Portland General Electric Company
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PortlandGeneral.com

March 15, 2017

Public Utility Commission of Oregon
Attn: Filing Center
201 High Street, S.E.
P.O. Box 1088
Salem, OR 97308-1088

RE: UM 1811 Direct Testimony and Supplemental Application for Transportation Electrification Programs

Enclosed for filing in the above referenced matter please find the following:

- Supplemental Application for Transportation Electrification Programs
- Direct Testimony of: Brian Spak, Jacob Goodspeed (PGE / 100)
    - Appendix A – Updated Cost Effectiveness Analysis
    - Appendix B – PGE Schedule 344 Electric Vehicle Highway Pilot Report

PGE submits this filing pursuant to Oregon Administrative Rules (OARs) 860-087-0001 through 860-087-0040, which implements Sections 20(3) of Senate Bill 1547, codified in Oregon Laws 2016, Chapter 028, Sections 20 and 29.

If you have any questions or require further information, please contact Jacob Goodspeed at (503)464-7806.

Please direct all formal correspondence and requests to the following email address: pge.opuc.filings@pgn.com

Sincerely,

Karla Wenzel
Manager, Pricing and Tariffs

Enclosure

UM1811 / PGE / 100
Spak – Goodspeed

BEFORE THE PUBLIC UTILITY COMMISSION

OF THE STATE OF OREGON

UM 1811

Transportation Electrification

PORTLAND GENERAL ELECTRIC COMPANY

Direct Testimony of

Brian Spak
Jacob Goodspeed

March 15 2017

I. Introduction and Summary

Q. Please state your names and positions with Portland General Electric ("PGE" or "Company").

A. My name is Brian Spak. I am the Manager of Customer Energy Solutions at PGE. My qualifications appear in Section VII of this testimony.

My name is Jacob Goodspeed. I am an analyst in Pricing and Tariffs for PGE. My qualifications appear in Section VII of this testimony.

Q. What is the Purpose of your testimony?

A. The purpose of this direct testimony is to provide support for PGE's application for transportation electrification programs ("application"), which was filed with the Public Utility Commission of Oregon ("OPUC" or "Commission") December 27, 2016 (and revised on March 15, 2017), and which was subsequently docketed as UM 1811. The application filing was made in accordance with Oregon Laws 2016, Chapter 028, Section 20, and Oregon Administrative Rules (OARs) 860-087-0001 through 860-087-0040.

Q. What is PGE seeking from the Commission in this docket?

A. PGE is requesting approval of our supplemental application for transportation electrification programs. Upon program approval, PGE intends to file for deferred accounting treatment and approval of an Electric Avenue network rate schedule.

Q. Please outline the programs PGE has proposed in the application.

A. PGE's application details the Company's near-term efforts to accelerate adoption of transportation electrification and efficiently integrate electric vehicles (EVs) into the grid through four proposals:

1. Education, Outreach, and Technical Assistance

2. Electric Mass Transit Pilot
3. Electric Avenue Network Pilot
4. Residential Smart Charging Pilot

Q. Why did PGE select these proposals?

A. These proposals were designed to meet the specified transportation electrification objectives of both the law and the resulting administrative rules: providing investments that are prudent, expected to be used and useful, expected to improve grid efficiency and operational flexibility, and expected to stimulate innovation, integration, and customer choice. We have selected programs that were designed to be modest in scope, maximizing the opportunity for learning and net benefit to customers, while minimizing cost.

Q. Has PGE sought feedback from external stakeholders in advance of filing the application?

A. Yes. PGE held two well attended public workshops on August 2 and October 13 to discuss proposal ideas, and PGE has met individually with stakeholders who have expressed a desire to do so.

Q. You mentioned filing an initial application and a supplemental. Does the supplemental application contain differences from the initial application filed December 27?

A. Yes. The supplemental application (filed March 15, 2017) contains updates, requested by OPUC Staff, to provide additional information and clarification regarding PGE's proposed transportation electrification programs. Although many of the changes are structural in nature, the application has been revised as follows:

- Research and Small Pilots – the research and small pilots section has been modified to reflect the fact that many of the research projects discussed in the original application are existing initiatives currently underway in PGE's research and development (R&D) program. PGE has modified this section to focus on a residential smart charging pilot, as it represents the incremental R&D efforts being proposed.

- Electric Avenue Expansion – the section of the application detailing our proposed Electric Avenue expansion has been modified to include an outreach budget for enrolling customers into the program.
- Education, Outreach, and Technical Assistance – provides more details about the specifics of the proposed program, along with a revised (downward) budget.
- Market barriers section of the application has been removed, and a market barriers subsection for each proposed program has been added.
- Timeline and budget subsections – additional detail has been added, as has a cost-effectiveness subsection to each of the individual pilot proposals.
- Navigant study on net benefits – has been amended to update the cost-effectiveness of the proposed programs with budget revisions and the portfolio of proposed programs.

II. Education, Outreach, and Technical Assistance

Q. Please describe PGE's Education, Outreach, and Technical Assistance program.

A. PGE proposes an education, outreach, and technical assistance pilot program designed to increase awareness of plug-in electric vehicles (PEVs) among PGE customers, and to ease uncertainty around the maintenance, reliability, and feasibility of driving electric. The Company will execute this pilot through leveraging existing outreach channels and a wide range of partners to cost-effectively reach potential EV drivers. The focus of education and outreach will be to provide technical assistance for commercial and industrial customers, specialized trainings and rewards for key industry stakeholders (such as auto dealers and homebuilders), conduct ride and drive events, and offer education regarding how time-of-use rates can help incentivize charging at a time that is most beneficial to both the customer and PGE's grid.

Q. What are the market barriers the education, outreach, and technical assistance efforts will address?

A. PGE has identified multiple barriers to customer consideration and purchase of electric vehicles. Our outreach and education program is specifically designed to accelerate the adoption of transportation electrification by helping customers overcome the following barriers:

- **Lack of Consumer Awareness:** A 2015 study by UC Davis highlights states that "a lack of general consumer awareness of this basic availability (of electric vehicles) is the first problem to be overcome to expand zero emission vehicle (ZEV) markets." [1] According to Ad Age and Business Insider, less than one tenth of one percent of

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[1] Kurani, Ken. "New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon". UC Davis. 2015.

automaker advertising in 2015 went toward educating consumers about the benefits of electricity as a fuel source[2][3][4]. Further, some automakers used the complexities and anxieties of driving electric vehicles to actively discourage consumers from choosing a battery electric vehicle (BEV). In a 2014 study of 500 PGE customers, just 9% of customers reported that they are very knowledgeable about PEV technology and 36% of customers "are not at all knowledgeable about PEVs."[5]

- **Lack of auto dealer education/awareness:** Sierra Club's 2016 "Rev Up EVs" report studied the EV buying process at 308 auto dealerships across 10 states, including Oregon, and discovered that dealerships with high EV conversion "have their salespeople participate in regular trainings to keep up to date on EV technology and public policies." Dealerships with low employee knowledge of EV technology and policy miss an opportunity to successfully promote electric vehicles.
- **Challenges to home charging:** Though most EV charging occurs at home, there are numerous customer segments that do not have access to home charging. Many customers live in areas that lack off-street parking or a garage (including many multi-family customers). Without adequate information about how and where a customer can charge, these customers may not consider electric vehicles as a viable option.

Q. Please detail the components of the Education, Outreach, and Technical Assistance pilot that are designed to overcome the market barriers PGE has identified.

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[2] O'Reilly, Laura. "These are the 10 companies that spend the most on advertising." Business Insider. 6 Jul. 2015. http://www.businessinsider.com/10-biggest-advertising-spenders-in-the-us-2015-7
[3] Morris, Charles. "Auto Industry (except Tesla) Spends an Average $1,000 per Vehicle in Advertising." Charged EVs., 15 July 2016. https://chargedevs.com/newswire/auto-industry-except-tesla-spends-an-average-1000-per-vehicle-in-advertising/
[4] Maddox., Kate. "Global Ad Spending Will Be Up an Average 4.2% Next Year." Advertising Age., 11 June 2015. http://adage.com/article/btob/global-ad-spending-average-4-2-year/298980/
[5] 2014 PGE Customer Survey

A. PGE proposes to overcome identified market barriers through five discrete outreach and education programs:

- **Specialized Training:** We intend to conduct 5-10 specialized training sessions per year. These trainings will be targeted to auto dealerships, builders/electricians, facility managers, and sustainability managers.
- **Partner Rewards:** PGE proposes to create outreach material that details the benefits of driving electric. Our partners in this effort will include ride and car share companies, builders, and auto dealerships. Our intent is to provide small monetary rewards to these partners for sharing outreach information about the benefits of electric vehicles and for building "EV-ready" homes that include a dedicated 240V outlet to enable the installation of residential charging equipment.
- **Ride & Drive:** PGE intends to contract with a 3rd party to conduct up to 10 ride and drive events per year, with the goal of getting 5,000 customers over the life of the pilot to test drive a plug-in electric vehicle. These events will feature multiple make and models of electric vehicle, educational material on electric vehicles, and experts onsite to answer questions.
- **Time-of-Use (TOU) Outreach to EV Drivers:** Many EV drivers have the most to gain from a TOU rate, so we will develop marketing collateral and technical assistance materials that highlight these benefits. For charging service providers and site owners, we will continue to offer and educate customers about Schedule 38, a rate which does not include a demand charge component.
- **Regional Market Transformation Activities:** We anticipate collaborating with regional stakeholders on broader market transformation to promote effective

standards for residential and workplace charging stations (e.g. efficiency, functionality, etc.), best practices for retail displays, and charging network interoperability between regional utilities. To the extent opportunities to collaborate with other utilities regionally or nationally present themselves, PGE anticipates using a portion of the outreach funds to promote regional market transformation.

- **Technical Assistance:** PGE proposes to expand the ad-hoc technical assistance that we currently offer to business customers. We intend to expand our technical assistance offering by creating a formal EV technical assistance program for non-residential customers considering fleet electrification or installing workplace charging infrastructure. Additionally, the program will provide support to transit agencies, low-income service providers, and community-based organizations that are considering procurement of electric vehicles.

Q. What are the learning objectives of the Education and Outreach component of the pilot?

A. Through the pilot project, PGE hopes to learn:

- The impact of outreach efforts on awareness of electric vehicles in our service area.
- The impact of technical assistance programs on the installation of workplace EV chargers.
- The impact of outreach efforts on the consideration of electric vehicle for new car shoppers.
- The impact of outreach efforts on overall sales and leases of electric vehicles in the service area.

- The major challenges business customers face when planning for and siting electric vehicle charging infrastructure.
- The impact of outreach efforts on customer awareness and adoption of TOU rates

Q. How does PGE plan to measure "success" in an education and outreach program such as this?

A. We will test the success of this effort by looking at the following:

- Measure the impacts – Some of the components' impacts on customer adoption are large and concentrated enough to be directly measured – for example, surveys of customers served by technical assistance and the ride and drive events will provide useful metrics of those channels' impact on customer vehicle purchases.
- Survey customers on their awareness of electric vehicles and their exposure to our electric vehicle marketing campaigns. This approach will provide important data in case impacts are difficult to decipher from market-level sales data analysis. We will also ask customers whether marketing influenced their purchase as an indicator of effectiveness.
- Deploy survey instruments to a variety of populations, including:
- Recent EV purchasers
- Recent technical assistance customers
- Recent non-EV purchasers
- Trade allies (dealers, manufacturers)
- Key stakeholders (environmental organizations, transportation authorities, program staff)

Data collected from these populations will be critical in measuring impacts at each step of the vehicle purchasing process and on EV owners' charging behavior.

Q. Has PGE conducted any analysis regarding the benefit to customers of a targeted outreach and education program?

A. Yes. PGE has commissioned a study by Navigant Consulting (attached as Appendix A) that details the net benefits to customers of electric vehicles added in PGE's service area. The effectiveness from a benefits perspective of an outreach and education program is analyzed by using three separate tests from the California Standard Practice Manual: the Ratepayer Impact Measure Test (RIM) looks at the cost/benefit strictly from the point of view of customer bills, the Total Resource Cost Test (TRC) views the integration of electric vehicles from the perspective of a utility resource option, and the Societal Cost Test, which looks at the utility and non-utility impacts of the program. PGE's proposed outreach and education program is estimated to pass the net benefit test (in 2017 dollars) on all three measures. The estimated total net benefit for each test is shown in Table 1 below.

Customer Perspective Test (RIM)	Total Resource Cost Test (TRC)	Societal Cost Test (SCT)
$2,089,176	$3,465,122	$4,234,224

Table 1 – Net Benefit Test for Education, Outreach, and Technical Assistance Pilot

Q. PGE projects spending $2.54 million on this program; can you give more detail on how this amount will be spent?

A. Yes. Table 2 below details PGE's planned outreach and education spending:

Table 2 – Education, Outreach, and Technical Assistance estimated budget

Cost Element	Detail	2018	2019	2020	2021	2022
Technical Assistance	1 FTE	$ 183,000	$ 188,500	$194,200	$200,000	$206,000
Technical Assistance	Collateral and web	$ 25,000	-	$ 25,000	-	-
Specialized Training	Curricula development	$ 22,500	-	$ 22,500	-	-
Specialized Training	Collateral, tools, handouts	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Specialized Training	Administration/Trainin g	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Partner Rewards	Content creation/admin	$ 60,000	$25,000	$25,000	$25,000	$25,000
Partner Rewards	Builder rewards	$6,250	$ 18,750	$ 25,000	$ 25,000	$ 25,000
Partner Rewards	TNC Rewards	$15,000	$ 22,500	$ 37,500	$ 60,000	$ 60,000
Partner Rewards	Print collateral	$7,500	$ 15,000	$ 22,500	$ 25,000	$ 25,000
Ride &drive/pop-ups	Planning & Development	$25,000	-	-	-	-
Ride &drive/pop-ups	Event management	$100,000	$ 100,000	$ 100,000	$ 100,000	$100,000
Regional Market Transformation Activities		$50,000	$ 50,000	$ 50,000	$50,000	$50,000
	Total	$ 524,250	$ 449,750	$ 531,700	$ 515,000	$ 521,000

Q. Will PGE use a competitive request for proposal (RFP) process to procure services?

A. Yes. A competitive RFP process will be used to select one or more vendors to support:

- Outreach content material design and development (web, print, video);
- Develop specialized curricula and training materials for key industry stakeholders;
- Conducting specialized trainings;
- Content creation and administration of partner rewards pilots; and
- Planning and executing ride and drive events.

III. TriMet Fleet Electrification (Electric Mass Transit Pilot)

Q. Please explain the electric mass transit pilot that was proposed by PGE in the application.

A. PGE proposes to install and manage six electric bus charging stations (five 100-kW depot chargers and one 300-kW en-route charger) for use as part of a mass transit electrification pilot with TriMet.

Q. Will distribution system upgrades be necessary to accommodate these high demand chargers?

A. Yes. As with most new service, there are localized upgrades needed to support the load. PGE plans to make the following upgrades to accommodate the charging needs of this pilot:

- Run new conduit to TriMet property;
- Install a transformer pad and a 500 kV transformer to serve new load;
- Install five 100kW bus chargers in TriMet garage;
- Upgrade distribution to support the en-route charger; and
- Install one (1) 300 kW en-route charger

Q. What are PGE's intended learnings of the pilot?

A. PGE will learn:

- The impacts of depot chargers on PGE's distribution system. Though these high-power chargers are not prevalent on our system today, it is likely they will proliferate over the next decade for bus and personal vehicle use—it is crucial we begin to understand how these impact the grid.
- Coincident and non-coincident peak demand impacts of high-powered bus charging.

- What additional infrastructure, if any, is needed to support and ensure reliable bus charging (and applicable costs).
- Fleet impacts and fleet facility upgrade costs (to support technical assistance to other bus-fleet customers).
- Charging infrastructure installation, operation, and maintenance costs.
- (Potentially) Ability to use energy storage to limit peaking impacts and distribution upgrades of extreme fast chargers.
- Customer charging behavior and ability to respond to price signals. Our initial deployment with TriMet will include time-of-use rates with demand charges (through Schedule 85-P). We intend to study the system impacts on peak days, evaluate the bus charging use case, assess the customer's needs, and develop models that we believe will be beneficial to all customers. We may include these alternative dynamic pricing elements in the future to maximize the benefit of this program to all customers.

Q. How will PGE evaluate the impacts of the TriMet pilot?

A. Evaluation of the impacts of the TriMet pilot is relatively straightforward in that the evaluator will gauge how many additional buses are attributable to PGE's involvement. For those buses, grid impact and diesel bus miles avoided will be calculated.

Q. Please explain why PGE is proposing to own the charging equipment.

A. In August 2016, TriMet announced that it had been awarded $3.1 million of grant funding from the Federal Transit Administration (FTA) to pilot the electrification of mass transit in the tri-county area. PGE's participation in this pilot – through owning and operating the charging equipment – allows TriMet to purchase an additional electric bus, enabling the electrification of an entire bus route. Accordingly, PGE's ownership will create additional learnings from their pilot bus deployment that may enable faster growth of the electric bus market in PGE's service area.

As TriMet explores the electrification of their entire bus fleet, PGE's ability to partner closely with TriMet to evaluate the current and future impacts to the grid should increase the benefits to all PGE customers of more electrified bus transit over time. Access to utilization data of these high impact chargers will inform load profiles and distribution system impacts associated with the chargers. These learnings will improve siting and allow us to better plan for future electric bus deployments.

Q. Will there be revenue associated with the installation and ownership of these chargers?

A. Yes. PGE proposes to procure and own the chargers, while TriMet will bear the cost of their installation and maintenance. The capital cost for the five chargers is $625,000. The incremental energy used by these new chargers will be separately metered and will be recovered through Schedule 85-P, TriMet's current retail rate. En-route chargers may be metered separately and incremental energy will be recovered through a standard retail rate. PGE will bear responsibility for maintaining the charging equipment and TriMet will pay costs associated with PGE's maintenance of the infrastructure on a time and materials basis.

IV. Electric Avenue Network

Q. Please describe PGE's Electric Avenue Expansion as outlined in the application.

A. As outlined in the filed application, PGE proposes to provide our customers a network of public quick charging (DC Quick Chargers or DCQCs) stations. The network will include:

- PGE's existing Electric Avenue site located at the World Trade Center in Portland.
- Six additional Electric Avenue community charging stations throughout our service area. Like the existing Electric Avenue, these community charging stations will consist of multiple dual-head fast chargers and a level 2 charger.
- Integrating (and upgrading where necessary) existing satellite public charging stations operated by PGE into the network.

All DCQCs will be equipped with two interoperable charging ports (SAE Combo and CHAdeMO) in order to accommodate nearly all mass market vehicles on the road. Providing visible and reliable charging infrastructure will increase accessibility for customers who currently drive an electric vehicle, and will promote the ease and feasibility of driving electric for customers who are considering an electric vehicle.

Q. Why is additional public charging infrastructure needed in PGE's service area?

A. Additional public charging infrastructure is needed to address barriers to increased adoption of electric vehicles. The barriers addressed through additional charging stations are:

- **Lack of visible and/or accessible charging infrastructure:** Cornell University has conducted research showing that in a study of 353 metro areas, an "increased availability of public charging stations has a statistically and economically significant impact on EV adoption decisions."[6] Further, a "lack of robust DC Fast Charging infrastructure is seriously inhibiting the value, utility, and sales potential of medium-range battery electric vehicles."[7] Despite most electric vehicle charging occurring at home, a UC Davis report notes "addressing concerns about availability of away from home charging is much about perception of an extensive fueling network."[8] The 2016 Transportation Vision Panel report to Oregon Governor Kate Brown notes that public charging availability and reliability are critical for customers considering purchasing an EV.

> *"Beyond simply installing chargers, the build-out of a robust, connected PEV charging infrastructure in Oregon is important to help bridge the gap between Innovators and Early Adopters. With the deployment of a robust fast-charging network, the Northwest PEV driver will no longer be limited to the 100-mile range of the typical PEV, but will be able to traverse the state to destinations that were previously unattainable."*[9]

- **Lack of home charging for significant portions of the population**: Roughly half of PGE's residential customers live in multifamily housing, which is a difficult segment to reach through residential charging. Moreover, many of PGE's residential customers live in single-family homes that either lack off-street parking or for whom the cost of re-wiring their own electric service is prohibitive to the installation of a dedicated home charger.
- **Lack of public charging for shared vehicles:** electric vehicles yield the most potential operation savings for customers that drive a lot. Many transportation network drivers (i.e. Uber and Lyft) as well as car share company fleet operators do not see electric vehicles as

[6] Li, S. et al., "The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts," Cornell University, June 2015.
[7] Hajjar, Norman, New Survey Data: BEV Drivers and the Desire for DC Fast Charging, Plug Insights, March 11, 2014.
[8] New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon (2015 UC Davis)
[9] Energize Oregon. http://www.oregon4biz.com/assets/docs/EVrpt2013.pdf

a reasonable solution for their needs due to the lack of public charging infrastructure. Car share vehicles essentially have no "home" at which to charge, and TNC drivers often need a quick fill-up while on the go. We have heard directly from these stakeholders that the largest barrier to adding EVs to their fleets is the availability of public quick charging infrastructure.

Q. Why is it necessary for PGE network locations to have more than one charger on-site?

A. Community charging stations with multiple chargers (known as co-locating) provide increased visibility, availability, and reliability of public charging infrastructure. By their nature, co-located chargers take up more space and are inherently more visible. Furthermore, PGE intends to site charging infrastructure in highly visible locations. By co-locating chargers, an EV in need is more likely to also receive a charge. The overwhelming majority of DCQC installations in PGE's service area today are single chargers. In those locations, a vehicle in need of a charge may not be able to receive one if another EV is charging, if an internal combustion engine vehicle has parked in the spot, or if the charger, for whatever reason, is out of service. Much like gas stations are structured today, co-locating chargers makes it more likely that a vehicle in need of a charge is able to receive one quickly and be on their way.

Q. Why is it necessary for a utility to own public charging infrastructure?

A. We have proposed ownership of public charging infrastructure because it is the most prudent use of customer funds to spur the public charging market. As outlined in our Schedule 344 Electric Vehicle Highway Pilot report (filed December 15, 2016 and included as Appendix B), publicly-available fast charging is a nascent market and the availability and accessibility of charging may be impacted by the stability of the Electric Vehicle Service Equipment

(EVSE) provider. Through partnership between PGE and EVSE providers, we are able to provide a more stable ownership model and increased certainty of charger availability.

Additionally, although PGE plans to own the charging infrastructure, we will issue RFPs for engineering/design, hardware, back-end payment network, and system maintenance.

Q. Does PGE have experience partnering with EVSE providers to install public charging infrastructure?

A. Yes. PGE has previously partnered with EVSE providers to install community charging stations as part of the Oregon Electric Vehicle Highway Pilot (Highway Pilot). The goal of the Highway Pilot was for PGE to assist EVSE providers in siting and installing publicly available charging stations in PGE's service area. The intended learnings were for PGE to study the impact of fast chargers on the grid infrastructure, customer charging behavior, and gain information to support outreach to EV drivers and site hosts – while allowing the EVSE providers to retain ownership and maintenance responsibility for the charging infrastructure. The pilot ultimately saw the installation of 14 co-located charging stations, each consisting of a fast charger and a level 2 charger.

Q. Does PGE currently own any public charging infrastructure?

A. Yes. PGE currently owns the Electric Avenue community charging station outside of our World Trade Center headquarters. Electric Avenue features 4 dual-head DC quick chargers and 1 dual-head level 2 charger.

Additionally, following the bankruptcy of one EVSE provider, and a second EVSE provider opting to exit the market, PGE assumed custodianship of 13 abandoned community charging stations installed as part of the Highway Pilot in order to ensure their availability and accessibility to customers. A complete list of the charging stations of which PGE has assumed custodianship is included below as Table 3.

Site[10]	Infrastructure Installed	Service Address[11]
1	Blink DCQC and 2 Blink L2	Redacted Portland, Ore.
2	Blink DCQC	Redacted Portland, Ore.
3	Blink DCQC and 1 Blink L2	Redacted Keizer, Ore.
4	Blink DCQC and 1 Blink L2	Redacted Sherwood, Ore.
5	Blink DCQC and 2 Blink L2	Redacted Wilsonville, Ore.
6	Blink DCQC and 3 Blink L2	Redacted Portland, Ore.
7	2 Blink L2	Redacted Salem, Ore.
8	Blink DCQC and 2 Blink L2	Redacted Silverton, Ore.
9	Blink DCQC and 2 Blink L2	Redacted Woodburn, Ore.
10	Efacec DCQC and Opconnect L2	Redacted Tigard, Ore.
11	Efacec DCQC and Opconnect L2	Redacted Tigard, Ore.
12	Efacec DCQC and Opconnect L2	Redacted Salem, Ore.
13	Efacec DCQC and Opconnect L2	Redacted Gladstone, Ore.
14	Efacec DCQC and Opconnect L2	Equipment removed upon customer request

Table 3 – charging stations of which PGE has assumed custodianship

Q. Please describe how the Electric Avenue expansion as requested in the application does not impede or reduce EVSE competition in Oregon.

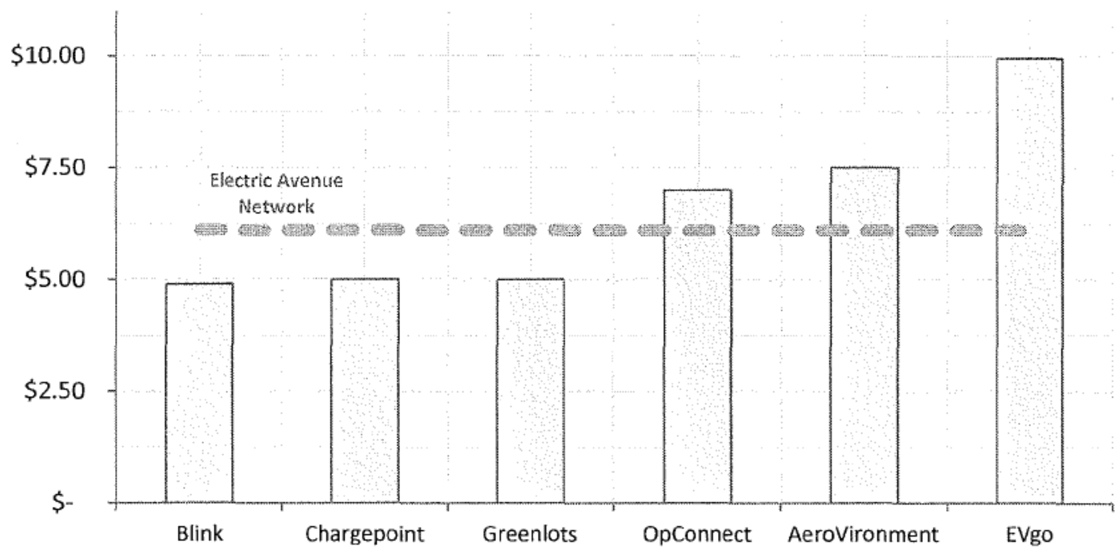
A. The proposed expansion of the Electric Avenue system is designed as pilot program to assist PGE in determining how customers use visible public charging, how visible charging infrastructure impacts customer attitudes toward purchasing electric vehicles, and how customer usage patterns can be integrated with our distribution system. With over 50

[10] Customer name redacted under OAR 860-001-0070. Available upon Staff request.
[11] Service address redacted under OAR 860-001-0070. Available upon Staff request.

