explanation: The effect of this intervention is estimated to subsidize 50 percent of the cost of electric utility upgrades and grid interconnection for DC fast charging sites ($10,000) and 50 percent of the cost of construction and equipment installation ($13,000 for DC fast charging sites and $2,000 for Level 2 charging sites).

Legal/Regulatory Barriers: Amending building codes could require legislative action at the state or local level.

Financial Performance Results: The results of the financial analyses, presented in **Table 28**, show that:

- Adopting EV-ready building codes can improve the financial performance for the owner-operator, for sites where the updated building codes have taken effect.
- However, the owner-operator does not achieve profitability under Business Model 1 after a 50 percent decrease in installation costs as a result of adopting EV-ready building codes. In addition, the owner-operator's payback is more than five years under Business Models 2 or 3.
- In the high scenario, a relatively optimistic 75 percent decrease in installation costs would improve the financial performance enough to achieve profitability for the owner-operator under Business Model 1 and reduce the owner-operator's payback to within six years for Business Models 2 and 3—close to reaching the five-year threshold.

TABLE 28: Effects of Building Codes on the NPV and Payback for Each Business Model

This table compares the impacts on project financial performance of adopting EV-ready building codes under three scenarios: 25, 50, and 75 percent reductions in installation costs. Where applicable, project payback in years is shown in parentheses. The NPV and payback for the public sector do not account for the social benefits of EV market development. The cost to the public sector does not include administration or other costs associated with implementing the building code intervention.

BUSINESS MODEL		BASE	LOW	MEDIUM	HIGH
Contribution by Private Sector Partners		As modeled in Chapter 2 (no public intervention)	25% installation cost subsidy	50% installation cost subsidy	75% installation cost subsidy
Business Model 1 Applied to I-90 Charging Gap	Project	–$87,777	–$34,178	+$14,561 (10)	+$63,299 (8)
	Owner-Operator	–$118,207	–$92,107	–$44,629	+$2,849 (10)
	Private Sector Partner (Automaker)	+$19,532 (5)	+$45,570 (1)	+$45,570 (1)	+$45,570 (1)
	Public Sector	N/A	$0	$0	$0
Business Model 2 Applied to Ocean Shores Charging Gap	Project	+$292,320 (6)	+$334,348 (5)	+$376,377 (4)	+$418,405 (4)
	Owner-Operator	+$49,439 (9)	+$90,381 (8)	+$131,322 (7)	+$172,263 (6)
	Private Sector Partners (Local Businesses)	+$206,566 (1)	+$206,566 (1)	+$206,566 (1)	+$206,566 (1)
	Public Sector	N/A	$0	$0	$0
Business Model 3 Applied to Tri-Cities/Walla Walla Charging Gap	Project	+$595,703 (6)	+$712,253 (5)	+$828,802 (5)	+$945,352 (4)
	Owner-Operator	+$54,166 (9)	+$167,700 (8)	+$281,235 (7)	+$394,769 (6)
	Private Sector Partners (Automaker, Local Businesses)	+$457,312 (2)	+$457,312 (2)	+$457,312 (2)	+$457,312 (2)
	Public sector	N/A	$0	$0	$0

Consumer Education

The public sector could help improve the financial performance of private-sector EV charging station investments by developing and implementing a campaign to educate consumers about EVs, including public awareness campaigns, ride-and-drives, media engagement, and employee engagement programs.

A consumer education program could improve the financial performance of charging station investments by accelerating consumer adoption of EVs, thereby increasing station utilization growth rates.

Medium Scenario Explanation: The effect of this intervention is estimated to increase the annual charging station utilization growth rate from 15 to 18 percent.

Legal/Regulatory Barriers: There are no legal or regulatory barriers to implementing a consumer education campaign.

Financial Performance Results: The results of the financial analyses, presented in **Table 29**, show that:

- Consumer education campaigns may be a cost effective way to moderately increase consumer adoption of EVs, but education campaigns alone are unlikely to substantially improve the business case for investing in EV charging stations.

TABLE 29: Effects of Extending Consumer Education on the NPV and Payback for Each Business Model

This table compares the impacts on project financial performance of consumer education programs under three scenarios: 16, 18, and 20 percent increases in charging station utilization growth rates. Where applicable, project payback in years is shown in parentheses. The NPV and payback for the public sector do not account for the social benefits of EV market development. Costs for the public sector to administer the program are not included.

BUSINESS MODEL		BASE	LOW	MEDIUM	HIGH
Contribution by Private Sector Partners		As modeled in Chapter 2 (no public intervention with 15% growth rate)	16% utilization growth rate	18% utilization growth rate	20% utilization growth rate
Business Model 1 Applied to I-90 Charging Gap	Project	–$87,777	–$78,852	–$62,154	–$47,871
	Owner-Operator	–$118,207	–$109,916	–$94,368	–$80,995
	Private Sector Partner (Automaker)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)
	Public Sector	N/A	$0	$0	$0
Business Model 2 Applied to Ocean Shores Charging Gap	Project	+$292,320 (6)	+$311,370 (5)	+$346,121 (5)	+$376,614 (5)
	Owner-Operator	+$49,439 (9)	+$61,796 (8)	+$84,491 (8)	+$104,428 (7)
	Private Sector Partners (Local Businesses)	+$206,566 (1)	+$211,870 (1)	+$221,493 (1)	+$230,053 (1)
	Public Sector	N/A	$0	$0	$0
Business Model 3 Applied to Tri-Cities/Walla Walla Charging Gap	Project	+$595,703 (6)	+$639,778 (6)	+$720,391 (6)	+$790,881 (6)
	Owner-Operator	+$54,166 (9)	+$84,432 (9)	+$140,157 (8)	+$188,949 (8)
	Private Sector Partners (Automaker, Local Businesses)	+$457,312 (2)	+$467,917 (2)	+$487,174 (2)	+$504,277 (2)
	Public Sector	N/A	$0	$0	$0

A consumer education campaign can improve the financial performance for the owner-operator, but not enough for the owner-operator to achieve profitability under Business Model 1 or to reduce the owner-operator's payback to five years under Business Models 2 or 3.

Extending BEV Sales Tax Exemption

The public sector could help improve the financial performance of private-sector EV charging station investments by extending the existing sales tax exemption for BEVs, which is set to expire on June 30, 2015.

The sales tax exemption is a significant consumer incentive for the purchase of BEVs. Currently, the BEV sales tax exemption allows BEV buyers to avoid paying taxes equal to 8.8 percent of the vehicle purchase price (6.8 percent state sales tax plus 2 percent for local sales tax on average). For a $30,000 vehicle, this results in savings to the consumer of $2,640 at the time of the vehicle purchase.

Extending the exemption could improve the financial performance of charging station investments by accelerating consumer adoption of EVs, thereby increasing station utilization growth rates.

Medium Scenario Explanation: This intervention is estimated as increasing the annual growth rate of charging station utilization from 15 to 22 percent. Each of the low, medium, and high scenarios assumes that the BEV sales tax exemption is extended for five years.

Legal/Regulatory Barriers: The existing sales tax exemption for BEVs is currently set to expire on June 30, 2015. Extending and/or modifying the sales tax exemption would require legislative action.

Financial Performance Results: The results of the financial analyses, presented in **Table 30**, show that:

- Extending the BEV sales tax exemption is likely to significantly accelerate consumer adoption of EVs, but the extension alone is unlikely to make compelling the business case for investing in EV charging stations in the near term since none of the business models yield a payback of five years or less.
- Extending the BEV sales tax exemption can improve the financial performance for the owner-operator, but not enough for the owner-operator to achieve profitability under Business Model 1 or to reduce the owner-operator's payback to five years under Business Models 2 or 3.

Shared-Use EV Charging Stations

State or municipal public fleets considering incorporating EVs in their vehicle fleets could share a privately owned and operated DC fast charging station with the general public, rather than deploy a dedicated charging station with restricted access. At applicable sites with sufficient public sector and private sector charging demand, sharing stations in this way could help improve the financial performance of private-sector EV charging station investments by increasing their utilization.

Medium Scenario Explanation: The effect of this intervention is estimated to increase initial DC fast charging station utilization by 1 session per day—a 30 percent increase. It will also increase the maximum charging station utilization by 1 session per day—a 10 percent increase—because many public fleet vehicles can charge during periods when consumer demand for charging is low, such as at night.

Legal/Regulatory Barriers: There are no barriers to the state or a city entering into a procurement contract to make use of a privately-owned station, which is the arrangement analyzed in this study.

Financial Performance Results: The results of the financial analyses, presented in **Table 31**, show that:

- Shared-use of EV charging stations can improve the financial performance for the owner-operator, but not enough for the owner-operator to achieve profitability under Business Model 1 or to reduce the owner-operator's payback to five years under Business Models 2 or 3.

TABLE 30: Effects of Extending BEV Sales Tax Exemption on the NPV and Payback for Each Business Model

This table compares the impacts on project financial performance of extending the BEV sales tax exemption under three scenarios: 18, 22, and 26 percent annual increases in charging station utilization growth. Where applicable, project payback in years is shown in parentheses. The NPV and payback for the public sector do not account for the social benefits of EV market development. Lost tax revenue for the public sector is not included.

BUSINESS MODEL		BASE	LOW	MEDIUM	HIGH
Contribution by Private Sector Partners		As modeled in Chapter 2 (no public intervention with 15% utilization growth rate)	18% utilization growth rate	22% utilization growth rate	26% utilization growth rate
Business Model 1 Applied to I-90 Charging Gap	Project	–$87,777	–$62,154	–$36,912	–$17,735
	Owner-Operator	–$118,207	–$94,368	–$70,669	–$52,536
	Private Sector Partner (Automaker)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)
	Public Sector	N/A	$0	$0	$0
Business Model 2 Applied to Ocean Shores Charging Gap	Project	+$292,320 (6)	+$346,121 (5)	+$398,999 (5)	+$438,826 (5)
	Owner-Operator	+$49,439 (9)	+$84,491 (8)	+$119,259 (7)	+$145,665 (7)
	Private Sector Partners (Local Businesses)	+$206,566 (1)	+$221,493 (1)	+$236,304 (1)	+$247,513 (1)
	Public Sector	N/A	$0	$0	$0
Business Model 3 Applied to Tri-Cities/Walla Walla Charging Gap	Project	+$595,703 (6)	+$720,391 (6)	+$843,011 (5)	+$935,435 (5)
	Owner-Operator	+$54,166 (9)	+$140,157 (8)	+$225,529 (8)	+$290,419 (7)
	Private Sector Partners (Automaker, Local Businesses)	+$457,312 (2)	+$487,174 (2)	+$516,792 (2)	+$539,207 (2)
	Public Sector	N/A	$0	$0	$0

TABLE 31: Effects of Shared-Use EV Charging Stations on the NPV and Payback for Each Business Model

This table compares the impacts on project financial performance of shared-use of EV charging stations under three scenarios: 25, 50, and 75 percent increase in initial charging station utilization; and maximum utilization level (5, 10, and 20 percent increase). Where applicable, project payback in years is shown in parentheses. The NPV and payback for the public sector do not account for the social benefits of EV market development. The cost to the government of paying for charging services is not included.

BUSINESS MODEL		BASE	LOW	MEDIUM	HIGH
Contribution by Private Sector Partners		As modeled in Chapter 2 (no public inter-vention)	15% increase initial charging station utilization; 5% increase maximum utilization level	30% increase initial charging station utilization; 10% increase maximum utilization level	60% increase initial charging station utilization; 20% increase maximum utilization level
Business Model 1 Applied to I-90 Charging Gap	Project	–$87,777	–$44,707	–$3,315	+$74,562 (8)
	Owner-Operator	–$118,207	–$77,725	–$38,766	+$34,686 (9)
	Private Sector Partner (Automaker)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)	+$19,532 (5)
	Public Sector	N/A	$0	$0	$0
Business Model 2 Applied to Ocean Shores Charging Gap	Project	+$292,320 (6)	+$384,857 (5)	+$472,737 (4)	+$638,839 (3)
	Owner-Operator	+$49,439 (9)	+$109,817 (7)	+$167,312 (6)	+$276,110 (5)
	Private Sector Partners (Local Businesses)	+$206,566 (1)	+$233,023 (1)	+$258,142 (1)	+$305,793 (1)
	Public Sector	N/A	$0	$0	$0
Business Model 3 Applied to Tri-Cities/Walla Walla Charging Gap	Project	+$595,703 (6)	+$809,486 (5)	+$1,012,849 (5)	+$1,396,987 (4)
	Owner-Operator	+$54,166 (9)	+$201,903 (8)	+$342,881 (7)	+$609,456 (5)
	Private Sector Partners (Automaker, Local Businesses)	+$457,312 (2)	+$510,226 (2)	+$560,459 (1)	+$655,763 (1)
	Public Sector	N/A	$0	$0	$0

3.4 COMBINATIONS OF PUBLIC SECTOR INTERVENTIONS AIMED AT ATTRACTING PRIVATE INVESTMENT IN EV CHARGING

Under current market conditions, the three business models are not financially viable today without public interventions if the owner-operator requires a payback of five years or less. It will likely take a combination of public sector interventions to make the business models viable and enticing to private investors in the near term. This section explores example combinations of public sector interventions that could improve the expected financial performance of charging station deployment projects.

For each of the three business models from Chapter 2, two financial analyses are presented to demonstrate the level and length of public interventions that may be required to make the business models viable. First, a combination of public interventions was analyzed to demonstrate what is needed to make the business model financially viable for the owner-operator in the near term (2015-2020). Second, assuming these interventions take place and the EV market continues to grow, an analysis was completed on the financial viability for the owner-operator of the business model in the future (2020).

> ***If interventions by the public sector today help increase market demand for EVs and charging services, then the business models could be viable in five years without further public sector intervention***

The results of the financial analyses show that all three business models will require public sector interventions today in order to attract more private investment. The analyses also show that if the public sector interventions provided from 2015-2020 help the EV market to develop, no public sector intervention are likely to be needed after 2020 to make EV charging business models sustainable.

For the near-term public intervention analyses, a combination of three public interventions resulted in the owner-operator achieving payback on investment within five years:

- Low-interest loans;
- Grants; and
- Extension of the BEV sales tax exemption.

This combination of public interventions is not intended as a policy recommendation. Instead, this combination is presented to demonstrate a level of public intervention that could make deployment of charging stations enticing to investors today. These interventions were not arbitrarily selected for use as examples, however. Rather, they were selected because:

- There is a high degree of confidence that they can improve the financial performance of projects in the near term;
- They are broadly applicable to a variety of charging station projects and locations in the state; and
- They are relatively straightforward to implement and administer.

The public sector interventions in place from 2015 to 2020 are expected to drive increased EV adoption, and the resulting increase in charging station utilization. The analyses after 2020 assume a decreased cost for DC fast charging station equipment.[33]

Table 32 shows the expected numbers of EVs on the road (and resulting charging station utilization) in two scenarios: the base case, where the BEV sales tax exemption ends on June 30, 2015; and a 5-year extension of the sales tax exemption. For example, by 2020, the base case says one can expect 21,674 EVs on Washington's roadways; if the sales tax exemption continues until 2020, one could expect to see an additional 7,450 EVs on Washington's roadways—29,124 compared to 21,674 in the base case.

The cost of DC fast charging station equipment is expected to decrease in the future based on interviews with EV industry representatives, who expect costs to decline as the EV market develops due to increasing scale of equipment production, learning-by-doing, and market competition among equipment suppliers. The analyses assume that DC fast charging equipment costs decline to $25,000 per station five years from now (from $35,000 in the present-day base case).

With these cost reductions, public sector interventions from 2015-2020, and sustained EV market development, these projections show that public sector interventions may no longer be needed to attract private investment in charging stations after 2020.

Business Model 1: Analysis of Near-Term Scenario with Three Public Interventions

Significant public intervention is needed in the near term for Business Model 1, as applied to the I-90 Charging gap, to be financially attractive for the owner-operator.

TABLE 32: Comparison of EV Charging Station Utilization Growth Rates and Associated Number of EVs on the Road under Three Scenarios

	BASE CASE		5-YEAR EXTENSION OF BEV SALES TAX EXEMPTION	
	Assumed annual growth rate in station utilization	Implied number of EVs registered in WA	Assumed annual growth rate in station utilization	Implied number of EVs registered in WA
2011	N/A (historical)	1,121	N/A (historical)	1,121
2012	N/A (historical)	2,927	N/A (historical)	2,927
2013	N/A (historical)	8,148	N/A (historical)	8,148
2014	15%	9,370	15%	9,370
2015	15%	10,776	22%	11,432
2016	15%	12,392	22%	13,947
2017	15%	14,251	22%	17,015
2018	15%	16,389	22%	20,758
2019	15%	18,847	22%	25,325
2020	15%	21,674	15%	29,124
2021	15%	24,925	15%	33,492
2022	15%	28,664	15%	38,516
2023	15%	32,963	15%	44,293

In this scenario, the public sector provides the owner-operator with a one-time $112,320 low-interest loan and a one-time $222,394 grant. The public sector also extends the BEV sales tax exemption, which increases annual station utilization growth from 15 to 22 percent. The private sector partner (an automaker) also contributes $7,000 per DC fast charging station ($42,000 total for the 6 DC fast charging stations). **Table 33** summarizes the private and public sector interventions required for the owner-operator to reach payback within five years.

Both the public and private sectors play substantial roles in capitalizing the project. In total, this network of stations costs $561,600 up front to deploy and is funded by 20 percent private sector equity, 20 percent private sector loans, 20 percent public sector loans, and 40 percent public grants, as shown in **Figure 33**. The $42,000 contribution from the automaker was treated as revenue to the owner-operator, not capitalization, in this analysis.

The financial analysis results for each entity under this scenario, presented in **Table 34**, show that:

- The owner-operator reaches payback within five years, with a project NPV of +$132,579. The

FIGURE 33: Business Model 1 Project Capitalization with Public Sector Interventions for a 2015 Project (Total Project Cost: $561,600)

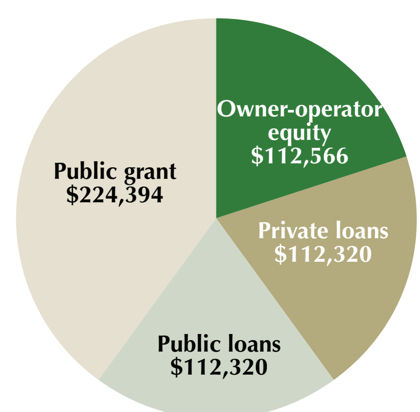


TABLE 33: Summary of Business Model 1 and Public Sector Interventions for a 2015 Project to Enable BEV Travel between Seattle and Spokane along I-90

INTERVENTION	EXPLANATION	COST
Automaker (Business Model 1)		
Upfront Cash Transfer	Automaker contributes $42,000 in cash to owner-operator	$42,000 up front (no expectation of repayment from owner-operator)
Public Sector		
Low-Interest Loan	Public sector provides loans of $112,320 to owner-operator at an interest rate of 5.4% (33% lower than assumed private-sector loan interest rate of 8%)	$112,320 up front, with expectation of repayment of principal plus interest (but bearing some risk of loan default)
Grant	Public sector provides grant of $222,394 to owner-operator	$222,394 up front (no expectation of repayment from owner-operator)
Extending BEV Sales Tax Exemption	State sales tax exemption for BEVs extended, increasing expected charging station utilization growth rate to 22% (from 15%)	Cost (lost tax revenue) depends on future EV sales

TABLE 34: Financial Results of Applying Business Model 1 and Public Sector Interventions for a 2015 Project (e.g., Starting in 2015)

Financial performance of business model with no public intervention included for comparison.

	RESULT	
	Base case scenario (no public intervention)	**Public sector intervention scenario**
Owner-Operator Perspective		
NPV	–$118,207	+$132,579
Payback Period	No payback	5 years
Automaker Perspective		
NPV	+$19,532	+$19,532
Payback Period	5 years	5 years
Public Sector Perspective		
NPV	N/A	–$222,394
Payback Period	N/A	No payback
Total Project Level Perspective		
NPV	–$87,777	–$65,647
Payback Period	No payback	No payback

The NPV and payback for the public sector do not account for the social benefits of EV market development.

owner-operator needs both the automaker's subsidy and the public sector interventions in order to reach payback within five years. If either drops out, payback is greater than five years, and it is not financially attractive for the owner-operator.

- The automaker reaches payback in five years with a project NPV of +$19,532. As a result, the business model is sustainable from the automaker's perspective.
- The NPV for the public sector is –$222,394—a loss equal to the amount of the grant because the loan is assumed to be repaid and the government is assumed to lend at their own cost of funds, which exactly offsets the value of the interest payments. This NPV does not account for the risk of loan default.

Business Model 1: Analysis of Future Scenario after Five Years of Public Intervention and EV Market Development

In the future and if the EV market grows successfully, executing the same charging project that addresses the I-90 Charging Gap using Business Model 1 will be financially attractive for the owner-operator with no public intervention.

In this future scenario, Business Model 1 can be successful without public sector intervention due to increased charging station utilization and decreased equipment costs as the EV market develops.

In this scenario, the private sector partner (an automaker) contributes $7,000 per DC fast charging station ($42,000 total for the 6 DC fast charging stations). The public sector provides no funding.

Table 35 summarizes the private sector roles and previous public sector interventions required for the owner-operator to reach payback within five years with no public sector interventions.

In this scenario, the private sector capitalizes the entire project. This network of stations costs $508,170 to deploy and is funded by 40 percent private sector equity and 60 percent private sector loans, as shown in **Figure 34**. The $42,000 contribution from the automaker was treated as revenue to the owner-operator, not capitalization, in this analysis.

FIGURE 34: Business Model 1 Project Capitalization for a 2020 Project (Total Project Cost: $508,170)

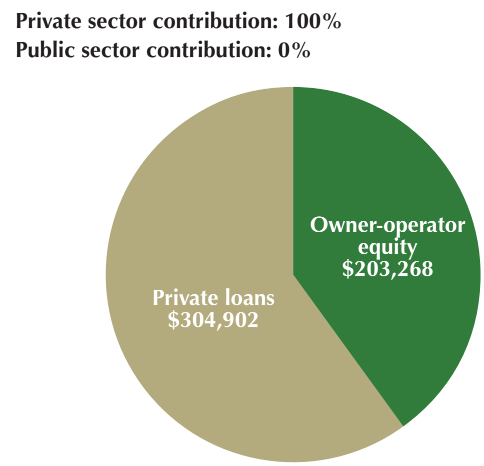


TABLE 35: Summary of Business Model 1 and Public Sector Interventions for a 2020 Project to Enable BEV Travel between Seattle and Spokane along I-90

INTERVENTION	EXPLANATION	COST
Automaker (Business Model 1)		
Upfront Cash Transfer	Automaker contributes $42,000 in cash to owner-operator	$42,000 up front (no expectation of repayment from owner-operator)
Public Sector		
Extending BEV Sales Tax Exemption (Prior)	Assumes state sales tax exemption for BEVs ends in 2020. From 2015–2020, the exemption generated 22% annual charging station utilization growth rate After 2020, with the ending of the sales tax exemption growth reverts to 15%.	N/A

The financial analysis results presented in **Table 36** show that:

- The owner-operator reaches payback within five years, with a project NPV of +$115,566.
- The automaker reaches payback in five years with a project NPV of +$19,532.
- The public sector does not provide any interventions.

Business Model 2: Analysis of Near-Term Scenario with Three Public Interventions

Significant public intervention is needed in the near term for Business Model 2, applied to the Ocean Shores Charging Gap, to be financially attractive for the owner-operator.

In this scenario, the public sector provides the owner-operator with a $150,450 low-interest loan and an $83,750 grant. The public sector also extends the BEV sales tax exemption until 2020, which increases station utilization growth from 15 to 22 percent. The private sector partners (a group of local businesses contributing to a funding pool) also collectively contribute between $28,000 and $84,125 annually to the owner-operator. **Table 37** summarizes the private and public sector interventions required for the owner-operator to reach payback within five years.

The public and private sector play contribute almost an equal share to the project capitalization. In total, this network of stations costs $501,500 to deploy and is funded by 23 percent private sector equity, 30 percent private sector loans, 30 percent public sector loans, and 17 percent public grants, as shown in **Figure 35**.

