BUSINESS

BUSINESS MODELS FOR FINANCIALLY SUSTAINABLE EV CHARGING NETWORKS

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

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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:

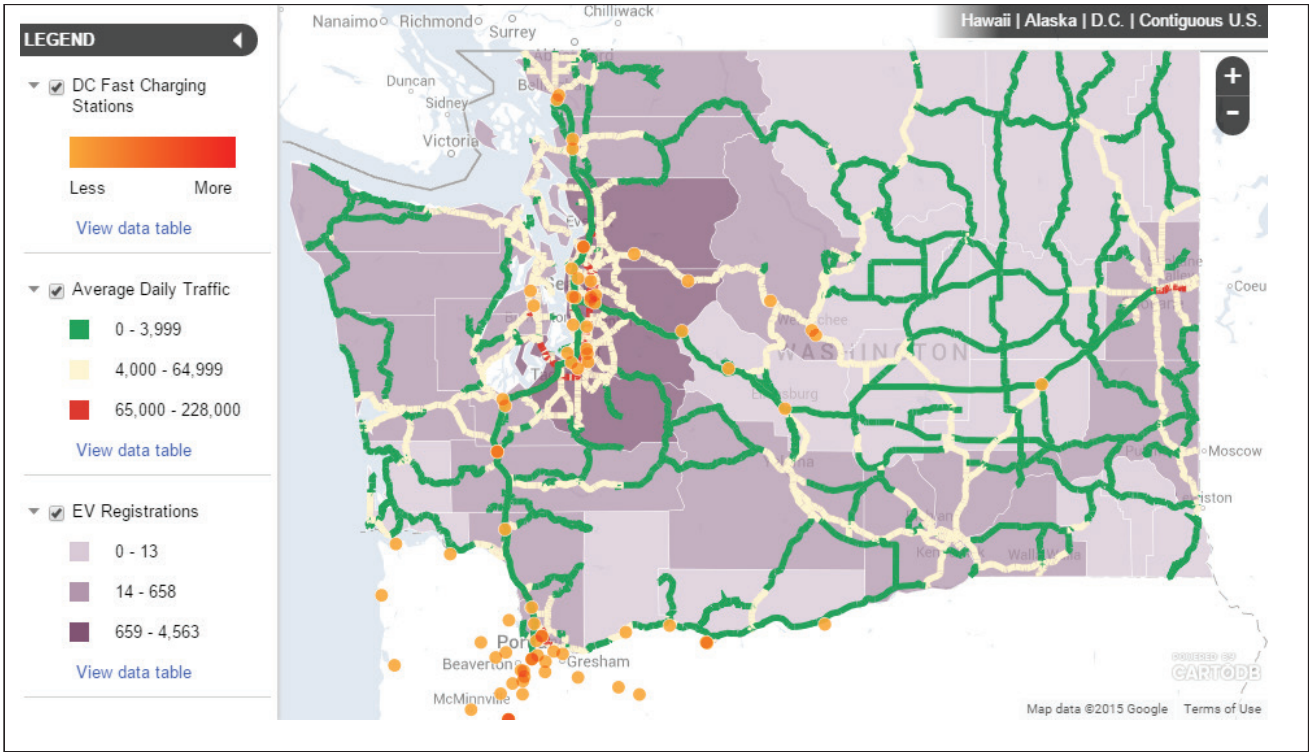
- **I-90 Charging Gap:** Travel from the Puget Sound Region to Spokane along Interstate 90 (I-90).
- **Ocean Shores Charging Gap:** Travel from the Puget Sound Region to the Pacific Coast.
- **Tri-Cities/Walla Walla Charging Gap:** Travel from the eastern and western part of the state along I-90 to the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

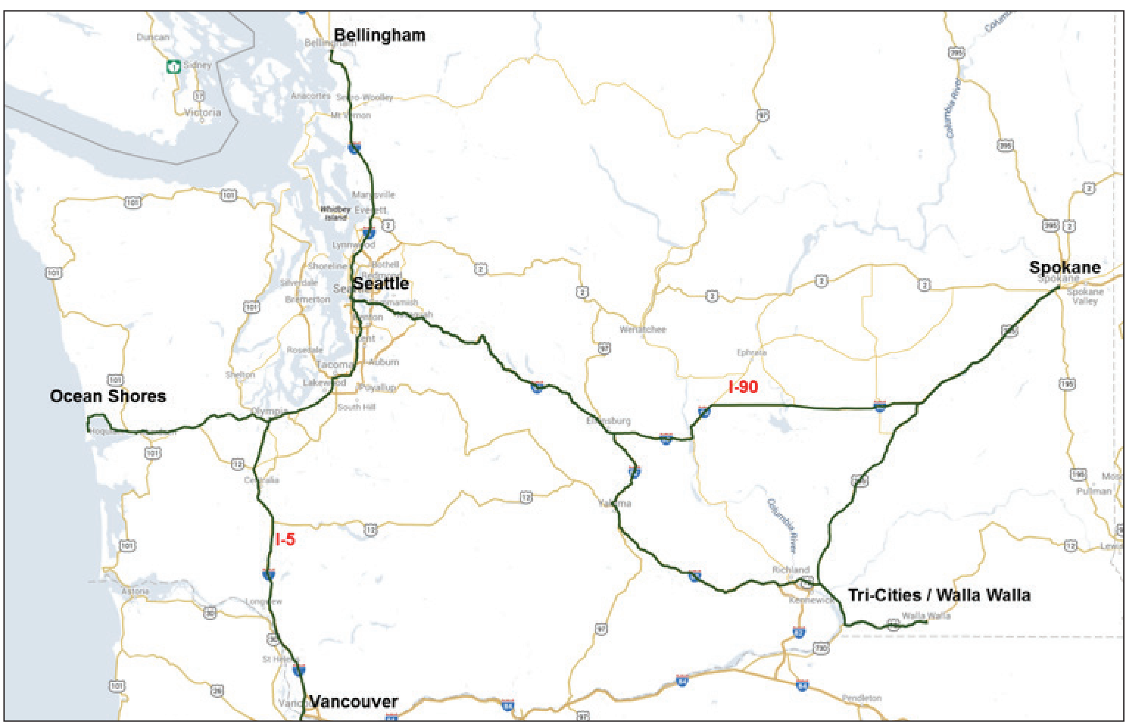
One promising opportunity to improve the financial performance of charging station investments is to develop business models that, through private partnerships and joint investment strategies, capture other types of business value in addition to selling electricity. This might include tourist revenue 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

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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.

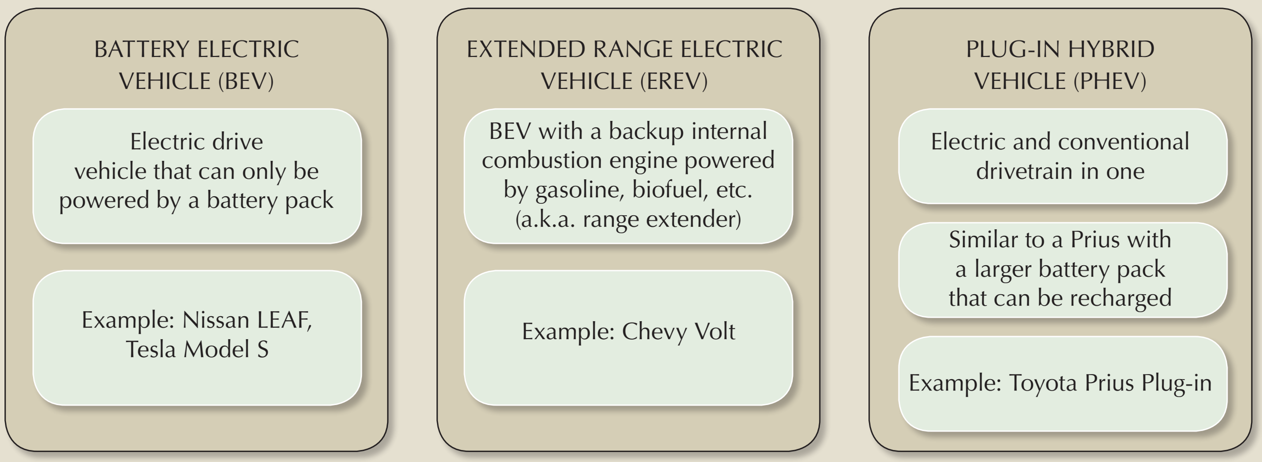
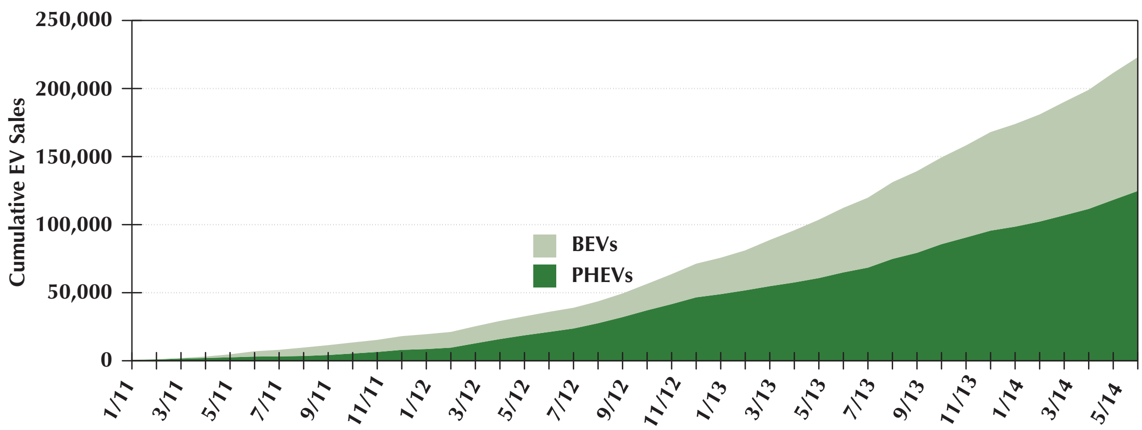


FIGURE 1: PHEVs Have Outsold BEVs in the United States by More Than 25 Percent

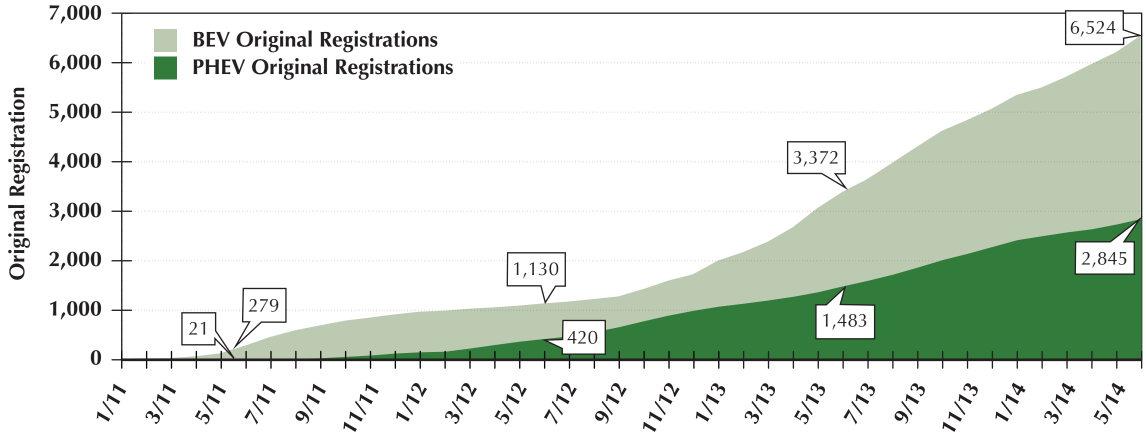
124,718 PHEVs and 98,267 BEVs have been sold in the United States through June 2014. PHEVs have consistently outsold BEVs on a monthly basis since early 2011.