DCQCs in the Portland metropolitan statistical area, the expansion of six new community stations is not expected to saturate the market.

Additionally, we have analyzed publicly available charger pricing data to estimate the average customer costs for using public charging infrastructure. We then developed Electric Avenue Network pricing to avoid undercutting the market-based pricing offered by other providers. A comparison of the Electric Avenue Network pricing and market rate pricing is show in figure 1 below.

Figure 1: Comparison of proposed Electric Avenue rate and Market Rates



Q. What is the approximate cost of this program, and how does PGE plan to recover this amount?

A. The cost of the Electric Avenue expansion is estimated to be $4.1 million, with $3.5 million estimated in revenues from subscriptions and pay-per-use charges (10-year NPV). This estimate does not include credits associated with the low-carbon fuel standard or any other environmental compliance benefit. It also does not factor in the general downward rate pressure that should occur as a result of more electric vehicles integrating into the grid.

PGE intends to create an end-use charging rate schedule to administer the prices associated with this pilot, with a balancing account attached to the schedule. At the end of each year, PGE will analyze the revenue collected, operating costs, and utilization and will adjust pricing for the upcoming year accordingly. We intend to offset customer costs associated with the expansion of the Electric Avenue network primarily through competitive pricing.

Q. Please describe the end-use pricing offerings that PGE has proposed in the application.

A. PGE proposes two pricing options for end-use charging customers. These prices will be administered through a rate schedule specifically for end-use public charging.

Monthly Subscription: the customer will pay a flat monthly fee and in exchange, will not be required to pay an additional fee when utilizing an Electric Avenue charger off-peak. Only PGE customers will be eligible to register for this option.

Pay-per-use: customers who do not wish to subscribe (or who do not reside in PGE's service area), will pay a fixed charge per use to cover administrative and system costs to serve this customer.

To send appropriate price signals and to discourage public charging during periods of system constraint, all customers of an Electric Avenue charger may be charged for on-peak energy consumption. PGE proposes to use Schedule 6's two period time of use defined summer hours to identify on-peak periods (on-peak is defined as 3pm-8pm M-F excluding holidays)[12]. The proposed pricing structure for Electric Avenue Network sites is shown in Table 4 below:

[12] https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_006.pdf

	Monthly Fee ($/mo.)		**Off-Peak Charge** ($/charge)		**On-Peak Energy Charge** ($/kWh)
Option 1: Monthly Subscription	$25.00	+	-	+	$0.19
Option 2: Pay-per-Use (registered)	-		$5.00		$0.19

Table 4: Proposed Electric Avenue Pricing

Q. If modifying the prices in this pilot is not sufficient to recover the costs of this program, how would PGE propose to recover the costs?

A. PGE intends to use price modification from year to year as the primary tool to attempt revenue neutrality in the Electric Avenue pilot. If utilization of our charging infrastructure is not sufficient to recover the full cost, we would propose to account for and recover the remaining amount through the TE deferral mechanism discussed in section VI.

V. Residential Smart Charging Pilot

Q. Please describe PGE's proposal to conduct a Residential Smart Charging pilot, as described in the filed application.

A. We intend to create a research and development pilot for up to 200 customers, which will focus on demand response opportunities associated with residential charging. The pilot will explore customer impacts and achievable curtailment from residential charging.

Q. What is the learning that PGE hopes to achieve through the residential smart charging pilot?

A. PGE will use this pilot to foster learning around electric vehicle grid integration, customer experience, and customer response to price signals to shift charging loads to off-peak periods.

Data from the chargers will allow for estimation of the load characteristics of the chargers. A third-party evaluator will compare the chargers to other chargers and/or to the same chargers during periods when the device is not being controlled. This comparison will allow for an estimation of the changes in load attributable to the pilots.

Q. What will the evaluation metrics of this program be?

A. The pilot will evaluate:

- what tactics achieve program participation,
- whether a small incentive influences a customer's decision to purchase a smart charger,
- how much load can feasibly be shed or shifted from a residential charging station,
- technical and OEM viability,
- customer attrition, and

- cost-effectiveness.

Q. What is the benefit to customers of PGE conducting this program?

A. This pilot will give PGE greater insight into the residential charging behavior of customers, including whether customers are responsive to curtailment and load-shifting signals from the utility and the degree to which the coincidence of EV charging provides for a cost-effective demand response resource. This pilot will examine improved electric vehicle grid integration and the potential value of PGE flexibility in curtailing charging or shifting load to times of high renewable production.

VI. Cost Recovery

Q. Please provide an overview of the incremental cost recovery mechanisms that PGE plans to pursue.

A. Upon approval of the application, and pursuant to ORS 757.259 and OAR 860-027-0300, PGE intends to request authorization to defer for later ratemaking treatment of the incremental revenue requirement associated with the transportation electrification pilots outlined in our application. If a deferral is filed and approved, PGE would record the deferred amounts as a regulatory asset in FERC account 182.3, Other Regulatory Assets, with a credit to FERC account 407.4, Regulatory Credits.

The amounts deferred would include the revenue requirement of the Electric Avenue Pilot, the chargers associated with the Electric Mass Transit pilot, administration of the smart charging pilot, and education, outreach, and technical assistance costs associated with accelerating transportation electrification. The revenue associated with Electric Avenue subscriptions and usage, as well as the revenue associated with Electric Mass Transit, would be included as a regulatory credit to offset the costs. The estimated cost and revenue amounts are shown in Table 5 below.

	Estimated Revenue Requirements	**Estimated Customer Payments**	**Net Revenue Requirement**
Outreach and Technical Assistance	$ 2,054	-	$ 2,054
Electric Mass Transit	$ 1,239	$ 641	$ 598
Electric Avenue Network	$ 4,098	$ 3,547	$ 591
Bring Your Own Charger	$ 171	-	$ 171
Pilot Evaluation	$ 581	-	$ 581
Total	$ 8,142	$ 4,188	$ 3,954

Table 5: Revenue Requirement Summary ($000)

Q. Please explain the difference in treatment between the Electric Avenue expansion pilot and the other pilot programs that PGE has proposed in the application.

A. PGE intends for the Electric Avenue pilot to generate revenue to mitigate its cost. At the end of each year, the revenues collected will be compared to forecast and end-user prices may be adjusted for the upcoming year. However, as this is an emerging market and EV adoption into the future is difficult to forecast, PGE proposes installing a rate schedule specific to the end-use charging, with revenues being recorded in FERC account 407.4, Regulatory Credits. The revenue generated through both charging subscriptions and per-use charging would be used to offset the cost of the programs included in the application, starting with the Electric Avenue pilot.

PGE intends to request an Electric Avenue balancing account as part of the deferral application, which would allow PGE to track revenues generated by Electric Avenue compared to the actual cost of the pilot.

Q. In the event that the Electric Avenue expansion pilot is ultimately revenue-positive, how would PGE use the net gain from this program?

A. In the event that revenue from the Electric Avenue expansion is in excess of the cost of the pilot, PGE proposes to use this surplus to offset the costs of other approved pilot programs from the application. In the unlikely event that revenue generated from the Electric Avenue pilot is greater than the costs of all the pilots listed in the application, surplus revenue would be refunded to customers.

Q. If revenue is insufficient to cover the cost of all the pilots, how does PGE propose to collect the deferred costs?

A. If Electric Avenue expansion costs exceed revenues, as depicted in Table 5, we would propose to recover the remaining balance through a supplemental schedule. According to the net cost estimates in Table 3, we estimate the overall price impact to be approximately 0.22%.

Q. If PGE were not authorized to defer the costs associated with these programs, would PGE plan to implement these programs anyway?

A. No. If a deferral is not granted, PGE would not conduct the programs outlined in the application.

VII. Qualifications

Q. Mr. Spak, please state your educational background and experience

A. I received a Bachelor of Arts in Letters, Arts, & Sciences from Penn State University and a Master of Arts degree in Global Environmental Policy from American University. Prior to my current role I managed PGE's federal government affairs function. I also have nearly a decade of experience as a sustainability and energy policy consultant to institutional investors, Fortune 500 companies, environmental NGOs, and clean tech companies in Washington DC.

Q. Mr. Goodspeed, please state your educational background and experience.

A. I received a Bachelor of Arts degree in Public Policy from Washington State University and a Master of Business Administration degree from the University of New Orleans. I accepted my current role at PGE in 2016, and have previously worked in Senior Pricing Analyst and Pricing Lead roles for Entergy Services, Inc., providing pricing and rate design support to Entergy Louisiana LLC., Entergy Texas Inc., Entergy New Orleans Inc., and Entergy Arkansas Inc. I have also served as a financial analyst in Entergy's nuclear organization.

Q. Does this conclude your testimony?

A. Yes.

Cost Effectiveness Analysis of Transportation Electrification Program Options

Presented to:

Portland General Electric

Portland General Electric

121 SW Salmon St,

Portland, OR 97204

December 19, 2016

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Table of Contents

Executive Summary

PGE seeks to compare program options to determine which programs will cost-effectively support the transportation electrification market and to understand the cost effectiveness of a transportation electrification portfolio as a whole. The goal of this study was to develop a framework to continuously evaluate and improve PGE's transportation electrification support efforts, then apply that framework to PGE's proposed portfolio to provide initial indications about cost effectiveness.

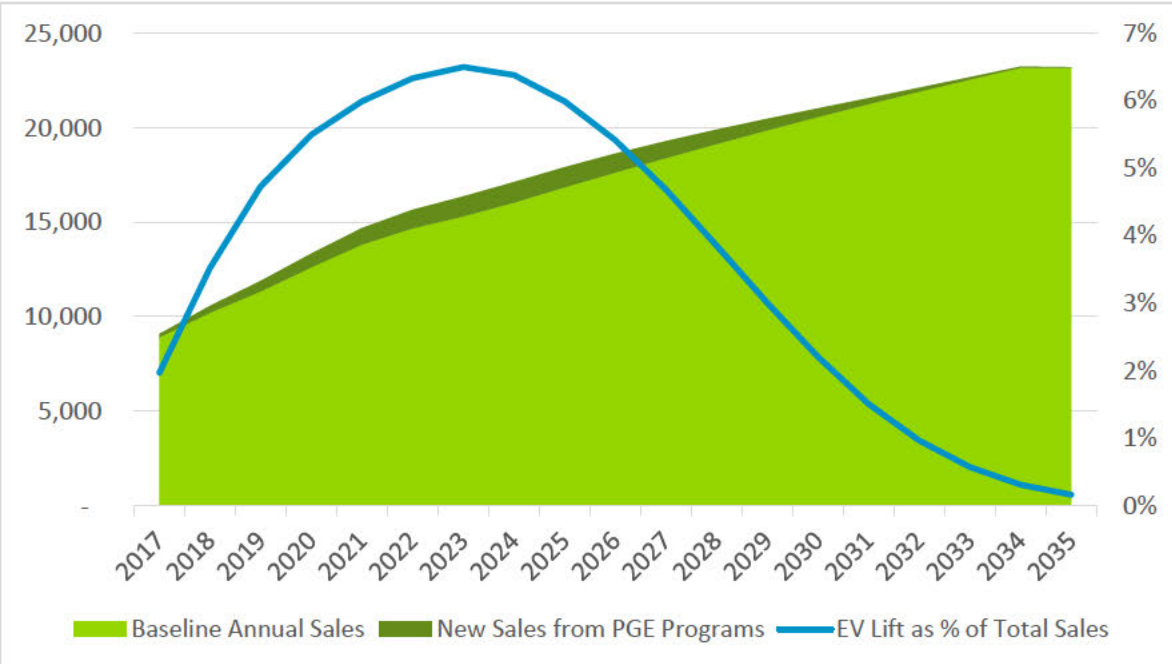
Through the course of this study, Navigant developed a cost effectiveness framework for transportation electrification support efforts that builds on the methodologies employed in other jurisdictions, including California and Seattle, and is consistent with the framework that PGE set forth for demand response cost effectiveness.[1] The framework sought to answer two questions:

- What is the baseline electric vehicle market and PGE's influence on the market (i.e., electric vehicle "lift")?
- What are the costs and benefits for each program and the portfolio of transportation electrification programs as a whole?

The analysis considered these questions for PGE's Electric Mass Transit 2.0, Outreach & Education, and Community Charging Infrastructure programs, as well as PGE's transportation electrification portfolio as a whole. To do this, Navigant developed a baseline forecast of electric vehicles within PGE's service area, then forecasted the estimates of each program's influence on the market, and finally monetized the value streams identified for each program.

Navigant found that the electric vehicle lift caused by PGE programs represents an average increase of roughly five percent new vehicle sales in the total cumulative electric vehicle sales forecast. Annual forecast electric vehicle sales and electric vehicle lift are shown in Figure 1.

As Figure 1: Annual Baseline and New Sales in PGE Territory

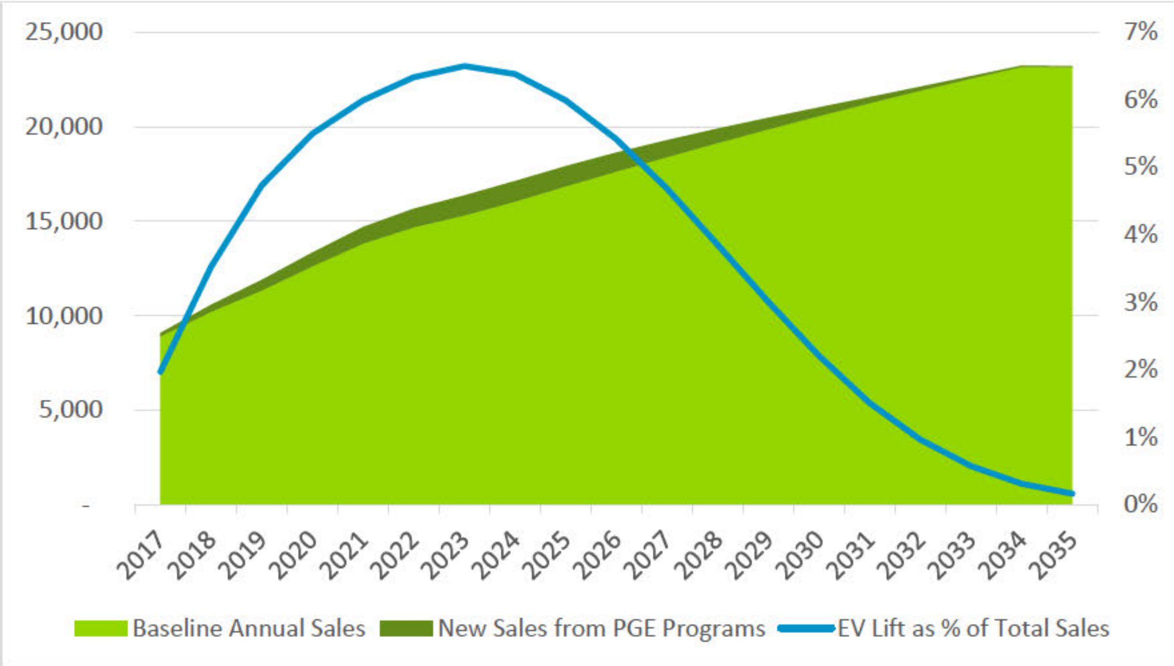


Source: Navigant analysis, 2016

[1] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf.

shows, PGE's Light Duty Vehicle programs are expected to be cost effective. When combined with the Electric Mass Transit 2.0 program, PGE's transportation electrification market support efforts are cost effective at the portfolio level.

Figure 1: Annual Baseline and New Sales in PGE Territory



Source: Navigant analysis, 2016

Table 1: Summary of Net Benefits by Program and Cost Effectiveness Test

	Rate Impact Measure Test	Total Resource Cost Test	Societal Cost Test
Net Benefits By Program (2017 $)			
DCQC Stations	$4,044,163	$2,297,870	$3,739,595
Education and Awareness	$2,089,176	$3,465,122	$4,234,224
Electric Mass Transit 2.0	$(1,037,395)	$(1,059,005)	$(1,332,532)
Overall Portfolio	**$5,095,945**	**$4,703,987**	**$6,641,287**
Net Benefits Per Vehicle (2017 $)			
DCQC Stations	$994	$592	$946
Education and Awareness	$734	$1,182	$1,452

Electric Mass Transit 2.0	$(1,037,395)	$(1,059,005)	$(1,332,532)

Source: Navigant analysis, 2016

Section I Introduction and Background

PGE seeks to compare program options to determine which programs will cost-effectively support the transportation electrification market and to understand the cost effectiveness of a transportation electrification portfolio as a whole. The goal of this study was to develop a framework to continuously evaluate and improve PGE's transportation electrification support efforts, then apply that framework to PGE's proposed portfolio to provide initial indications about cost effectiveness.

The framework is based on past studies and research:

- Studies in other jurisdictions (California and Seattle) quantify net benefits of electric vehicles on a per vehicle basis.
- Independent researchers develop electric vehicle sales forecasts based on market factors.
- State and local policymakers set electric vehicle sales goals.
- This framework is consistent with and builds upon the framework that PGE set forth for demand response cost effectiveness.[2]

The framework will allow PGE to:

- Determine net benefits on a per electric vehicle basis using different cost tests typically used for utility resource planning.
- Track transportation electrification market progress over time.
- Begin to attribute market progress to transportation electrification support efforts offered by PGE's portfolio of programs.

The scope of the analysis discussed in this report focused on the following program options:

- Outreach & Education
- Community Charging Infrastructure
- Electric Mass Transit 2.0

PGE is also currently conducting R&D pilots for transportation electrification; however, this analysis does not include R&D, given the focus is on longer-term learning, rather than direct market impacts, and does not lend itself to the same type of cost effectiveness analysis.

The remainder of this report includes the following sections:

- Section II outlines the cost effectiveness methodology employed for this analysis. This includes a description of the electric vehicle market forecast methodology, forecast estimates of PGE's influence on the market, and all monetized value streams in the analysis.
- Section III summarizes the results of the analysis by cost test and in terms of the additional electric vehicles sold as a result of PGE's programs.
- Section IV concludes findings from the analysis and provides a directive for further research required to more accurately assess the cost effectiveness of the PGE's transportation electrification programs going forward.

Section II Methodology

[2] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf. See also EPRI http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=3002007751.

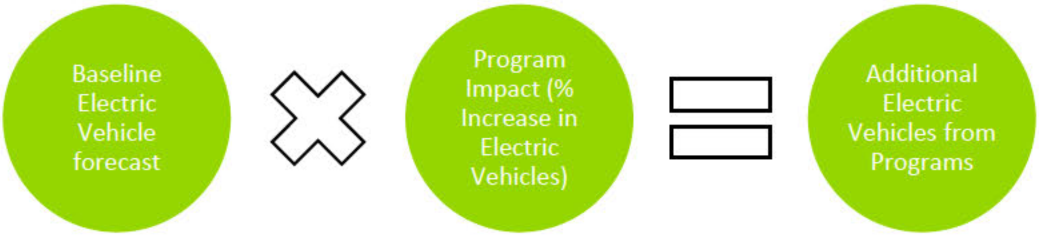
This section presents a high-level overview of the methodology, with more detailed information provided on the methodology for developing the baseline electric vehicle forecast and the transportation electrification program impacts.

Appendix B provides more detail on the overall methodology.

2.1 Overview of Methodology

The analysis was structured in two steps outlined below.

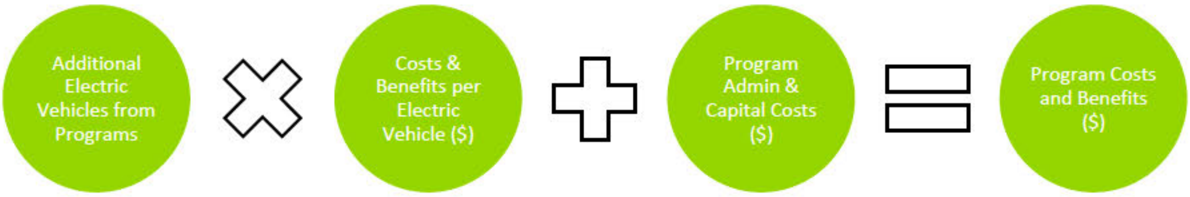
Step 1: What is the baseline electric vehicle market and PGE's influence on the market?



Source: Navigant analysis, 2016

Step 1 quantifies the additional electric vehicle sales attributed to PGE's programs, also known as "electric vehicle lift". The basis of this analysis is a baseline electric vehicle forecast by zip code in PGE's service area created by Navigant Research, as described in more detail in Section 2.2. The team defined the program impact using customized Weibull distributions to simulate market diffusion of electric vehicles based on the rationale for each program, as described in more detail in Section 2.3.

Step 2: What are the costs and benefits for each program?



Source: Navigant analysis, 2016

Step 2 quantifies the additional value streams (in terms of both costs and benefits) from each additional electric vehicle in the market. From there, addition of the overall program administrative and capital costs yields the total costs and benefits for each program.

As part of Step 2, Navigant assessed fourteen cost and benefit streams for transportation electrification cost effectiveness. Table 1 summarizes the cost and benefit streams quantified in this analysis by cost test.

This framework for transportation electrification cost effectiveness builds on the framework Navigant developed in coordination with PGE for demand response cost effectiveness,[3] with adjustments for costs and benefits specific to transportation electrification. The framework is consistent with the methods proposed in the California Public Utilities Commission's *2010 Demand Response Cost Effectiveness Protocols* and similar to the framework used in other jurisdictions, such as Seattle City Light and the Electric Power Research Institute.[4] Appendix A provides more information on each of the cost and benefit streams, including the definition, calculation description, and monetization unit.

[3] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf

[4] Seattle City Light Transportation Electrification: Technical Impacts, Market Research, Program Design. 2015. See also EPRI http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=3002007751

Given the nascent and uncertain future of the impact of utility programs on electric vehicle adoption, the inputs and assumptions used within this analysis should be regarded as early indicators of market trends, with a high degree of uncertainty. Over time, Navigant expects that the uncertainty bands will narrow as the industry collects more robust data through retrospective evaluation, bringing the impact of programs on electric vehicle adoption into focus.

Table 2 below summarizes the cost effectiveness tests and value streams used in the transportation electrification analysis. Note that the Pre-Existing Program benefits and costs refer to PGE revenues and costs from the existing Electric Avenue, Blink, and Powin charging stations respectively.

Table 2. Summary of Cost-Effectiveness Tests and Proposed Value Streams for Transportation Electrification Programs[5]

Cost/Benefit Category	Total Resource Cost Test	Rate Impact Measure Test	Societal Cost Test
Avoided Gasoline Costs	Benefit		Benefit
Increased Capacity Costs	Cost	Cost	Cost
Reduced Fuel Emissions			Benefit
Increased Energy Emissions			Cost
Increased Electricity Sales		Benefit	
Increased Energy Supply Costs	Cost	Cost	Cost
Customer Tax Credits – Federal	Benefit		Benefit
Customer Tax Credits – State	Benefit		
Customer O&M Savings	Benefit		Benefit
Utility Tax Credits – Federal	Benefit	Benefit	Benefit
Utility Tax Credits – State	Benefit	Benefit	
Pre-Existing Program Benefits	Benefit		
Pre-Existing Program Costs	Cost		
Utility Capital Costs	Cost	Cost	Cost
Utility O&M Costs	Cost	Cost	Cost
Utility Admin Costs	Cost	Cost	Cost
Customer Charger Costs	Cost		Cost
Customer Vehicle Costs	Cost		Cost
O&M Payments from TriMet		Benefit	
Federal Bus Electric Vehicle Grant	Benefit		Benefit

[5] Cost and benefit designations for each stream are based on Navigant analysis and California Public Utilities Commission, Attachment 1: *2010 Demand Response Cost Effectiveness Protocols*

Source: Navigant analysis, 2016

Several potential benefits and costs of transportation electrification were excluded from the analysis, due to the uncertainty associated with quantifying and monetizing the benefit. These include:

- The value of Low Carbon Fuel Standard[6] credits that PGE may earn as a result of the programs.
- The value of ancillary services and/or power quality services that transportation electrification may provide to PGE's distribution grid.
- Non-energy and non-emission-related benefits from transportation electrification, including enhanced public image for PGE and the City of Portland, customer satisfaction, noise pollution, etc.
- Additional potential costs of transmission and distribution

2.2 Baseline Electric Vehicle Forecast

Navigant Research uses a technology competition model to forecast electric vehicle sales at the national level. The forecast model uses high-level macroeconomic factors like gross domestic product and population as well as vehicle density and historic sales data to project overall light vehicle market growth. Sales forecasts per technology segment analyzed are determined by estimating the market share of the technology against competing platforms as a function of a number of variables that feed into the consumer choice such as: purchase and operating costs, vehicle range, refueling/recharging infrastructure and other factors influencing electric vehicle capability and convenience.

Results from the national sales model for PHEVs and BEVs are then fed into a model that disaggregates the forecasts by state. State PEV sales are disaggregated based on state and local purchase incentives, mandates, retail fuel prices, demographics, and historic sales data.

Results from the state-level disaggregation are fed into a model that further disaggregates the forecasts by county. This county-level disaggregation is based on consumer demographics, estimated county vehicle market size as a function of population density, sales history, and data derived from Navigant Research's *Electric Vehicle Consumer Survey*.

The Electric Vehicle Consumer Survey is used to determine the demographic distribution profile of the ideal PEV market. This PEV profile is used to compare demographic distributions among geographic jurisdictions in terms of potential interest in PEVs. The demographic characteristics analyzed include age, household income, and education. The PEV profile in 2016 is skewed toward younger, wealthier, and more educated population segments.

Navigant Research's underlying data on electric vehicle sales is updated depending on the level of its geographic granularity and availability. National level sales data is tracked monthly and is widely available publically; state level sales data is less available publically with the nearest tracking reports typically lagging the market by four to five months; lesser geographic segmentations are typically not available publically, however state DMV's do sometimes provide vehicle sales and registration data on request. Navigant Research does however collect county level vehicle registration data from a vendor on an annual basis. Figure 2 shows the plug-in electric vehicle sales in the region from 2011 through 2015.