The financial analysis results presented in **Table 38** show that:

- The owner-operator reaches payback within five years, with a project NPV of +$211,690. The owner-operator needs both the local business funding pool subsidy and the public sector interventions in order to reach payback within five years. If either is unavailable, payback is greater than five years, and it is not financially attractive for the owner-operator.
- The local business funding pool reaches payback within 1 year with a project NPV of +$236,304.
- The NPV for the public sector is –$83,750—a loss equal to the amount of the grant because the loan is assumed to be repaid and the government is assumed to lend at their own cost of capital, which exactly offsets the value of the interest payments. This NPV does not account for the risk of loan default.

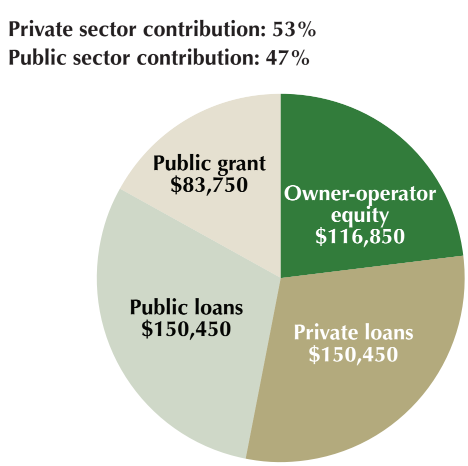
TABLE 36: Financial Results of Applying Business Model 1 for a 2020 Project

	RESULT	
	Base case scenario (no public intervention)	**Public sector intervention scenario**
Owner-Operator Perspective		
NPV	–$118,207	+$115,566
Payback Period	No payback	5 years
Automaker Perspective		
NPV	+$19,532	+$19,532
Payback Period	5 years	5 years
Public Sector Perspective		
NPV	N/A	N/A
Payback Period	N/A	N/A
Total Project Level Perspective		
NPV	–$87,777	+$155,450
Payback Period	No payback	5 years

TABLE 37: Summary of Business Model 2 and Public Sector Interventions for a 2015 Project to Enable EV Travel to and within Ocean Shores

INTERVENTION	EXPLANATION	COST
Local Business Partners (Business Model 2)		
Annual Cash Transfer	Local business partners collectively contribute between $28,000 and $84,125 annually into a funding pool that is provided to the owner-operator as a cash transfer	$28,000 in year one increasing to $84,125 by year nine and staying at the level until year 10 (no expectation of repayment from owner-operator)
Public Sector		
Low-Interest Loan	Public sector provides loans of $150,450 to owner-operator at an interest rate of 5.4% (33% lower than assumed private loan interest rate of 8%)	$150,450 up front, with expectation of repayment of principal plus interest (but bearing some risk of loan default)
Grant	Public sector provides grant of $83,750 to owner-operator	$83,750 up front (no expectation of repayment from owner-operator)
Extending BEV Sales Tax Exemption	State sales tax exemption for BEVs extended to 2020, increasing expected charging station utilization growth rate to 22% (from 15%)	Cost depends on future EV sales

FIGURE 35: Business Model 2 Project Capitalization with Public Sector Interventions for a Near-Term Project (Total Project Cost: $501,500)



Business Model 2: Analysis of Future Scenario after Five Years of Public Intervention and EV Market Development

In the future and if the EV market grows successfully, executing the same charging project that addresses the Ocean Shores Charging Gap using Business Model 2 will be financially attractive for the owner-operator with no public intervention.

In this future scenario, Business Model 2 can be successful without public sector intervention because increased charging station utilization and decreased equipment costs as the EV market develops.

In this scenario, the private sector partners (a group of local businesses contributing to a funding pool) collectively contribute between $28,000 and $84,125 annually to the owner-operator. The public sector provides no funding.

Table 39 summarizes the private sector roles and previous public sector interventions required for the owner-operator to reach payback within five years with no public sector interventions.

TABLE 38: Financial Results of Applying Business Model 2 and Public Sector Interventions for a 2015 Project

The NPV and payback for the public sector do not account for the social benefits of EV market development.

	RESULT	
	Base case scenario (no public intervention)	**Public sector intervention scenario**
Owner-Operator Perspective		
NPV	+$49,439	+$211,690
Payback Period	9 years	5 years
Automaker Perspective		
NPV	+$206,566	+$236,304
Payback Period	<1 year	<1 year
Public Sector Perspective		
NPV	N/A	–$83,750
Payback Period	N/A	No payback
Total Project Level Perspective		
NPV	+$292,320	+$417,251
Payback Period	6 years	6 years

TABLE 39: Summary of Business Model 2 and Public Sector Interventions for a 2020 Project to Enable EV Travel to and within Ocean Shores

INTERVENTION	EXPLANATION	COST
Private Sector Partner (Business Model 2)		
Annual Cash Transfer	Local business partners collectively contribute between $62,275 and $84,125 annually into a funding pool that is provided to the owner-operator as a cash transfer	$62,275 in year one increasing to $84,125 by year four and staying at the level until year 10 (no expectation of repayment from owner-operator)
Public Sector Partner		
Extending BEV Sales Tax Exemption (Prior)	Assumes state sales tax exemption for BEVs ends in 2020. From 2015-2020, the exemption generated 22% annual charging station utilization growth rate After 2020, with the ending of the sales tax exemption growth reverts to 15%.	N/A

In this scenario, the private sector capitalizes the entire project. In total, this network of stations costs $481,275 up front to deploy and is funded by 40 percent private sector equity and 60 percent private sector loans, as shown in **Figure 36**.

The financial analysis results for each entity under this scenario, presented in **Table 40**, show that:

- The owner-operator reaches payback within 3 years, with a project NPV of +$347,310.
- The local business funding pool reaches payback within a year with a project NPV of +$327,135.

The public sector provides no interventions.

Business Model 3: Analysis of Near-Term Scenario with Three Public Interventions

Significant public intervention is needed in the near term for Business Model 3, applied to the Tri-Cities/Walla Walla Charging Gap, to be financially attractive for the owner-operator.

FIGURE 36: Business Model 2 Project Capitalization for a 2020 Project (Total Project Cost: $481,275)

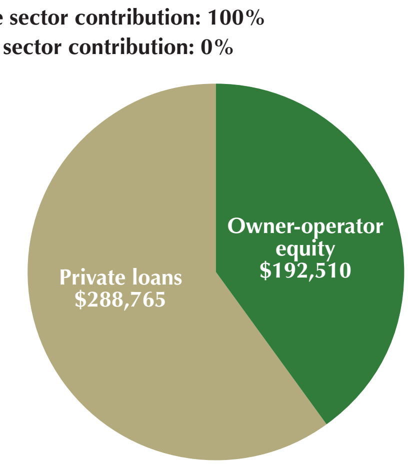


TABLE 40: Financial Results of Applying Business Model 2 and Public Sector Interventions for a 2020 Project

	RESULT	
	Base case scenario (no public intervention)	**Public sector intervention scenario**
Owner-Operator Perspective		
NPV	+$49,439	+$347,310
Payback Period	9 years	3 years
Automaker Perspective		
NPV	+$206,566	+$327,135
Payback Period	<1 year	<1 year
Public Sector Perspective		
NPV	N/A	N/A
Payback Period	N/A	N/A
Total Project Level Perspective		
NPV	+$728,746	+$292,320
Payback Period	2 years	6 years

Under this scenario, the public sector provides the owner-operator with a $415,230 low-interest loan and a $415,230 grant. The public sector also extends the BEV sales tax exemption to 2020, which increases station utilization growth. An automaker also contributes $7,000 per DC fast charging station and $500 per Level 2 charging station ($95,000 total for 10 DC fast charging stations and 50 Level 2 stations). In addition, a group of local businesses contributing to a funding pool collectively contribute between $56,000 and $168,250 annually to the owner-operator. **Table 41** summarizes the private and public sector interventions required for the owner-operator to reach payback within five years.

The public and private sector play contribute almost an equal share to the project capitalization. In total, this network of stations costs $1,384,100 to deploy and is funded by 23 percent private sector equity, 30 percent private sector loans, 30 percent public sector loans, and 17 percent public grants, as shown in **Figure 37**. The $95,000 contribution from the automaker was treated as revenue to the owner-operator, not capitalization, in this analysis.

FIGURE 37: Business Model 3 Project Capitalization with Public Sector Interventions for a 2015 Project (Project Cost: $1,384,100)

Private sector contribution: 53%
Public sector contribution: 47%

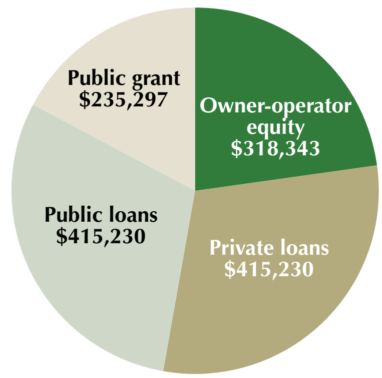


TABLE 41: Summary of Business Model 3 and Public Sector Interventions for a 2015 Project to Enable EV Travel to and within Tri-Cities and Walla Walla

INTERVENTION	EXPLANATION	COST
Automaker / Local Business Partners (Business Model 3)		
Upfront Cash Transfer	Automaker contributes $95,000 in cash to owner-operator	$95,000 up front (no expectation of repayment from owner-operator)
Annual Cash Transfer	Local business partners collectively contribute between $56,000 and $168,250 annually into a funding pool that is provided to the owner-operator as a cash transfer	$56,000 in year one increasing to $168,250 by year nine and staying at the level until year 10 (no expectation of repayment from owner-operator)
Public Sector		
Low-Interest Loan	Public sector provides loan of $415,230 to owner-operator at an interest rate of 5.4% (33% lower than assumed private loan interest rate of 8%)	$415,230 up front, with expectation of repayment of principal plus interest (but bearing some risk of loan default)
Grant	Public sector provides grant of $237,500 to owner-operator	$237,500 up front (no expectation of repayment from owner-operator)
Extending BEV Sales Tax Exemption	State sales tax exemption for BEVs extended to 2020, increasing expected charging station utilization growth rate to 22% (from 15%)	Cost (lost tax revenue) depends on future EV sales

The financial analysis results for each entity under this scenario, presented in **Table 42**, show that:

- The owner-operator reaches payback within five years, with a project NPV of +$485,225. The owner-operator needs both the private partner subsidies (from the automaker and the group of local businesses) and the public sector interventions in order to reach payback within five years. If either drops out, payback is greater than five years, and it is not financially attractive for the owner-operator.
- Together, the private funding partners (the automaker and the local businesses) reach payback within 2 years with a project NPV of +$516,792.
- The NPV for the public sector is –$237,500—a loss equal to the amount of the grant because the loan is assumed to be repaid and the government is assumed to lend at their own cost of capital, which exactly offsets the value of the interest payments. This NPV does not account for the risk of loan default.

Business Model 3: Analysis of Future Scenario after Five Years of Public Intervention and EV Market Development

In the future and if the EV market grows successfully, executing the same charging project that addresses the Tri-Cities/Walla Walla Charging Gap using Business Model 3 will be financially attractive for the owner-operator without the need for any public intervention.

In this future scenario, Business Model 3 can be successful without public sector intervention because increased charging station utilization and decreased equipment costs as the EV market develops.

Under this scenario, an automaker contributes $7,000 per DC fast charging station and $500 per Level 2 charging station ($95,000 total for 10 DC fast charging stations and 50 Level 2 stations). In addition, a group of local businesses contributing to a funding pool collectively contribute between $124,550 and $168,250 annually to the owner-operator. The public sector provides no funding.

TABLE 42: Financial Results of Applying Business Model 3 and Public Sector Interventions for a 2020 Project

	RESULT	
	Base case scenario (no public intervention)	**Public sector intervention scenario**
Owner-Operator Perspective		
NPV	+$485,225	+$54,166
Payback Period	5 years	9 years
Automaker Perspective		
NPV	+$457,312	+$516,792
Payback Period	2 years	2 years
Public Sector Perspective		
NPV	N/A	–$237,500
Payback Period	N/A	No payback
Total Project Level Perspective		
NPV	+$595,703	+$879,666
Payback Period	6 years	6 years

The NPV and payback for the public sector do not account for the social benefits of EV market development.

Table 43 summarizes the private sector roles and previous public sector interventions required for the owner-operator to reach payback within five years with no public sector interventions.

In this scenario, the private sector capitalizes the entire project. This network of stations costs $1,308,030 to deploy and is funded by 40 percent private sector equity and 60 percent private sector loans, as shown in **Figure 38.**

The financial analysis results presented in **Table 44** show that:

- The owner-operator reaches payback within 3 years, with a project NPV of +$805,762.
- Together, the private funding partners (the automaker and the local businesses) reach payback within a year with a project NPV of +$698,446.
- The public sector provides no interventions.

FIGURE 38: Business Model 3 Project Capitalization for a 2020 Project (Total Project Cost: $1,308,030)

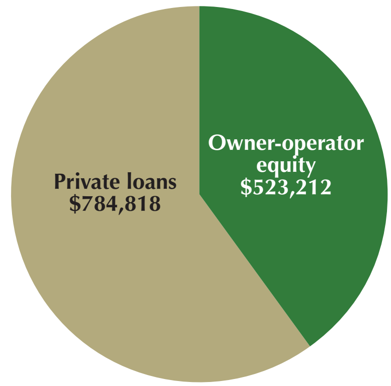


TABLE 43: Summary of Business Model 3 and Public Sector Interventions for a 2020 Project to Enable EV Travel to and within Tri-Cities and Walla Walla

INTERVENTION	EXPLANATION	COST
Automaker / Local Business Partners (Business Model 3)		
Upfront Cash Transfer	Automaker contributes $95,000 in cash to owner-operator	$95,000 up front (no expectation of repayment from owner-operator)
Annual Cash Transfer	Local business partners collectively contribute between $124,550 and $168,250 annually into a funding pool that is provided to the owner-operator as a cash transfer	$124,550 in year one increasing to $168,250 by year nine and staying at the level until year 10 (no expectation of repayment from owner-operator)
Public Sector		
Extending BEV Sales Tax Exemption	Assumes state sales tax exemption for BEVs ends in 2020. From 2015-2020, the exemption generated 22% annual charging station utilization growth rate After 2020, with the ending of the sales tax exemption growth reverts to 15%.	N/A

TABLE 44: Financial Results of Applying Business Model 3 for a 2020 Project

	RESULT	
	Base case scenario (no public intervention)	**Public sector intervention scenario**
Owner-Operator Perspective		
NPV	+$54,166	+$805,762
Payback Period	9 years	3 years
Automaker Perspective		
NPV	+$457,312	+$698,446
Payback Period	2 years	<1 year
Public Sector Perspective		
NPV	N/A	N/A
Payback Period	N/A	N/A
Total Project Level Perspective		
NPV	+$595,703	+$1,630,710
Payback Period	6 years	2 years

The NPV and payback for the public sector do not account for the social benefits of EV market development.

3.5 Sources for Funding for Public Sector Interventions

A range of potential revenue sources was identified to fund the public sector interventions including an increase in the EV registration fee, significantly reducing the BEV sales tax rate, and state and federal transportation funds. For context on the revenue raised through the methods presented in this section, the three charging projects presented in this chapter would require $545,000 in grants and $675,000 in low-interest loans. The financial analyses completed in this chapter show that increased EV adoption is critical to the success of privately funded charging infrastructure in the near future. Increasing fees or other costs on EV drivers could hurt adoption and affect the financial viability of private sector charging projects.

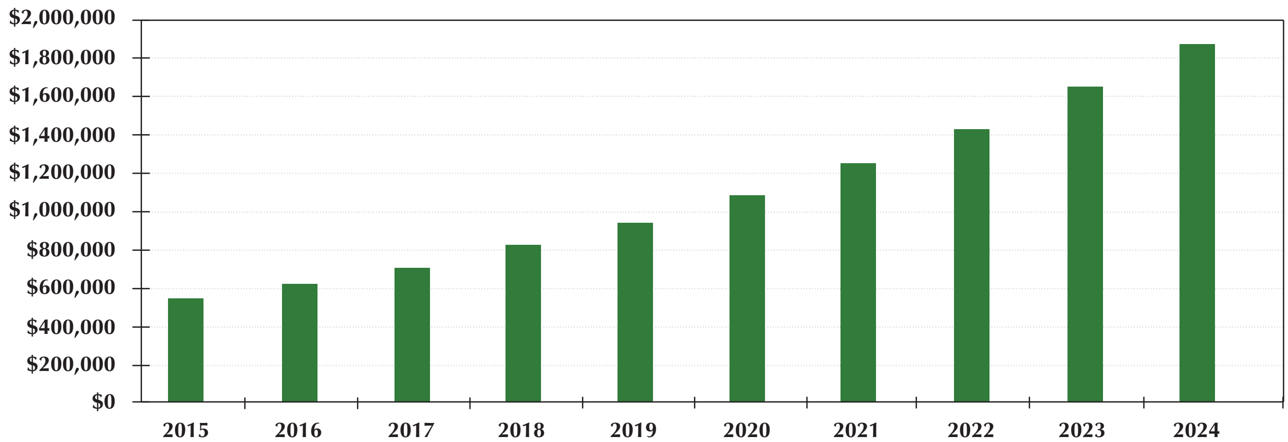
EV Registration Fee Increase

The state government could raise revenue to pay for EV infrastructure deployment support by adding a new $50 fee for PHEVs and BEVs, and dedicating the revenue from that fee to public sector interventions. For BEVs, Washington state already charges a $100 annual registration fee in addition to the standard vehicle registration fee. If this new fee were established, BEV drivers would face $150 in annual fees and PHEV drivers would face $50 in new fees. These increased fees could hurt EV adoption and affect the financial viability of private sector charging projects.

A $50 BEV and PHEV fee could generate $1.9 million in annual revenue by 2024, as shown in **Figure 39: Annual Public Revenue from a $50 EV Fee**. For the

FIGURE 39: Annual Public Revenue from a $50 EV Fee

These public revenue estimates assume that the number of EVs on the road in the state grows from 8,140 (in 2013) at an annual rate of 15 percent.



2015-17 biennium, a $50 fee would generate $1.3 million. This assumes the BEV sales tax exemption ends on June 30, 2015. If it is extended through 2020, this fee could raise $1.5 million in the 2015-17 biennium and $2.5 million in 2024.

If the goal of an EV fee increase is to fund government policies aimed at accelerating EV charging market development, then the fee's effect on EV sales should also be considered. Although a $50 increase in the annual registration fee is a minor expense compared to the total cost of owning an operating a vehicle, a highly visible fee increase could deter some consumers from purchasing EVs.

Establishing a new EV fee would require legislative action.

Revenues for Reduced EV Sales Tax Rate

Washington could fund EV infrastructure deployment public interventions by imposing a small EV sales tax on BEVs and PHEVs, and dedicating that revenue to public sector interventions. This action calls for a 0.88 percent sales tax for BEVs and PHEVs (90 percent below the normal rate of 8.8 percent).

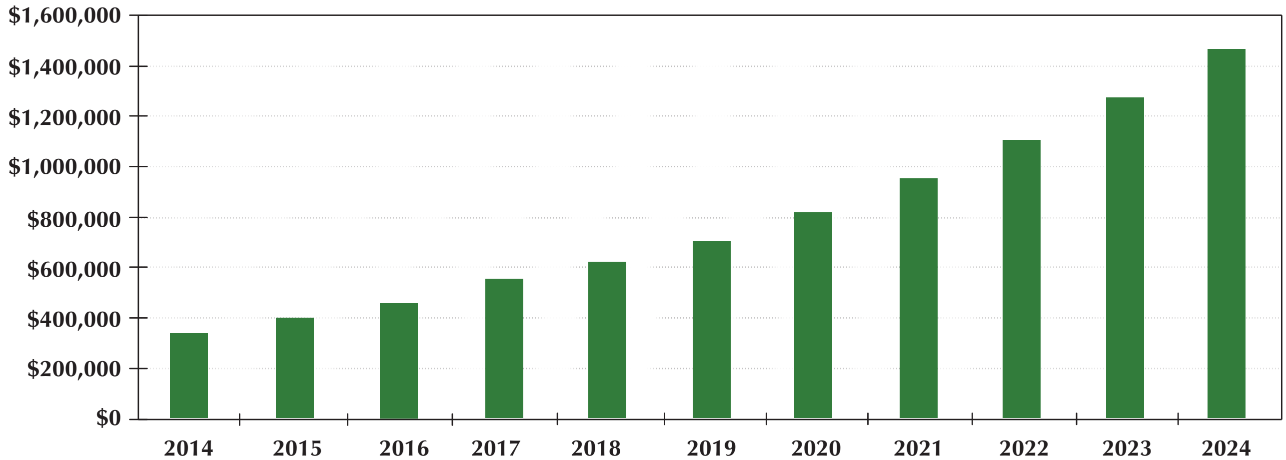
Washington state currently offers a sales tax exemption for BEVs that allows buyers to avoid paying taxes equal to 8.8 percent of the vehicle purchase price (6.8 percent state sales tax plus 2 percent local sales tax on average). For a $30,000 vehicle, this results in savings to the consumer of $2,640. This purchase incentive policy is set to expire on June 30, 2015. PHEVs are not eligible for this exemption.

The analyses presented earlier in this chapter show that extending the BEV sales tax exemption is one of the key policies needed to make the charging projects attractive to private investors in the short term—and potentially eliminate the need for public subsidies after 2020. Increases in the upfront cost of BEVs could affect market adoption and make investment in charging infrastructure less attractive to private investors. On the other hand, lowering the sales tax rate for PHEVs would encourage adoption of those vehicles. Thus, the source of funding here attempts to balance the need for funding certainty for charging projects and the desire to encourage EV purchases.

If the EV sales tax is reduced to 0.88 percent (90 percent below the normal rate of 8.8 percent), then the annual tax revenue generated from EV sales could reach $1.5 million by 2024, as shown in **Figure 40: Annual Public Revenue for Reduced EV Sales Tax Rate**. In the 2015-17 biennium, a 0.88 percent sales tax on EVs would generate $990,000. However, this would reduce the sales tax revenue from PHEVs that is currently deposited in the state's general fund.

FIGURE 40: Annual Public Revenues for Reduced EV Sales Tax Rate

These revenue estimates assume that the number of EVs on the road in the state grows from 8,140 (in 2013) at an annual rate of 15 percent. The estimate below assumes that EV drivers are charged a sales tax rate of 0.88 percent (90 percent below the normal rate of 8.8 percent). An average EV purchase price of $30,000 (before any tax incentives) is assumed for 2013, which increases annually at a rate of 0.6 percent.



There is a range of options that the state may consider both for using the BEV sales tax exemption as a consumer incentive and for using EV sales tax revenues to fund EV charging station policies. The existing BEV sales tax exemption could be extended in a modified form, or allowed to expire. Additionally, under any of these scenarios, the state may choose to use some or all of EV sales tax revenues for EV infrastructure support. Dedicating a portion of the EV sales tax revenues to a fund dedicated to EV charging station infrastructure development would require legislative action.

Other State and Federal Funding Sources

Aside from dedicated funding streams from EV registration fees or sales taxes, Washington could use other state and federal funding sources to pay for EV infrastructure deployment interventions.

Washington could allocate general state funds or state transportation funds to EV charging station program, although these funding sources are subject to competing budgetary priorities.

Federal funding sources may also be available for EV charging programs. Funds from the U.S. Department of Transportation's Surface Transportation Program (STP)[34] and Congestion Mitigation and Air Quality Improvement (CMAQ) Program[35] are eligible to be used for EV charging infrastructure. In addition, federal agencies, such as the U.S. Department of Energy frequently offer grant opportunities for which EV infrastructure projects are eligible. Notably, the West Coast Electric Highway was funded in part by the U.S. Department of Energy, together with funding from private companies and large employers.[36]

CONCLUSION AND NEXT STEPS

Washington drivers prefer BEVs to PHEVs by a more than 2-to-1 margin. Because BEVs generally need recharging more often than PHEVs, the current distribution of charging stations in the state's publicly available network limits travel for the state's BEV drivers.

EV owners and publicly available charging stations tend to be found in the same regions of the state. The vast majority of EVs and charging stations are in the state's most populous region around Puget Sound, with most in King County. Publicly available charging stations are comparatively sparse around the rest of the state, with the exception of the Vancouver, Washington area near Portland, Oregon.

Because of this, many travel destinations are inaccessible to BEV drivers, confining most travel to the Interstate 5 corridor, King County, and the Vancouver region. Additional charging infrastructure is needed to facilitate travel to the Pacific Coast, between the eastern and western part of the state along Interstate 90, and to the Tri-Cities and Walla Walla region, as well as elsewhere in the state.