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.

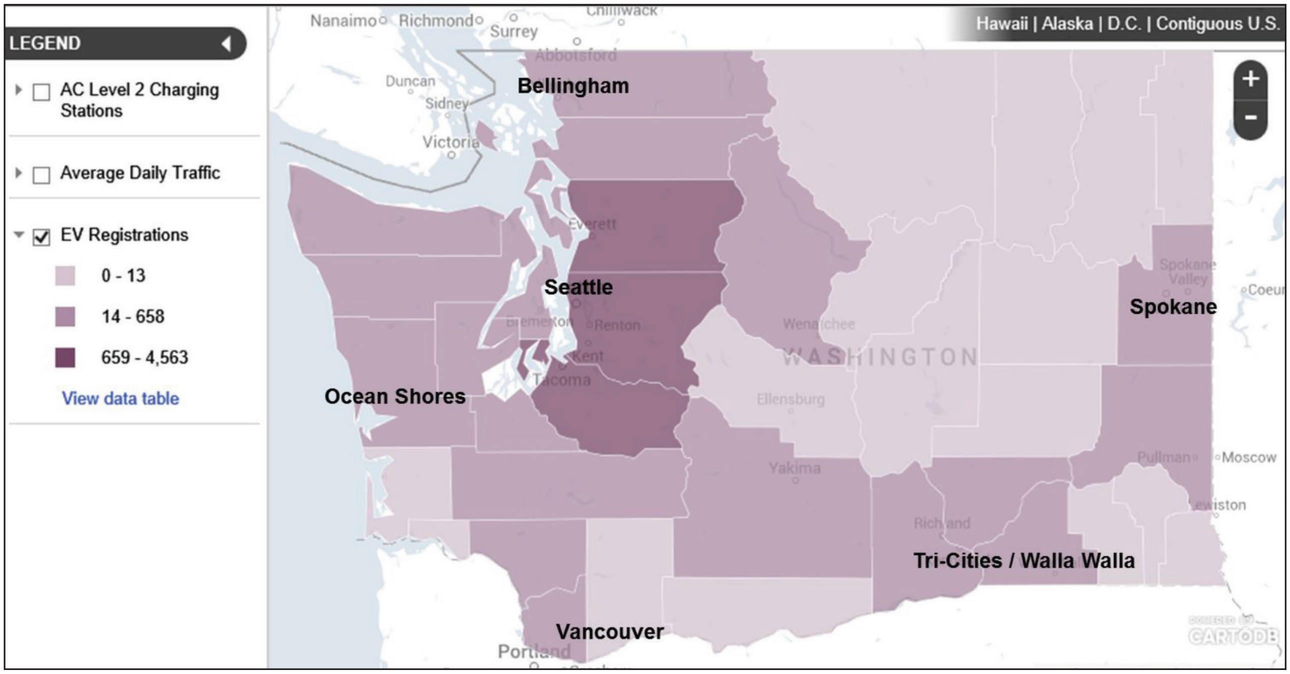
Geographic Distribution of EVs

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.

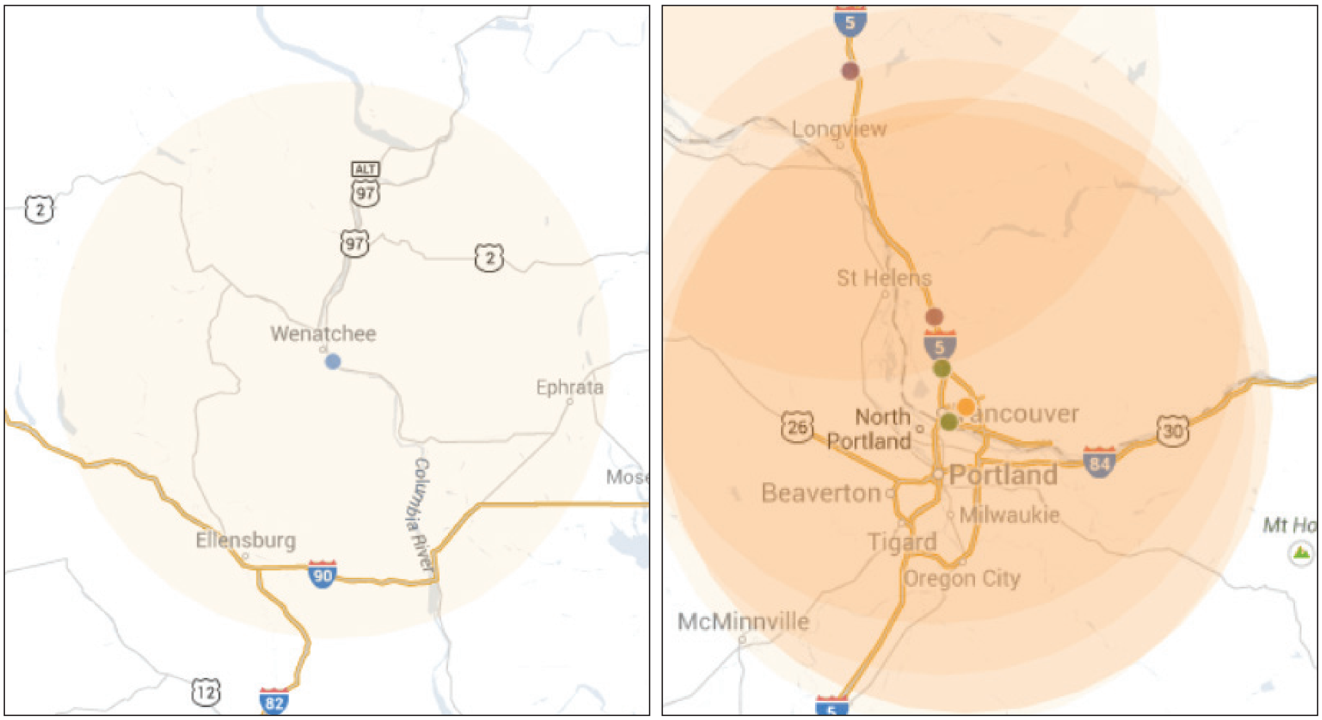
One measure of the effectiveness of station siting and the need for additional stations is the utilization of a charging station—the share of time a station is charging a vehicle. As the use of charging stations increases and charging congestion becomes an issue, drivers will face greater risk of extended 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.

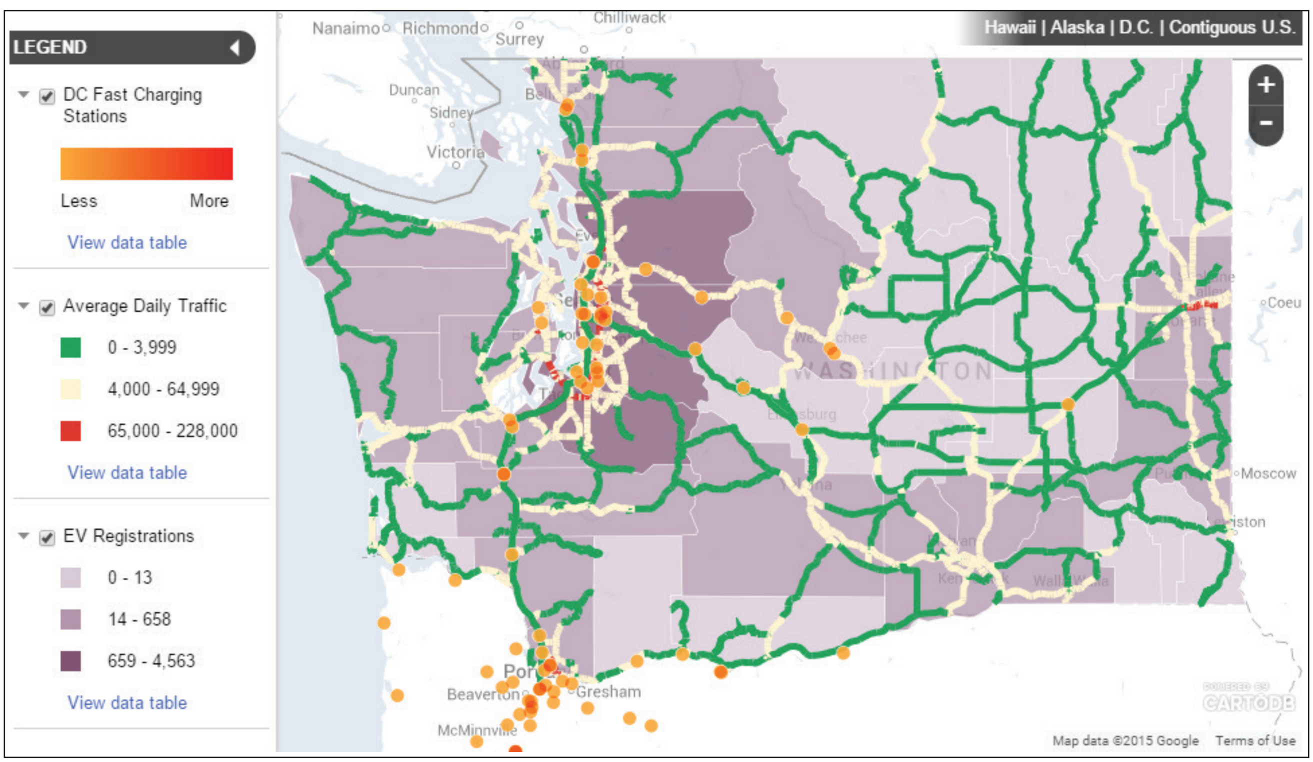
There were 40 DC fast charging locations in Washington as of June 2014.[5] Charging locations are concentrated where EVs are registered and where vehicle traffic is heaviest, with the exception of segments of I-5 and U.S. 2. See **Figure 6** for a map of all DC fast charging locations, EV registrations,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

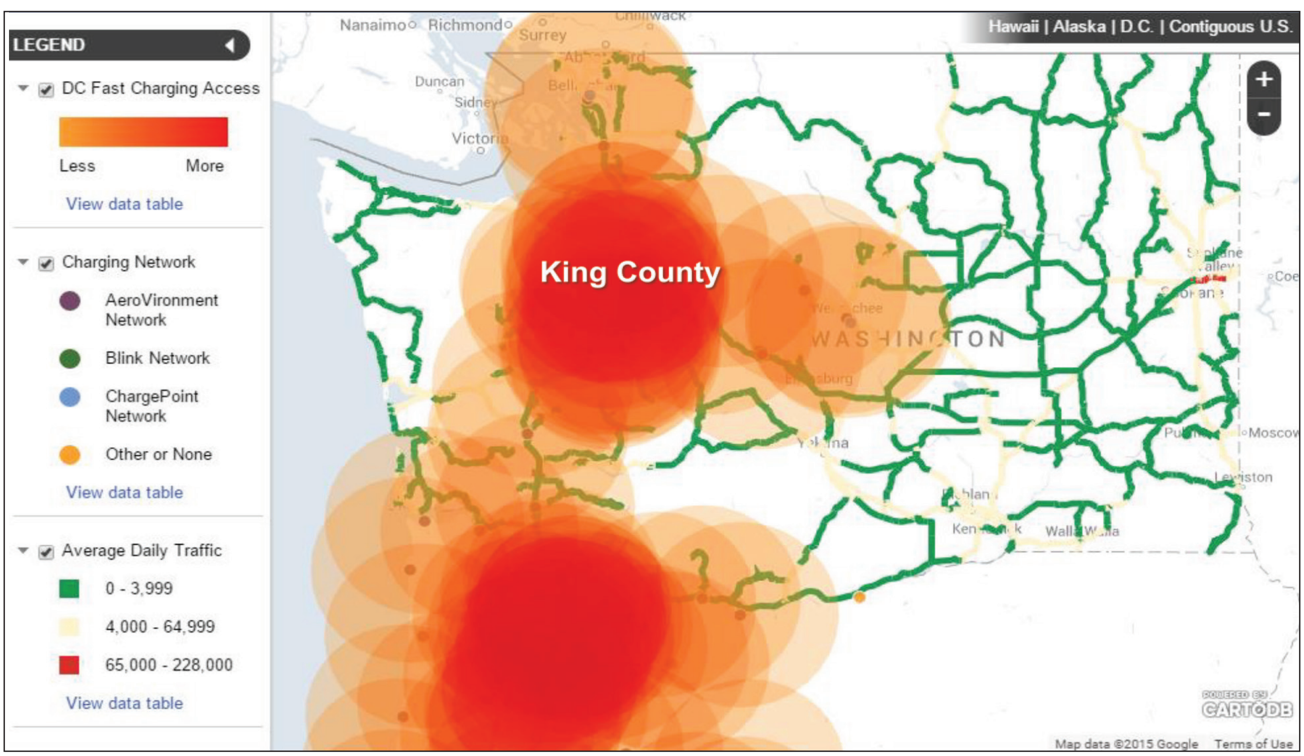
1.6 LEVEL 2 CHARGING NETWORK ASSESSMENT

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]