[6] See SB 324 https://olis.leg.state.or.us/liz/2015R1/Measures/Overview/SB324

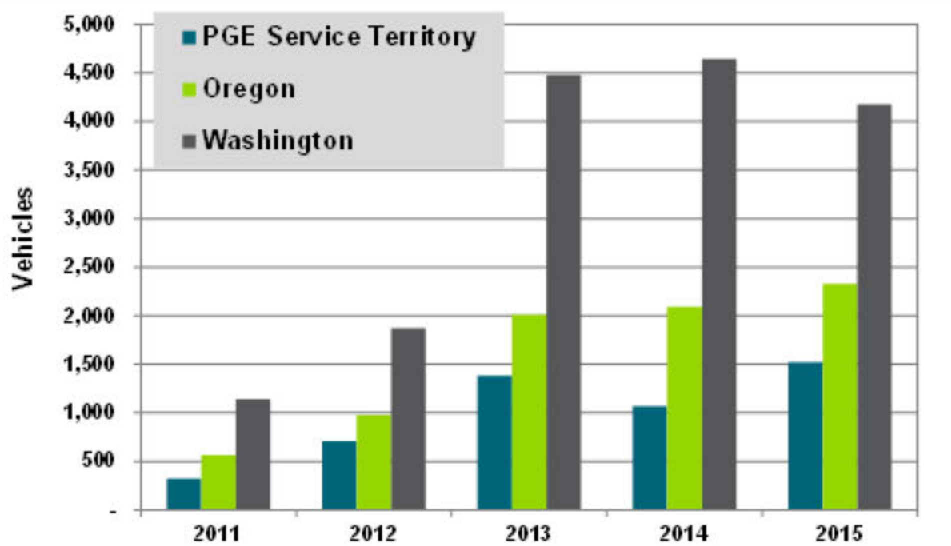


Figure 2: PEV Sales in Oregon, Washington, and PGE Service Territory 2011-2015

Source: Navigant Research analysis, 2016

2.3 Transportation Electrification Program Impact

As electric vehicles are a relatively new product, and utility electric vehicle programs have little history, estimates of PGE's impact on the local electric vehicle market are heavily assumption laden. The quickly evolving technologies and business models of the electric vehicle and infrastructure market continue to make empirical analysis of specific market development efforts difficult and few studies exist isolating the impact infrastructure or consumer education have on the electric vehicle market. Regardless of this aspect, it is clear, that investments in charging infrastructure and consumer education are highly likely to positively influence the market.

Navigant Research's *Electric Vehicle Consumer Survey* indicates a lack of charging infrastructure and familiarity with electric vehicles as primary disadvantages to electric vehicle ownership among respondents[7]. In order to capture the impact of PGE's program, the team first assessed what the impact of each program may be using what little data is available on traditional OEM consumer education spending estimates per vehicle sale and the historic growth of infrastructure relative to the electric vehicle market in the PGE service area. These impacts were then distributed over the forecast period under the assumption that impacts would vary over time based on the maturation of both the infrastructure and vehicle technologies and markets.

2.3.1 Education and Awareness Program

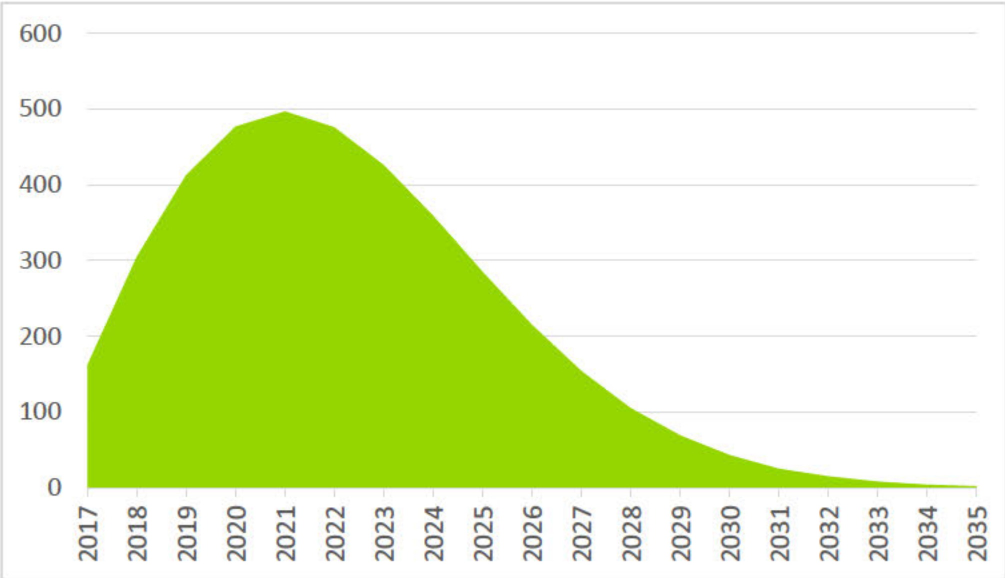
Surveys of PGE customers show that[8] awareness of plug-in electric vehicles is low and uncertainty regarding operation, reliability, costs, and charging is high relative to the conventional vehicle options.

[7] 26 percent of respondents identified a lack of places to charge as the primary disadvantage to PEV ownership, 18 percent cited cost, 17 percent cited range; the remainder cited other concerns including battery reliability and technology unfamiliarity among others.
[8] 2014 PGE Customer Survey

This is consistent with customer survey results throughout the United States[9] Given that, we assume:

- An education/marketing program's direct impact on the electric vehicle market would have the largest impacts early in the forecast period when the average consumer is less aware/educated on the technology.
- As the technology matures the average consumer will become more educated through other avenues and the impact of the "utility" electric vehicle program will diminish over time.
- The program's impacts will improve over the first years of the forecast period as administrators identify and replicate best practices.

Table New



3.

Electric Vehicles from Education and Awareness Program

shows the distribution of the electric vehicle market lift on behalf of the education and awareness program.

Table 3. New Electric Vehicles from Education and Awareness Program

Source: Navigant analysis, 2016

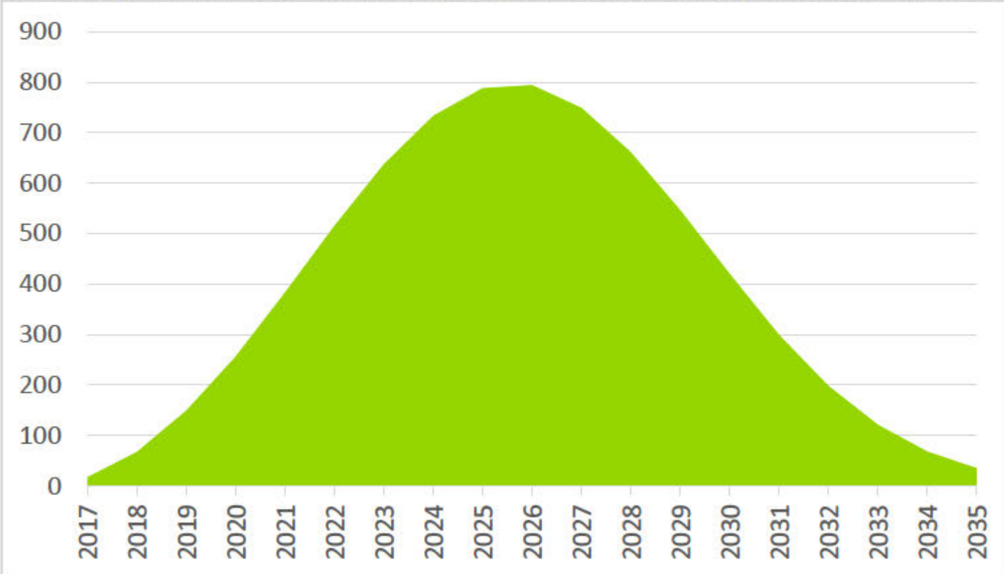
2.3.2 Community Charging Infrastructure Program

Though range anxiety and a lack of charging infrastructure are often cited as the primary drawbacks to purchasing a PEV,[10] there is uncertainty in the industry regarding which technical infrastructure

[9]Navigant Research, Electric Vehicle Geographic Forecast Report, 2016
[10] Navigant Research, Electric Vehicle Geographic Forecast Report, 2016

solution[11] is the most impactful in resolving the range/infrastructure nexus. Regardless, all technical solutions are likely to mature and lead to greater consumer understanding of how an electric vehicle may replace their existing conventional vehicle. Additionally, the existence of visible charging infrastructure creates more awareness of Electric Vehicles as a potential transportation choice. Given that, we assume:

- The PGE DCQC network would be established early in the forecast period,
- The initial impact of the DCQC network would be small but would grow quickly as consumers'



  awareness of the network grows. The vehicle purchase cycle is a long (5-10 years) so the impacts of the programs are delayed accordingly. Though these programs are expected to increase Electric Vehicle adoption, they will not change the car purchasing process overnight.
- Growing availability of 200 mile+ BEVs[12] would also increase the impact the DCQC network would have on the market in the near term, and
- New electric vehicle Charging Services (Multiple Unit Dwellings, Workplace) will develop over time and new technologies (wireless charging, faster DCQC)[13] will be introduced that will diminish the impact of the DCQC network on the electric vehicle market in the latter portion of the forecast.

Error! Reference source not found. shows the distribution of electric vehicle lift from the community charging infrastructure program.

Table 4. New Electric Vehicles from Community Charging (DCQC Stations) Program

Source: Navigant analysis, 2016

2.3.4 Electric Mass Transit 2.0 Program

Through this analysis, PGE also sought to explore the cost effectiveness of a unique charger lease

[11] Potential solutions include: denser public charging, faster public charging, increased availability of MUD or 'end of commute' charging infrastructure
[12] Navigant Research, Electric Vehicle Market Forecast Report, 2015
[13] Navigant Research, Electric Vehicle Charging Services, 2016

program established with TriMet, Portland's public transit entity.

TriMet received a federal grant to pursue electrification of a portion of the bus fleet in Portland. The grant was sufficient enough for TriMet alone to purchase four electric buses and the associated charging infrastructure. TriMet later discovered that, through a partnership with PGE under PGE's Electric Mass Transit 2.0 program, PGE could construct and own the charging infrastructure and TriMet would pay PGE for O&M to utilize the chargers to power their fleet. This would allow TriMet to use operating budget for the charging infrastructure, and utilize the federal grant to purchase an additional bus, for a total of five buses.

For the purposes of this cost benefit analysis, the team assumed the following:

- The known impact of the program is a single bus. Though this program could result in incremental electric vehicle lift at a later date, no additional lift beyond the known impact was forecast for this analysis.
- All chargers and associated installation costs are considered utility capital costs.
- Lease payments to PGE from TriMet are considered a benefit in the RIM, but a transfer in the TRC and SCT.
- The federal grant per bus ($430,000) to TriMet is included as a benefit in the Total Resource Cost test, but as a transfer in the Societal Cost Test.
- The utility tax credit value stream includes the Oregon Alternative Fuels Infrastructure Tax Credit[14], assumed to expire in 2020.

Table 5 summarizes the cost and benefit streams quantified in this analysis by cost test.

Table 5. Summary of Cost-Effectiveness Tests and Proposed Value Streams for Electric Mass Transit 2.0 Program

[14] http://www.afdc.energy.gov/fuels/laws/NG/OR

Cost/Benefit Category	Total Resource Cost Test	Rate Impact Measure Test	Societal Cost Test
Avoided Gasoline Costs	Benefit		Benefit
Increased Capacity Costs	Cost	Cost	Cost
Reduced Fuel Emissions			Benefit
Increased Energy Emissions			Cost
Increased Electricity Sales		Benefit	
Increased Energy Supply Costs	Cost	Cost	Cost
Customer O&M Savings	Benefit		Benefit
Utility Tax Credits - State	Benefit	Benefit	
Utility Capital Costs	Cost	Cost	Cost
Utility O&M Costs	Cost	Cost	Cost
Customer Vehicle Costs	Cost		Cost
O&M Payments from TriMet		Benefit	
Federal Bus Electric Vehicle Grant	Benefit		Benefit

Source: Navigant analysis, 2016

Section III Results

This section presents the market impacts from PGE's transportation electrification programs, as well as the costs and benefits of the transportation electrification portfolio from different cost test perspectives.

Navigant developed costs and benefits using both a flat rate structure and a residential time-of-use rate structure[15]. While the time-of-use structure provided greater net benefits, the difference between the two scenarios is slight due to the following factors:

- Electric vehicle charging times are somewhat flexible and shift away from peak times under the time-of-use rate.
- The off-peak rate is approximately 70 percent of the flat rate, meaning that relative to the flat rate structure, revenue gains from charging during peak times are largely offset by the majority of charging occurring during off-peak times under the time-of-use rate.
- A portion of Electric Vehicle charging occurs at the workplace, which is subject to commercial

[15] The flat structure is residential Schedule 7 Standard Service option, the time-of-use rate is the Schedule 7 TOU Portfolio option. https://www.portlandgeneral.com/our-company/regulatory-documents/tariff

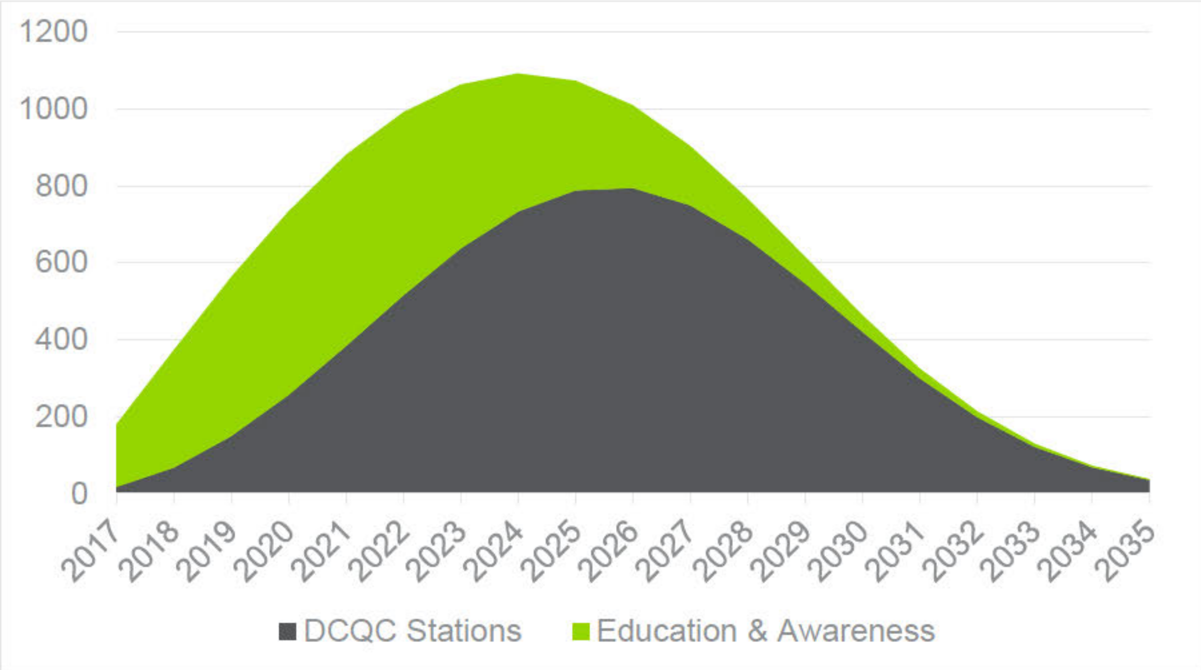
rates.

This report conservatively presents results using the flat rate scenario only.

3.1 Electric Vehicle Market Impacts

The cost effectiveness analysis looked at additional electric vehicles sold (i.e., "electric vehicle lift") as the unit basis for program-level costs and benefits.

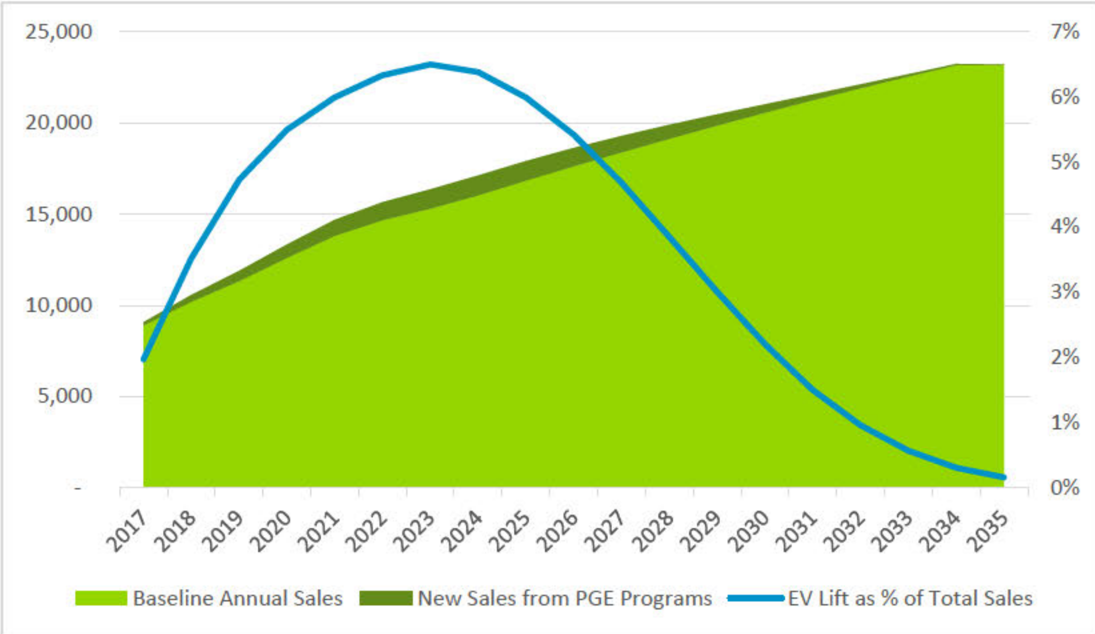
Table 6. New Electric Vehicles by Program



Source: Navigant analysis, 2016.

The electric vehicle lift caused by PGE programs represents an average increase of roughly five percent new vehicle sales in the total cumulative electric vehicle sales forecast.

Table 7. Cumulative Electric Vehicles in PGE Territory



Source: Navigant analysis, 2016

The electric vehicle lift caused by PGE programs represents 3.4 percent of total annual sales during the analysis period.

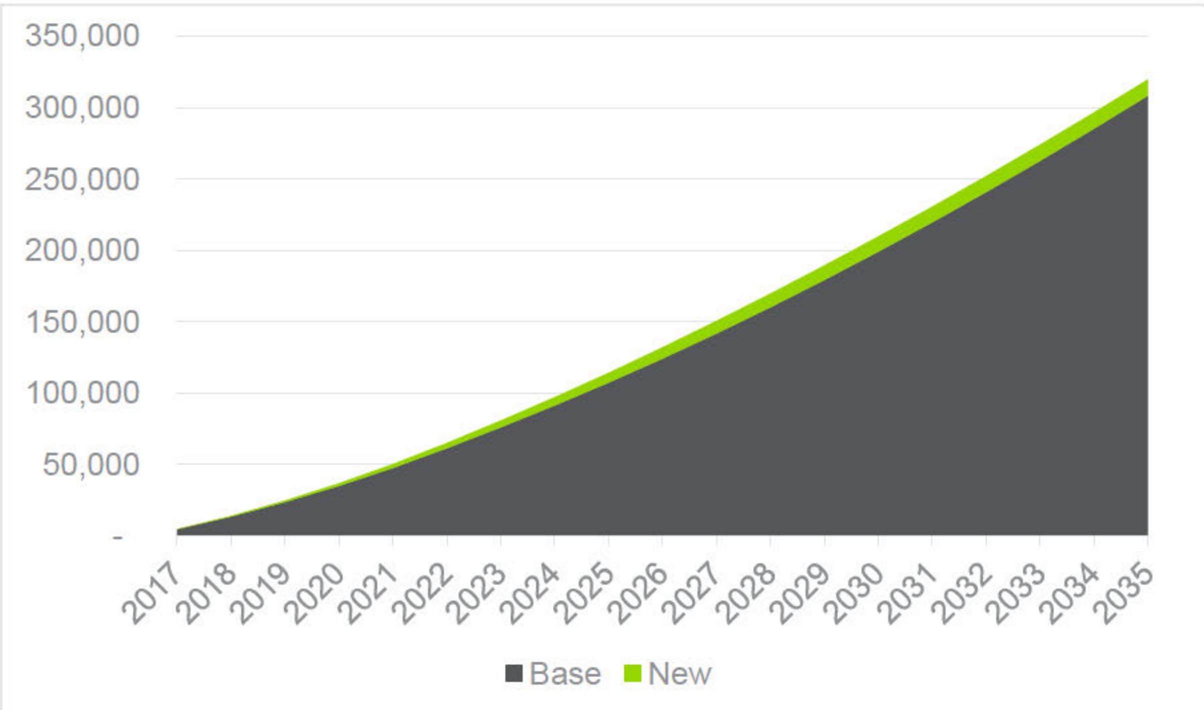


Table 8. Annual Baseline and New Sales in PGE Territory

Source: Navigant analysis, 2016

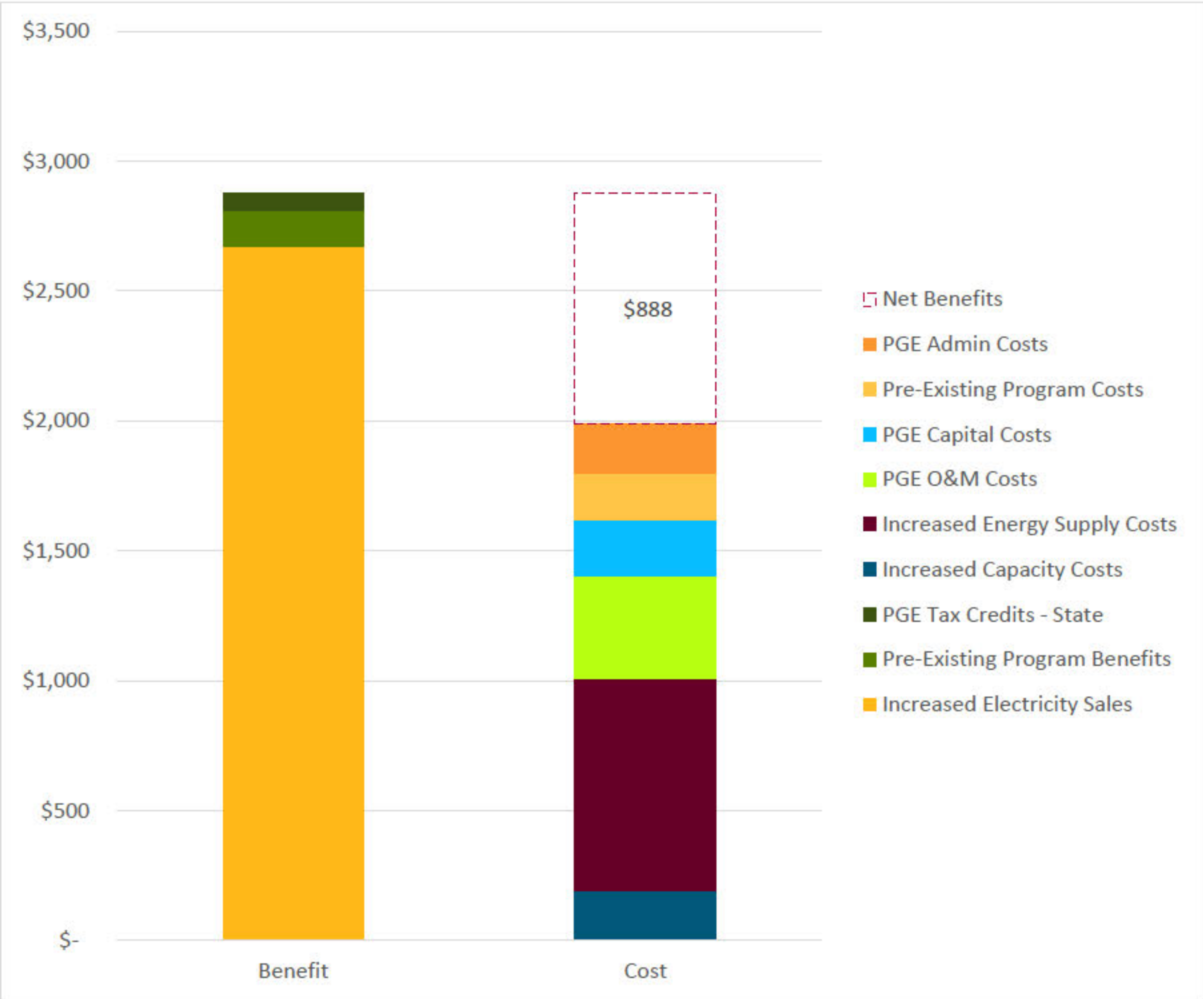
3.2 Rate Impact Measure (RIM) Test

This section presents the RIM test results for PGE's transportation electrification portfolio, as a whole.

The RIM test measures the net benefits of a program from the perspective of ratepayers. It is used to especially protect the interests of customers who are not program participants. Since programs are typically funded by customers, the cost streams included in the RIM test are overhead costs and capital costs. The benefit streams used in this test are increased revenue from electricity sales, and tax credits received by the utility.

The portfolio of programs result in a net revenue of approximately $888 per light duty vehicle.

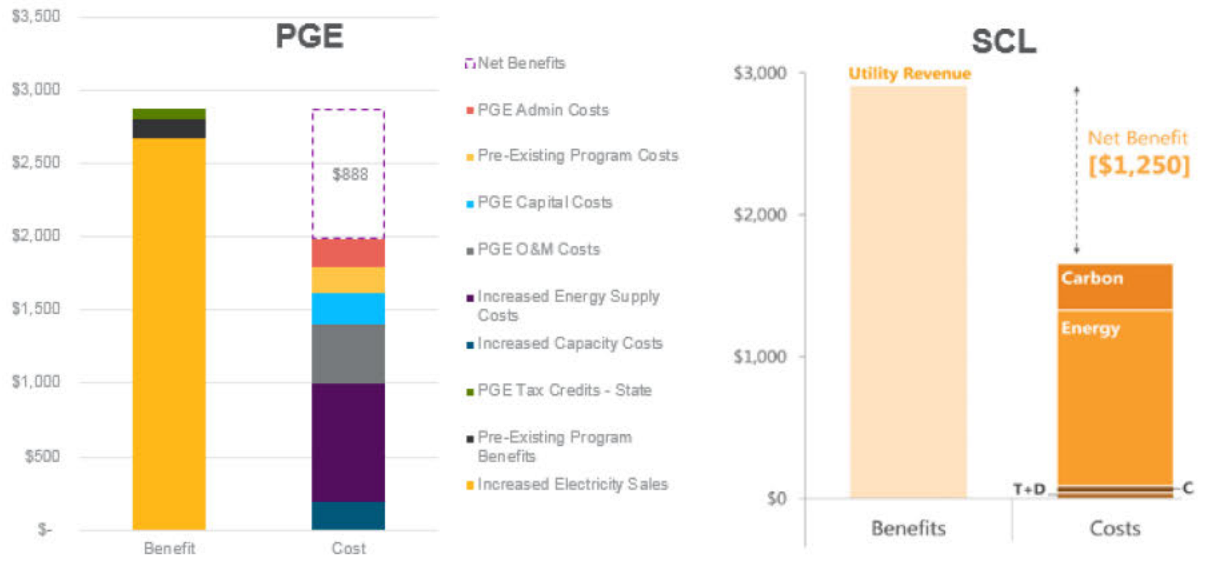
Table 9. Per Vehicle Benefits and Costs with RIM Test



Source: Navigant analysis, 2016

The results of PGE's analysis are roughly consistent with a recent analysis performed by Seattle City Light.