It is currently challenging to construct a profitable business case for EV charging investments. The business case is challenging because of high initial investment costs, low and uncertain near-term demand for publicly available charging, and the limited ability and willingness for consumers to substitute commercial charging for affordable home charging (or gasoline use for PHEVs).

As a result, charging station business models that rely solely on direct revenue from EV charging services are currently not financially feasible. In order to build a business case that will attract capital and convince the private sector to invest in EV charging, total revenues must be greater than the project's total cost, and provide an acceptable level of profit. There are four general ways to improve the financial performance of charging station projects: increase revenues, decrease capital costs, decrease operating costs, and/or decrease the cost of funds for the project.

One promising opportunity to improve the financial performance of charging station investments is to develop business models that, through private partnerships and joint investment strategies, capture other types of value for diverse businesses, in addition to selling electricity. This might include EV tourist revenue for retailers and tourism businesses that have increased sales when located near EV charging stations; automaker revenue from selling more EVs; as well as non-revenue value such as "clean energy" marketing and brand-strengthening opportunities for businesses visibly involved in EV charging deployment projects.

The business models developed for this study demonstrate how business partnerships that identify and capture the broader value of charging stations can materially improve the financial performance of EV charging projects and increase private sector investment. However, they also show that it is unlikely that the private sector will implement these business models in the near term, because investors would likely view the financial performance of these charging station investments as unfavorable under current market conditions. Many private investors are only interested in projects that can achieve payback within five years, a threshold that none of the business models is currently estimated to meet.

In the near term as the EV market develops, public interventions can help make charging station investments more financially attractive to investors. With sustained EV market development, public sector interventions may no longer be needed to attract private investment in charging stations after five years.

> ***In January 2015, BMW, Volkswagen, and Nissan announced plans to invest in 1,000 publicly available charging stations in major east and west coast markets.***

There is growing evidence that a key finding of this report—that diverse businesses may be willing to help fund charging station deployment because of the indirect benefits they receive—is gaining traction in the United States. In January 2015, automakers including BMW, Volkswagen, and Nissan announced major investments in publicly available charging infrastructure that aim to install more than 1,000 charging stations in key markets in Oregon, California, the northeast, and elsewhere.

Building off the momentum created by these newly announced projects, Washington could demonstrate the business models presented in this study through a new pilot program. One way to structure such a pilot program would be for the state to call for private sector partners to apply for grants or low-interest loans to lower the cost of funds for a charging project. The state could fund the program through a combination of increased fees on EV drivers, general revenue, and/or other sources.

Under such a pilot program, applicants would need to demonstrate that their proposed project addresses a specific charging infrastructure gap in the state. The project could address travel to a specific region, within a targeted area, or a combination of both. Applications would be expected to present a clear case for the value proposition of filling the charging gap and provide evidence that the project would be profitable and sustainable for the charging network owner-operator and any private sector partner. The EV Charging Financial Analysis Tool created for this study could be used to help evaluate the viability of potential projects for this pilot program.

APPENDICES

APPENDIX A: STUDY PROCESS

The Washington State Legislature's Joint Transportation Committee selected C2ES to develop new business models that will foster private sector commercialization of public EV charging services. The study was divided into three main activities: evaluating the current EV charging network, developing new business models for EV charging, and identifying the role of the public and private sectors in implementing those business models. See **Figure 41: Study Process Overview** for an overview of the study process.

To assist in completing the study, an advisory panel of state legislators, industry experts, and other key stakeholders was assembled to guide the direction of the study, provide input, and be a resource to the consultant team. The advisory panel met three times in person and twice via webinar. Below is a table listing the members of the advisory panel.

In addition to the advisory panel, a workgroup of staffers from the State Legislature and state agencies provided guidance to C2ES throughout the project. The staff workgroup met frequently via conference call and in person ahead of each advisory panel meeting. The table below lists the members of the staff workgroup.

The first step of the study was to assess the state of EV charging in Washington. C2ES assembled time-series data on EV charging stations and vehicles by county and ZIP code. These data were assembled in a single Microsoft Excel workbook called the Public Charging Network Database. C2ES also created a series of interactive, web-based maps with these data to identify charging infrastructure gaps. C2ES then wrote a paper evaluating of the public charging network in the state. The report, *Assessing the Electric Vehicle Charging Network in Washington State*, was published in September 2014 and is available online at JTC's website, http://leg.wa.gov/JTC/Documents/Studies/EV/Task1_Final.pdf, and on C2ES's website, www.c2es.org. The work for this step is summarized in Chapter 1 of this report.

The next step was to identify business models for EV charging that the private sector could implement. The key event of this part of the study was an all-day, in-person workshop on business models. Participants included members of the Advisory Panel, the staff workgroup, and other experts. The workshop began with an opening plenary session based on a simple business model for publicly available charging that Washington state had already explored. Following the plenary session, each workshop participant was assigned to one

FIGURE 41: Study Process Overview

EVALUATE CURRENT STATUS OF EV CHARGING IN WASHINGTON

Construct Public Charging Network Database

Create interactive maps for charging suitability assessment

Provide insights into role of public charging networks in encouraging EVs

Summarize findings

May–August 2014

DEVELOP BUSINESS MODELS

Leverage C2ES's AFV Finance Initiative

Conduct Business Model Workshop

Create 3 Business Model Summaries

July–November 2014

IDENTIFY PUBLIC & PRIVATE ROLES

Execute financial analysis on business model viability

Identify public sector role in addressing barriers to private investment

October–December 2014

TABLE 45: Study Advisory Panel

NAME	POSITION REPRESENTING ON PANEL	TITLE	LOCATION
Representative Judy Clibborn	State Representative, 41st District	Joint Transportation Committee (JTC) Co-Chair	Mercer Island
Representative Ed Orcutt	State Representative, 20th District	JTC Executive Committee Member	Kalama
Representative Jake Fey	State Representative, 27th District	House Transportation Committee Member	Tacoma
Representative Drew MacEwen	State Representative, 35th District	House Republican Caucus Member	Union
Representative Chad Magendanz	State Representative, 5th District	House Republican Caucus Member	Issaquah
Senator Mark Mullet	State Senator, 5th District	Senate Transportation Committee Member	Issaquah
Sandra Pinto de Bader	Representative from city or county that owns/operates EV charging stations	Environmental Sustainability Policy Advisor City of Seattle Office of Sustain-ability	Seattle
Ron Johnston-Rodriguez	EV professional who has developed EV charging infrastructure along popular tourist routes or recreational destinations	Principal, RJR & Associates Director, Plug-in North Central Washington	Wenatchee
Stephen Johnsen	EV driver with demonstrated knowledge of the charging needs of a broad range of EV drivers	President, Seattle EV Association (SEVA)	Seattle
David Peterson	Representative from manufacturer of battery electric vehicles	Nissan North America, Inc.; EV Regional Manager –West, Marketing & Sales Strategy	Franklin, Tennessee
Glen Stancil	Representative from EV charging service industry	Vice President, NRG Energy EV Services (eVgo)	Houston, Texas
Colleen Quinn	Representative from EV charging service industry	ChargePoint	New York City
Ben Farrow	Representative from investor-owned electric utility	Program Manager of Emerging Technologies, Puget Sound Energy (PSE)	Bellevue
Wayne Amondson	Representative from consumer-owned utility such as a public utility district (PUD)	Senior Project Engineer, Cowlitz PUD	Kelso

Continued on following page

TABLE 45: Study Advisory Panel *Continued from previous page*

NAME	POSITION REPRESENTING ON PANEL	TITLE	LOCATION
Scott DeWees	Representative from Western Washington Clean Cities Coalition	Clean Transportation Project Manager, Puget Sound Clean Air Agency	Seattle
Tonia Buell	Representative from WSDOT responsible for EV charging infrastructure	Acting Director, Public Private Partnerships, WSDOT	Olympia
Jeff Doyle	Citizen	Former Director, Public Private Partnerships, WSDOT	Olympia
Charles Knutson	Governor's Office	Office of Financial Management, Transportation Policy Advisor	Olympia

of three breakout groups. Each group explored three types of EV charging infrastructure gaps, and discussed alternative ways to finance charging stations. Following the workshop, financial analyses were conducted on business models when applied to specific charging infrastructure gaps. The analyses conducted for this step are summarized in Chapter 2 of this report.

The final step was to assess varying roles of the public sector in supporting the business models in order to encourage private sector investment in EV charging. This work assessed the effect of a combination of actions by the public sector on the financial performance of implementing each business model. The analyses conducted for this step are summarized in Chapter 3 of this report.

TABLE 46: Study Staff Workgroup

PARTICIPANT	ORGANIZATION
Mary Fleckenstein	JTC Staff, Project Manager
Beth Redfield	JTC Staff
Andrew Russell	House Transportation Committee Staff
Jerry Long	House Transportation Committee Staff
Kim Johnson	Senate Transportation Committee Staff
Dana Quam	Legislative Caucus Staff
Debbie Driver	Legislative Caucus Staff
Jackson Maynard	Legislative Caucus Staff
Nick Bowman	Legislative Caucus staff
Alyson Cummings	Office of Financial Management
Peter Moulton	Department of Commerce

APPENDIX B: EV CHARGING FINANCIAL ANALYSIS TOOL AND MODELING ASSUMPTIONS

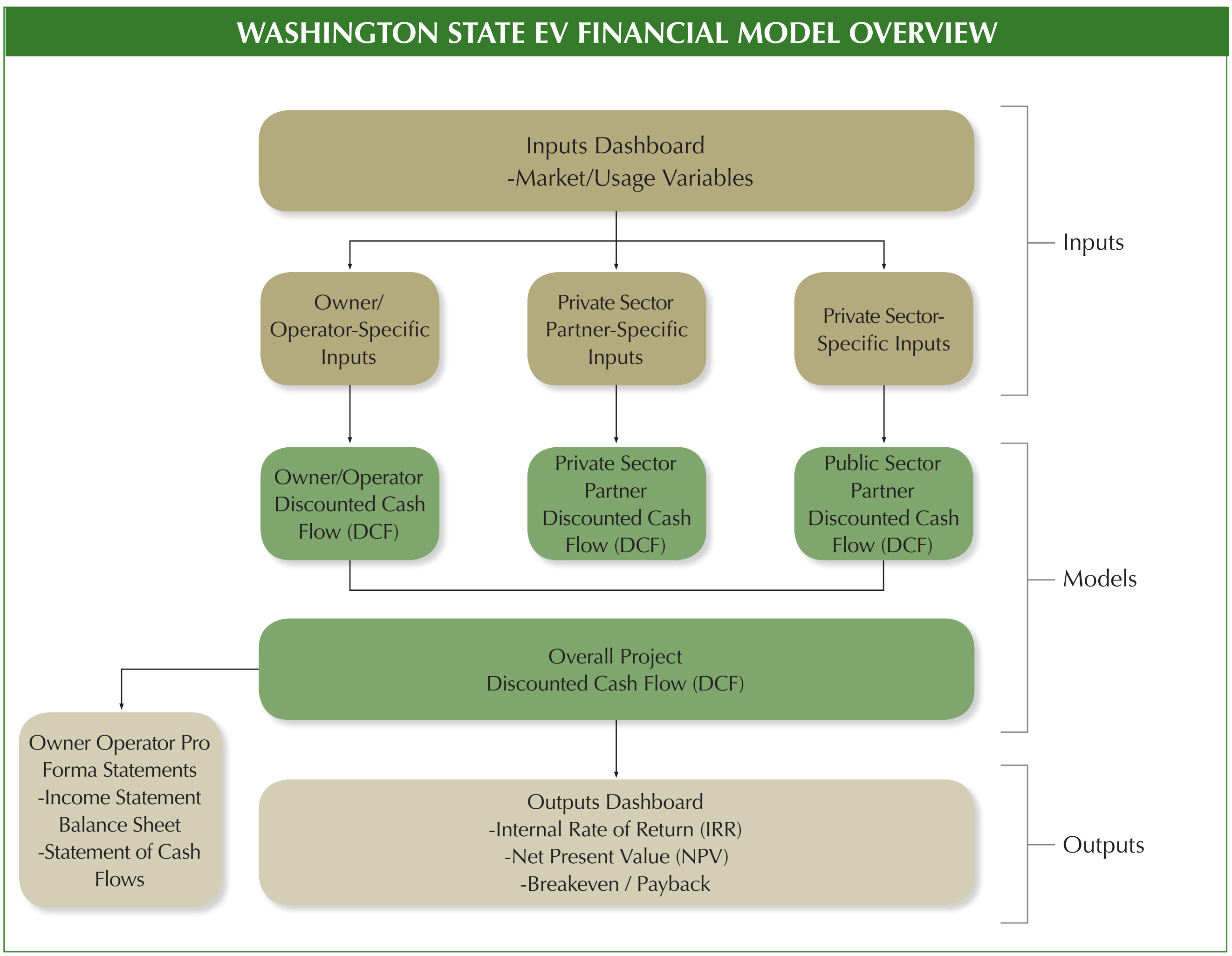
To evaluate the business case for each player involved in these business models, C2ES and Cadmus Group developed the EV Charging Financial Analysis Tool to analyze a variety of alternative EV charging investment arrangements under a wide range of market assumptions. The tool uses the discounted cash flow (DCF) analysis method to determine the expected financial returns for EV charging infrastructure investments over the expected lifetime of the charging equipment based on inputs provided by the user. The tool also provides financial viability metrics from the perspective of both private and public sectors as well as sensitivity analyses for key inputs and assumptions.

The tool can estimate the performance of a charging station deployment project from four distinct perspectives:

- Charging station project owner-operator
- External project partner (e.g., large business funding partner funder, tourism bureau, chamber of commerce, or a group of local businesses contributing to a deployment "funding pool")
- State or local government
- Total project performance as a whole as if all of the entities' perspectives are combined into a single entity

Each perspective was modeled with its own DCF analysis, which allows for calculation of project cash flows, internal rates of return (IRR), and payback to be calculated from each perspective. In addition, the charging station project owner-operator perspective is modeled as a standalone business, with income statements, balance sheets, and cash flows that encapsulate the performance of the charging services business as an independent

FIGURE 42: Overview of EV Charging Financial Analysis Tool Structure



entity (not simply as a small project conducted by a larger existing company). The model is also capable of accounting for business funding partners or funding pool contributors who also act as charging station owner-operators. An overview of the EV Charging Financial Analysis Tool structure is presented in the figure below.

There are four categories of user input:

- **Market Inputs:** Contains inputs related to the expected overall demand for EV charging services and expected growth in that demand. The user can select one of two options for entering expected charging station utilization. The first option attempts to derive utilization from traffic patterns along the route. The second option allows the user to enter utilization numbers directly.
- **Owner-Operator Inputs:** Contains inputs for the owner-operator organization, including unique information on up to three kinds of charging equipment, revenue sources, additional costs, assumptions regarding how the investment will be funded, and assumptions used in the production of a set of financial statements for the owner-operator.
- **Private Sector Partner Inputs:** Contains inputs related to the revenue sources and costs for the private sector partner. The Tool allows for three sources of revenue: revenue from site leasing, revenue from sales due to increased traffic at the site, and indirect revenue (revenue unrelated to time spent by the customer at a charging site). These can be used in conjunction with each other or independently. The user can also customize the amount of revenue that be shared with the owner operator and whether the private sector partner will provide a subsidy
- **Public Sector Partner Inputs:** Contains inputs that define the involvement of the public sector including whether the public sector will provide low interest debt, equity, a one-time grant, or ongoing financial support.

The Tool contains a dashboard of outputs that displays key performance metrics for each of the partners. Financial metrics include:

- **Total Capital Investment:** The total outlay of funds by all participating organizations.

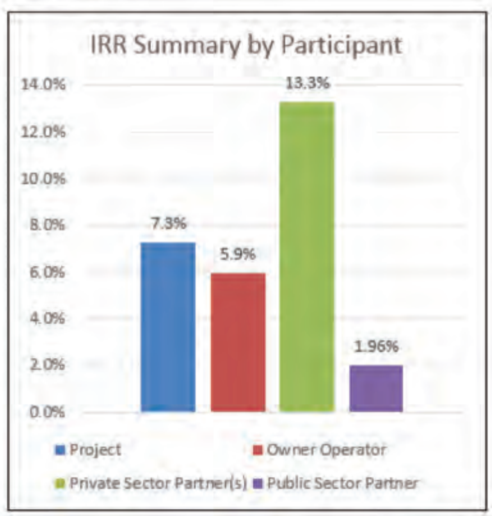
FIGURE 43: Sample of the Dashboard Output for the EV Charging Financial Analysis Tool

Financial Performance Statistics

Project		
Total Capital Investment	$	1,409,000
Total Net Present Value	$	410,681
Total Internal Rate of Return (IRR)		7.3%
Discounted Payback (Years)		8.0
Owner Operator		
Total Capital Investment (Equity)	$	563,600
Total Net Present Value	$	167,743
Total Internal Rate of Return (IRR)		5.9%
Discounted Payback (Years)		8.0
Private Sector Partner(s)		
Total Capital Investment	$	-
Total Other Contributions	$	1,336,350
Total Net Present Value	$	151,763
Total Internal Rate of Return (IRR)		13.3%
Discounted Payback (Years)		7.0
Public Sector Partner		
Total Capital Investment	$	253,620
Total Other Contributions	$	-
Total Net Present Value	$	27,257
Total Internal Rate of Return (IRR)		1.96%
Discounted Payback (Years)		9.0
Other Non-Partner Private Sector		
Total Capital Investment (Loans)	$	591,780

Charging Infrastructure Statistics

Total New Sites
20
Total New Stations
60
Number of Charging Sessions Provided
215,757
kWh of Charging Provided
2,562,110



- **Net Present Value (NPV):** Shows the net profit or loss an investment by summing incoming and outgoing cash flows over the expected lifetime of the charging equipment and adjusting for the time value of money. A positive NPV indicates an investment will result in a net profit in today's money. A negative NPV indicates a net loss in today's money.
- **Internal Rate of Return:** Measures the profitability of an investment. Expressed in an annual rate.
- **Discounted Payback:** A simple payback (or break-even measure) based on cash flows adjusted for the time value of money.

The dashboard also displays non-financial metrics like number of charging sites, number of new stations, projected number of charging sessions provided over the 10-year analysis timeframe and charging energy provided.

The Tool also provides a series of sensitivity analysis charts as output. The sensitivity analysis charts isolate a single input and run multiple versions of a scenario varying only that input. The chart shows how the results of the analysis would be different for each of the partners if that assumption were higher or lower than initially projected (all other inputs held equal). The figure below shows how the net present value of the scenario would change if the annual growth rate in charging station utilization were higher or lower than projected, over a range from 0 percent utilization to 45 percent utilization.

The Tool also includes a set of financial statements for the owner-operator. These statements include:

- **Income Statement:** Shows the revenues, costs, and resulting income for the owner-operator over the expected lifetime of the charging equipment.
- **Balance Sheet:** Shows the assets, liabilities, and resulting equity for the owner-operator over the expected lifetime of the charging equipment.
- **Statement of Cash Flows (SCF):** Shows the flow of money in and out of owner-operator organization and the resulting cash balance over the expected lifetime of the charging equipment.

The financial statements may be of interest to potential partners in the private sector who are considering pursuing an owner-operator role.

Below are a selection of the assumptions used in the analysis for Chapters 2 and 3.

FIGURE 44: Example Sensitivity Analysis from the EV Charging Financial Analysis Tool

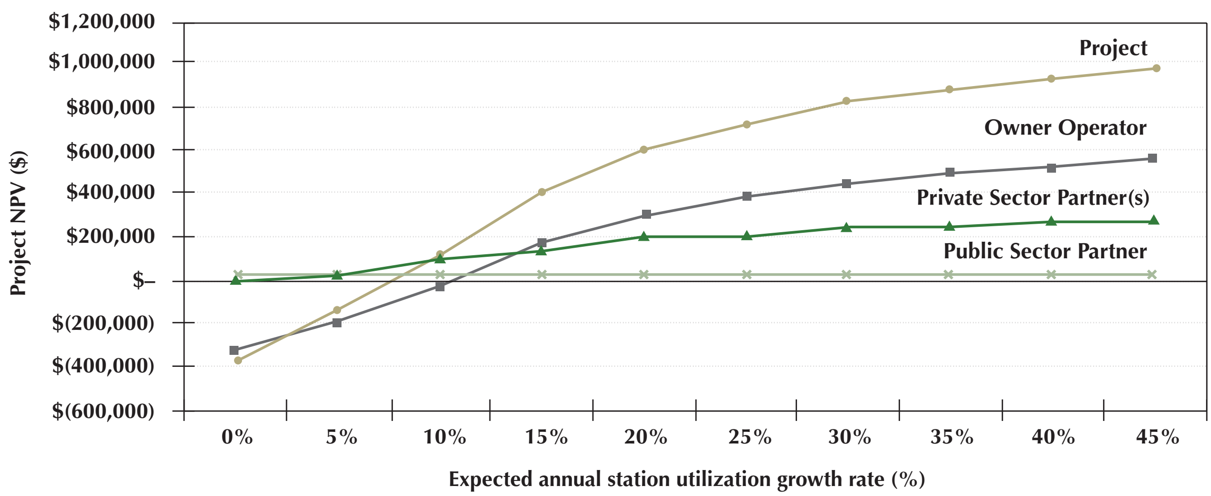


TABLE 47: Selection of Assumptions from Financial Analysis

PARAMETER		ASSUMPTION	SOURCE
Capital costs			
Charging station equipment	DC fast charging station	$35,000 per unit	Plug-In America and ABB Ltd.
	Level 2 station	$2,500 per unit	Washington State Department of Transportation (WSDOT)
Station utilization			
Station utilization in first year	DC fast charging station	1,200 sessions (3.3 sessions per day)	C2ES assumption
	Level 2 station	400 sessions (1.1 sessions per day)	C2ES assumption
Annual growth rate of station utilization		15%	C2ES assumption
Maximum number of charging sessions per station per year	DC fast charging station	3,650 sessions (10 sessions per day)	C2ES assumption
	Level 2 station	1,200 (3.3 sessions per day)	C2ES assumption
Owner operator direct revenue			
Per-energy user fee	DC fast charging station	$0.50/kWh	C2ES assumption
	Level 2 station	$0.25/kWh	C2ES assumption
Per session fee		None	N/A
Subscription revenue	Number of subscribers first year	None	N/A
	Annual growth rate in number of subscribers	None	N/A
	Subscription fee	None	N/A
At-station advertising revenue		None	N/A
Value of station to automaker (Business Model 1 and Business Model 3)			
Indirect value of charging station to funding partner (NPV of future value streams)	DC fast charging station	$12,250 per station (equivalent to $9,164 annual revenue)	C2ES assumption
	Level 2 station	$875 per station (equivalent to $655 annual revenue)	C2ES assumption
Percent of charging equipment cost subsidized		20%	C2ES assumption
Value of station to retailer (Business Model 2 and Business Model 3)			
Average expected retail revenue per customer during on-site charging		$1/minute	C2ES assumption
Maximum expected retail revenue per customer per session		$25	C2ES assumption
Annual revenue sharing agreement		10%	C2ES assumption
Owner operator initial capitalization			
Percent equity funded		40%	C2ES assumption
Percent debt funded		60%	C2ES assumption
Private sector cost of debt, long term (loan interest rate)		8%	C2ES assumption

APPENDIX C: DATA SOURCES

The following summarizes the data sources used throughout this document. Publicly available data are noted.

Publicly Available Charging Station Network Locations: The U.S. Department of Energy's Alternative Fuel Data Center provided a database of all charging locations throughout the United States. The dataset is updated monthly. Source: http://www.afdc.energy.gov.

Washington State Average Daily Traffic: Washington State Department of Transportation provided detailed data on the average daily traffic for all major roads in the state. Source: http://www.wsdot.wa.gov/mapsdata/tools/traffictrends.

ChargePoint Network: ChargePoint provided monthly usage data for all its publicly available charging locations in Washington from January 2011 to June 2014.

AeroVironment Network: Washington State Department of Transportation provided monthly usage data for DC fast charging stations operated on the AeroVironment Network from January 2011 to December 2013.

Vehicle Registrations: Washington State Department of Licensing provided monthly data for vehicle registrations, including battery electric and plug-in hybrid electric vehicles from January 2011 to December 2013.