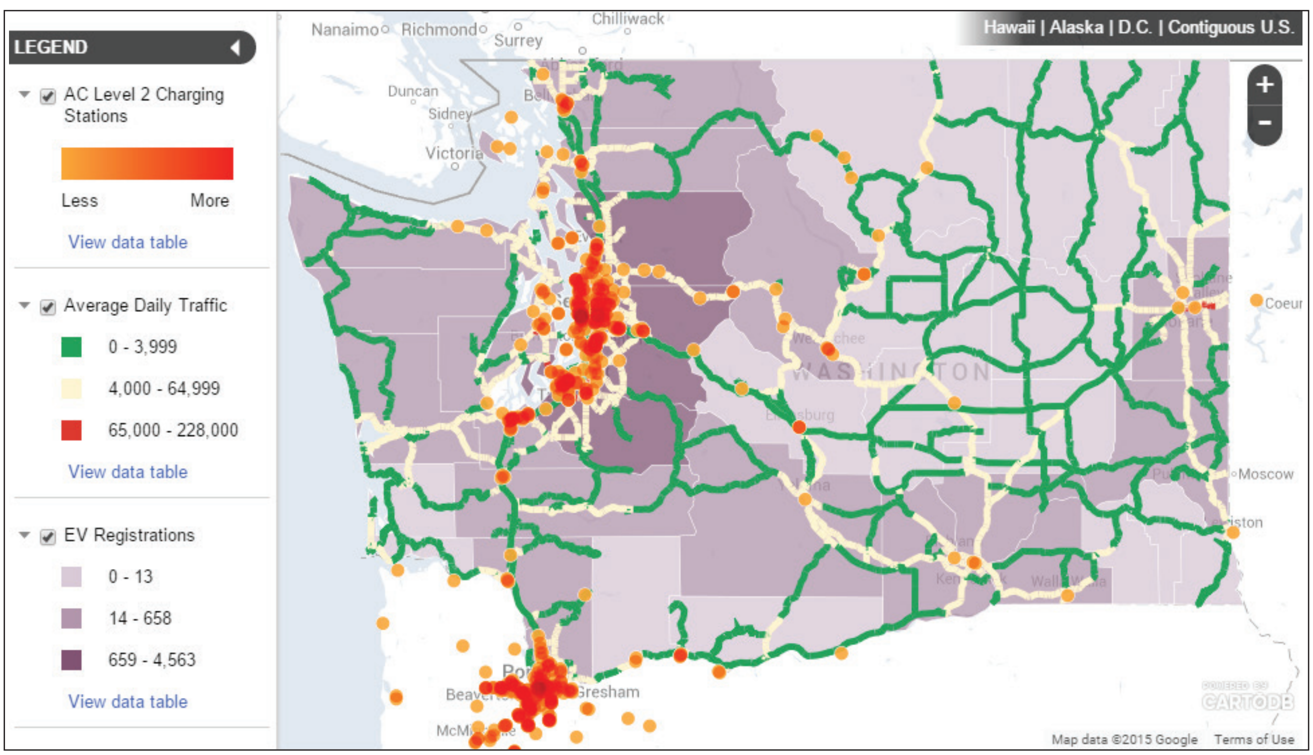
Even though Washington has one of the most extensive Level 2 charging networks in the United States, it may not be enough to accommodate the current EV fleet in the state. There are 414 Level 2 charging locations with 891 charging ports. See **Figure 8** for a map of all Level 2 charging locations, EV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

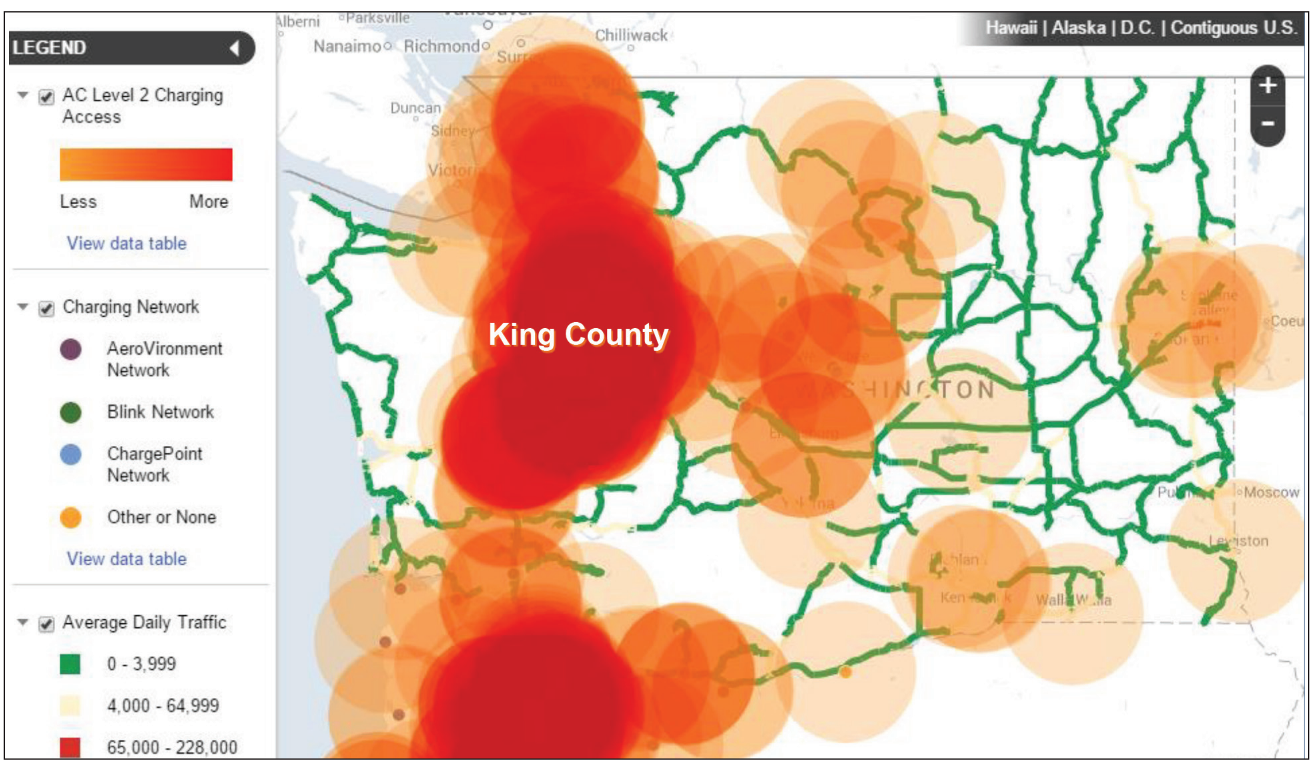
Level 2 charging stations are typically located in places where drivers are expected to spend longer than an hour. On a daily basis, drivers typically stay close to where they live, so locating publicly available charging near where EVs are registered is sensible to extend daily travel beyond what home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

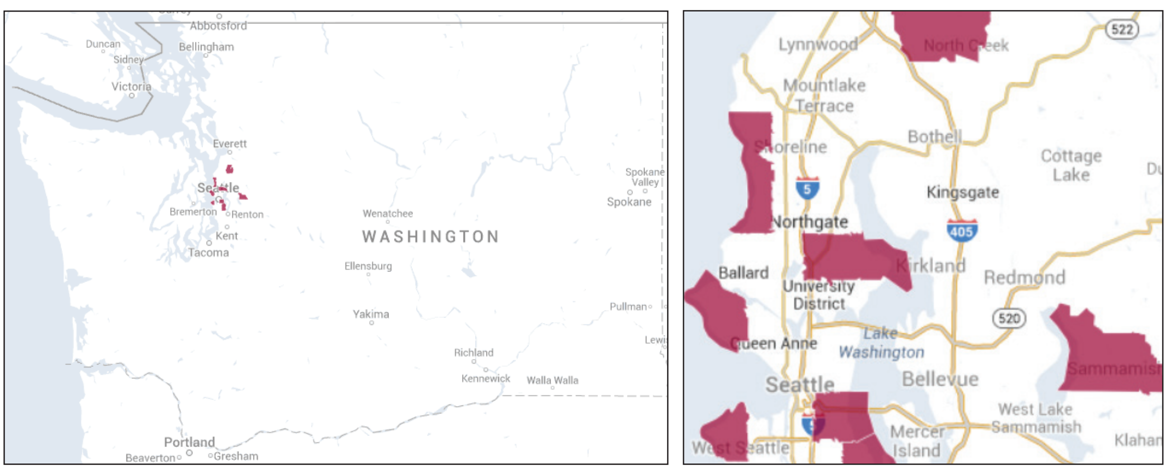
The ZIP codes below have no publicly available Level 2 charging station as of June 2014. The vehicle counts in this table are through December 2013.