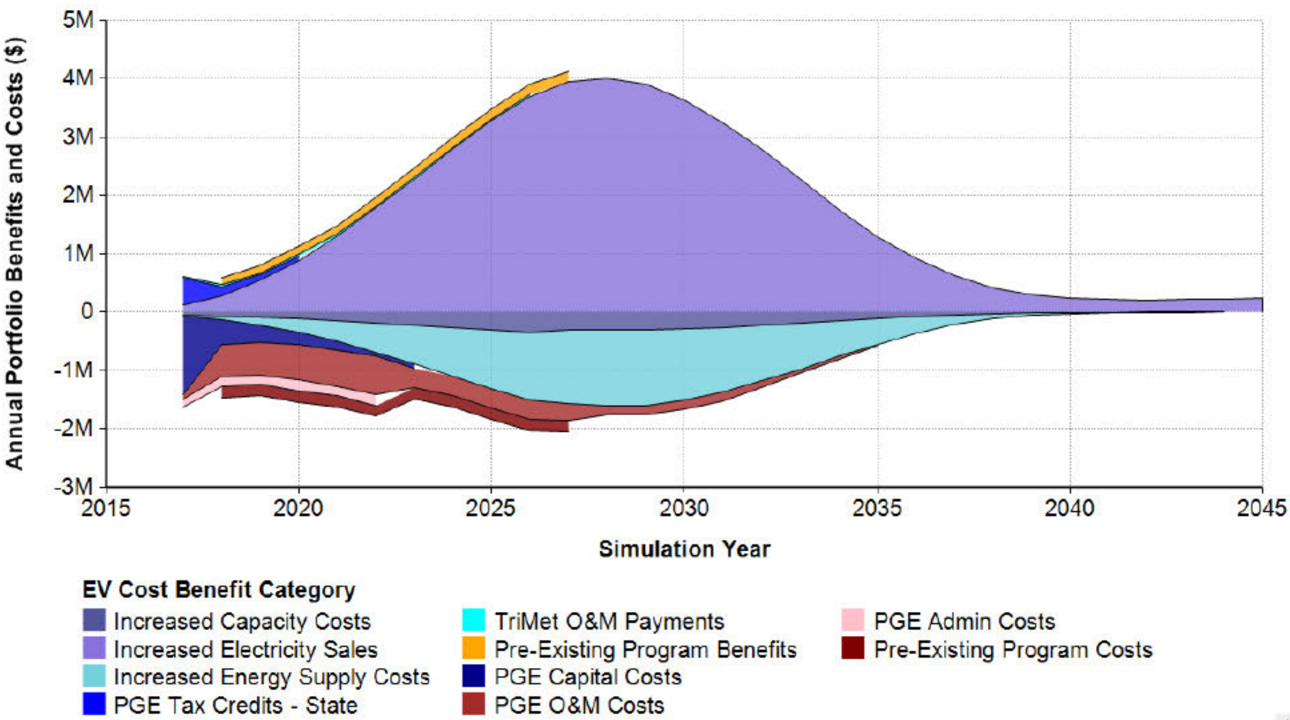
Table 10. Comparison of Results between PGE and Seattle City Light



Sources: Navigant analysis, 2016. Seattle City Light Transportation Electrification: Technical Impacts, Market Research, Program Design. 2015.

The time series graph below shows the quantified value streams for the RIM (costs and benefits) over time at the portfolio level. These results include the Electric Mass Transit 2.0 Program.

Table 11. Annual Portfolio Costs and Benefits with RIM Test



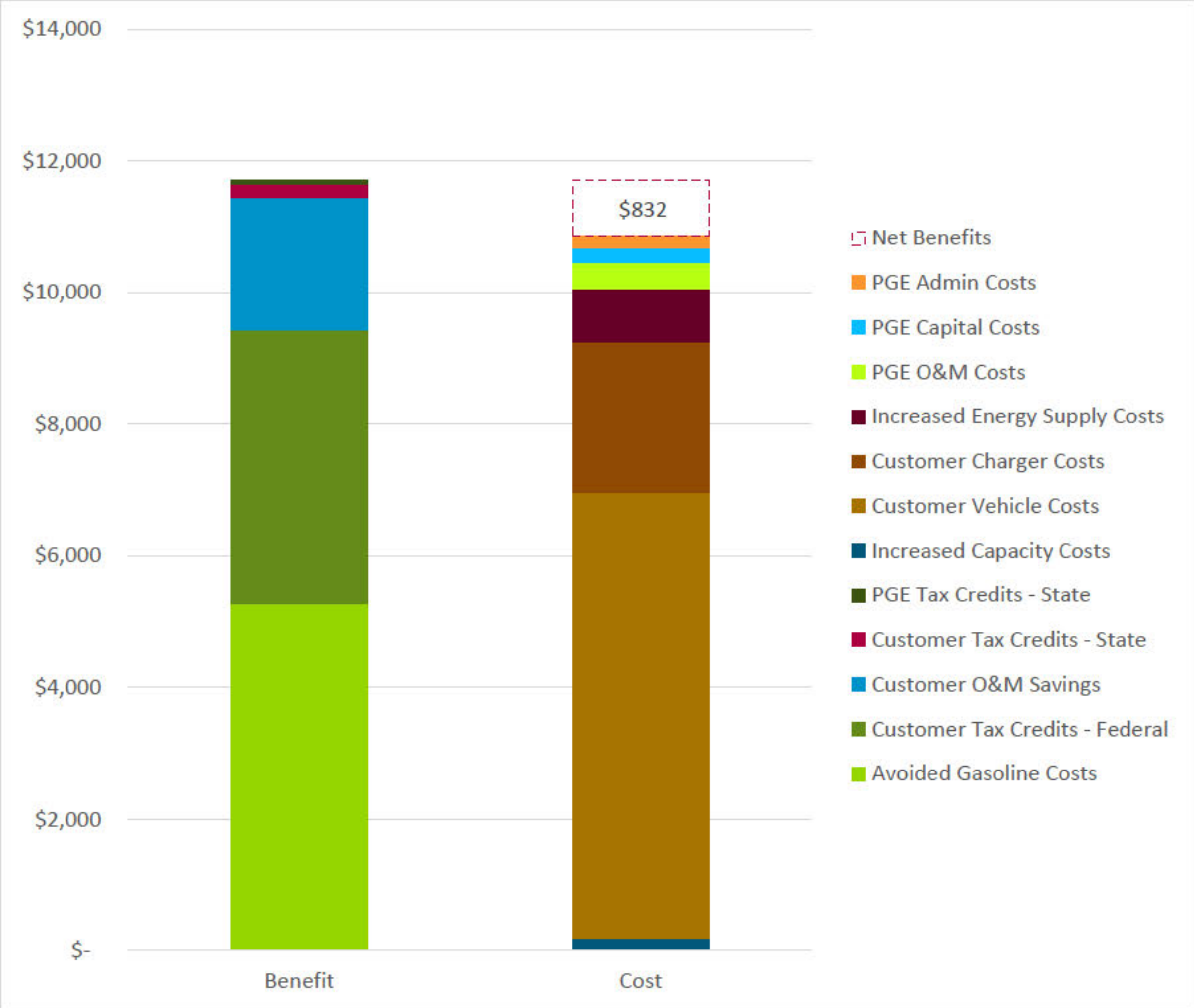
Source: Navigant analysis, 2016

3.3 Total Resource Cost (TRC) Test

The TRC measures net benefits of a program for all stakeholders involved. The cost streams included in the TRC test are overhead and capital costs incurred by the utility, as well as incremental costs of purchasing and installing equipment (e.g., vehicles and chargers) incurred by customers. The benefit streams used in this test are avoided costs of energy, capacity and gasoline; tax credits, and other non-energy benefits such as operations and maintenance savings. Increased electricity sales are not included in the TRC as they offset each other. Increased sales is a cost to customers on their electricity bills, while it is a benefit to the utility in the form of additional revenue.

The graph below shows the portfolio results per light duty vehicle using the TRC.

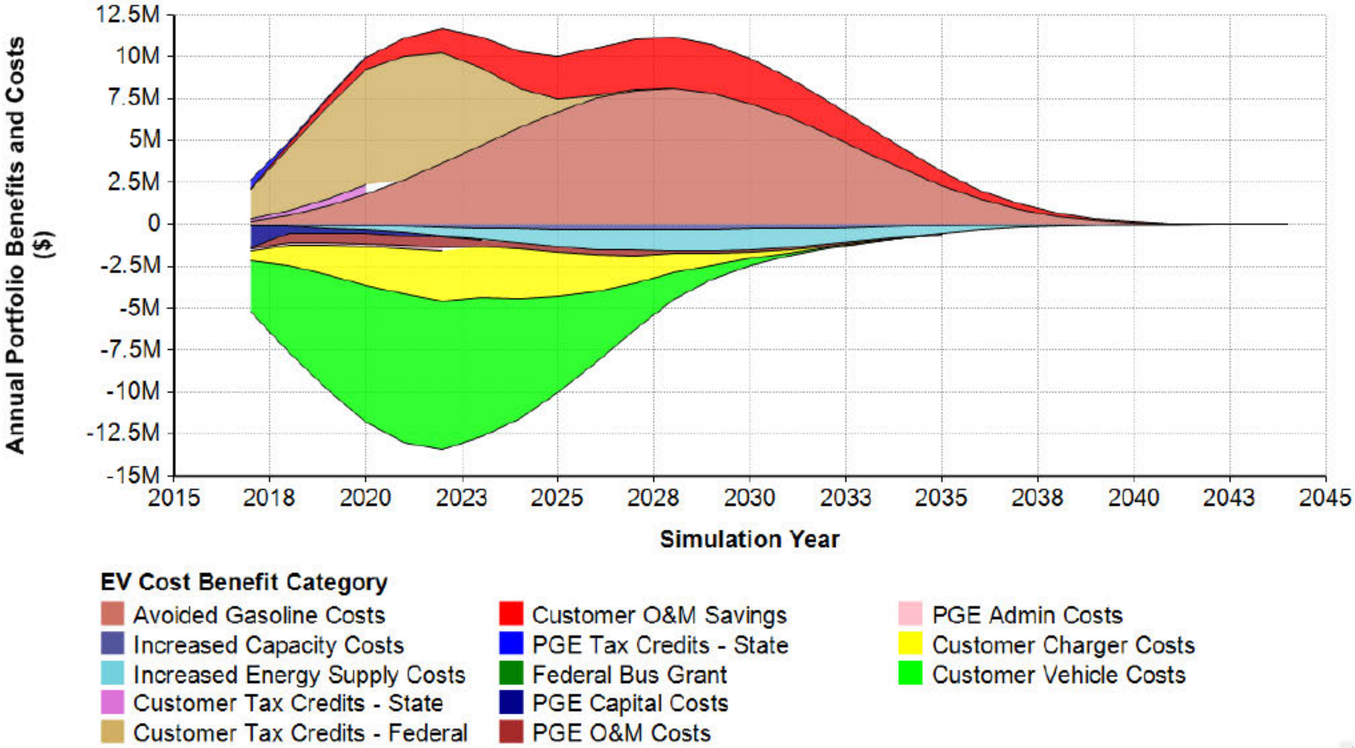
Table 12. Per Vehicle Benefits and Costs with TRC Test



Source: Navigant analysis, 2016

The time series graph below shows the quantified value streams for the TRC (costs and benefits) over time at the portfolio level, including the Electric Mass Transit 2.0 Program.

Table 13. Annual Benefits and Costs with TRC Test



Source: Navigant analysis, 2016

3.4 Societal Cost Test (SCT)

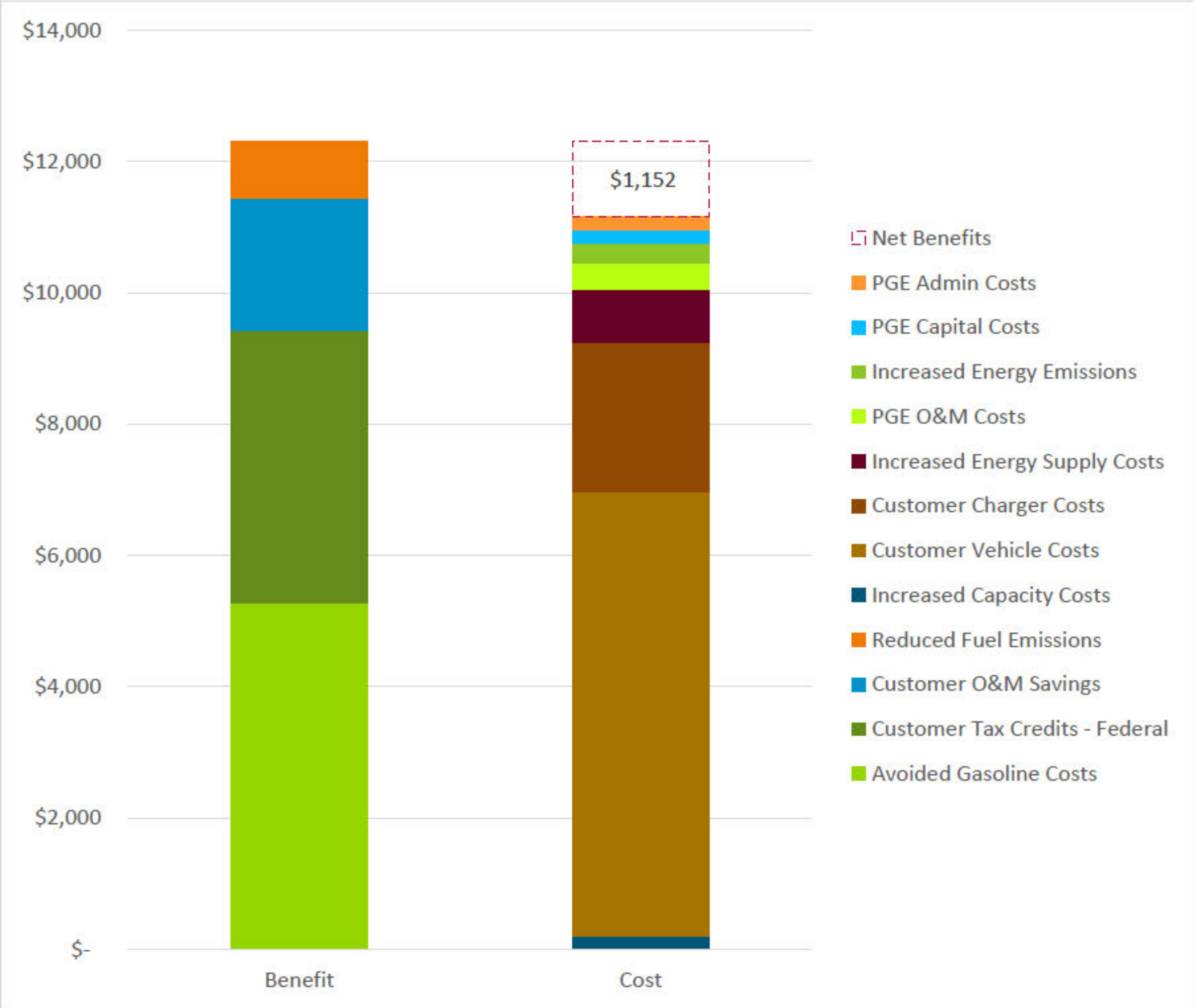
The SCT measures net benefits of a program for society at large. For this analysis, it is similar to the TRC, with the addition of benefits from reduced emissions, and the subtraction of state tax credits (tax credits are considered a transfer payment from the government to the recipient in the SCT, yielding no net benefit). As this analysis was conducted in response to Chapter 28, Oregon Laws 2016, the analysis team decided to define society as those within the state of Oregon[16]. Therefore, state tax credits are transfer payments in this analysis, while federal tax credits are still considered benefits. Notably, absent the tax credits, the programs are a net cost to society, due to the high incremental cost of an electric vehicle relative to internal combustion engine vehicles. As electric vehicles become more prevalent in the market, economies of scale will likely substantially reduce these incremental costs, yielding a significant net benefit to society per electric vehicle.

This analysis conservatively estimates the impact of only benefits to society that are easily monetized using Environmental Protection Agency values for the social cost of carbon[17], and does not consider other difficult-to-monetize benefits from transportation electrification[18].

The graph below shows the portfolio results per light duty vehicle using the SCT.

[16] During workshops conducted throughout Summer and Fall 2016, stakeholders did not object to this approach.
[17] https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2016orLaw0028.pdf
[18] Such benefits may include building demand response, ancillary service, or transactive energy market potential for PGE, national energy security from reduced reliance on foreign energy sources, PGE and City of Portland public relations.

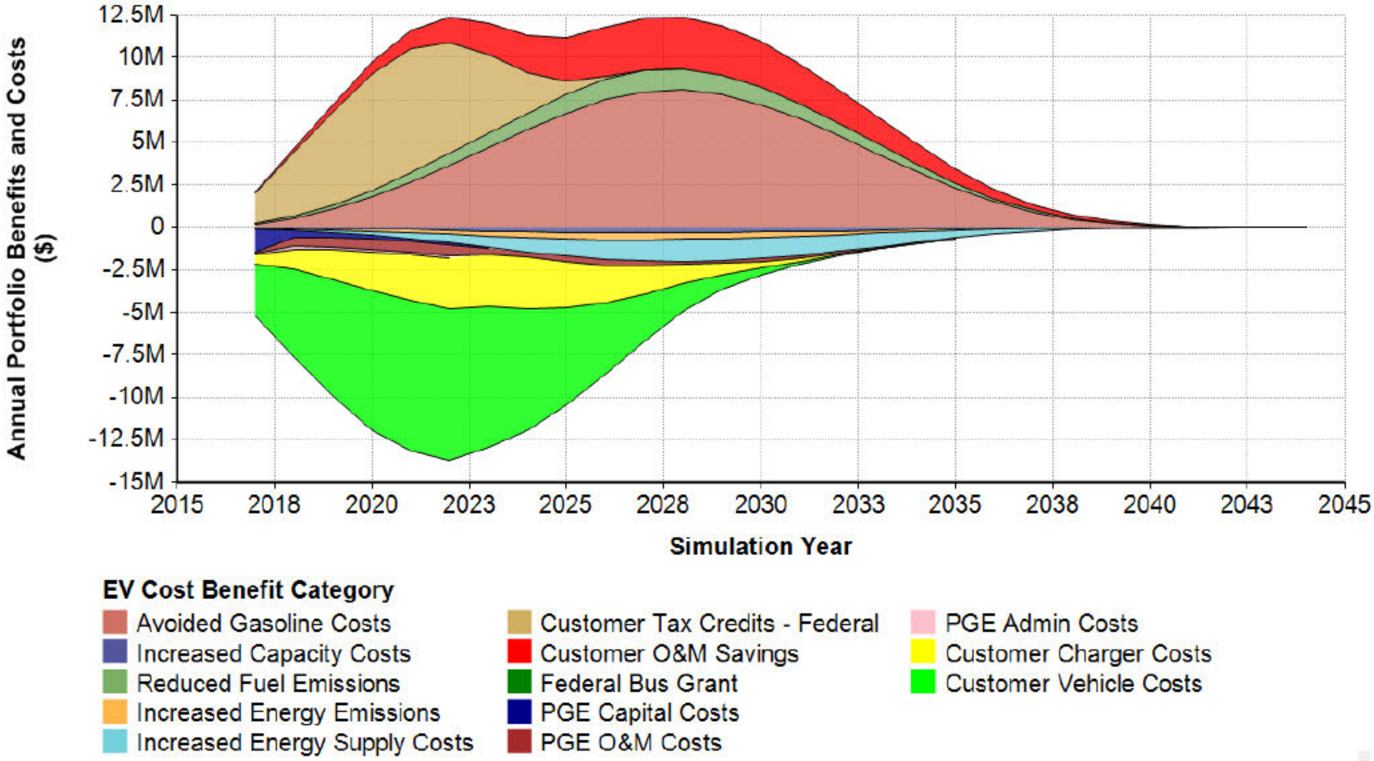
Table 14. Per Vehicle Benefits and Costs with SCT Test



Source: Navigant analysis, 2016

The time series graph below shows the quantified value streams for the SCT (costs and benefits) over time at the portfolio level, including the Electric Mass Transit 2.0 Program.

Table 15. Annual Benefits and Costs with SCT Test



Source: Navigant analysis, 2016

3.5 Electric Mass Transit 2.0 Program Results

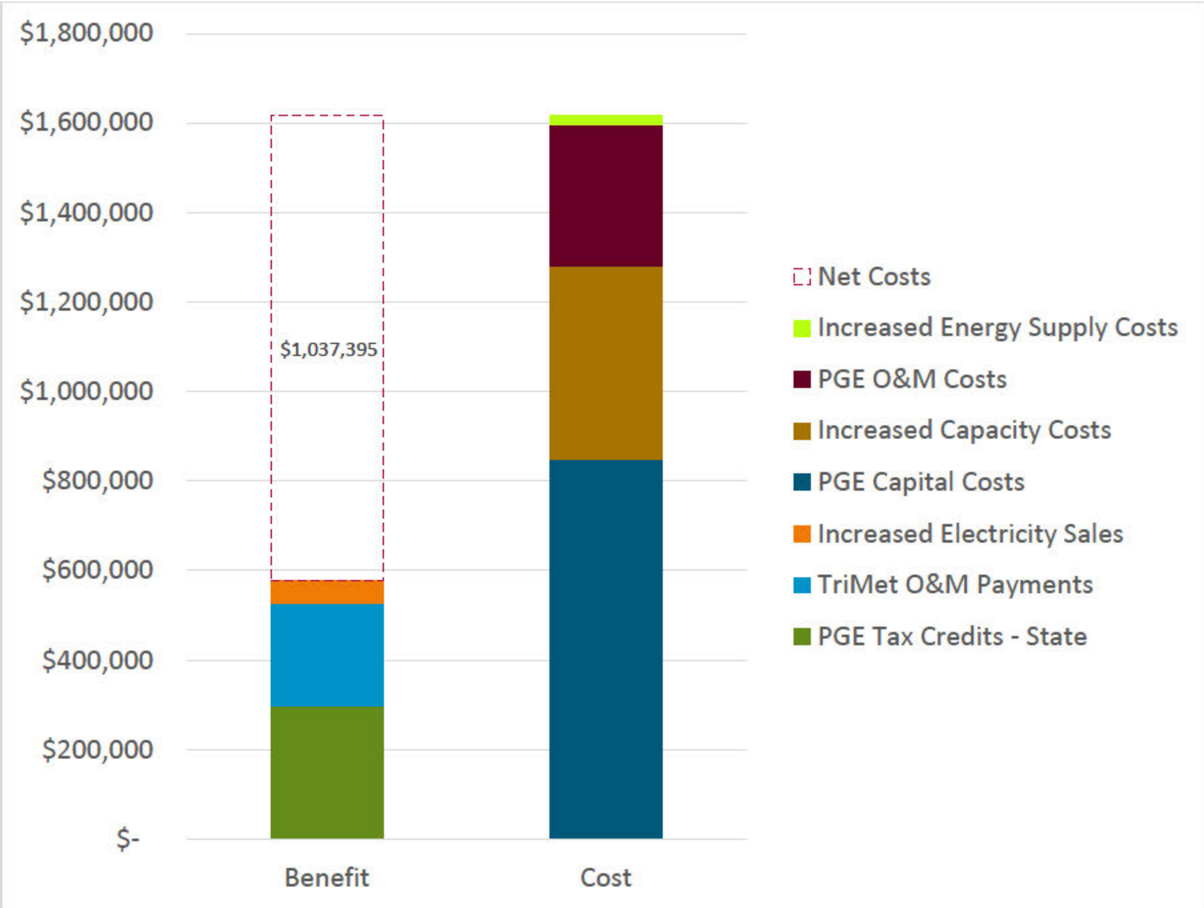
This section provides more detail on the results for the Electric Mass Transit 2.0 program individually, given the unique nature of this program within PGE's electrification transportation portfolio.

The Electric Mass Transit 2.0 program enables TriMet to purchase one additional bus. The program appears to have a net cost, predominately because the full cost of five chargers are incurred as utility capital costs, while the analysis only counts the benefits of the one additional bus attributed to the program. This is a conservative analysis, based strictly on the known impact of the chargers increasing the TriMet fleet by one bus. In reality, these five chargers could power significantly more than one or even five electric buses in the future. However, in order to stay consistent with the methodology employed in response to previous dockets[19] the analysis strictly accounts for only incremental costs and benefits as a direct result of the program.

The Electric Mass Transit 2.0 program results in a net cost of approximately $1 million according to the RIM test.