EV Project and ChargePoint America: The U.S. Department of Energy Clean Cities Program and Idaho National Laboratory provided ZIP code level data for Level 2 and DC fast charging stations for the federally funded initiative called the EV Project operated on the Blink Network. The period covered by these data is January 2011 through December 2013.

ENDNOTES

1 General Motors Alex Keros, EV Roadmap 7, July 24, 2014. https://www.evroadmapconference.com/program/.

2 Wall Street Journal. 2014. Atlanta's Incentives Lift Electric Car Sales. June 4. Accessed September 21, 2014. http://online.wsj.com/articles/why-electric-cars-click-for-atlanta-1401922534.

3 Only Vermont, Hawaii, and Oregon have a higher ratio of charging locations to people. U.S. DOE, AFDC website. U.S. Census Bureau.

4 InsideEVs. 2014. Blinkless in Seattle. July 31. Accessed September 21, 2014. http://insideevs.com/blinkless-seattle/#comment-499326.

5 U.S. DOE. 2014. Alternative Fuels Data Center. http://www.afdc.energy.gov.

6 Buell, Tonia, interview by Nick Nigro. 2014. Conversation about the West Coast Electric Highway (July).

7 Doyle, Jeff, interview by Nick Nigro. 2014. Conversation about the West Coast Electric Highway (July).

8 C2ES. 2014. DC Fast Charging in Washington State. August. Accessed September 21, 2014. http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/maps/wa-dc-fast-charging-network.

9 Plug-in North Central Washington. 2014. High Amperage Level 2 Charging Network. Accessed September 21, 2014. http://www.pluginncw.com/high-amperage-level-2-charging-network.

10 National Research Council. 2013. Transitions to Alternative Vehicles and Fuels. Washington, DC: National Academies Press. http://www.nap.edu/catalog.php?record_id=18264.

11 Federal Highway Administration. 2011. Summary of Travel Trends: 2009 National Household Travel Survey. Washington, DC: Federal Highway Administration. Accessed September 21, 2014. http://nhts.ornl.gov/2009/pub/stt.pdf.

12 The creation of the Interstate Highway Program prevented the commercialization of the rights-of-way along the U.S. Interstate System at its inception in 1956. Interstates built before 1960 (e.g., Interstate 95) are exempted. See http://www.fhwa.dot.gov/interstate/faq.htm#question31.

13 Sarah Dougherty and Nick Nigro. 2014. *Alternative Fuel Vehicle and Fueling Infrastructure Deployment Barriers and The Potential Role of Private Sector Financial Solutions,* Center for Climate and Energy Solutions, Arlington, VA (April), available at http://www.c2es.org/docUploads/barriers-to-private-finance-in-afvs-final-12-20-13.pdf.

14 C2ES. 2014. "Electric Vehicle (EV) and Market Technology Overview." EV Study Advisory Panel Meeting #1. Olympia, Washington: Center for Climate and Energy Solutions.

15 DC fast-charger costs estimated for dual-output, revenue-grade, unit connected to back-office and purchased in volume of 5-10 units. From personal communication with ABB and http://www.pluginamerica.org/accessories.

16 U.S. EIA. 2014. Washington Electricity Profile. Accessed September 22, 2014. http://www.eia.gov/state/rankings/?sid=WA#series/31. Chelan County Public Utility District. 2012. Rates and Policies. Accessed September 21, 2014. http://www.chelanpud.org/rates.html.

17 The cost of funds was assumed to be 15 percent because charging infrastructure could be viewed as relatively risky by lenders and investors due to the challenging business case.

18 C2ES. 2012. "An Action Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid." Center for Climate and Energy Solutions. March. Accessed December 4, 2013. http://www.c2es.org/initiatives/pev/action-plan-report.

19 Williams, Juliana, and Ann Rendahl, interview by Nick Nigro. 2014. Conversation about Washington Electric Utility Regulation (July 15).

20 New York Times. 2015. Nissan Plans 1,000 New Stations to Quickly Charge Electric Cars. January 26. Accessed February 11, 2015. http://www.nytimes.com/2015/01/27/business/nissan-plans-1000-new-stations-to-quickly-charge-electric-cars.html?_r=1. Forbes. 2015. Striking Back Against Tesla, BMW And Volkswagen Team Up To Build 100 Fast Charging EV Stations. January 22. Accessed February 11, 2015. http://www.forbes.com/sites/aarontilley/2015/01/22/bmw-volkswagen-100-fast-charging-stations.

21 The value of charging stations to the automaker was calculated using the formula below:

Charging Station Value = EV to Charging Station Ratio × Marketing Funds Per EV × Charging Allocation

Assuming: auto dealers commonly spend up to 1 percent of total sales on marketing, or $300 for a $30,000 EV; the current ratio of charging stations to EVs in Washington is 9:1 for Level 2 charging stations and 135:1 for DC fast charging stations; and an automaker allocates only 17 percent of its marketing budget to charging stations.

22 Green Car Reports. 2013. Nissan Offers $15,000 For New Electric-Car Quick Chargers By Dec 31. October 11. Accessed February 9, 2015. http://www.greencarreports.com/news/1087580_nissan-offers-15000-for-new-electric-car-quick-chargers-by-dec-31.

23 Puget Sound Energy sold 11.3 megawatt-hours per household per year in 2012. http://www.eia.gov/electricity/sales_revenue_price/xls/table6.xls

24 The NPV formula below defines an expected value of a charging station over its life for an IOU.

Charging Station Value = NPV (Total Kilowatt Hours Per Station × Retail Electricity Price × Margin, Discount Rate)

The scenario calculation assumed the default assumptions from the financial analysis in Task 2 on use and electricity price, a 10 percent margin, and a 5 percent discount rate.

25 Washington State Legislature. 2001. WAC 480-100-223. Advertising. Accessed February 9, 2015. http://apps.leg.wa.gov/WAC/default.aspx?cite=480-100-223.

26 The formula below defines an expected value of a charging station each year for a retailer.

Annual Charging Station Value = Max($1 × Charging Session in Minutes,$25)× Annual Charging Sessions × Share of Sales

The scenario calculation assumed the default assumptions from the financial analysis in Task 2 on charging session length and annual charging sessions, and a 10 percent share of sales.

27 The current generation of PHEVs do not support DC fast charging, but this may change with future offerings.

28 A maximum utilization rate is assumed because stations are not used equally throughout the day and, above a certain utilization level, station crowding and long wait times become issues.

29 The interest rate of 5.4 percent was chosen because this is a common rate for State of Washington certificates of participation, according to Jerry Long, Washington State House Transportation Committee Fiscal Analyst. http://www.tre.wa.gov/investors/archivedOfficialStatements-COPs.shtml.

30 Although charging station utilization growth modeled as growing at 15 percent per year, utilization is also capped at a maximum level for to account for crowding and variability in charging rates throughout the day.

31 The following calculation assumes all ZEVs sold in Washington are EVs. If statewide annual light-duty vehicle sales grow at a rate of 2 percent from 192,524 in 2012, then approximately 249,000 vehicles will be sold in 2025. Based on this sales forecast and the annually escalating requirements of the ZEV program, the number of ZEVs sold in the state would grow to 39,800 by 2025. The number of ZEVs on the road in the state would grow from approximately 20,000 in 2017 to 191,000 in 2025. A 30 percent annual growth in the number of ZEVs assumes the number of ZEVs on the road grows from 20,000 in 2017 to 163,000 in 2025.

32 Washington State Legislature. 2005. Department of ecology to adopt rules to implement California motor vehicle emission standards - Limitations - Advisory group - Exemptions. Accessed February 9, 2015. http://apps.leg.wa.gov/RCW/default.aspx?cite=70.120A.010.

33 The near-term and future financial analyses are provided as demonstrations of the level of public intervention that would be required for the business models to be sustainable under different sets of market assumptions. These analyses are not forecasts. The near-term and future analyses are also not intended to be interpreted as two sequential projects for two reasons. First, the two analyses compare the performance of a single deployment project under near-term market assumptions and in future assumptions in order to demonstrate how this project's performance—and the need for public intervention—could change as the EV market develops. Second, the near-term and future analyses represent two alternative views of the future of utilization growth, so they cannot be considered together as sequential projects.

34 Legal Information Institute. 2015. 23 U.S. Code SS 133 - Surface transportation program. Accessed February 9, 2015. http://www.law.cornell.edu/uscode/text/23/133.

35 Legal Information Institute. 2015. 23 U.S. Code SS 133 - Surface transportation program. Accessed February 9, 2015. http://www.law.cornell.edu/uscode/text/23/149.

36 Washington State Department of Transportation. 2014. West Coast Electric Highway. Accessed February 9, 2015. http://www.westcoastgreenhighway.com/electrichighway.htm.

The Center for Climate and Energy Solutions (C2ES) is an independent non-profit, non-partisan organization promoting strong policy and action to address the twin challenges of energy and climate change. Launched in 2011, C2ES is the successor to the Pew Center on Global Climate Change.

CENTER FOR CLIMATE
AND ENERGY SOLUTIONS

2101 Wilson Blvd., Suite 550
Arlington, VA 22201
P: 703-516-4146
F: 703-516-9551

WWW.C2ES.ORG

BUSINESS

ASSESSING THE ELECTRIC VEHICLE CHARGING NETWORK IN WASHINGTON STATE

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

by

Nick Nigro
Jason Ye
Matt Frades

Center for Climate and Energy Solutions

September 2014

The Washington State Legislature is interested in exploring government's role in fostering new business models that will expand the private sector commercialization of electric vehicle (EV) charging services. This paper provides an assessment of the existing EV publicly available charging network in Washington. The paper begins with the challenges of ensuring adequate access to EV charging infrastructure and identifies the barriers to increasing the private sector role in expanding charging access. Next, the paper assesses the current state of publicly available charging infrastructure in the state and identifies where additional infrastructure may be needed. Finally, the paper investigates specific travel corridors where private investment could increase EV adoption.

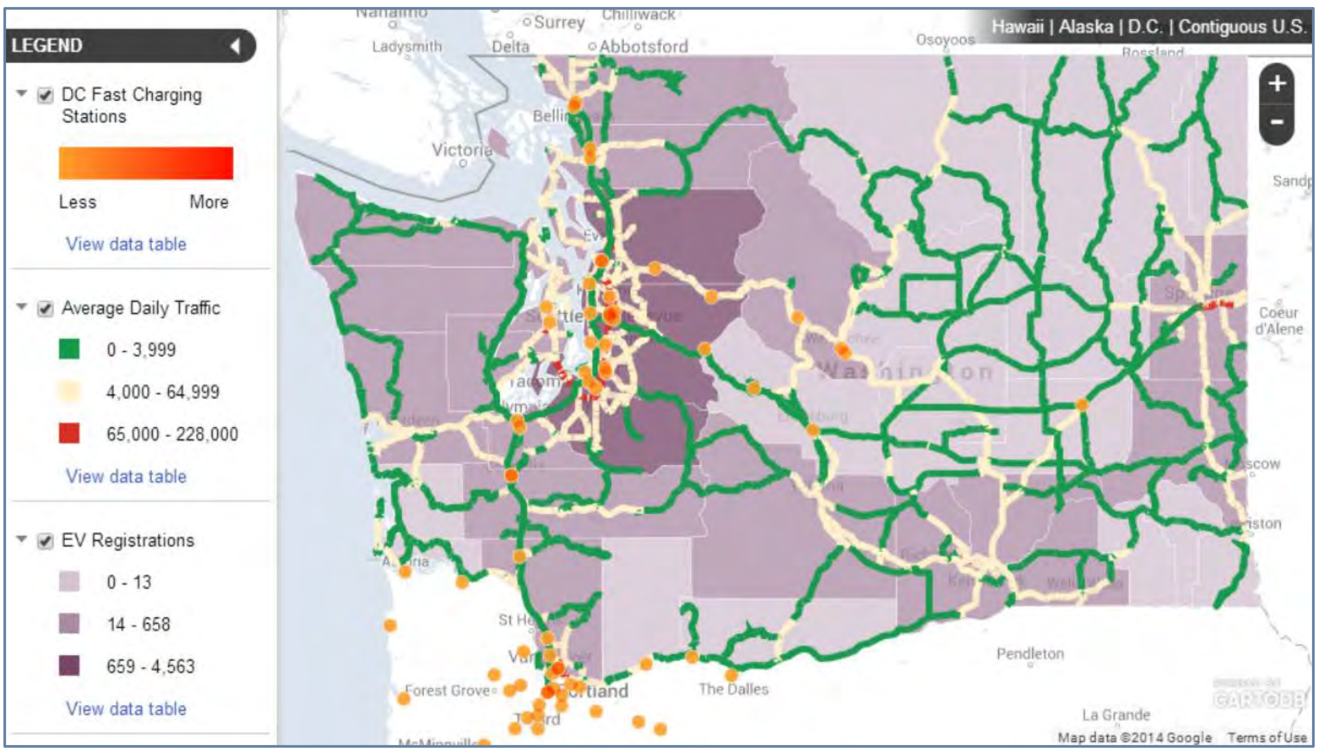
Table of Contents

EXECUTIVE SUMMARY

Electric vehicles (EVs) are a small, but fast growing part of the passenger vehicle market in the United States. In the state of Washington, EVs have been more popular than in other markets, in part because of action by the state government to build out publicly available charging infrastructure. The Washington State Legislature is interested in exploring government's role in fostering new business models that will expand the private sector commercialization of EV charging services.

This paper provides an assessment of the existing EV publicly available charging network in Washington. The paper begins with the challenges of ensuring adequate access to EV charging infrastructure and identifies the barriers to increasing the private sector role in expanding charging access. Next, the paper assesses the current state of publicly available charging infrastructure in the state and identifies where additional infrastructure may be needed. Finally, the paper investigates specific travel corridors where private investment could increase EV adoption.

FIGURE 1: DC Fast Charging Network Intensity Map as of June 2014



Large segments of many major roadways do not have any publicly available DC fast charging. Major roadways are denoted by green, yellow, and red colors depending on the average daily traffic in 2012.

Source: C2ES. 2014. DC Fast Charging Network in Washington State. August. Accessed September 21, 2014. http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/maps/wa-dc-fast-charging-network.

While the national trend has been for plug-in hybrid vehicle (PHEV) adoption to outpace battery electric vehicle (BEV) adoption, Washington has not followed this trend. Washington has more than twice the number of BEVs on the road as PHEVs. As of December 2013, there were 5,655 BEVs registered in the state compared to only 2,493 PHEVs, according to the Washington Department of Licensing.

In most Washington counties, the distribution of EVs is roughly proportional to that of regular passenger vehicles.

EVs are concentrated in five counties, which make up 85 percent of the EV registrations, but only 64 percent of total passenger vehicle registrations. EVs are particularly concentrated in King County, which is home to 56 percent of EVs registered in the state, compared with 30 percent of total passenger vehicles.

Washington has 423 publicly available charging locations as of June 2014, giving it the fourth highest per capita publicly available charging network in the country.[1] A relationship may exist between the number of EVs and the number of publicly available charging locations in a county. These charging stations are primarily concentrated in the state's most populous region around Puget Sound. King County also contains 57 percent of the state's Level 2 charging locations and 39 percent of DC fast charging locations. Publicly available charging stations around the rest of the state are mostly sparse, with the exception of the Vancouver area near Portland, Oregon.

The direct current (DC) fast charging network in Washington provides access to charging along much of the Interstate 5 corridor and in King County, but DC fast charging is unavailable in much of the state (see Figure 1). The alternating current (AC) Level 2 charging network in Washington provides access in King County, but does not provide access in much of the rest of the state outside of Vancouver. Seventy-four percent of populated ZIP codes in the state, covering 44 percent of the population, have no Level 2 charging stations. As a result, many possible destinations may be inaccessible to BEV drivers.

Based on travel simulations completed, EVs with longer electric-only ranges are more likely to complete trips with the current charging infrastructure. Any BEV on the market today can travel from Seattle to Portland, Oregon along Interstate 5 because of the relatively high density of publicly available charging stations. However, additional charging infrastructure is needed to facilitate travel to the Pacific Coast and between the eastern and western part of the state along Interstate 90.

ACKNOWLEDGEMENTS

The Center for Climate and Energy Solutions (C2ES) would like to thank the Washington State Legislature Joint Transportation Committee for providing financial support for this report. C2ES would also like to thank the following for their substantial input: Representative Judy Clibborn, Representative Ed Orcutt, Representative Jake Fey, Representative Drew MacEwen, Representative Chad Magendanz, Senator Mark Mullet, Representative Dick Muri, Wayne Amondson, Scott DeWees, Ben Farrow, Stephen Johnsen, Ron Johnston-Rodriguez, Charles Knutson, Dan O'Shea, David Peterson, Sandra Pinto de Bader, Colleen Quinn, Glen Stancil, Nick Bowman, Tonia Buell, Alyson Cummings, Jeff Doyle, Debbie Driver, Mary Fleckenstein, Kim Johnson, Jerry Long, Jackson Maynard, Peter Moulton, Sonia Plasencia, Dana Quam, Beth Redfield, and Andrew Russell.

INTRODUCTION

Electric vehicles (EVs) are a small, but fast growing part of the passenger vehicle market in the United States. In the state of Washington, EVs have been more popular than in other markets, in part because of action by the state government to build out publicly available charging infrastructure. The Washington State Legislature is interested in exploring government's role in fostering new business models that will expand the private sector commercialization of EV charging services. This paper is part of a project on expanding the role of private sector investment in publicly available EV charging throughout Washington (see Box 1).

The paper provides an assessment of the existing EV publicly available charging network in Washington. The first section identifies the challenges of ensuring adequate access to EV charging infrastructure and the barriers to increasing the private sector role in expanding charging access. The next section assesses the current state of charging infrastructure in the state and identifies where additional infrastructure may be needed. The third section investigates specific travel corridors where private investment could increase EV adoption. Finally, the paper offers conclusions and identifies next steps for the project.

Box 1. Business Models for Financially Sustainable EV Charging Networks

The Washington State Legislature's Joint Transportation Committee selected C2ES to develop new business models that will foster private sector commercialization of public EV charging services. First, C2ES will assess the state of EV charging in Washington and create useful products for the state to perform similar assessments as the market evolves. Second, leveraging its experience with the Alternative Fuel Vehicle (AFV) Finance Initiative and similar activities, C2ES will identify and evaluate business models for EV charging in Washington. Finally, C2ES will develop recommendations on the role of the public sector in supporting those business models in order to maximize private sector investment in EV charging.

Evaluate Current Status of EV Charging in Washington

- Construct Public Charging Network Database
- Create interactive maps for charging suitability assessment
- Provide insights into role of public charging networks in encouraging EVs
- Summarize findings

May – August 2014

Develop Business Models

- Leverage C2ES's AFV Finance Initiative
- Conduct Business Model Workshop
- Create 2-3 Business Model Summaries

July – November 2014

Identify Public & Private Roles

- Execute financial analysis on business model viability
- Identify public sector role in addressing barriers to private investment

October – December 2014

This project is a part of C2ES's AFV Finance Initiative. More information is available at www.c2es.org/initiatives/alternative-fuel-vehicle-finance.

THE CHALLENGE OF EXPANDING THE PRIVATE SECTOR ROLE IN OFFERING EV CHARGING SERVICES

While state and federal governments have played a central role in providing EV charging infrastructure to date, greater private investment will be needed to ensure adequate access to publicly available charging stations to continue to advance EV adoption. However, it is currently challenging to construct a profitable business case for EV charging investments for several reasons.

EV charging business models face barriers including high capital costs for new infrastructure and the associated financing costs, as well as operating costs. Deploying a charging station requires an upfront capital investment for equipment and installation, which ranges from $500 to $5,000 for an alternating current (AC) Level 2 charging station or $50,000 to $150,000 for a direct current (DC) fast charging station (see Box 2).[2] If nascent technologies and standards change, EV charging locations will require additional capital infusions to fund station retrofits. Access to public or private financial capital needed for these investments may present an additional barrier. Charging station hosts or service providers may also bear substantial operating costs, including electricity distribution costs associated with powering DC fast charging stations or sites with multiple Level 2 charging stations. Electricity regulators could reduce these operating costs through new electricity rate structures.[3]

On the revenue side, charging station investors face the headwinds of low and uncertain near-term demand for publicly available charging, as well as limited consumer willingness to pay for publicly available charging due to competition with relatively inexpensive home charging. In Washington, residential electricity prices averaged only $0.08 per kilowatt-hour in April 2014, with prices as low as $0.03 per kilowatt-hour.[4] In addition, the potential for charging stations to capture indirect revenue—such as increased retail sales near publicly available charging locations—from charging stations is uncertain and not well recognized.

MODELS OF EV INFRASTRUCTURE DEPLOYMENT AND VALUE CAPTURE

Public and private entities could employ a variety of models to deploy and manage EV charging infrastructure. This section considers four questions in order to understand the range of possible models and, in subsequent phases of this project, enable comparison and evaluation of these models.

Box 2. EV Charging Installation Cost for West Coast Electric Highway

One of the main barriers to deploying DC fast charging stations is the high cost of installation. Until 2013, DC fast charging equipment was not readily available and costs were high as a result. Over time, equipment costs have declined and providing a high-powered connection to the electrical grid now constitutes much of the installation cost.[5] Below is the cost summary for DC fast charging stations installed in Washington for the West Coast Electric Highway project. Installation of these stations was completed in 2012. More information is available online at http://www.westcoastgreenhighway.com/electrichighway.htm.

COMPONENT	COST (2012)
DC fast charging equipment	$58,000 per unit
Level 2 charging station co-located with DC fast charging station	$2,500 per unit
Equipment installation (labor and electric-panel upgrade)	$26,000 per location
Host-site identification, analysis, and screening	$5,000 per location
Negotiation, legal review, and execution of lease	$6,000 per location
Utility interconnection	$12,500 to $25,000 per location
Total	$109,500 to $122,000

Source: Washington State Department of Transportation

1. What are the critical functions and stakeholders in an EV charging network?

While this paper is focused on EV charging services specifically, it is helpful to consider the broader set of products and services needed to support an EV charging network, depicted in Figure 2, which include that:

- Installation sites must be selected to host EV charging stations;
- Electricity must be generated, transmitted and distributed to supply electricity to EV charging sites;
- Charging station equipment must be manufactured and purchased by an EV charging service provider; and
- EVs must be manufactured and purchased.

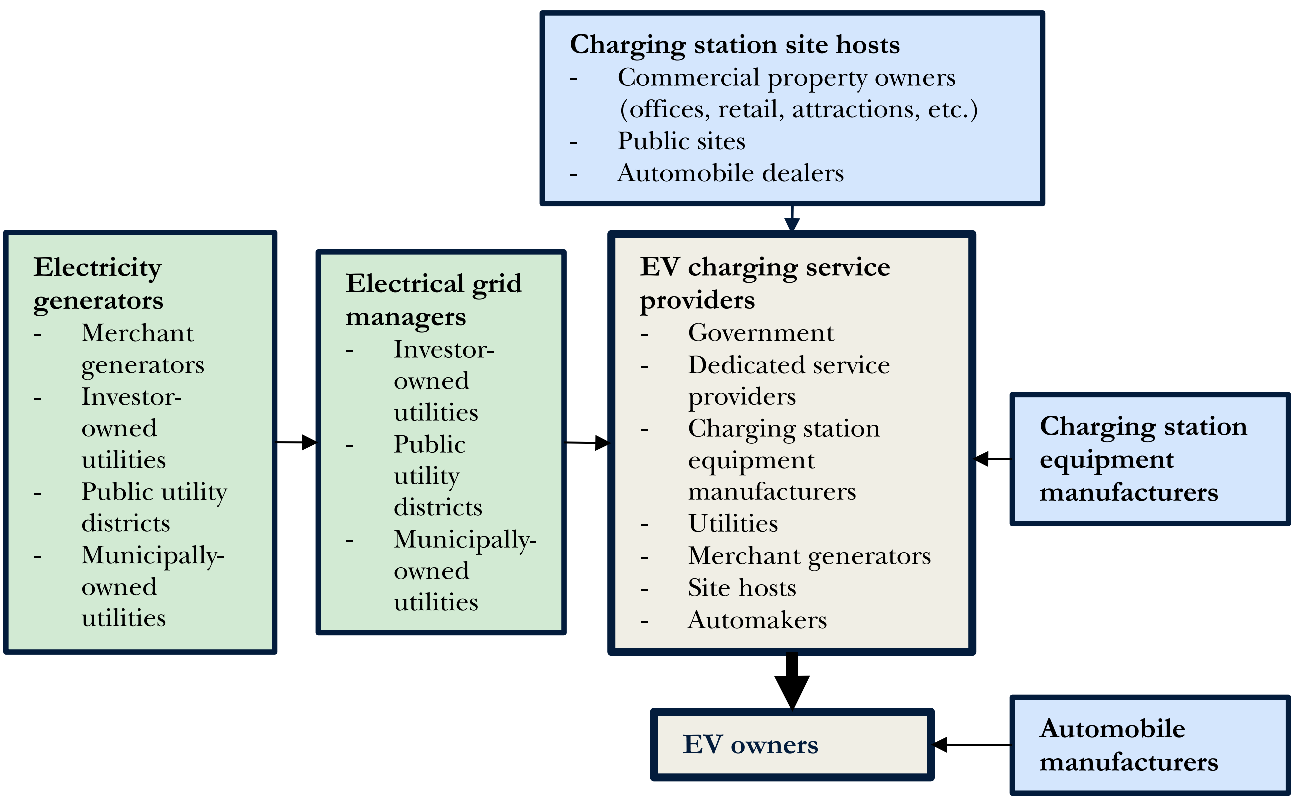
Each of these functions is essential to providing charging services, and several of these functions can be carried out by multiple types of stakeholders, listed in Figure 2.