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

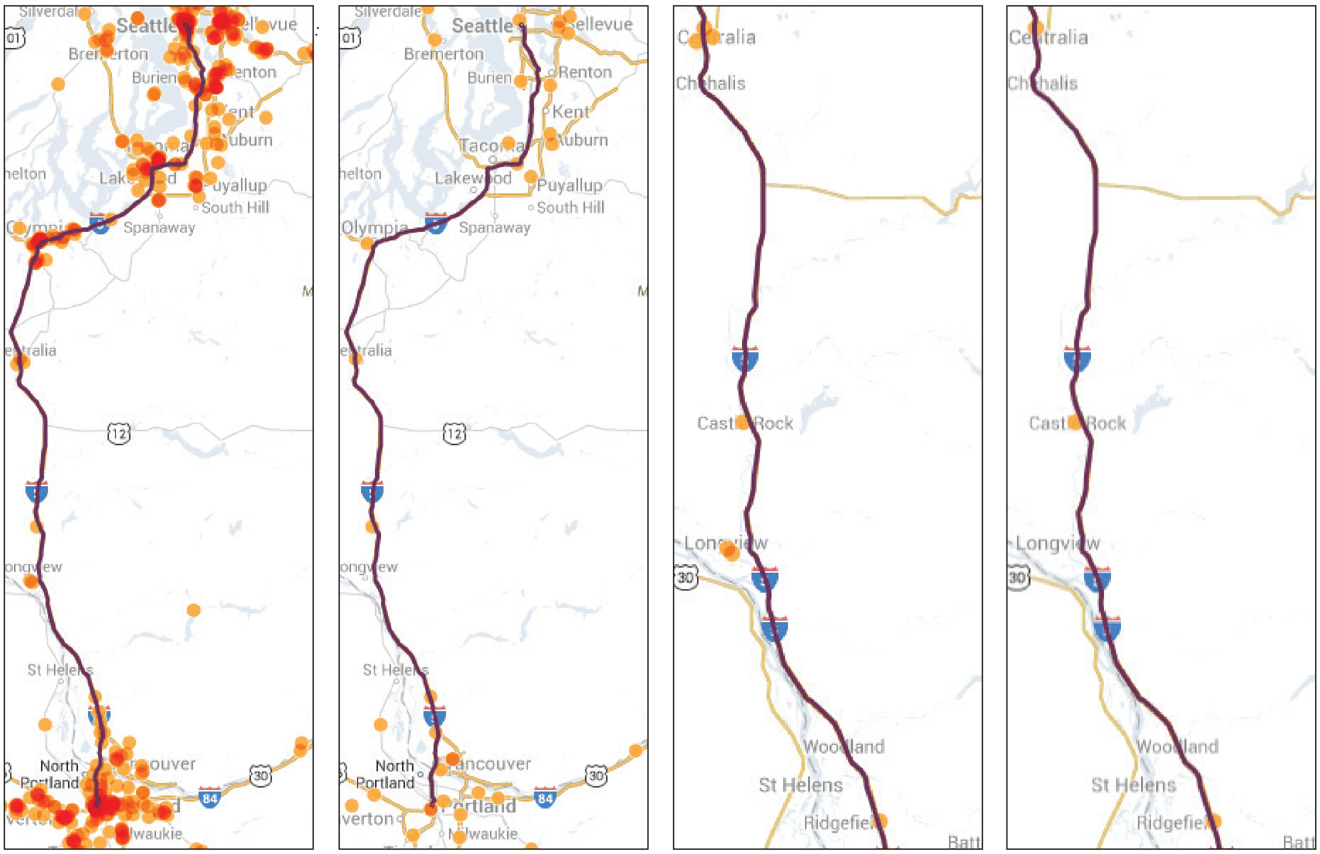
TABLE 4: Travel between Seattle, Washington and Portland, Oregon

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.

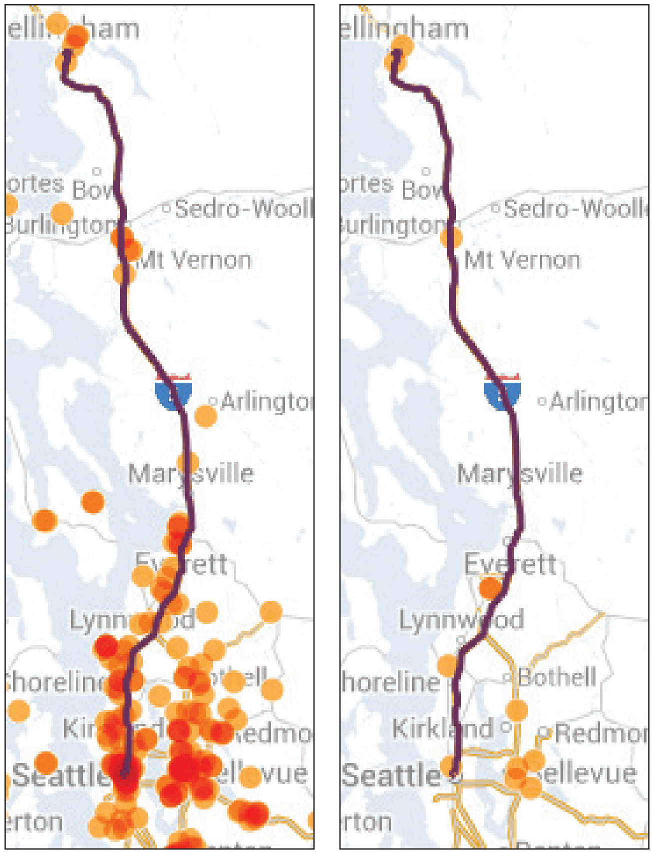
TABLE 5: Travel between Seattle and Bellingham

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.

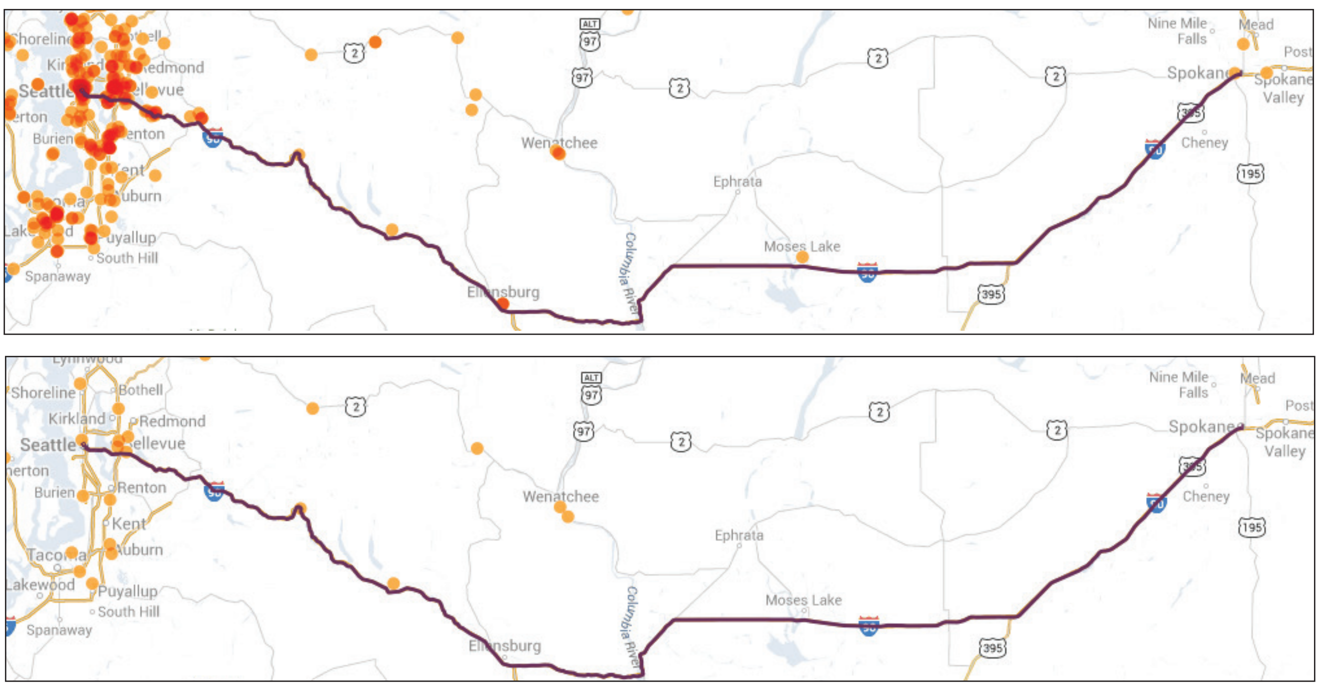
TABLE 6: Travel between Seattle and Spokane

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.

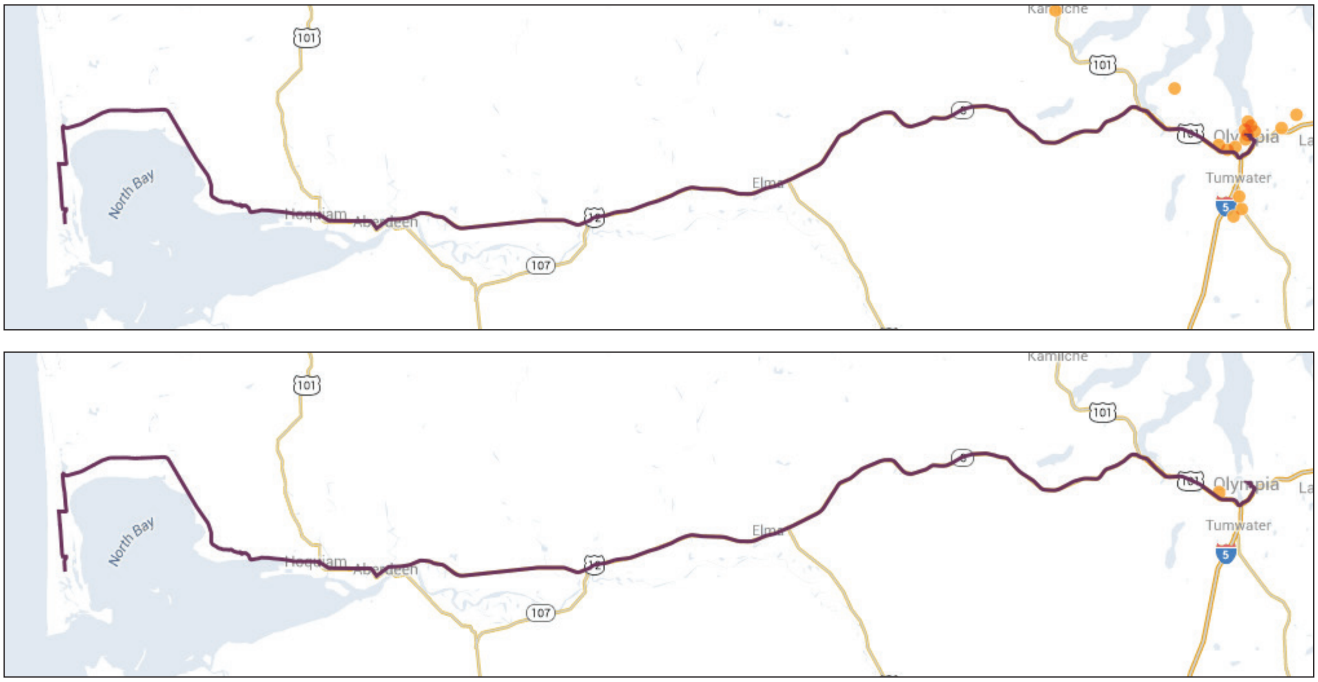
TABLE 7: Travel between Olympia and Ocean Shores

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."