[19] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf

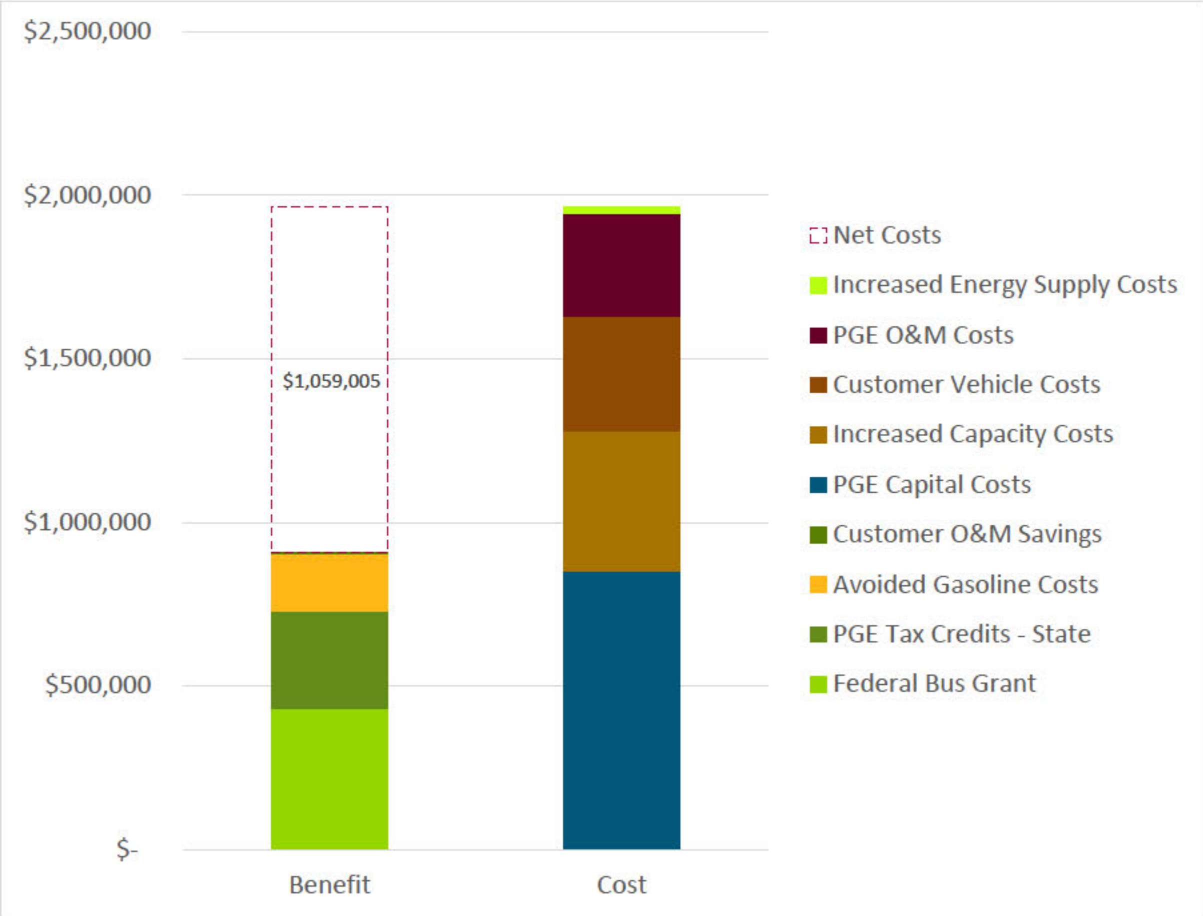
Table 16. Electric Mass Transit 2.0 Costs and Benefits with RIM Test



Source: Navigant analysis, 2016

The Electric Mass Transit 2.0 program results in a net total resource cost of approximately $1 million.

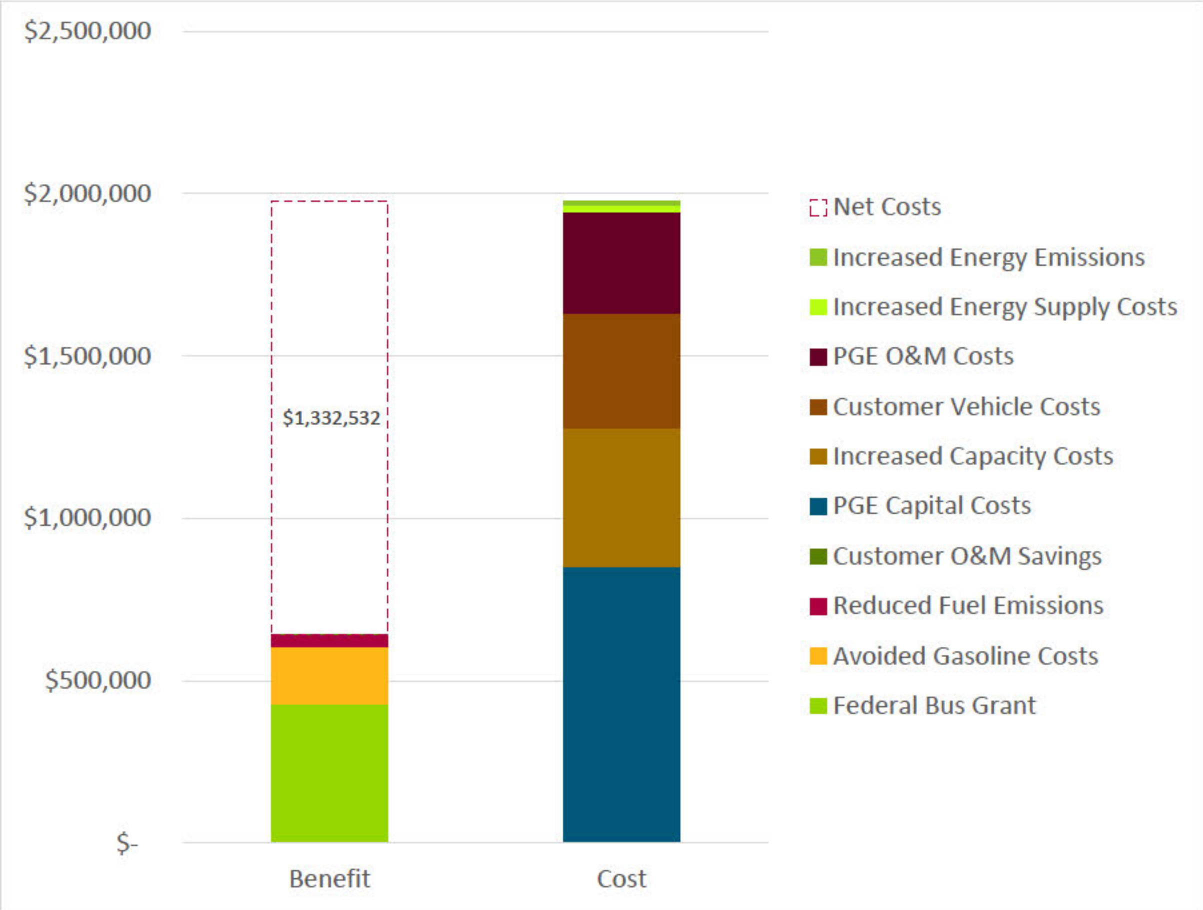
Table 17. Electric Mass Transit 2.0 Costs and Benefits with TRC Test



Source: Navigant analysis, 2016

The Electric Mass Transit 2.0 program results in a net societal cost of approximately $1.3 million. Consistent with the light duty vehicle analysis above, the societal cost test considers costs and benefits from the perspective of the state of Oregon. Therefore, the federal grant for the purchase of a single bus is considered a benefit in this analysis.

Table 18. Electric Mass Transit 2.0 Costs and Benefits with SCT Test



Source: Navigant analysis, 2016

Section IV Conclusions and Directions for Future Research

Based on the results presented above, PGE's transportation electrification program portfolio is expected to be a cost effective investment for PGE and their customers. In the future, additional research that may provide greater certainty in future cost effectiveness analyses for PGE's transportation electrification programs includes:

- Develop a framework to track key performance metrics and evaluate the impact of the transportation electrification program portfolio.
- Assess opportunities for transportation electrification to contribute to demand response and/or ancillary service benefits for PGE.
- Determine optimal criteria for siting of community charging infrastructure, and analyze traffic patterns, demographics, zoning restrictions, visibility etc. to optimize placement community charging infrastructure.

This framework is consistent with and builds upon the framework that PGE set forth for demand response cost effectiveness. PGE will continue to build on this robust framework as the Company continues to further develop customer-facing programs for encouraging adoption of distributed energy resources.

Appendix A. Cost Effectiveness Framework Definitions

Table 19. Cost Effectiveness Framework Definitions

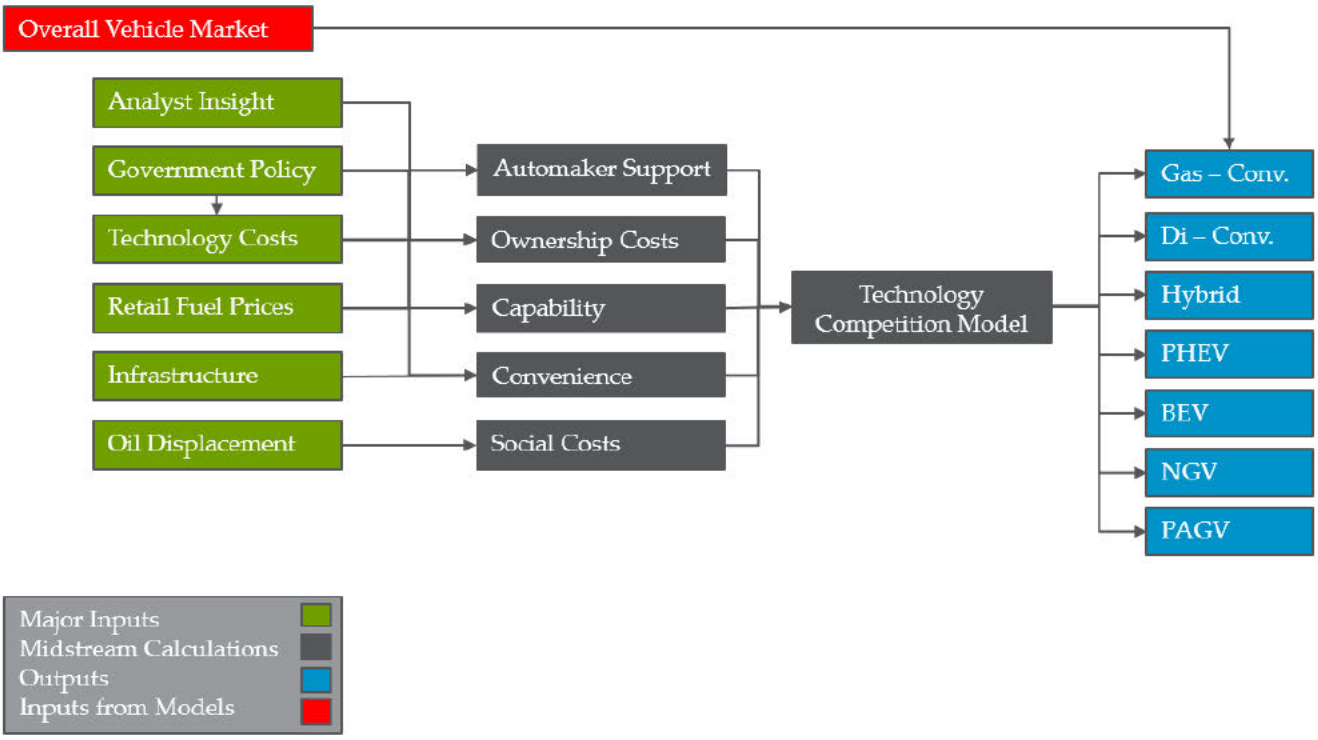
Cost/Benefit Category	Definition	Calculation Description	Monetization Unit
Avoided Gasoline Costs	A customer's value of avoided gasoline purchases	Based on VMT and fuel efficiency of the baseline gasoline powered vehicle	$/gallon of gasoline
Increased Capacity Costs	PGE's increased costs of capacity from providing electric vehicle charging service	Based on electric vehicle charging coincidence with system peak demand (MW)	the inverse of avoided capacity costs ($/MW)
Reduced Fuel Emissions	CO_2, NO_x, and PM reductions from reduced gasoline consumption	Fuel emissions intensity (tons/gal) * gallons avoided	Cost of emissions ($/ton) by emissions type
Increased Energy Emissions	CO_2, NO_x, and SO_x emissions increases from more electricity consumption	Grid emissions intensity (tons/MWh) * increased energy consumption (MWh)	
Increased Electricity Sales	PGE revenue from increased electricity sales (MWh) due to electric vehicle charging	Electric vehicle charging consumption (kWh). Loadshape varies by sector and rate type	Retail rates by sector ($/kWh) varies by on/mid/off-peak and season
Increased Energy Supply Costs	PGE's increased costs of energy from providing electric vehicle charging service	electric vehicle charging consumption (annual kWh)	the inverse of avoided energy costs ($/MWh)
Customer Tax Credits	Customer tax credits for electric vehicle or EVSE purchases from federal and state sources	Vehicle purchase credit ($/electric vehicle) and Alt fuel infrastructure tax credit ($/project). With phase out assumptions.	
Customer O&M Savings	The decreased O&M associated with electric vehicles	Electric vehicle O&M costs relative to baseline vehicle O&M	Annual O&M savings ($/year)
Utility Tax Credits	PGE tax credits for EVSE purchases from federal and state sources	Alt fuel infrastructure tax credits (federal and state; percent of project costs). Phase out assumptions.	
Utility Capital Costs	PGE costs for installing DCQC and L2 chargers at public stations	Equipment, installation, interconnection, permitting costs for stations	$/station
Utility O&M Costs	PGE annual costs for O&M	DCQC station O&M, as well as marketing dollars for the Education & Awareness	$/year by program
Utility Admin Costs	PGE costs for administering the programs	Any additional FTEs for program admin	$/year by program
Customer Charger Costs	Customer costs for L2 chargers	Assume a percent of vehicle purchases also include L2 residential charger purchase	$/charger
Customer Vehicle Costs	Customer costs for electric vehicles	Incremental cost of electric vehicle over baseline gasoline vehicle	$/electric vehicle

Source: Navigant analysis, 2016

Appendix B. Visual Overview of Electric Vehicle Forecast Methodology

The following slides provide an overview of the electric vehicle baseline forecast methodology. Section 2.2 also contains detail on the methodology.

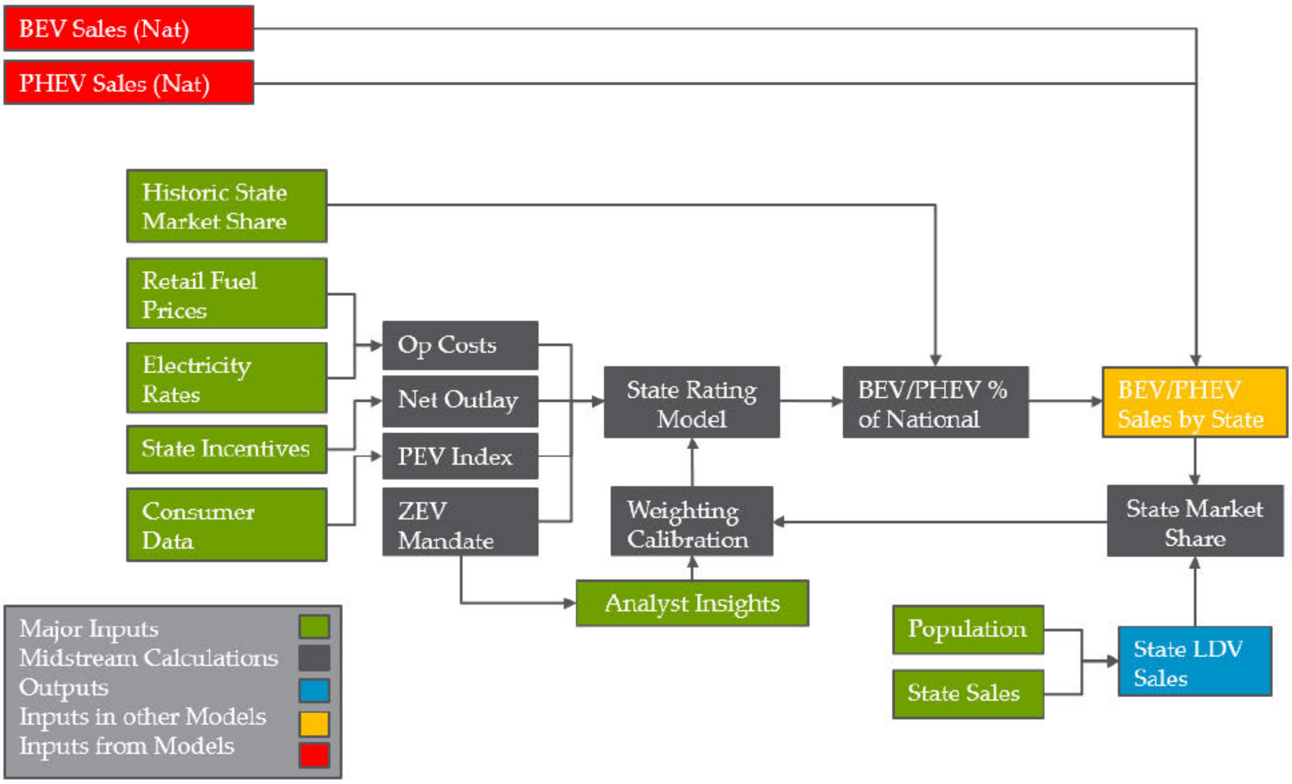
Figure 3: Electric Vehicle Forecast Method: Technology Adoption



Source: Navigant analysis, 2016

The above influence diagram visualizes the component of Navigant Research's national vehicle sales forecast model which determines market share of various vehicle fuel and powertrain combinations. The results of the model are disaggregated by lesser geographic jurisdictions.

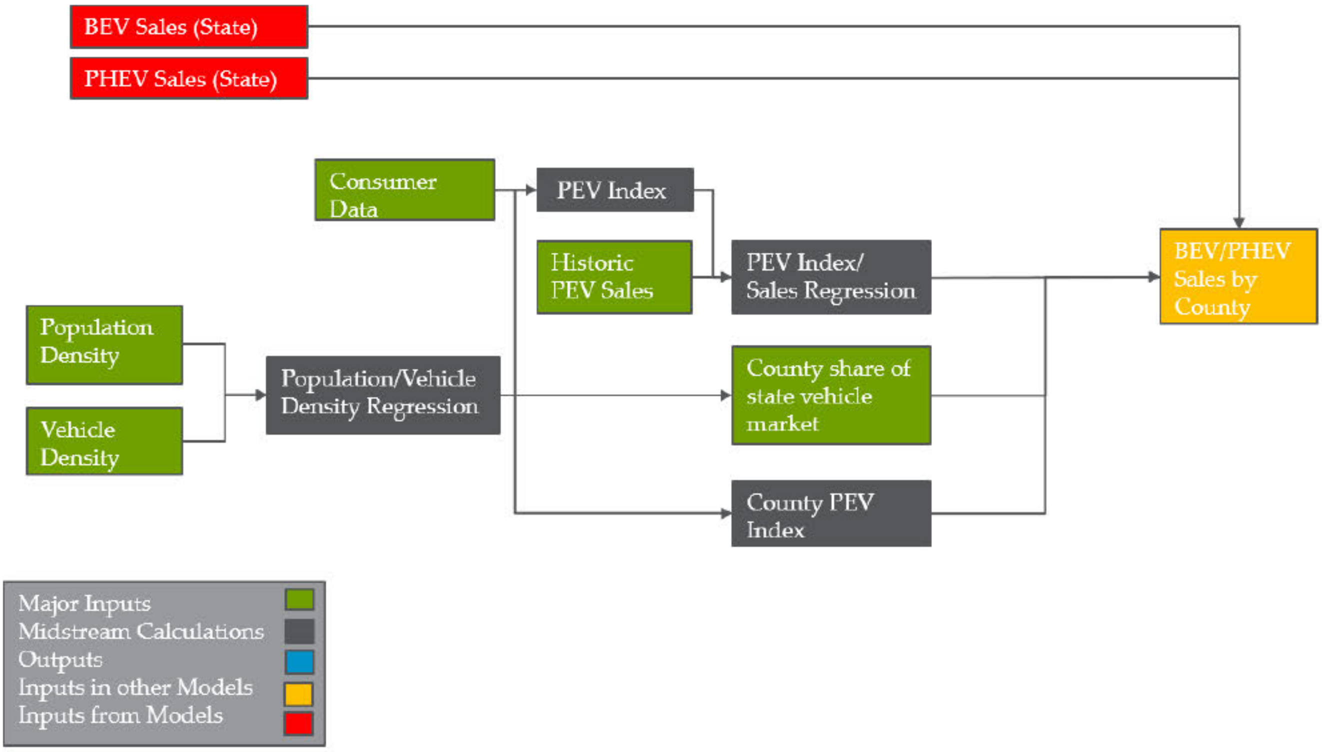
Figure 3: Electric Vehicle Forecast Method: State Disaggregation



Source: Navigant analysis, 2016

This influence diagram visualizes the first disaggregation of Navigant Research's national vehicle sales forecast model. This disaggregation is a function of a number of parameters including state regulations, incentives, retail fuel prices and electricity rates, demographics, and historic sales.

Figure 4: Electric Vehicle Forecast Method: County Disaggregation

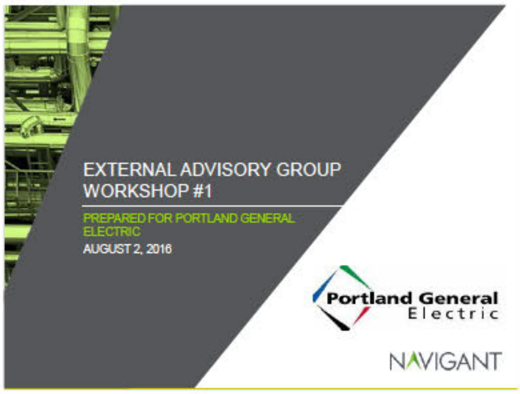


Source: Navigant analysis, 2016

This influence diagram visualizes the second disaggregation of Navigant Research's national vehicle sales forecast model. This disaggregation is primarily a function of historic sales, demographics, and population density.

Appendix C. Stakeholder Workshop #1

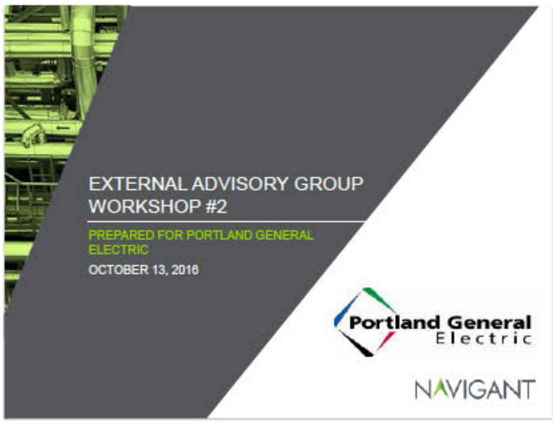
See attached presentation for the first external stakeholder workshop, conducted on August 2, 2016.



Source: Navigant analysis, 2016

Appendix D. Stakeholder Workshop #2

See attached presentation for the second external stakeholder workshop, conducted on October 13, 2016.



Source: Navigant analysis, 2016

Portland General Electric
121 SW Salmon Street • Portland, Ore. 97204
PortlandGeneral.com

December 15, 2016

Public Utility Commission of Oregon
Attn: Filing Center
201 High St. SE, Suite 100
P.O. Box 1088
Salem, OR 97308-1088

RE: Portland General Electric Report on Electric Vehicle Highway Pilot

Summary

On March 14, 2012, Portland General Electric Company (PGE or Company) submitted a proposal to the Oregon Public Utility Commission (OPUC or Commission) for an Oregon Electric Vehicle Highway Pilot (pilot). The purpose of the pilot was to allow PGE to assist Electric Vehicle Service Providers (EVSPs) in siting and installing publicly available charging stations in PGE's service area. In the pilot, the EVSPs own and maintain the charging stations, and only charging stations fully funded through a public grant are eligible for inclusion in the program. The learning objectives targeted by PGE were threefold: 1) to study the impact of charging on the grid infrastructure, 2) learn more about location and siting costs of Direct Current Quick Chargers (DCQCs) and implications for the Company's business processes, and 3) gain information to support outreach and education to customers about EVs and the equipment that supports their charging.

As detailed in PGE's supplement to the initial pilot program filing (dated April 3, 2012 with an effective date of April 11, 2012), PGE proposed to provide power to the EVSPs under either Schedule 32 (Small Nonresidential Standard Service) or Schedule 38 (Large Nonresidential Optional Time of Day Standard Service). Charging infrastructure in the pilot was to include up to 20 DCQCs and up to 40 Level II (240 volt) stations along the Interstate 5 and Interstate 205 corridors and related arterials. The rider associated with the filing of the pilot – Schedule 344 – was proposed as supplemental to Schedules 32 and 38. The pilot was approved on the April 10, 2012 public meeting, effective April 11, 2012, with a planned termination date of December 31, 2013.

From this pilot PGE gained valuable experience in the transportation electrification field, and captured three key learnings:

i) **Driver demand for DCQC stations is growing** – both the number of charges and total energy used has increased at PGE-partnered DCQC stations throughout the life of the pilot (as shown in Figure 6);
ii) **A non-demand (energy only) site host price is crucial for DCQC stations that are not highly utilized** – customers with a charging station load factor of <20% would see a significant impact on their bill from demand charges[1]. Providing an energy-only price allows PGE to recover costs while encouraging further development of charging stations;
iii) **Partnership between PGE and the EVSPs was essential** – by actively listening to the needs of customers and the voices of stakeholders, we were able to use our partnership with EVSPs to give peace of mind to site hosts regarding installation costs, maintenance responsibilities, and charger siting. This partnership also allowed PGE to take an active role in keeping the charging stations operational and available, when necessary.

[1] https://avt.inl.gov/sites/default/files/pdf/EVProj/EffectOfDemandChargesOnDCFCHosts.pdf

Partnership with ECOtality

In August 2009, ECOtality (synonymously referred to as "Blink" or "eTec") announced the receipt of $99.8 million of federal funds to test and analyze electric vehicle usage and charging infrastructure throughout five markets in the United States. On August 9, PGE was announced as ECOtality's partner in the United States Department of Energy (USDOE) "EV Project" for public charging infrastructure deployment within the Portland Metropolitan Statistical Area (MSA). As part of this agreement, PGE took a lead role in site selection, customer outreach, and facilitation of DCQC site agreements between ECOtality and local business owners. The locations of the ECOtality installations are shown below in table 1.

Site[2]	Infrastructure Installed	Service Address[3]	PODID[4]
1	Blink DCQC and 2 Blink L2	Redacted Portland, Ore.	N/A
2	Blink DCQC	Redacted Portland, Ore.	N/A
3	Blink DCQC and 1 Blink L2	Redacted Keizer, OR	N/A
4	Blink DCQC and 1 Blink L2	Redacted Sherwood, Ore.	N/A
5	Blink DCQC and 2 Blink L2	Redacted Wilsonville, Ore.	N/A
6	Blink DCQC and 3 Blink L2	Redacted Portland, Ore.	N/A N/A
7	2 Blink L2	Redacted Salem, Ore.	N/A
8	Blink DCQC and 2 Blink L2	Redacted Silverton, Ore.	N/A
9	Blink DCQC and 2 Blink L2	Redacted Woodburn, Ore.	Removed[5]

Table 1 – Blink/PGE charging stations installations as part of EV Highway Pilot

PGE assumed the business relationship with ECOtality through a Charging Station Host Agreement, allowing the site partner/property owner to sign a Property Owner Consent (POC) agreement with ECOtality. This arrangement allowed the DCQC and Level II chargers to be placed on the customer's premise, but left the operational challenges (maintenance, installation costs, electricity costs, potential revenue collection) to the ECOtality/PGE partnership. We found this to be a helpful and necessary arrangement, as at the time many business owners were unfamiliar with electric vehicle charging and were hesitant to invest in an upstart company and a nascent market with so many potential challenges (A few of the barriers we heard from potential site partners during our outreach are shown in Figure 2). We found that the participation of PGE in the siting, facilitation, and maintenance of chargers helped to ease the concerns of potential customers.