2. Which entities are positioned to provide EV charging services?

As shown in Figure 2, the function of the EV charging service provider could be played by many alternative stakeholders, including:

- dedicated charging service companies,
- charging equipment manufacturers,
- property owners acting as site hosts,
- automakers,
- electric utilities,
- electricity generators, and
- state and local governments.

FIGURE 2: Public EV Charging Network Roles and Flows of Products and Services



Roles needed to support an EV charging network are depicted as boxes and titled within each box in bold. Stakeholders that could play each role are bulleted within each box in cases where more than one stakeholder could play a role. Flows of products and services are depicted as arrows.

Source: C2ES

These stakeholders differ in their potential interests in and concerns about EV charging deployment. Each stakeholder's perspective on EV charging deployment opportunities is presented in Table 1 and challenges are presented in Table 2. Notably, stakeholders face many of these benefits and concerns whether or not they directly assume the function of EV charging service provider.

3. How would these entities derive value from providing such a network?

In order for any of these entities to consider investing in EV charging, they will need to expect that the project will generate value that is greater than its total cost. For commercial entities, the monetary value of EV charging projects is of primary concern. For government entities, the social benefits of EV charging deployment may also be considered.

The monetary value of providing EV charging services is dependent on the total revenue these services generate. The most straightforward sources of revenue are station user fees. User fees may be collected at the time of charging, through a flat fee per charging session, a fee based on the time spent parked or connected to the charging station, or a fee based on the amount of energy used. Alternatively, user fees may be collected through subscriptions, membership fees, or permits.

EV charging stations may also generate additional types of indirect revenue streams for businesses. For example, offering EV charging at retail locations may increase sales revenue by drawing EV drivers to the destination and by increasing customer time spent parked at these locations. EV charging infrastructure deployment may increase sales of EVs, potentially increasing expected automaker revenues as they work to drive down costs for these advanced technology vehicles. Over a longer time frame, technology and infrastructure development may enable EVs to provide vehicle-to-building (V2B) and vehicle-to-grid (V2G) power services that generate additional revenues or cost savings. Some businesses may choose to bear the costs of offering charging services based on the value of these indirect revenue streams.

In addition to the monetary value of charging services, state and local governments and public utilities may consider the social benefits associated with increased EV deployment, including public health, environmental, economic development, and energy security benefits.[6] The value of these benefits is uncertain and difficult to quantify.

4. What sources of financial capital are available to fund station deployment and operations?

Any entity seeking to deploy EV charging infrastructure will need financial capital to fund upfront costs (equipment and installation) and operating costs (electricity, maintenance, and supporting services). Upfront capital costs could be funded in several ways:

- Commercial entities may choose to devote their own available cash-on-hand to deploy and operate charging stations.
- Private financing through commercial loans or leases may be used to secure adequate funds for deployment.
- Deployments of larger-scale networks of EV charging stations may be financed with capital from third-party investment partners.
- Investor-owned electric utilities may finance EV charging station projects using shareholder revenues.[7]
- Electric utility ratepayer fees.

The public sector may contribute funds to EV charging deployment projects, either by owning and operating stations themselves, or by subsidizing commercially managed deployments. Funding for public investment in charging stations could come from tax revenues. Charging station subsidies could take the form of grants, rebates, tax credits, or low-cost lending programs. Notably, such programs in Washington must be designed to ensure compliance with constitutional limitations on any gifting of public funds and/or loaning of state credit.

Taken together, these four questions—what is a charging network, who can provide it, how is value captured, and how is it funded—frame the challenges of and opportunities for ensuring adequate access to publicly available charging infrastructure and expanding the private sector role in this effort. The next section investigates the current state of EV market station usage in Washington to better understand both the needs of EV drivers and the potential for revenue generation from charging station investments.

TABLE 1: Opportunities from the deployment of EV charging from stakeholders' perspective

	PUBLIC / GOVERNMENT	PUBLIC UTILITY DISTRICTS AND MUNICIPALLY-OWNED UTILITIES	INVESTOR-OWNED ELECTRIC UTILITIES	MERCHANT ELECTRICITY GENERATORS	DEDICATED CHARGING SERVICE PROVIDERS	CHARGING EQUIPMENT MANUFACTURERS	AUTOMAKERS	CHARGING SITE PROPERTY OWNER
Vehicle fuel cost savings	X							
Reduced environmental and public health costs	X	X						
Economic development from EV and charging station use	X	X						X
Increased electricity use		X	X	X				
More efficient use of off-peak generation capacity	X	X	X	X				
Long-term prospect of vehicle-to-building and vehicle-to-grid benefits	X	X	X	X	X	X	X	X
Greater EV sales							X	
Sales of EV charging equipment						X		
Increased retail sales from offering charging on site								X
Sales of charging network support services		X	X		X			X

For each stakeholder, opportunities that are within their scope of interest are indicated with an 'X.' Opportunities are presented as general categories that are illustrative of stakeholders' primary motivations.

Source: C2ES

TABLE 2: Challenges from EV charging deployment from stakeholders' perspective

	PUBLIC / GOVERNMENT	PUBLIC UTILITY DISTRICTS AND MUNICIPALLY-OWNED UTILITIES	INVESTOR-OWNED ELECTRIC UTILITIES	MERCHANT ELECTRICITY GENERATORS	DEDICATED CHARGING SERVICE PROVIDERS	CHARGING EQUIPMENT MANUFACTURERS	AUTOMAKERS	CHARGING SITE PROPERTY OWNER
Cost to public of charging investment and subsidies / equity concerns	X	X	X					
High-power charging impacts on grid reliability / need for distribution upgrades	X	X	X					
Vehicle-to-building technology could reduce demand for grid electricity		X	X	X				
Financial sustainability of charging station investment	X	X	X	X	X			X
Rate of return of charging station investment				X	X			
Uncertain impacts of charging station deployment on EV adoption	X						X	
Lack of interest in owning and operating charging infrastructure	X	X	X				X	

For each stakeholder, challenges that are within their scope of interest are indicated with an 'X.' Challenges are presented as general categories that are illustrative of stakeholders' primary concerns.

Source: C2ES

THE WASHINGTON EV MARKET

This section provides an overview of the EV market in Washington with a focus on why battery electric vehicles (BEVs) have been more popular than plug-in hybrid electric vehicles (PHEVs), see Box 3. This section also describes a potential relationship between the concentration of EVs and charging locations at the county level.

Box 3. Defining the Types of EVs

Battery electric vehicles (BEVs) are powered by rechargeable batteries. Many BEVs currently available can only travel 100 miles or less on a single charge. As a result, BEVs require a robust fast charging network to enable long distance travel. A plug-in hybrid electric vehicle (PHEV) can be powered by batteries and/or a gasoline-powered internal combustion engine. The flexibility offered by the gasoline engine enables a PHEV to travel more easily without the need to stop and recharge the vehicle's battery. On the other hand, PHEVs typically have less than 40 miles of all-electric range, so their share of electric miles traveled decreases on longer trips unless the batteries are recharged.

EV ADOPTION OVER TIME AND THE RATIO OF BEVS TO PHEVS

While the national trend has been for PHEV adoption to outpace BEV adoption, Washington has not followed this trend. Many studies have concluded that PHEVs are likely to be more popular than BEVs in the near term because of the high cost of batteries and the lack of charging infrastructure.[8] Figure 3 shows the national EV market has followed this projection, with 27 percent more PHEVs sold than BEVs. Washington, however, has more than twice the number of BEVs on the road as PHEVs, as shown in Figure 4. As of December 2013, there were 5,655 BEVs registered in the state compared to only 2,493 PHEVs according to the state's Department of Licensing.

TABLE 3: EVs registered in Washington

	2011	2012	2013
PHEVs Registered	125	1,056	2,493
BEVs Registered	1,121	1,871	5,655
Total EVs	1,246	2,927	8,148
Total Passenger Vehicles	4,315,782	4,284,923	4,401,768
U.S. Cumulative EV Sales	17,655	70,301	165,663

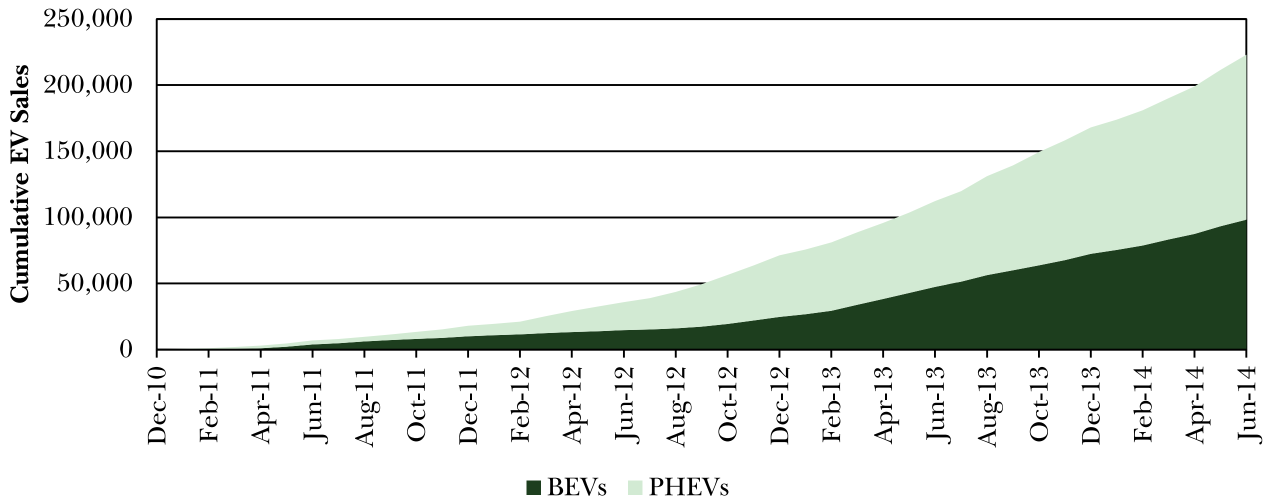
The total for registrations was calculated by adding all registration-related transactions provided by Department of Licensing: 'original,' 'registration renewal,' 'title transfer,' and 'other.'

Source: Washington State Department of Licensing, Hybridcars.com

One possible explanation for the popularity of BEVs over PHEVs in Washington is the presence of state policy incentives. A time-of-purchase sales tax exemption only available for BEVs amounts to a multi-thousand dollar "discount" for a BEV compared to a PHEV. Automakers have indicated that sales can be increased through incentives available for use at the time of vehicle purchase, especially incentives in excess of $1,000.[9] Notably, BEVs are also much more popular than PHEVs in Georgia, where a $5,000 vehicle tax credit and high-occupancy vehicle lane access are both available only to BEVs. These incentives have helped make Atlanta the top market for the all-electric Nissan LEAF for many months.[10]

Because BEVs outnumber PHEVs by a large margin in Washington, charging infrastructure needs in Washington may differ from those in other markets. Washington EV drivers may need greater access to high-powered charging to meet their travel needs than drivers in other states.

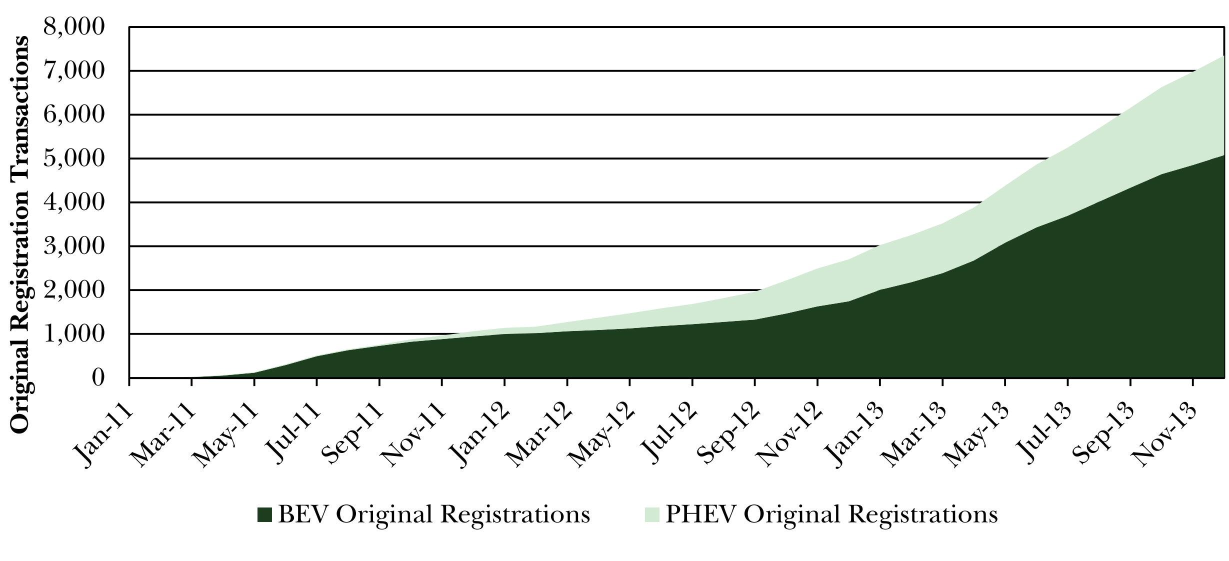
FIGURE 3: PHEVs have outsold BEVs in United States by over 25 percent.



124,718 PHEVs and 98,267 BEVs have been sold in the United States through June 2014. PHEVs have consistently outsold BEVs on a monthly basis since early 2011.

Source: Hybridcars.com. 2014. Hybrid Market Dashboard. July. Accessed September 21, 2014. http://www.hybridcars.com/market-dashboard.html.

FIGURE 4: BEVs Have Outsold PHEVs in Washington by a Large Margin



This figure shows the history of original registrations for BEVs and PHEVs from January 2011 to December 2013. An original registration occurs when a vehicle owner first registers the vehicle in Washington. The figure shows new and used vehicles as they were first registered. Washington differs from the national EV market because BEVs have outsold PHEVs by a large margin. The actual number of vehicles on the road will differ from the total vehicles shown below at any given time because it does not include the existing vehicle stock.

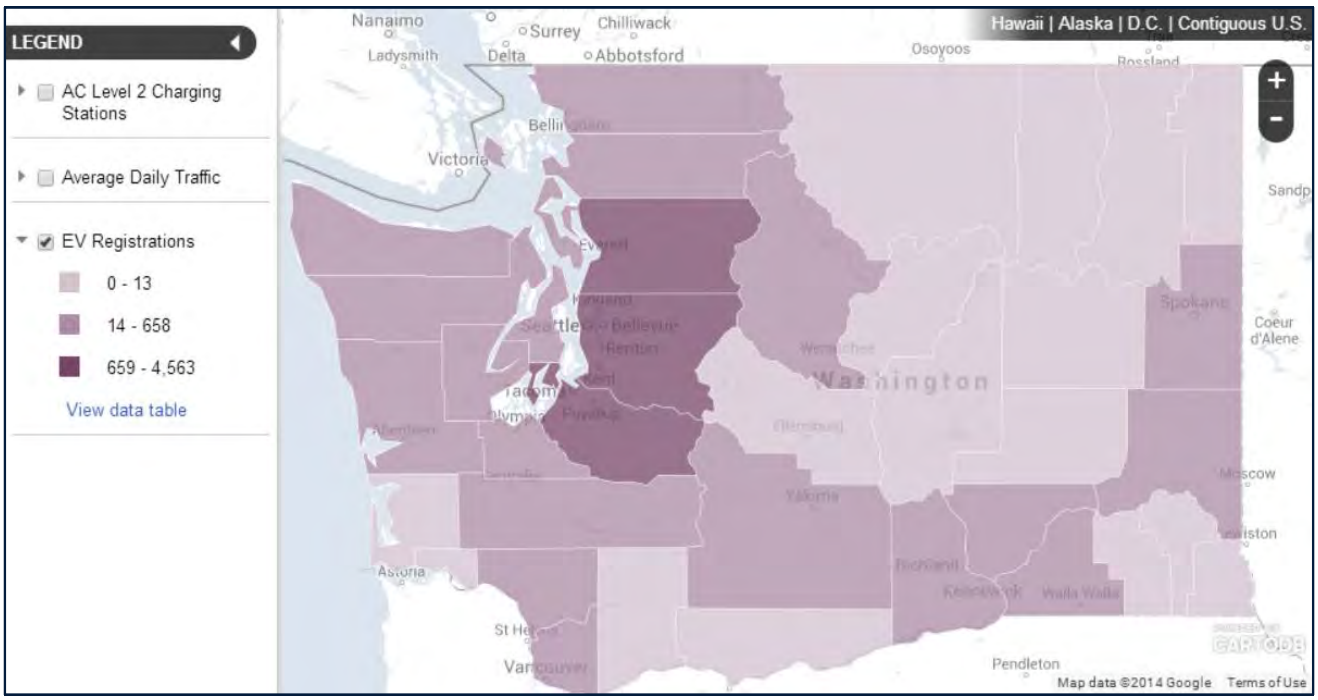
Source: Washington Department of Licensing.

GEOGRAPHIC DISTRIBUTION OF EVS

In most Washington counties, the distribution of EVs is roughly proportional to that of regular passenger vehicles. EVs are concentrated in five counties, which make up 85 percent of the EV registrations (see Table 4), but only 64 percent of total passenger vehicle registrations.

A relationship may exist between the number of EVs and the number of publicly available charging locations in a county. EVs are particularly concentrated in King County, home to 56 percent of EVs registered in the state, compared with 30 percent of total passenger vehicles. King County also contains 57 percent of the Level 2 charging locations and 39 percent of DC fast charging locations. Considering that Level 2 charging stations are often intended to accommodate average daily travel needs, a similar share of Level 2 charging locations and EV registrations in a county is intuitive. For example, 57 percent of Level 2 charging locations and 56 percent of EVs are in King County. On the other hand, a strong relationship between DC fast charging and BEV sales is less likely at the county level since DC fast charging is often cited as enabling travel to and from distant locations.

FIGURE 5: Registered EVs in Washington by county through December 2013



Nearly all EVs in Washington are registered in the Puget Sound region. Many counties have very few EVs registered, denoted by the lightest purple color.

Source: C2ES. 2014. AC Level 2 Charging Network in Washington State. August. Accessed September 21, 2014. http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/maps/wa-ac-level-2-charging-network.

TABLE 4: Top 5 Counties for EV registrations (December 2013)

COUNTY	BEVS REGISTERED	PHEVS REGISTERED	EVS REGISTERED	POPULATION (%)	BEV (%)	PHEV (%)	EV (%)	DC FAST CHARGING LOCATIONS (%)	AC LEVEL 2 CHARGING LOCATIONS (%)
Clark	278	157	435	6.3%	5%	6%	5%	15%	3%
King	3433	1130	4563	28.8%	61%	45%	56%	43%	60%
Kitsap	264	107	371	3.7%	5%	4%	5%	5%	3%
Pierce	399	260	659	11.8%	7%	10%	8%	5%	11%
Snohomish	569	272	841	10.6%	10%	11%	10%	8%	8%

These five counties make up 85 percent of total EV registrations. Percentages in this table are a share of state totals.

Source: Washington State Department of Licensing; U.S. Census Bureau, U.S. Department of Energy

CHARGING NETWORK ASSESSMENT

This section assesses the ability of the existing publicly available charging network to enable travel throughout Washington, considering the location of EVs and average daily traffic. It begins with a description of assumptions about vehicle and charging technologies that formed the basis for the analysis. The section then describes an independent assessment of the DC fast charging and AC Level 2 charging networks. An assessment of the EV charging network in Washington depends on the charging technology supported by existing charging stations and the charging needs demanded by different EV technologies. Although these assessments were performed separately, the two charging technologies can complement each other to accommodate average daily driving needs and the occasional long distance trip.

Washington has 423 publicly available charging locations as of June 2014, giving it the fourth highest per capita publicly available charging network in the country.[11] These charging stations are primarily concentrated in the state's most populous region around Puget Sound. Publicly available charging stations around the rest of the state are mostly sparse, with the exception of the Vancouver area near Portland, Oregon. There are three publicly available charging networks in the state: AeroVironment, Blink, and ChargePoint. Tesla's fast charging network is only available to Tesla vehicles and is not considered in this analysis.

VEHICLE AND CHARGING TECHNOLOGIES CONSIDERED AND ASSUMPTIONS

The following section describes the vehicle and charging technologies considered in the network assessment and any assumptions used in the analysis. For example, an EV can be expected to travel 3.5 miles with each kilowatt-hour (kWh) of energy delivered to its batteries, or by charging the vehicle at 1 kilowatt (kW) for an hour (see Figure 6). Charging a vehicle at 30 kW for 30 minutes provides about 50 miles of range. Thus, the higher the power the charging station provides to the vehicle, the faster the vehicle's batteries can recharge.

Competing Charging Equipment Standards in the Marketplace

An EV can recharge at three power levels: AC Level 1, AC Level 2, and DC fast charging (see Figure 6). Most BEVs support all three levels of charging while current PHEVs only support AC Level 1 and 2. All EVs support a common standard for charging at AC Level 1 and 2, but there are three competing standards for DC fast charging presently.

All EVs are currently equipped with the Society of Automotive Engineers (SAE) J1772 connector for AC

Level 2 charging. Siting for Level 2 charging stations is typically done at locations where drivers are expected to spend several hours, such as retail outlets, public parks, recreational areas, public parking lots, and sports stadiums. The power level for Level 2 goes up to 19.2 kW, but is typically offered at 3.3 kW or 6.6 kW.

DC fast charging provides rapid battery recharging at a somewhat similar timeframe as refueling a conventional gasoline powered vehicle. It is intended to enable long distance EV travel and accommodate EV owners without access to convenient, daily charging at the home or workplace. These charging stations are often sited at locations where drivers are expected to spend less than 30 minutes, such as along the roadway, similar to a gasoline station. An adequate DC fast charging network must link major roadway segments with enough charging density to minimize the risk of being stranded or the need to wait for an excessive amount of time to access the station.

FIGURE 6: Charging Levels Explained

Low – AC 120V *"AC" LEVEL 1*	Medium – AC 240V *"AC" LEVEL 2*	High – DC Fast Charge *"DC" LEVEL 2*
•Uses standard outlet •Power requirements similar to a toaster •Adapter comes with the car •Accommodates average daily driving needs •Very low cost installation, often free •*Fully charge a Nissan LEAF: 17 hours*	•Requires high-voltage circuit •Power requirements similar to an electric clothes dryer •Charging stations can cost about $500 •Installation costs vary widely (~$1,500) •*Fully charge a Nissan LEAF in 3.5-7 hours*	•Requires very high voltage circuit & 3-phase power •Power requirements are up to max power for 15 homes •No common standard for electric vehicles (CHAdeMO, SAE, Tesla) •Very high installation cost (~$100,000) •Equipment costs vary widely •*80% charge a Nissan LEAF in 20 minutes*

This figure explains the three kinds of EV charging. AC Level 1 is not included in the scope of this work.

Source: SAE. 2011. SAE Charging Configurations and Ratings Terminology. Accessed September 21, 2014. http://www.sae.org/smartgrid/chargingspeeds.pdf.