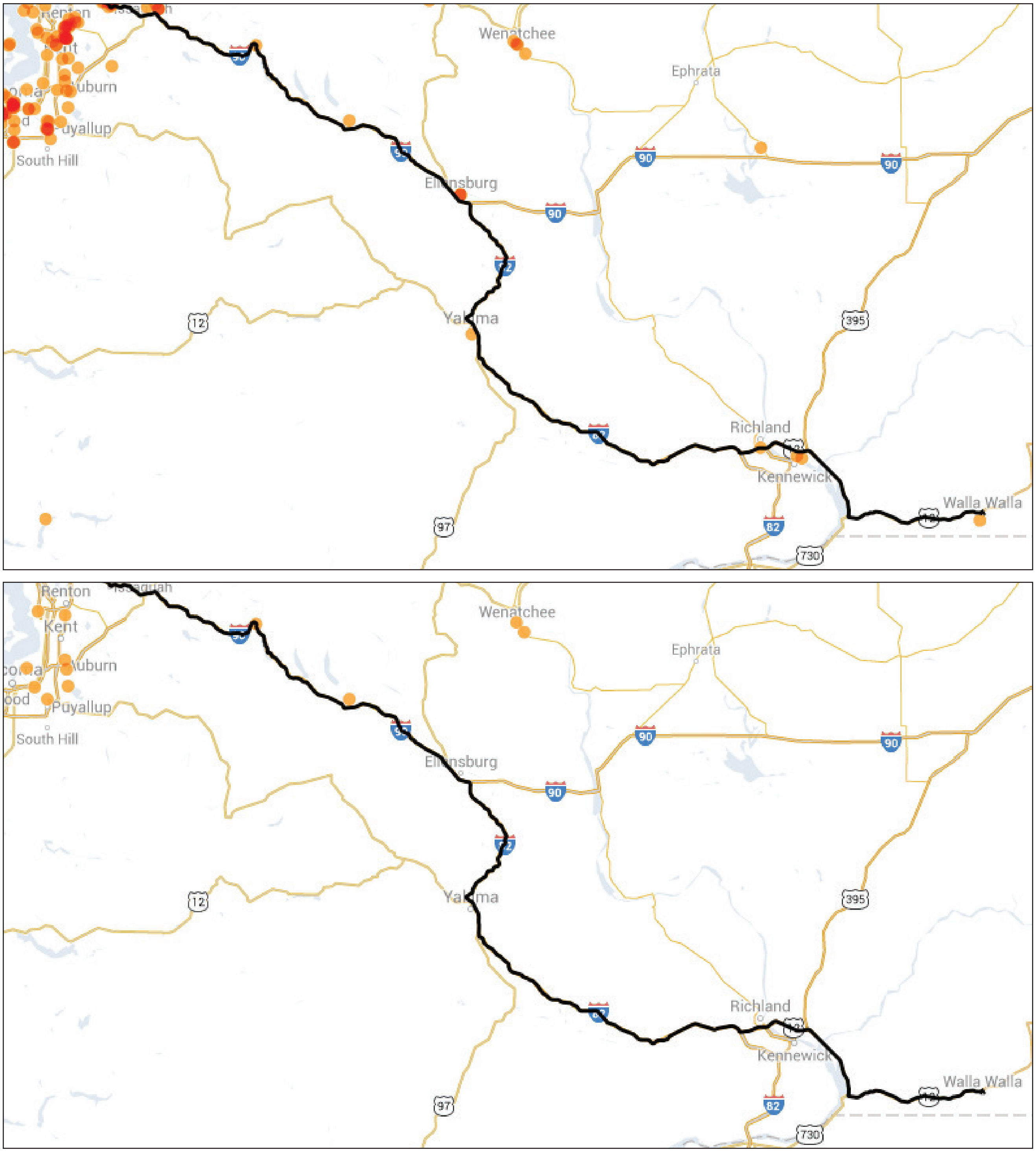
CHARGING TYPE	VEHICLE	MILES TRAVELED	NUMBER OF CHARGING STOPS	DRIVE TIME (MIN)	CHARGE TIME (MIN)	TOTAL TIME (MIN)
N/A	Gasoline Powered	272	N/A	243	N/A	254
DC Fast Charging	BEV-40	X	X	X	X	X
DC Fast Charging	BEV-80	X	X	X	X	X
DC Fast Charging	BEV-200	275	1	263	58	321
Level 2	BEV-40	X	X	X	X	X
Level 2	BEV-80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

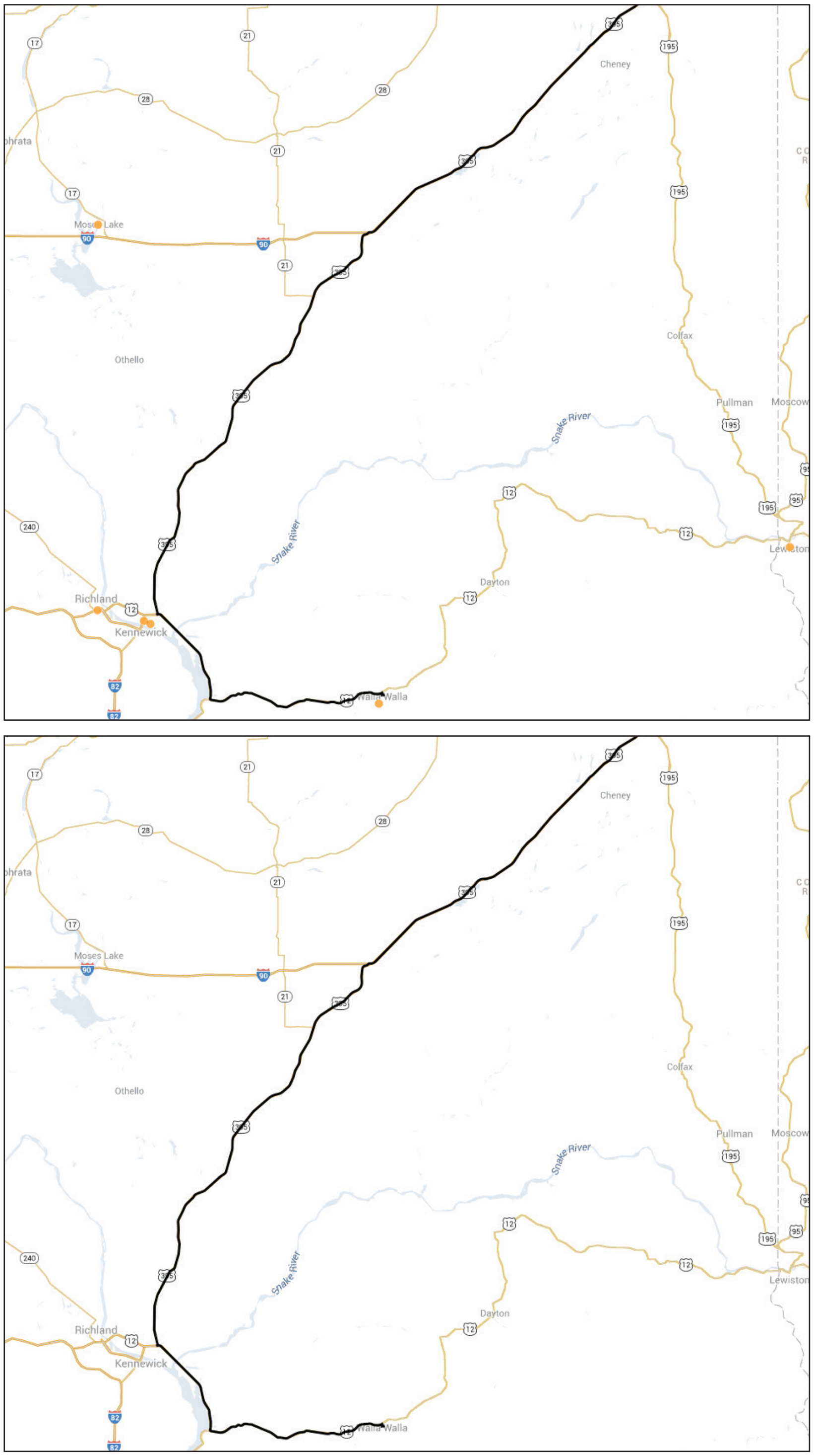
TABLE 9: Travel between Spokane and Walla Walla

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:

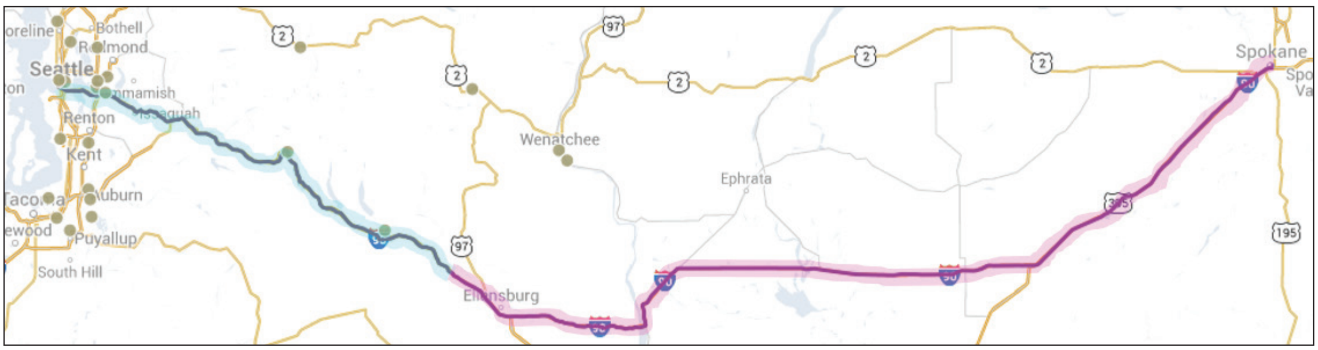
- The need for additional Level 2 chargers in urban areas, especially where EV owners do not have access to a garage for home charging, such as in Seattle; and
- The need for additional charging stations on I-5 outside of the Seattle and Vancouver area, where coverage is currently sparse, to reduce travel 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]

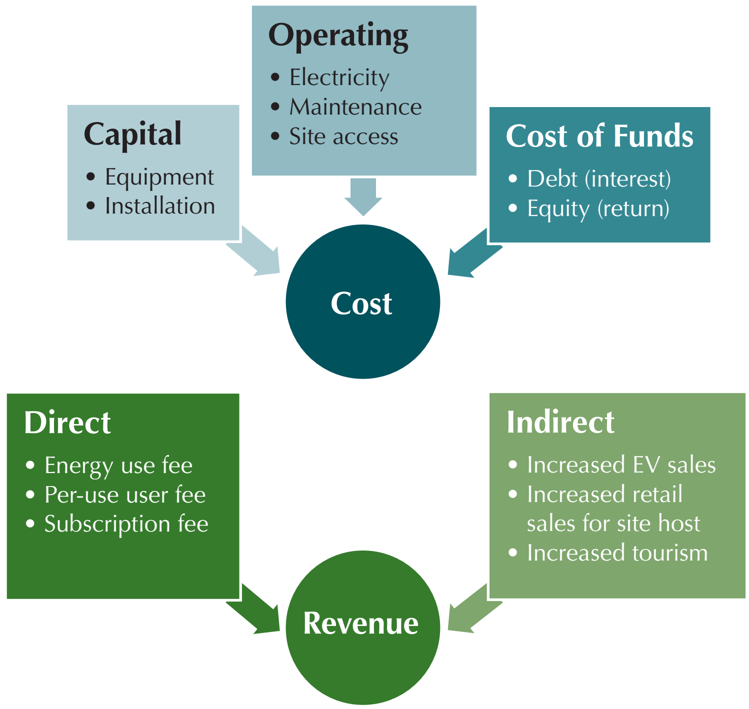
Where:

- *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.

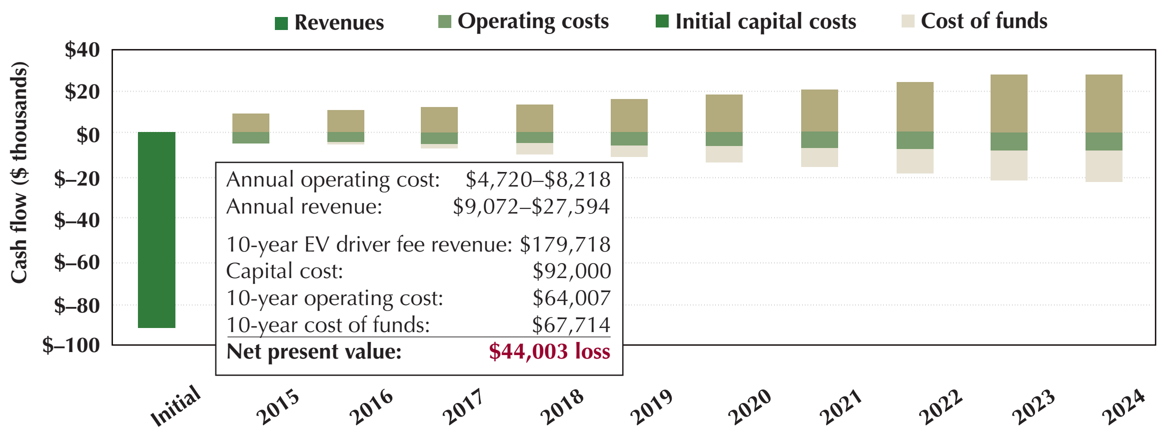
2.4 EV CHARGING DEPLOYMENT MODELS AND ROLES FOR PUBLIC AND PRIVATE ENTITIES

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.