2 Customer name redacted under OAR 860-001-0070. Available in confidential Appendix A.
3 Service address redacted under OAR 860-001-0070. Available in confidential Appendix A.
4 Redacted under OAR 860-001-0070. Available in confidential Appendix A.
5 Infrastructure removed at customer request

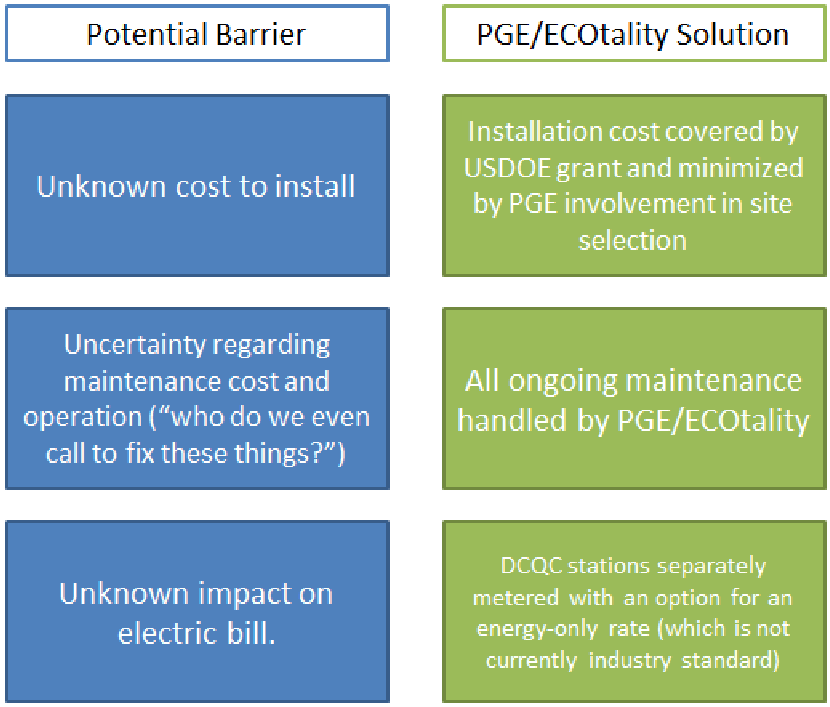


Figure 2 – barriers to charging infrastructure development and PGE/ECOtality solution

As of September 2013, PGE and ECOtality had completed 8 sites (with the 9th site in progress and close to completion) with 11 sites still to be selected. On September 16, 2013, ECOtality filed for Chapter 11 bankruptcy protection, with all assets scheduled for auction the following month.

Pilot Extension and Revisions

Advice number 13-21 was filed by PGE on October 28, 2013, officially notifying the OPUC of the impact of the ECOtality bankruptcy on the pilot and detailing progress under the pilot to date. The advice filing requested an extension of the program termination date from December 31, 2013 to December 31, 2015.

In the initial pilot program filing, PGE did not anticipate that EV charging equipment manufacturers and automakers may have an interest in donating EV charging equipment to demonstrate their technology[6]. Since the pilot originally targeted "publicly funded" projects, PGE declined any offers of donated infrastructure prior to the filing of Advice 13-21. Along with extending the term of the pilot, Advice 13-21 added a special condition for donated equipment that allowed PGE to accept no-cost charging infrastructure or funding from manufacturers. The program modifications requested were approved at the November 26, 2013 public meeting and became effective the following day.

Following the extension and revision of the pilot, PGE worked closely with two auto manufacturers [7]who provided a majority of the funding to install 5 additional DCQC stations (shown in Table 3 below). In accordance with Advice 13-21, PGE contracted with an Oregon company – Powin – to own and maintain the five donated chargers.

---

[6] As additional standards emerged for the rapid charging of battery-only EVs during the course of the pilot, interest in funding sites grew among auto manufacturers.

[7] The signed agreements between PGE and the auto manufacturers contain "no publicity" language, thus the names of the automakers have been omitted under the terms and conditions of OAR 860-001-0070. Further information can be provided upon Staff request.

Site Name[8]	Equipment	Service Address	Point of Delivery ID # (PODID)[9]
1	Efacec DCQC and Opconnect L2	Redacted Tigard, Ore.	N/A
2	Efacec DCQC and Opconnect L2	Redacted Tigard, Ore.	N/A
3	Efacec DCQC and Opconnect L2	Redacted Salem, Ore.	N/A
4	Efacec DCQC and Opconnect L2	Redacted Gladstone, Ore.	N/A
5	Efacec DCQC and Opconnect L2	Redacted Portland, Ore.	Removed

Table 3 – PGE/Powin Charging Station installations as part of EV Highway Pilot

The original tranche of ECOtality-installed charging stations was under the CHAdeMO standard, which could charge only a limited number of auto manufacturers' electric vehicles. As technology evolved and more products were launched in the EV space, a standard called Combined Charging System (CCS) Standard or SAE Combo emerged. Tesla Motors also came out with their own standard to support their vehicles. The table below shows the current charging standards and the vehicles supported by each standard.

Table 4 – DC Quick Charge Standards and vehicles supported

Standard	Vehicles supported
CHAdeMO (9 Blink Sites)	Nissan Leaf, Kia Soul EV, Mitsubishi iMiEV, Tesla (with a Tesla made adapter)
Combined Charging System (CCS) or SAE COMBO (5 Powin Sites)	Chevy Spark EV, BMW i3, VW e-Golf, Chevy Bolt
Tesla Supercharger	Tesla Model S and Model X, Model 3 Total

The five Powin installations detailed in Table 3 – as part of the revised pilot program – comprised the first network of chargers in North America to have dual connectors supporting the CHAdeMO DCQC Standard and the CCS Standard.

PGE Ownership of Sites

Following the bankruptcy of ECOtality, resulting in stranded DCQC and Level II charging stations, there was understandable concern heard from customers, automakers, and interested stakeholders about the future of the Blink charging portion of the West Coast Electric Highway in the Portland MSA. PGE assumed ownership and maintenance of the Blink charging infrastructure that was installed through partnership with PGE (both DCQC and Level II). There was no financial transaction associated with this change in ownership; PGE considered the assets abandoned in place upon expiration of the site agreements and notified Car Charging Group, Inc. (CCG), the ultimate purchaser of ECOtality's bankruptcy assets. The letter sent from PGE to CCG/Blink is included as Appendix B; acknowledgement of receipt of the letter is included as Appendix C. PGE has coordinated maintenance of these sites with CCG and other third parties in the time since. PGE will return the assets to CCG upon the end of useful life, upon request.

Shortly following the completion of the five installations undertaken after approval to extend the pilot, Powin decided they would not continue to own and maintain EV infrastructure in Oregon. PGE stepped in and purchased the assets from Powin in an effort to ensure the continued functioning of charging stations, and has kept the charging infrastructure operational and available for customers in the time since.

[8] Customer name redacted under OAR 860-001-0070. Available in confidential Appendix A.
[9] Redacted under OAR 860-001-0070. Available in confidential Appendix A.

Figure 5 below shows the locations of all the current public DCQC locations in the PGE service area. The sites that were installed through EV Highway Pilot partnerships with PGE are circled – the nine Blink sites are in blue and the 5 former Powin sites are in red. The book value of both the Blink and Powin sites that PGE has assumed custodianship of is zero and the total cost to PGE has been negligible.

Portland and Salem Service Area
PGE partnership locations with Blink/Powin are circled

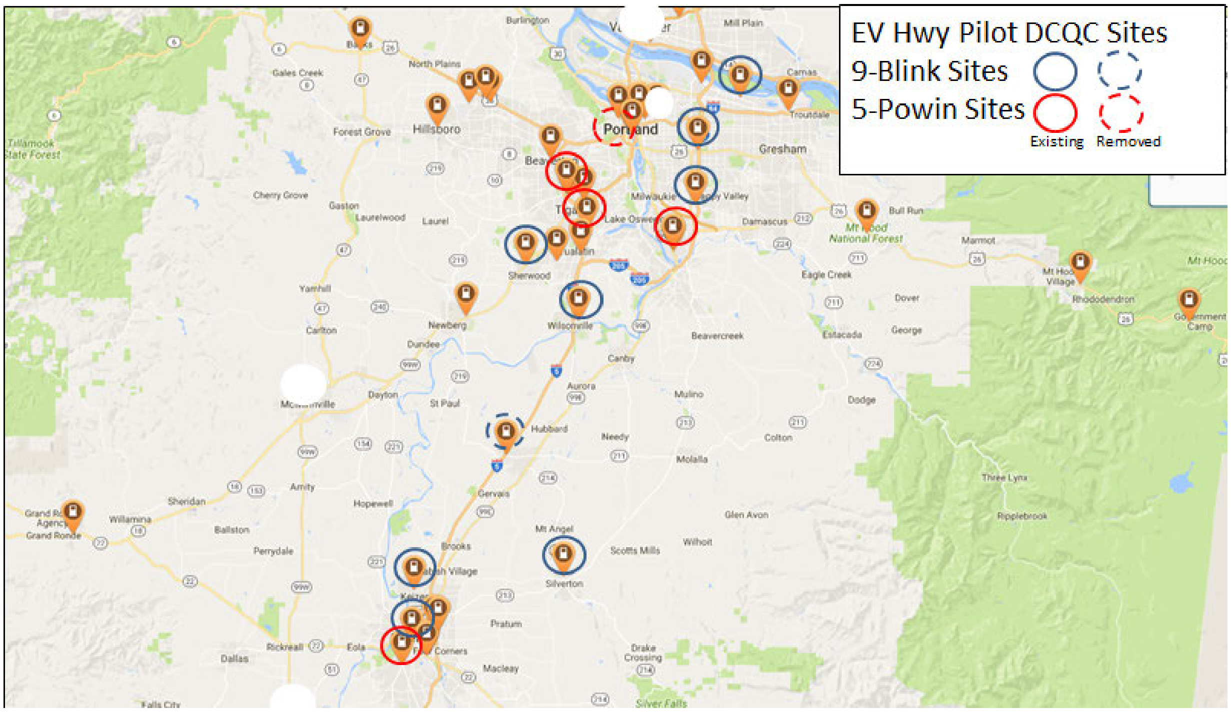


Figure 5 – Blink and Powin sites of which PGE has assumed custodianship.

Pilot Costs

A full summary of pilot installation costs – including PGE's share where applicable – is included in Appendix D.

PGE, working in part with ECOtality, managed the installation of a total of 14 DCQC and 21 Level 2 (including one installation on the State Capitol grounds that PGE does not own or maintain) stations as part of this pilot. Most sites installed one DCQC and one level 2 station at each location. The IBEW site was just a DCQC as they had already installed level 2 stations previous to PGE's involvement. PGE has since assumed custodianship of all sites installed in partnership with Blink and Powin. A high-level summary of infrastructure costs is shown below:

Charging Equipment Costs	Installation Costs	Total Project Costs	PGE Amount
$626,910	$279,325	$906,235	$44,182
		PGE paid percentage	4.88%

Table 6 – Infrastructure cost summary

Average cost per DCQC Site $64,731

Lessons Learned

1) Driver demand for DCQC stations is growing:

- DCQC infrastructure is in demand from customers, and the utilization of the assets installed through these partnerships has grown as EVs have become more prevalent in PGE's service area. We have seen steadily increasing use of these charging stations since their installation in both number of charging events and total energy used[10]. A summary of utilization of the original nine installations is shown in the tables below.

Energy Use (kWh)	2012	2013	2014	2015	2016[11]	Total
DCQC	762	38,420	30,576	53,486	51,857	175,100
L2	304	3,320	8,766	10,307	5,917	28,613
Total	1,065	41,739	39,343	63,793	57,774	203,714

Charges	2012	2013	2014	2015	2016	Total
DCQC	80	4,317	3,529	6,548	6,392	20,866
L2	77	505	1,091	1,456	1,150	4,279
Total	157	4,822	4,620	8,004	7,542	25,145

Table 7 – kWh used and number of charges, 2012 – November 2016.

2) Pricing and grid impact:

- Generally speaking, a DCQC does not draw the rated demand from the grid. In our experience, a 50 kW nameplate rated DCQC resulted in a peak demand of 22 to 25 kW. This is due to the load shape of a typical charge and PGE's interval metering (30 minute intervals): the charger typically draws nameplate rated demand for less than 10 minutes on the initial part of the charge, followed by either termination of the charge or drastically reduced demand as the charge completes. Subsequent observations and technological advancements may identify higher peak impacts due to the development of adapter technology. Chargers manufactured by Tesla now allow a Tesla Model S or X, and soon the Model 3, to charge at a DCQC station using the CHAdeMO connector. A typical Model S or X can draw the full rated load of the charger for up to 120 minutes to fully charge a 60-100 kWh battery. Future vehicles such as the Chevrolet Bolt and longer range Nissan Leaf may show similar load characteristics.

- The finding that DCQC infrastructure typically has a lower peak demand compared to rated nameplate capacity may have an impact on how electric utilities approach pricing power sold to site hosts. The current standard is generally to assess commercial and industrial customers (an approximate peer to a DCQC in terms of nameplate peak capacity) a demand charge to compensate the utility for the transmission and distribution infrastructure built to serve the customer's facility. However, we have had a considerable amount of success with our Schedule 38 offering through this pilot, which assesses site hosts an energy-only price and is seen as EV friendly by automakers and charging providers.

- The impact of PGE's Schedule 38 price offering (an optional schedule that extends to 200kW while maintaining an energy-only construct; Schedule 83 serves the same customer class but with a demand charge) was the subject of an Idaho National Laboratory white paper[12] examining the impact of demand

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[10] 2016 data is only available through November, extrapolating energy and charge numbers will likely lead to all-time utilization highs for 2016.
[11] 2016 data is only available through November.
[12] https://avt.inl.gov/sites/default/files/pdf/EVProj/EffectOfDemandChargesOnDCFCHosts.pdf

charges on 50kW DCQC. The paper concluded that the low load-factor characteristics associated with DCQC would lead to a higher bill if a demand component were included in the pricing.

- PGE has since received requests for information from numerous utilities, Idaho National Laboratory, Edison Electric Institute (EEI), and Georgetown Climate Research Center regarding the pricing construct of Schedule 38 and how that construct could be adapted to other utilities.

3) Location and siting costs of DC quick chargers and implications for the Company's business processes:

- PGE's active involvement in the location and siting process has reduced the need for system upgrades. PGE worked with ECOtality to select general areas where DCQC stations were needed. Scoping drives were then done to look for suitable locations (suitability was focused on lower cost sites and included but was not limited to: 24 hour services nearby, ample parking, close to existing PGE distribution infrastructure). Site visits by staff knowledgeable in the distribution system worked to eliminate site locations where major system upgrades would be needed. Transformers were checked for capacity and room for service conductors. When working with Powin, a similar process was undertaken, although one site needed a new pole-mounted transformer.

- We were able to reduce installation costs by using 208v DCQC installations rather than 480v. Blink DCQCs came in two configurations: one for 480 volt 3-phase service and the other for 208 volt three-phase service. In most areas of the country, Blink DCQCs were 480 volt installations; this installation requires an extra transformer and extra panel to serve level 2 stations at the site, which typically adds $4k to $5k to an installation. Additionally, the 480v units had a longer delivery times.

- PGE has gained additional knowledge about the load requirements of DCQC and Level II chargers, which could be used for future line extension allowance requests. Upon initiation of this pilot, PGE's Line Extension Allowance (LEA) did not have any estimates for the estimated added load of EV charging stations. Additionally, we did not have experience in the actual demand drawn from the stations vs. the nameplate connected load. We made some educated assumptions to come up with an LEA for these sites.

- The infrastructure in place as a result of PGE's participation in the EV Highway Pilot allowed greater visibility into customer charging behavior in the Portland Metropolitan Statistical Area. The DCQC white papers completed by Idaho National Lab relied heavily on these installations for the assumptions and learnings in the Willamette Valley.

4) Additional Learnings

- As part of the pilot, we were able to work directly with customers and hear their successes and challenges regarding hosting a charging station on their property. This will factor into future site selection decisions and site partner outreach programs.

- PGE commissioned an engineering study to examine the depth needed for a concrete pad to support DCQCs, which ultimately led reduced installation costs for subsequent charging stations. As part of the installation of the Blink EV Charging stations, the manufacturer initially recommended a concrete pad for the charger to be roughly 3 feet deep. This requirement was very conservative as it used a limitation based on the frost depths across the country.

- National Electric Code allowed a 200 amp service to serve the DCQC stations, a California Authority Having Jurisdiction (AHJ) made a ruling that required a 400 amp Service, which added thousands of dollars in a change order for a project in progress. PGE got a ruling from the state of Oregon Electrical Code Staff allowing the 200 amp service. Ecotality paid for additional costs for that project and future ones they required a 400 amp service.

- The installation of the charging infrastructure through the EV Highway Pilot has allowed far greater visibility into customer charging behavior, system impacts, and technological constraints. The ability for

PGE to represent the Portland MSA has allowed for learning nationwide as evidenced by data inclusion in the following white papers by the Idaho National Labs: "What Were the Use Patterns Observed at the Highly Utilized Direct Current Fast Charge Sites[13]," "What were the Cost Drivers for the Direct Current Fast Charging Installations[14]," "DC Fast Charge – Demand Charge Reduction[15]," and "DC Fast Charger Usage in the Pacific Northwest[16]."

Potential Topics for Further Research

PGE's learning and insight will inform future decisions for EV-related activities. Subsequent learnings could include:

- Further explore opportunities to use price signals to promote public charging – this could potentially include a time of use component to encourage off-peak charging by customers.
- Continue to monitor new technology to determine actual capacity needs of charging stations and how that may modify site selection criteria.
- Continue to explore the relationship between visible charging infrastructure and the willingness of customers to change from an internal combustion engine vehicle to an electric vehicle.
- Explore small pilot activities such as curtailable charging through DCQC infrastructure.

PGE will continue to work closely with OPUC Staff and other interested parties to determine the next appropriate steps regarding the electrification of transportation in Oregon.

[13] https://avt.inl.gov/sites/default/files/pdf/EVProj/WhatWereTheUsePatternsObservedAtHighlyUtilizedDCFCSites.pdf
[14] https://avt.inl.gov/sites/default/files/pdf/EVProj/WhatWereTheCostDriversForDCFCinstallations.pdf
[15] https://avt.inl.gov/sites/default/files/pdf/EVProj/DCFastCharge-DemandChargeReductionV1.0.pdf
[16] https://avt.inl.gov/sites/default/files/pdf/evse/INL_WCEH_DCFCUsage.pdf

Appendices

A. Installed EV Charging Equipment
B. Letter from PGE to CCG/Blink
C. Acknowledgement Letter from CCG/Blink to PGE
D. Site Equipment and Installation Costs

EV Highway Pilot Report

Appendix A

Installed EV Charging equipment as part of pilot

Confidential and subject to the terms and conditions of OAR 860-001-0070

Provided in Electronic Format (CD) only

EV Highway Pilot Report

Appendix B

Letter from Portland General Electric to Blink/CCG

Confidential and subject to the terms and conditions of OAR 860-001-0070

Provided in Electronic Format (CD) only

EV Highway Pilot Report

Appendix C

Acknowledgement Letter from CCG/Blink to PGE

Confidential and subject to the terms and conditions of OAR 860-001-0070

Provided in Electronic Format (CD) only

EV Highway Pilot Report

Appendix D

Site Equipment and Installation costs

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Provided in Electronic Format (CD) only

Transportation Electrification Plan

MARCH 2017

PGE

Revision History

Table 1: Filing Revision History

<table>
<tr><th>Version</th><th>Date</th><th>Revision Notes</th></tr>
<tr><td>1</td><td>12/27/16</td><td>Original Filing</td></tr>
<tr><td>2</td><td>03/15/16</td><td>
Research and Small Pilots – the research and small pilots section has been removed because many of those research projects are existing initiatives underway through PGE's R&D program.
A summary of existing and planned R&D initiatives is included in Section 1.5(b).
The section was replaced with Section 3.4: Residential Smart Charging Pilot, which has not yet been funded.
Restructured all sub-headings for Proposed Pilots section (Section 3)
Added detail to timeline and budgets subsections
Included cost-effectiveness subsection
Removed market barriers chapter and created market barriers subsection for each pilot
Outreach and Technical Assistance
More details about the specifics of the proposed program have been shared, along with a revised (downward) budget.
Electric Avenue Network
Added funding for outreach and enrolling customers into the network.
Cost Effectiveness Analysis (Navigant Whitepaper) updated to reflect updated costs.
</td></tr>
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Contents

Acronyms

AC .... Alternating Current
AFVI .... Alternative Fuel Vehicle Infrastructure
AMI .... Advanced Metering Infrastructure
BEV .... Battery Electric Vehicle
BYOT .... Bring Your Own Thermostat
CBO .... Community Based Organization
CEO .... Chief Executive Officer
CPUC .... California Public Utilities Commission
CUB .... Oregon Citizen's Utility Board
DC .... Direct Current
DCQC .... Direct Current Quick Charger
DEQ .... Department of Environmental Quality
DER .... Distributed Energy Resource
DLC .... Direct Load Control
DMW .... Department of Motor Vehicles
DR .... Demand Response
EAV .... Electric Autonomous Vehicle
EEI .... Edison Electrical Institute
EPA .... Environmental Protection Agency
EPRI .... Electric Power Research Institute
EV .... Electric Vehicle
EVSE .... Electric Vehicle Supply Equipment
FCEV .... Fuel Cell Electric Vehicle
FERC .... Federal Energy Regulatory Commission
FHA .... Federal Highway Administration
FTA .... Federal Transit Administration
FTE .... Full-Time Equivalent
GDP .... Gross Domestic Product
GM .... General Motors
GTM .... Greentech Media
GWh .... Gigawatt hour
HB .... House Bill
HECO .... Hawaiian Electric Company
ICEV .... Internal Combustion Engine Vehicle
IOU .... Investor Owned Utility
KCP&L .... Kansas City Power & Light
kV .... Kilovolt
kW .... Kilowatt
kWh .... Kilowatt Hour
L1 .... Level 1 (Charger)

L2 .... Level 2 (Charger)
LCFS .... Low Carbon Fuel Standard
MSA .... Metropolitan Statistical Area
MW .... Megawatt
MWa .... Average Megawatt
MWh............................. Megawatt Hour
NEEA .... Northwest Energy Efficiency Alliance
NGO .... Non-Governmental Organization
NOx............................... Nitrous Oxides
NPV .... Net Present Value
NRDC............................ National Resources Defense Council
NREL............................. National Renewable Energy Laboratory
NWEC............................ Northwest Energy Coalition
O&M .... Operations & Maintenance
OCCP .... Open Charge Point Protocol
ODOT .... Oregon Department of Transportation
OEC .... Oregon Environmental Council
OEM.............................. Original Equipment Manufacturer
OPUC .... Oregon Public Utility Commission
PEVs .... Plug-in Electric Vehicles
PG&E............................. Pacific Gas and Electric
PGE .... Portland General Electric
PHEV .... Plug-in Hybrid Electric Vehicle
PIGS .... Personal, Internal Combustion, Gas-powered, Steel-dominated vehicles
R&D.............................. Research and Development
RFI................................. Request for Information
RFID .... Radio-frequency identification
RFP................................ Request for Proposals
RIM .... Ratepayer Impact Measure (Utility Customer Perspective)
RMI .... Rocky Mountain Institute
RPS............................... Renewable Portfolio Standard
SAE............................... Society of Automotive Engineers
SB.................................. Senate Bill
SCE .... Southern California Edison
SCL .... Seattle City Light
SCT .... Society Cost Test
SDG&E .... San Diego Gas and Electric
SEALS .... Shareable, Electrified, Autonomous, Lightweight, Service vehicles
SMUD............................ Sacramento Municipal Utility District
SUV .... Sports Utility Vehicle
T&D.............................. Transmission & Distribution
TNC .... Transportation Network Company

TOU.............................. Time of Use
TRC............................... Total Resource Cost
USDOE .... US Department of Energy
USDOT .... US Department of Transportation
V2G .... Vehicle-to-Grid
VW .... Volkswagen
WEIL............................. Western Energy Industry Leaders
ZEV............................... Zero Emissions Vehicle

Executive Summary

Portland General Electric Company (PGE) is pleased to file this transportation electrification plan and program proposals as directed by Chapter 28, Oregon Laws 2016. In the passing of Chapter 28, Oregon Laws 2016, the state legislature acknowledges that there is a role for electric companies to play in accelerating transportation electrification.

In the long term, PGE envisions a world where hundreds of thousands of electric vehicles are on the road and meaningfully support the operation of the electric grid. As electricity continues to grow as a transportation fuel, and electric vehicle adoption grows in our service area, we see EVs playing a key role in helping integrate the new variable resources that will be added to PGE's grid in order to meet the 50% Renewable Portfolio Standard mandate.

To achieve this vision, our key goals in this Plan are to:

1. Increase customer acquisition of electric vehicles and other electric transportation options in our service area; and
2. Begin efficiently integrating electric vehicles into our system.

Analysis suggests that each new electric vehicle added to a home in our service area provides a benefit to all of our customers today. The typical electric vehicle uses existing grid infrastructure when it is otherwise underused, thereby creating downward pressure on prices. Accordingly, electric company programs that encourage our customers to acquire EVs – while ensuring that the vehicle connects to our system as efficiently if not more efficiently than the standard EV does today – are appropriate to examine.

The following pilot proposals will promote customer acquisition of electric vehicles, facilitate electric vehicle use through a reliable and accessible charging network, and build a foundation of knowledge and experience that will enable PGE to most efficiently integrate electric vehicles in the future:

1. **Electric Mass Transit 2.0:** PGE proposes a pilot to install and manage 6 electric bus charging stations (5 depot chargers and 1 en-route charger) for use by TriMet. PGE's involvement in the pilot will allow TriMet to use grant funding from the Federal Transit Administration (FTA) to purchase an additional electric bus, thus enabling the electrification of an entire bus route. Each bus will have a roughly 250 kWh battery; for context, their combined energy rating (1.25 MWh) will be equal to PGE's Salem Smart Power Center. By owning and managing the charging infrastructure, PGE will be able to obtain key learnings that will allow us to most advantageously integrate the considerable demand that may emerge from future electric bus charging infrastructure. The pilot will evaluate distribution system impacts and customer service considerations by studying coincident peak, non-coincident peak, feeder voltage dynamics, charging behaviors, and load profiles. Additionally, PGE will explore locating energy storage at the site of the en-route charger to minimize distribution upgrade costs and impacts of

coincident peak as an element of UM 1751 (Energy Storage Docket). PGE would procure and own the chargers, while TriMet would bear the cost of their installation and maintenance. The cost for the five chargers and ongoing operations less payments from TriMet is $598,000 (10-yr NPV). TriMet will pay the applicable tariffed rate for electricity from the charging stations.