DC fast charging stations can provide power to a vehicle's batteries at up to 90 kW, though stations typically only provide power at a rate up to 50 kW. There are currently three competing standards for DC fast charging, and they are not inter-operative, making it more challenging for drivers to charge their vehicles. As a result, the business case for private investment in DC fast charging is made more complicated than if there were only one standard. The three DC fast charging standards are:

- CHAdeMO: a standard developed by an association of Japanese companies and followed by Nissan and Mitsubishi.
- SAE J1772 Combo: a standard developed and adopted by the Society of Automotive Engineers in conjunction with the J1772 connector standard used for AC Level 2 charging and followed by most American and European automakers. There were no SAE J1772 Combo charging stations in Washington as of June 2014.
- Tesla: a proprietary standard developed by Tesla Motors that is currently only compatible with Tesla vehicles.

AC Level 1 charging can be accommodated through a standard 120 Volt power outlet using an automaker-supplied charging adapter. Power levels at AC Level 1 only go up to 1.4 kW and are out of scope for this project.

Box 5. Charging Station Utilization

One measure of the effectiveness of station siting and the need for additional stations is the utilization percent of a charging station—the share of time a station is charging a vehicle. If a station has a low utilization, it is possible that an additional station in that location will be unnecessary.

Utilization is not the only metric to evaluate effective charging siting and, depending on the stakeholder's point of view, it may not be the most important metric. For example, some stations will not be used frequently because they are intended to facilitate travel to rural parts of the state.

However, utilization can help assess the business case for charging stations when the business model's success depends on delivering energy at an expected frequency (e.g., a pay-per-use station). For those business models to be effective, the station utilization must meet the expectations the business defined to its investors before the station was installed.

For this study, the following formula was used to separately calculate Level 2 and DC fast charging station utilization using ZIP code-level data:

$$Utilization\_Percent = \frac{Time\_Charging\_Vehicle}{Days\_in\_Month \times Expected\_Hours\_in\_Operation \times Charging\_Count}$$

Where

- *Time_Charging_Vehicle* is the number of hours the charging station is delivering power to the vehicle in a month in a ZIP code.
- *Expected_Hours_in_Operation* is eight, the number of hours a charging station could be expected to be in use in a 24-hour period assuming it is sited at a typical public location.
- *Charging_Count* is the total number of charging locations (DC fast charging) or ports (AC Level 2) that provided energy in a month in a ZIP code.

For example, 5 charging stations in Longview charged vehicles for 128 hours in May and 186 hours in June. Using the formula above, Longview had a utilization rate of 10.3 percent in May and 15 percent in June.

Charging Equipment Capabilities

An assessment of EV travel along major corridors in Washington must consider charging by location and power level, charging station density, and traffic conditions. Using maps to assess EV travel is an intuitive way to assess overall travel potential for EVs throughout the state.

Box 4. BEV Charging Time for a 50-mile Trip

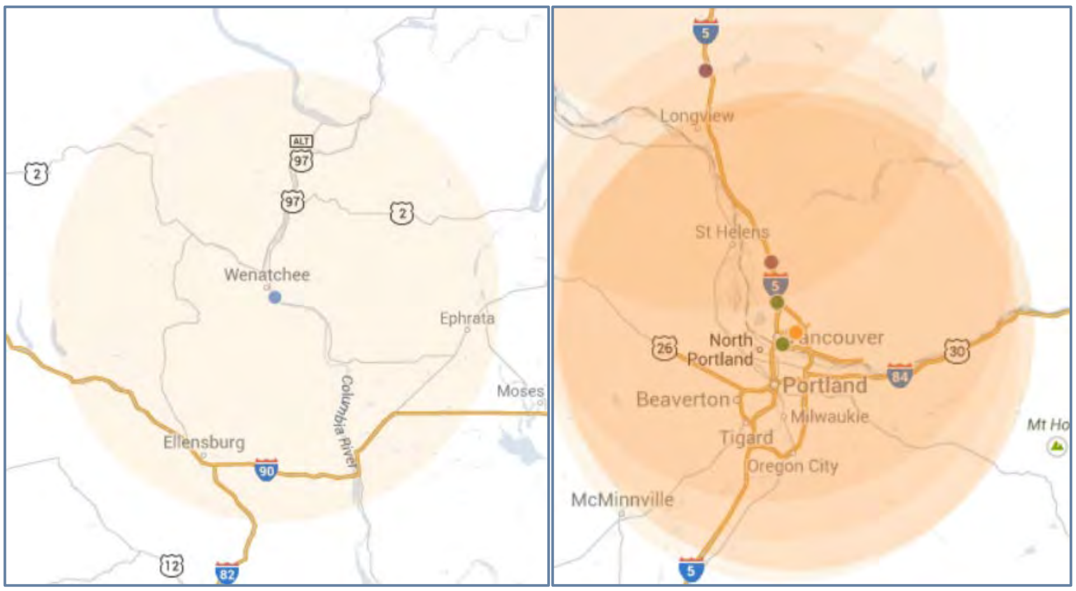
DC Fast Charging: 20 minutes at 50 kW

AC Level 2: 2.5 hours at 6.6 kW

AC Level 2: 4.5 hours at 3.3 kW

Maps can demonstrate at a glance the expected travel range of a charging location (see Figure 7). The maps created for this analysis served as a tool to assess the range of an EV that charges for a fixed period at different types of charging stations, and the risk that vehicles will not be able to access that charging location. These maps include fixed-size circles that provide an estimate of electric miles traveled following a reasonable amount of time to recharge the vehicle's battery. For DC fast charging, fixed-size circles are calculated assuming 30 minutes of charging at a conservative 30 kW. For AC Level 2 charging, fixed-size circles are calculated assuming 90 minutes of charging at 6.6 kW. Both charging levels assume 3.5 miles traveled for each kWh of battery energy stored. The resulting driving range calculations are then decreased by 20 percent to account for the lack of direct roads from an origin to a destination, yielding circles with a radius of 40 miles for DC fast charging and 28 miles for AC Level 2 charging.

FIGURE 7: Using Maps to Demonstrate Expected Travel Range of a Charging Location



These images demonstrate how fixed-size circles can convey expected travel from a charging location at a glance. The image on the left is of a single charging location (blue dot) in Wenatchee, Washington with a semi-transparent, fixed-size circle of 40 miles around the charging location. The image on the right is of five charging locations around Vancouver, Washington; each point also contains semi-transparent, fixed-sized circles of 40 miles around the charging locations. The fixed-size circles demonstrate the expected range after charging a vehicle at that location. The overlap of several locations denoted by a darker orange color indicates a greater likelihood that a charging location will be available in that area.

Source: C2ES

The circles drawn along a travel corridor provide a means of assessing charging location density and travel risk. That is, the darker the circles, the more charging locations in an area, resulting in reduced risk of individual station outages or unexpected wait times. In assessing the viability of the charging network, redundancy and reduced risk are keys to overcoming consumers' fear of exhausting the vehicle's battery energy either during the course of a trip or in additional driving required to find a station. Station outages are an important consideration in Washington, as it has experienced issues with the reliability of the Blink Network stations.[12]

As utilization of charging infrastructure increases in certain locations and charging congestion becomes an issue, drivers will face greater risk of extended trip times as they wait to charge their vehicle. Future versions of this map could account for congestion using expected utilization by altering the color or density of the circles around the charging location.

DC FAST CHARGING NETWORK ASSESSMENT

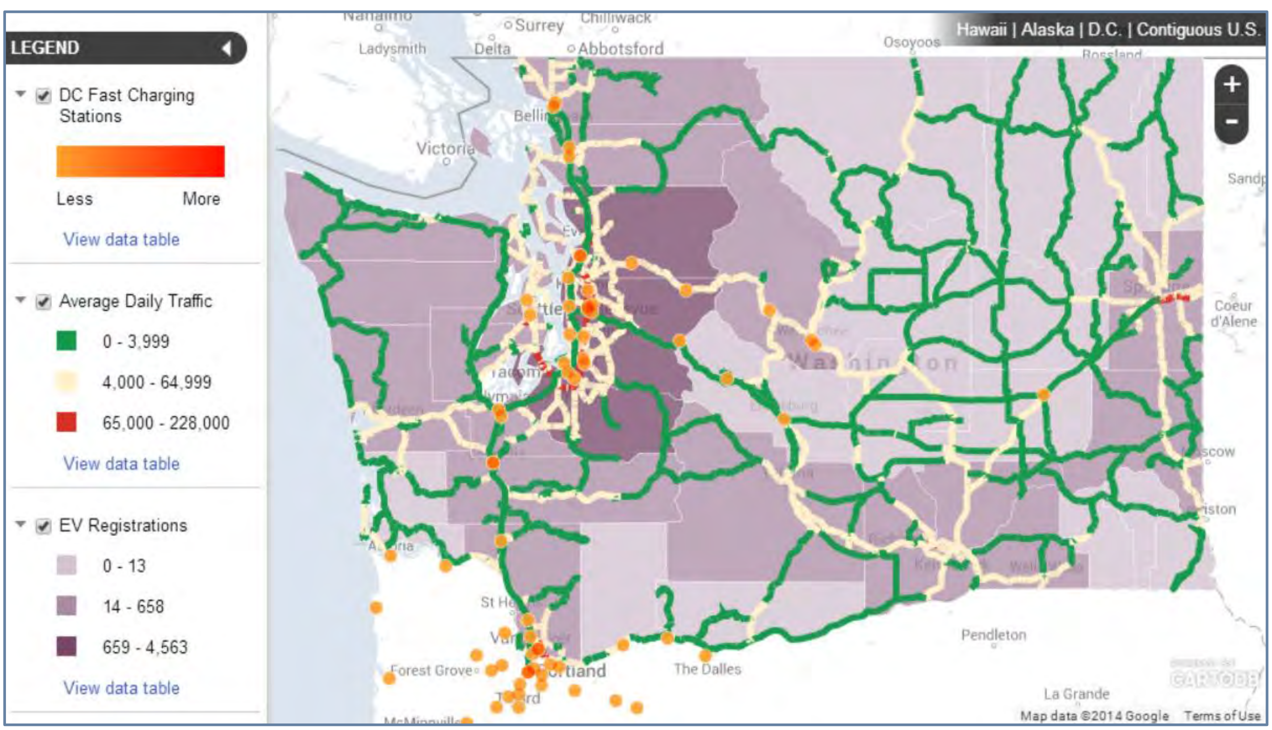
The DC fast charging network in Washington provides access to charging along much of the Interstate 5 corridor and in King County, but DC fast charging is unavailable in much of the state. Table 5 summarizes DC fast charging locations by charging network. The network consists of stations that either support the CHAdeMO standard or Tesla vehicles. As of June 2014, no DC fast charging stations existed in the state that supported the SAE Combo standard.

The Washington State Department of Transportation and Department of Commerce funded the installation of charging locations operated by the AeroVironment Network. The locations for the AeroVironment stations were picked to complement other planned DC fast charging locations around Puget Sound (operating on the Blink Network) to enable travel to more destinations in the state. Publicly available charging locations include private retail locations such as shopping malls, restaurants, and fueling stations in addition to two "gateway" safety rest areas along Interstate 5.[13]

The Blink Network was funded in part by a federal grant through the American Recovery and Reinvestment Act. As with AeroVironment charging stations, stations on the Blink Network currently support only the CHAdeMO fast charging standard. Charging locations operating on the Tesla Network can only be accessed with Tesla EVs presently.

There are currently 42 DC fast charging locations in Washington (see Figure 8).[14] Although many locations include more than one DC fast charging port, only Tesla enables more than one vehicle to charge at a time.[15] For other providers, charging is limited to the number of locations rather than the number of charging ports. This means that drivers looking to "charge and go" run the risk of having to wait for an extended period if a charging ports is occupied, since reserving access to a station can be difficult. Additionally, in cases where only one port or station is found within a county, drivers run the additional risk of the station being out of service.

Figure 8: DC Fast Charging Network Intensity Map as of June 2014



Large segments of many major roadways do not have any publicly available DC fast charging. Major roadways are denoted by green, yellow, and red colors depending on the average daily traffic in 2012.

Source: C2ES. 2014.

TABLE 5: DC Fast Charging Network Summary

COUNTY	AEROVIRONMENT NETWORK	BLINK NETWORK	CHARGEPOINT NETWORK	OTHER OR NONE	TESLA NETWORK	TOTAL LOCATIONS (PORTS)
Chelan	2 (2)					**2 (2)**
Clark	1 (1)	2 (4)	1 (1)	1 (1)		**5 (7)**
Cowlitz	1 (1)					**1 (1)**
Douglas			1 (1)			**1 (1)**
King	1 (1)	9 (18)	1 (1)	3 (3)		**14 (23)**
Kitsap		2 (4)				**2 (4)**
Kittitas	2 (2)				1 (5)	**3 (7)**
Lewis	1 (1)				1 (10)	**2 (11)**
Pierce		1 (2)	1 (1)			**2 (3)**
Skagit	1 (1)				1 (8)	**2 (9)**
Snohomish	1 (1)		1 (1)	2 (2)		**4 (4)**
Thurston	1 (1)		1 (1)			**2 (2)**
Whatcom	1 (1)			1 (1)		**2 (2)**
Total Locations (Ports)	**12 (12)**	**14 (28)**	**6 (6)**	**7 (7)**	**3 (23)**	**42 (76)**

Values in parentheses are the total number of charging ports.

Source: U.S. Department of Energy (DOE). 2014. Alternative Fuels Data Center. Accessed September 21, 2014. http://www.afdc.energy.gov.

As seen in Figure 8 and Figure 9, DC fast charging locations are concentrated in the Puget Sound region with some stations located along U.S. 2, Interstate 90, and Interstate 5. AeroVironment and Blink make up over 60 percent of the DC fast charging locations. Blink Network stations are concentrated in King County while AeroVironment Network stations are spread throughout 10 counties (see Table 5).

King County (Seattle) has the largest concentration of stations with 33 percent of total locations and 30 percent of total charging ports. The Blink Network operates nine locations, or 64 percent of the total, while three are operated by Nissan dealerships. In and around this area, the minimal distance between stations indicates that there is a high probability that an EV driver will be able to access a DC fast charging location.

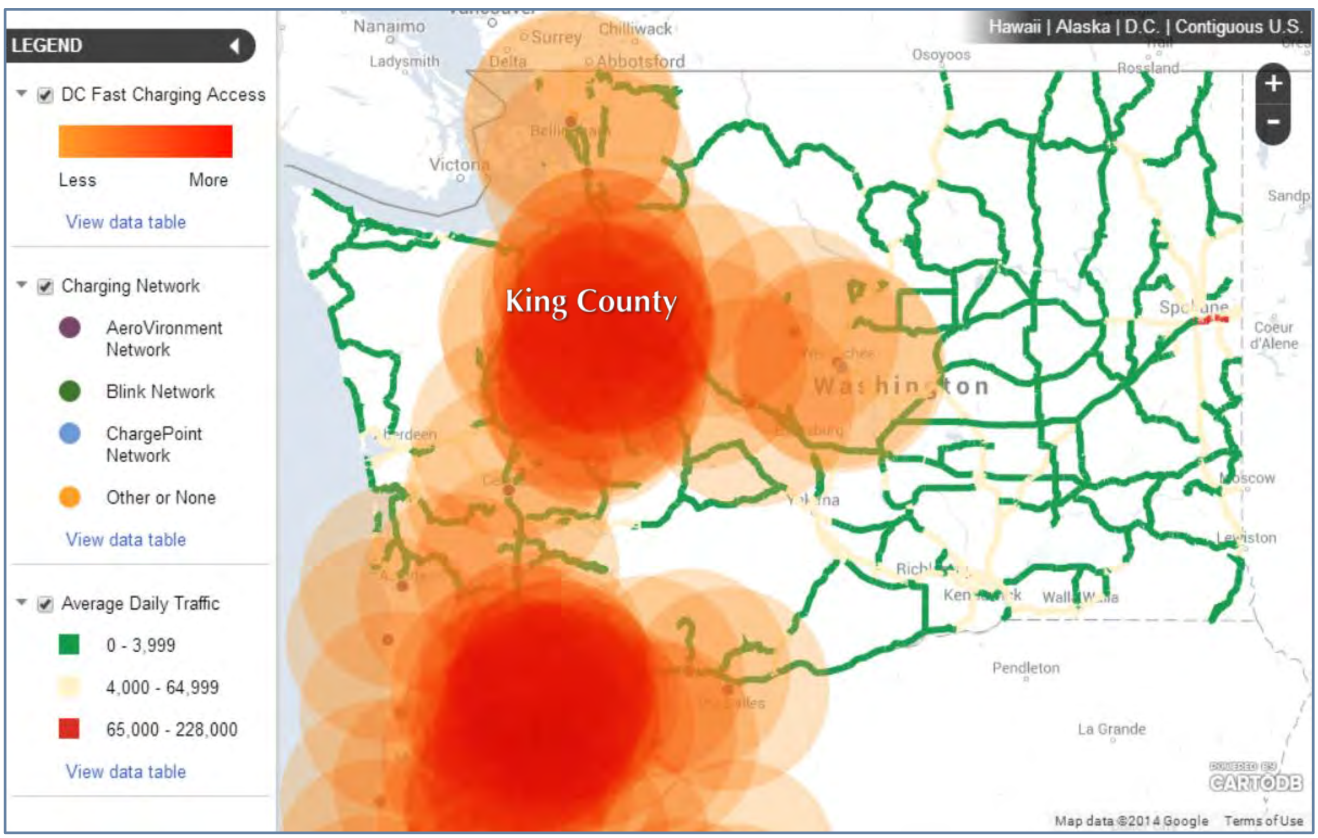
Figure 9 also shows that DC fast charging is very accessible in King County. The dark orange circles indicate significant redundancy in charging locations within the expected range of a DC fast charging station. As a result, drivers will likely have more confidence that DC fast charging station in and around King County will be available when needed, though the large number of EVs in King County could lead to wait times.

As mentioned above, the spacing of charging locations along the Interstate 5, U.S. 2, and Interstate 90 corridors was intended to enable travel from Bellingham to Vancouver (north to south along Interstate 5), Everett to

Wenatchee (west to east along U.S. 2), and Seattle to Ellensberg (west to east along Interstate 90). When traveling away from King County along Interstate 5, Interstate 90, and U.S. 2, however, the network becomes less dense, with only a single charging location connecting some portions of the roadway. The lack of redundant charging in these areas could discourage some drivers from making trips, or could prolong trips due to station outages or excessive wait times. As one travels towards the Oregon border along Interstate 5 the density of DC fast charging locations increases again, indicating DC fast charging stations are accessible in and around Vancouver.

Notably, there is very little connectivity for the DC fast charging network outside of Interstate 5 and parts of U.S. 2 and Interstate 90. Although these areas are less traveled than the roadways around Seattle on average, access to these parts of the state is an essential component to an adequate DC fast charging network. No DC fast charging exists east of Ellensberg and Wenatchee on U.S. 2 and Interstate 90, meaning east-west travel across the entire state for most BEVs is not possible. There are also no DC fast charging stations in or around Spokane. Access to the Pacific coast is also severely limited due to a lack of DC fast charging stations west of Centralia and Olympia. In addition, segments of Interstate 90, U.S. 395, Interstate 82, and Route 12 have moderate daily traffic, ranging from 6,000 to over 20,000 vehicles, but have few or no DC fast charging locations.[16]

Figure 9: DC Fast Charging Access as of June 2014



This map shows the expected electric-only range provided by DC fast charging locations. Each semi-transparent circle is 40 miles wide, the expected range provided after 30 minutes of charging. The circles' transparency provides a way to view the density of DC fast charging stations in an area.

Source: C2ES. 2014.

Box 6. DC Fast Charging Usage

Utilization helps explain how frequently a station is used and the possible need for additional stations at a location. The table below shows the top 10 locations by ZIP code in 2013, as measured in energy provided to EVs. In 4 ZIP codes, only one DC fast charging station was measured.

Further examination of frequently used stations might reveal station congestion, indicating additional charging stations may be needed at or near that location.

TABLE 6: Top 10 ZIP Codes for DC Fast Charging (January-December 2013)

ZIP CODE	COUNTY	TOTAL ENERGY DELIVERED (KWH)	AVERAGE UTILIZATION (%)	CHARGING LOCATIONS
98424	Pierce	22,622	30.6%	1
98122	King	21,087	32.2%	1
98007	King	17,297	23.9%	1
98233	Skagit	15,811	27.4%	1
98109	King	15,701	24.1%	1
98034	King	14,566	20.3%	1
98225	Whatcom	13,880	25.9%	1
98294	Snohomish	13,729	21.4%	1
98125	King	11,234	16.6%	1
98531	Lewis	8,404	18.3%	1

This table shows the most popular locations for DC fast charging for the AeroVironment and Blink Networks.

Source: Idaho National Laboratory, Washington State Department of Transportation

AC LEVEL 2 CHARGING NETWORK ASSESSMENT

The AC Level 2 charging network in Washington provides EV charging access in King County, but does not provide access in much of the rest of the state outside of Vancouver. Seventy-four percent of populated ZIP codes in the state, covering 44 percent of the population, have no Level 2 charging stations. As a result, many possible destinations for drivers may be inaccessible to BEVs.

Although Level 2 and DC fast charging complement each other, the assessment here assumes that Level 2 charging stations power all miles traveled by both BEVs and PHEVs.

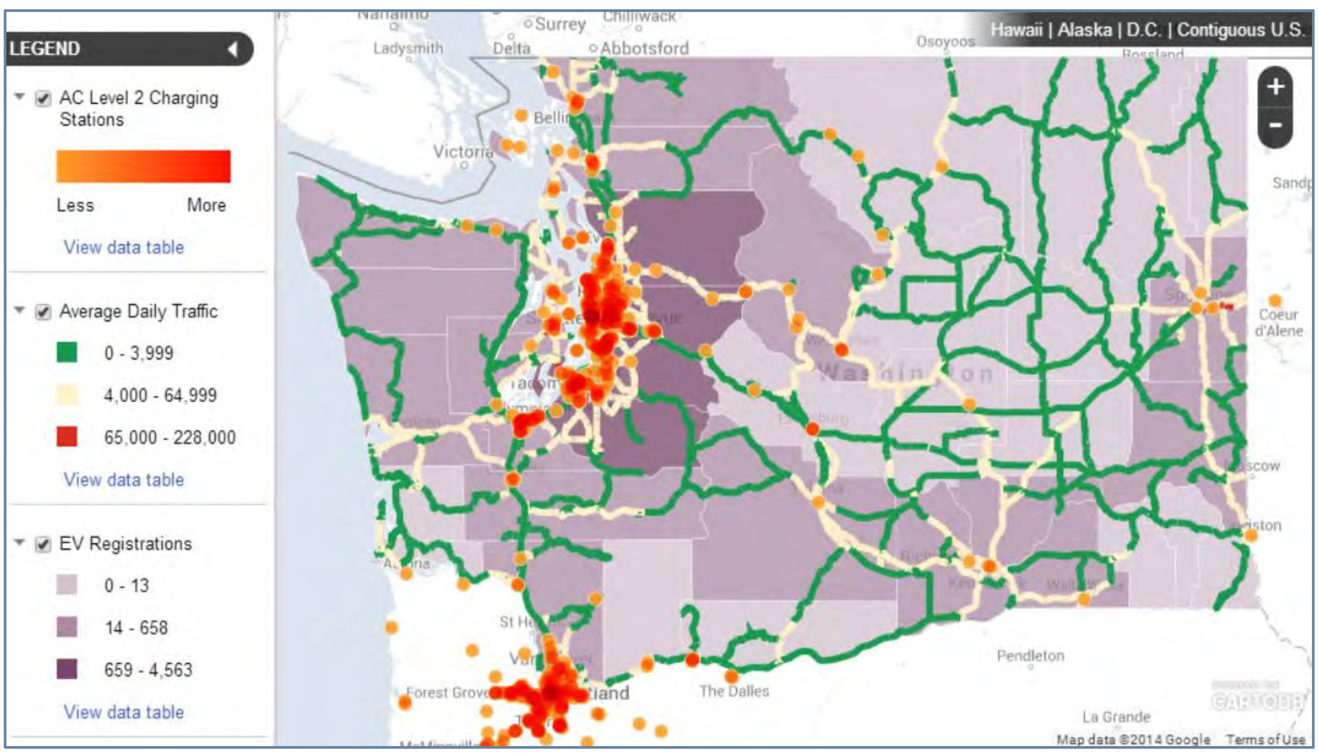
Even though Washington has one of the most extensive Level 2 charging networks in the United States, it may not be enough to accommodate the current EV fleet in the state. Studies have suggested that a Level 2 charging port can accommodate less than 3 EVs. There are 19 EVs for every Level 2 publicly available charging location or 9 EVs for every Level 2 charging ports.