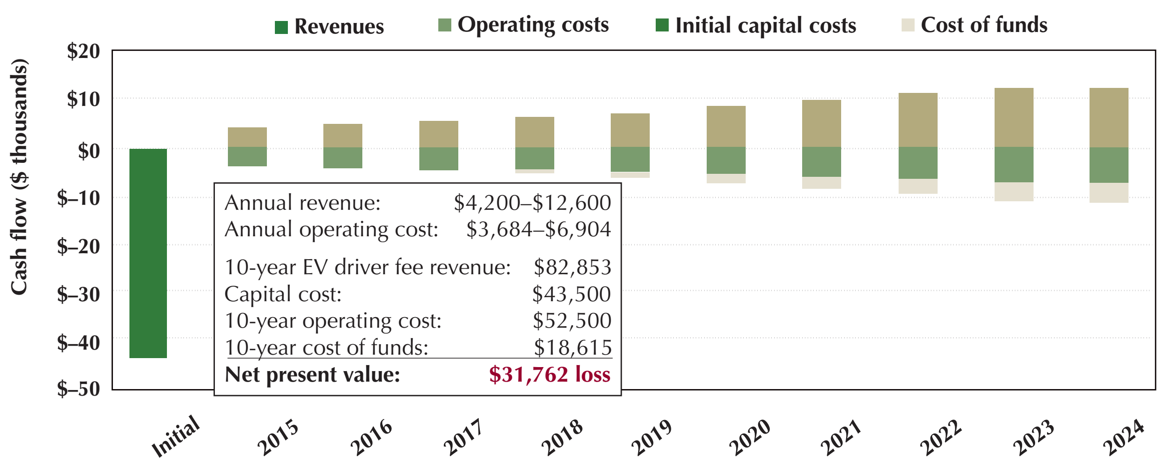
FIGURE 24: Investments in Charging Stations (DC Fast Charging and Level 2) Lose Money over Project Lifetime

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



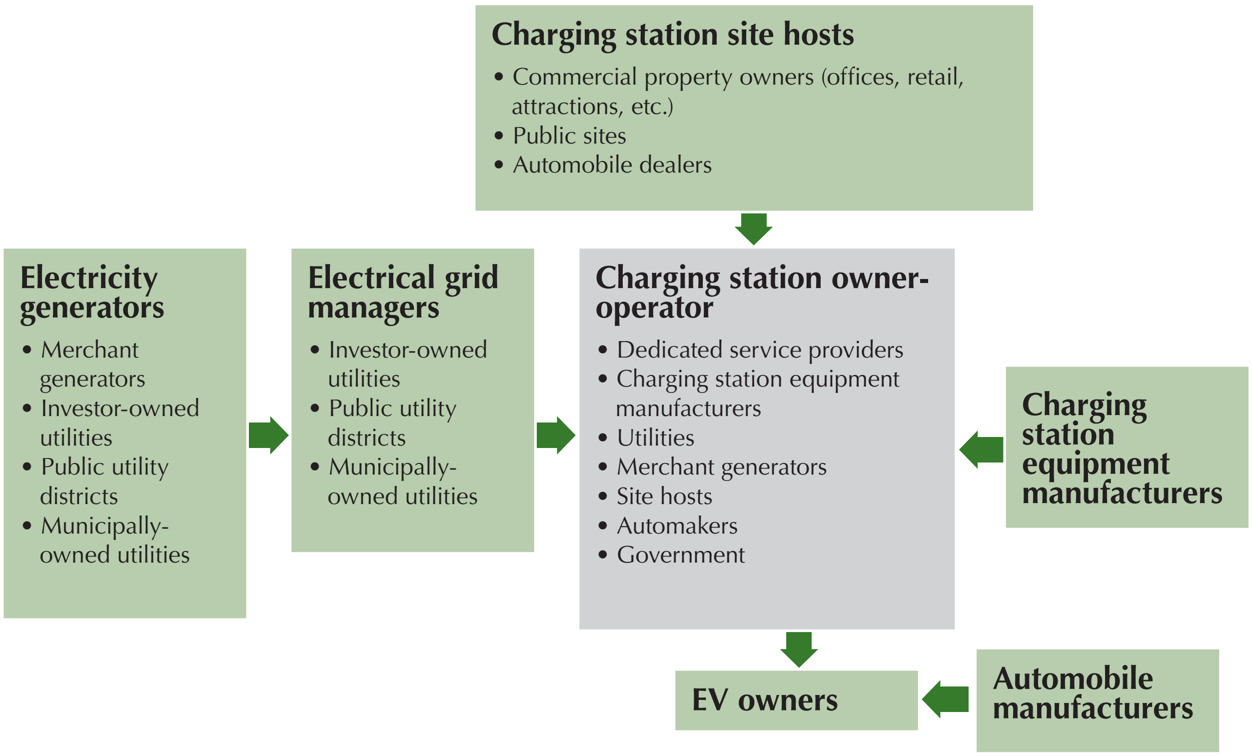
What are the critical components of an EV charging network?

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

PRIVATE SECTOR PARTNER	PARTNER BENEFITS	ESTIMATED PARTNER CONTRIBUTIONS	
		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.

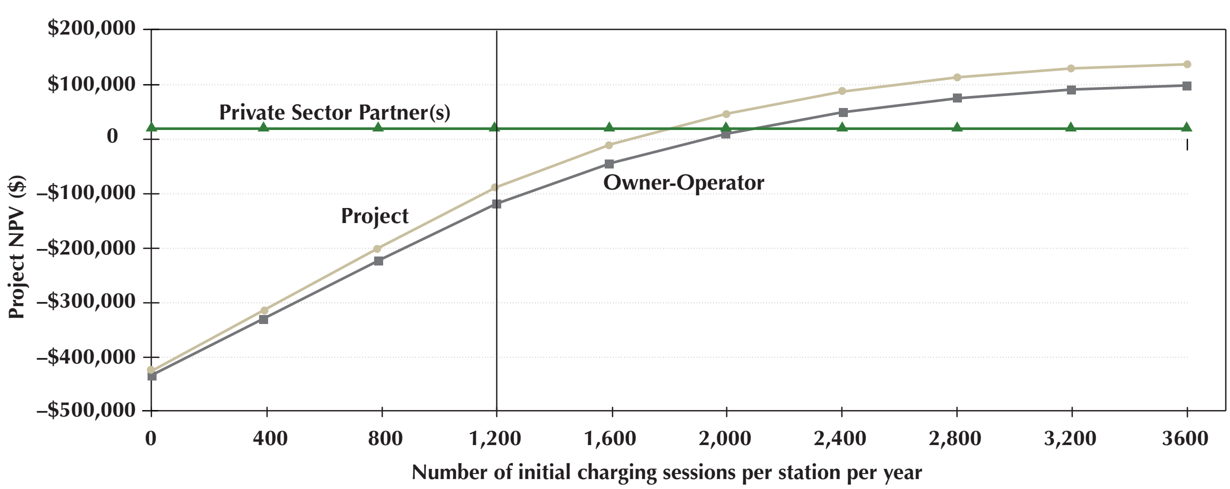
These sensitivity analyses, and others, are described in detail below.

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

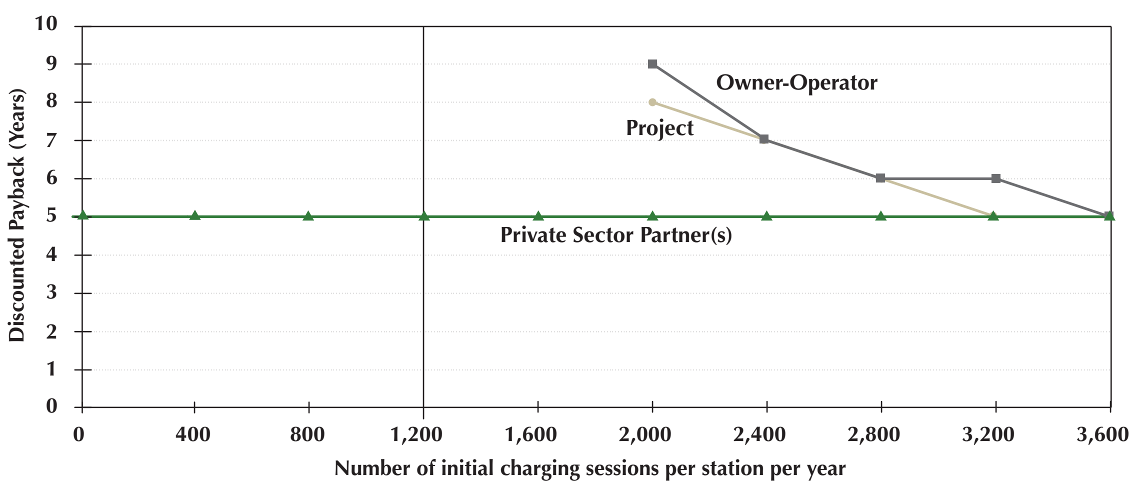
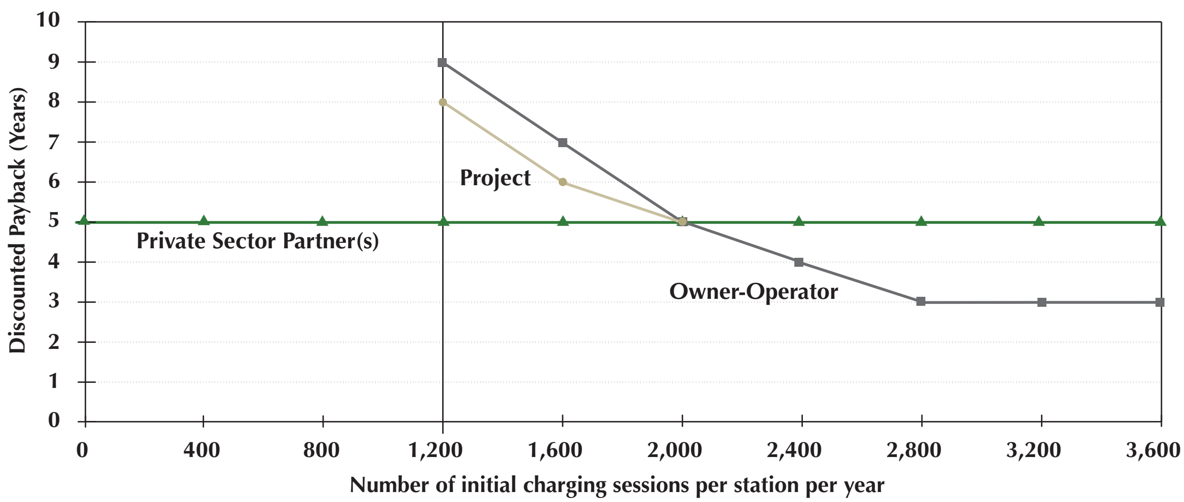


FIGURE 28: Business Model 1 Project Payback (Charging Station Utilization Sensitivity and User Fee of $0.70 per Kilowatt-Hour)

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).