2. **Outreach and Technical Assistance**: The largest barrier to electric vehicle adoption is lack of consumer awareness. To raise awareness of the benefits of driving electric, we propose a 5-year pilot for strategic outreach, education, and technical assistance, including an incremental full-time employee (FTE) to manage these efforts. The pilot will provide technical assistance for commercial and industrial customers (including non-profits that support low-income communities), specialized trainings for key industry stakeholders (e.g. dealers and builders), partner rewards pilots, ride and drive events, and education on whole-house time-of-use rates to residential customers who drive electric vehicles. We will leverage existing outreach channels and a wide range of partners to most cost-effectively reach key audiences. The estimated cost of this pilot is $2.1M (10-yr NPV).

3. **Community Charging Infrastructure Pilot:** PGE endeavors to build on the success of Electric Avenue, a group of five electric vehicle stations located at World Trade Center in downtown Portland, by building six additional Electric Avenue sites. The sites will each include up to four dual-head fast chargers and one level 2 charger for accessibility. Similar to a gas station, this model co-locates several chargers, increasing the chance that drivers in need will be able to find a functional and available charger, thereby effectively improving the availability and reliability of public charging infrastructure. The network will also include the 11 charging stations owned by PGE as a legacy of the EV Highway pilot. Our vision is to have these sites – geographically dispersed throughout the service area – serve as a harbinger of the availability of electricity as a transportation fuel. The sites will increase the visibility of electricity as a transportation fuel and empower the many customers who need to see convenient public charging infrastructure in order to consider an EV. An exciting feature of this pilot will be to examine the impact of community charging infrastructure on increasing the adoption of electric vehicles by transportation network companies (e.g., Uber and Lyft), car-sharing companies (e.g., Reach Now), and the home-charging challenged (i.e. those who live in multifamily buildings or do not have off-street parking with electric service). The pilot will allow us to test price signals to encourage off-peak charging, promote charging when excess renewables are available, and (in the future) enable (and reward) customers to discharge their vehicle batteries to the grid. Prices for charging at these stations will be in line with existing market rates and may employ time-variant pricing to promote charging at times aligned with the needs of today's electric system. We anticipate the total cost of the pilot to be $4.1M and expect it to generate $3.5M in revenues from subscriptions and usage charges (10-yr NPV).

4. **Residential Smart Charging Pilot (DR):** This pilot would offer incentives to customers who have or purchase qualifying DR-enabled home charging equipment. The pilot will test the effectiveness of home charging DR and customer satisfaction. The estimated cost of outreach, incentives, and program administration is $171,000 (10-yr NPV).

For each pilot, PGE plans to follow our standard model of requiring a competitive request for proposal process to ensure PGE's customers realize maximum value while fostering competition. PGE will report back to the OPUC every two years on the progress of each pilot.

In total, PGE estimates that the proposed transportation electrification pilots will cost $8.1M and generate $4.2M in customer payments (using a 10-year NPV):

Table 2: Estimated Transportation Electrification Pilots Financial Summary, by Program, 10-yr NPV (2017 $), ($,000)

	Total Revenue Requirements	Est. Customer Payments	Net Costs (Rev Req. less Cust. Payments)
Outreach and Technical Assistance	$ 2,054	-	$ 2,054
Electric Mass Transit 2.0	$ 1,239	$ 641	$ 598
Electric Avenue Network	$ 4,098	$ 3,547	$ 591
Bring Your Own Charger	$ 171	-	$ 171
Pilot Evaluation	$ 581	-	$ 581
Total	$ 8,142	$ 4,188	$ 3,954

Upon approval of these pilot proposals by the OPUC, PGE intends to file a deferral to recover these net costs.

In addition to better understanding grid impacts of transportation electrification and effectiveness of grid-integration strategies, PGE anticipates that new EVs on the grid as a result of the proposed pilots will have a benefit-cost ratio of 1.33 and create a net benefit of $5.0M (using a customer perspective test) for all PGE customers through increased electricity sales, creating downward pressure on customer prices:

Table 3: Transportation Electrification Pilots Cost-Effectiveness Summary, NPV (2017$), ($,000)

	Customer Perspective (RIM)	Total Resource Cost (TRC)	Societal Cost Test (SCT)
Benefits	$ 20,422	$ 81,666	$ 85,634
Costs	$ 15,326	$ 76,962	$ 78,993
Net Benefit	**$5,096**	**$ 4,704**	**$ 6,641**

Additionally, we anticipate the pilot programs to help the state of Oregon meet its greenhouse gas reduction goals by preventing 595,071 metric tons of CO_2 emissions from being emitted.

In conclusion, through an extensive stakeholder outreach process, we have developed a suite of pilot programs designed to support the growth of electricity as a transportation fuel in PGE's service area and integrate this new electricity use into PGE's system efficiently. These pilots will raise awareness of the benefits of electric transportation, encourage positive charging habits, grow the number of electric vehicles on our roads, increase the visibility, reliability, and experience of public vehicle charging, and help PGE learn about the challenges and opportunities of a significant increase of electric vehicles on the road.

Section 1. Background

1.1. Chapter 28, Oregon Laws 2016

In the 2016, the State of Oregon legislature adopted Chapter 28, Oregon Laws 2016[1] with the intent of eliminating coal from the electricity supply, increasing renewable energy production, and promoting alternative technologies that reduce carbon and/or aid in efficiently integrating renewables onto the grid. The legislation includes a section that directs investor owned utilities (IOUs) to file applications with the Oregon Public Utilities Commission (OPUC) for programs to accelerate transportation electrification. Such programs "may include prudent investments in or customer rebates for electric vehicle charging and related infrastructure."[2] These programs are to be consistent with the Legislative Assembly's findings related to transportation electrification, including that electric companies "increase access to the use of electricity as a transportation fuel"; that "electric vehicles should assist in managing the electrical grid" and that the vehicles' ability to assist in managing the grid creates the potential for attaining a "net benefit for the customers of the electric company".[3]

When considering programs and determining cost recovery, the Commission shall consider if investments are:

- In the service territory ;
- Prudent;
- Expected to be used and useful;
- Are expected to improve grid efficiency and operational flexibility (including renewable integration);
- Expected to stimulate innovation, competition, and customer choice.[4]

1.2. Legislative Rulemaking (AR-599)[5]

Following the passage of Chapter 28, Oregon Laws 2016, a rulemaking process was initiated by the Oregon Public Utility Commission (OPUC). Interested stakeholders came together and provided input on how a Transportation Electrification Program should be structured in the State of Oregon. The rulemaking process included multiple rounds of written comments, as well as technical conferences which included all three investor-owned utilities.

The draft rule was filed with the Oregon Secretary of State on July 13, 2016, and the OPUC adopted Oregon Administrative Rule 860-087 (Transportation Electrification Programs) on November 26, 2016 (Order No. 16-477).[6]

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[1] https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2016orLaw0028.pdf
[2] Sec. 20.3
[3] Sec. 20.2
[4] Sec. 20.4
[5] http://apps.puc.state.or.us/edockets/docket.asp?DocketID=20129

1.3. Stakeholder Engagement

In preparation for filing this Plan, PGE provided external stakeholders several opportunities to contribute to our planning and provide feedback on our proposed ideas. PGE's workshops included participation from customers, regulators, automakers, peer electric companies, equipment manufacturers, government bodies, and non-governmental organizations.

Table 4: Transportation Electrification Stakeholder Workshops

Date	Workshop Topics
08/02/2016	PGE Experience, Market Landscape, Proposal Ideation, Valuation
10/13/2016	Proposal Plans, Preliminary Valuation Estimates
11/07/2016	Low-income engagement

In addition to these open workshops, PGE also held a number of smaller, topic-driven meetings and phone calls with a variety of stakeholders. For example, PGE held a roundtable discussion on cost-effectiveness methodologies and approaches, with representatives from the OPUC staff, the Oregon Citizen's Utility Board (CUB), Natural Resources Defense Council (NRDC), Northwest Energy Coalition (NWEC), and the Oregon Environment Council (OEC) in August. In November, PGE convened a number of stakeholders to discuss the Low Carbon Fuel Standard (LCFS) and how that state policy may impact the transportation electrification plan and programs. PGE has developed this Plan in consideration of the ideas and questions raised by stakeholders at these workshops and meetings.

[6] http://apps.puc.state.or.us/orders/2016ords/16-447.pdf

1.4. Current State: Public Charging Infrastructure in Oregon

Today, there are 182 public quick charging stations in Oregon at 105 sites. Excluding Tesla sites which are only accessible by Tesla vehicles, 82% of public quick chargers were installed or funded by federal grants (61%) or auto manufacturers (21%). The challenge with these funding sources is that they do not have a long-term business interest in operating and maintaining public charging infrastructure, and often chargers receive inadequate maintenance. Generally speaking, the private market is not taking an active role in installing public quick chargers in Oregon:

Table 5: Public DC Quick Chargers in Oregon by Network

Network Provider	Connector Type	Funding Source	No. of Sites	No. of Chargers	Installation Date
Aerovironment	CHAdeMO	ARRA Grant	44	44	2012-2013
Blink	CHAdeMO	USDOE Grant	14	14	2011-2012
Chargepoint	Dual-head	Auto Manufacturers	7	7	2016
	CHAdeMO	Auto Manufacturers	3	3	2016
EVgo	Dual-head	Self-funded	8	8	2015-2016
Greenlots	Dual-head	Auto Manufacturers	2	2	2016
Opconnect	Dual-head	Auto Manufacturers	8	8	2014-15
	Dual-head	Private Party	2	2	2014
Tesla	Tesla	Self-funded	12	87	2013-2016
Other	CHAdeMO	Business owners	3	3	2010-2012
	Dual-head	World Trade Center	1	4	2015
		Total	**104**	**182**	

The table above reveals several interesting facts about the current state of the fast charging market in Oregon.

- Public quick chargers are not accessible to everyone: There are two primary plugs that electric vehicles and chargers can connect: CHAdeMO and SAE Combo. Some manufacturers use the former and others, the latter. The two cannot be used interchangeably. Only 31 (16%) of public quick chargers in Oregon have dual-head connectors, providing accessibility to all EV drivers, and 48% of public quick chargers are only accessible by Tesla drivers. For comparison there are 915 gas fueling stations in Oregon.[7]

[7] https://oregoneconomicanalysis.com/2012/02/13/self-service-gas-and-taxes/

- Public quick charging sites are not adequately deployed: Outside of PGE's Electric Avenue and Tesla's sites, just one charging site has two DCQCs; the others just have a single quick charging station at each site. Accordingly, if someone is using the charging station, it is blocked by a non-electric vehicle, or the charging station is out-of-service for any reason, the customer who needs a charge cannot get one. Additionally, many of these sites are at capacity—they were designed for just a single charger. Because the sites were not future-proofed, adding additional chargers or faster chargers would require significant, costly infrastructure upgrades.

Additionally, what the table does not reflect is that things happen to businesses that install or maintain charging infrastructure (particularly those funded by grants or auto manufacturers whose primary business is not operating and maintaining EV charging stations): site hosts lose interest in maintaining the equipment; equipment providers go bankrupt or shift their business interests; companies are acquired or restructured. These changes have affected and will likely continue to shape Oregon's charging landscape. When ECOtality filed for bankruptcy in 2013, hundreds of public chargers were abandoned with no agreements in place to maintain the equipment. PGE has since taken ownership of 8 of those quick chargers, which were part of Schedule 344: Oregon Electric Vehicle Hwy Pilot Rider, to ensure they remain accessible and reliable.

The last row above refers to PGE's installation of Electric Avenue 2.0 at our World Trade Center headquarters on July 18, 2015. The electric vehicle charging hub features 4 dual-head DC quick chargers and 1 dual-head level 2 charger. The facility aims to be inclusive of all vehicles and available when anyone needs a charge. By providing 5 chargers, customers can reliably count on being able to find an open, functioning spot when they need a charge. To date the site has delivered more than 200,000 kWh and powered nearly 1,000,000 electric miles. Additionally, the site's visible and pedestrian-friendly location fosters frequent conversations between EV drivers and passersby. This has been a great way for more people to become aware of the benefits of electric vehicles.

1.5. Current State: PGE's Existing EV Programs, Research, and System Impacts

1.5(a) Existing Programs

Today about 10,000 PGE customers drive a plug-in electric or plug-in hybrid electric vehicle. For those customers and others interested in exploring electric vehicles, PGE offers assistance in the following ways:

Whole Home TOU:

PGE offers all residential customers a whole-home TOU rate through Schedule 7. The rate offers customers a discount on electricity consumed after 10pm. Though not specific to electric vehicle owners, PGE encourages EV drivers to consider this as an option to further reduce their vehicle operating costs.

EV-only (sub-metered) TOU:

Through Schedule 7, PGE also offers a TOU rate for separately metered service used exclusively for the purpose of EV charging. In order to participate in this option, the customer must (at his or her own expense) install all necessary equipment (including the revenue-grade meter) in order to participate in this option. The sub-metered rate is cost preventative for customers and has ultimately yielded no participation to date.

As an alternative to reduce costs, PGE has considered using “smart” residential charging units with internal metering capabilities; however, there are no industry standards or best practices on utilities measuring, verifying, and performing on-going testing of the metering in these devices to ensure they are consistently revenue grade.

Ad Hoc Technical Assistance

For commercial and industrial customers interested in electrifying their fleet or installing workplace chargers for their employees, PGE provides ad hoc consultations to help customers in evaluating electric service, siting, and other design considerations. In 2016, PGE helped roughly 20 customers with such questions.

Additionally, PGE has recently begun to conduct 1-2 broad-based community based organization (CBO) educational meetings each year (based on demand) to provide basic education to organizations on how EVs work, how they could benefit the CBOs, and how they could benefit the communities that they serve. These workshops will also encourage agencies to enroll in technical assistance and/or charging programs.

Public Charging

Electric Avenue 2.0 at our World Trade Center offices in Portland has been a success; the site, activated on July 18, 2015, hosts four dual-head DCQCs and one dual-head L2 charger. To date Electric Avenue 2.0 has delivered more than 200,000 kWh and powered more than 1,000,000 electric miles. The site’s visible and pedestrian-friendly location fosters frequent conversations between EV drivers and passersby. This has been a great way for more people to become aware of the benefits of electric vehicles.

Additionally as indicated in Section 1.4, PGE has since taken ownership of several quick chargers, which were part of Schedule 344: Oregon Electric Vehicle Hwy Pilot Rider and originally owned by EVSEs that have since gone bankrupt, to ensure they remain accessible and reliable for those who depend on them.

Public Charging Rates

PGE currently offers three standard price options for public charging infrastructure for site hosts – one of these prices includes a demand component, while two are energy based and do not include any demand charges. The structure of the currently available rates is as follows:

- **Schedule 32 (Small Nonresidential Standard Service; <30kW)** applies to small commercial customers. It does not include a demand component and has both a standard and time of use (TOU) option for energy price. Businesses may elect to add EV charging to their existing service – provided it does not take them over the 30kW limit – or they may separately meter PEV charging services under Schedule 32 TOU. If a customer chooses separately metered service, they are responsible for the costs associated with the second meter, along with the basic charge, transmission charge, and distribution charge associated with the second meter.

- **Schedule 38 (Large Nonresidential Optional Time-of-Day Standard Service; 30-200kW)** is available to customers who are served at secondary voltage with a monthly demand that does not exceed 200 kW more than once in the preceding 13 months. This rate does not include a demand component, and assesses energy charges for both on-peak and off-peak periods. On peak is weekday from 7 a.m. to 8 p.m., any other time is considered to be off-peak. As with Schedule 32, charging infrastructure can be included on this price along with existing business service, or can be separately metered. The lack of a demand charge on this rate makes it particularly attractive to providers of public charging infrastructure that receives relatively light usage.

- **Schedule 83 (Large Nonresidential Standard Service)** is designed for customers receiving service at secondary voltage whose demand has not exceeded 200 kW more than six times in the preceding 13 months and has not exceeded 4,000 kW more than once in the preceding 13 months, or with seven months or less of service has not had demand exceeding 4,000 kW. This rate reflects a more “traditional” pricing design for non-residential customers, as it includes a demand component and a lower energy charge, which means that as customer load factor increases, the overall price decreases. Customers may use this rate for charging infrastructure when it is part of an integrated service with their existing load, or may separately meter under the Schedules 32 or 38 options.

1.5(b) Existing and Planned Research

PGE currently has a number of electric vehicle research projects that utilize existing staff and R&D budget. No incremental resources are being requested for research indicated in this section. Rather, the purpose of the section is to describe existing projects that help us better understand customer and system impacts associated with charging, rate design, demand response, and vehicle to grid.

Employee Research Pilot

To date, PGE has more than 90 employees who own or lease an electric vehicle. In 2016 we launched an employee research project to study charging behavior (home, public, and workplace), TOU rates, and demand response/smart charging.

The project aims to give PGE better understanding on where and when people charge, how TOU rates impact home charging habits (and use of other appliances in the home), and the impacts of curtailing charging loads at home and work. Key elements of the study include:

- **Time of Use:** On average, more than 80% of EV charging happens at drivers' homes—as a result we understand the importance of looking for pricing and control strategies at the premises.[8] As such, half of the participating employees have been randomly selected to be put on Schedule 7's whole-home TOU rate which offers savings of greater than 40% for shifting energy consumption to off-peak hours.[9,10] The study will compare TOU participants versus non-participants and evaluate impacts on charging behavior as well as energy-use for all devices in the home.
  Note: this is PGE's historic rate schedule and not the pricing options offered in PGE's current TOU pilot program, Flex.
- **Smart Charging:** 20 employees in the pilot are utilizing a DR-enabled home charging station; additionally all employees are eligible for free workplace charging (some of which is DR-enabled). The study aims to evaluate practical feasibility, customer experience, and achievable curtailment from smart charging. Additionally, we will directly engage with several employees to program their vehicles to charge on a schedule.
- **Public Charging Behavior:** all participating employees are responsible for keeping a vehicle charging log to track public charging events. We will be evaluating these logs to better understand what drives people to charge outside of the home and workplace, how often they publically charge, where they charge, and for how long they charge.
- **Survey Data:** Additionally, PGE intends to use the employee group to periodically survey for EV-related insights.

We anticipate that the learnings from this study will inform future program design to help efficiently integrate customer EVs into PGE's grid.

Enrollment for the pilot was launched in January, 2016 and will continue through the end of 2017 (extended through 2018 if additional enrollments are required). Data collection will go through 2019.

Workplace Smart Charging Pilot

There is clear value associated with employers installing workplace charging for their employees: NRDC explains that workplace chargers not only extend ranges but also increase EV

[8] 2016. *Fully Charged: How Utilities Can Help Realize Benefits of Electric Vehicles in the Northeast*. Prepared for Sierra Club by VEIC. http://www.sierraclub.org/sites/www.sierraclub.org/files/uploads-wysiwig/20160906%20Northeast%20EV%20utility%20report%20(1).pdf

[9] https://www.portlandgeneral.com/residential/power-choices/time-of-use/time-of-use-pricing

[10] https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_007.pdf

visibility.[11] USDOE supports this claim stating that "employees at participating workplaces are up to 20 times more likely to drive electric vehicles."[12] One interviewed customer actually cited workplace charging as the tipping point for going electric: "Seeing it at work made me think it was possible." [13]Workplace charging clearly has a role to play in expanding adoption of electric vehicles; however, it does present a potential grid challenge as it could encourage charging during on-peak hours. (Depending on the emergence of solar energy, today's peak hours, could be tomorrow's off-peak.)

PGE has already commenced an employee workplace smart charging pilot at its own workplace sites. Currently PGE has 69 workplace charging spots at 18 sites; 20 of those chargers are DR-enabled. We anticipate carefully piloting this concept with some of our customers, but it is important that we expand this pilot carefully and strategically as curtailment of EVSEs has unique customer impacts not fully comparable to other direct load control (DLC) programs (i.e. heating, cooling, and hot water):

- **Utility of vehicle:** unlikely heating and cooling, EVs are often on the move and not connected to PGE's grid. If a customer does not get a full charge while at work or while patronizing a business, it is conceivable that they may not have enough charge to reach their next destination. We must start slowly with expanding this pilot to ensure a positive customer experience.
- **Impact on our customers' customers:** It is one thing to curtail charging on our own employees at our facilities, however, when we begin curtailing customers' charging stations, we will also likely impact their customers and employees. This creates two-tiers of customer service, again adding to the emphasis that we must start slow to ensure a positive experience for all.
- **Lack of consistent load profiles/use cases:** Unlike many technologies/customer classes, there are no clear load profiles associated with workplace/business charging infrastructure. This raises questions of (1) how much potential value there is with workplace smart charging, (2) how to standardize program design such that programs are still relevant to most, and (3) how do we ensure positive customer experience despite likely different charging experiences at different sites.

In 2018, PGE intends to collaborate with 1-2 business customers who intend to install 5-20 electric vehicle charging stations at their site(s). We plan to offer those customers $1,000 per charger to procure charging infrastructure that is DR-enabled and for committing to up to 10 curtailments per year. If the pilot proves successful, PGE may expand the pilot to additional customers in the service area.

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[11] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).
[12] http://energy.gov/eere/vehicles/ev-everywhere-workplace-charging-challenge
[13] Customer interview. July, 2016. Conducted by Keller.

Additionally, PGE intends to cover the entire installation cost of workplace charging for up to 3 CBOs that buy or otherwise secure access to an EV for a minimum of a 3-year period. The organizations will pay only for the energy that the chargers use; however, the chargers will be DR-enabled and integrated into the workplace pilot.

The pilot will study electric vehicle grid integration and aims to provide PGE with improved flexibility in curtailing or shifting charging loads to off-peak periods or periods of excess renewable energy.

The pilot will evaluate: achievable coincident demand reductions, reliability of demand reductions, customer experience (both facilities and end-use vehicle owners). The pilot should yield results that inform future program designs, such as program costs, achievable curtailment, and attribution.

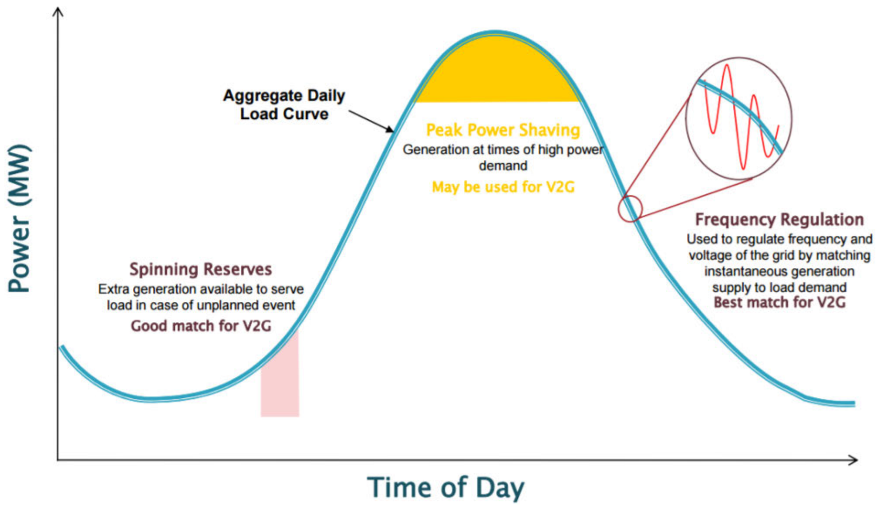
We intend to fund the study through PGE's existing R&D budget. No incremental funding is being requested at this time.

Vehicle to Grid

It is not difficult to imagine that more than 10% of the vehicles in PGE's service area will be plug-in electric vehicles within the next 20 years. Two hundred thousand PEVs represent 5,000 – 10,000 MWh of potential distributed energy resources that could add value to PGE's grid. For context, PGE delivered 19,382,000 MWh of retail energy in 2015.[14] The large potential storage resource has the ability to provide a variety of vehicle-to-grid (V2G) applications (i.e. Vehicle-to-Home). V2G is used to describe the energy flow back from a vehicle's battery to the electric grid (much like excess generation of a solar array). Potential applications include: spinning reserves for regulating fluctuations in renewables, peak power shaving, frequency regulation, emergency backup power, and other ancillary services.

[14] http://investors.portlandgeneral.com/common/download/download.cfm?companyid=POR&fileid=881574&filekey=BA0FEC70-5C54-4A23-87B6-BB37D1574A5F&filename=2015_Annual_Report.pdf

Figure 1: Visualization of Vehicle to Grid Use Cases[15]



Today, unfortunately, OEM warranties for PEV batteries are "not structured to allow battery discharge onto the grid. V2G may void the battery warranty, depending on the terms of the warranty structure and the design of the battery."[16] As such, no vehicles sold today are enabled for V2G use-cases (though some can be converted by an over-the-air software update). Additionally, V2G applications are further complicated by the fact that drivers need batteries to have adequate charge to accommodate their next trip. "Business models which inconvenience or harm drivers in any way are unlikely to scale; drivers will be less willing to volunteer their vehicle for ancillary services if there is a risk of being stranded with a dead or worn out battery."[17]

Though V2G presents clear challenges, the opportunity it presents creates real potential value for low-cost grid benefit to all customers. Accordingly, we are launching a V2G demonstration project with V2G-enabled Nissan Leaf and a 2-way charging station at a PGE site.

The demonstration project is a partnership with Nissan and will use one PGE fleet vehicle interconnected regularly to a PGE facility using a 10 kW 2-way charging station from Princeton Power Systems (the same equipment used at the V2G pilot at Los Angeles Air Force Base).[18] PGE will utilize an off-warranty Nissan Leaf at the charger to test various charge/discharge scenarios and use cases.

[15]Gorguinpour, Camron. "DOD Plug-In Electric Vehicle Program: The DOD V2G Pilot Project." http://electricvehicle.ieee.org/files/2013/03/DoD-Plug-In-Electric-Vehicle-Program.pdf

[16] www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7744

[17](2015) Cooperative Research Network. *Managing the Financial and Grid Impacts of Plug-in Electric Vehicles*

[18]http://www.energy.ca.gov/research/notices/2015-12-14_workshop/presentations/13__CTC_Los_Angeles_Air_Force_Base__Genseal_Kenner.pdf

The project will study:

- Interconnection considerations associated with 2-way inverter/charging stations
- Power quality and reliability of exported power from 2-way inverter/charging stations
- Impact of V2G on vehicle's battery, based on various cycling patterns and use cases
- The learnings may inform pilot design with long-term parking sites in our service area (e.g. airports). By partnering with this type of organization we could potentially offer customers discounted parking in exchange for leaving their vehicle connected and available for ancillary services while they are away.

Equipment for this pilot was procured and installed in 2016. The system is undergoing commissioning and testing in Q1/Q2 of 2017. The intent is to begin testing charge/discharge cycles with the charger in Q2 2017.