Level 2 charging can play an integral role at trip destinations because Level 2 charging provides energy to an EV at a rate that requires several hours to fully recharge. Drivers are unlikely to use AC Level 2 charging stations to travel along highway corridors because of these long charging times. Instead, these charging stations are typically located in places where drivers are expected to charge for longer than an hour (e.g., shopping malls and other retail outlets, workplaces, and public parking garages). For example, Plug-in North Central Washington has a program to promote EV tourism by facilitating the installation of Level 2 charging stations at businesses throughout the region.[17]

Even though Washington has one of the most extensive Level 2 charging networks in the United States, it may not be enough to accommodate the current EV fleet in the state. There are 418 Level 2 charging locations with 893 charging ports. Unlike DC fast charging stations, most locations can charge more than one vehicle at a time. There are 19 EVs for every Level 2 publicly available charging location or 9 EVs for every Level 2 charging ports. These ratios indicate far less publicly available charging is available than studies have assumed would be necessary to provide adequate publicly available charging. For example, the National Research Council's 2013 report Transitions to Alternative Vehicles and Fuels assumed one Level 2 charging port would be needed for 2.5 EVs.[18]

The Blink and ChargePoint networks have nearly the same number of charging locations and ports, making up 36 and 35 percent of the network, respectively. AeroVironment only has 15 charging locations, which complement the DC fast charging stations installed in partnership with the Washington State Department of Transportation.

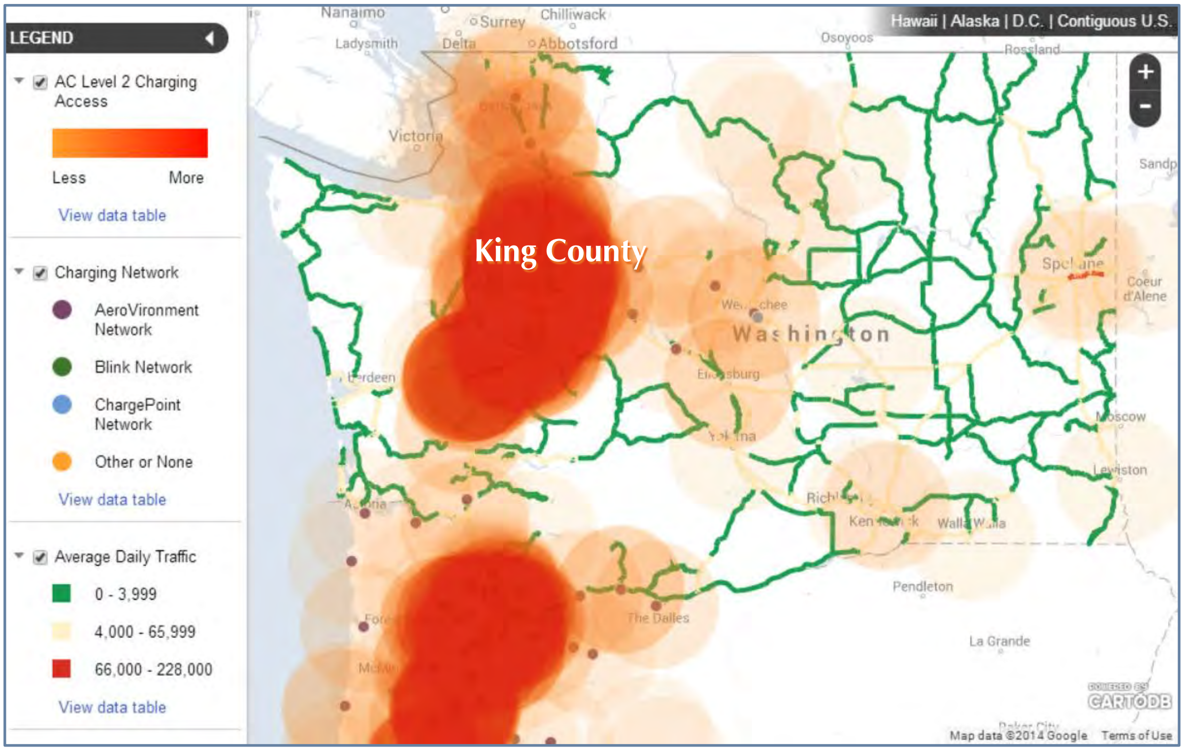
FIGURE 10: AC Level 2 Charging Network Intensity Map as of June 2014



There is a heavy concentration of charging stations in Puget Sound region with very little charging outside that area except for Vancouver, Washington. Large segments of many major roadways do not have any publicly available AC Level 2 charging. Major roadways are denoted by green, yellow, and red colors depending on the average daily traffic.

Source: C2ES. 2014.

FIGURE 11: AC Level 2 Charging Access as of June 2014



This map shows the expected electric-only range provided by AC Level 2 charging locations. Each semi-transparent circle is 28 miles wide, the expected range provided after 90 minutes of charging. The circles' transparency provides a way to view the density of AC Level 2 charging stations in an area.

Source: C2ES. 2014.

King County contains 57 percent of the Level 2 locations, but only 29 percent of total population in the state. Part of this additional charging may be explained by a 9 percent jump in population during the workday from commuters.[19] More likely, however, is the fact that 55 percent of registered EVs reside in the county. Similar to the DC fast charging network, Figure 11 shows drivers in King County have numerous access points to Level 2 charging stations. The deep orange color indicates there are redundant charging locations in the same area, improving the likelihood a driver can access a publicly available charging station. The map only conveys access, however, meaning drivers may be required to wait to charge if utilization at these stations is high.

As mentioned previously, Level 2 charging stations are typically located in places where drivers are expected to spend longer than an hour. On a daily basis, drivers typically stay close to where they live, so locating publicly available charging near where EVs are registered is sensible to extend daily travel beyond what home charging can provide. Of the populated ZIP codes in Washington with an EV registered, 59 percent do not have a Level 2 charging station. In fact, there are nine ZIP codes with more than 50 EVs registered and no Level 2 charging stations (see Table 7). All but one of those ZIP codes are in the Seattle area (see Figure 12). The ZIP code with the highest ratio of EVs to publicly available charging stations is 98053 in Redmond, with 132 EVs and only one publicly available charging station.

On occasion, EV drivers can be expected to take trips beyond the electric range near their home and charging at their destination may be required. Many locations throughout the state have no Level 2 charging stations. In counties constituting 25 percent of Washington's population, there are less than five Level 2 charging ports. EV drivers may be unable to travel to these locations.

TABLE 7: ZIP Codes with More than 50 EVs and No Public AC Level 2 Charging Stations

ZIP CODE	PRIMARY CITY	COUNTY	BEVS REGISTERED	PHEVS REGISTERED	EVS REGISTERED
98012	Bothell	Snohomish	63	36	99
98074	Sammamish	King	120	17	137
98115	Seattle	King	121	34	155
98116	Seattle	King	42	20	62
98118	Seattle	King	38	13	51
98144	Seattle	King	44	18	62
98177	Seattle	King	50	16	66
98199	Seattle	King	44	14	58
98607	Camas	Clark	39	13	52

All ZIP codes with 50 or more EVs as of December 2013 and no Level 2 charging stations.

Source: Washington State Department of Licensing, U.S. DOE. 2014.

FIGURE 12: ZIP Codes with More than 50 EVs and No Public AC Level 2 Charging Stations

All ZIP codes with 50 a more EVs as of December 2013 and no Level 2 charging stations. 98607 in Clark County is not shown.

Source: Washington State Department of Licensing, U.S. DOE. 2014.

Box 7. AC Level 2 Charging Usage

For Level 2 charging stations, utilization can be an important metric depending on the purpose of the station. For example, if the station is intended to increase retail sales by providing EV drivers a place to charge while they shop, utilization provides evidence of whether or not that goal is being met. On the other hand, charging intended to provide access to popular public attractions, such as a public park, might require less use to validate the station's installation.

Table 8 shows charging use on the ChargePoint network in 2013 for the 5 ZIP codes that provided the most energy to EVs. The utilization in all but one ZIP code was greater than 25 percent with a relatively large sample of 50 or more ports per ZIP code. Utilization rates higher than 25 percent indicate that a driver may have to wait to use a charging station.

TABLE 8: AC Level 2 Charging Use in 2013

ZIP CODE	TOTAL ENERGY DELIVERED (KWH)	AVERAGE UTILIZATION (%)	CHARGING PORTS
98075	17,223	43.7%	48
98055	19,457	28.8%	72
98033	22,207	27.8%	81
98004	51,778	22.6%	241
98101	13,329	11.5%	130

This table shows 5 ZIP codes with that have delivered the most energy from January to December 2013 in the ChargePoint network. All ZIP codes are in King County.

Source: ChargePoint

BEV TRAVEL ALONG KEY WASHINGTON STATE CORRIDORS

This section simulates travel for BEVs in four key traffic corridors in Washington, including three simulations along the heavily-traveled Interstates 5 and 90, and one simulation from the state's capital, Olympia, to the Pacific Coast. The purpose of these simulations is to evaluate an EV driver's ability to travel using the existing publicly available charging network based on practical assumptions.

Drivers in the United States generally drive less than 30 miles per day.[20] As such, daily driving needs for EV drivers can often be met with a single charge while at home or at work. However, longer trips from home requires publicly available charging infrastructure to extend the potential travel range of EVs and to reduce EV drivers' "range anxiety," which is the fear of running out of power along the road and being stranded. Adequate charging infrastructure serves to mitigate range anxiety concerns.

EV travel throughout Washington is contingent on EV battery capacity and the availability of publicly available charging stations along key travel corridors. Based on travel simulations completed, EVs with longer electric-only ranges are more likely to complete trips with the current charging infrastructure. Any BEV on the market today can make the trip along Interstate 5 from Seattle to Portland, Oregon because of the relatively high density of publicly available charging stations. However, additional charging infrastructure is needed to facilitate travel to the Pacific Coast and between the eastern and western part of the state along Interstate 90.

OVERVIEW OF TRAVEL SIMULATION

Evaluations on EV travel were completed using a combination of traffic data from the 2013 Washington Department of Transportation Annual Traffic Report and the U.S. Department of Energy's Alternative Fuel Data Center listing of publicly available charging stations as of June 2014. Travel was simulated along four routes in Washington to gauge coverage of existing publicly available charging stations for BEVs. The simulations identified:

- Whether travel was possible along these routes, using the AC Level 2 charging network or the DC fast charging network;
- Areas with high charging station density and areas with low charging station density; and
- Noticeable coverage gaps that would be critical to completing travel along the preferred routes.

The simulations examined travel along preferred routes: using I-5 to travel between Seattle and Portland, using I-5 to travel between Seattle and Bellingham, using I-90 to travel between Seattle and Spokane, and using US-101 North and South to travel between Olympia and Port Angeles.

Travel analysis of these routes are divided into thirds to better assess publicly available charging station density along portions of the route, and to identify noticeable coverage gaps along the route.

TRAVEL SIMULATION ASSUMPTIONS

The simulations used three illustrative examples of battery electric vehicles: a BEV-40 with a range up to 40 miles, a BEV-80 with a range up to 80 miles, and a BEV-200 with a range up to 200 miles. These BEVs are meant to be illustrative and are not intended to reflect current options in the marketplace. Importantly, only Tesla Motors offers a BEV with a range of 200 miles or more, so conclusions drawn in the simulations do not reflect experiences of most BEV drivers in Washington.

PHEV are not included in these simulations because they do not have the same range issues as a BEV. PHEVs have both a battery and a gasoline-powered internal combustion engine, so they do not have the same degree of dependency as BEVs on publicly available charging infrastructure. In addition, BEV adoption in Washington has outpaced PHEV adoption. There are nearly two BEVs for every one PHEV in Washington.

For travel along these routes, the BEVs followed the speed limit and started the trip with a full charge. In most instances, the BEVs charged once the battery reached about a 20 percent state of charge to account for range anxiety, and BEVs would reach the final destination with a 20 percent state of charge.[21] At each charging station, the BEVs charged only enough to make it to the next charging stop or final destination to minimize charge time.

Under these simulations, BEVs made exclusive use of either the DC fast charging network or the AC Level 2 network to recharge. In some instances, the BEV charged above 80 percent battery capacity or the BEV battery dropped below a 20 percent state of charge to travel to the next charging station. The simulations assumed DC fast charging stations had a power output of 30 kW and AC Level 2 charging stations had a power output of 6.6 kW.

For each route and vehicle type, the simulations determined the actual distance of the trip, the number of charging station stops, the minimum charge time based on the number of charging stops, and total drive time under normal traffic conditions. The total trip time was calculated as the sum of driving time and charge time.

The publicly available charging infrastructure along any route was considered adequate as long as a BEV driver could complete travel along the route relying only on the publicly available charging network.

SIMULATION 1: TRAVEL BETWEEN SEATTLE AND PORTLAND ALONG INTERSTATE 5

The route along I-5 between Seattle, Washington and Portland, Oregon was divided into three parts. The northern portion connected Seattle and Olympia, the middle portion connected Olympia and Ridgefield, and the southern portion connected Ridgefield and Portland.

Publicly available charging infrastructure is in place to complete travel between Seattle, Washington and Portland, Oregon in all simulations. The total trip time along the preferred route was longer for BEVs than a gasoline-powered vehicle because of the time required to charge the vehicle (see Table 9). A fully fueled gasoline-powered vehicle would take 3 hours to travel 175 miles on I-5 between Seattle and Portland. The total trip time for BEVs using the DC fast charging network ranged from 3 to 4.5 hours, and the charge time ranges from 4 to 33 percent of total time. This trip was 20 minutes to 1.5 hours longer than a trip made with a gasoline-powered vehicle. The total trip time for EVs using the Level 2 network ranged from 8 to 9.5 hours, and the charge time ranged from 4 percent to two-thirds of total drive time. The total trip was 50 minutes to 6.5 hours longer than a trip made with a gasoline-powered vehicle.

The high concentration of publicly available charging locations along the upper and lower portion of the route enable BEVs to easily travel along these portions of the route. There are 12 DC fast charging locations and 207 Level 2 charging locations in and around Seattle, and there are 5 DC fast charging locations and 20 Level 2 charging locations in and around Vancouver. All BEVs in the simulations were able to travel the upper and lower portions of the route without the vehicles' battery dropping below a 20 percent state of charge.

The low number of publicly available charging locations in the middle portion of the route makes existing charging locations critical to completing the trip. There are 2 DC fast charging locations and 6 Level 2 charging locations along the middle portion of the route. As such, travel along this route for the BEV-40 and the BEV-80 was dependent on charging locations located in Castle Rock and Ridgefield, see Figure 13.

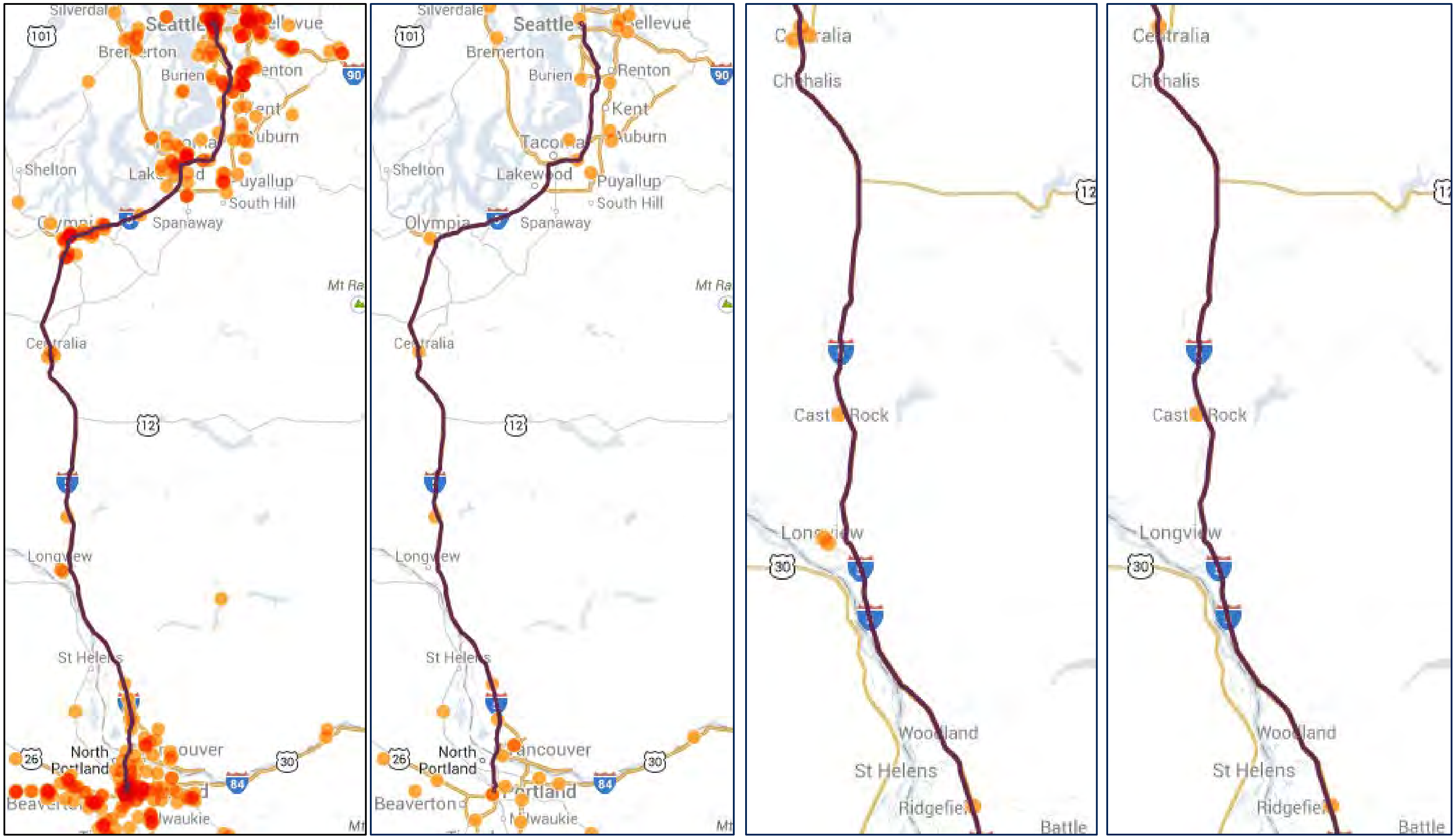
Travel between these two cities resulted in the BEV-40 dropping to a 10 percent state of charge. Installing additional Level 2 charging locations between these two cities would allow the BEV-40 to travel this portion of the route and not drop below a 20 percent charge level. There is one DC fast charging station between Centralia and Ridgefield—located in Castle Rock—which was a critical stop for the BEV-80 to complete the trip. Installing additional DC fast charging locations between Centralia and Ridgefield would alleviate dependency on the one Castle Rock publicly available charging station for BEV-80 travel. The BEV-200 only needed to make one charging stop and is not reliant on publicly available charging locations in the southern portion of the route.

TABLE 9: Travel between Seattle, Washington and Portland, Oregon

CHARGING TYPE	VEHICLE	MILES TRAVELED	CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	173	N/A	170	N/A	170
DC Fast Charging	BEV-40	178	5	184	83	267
DC Fast Charging	BEV-80	175	2	184	64	248
DC Fast Charging	BEV-200	174	1	184	8	192
AC Level 2	BEV-40	179	4	188	381	569
AC Level 2	BEV-80	178	2	178	288	466
AC Level 2	BEV-200	174	1	184	37	221

Total trip time was longer for BEVs versus a gasoline-powered vehicle because of charging time. BEVs with a larger battery capacity had to make fewer charging stops and generally spent less time charging. All BEVs simulated were able to complete travel between Seattle, Washington and Portland, Oregon.

FIGURE 13: Publicly Available Charging Locations between Seattle and Portland and between Centralia and Ridgefield



The figures on the left show existing AC Level 2 and DC fast charging locations, respectively, between Seattle and Portland. The figures on the right shows existing AC Level 2 and DC fast charging locations, respectively, between Centralia and Ridgefield.

SIMULATION 2: TRAVEL BETWEEN SEATTLE AND BELLINGHAM ALONG INTERSTATE 5

The route along I-5 between Seattle and Bellingham was divided into three parts. The northern portion connected Bellingham and Burlington, the middle portion connected Burlington and Everett, and the southern portion connected Seattle and Everett.

Publicly available charging infrastructure is in place to complete travel between Seattle and Bellingham in all but one simulation. The total trip time along the preferred route was longer for BEVs than a gasoline-powered vehicle because of the time required to charge the vehicle (see Table 10). A fully fueled gasoline-powered vehicle would take 1.5 hours to travel 90 miles on I-5 between Seattle and Bellingham. The BEV-40 would not be able to complete travel along the preferred route using the existing DC fast charging network. The total trip time for the BEV-80 and BEV-200 using the DC fast charging network ranged from 1.5 to 2.8 hours, and the charge time was up to 15 percent of the total drive time. For a BEV, this trip could be up to 15 minutes longer than a trip made with a gasoline-powered vehicle. The total trip time for BEVs using the Level 2 network ranged from 1.5 to 4 hours, and the charge time ranged from 40 to 60 percent of total drive time. The trip was 2.3 to 2.5 hours longer than a trip made with a gasoline-powered vehicle.

The high concentration of publicly available charging locations in the southern portion of the route enables BEVs to easily travel along this portion of the route. There are 12 DC fast charging locations and 210 Level 2 charging locations in and around Seattle, and there are 2 DC fast charging locations and 2 Level 2 charging locations in and around Burlington. All BEVs in the simulations were able to travel the lower portion of the route without the vehicles' battery dropping below a 20 percent state of charge.

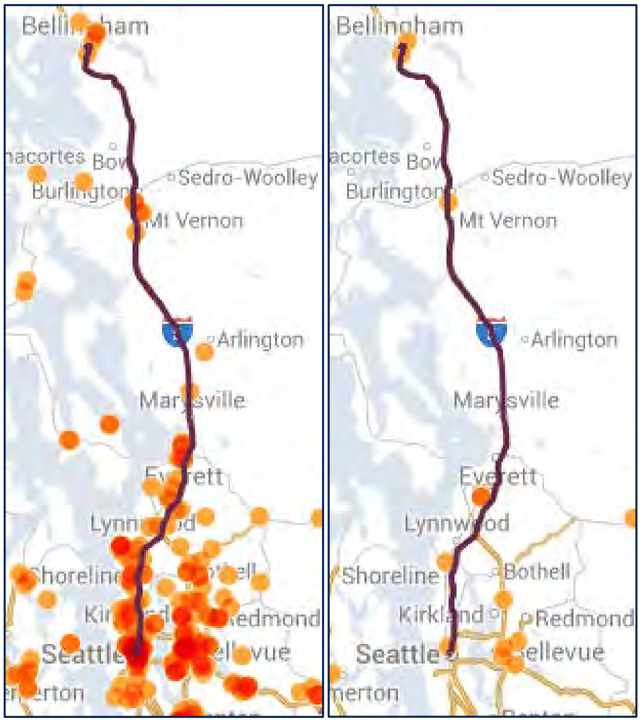
The low number of publicly available charging locations located in the middle and northern portion of the route makes the charging stations located in the southern portion of the route critical to completing the trip. There are 2 DC fast charging stations and 5 Level 2 charging stations along the middle and northern portion of the route. The BEV-80 was able to complete this trip using the DC fast charging network as long as it charges between Burlington and Seattle. Conversely, the BEV-40 was unable to complete the trip because the distance between the Burlington and Everett DC fast charging station was greater than the vehicle's range. Installing additional DC fast charging locations between these two cities would allow the BEV-40 to complete travel along this route. There are an adequate number of Level 2 charging locations for the BEV-40 and BEV-80 to complete travel. However, installing additional Level 2 charging locations between Burlington and Everett would allow the BEV-40 to make one less charging stop along this route. The BEV-200 would not need to make a charging stop when traveling the preferred route.