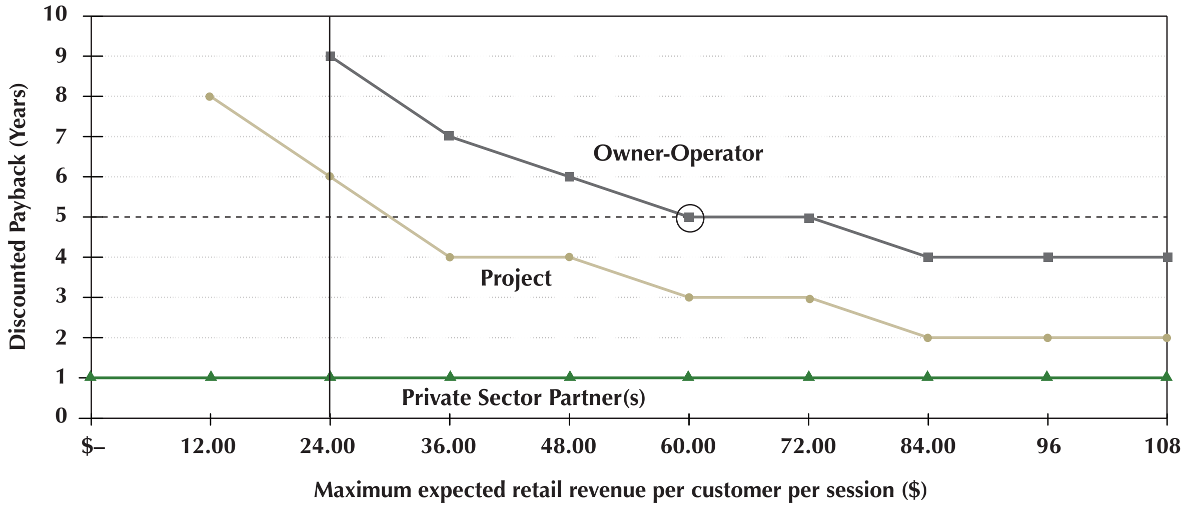
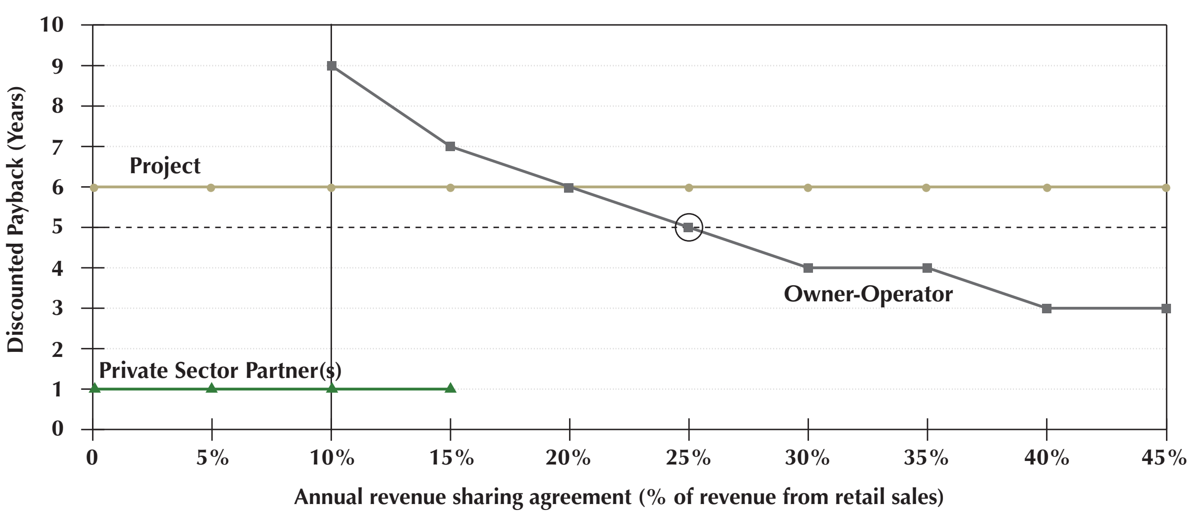


FIGURE 30: Business Model 2 Project Payback (Revenue Increase Percent Shared by Local Businesses with Station Owner-Operator Sensitivity)

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).

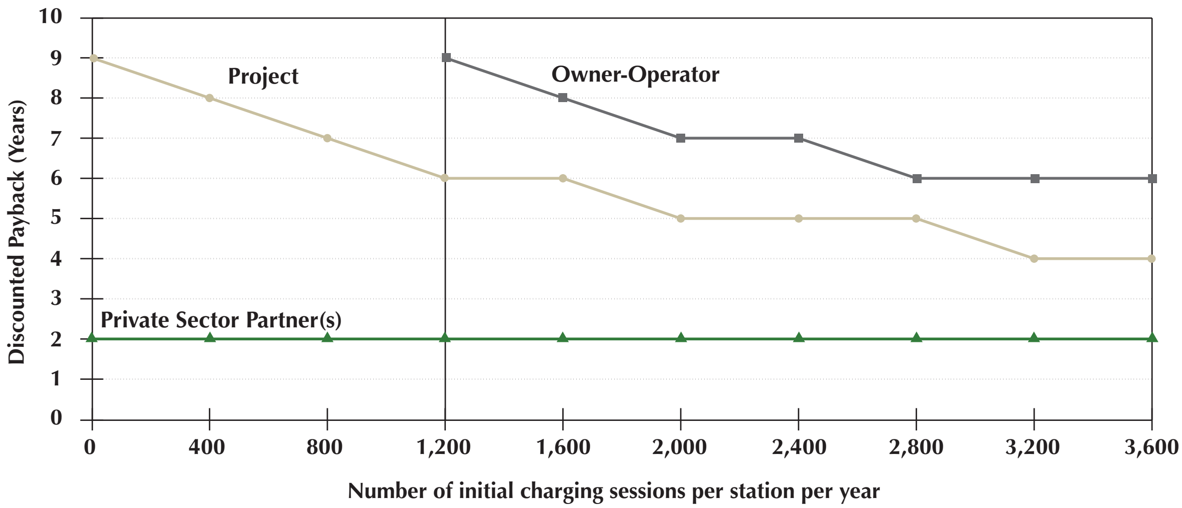
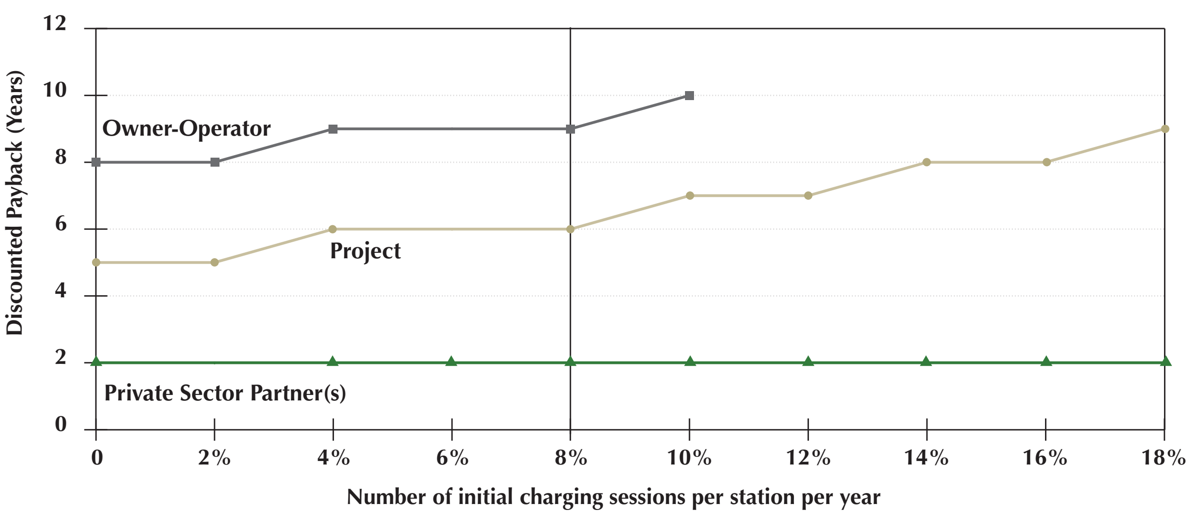


FIGURE 32: Business Model 3 Project Payback (Cost of Debt Sensitivity)

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)**

Private sector contribution: 40%
Public sector contribution: 60%

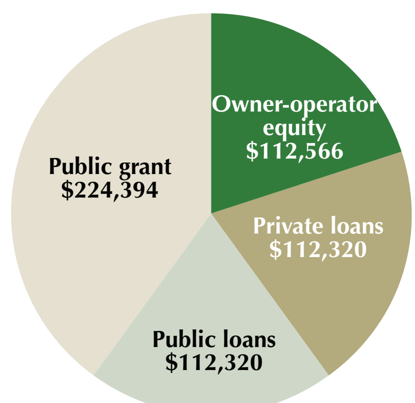


TABLE 33: Summary of Business Model 1 and Public Sector Interventions for a 2015 Project to Enable BEV Travel between Seattle and Spokane along I-90

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)

Private sector contribution: 100%
Public sector contribution: 0%

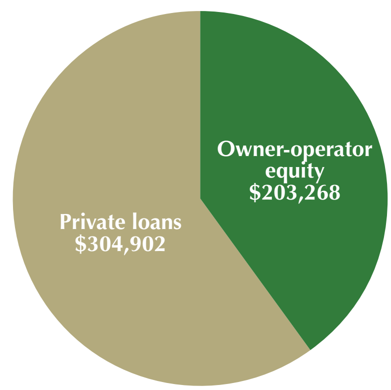


TABLE 35: Summary of Business Model 1 and Public Sector Interventions for a 2020 Project to Enable BEV Travel between Seattle and Spokane along I-90

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.

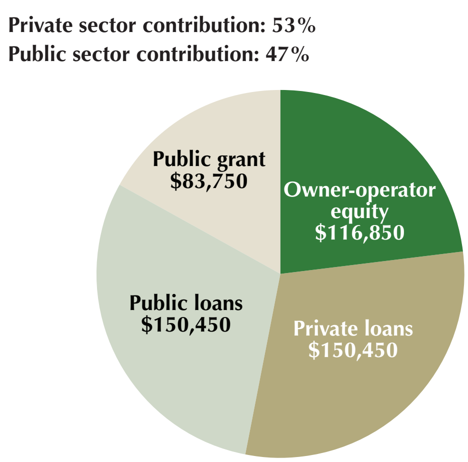
TABLE 36: Financial Results of Applying Business Model 1 for a 2020 Project

	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)

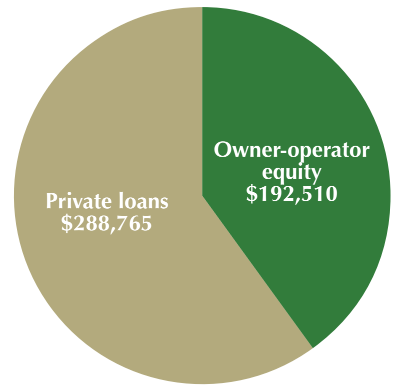


TABLE 40: Financial Results of Applying Business Model 2 and Public Sector Interventions for a 2020 Project

	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)

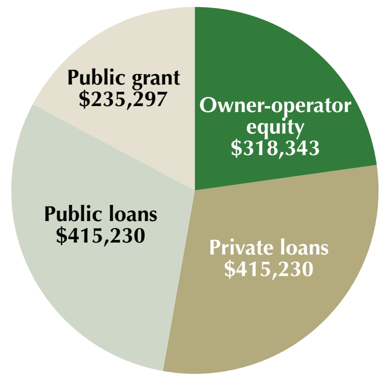


TABLE 41: Summary of Business Model 3 and Public Sector Interventions for a 2015 Project to Enable EV Travel to and within Tri-Cities and Walla Walla

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)

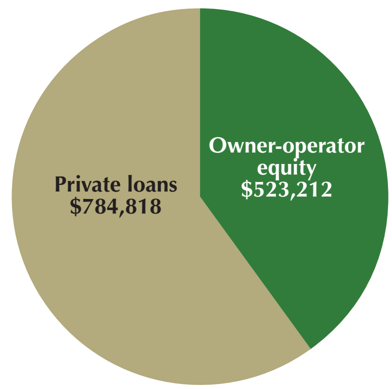


TABLE 43: Summary of Business Model 3 and Public Sector Interventions for a 2020 Project to Enable EV Travel to and within Tri-Cities and Walla Walla

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.