TABLE 10: Travel between Seattle and Bellingham

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	89	N/A	90	N/A	90
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	89	1	89	14	103
DC Fast Charging	BEV-200	89	0	90	0	90
AC Level 2	BEV-40	90	3	94	152	246
AC Level 2	BEV-80	90	1	93	68	161
AC Level 2	BEV-200	89	0	90	0	90

Total trip time was longer for BEVs versus a gasoline-powered vehicle because of charging time. BEVs with a larger battery capacity had to make fewer charging stops and spent less time charging. Most of the BEVs were able to complete travel between Seattle and Portland. The BEV-40 was unable to complete the trip due to a lack of publicly available charging locations, and is denoted with an "X."

FIGURE 14: Publicly Available Charging Locations between Seattle and Bellingham



The figure on the left shows existing AC Level 2 charging locations while the figure on the right shows existing DC fast charging locations.

SIMULATION 3: TRAVEL BETWEEN SEATTLE AND SPOKANE ALONG INTERSTATE 90

The route along I-90 between Seattle and Spokane was divided into three parts. The eastern portion connected Spokane and Moses Lake, the middle portion connected Moses Lake and Cle Elum, and the western portion connected Cle Elum and Seattle.

Existing publicly available charging infrastructure only allows a BEV-200 to complete travel between Seattle and Spokane. The BEV-40 and the BEV-80 were unable to complete travel between these two cities using the Level 2 network or DC fast charge network. The BEV-200 was able to complete travel between Seattle and Spokane. The total trip time along the preferred route is longer for the BEV-200 than a gasoline-powered vehicle because of the time required to charge the vehicle (see Table 11). A fully fueled gasoline-powered vehicle would take 4.3 hours to travel 280 miles on I-90 between Seattle and Spokane. The total trip time for the BEV-200 using the DC fast charging network was 5.5 hours, and the charge time was 20 percent of the total drive time. The trip time was 1.3 hours longer than a trip made with a gasoline powered vehicle. The total trip time for the BEV-200 using the Level 2 network was 9.5 hours, and the charge time was 55 percent of the total drive time. The trip time was 5.3 hours longer than a trip made with a gasoline-powered vehicle.

The high concentration of publicly available charging locations along the western portion of the route enables BEVs to easily travel along this portion of the route. There are 12 DC fast charging locations and 210 Level 2 charging locations in and around Seattle. All BEVs in the simulations were able to travel the western portion of the route without the vehicles' battery reaching a 20 percent state of charge.

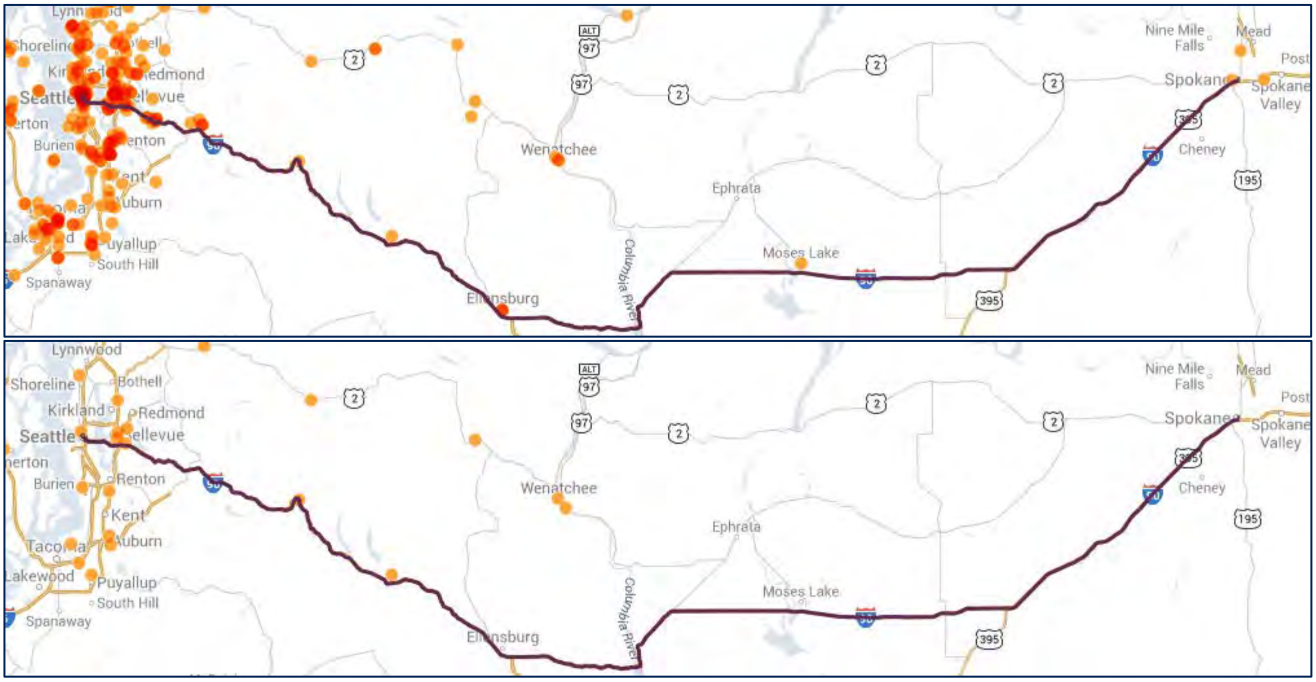
The low number of publicly available charging locations in the middle and eastern portion of the route prevents the BEV-40 and BEV-80 from completing the trip. There are 2 DC fast charging locations and 6 Level 2 charging locations along the middle and eastern portion of the route. There are no DC fast charging locations between Ellensburg and Spokane, and there are no Level 2 charging locations between Moses Lake and Spokane. Installing at least 6 DC fast charging locations and 6 Level 2 charging locations between Ellensburg and Spokane would allow the BEV-40 and BEV-80 to travel between Seattle and Spokane and not drop below a 20 percent charge level. The BEV-200 needed to make one charging stop and was only reliant on publicly available charging locations in Ellensburg to travel between Seattle and Spokane.

TABLE 11: Travel between Seattle and Spokane

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	279	N/A	254	N/A	254
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	X	X	X	X	X
DC Fast Charging	BEV-200	282	2	254	68	322
AC Level 2	BEV-40	X	X	X	X	X
AC Level 2	BEV-80	X	X	X	X	X
AC Level 2	BEV-200	282	2	254	318	572

The BEV-200 was able to complete travel along this route. Total trip time was longer for the BEV-200 versus a gasoline-powered vehicle because of charging time. The BEV-40 and BEV-80 were unable to complete travel between Seattle and Spokane due to a lack of publicly available charging locations, and is denoted with an "X."

FIGURE 15: Publicly Available Charging Locations between Seattle and Spokane



The figure on the top shows existing AC Level 2 charging locations while the figure on the bottom shows existing DC fast charging locations.

SIMULATION 4: TRAVEL BETWEEN OLYMPIA AND PORT ANGELES ALONG U.S. 101 NORTH

The route along US-101 North and South between Olympia and Port Angeles was divided into three parts. The northern portion connected Port Angeles and Sequim, the middle portion connected Sequim and Shelton, and the southern portion connected Shelton and Olympia.

Existing publicly available charging infrastructure only allows a BEV-200 to complete travel between Olympia and Port Angeles. The BEV-40 and the BEV-80 were unable to complete travel between these two cities using the Level 2 network or DC fast charge network (see Table 12). The BEV-200 was able to complete travel between Olympia and Port Angeles. The total trip time along the preferred route was equivalent for the BEV-200 and a gasoline-powered vehicle because the BEV-200 did not have to charge along the preferred route. Both the BEV-200 and a fully fueled gasoline-powered vehicle would take 2.3 hours to travel 140 miles along US-101 North between Olympia and Port Angeles.

There is a higher concentration of publicly available charging locations in the southern portion of the route versus the middle and northern portions of the route, though additional charging locations are needed for a BEV-40 and BEV-80 to complete the trip. There are 2 DC fast charging locations and 30 Level 2 charging locations in and around Olympia, and there are no DC fast charging locations and 2 Level 2 charging locations in and around Port Angeles.

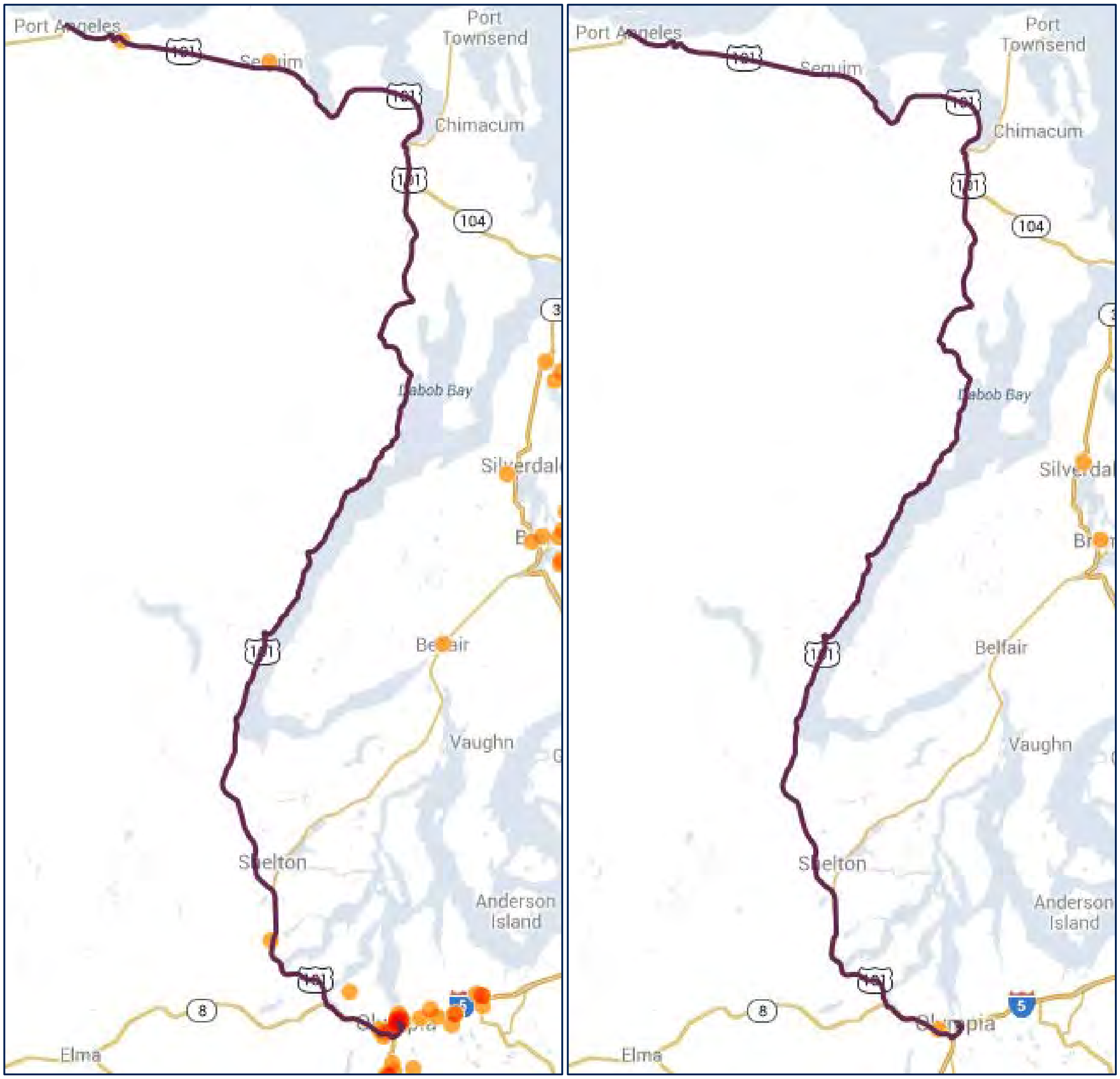
Additional publicly available charging locations in the upper and middle portion of the route are needed to facilitate travel for the BEV-40 and the BEV-80 using US-101 North and South. The BEV-200 did not need to make a charging stop along the preferred route.

TABLE 12: Travel between Olympia and Port Angeles

CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	120	N/A	137	N/A	137
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	X	X	X	X	X
DC Fast Charging	BEV-200	120	0	137	0	137
AC Level 2	BEV-40	X	X	X	X	X
AC Level 2	BEV-80	X	X	X	X	X
AC Level 2	BEV-200	120	0	137	0	137

The BEV-200 was able to complete travel along this route. Total trip time was the same for the BEV-200 versus a gasoline-powered vehicle because it did not have to charge. The BEV-40 and BEV-80 were unable to complete travel between Seattle and Spokane due to lack of publicly available charging locations, and is denoted with an “X.”

FIGURE 16: Publicly Available Charging Locations between Olympia and Port Angeles



The figure on the top shows existing AC Level 2 charging locations while the figure on the bottom shows existing DC fast charging locations.

CONCLUSIONS AND NEXT STEPS

Although Washington's EV network is ahead of most other states in the United States, many parts of the state remain inaccessible to EV drivers who rely on publicly available charging locations. As shown in the third travel simulation, for example, a lack of publicly available charging makes it impossible for most BEVs to travel between Seattle and Spokane. Widespread adoption of EVs depends in part on a robust publicly available charging network. Access to charging that enables EV drivers to travel desired destinations in a reasonable amount of time is essential for EVs to compete with gasoline-powered vehicles on a mass scale.

Washington has a disproportionate number of BEVs compared to PHEVs relative to the rest of the United States, indicating the state's charging network may be more dependent on high-powered charging to meet drivers' travel needs. The largest concentration of EVs is in King County, which corresponds well with the density of charging locations.

This assessment of the charging network's ability to facilitate EV travel in Washington is a first step in identifying business models that will foster private sector commercialization of EV charging services. Washington's network of EV charging consists of DC fast charging and AC Level 2 charging locations. These charging technologies can complement each other to enable EV drivers to complete daily travel needs along with occasional trips that require charging while in route.

DC fast charging is concentrated along the Interstate 5 corridor with little connectivity to other major roadways. AC Level 2 charging is mostly located in King County and near Vancouver, Washington. More publicly available charging is needed outside these regions to enable access to popular destinations, like the Pacific Coast, and to link major traffic corridors of the state, like Interstate 90.

Quantifying the success of charging station siting can be difficult because the motivation for a charging station may be to enable access to distant locations rather than delivering a significant amount of energy to EVs. At the same time, some business models for publicly available charging rely on frequent use in order to be profitable. Whether revenue comes directly from station use or indirectly from increased retail sales or other sources, more capital investment from the private sector is needed to provide adequate access to publicly available charging stations and continue to advance EV adoption.

The next step in this project is to identify and assess potential business models that could be deployed to provide access to publicly available charging in regions around Washington that currently have insufficient access to charging. A final report will then be delivered to the Washington State Legislature identifying recommendations on the role of the public sector in supporting those business models in order to maximize private sector investment in EV charging.

APPENDIX A: DATA SOURCES

The following summarizes the data sources used throughout this document. Publicly available data are noted.

Publicly Available Charging Station Network Locations: The U.S. Department of Energy's Alternative Fuel Data Center provided a database of all charging locations throughout the United States. The dataset is updated monthly. Source: http://www.afdc.energy.gov.

Washington State Average Daily Traffic: Washington State Department of Transportation provided detailed data on the average daily traffic for all major roads in the state. Source: http://www.wsdot.wa.gov/mapsdata/tools/traffictrends.

ChargePoint Network: ChargePoint provided monthly usage data for all its publicly available charging locations in Washington from January 2011 to June 2014.

AeroVironment Network: Washington State Department of Transportation provided monthly usage data for DC fast charging stations operated on the AeroVironment Network from January 2011 to December 2013.

Vehicle Registrations: Washington State Department of Licensing provided monthly data for vehicle registrations, including battery electric and plug-in hybrid electric vehicles from January 2011 to December 2013.

EV Project and ChargePoint America: The U.S. Department of Energy Clean Cities Program and Idaho National Laboratory provided ZIP code level data for AC Level 2 and DC fast charging stations for the federally funded initiative called the EV Project operated on the Blink Network. The period covered by these data is January 2011 through December 2013.

ENDNOTES

[1] Only Vermont, Hawaii, and Oregon have a higher ratio of charging locations to people. U.S. DOE, AFDC website. U.S. Census Bureau.

[2] Sarah Dougherty and Nick Nigro. 2014. *Alternative Fuel Vehicle and Fueling Infrastructure Deployment Barriers and The Potential Role of Private Sector Financial Solutions,* Center for Climate and Energy Solutions, Arlington, VA (April), available at http://www.c2es.org/docUploads/barriers-to-private-finance-in-afvs-final-12-20-13.pdf.

[3] In June 2014, Connecticut regulators approved a pilot project for Connecticut Light and Power to address electricity demand charges for DC fast charging stations. See http://www.transmissionhub.com/articles/2014/06/connecticut-regulators-approve-electric-vehicle-rate-rider-pilot-for-cl-p.html.

[4] U.S. EIA. 2014. Washington Electricity Profile. Accessed September 22, 2014. http://www.eia.gov/state/rankings/?sid=WA#series/31. Chelan County Public Utility District. 2012. Rates and Policies. Accessed September 21, 2014. http://www.chelanpud.org/rates.html.

[5] C2ES. 2014. "Electric Vehicle (EV) and Market Technology Overview." EV Study Advisory Panel Meeting #1. Olympia, Washington: Center for Climate and Energy Solutions.

[6] C2ES. 2012. "An Action Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid." Center for Climate and Energy Solutions. March. Accessed December 4, 2013. http://www.c2es.org/initiatives/pev/action-plan-report.

[7] Williams, Juliana, and Ann Rendahl, interview by Nick Nigro. 2014. Conversation about Washington Electric Utility Regulation (July 15).

[8] National Research Council. 2013. Transitions to Alternative Vehicles and Fuels. Washington, DC: National Academies

Press. http://www.nap.edu/catalog.php?record_id=18264.

[9] General Motors Alex Keros, EV Roadmap 7, July 24, 2014. https://www.evroadmapconference.com/program/

[10] Wall Street Journal. 2014. Atlanta's Incentives Lift Electric Car Sales. June 4. Accessed September 21, 2014. http://online.wsj.com/articles/why-electric-cars-click-for-atlanta-1401922534.

[11] Only Vermont, Hawaii, and Oregon have a higher ratio of charging locations to people. U.S. DOE, AFDC website. U.S. Census Bureau.

[12] InsideEVs. 2014. Blinkless in Seattle. July 31. Accessed September 21, 2014. http://insideevs.com/blinkless-seattle/#comment-499326.

[13] Doyle, Jeff, interview by Nick Nigro. 2014. Conversation about the West Coast Electric Highway (July).

[14] U.S. DOE. 2014. Alternative Fuels Data Center. Accessed September 21, 2014. http://www.afdc.energy.gov.

[15] Buell, Tonia, interview by Nick Nigro. 2014. Conversation about the West Coast Electric Highway (July).

[16] C2ES. 2014. DC Fast Charging in Washington State. August. Accessed September 21, 2014. http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/maps/wa-dc-fast-charging-network.

[17] Plug-in North Central Washington. 2014. High Amperage Level 2 Charging Network. Accessed September 21, 2014. http://www.pluginncw.com/high-amperage-level-2-charging-network.

[18] National Research Council. 2013. Transitions to Alternative Vehicles and Fuels. Washington, DC: National Academies Press. http://www.nap.edu/catalog.php?record_id=18264.

[19] U.S. Census Bureau. 2011. Commuting (Journey to Work). Accessed September 21, 2014. http://www.census.gov/hhes/commuting/data/acs2006_2010.html.

[20] Federal Highway Administration. 2011. Summary of Travel Trends: 2009 National Household Travel Survey. Washington, DC: Federal Highway Administration. Accessed September 21, 2014. http://nhts.ornl.gov/2009/pub/stt.pdf.

[21] The 20 percent charge level varies by battery capacity. At 20 percent capacity, C2ES assumes the driver will look for a publicly available charging station within about 6 percent of battery capacity.

CENTER FOR CLIMATE AND ENERGY SOLUTIONS

The Center for Climate and Energy Solutions (C2ES) is an independent nonprofit organization working to promote practical, effective policies and actions to address the twin challenges of energy and climate change.

2101 WILSON BLVD. SUITE 550 ARLINGTON, VA 22201 703-516-4146 C2ES.ORG

DOCKETED

Docket Number:	15-MISC-04
Project Title:	Fuels and Transportation Merit Review
TN #:	211159
Document Title:	Adopt-a-Charger Presentation
Description:	N/A
Filer:	Tami Haas
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	4/20/2016 11:27:21 AM
Docketed Date:	4/20/2016

Adopt a Charger

Lead Commissioner Technology Merit Review Workshop: Electric Vehicle Charging Infrastructure Project Success

April 25th, 2016

STATE OF CALIFORNIA
ENERGY COMMISSION
SINCE 1975

Adopt a Charger

- Adopt-a-Charger (AAC) is a nonprofit organization founded in March 2011 to accelerate the wide spread adoption of plug in electric vehicles by broadening the charging infrastructure. Our unique approach matches a sponsor with a host site located at a popular public destination: parks, colleges, museums, beaches and the like. By “adopting” a location, the sponsor agrees to pay for all equipment, installation, maintenance, electrical usage, and administration fees for three years.

Sponsors & Partners

Non Profit approach offers a unique business model

Cincinnati Zoo

Louisville, KY

Bay City State Park, MI

ChargeStarter.org in Missouri

Getty Center and Getty Villa

Main Lot: 4 – L2, 4-120v
TOH: 8 – L2, 7-120 v

South: 2-L2, 2-120 v
Central: 2-L2

Total Budget $75,500
March 2015 – 3 employee PEV
March 2016 – 36 employees PEV. April 2016 - Adding 10 L2 EVSE
**Future proof install – upsize transformer and install L2 every other space. Move cords not cars.

Direct Observation and Driver Communication

LOS ANGELES ZOO

CHECK IN ON
PlugShare

Adopt a Charger.org
SUPPORT FREE CHARGING
Scan the code to learn more
TO REPORT A PROBLEM CALL
(855) 99-ADOPT

We have had 332 check-ins in the first 5 months of operation.
93% are positive. 17 of the complaints related to the CCS not working, 5 complaints about all spots being taken, and 3 about hours of operation.

Will Rogers State Historic Park

Google donated Eaton EVSE

CALIFORNIA STATE PARKS SINCE 1864

Kenneth Hahn State Recreation Area Los Angeles County April 2016

COUNTY OF LOS ANGELES CALIFORNIA

SOUTHERN CALIFORNIA EDISON

An EDISON INTERNATIONAL® Company

South Coast AQMD

Hearst Castle San Simeon May 2016

TESLA

Old Town San Diego
State Historic Park
May 2016

Fort Ross
May 2016

Armstrong Woods
Fall 2016

Natural Bridges
Fall 2016

KASHIA POMO TRIBAL GOVERNMENT

Monterey Bay Unified Air Pollution Control District

Seacliff State Beach
Fall 2016

Fort Mason

Stinson Beach

Muir Woods

Adopt a Charger EVSE agnostic

LADOT
Robertson Garage
GE w/ RFID
$750 close out

LACMA
AV donated

Red Cross San Jose
Schneider $9,400
ChargePoint
$1.00/hour

Leviton - LADOT
Hollywood &
Highland
$750

Eaton
CSUOC
Donated by
Google

Crissy Field
Volta donated

I asked the EV driving community for their feedback and received 188 responses

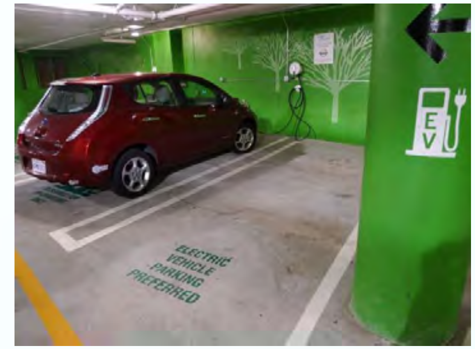
at the CA/NV border across the street from 8 Tesla Superchargers.

1. **Reliability is Top Priority**
2. **DC Fast Charging Along Corridors**
3. **Simple Low Cost Solutions. Level 1 for workplace and airport.**
4. **Enforcement of ICE vehicles parking in EV spots.**
5. **Solar!! So many people mentioned solar feed in tariffs, demand response, etc.**

Some of Adopt a Charger's other installations:

Point Reyes National Seashore

Cal State Long Beach



Music Concourse Garage Golden Gate Park

Malibu Creek State Park

LACMA

West Coast Electric Highway

Baldwin Hills Scenic Overlook

Thank You! Kitty.Adams@adoptacharger.org