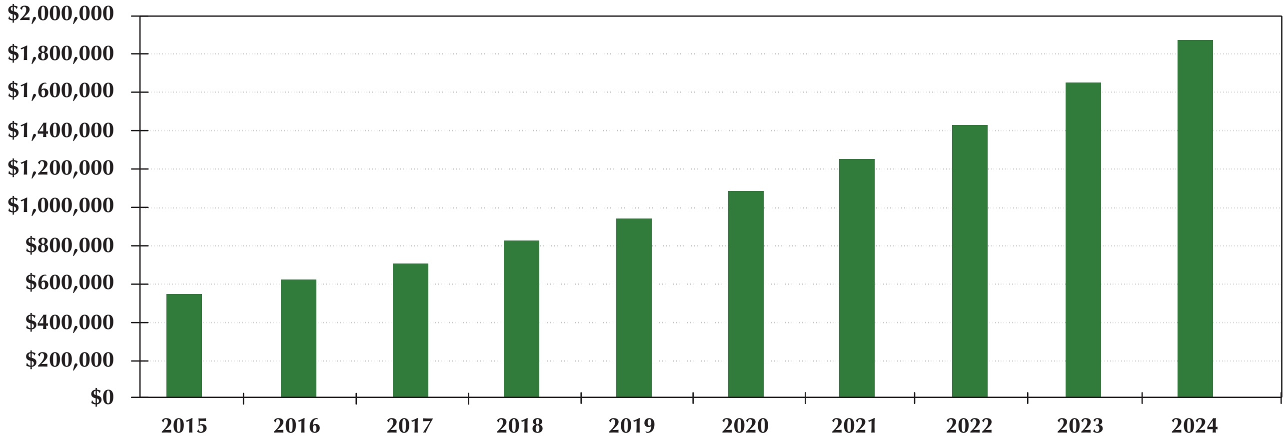
EV Registration Fee Increase

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).

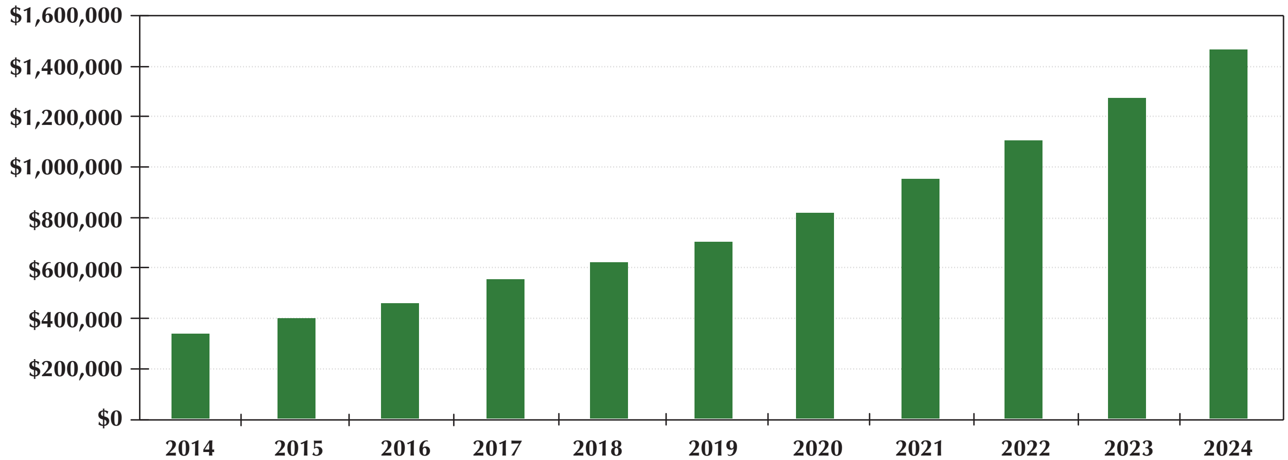
Washington state currently offers a sales tax exemption for BEVs that allows buyers to avoid paying taxes equal to 8.8 percent of the vehicle purchase price (6.8 percent state sales tax plus 2 percent local sales tax on average). For a $30,000 vehicle, this results in savings to the consumer of $2,640. 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	DEVELOP BUSINESS MODELS	IDENTIFY PUBLIC & PRIVATE ROLES
Construct Public Charging Network Database	Leverage C2ES's AFV Finance Initiative	Execute financial analysis on business model viability
Create interactive maps for charging suitability assessment	Conduct Business Model Workshop	Identify public sector role in addressing barriers to private investment
Provide insights into role of public charging networks in encouraging EVs	Create 3 Business Model Summaries	October–December 2014
Summarize findings	July–November 2014	
May–August 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

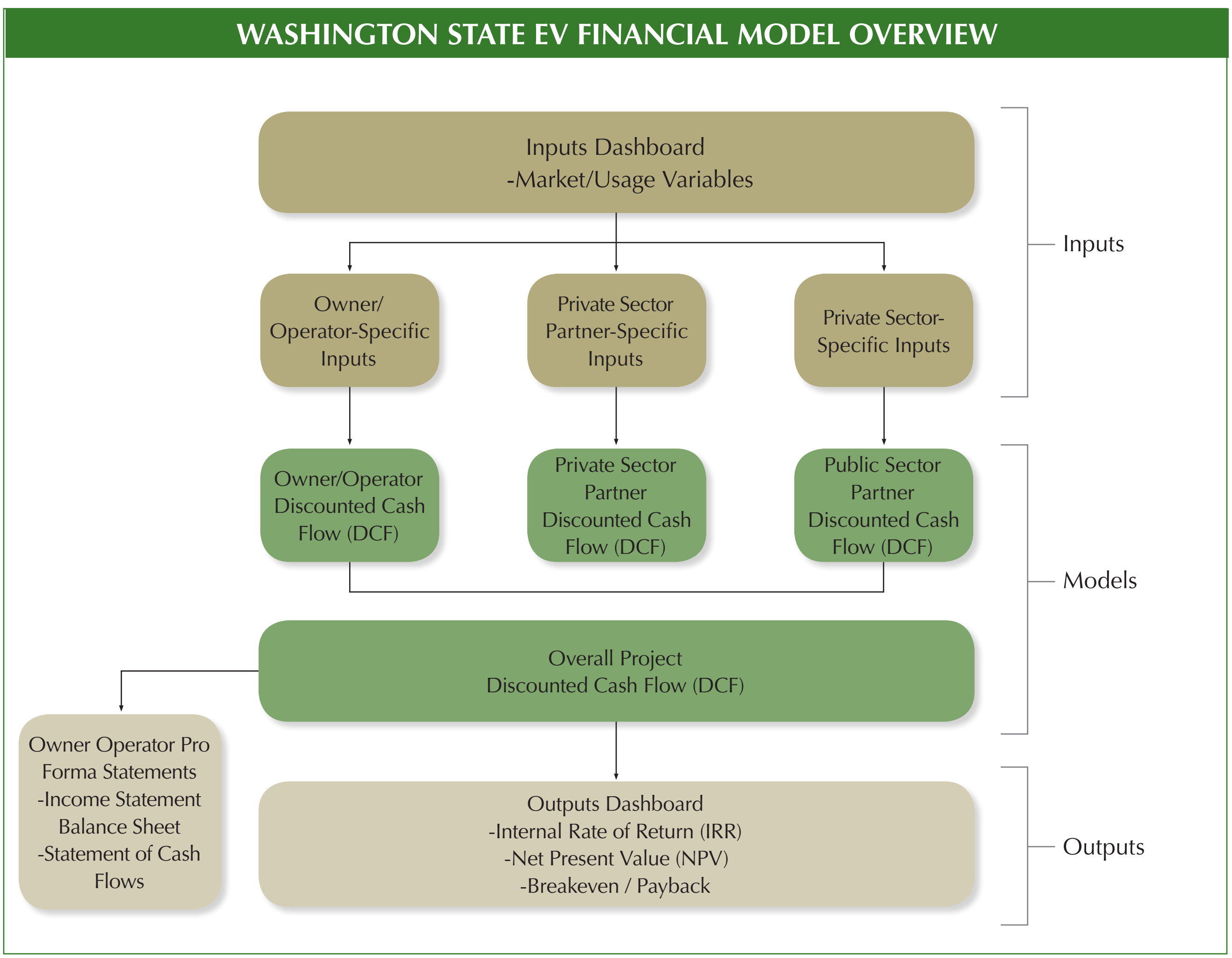
To evaluate the business case for each player involved in these business models, C2ES and Cadmus Group developed the EV Charging Financial Analysis Tool to analyze a variety of alternative EV charging investment arrangements under a wide range of market assumptions. The tool uses the discounted cash 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.

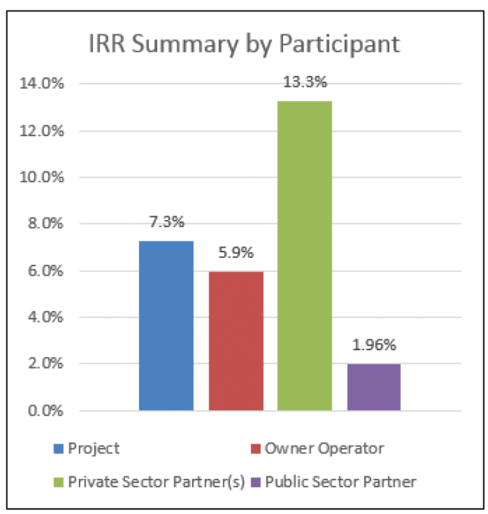
FIGURE 43: Sample of the Dashboard Output for the EV Charging Financial Analysis Tool

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

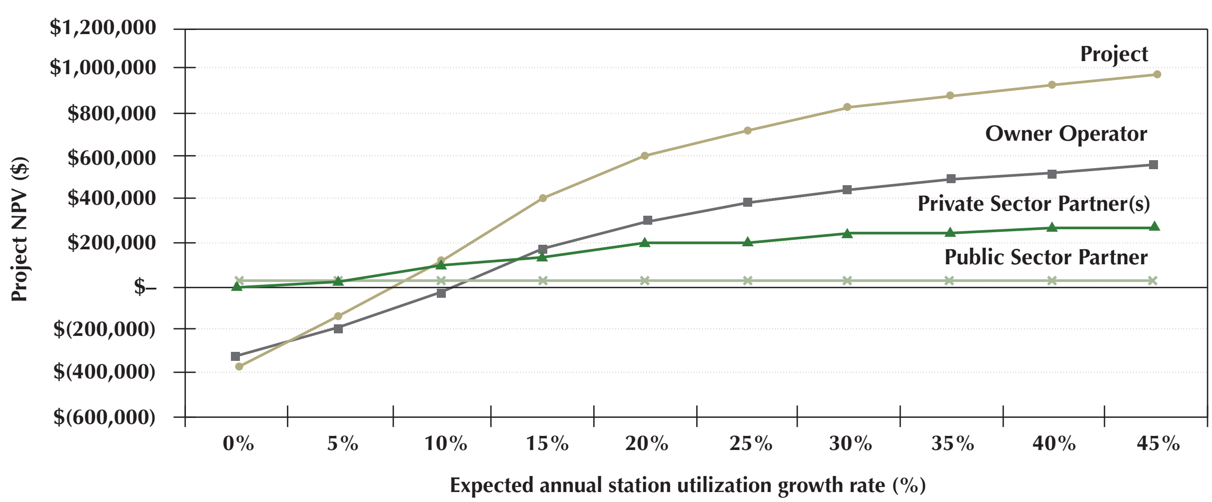


TABLE 47: Selection of Assumptions from Financial Analysis

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.

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