1.5(c) System Impacts Today

PGE's distribution system has adequate capacity to host the existing 10,000 EVs on the road. Additionally, we believe there is adequate capacity on all system substations and feeders to accommodate projected EV and fast charger growth across the system for the foreseeable future. As with all new loads on the system, localized upgrades may be necessary on a site by site basis (i.e. utilization transformers, vaults, etc.).

Section 2. Strategic Intent

2.1. Vision and Goals

The electric transportation landscape is rapidly changing: battery costs are falling, vehicle ranges are increasing, autonomous vehicles are being actively developed, and charging technologies are advancing. As electricity continues to grow as a viable transportation fuel and electric vehicle adoption grows in our service area, we see tremendous opportunity to integrate the new variable resources that will be added to PGE's grid in order to meet the 50% Renewable Portfolio Standard mandate. PGE envisions a system of hundreds of thousands of distributed electric vehicles that can actively be utilized by PGE to provide value to all customers by reducing fixed costs to all customers, providing ancillary services, integrating renewables, and increasing system reliability.

To achieve this vision, our key plan goals are to:

1. Increase the adoption of electric vehicles and other electric transportation options in our service area; and
2. Begin efficiently integrating electric vehicles into our system.

PGE has a long history of promoting transportation electrification. We have joined transportation electrification discussions with industry groups like Edison Electrical Institute (EEI), Rocky Mountain Institute (RMI), Western Energy Industry Leaders (WEIL), Electric Power Research Institute (EPRI), managed dozens of charging deployments, engaged and encouraged employee adoption of EVs, and guided customers through the process of electrifying their fleets and adding charging infrastructure to their buildings. Though we have a strong foundation, we remain years away from realizing that future state where we are able to utilize vehicles for efficient grid management and renewable energy integration.

Today, there are fewer than 10,000 electric vehicles in PGE's service area, representing < 300 MWh of potential battery storage. Additionally, there are no 2-way-enabled electric vehicles or charging stations that allow car batteries to discharge onto PGE's grid. As the Rocky Mountain Institute describes in their recent report, *Electric Vehicles as Distributed Energy Resources*:

> *"Currently, most manufacturers are not including onboard V2G capability in their vehicles (except for a few pilot programs and the newer Nissan Leaf models), and even where it is built-in, using it for Vehicle to Grid (V2G) would void the vehicle warranty. It's a classic chicken-and-egg problem: Manufacturers aren't including V2G features because there isn't a market, and there isn't a market because there aren't enough vehicles with those features."*[19]

[19] Chris Nelder, James Newcomb, and Garrett Fitzgerald, Electric Vehicles as Distributed Energy Resources (Rocky Mountain Institute, 2016), http://www.rmi.org/pdf_evs_as_DERs.

In the near term, PGE's efforts focus on accelerating adoption of electric transportation while developing and evaluating technologies and customer programs that will enable PGE to manage transportation loads effectively and efficiently in the future. EPRI's 2011 Transportation Electrification Technology Overview supports this approach:

> *"The short-term impacts for most utilities studies should be minimal and localized…EPRI believes that potential stresses on the electric grid can be fully mitigated through asset management, system design practices, and at some point, managed charging of PEVs to shift a significant of load away from system peak. A proactive utility approach of understanding where PEVs are appearing in their system, addressing near-term localized impacts, and developing both customer programs and technologies for managing long-term charging loads is most likely to effectively and efficiently enable even very large-scale PEV adoption."*[20]

Our near-term focus is to encourage and facilitate more people understanding the value of electricity as a transportation fuel, while building a foundation of programs and approaches that will allow our customers and electric system to realize maximum value when PEVs realize high penetration levels in the coming decades.

2.2. Guiding Principles

To align our stakeholders and to guide our planning, we have established a set of guiding principles that shape our thinking and program design:

Figure 2: PGE's Transportation Electrification Guiding Principles

Reliable and Safe	Accessibility and Inclusivity	Simple Customer Experience	Value-add Programs and Services
• Customers can depend on chargers to safely provide the power they need	• Ensure access to charging for the whole community	• Easier than driving on fossil fuels	• Leverage existing infrastructure and incentives to help us build the grid of the future

We believe these principles are consistent with the vision outlined by NRDC[21] for the utility's role in accelerating the electric vehicle market:

1. Remove barriers to adoption, ensure reliability, and maximize fuel cost savings
2. Close the charging infrastructure gap and promote equity
3. Capture the value of grid services and integrate renewable energy

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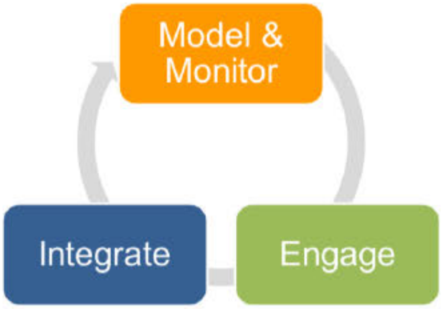
[20]Transportation Electrification: A Technology Overview EPRI, Palo Alto, CA: 2011. 1021334.

[21]Baumhefner, Hwang, Bull. NRDC. *Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles* (2016).

2.3. Alignment with Smart Grid Strategy

As we consider the development of a transportation electrification plan and a portfolio of potential transportation electrification programs, we are doing so within the context of PGE's Smart Grid Strategy[22]:

> PGE will advance the intelligent and integrated operation of our grid by leveraging technologies that deliver customer value and system benefits in a changing landscape. This 3-staged iterative approach will enable PGE to build an integrated grid that delivers values to all customers:
>
> ***Model and Monitor (Plan Ahead):***
>
> Leverage customer trends, grid data, policies, and modeling, to plan ahead by identifying potential pilots, demonstrations and programs. By understanding our system, customers, and industry trends, we can effectively plan and prioritize our research and development efforts.
>
> **Figure 3: PGE's Smart Grid Strategic Report**
>
> 
>
>
> ***Engage (Successfully Pilot):***
>
> Incorporate customer and stakeholder feedback as we start small in our deployment and testing of new technologies and programs. By being collaborative and proactive, we can develop pilots such that we can have meaningful, foundational learnings and deploy effective and valuable full-scale programs.
>
> ***Integrate (Moving to Scale):***
>
> Build upon our foundation as we move to scale on proven technologies that drive new customer value. Be a utility that is proactive, nimble, and flexible.
>
> As illustrated above, this is an iterative process—our programs and pilots will inform how we plan and prepare for the future. We anticipate this process is proactive and collaborative with the OPUC and other external stakeholders. We expect an on-going dialogue will allow us to evaluate and realize value from new and emerging technologies quickly. Our efforts will be information-driven and evolutionary (not revolutionary).

Our approved plan and programs will be deployed in a manner consistent with this strategy. We will monitor what is happening in the marketplace and in other states, start small, learn, and build upon our learnings. We expect continued engagement with the OPUC and other stakeholders and look forward to providing regular updates as directed by the long-term planning docket.

[22] PGE's 2016 Smart Grid Report (http://edocs.puc.state.or.us/efdocs/HAQ/um1657haq135730.pdf)

Section 3. Proposed Transportation Electrification Pilots

After reviewing dozens of potential program offerings, PGE proposes a portfolio of pilots that we believe provide the greatest opportunity to accelerate efficient deployment of electric transportation, while limiting risk to customers and building foundations that will enable future generations of EVs to aid in the efficient integration of renewable energy.

As mentioned in Section 2.3, the proposals model our smart grid strategic intent: monitor the industry and needs of our customers, start small and engage customers with meaningful pilots, and build upon learnings to create full-scale customer offerings.

3.1. Electric Mass Transit 2.0 (TriMet pilot)

3.1(a) Summary

PGE is proposing a pilot to install and manage 6 electric bus charging stations for use by TriMet. PGE's involvement in the pilot will allow TriMet to use grant funding from the Federal Transit Administration (FTA) to purchase an additional electric bus, thus enabling the electrification of an entire bus route. Each bus will have a roughly 250 kWh battery; for context, their combined energy rating (1.25 MWh) will be equal to PGE's Salem Smart Power Center. By owning and managing the charging infrastructure, PGE will be able to obtain key learnings that will allow us to most advantageously integrate the considerable demand that may emerge from future electric bus charging infrastructure. The pilot will evaluate distribution system impacts and customer service considerations by studying coincident peak, non-coincident peak, feeder voltage dynamics, charging behaviors, and load profiles.

3.1(b) Market Barriers

Though many transit agencies are interested in the long-term benefits of electrifying bus fleets (cost savings, carbon emissions, air quality improvement, and noise reductions), there are a number of market barriers that have limited the rate of adoption of electric buses:

Cost

Currently, an all-electric bus costs roughly $500,000 - $750,000 more than a traditional diesel transit bus (costs varying based on battery size, functionality, size, etc.). In addition to paying the incremental cost of the bus, transit agencies are also faced with the incremental cost of charging infrastructure. Incremental costs vary based on installation costs, and the size and number of chargers needed to fulfill the charging needs of the fleet being electrified.

Outside transit agencies' core competencies

In addition to the incremental costs of electric buses and associated charging infrastructure, transit agencies have no experience (and little interest) in maintaining and managing high-powered electric bus charging infrastructure. This is outside of the core competency of many fleet operators who specialize in transportation planning, logistics, and internal combustion vehicle maintenance.

Electrification pace limited by fleet replacement schedules

TriMet has determined that optimal asset utilization for its fixed route buses is up to 16 years of service and accumulation of 675,000 – 750,000 miles per bus; roughly 50-70 buses (7-10%) are replaced in TriMet's fleet each year. TriMet's fleet replacement schedule limits the pace at which they are likely to electrify their fleet.

Challenges with grid integration

Significant electric bus adoption requires integration into utility planning because of the size of electric bus batteries. A typical transit bus garage houses 50-100 buses; if each bus had a 250 kWh battery, a bus garage could have a flexible load of 12.5-25 MWh. Simple, straightforward charging of these buses would require significant upgrades; however smart charging and more advanced applications of the bus batteries could convert the load into a flexible resource that helps optimize the grid and integrate renewables. Moreover, electric buses impact distribution system planning because they typically require ultra-high-speed fast chargers (>300 kW). These chargers must be installed en-route in a location both suitable for intermittently supplying high-power electricity and convenient for drivers to take breaks.

Vendor risk

Most transit agencies rely upon one vendor for all of their bus fleet; this reduces cost and minimizes logistical challenges related to operations and maintenance, particularly with regard to replacement parts (for both "cosmetic" and mechanical elements of a bus). The traditional bus manufacturers that supply the buses for most transit agencies today, including TriMet's bus provider, New Flyer, have only recently begun to manufacture electric buses.

Technology risk

Because buses have fixed routes and are often travel many miles in a single trip, high efficiency batteries with a long life are important to the success of an electric bus fleet. As technology improves, electric buses are likely to travel farther and experience less degradation over time, both of which could mitigate risk for transit agencies. For this reason, few transit agencies have been willing to risk up-front capital today to buy electric buses—much like TriMet, many agencies are looking for grants and 3rd party resources to help fund initial bus electrification efforts.

3.1(c) Description

TriMet provides bus, light rail and commuter rail service in the Portland metro area with the intent of connecting people with their community, while easing traffic congestion and reducing air pollution — making our region a better place to live. TriMet serves over 100 million trips annually, including 45% of downtown Portland commuters. TriMet operates 654 buses in and around PGE's service area which are responsible for 23 million vehicle miles, 292 million passenger miles, and 62 million boarding rides in 2015. TriMet has expressed interest in electrifying 100% of their bus fleet over time to:

- Reduce fuel and maintenance costs;
- Reduce/eliminate environmental impacts associated with mass transit; and
- Reduce idling noise pollution when vehicles are stationary (e.g., driver breaks).

In August, 2016, Trimet received a $3.4 million grant from the Federal Transit Administration (FTA) to purchase 4 electric buses, 5 depot chargers, and 1 en-route charger.[23]

Though TriMet's grant includes funding for charging infrastructure, TriMet has stated that they welcome PGE's partnership in owning, operating, and maintaining charging infrastructure (See Appendix 3). Bus charging infrastructure, particularly en-route chargers, is utility-scale in nature. In addition, the heavy use of the infrastructure presents an opportunity for PGE to better understand the future system needs associated with a significantly more electrified TriMet fleet.

PGE proposes to install, operate, maintain, and own TriMet's bus chargers as a pilot to:

- help accelerate bus electrification; and
- begin evaluating utility system impacts associated with electric bus charging.

By reducing TriMet's up-front capital costs of charging infrastructure, they will be able to purchase a fifth electric bus. The five TriMet buses collectively will have 1.25 MWh of distributed energy storage, the same energy rating as PGE's 5 MW battery at the Salem Smart Power Center. TriMet has requested permission from FTA to shift some grant funds from charging infrastructure to purchase a fifth electric bus. FTA has provided preliminary approval of PGE's prospective role in the partnership, and is likely to allow it as a part of the final grant agreement. Finalization of the grant agreement and terms is expected in early 2017. The first deployment of the pilot project will include 5, 100 kW depot chargers in TriMet's garage, and 1, 300 kW en-route charger in a yet-to-be-determined location.

As part of the system upgrade necessary to adequately partner with TriMet for the fleet electrification pilot, PGE will undertake the following upgrades of the distribution system:

- Running new conduit across Merlo Road from PGE transformer to TriMet property;
- Installing a transformer pad and a 500 kV transformer to serve new load;
- Installing five (5) 100 kW bus chargers in TriMet's garage;
- Upgrading distribution to support en-route charger; and
- Installing of one (1) 300 kW en-route charger.

[23] http://news.trimet.org/2016/07/trimet-awarded-3-4-million-federal-grant-to-buy-its-first-electric-buses/

If any construction is undertaken or equipment installed to accommodate future load growth at the customer's facility that is above the needed equipment to serve the 500 kW load of garage chargers, it will be directly paid by TriMet. Costs associated with running new conduit (including trenching and boring) will be governed by PGE's Rule I line extension policy, and the costs above the line extension allowance may be negotiated between TriMet and PGE.

Storage Integration

HB 2193 mandates PGE to install 5 MWh of energy storage in the service area by 2020.[24] There may be an opportunity in making elements of both the storage mandate and the transportation electrification plan work together. By strategically locating an en-route bus charger and an appropriately sized battery, PGE may potentially reduce distribution system upgrade costs necessary for the charger installation (i.e. transformer, conductors, substation, etc.) and reduce coincident system peak demand attributable to the charger.[25,26,27,28]

Though battery sizing will be evaluated in the engineering phase of the project, PGE anticipates that a 250 kW/500 kWh battery should be sufficient to minimize local and system impacts associated with a high-powered en-route charger. The battery would be used in tandem with the grid to charge the bus or (if needed) could charge the bus independent of the grid. When the charger is not being utilized, PGE would utilize the battery for grid services.

Ability to pair the charger with energy storage will be heavily site-dependent and contingent on approval of PGE's proposal to be filed through UM 1751 (Energy Storage Program Guidelines). We are currently evaluating a variety of different locations, use cases, and technologies to fulfill the storage mandate. Including storage with charging infrastructure is a part of the discussion today but may not end up in the final proposal.

3.1(d) Objectives and Evaluations

Through the pilot project, PGE will learn:

- The impacts of depot chargers on PGE's distribution system and non-coincident peak loads. Though these high-power chargers are not prevalent on our system today, it is likely they will proliferate over the next decade for bus and personal vehicle use—it is crucial we begin to understand how these impact the grid.

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[24] https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/HB2193
[25] https://www.greentechmedia.com/articles/read/HECO-Tests-Batteries-to-Enable-DC-Fast-Charging-And-Avoid-Grid-Upgrades
[26] https://chargedevs.com/newswire/stationary-storage-system-enables-a-quick-charge-without-straining-the-grid/
[27] Bayram et al. Strategies for Competing Energy Storage Technologies for DC Fast Charging Stations. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6485950
[28] http://www.calstart.org/Libraries/Publications/Peak_Demand_Charges_and_Electric_Transit_Buses_White_Paper.sflb.ashx

- Coincident peak demand impacts of high-powered bus charging.
- The additional infrastructure, if any, needed to support and ensure high reliable bus charging infrastructure (and applicable costs).
- Fleet impacts and fleet facility upgrade costs (to support technical assistance to other bus-fleet customers).
- Charging infrastructure installation, operation, and maintenance costs.
- (Potentially) Ability to utilize energy storage to limit peaking impacts and distribution upgrades of extreme fast chargers.
- Our initial deployment with TriMet will include time of use rates with demand charges (through Schedule 85-P). We intend to study the system impacts on peak days, evaluate the bus charging use case, assess the customer's needs, and develop models that we believe will be beneficial to all customers. We may include these alternative dynamic pricing elements in the future to maximize the benefit of this program to all customers.

Evaluation of the impacts of this pilot is relatively straightforward in that the evaluator will gauge how many additional buses are attributable to PGE's involvement. For those buses, grid impact and diesel bus miles avoided will be calculated.

Additionally, the pilot will provide valuable insight regarding the operational feasibility of an electrified transit fleet as well as the impact of electrified mass transit on the utility grid (distribution system costs, coincident and non-coincident peak loads), operating costs, rate considerations, and system planning considerations. This learning could be applied to other bus operators (i.e. transit agencies, school districts, academic institutions, travel organizations, etc.) in PGE's service area interested in fleet electrification.

We will analyze non-coincident peaks, study customer charging behavior, and evaluate operational opportunities and challenges of both PGE and TriMet.

Electric mass transit creates a unique challenge and opportunity for both the transportation and grid planning functions of the future. PGE is excited about the opportunity this grant presents to both TriMet and PGE in starting small, learning, and building off our successes. As a component of this pilot, PGE hopes to work with TriMet on developing a short, mid, and long-term bus electrification plan which will include route plans, charger siting planning, and peak-mitigation planning.

3.1(e) Cost-Effectiveness and Assumptions

For the purposes of this cost benefit analysis, the team assumed the following:

- The known impact of the program is a single bus. Though this program could result in incremental electric vehicle lift at a later date, no additional lift beyond the known impact was forecast for this analysis.
- All chargers and associated installation costs are considered utility capital costs.

- Lease payments to PGE from TriMet are considered a benefit in the RIM, but a transfer in the TRC and SCT.
- The federal grant per bus ($430,000) to TriMet is included as a benefit in the Total Resource Cost test, but as a transfer in the Societal Cost Test.
- The utility tax credit value stream includes the Oregon Alternative Fuels Infrastructure Tax Credit (assumed to expire in 2020).
- This estimates do not include any credits associated with the low-carbon fuel standard or any other environmental compliance incentive

Using a Customer Perspective (RIM) test, the 20-year net cost of the proposed pilot is $ 1,037,395 (a detailed description of all cost effectiveness tests is available in Section 5.1(b) and Appendix 7). The TriMet program is a pilot designed to enable TriMet to purchase one additional bus. The pilot appears to have a net cost, predominately because the full cost of five chargers are incurred as utility capital costs, while the analysis only counts the benefits of the one additional bus attributed to the program. In reality, these five chargers could power significantly more than one or even five electric buses in the future. However, in order to stay consistent with the methodology employed in response to previous dockets (UM 1708) the analysis strictly accounts for only incremental costs and benefits as a direct result of the pilot. In many ways, this program is a large R&D pilot intended to inform future planning and program designs; accordingly, the cost-effectiveness is more consistent with a R&D project than a new program.

Results of all tests are included below:

Table 6: Electric Mass Transit Cost Effectiveness (Net Benefits) by Test Type, (2017 $)

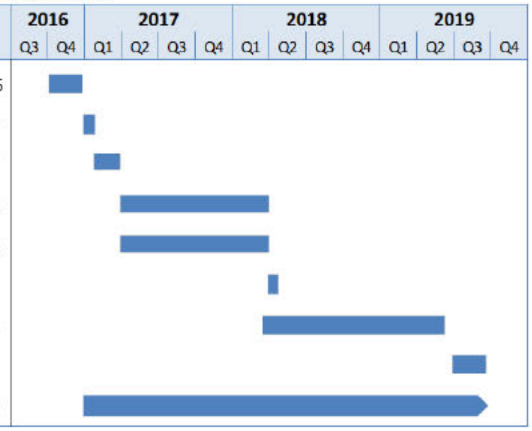
Customer Perspective Test (RIM)	Total Resource Cost Test (TRC)	Societal Cost Test (SCT)
$(1,037,395)	$(1,059,005)	$(1,332,532)

3.1(f) Schedule

TriMet's grant application allows for one year of planning, procurement, and construction of charging infrastructure (April 2017 – March 2018) such that they have charging infrastructure installed and functioning when their buses are delivered in March 2018. As such, we are seeking approval for this pilot in early 2017—a delay in approval on this pilot could complicate TriMet's project schedule.

Figure 4: TriMet's Grant Schedule[29]

Trimet Bus Project	Start	Finish
FTA Award & Sub-recipient contract execution	10/1/2016	12/30/2016
Project Planning & Initiation	1/3/2017	1/31/2017
Requirements Analysis	2/1/2017	3/31/2017
Bus Procurement & Build	4/3/2017	3/30/2018
Infrastructure Procurement, Design, & Build	4/3/2017	3/30/2018
Bus & Infrastructure Deployment	4/2/2018	5/1/2018
Deployment Validation	3/1/2018	5/31/2019
Project Closeout	6/3/2019	9/2/2019
Project Management, Reporting, & Operations	1/3/2017	8/31/2019



3.1(g) Budget

PGE proposes to procure and own the chargers, while TriMet would bear the cost of their installation and maintenance. The capital cost for the five chargers is $625,000.

Incremental energy used by these new chargers will be separately metered and will be recovered through Schedule 85-P, TriMet's current retail rate. En-Route chargers may be metered separately and incremental energy will be recovered through a standard retail rate.

PGE will be responsible for maintaining charging equipment and TriMet will pay costs associated with PGE's maintenance of the charging infrastructure on a time and materials basis.

Table 7: Electric Mass Transit 2.0 Estimated Budget, ($,000)

Cost Element	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Capital Carrying Costs	$ 141	$ 132	$ 121	$ 111	$ 103	$ 95	$ 88	$ 81	$ 74	$ 70
O&M Expenses	$ 79	$ 80	$ 82	$ 84	$ 85	$ 87	$ 89	$ 91	$ 93	$ 95
Tax Credits	($ 63)	($ 63)	($ 31)	($ 31)	($ 31)	-	-	-	-	-
Total Rev. Requirement	$ 157	$ 150	$ 172	$ 164	$ 157	$ 183	$ 177	$ 171	$ 167	$ 165
Est. Customer Payments	$ 79	$ 80	$ 82	$ 84	$ 85	$ 87	$ 89	$ 91	$ 93	$ 95
Net Costs	$ 78	$ 70	$ 89	$ 80	$ 72	$ 95	$ 88	$ 81	$ 74	$ 70

[29] TriMet Grant application to FTA, 2016.

Detail about the revenue requirements model, forecasts, and model assumptions are included in Appendix 1.

3.1(h) Vendor Selection

TriMet has elected to purchase their electric buses from their existing product vendor (New Flyer), and as a result we would procure compatible charging stations from the same manufacturer. These charging stations would be sole-sourced based on the needs of the customer. As the bus charging market evolves, we anticipate working with customers to create standard specifications for future bus charging infrastructure. These specifications would be used in RFPs and would be open for any charging manufacturer to bid on.

3.1(i) Risks

The lead time on TriMet's buses is approximately 18-months. If charging infrastructure is interconnected any earlier than the delivery of buses, there is risk that the equipment is underutilized for some period of time. Because the chargers will be ordered from the same manufacturer as the buses, there is little risk that delay would result in incompatible technologies. We will, however, be coordinating closely with TriMet to ensure charger installation is aligned with bus delivery.

Additionally, if TriMet abandons their electric bus program due to challenges with the technology or any other reason, the assets would be at risk of being stranded. In the unlikely event this occurs, we will work with TriMet and New Flyer to find a buyer of the infrastructure.

Though PGE is familiar with charging stations and related technologies, New Flyer's hardware is not one that we have worked with before, and it is new to the market. There is risk that the products have more maintenance and repair issues than estimated. Regular downtime would increase maintenance costs and create logistical challenges for TriMet service coordinators. Though a real risk, New Flyer is the leading bus manufacturer in the country, and we believe the material risk that they are unable to fulfill their commitment is low. To protect PGE and our customers' interests, we intend to ensure our purchase contracts include a clause that put supply or equipment failure risk on the vendor.

Because TriMet is choosing to sole source their charging buses (and consequently charging infrastructure), this pilot does not actively promote competition of bus charging manufacturers. That is the case, however, with or without PGE's involvement. We believe by being an active partner in this project, that we will generate learnings that will aid other transit agencies in electrifying their fleets. As those fleets electrify, markets for bus charging providers will grow. Additionally, charger manufacturers can learn from our experiences in this pilot to develop products that better meet customer and utility needs. While this initial purchase will be sole sourced, future standards around charging equipment options will open up future equipment purchases to be competitively procured.

3.1(j) Equity and Inclusion

Vermont Energy Investment Corporation's EV report outlines that low-income residents "tend to live in areas with the highest traffic and poorest air quality—which could be improved by transportation electrification. (Electric transit bus emissions) disproportionately benefit low-income urban communities because they operate in congested areas where air pollution is a problem."[30] We believe that by working with TriMet on bus electrification, we can make electric transit accessible to a broader population (including those who do not own a car), and we can improve the air quality in many low-income neighborhoods as well.

[30]2016. *Fully Charged: How Utilities Can Help Realize Benefits of Electric Vehicles in the Northeast*. Prepared for Sierra Club by VEIC. http://www.sierraclub.org/sites/www.sierraclub.org/files/uploads-wysiwig/20160906%20Northeast%20EV%20utility%20report%20(1).pdf

3.2. Outreach, Education, and Technical Assistance

3.2(a) Summary

To increase awareness and adoption of electric vehicles and to encourage smart EV charging, PGE proposes a broad outreach and technical assistance campaign. The pilot will provide technical assistance for commercial and industrial customers, specialized trainings for key industry stakeholders (i.e. dealers and builders), partner rewards, ride and drive events, and education on time-of-use rates to residential customers that drive electric vehicles.

A strategic outreach plan can increase awareness of the benefits of electric vehicles as well as promote smart charging that benefits all PGE customers.

According to EPRI,

> *"Utilities can play a specific and valuable role in educating their customers about adopting electric vehicles. Active outreach to its customers can increase the rate of vehicle adoption in its service territory, reduce customer confusion, and improve the utility's customer satisfaction. Utilities have a prior history of informing and educating their customers on new consumer products—energy efficient appliances, for example. Customer education can also serve as a strategy to manage the grid impacts of PEVs, primarily by educating PEV adopters on grid-friendly charging behaviors."*[31]

3.2(b) Market Barriers

Lack of Awareness

Lack of awareness is the single largest barrier to adoption of electric vehicles. More than one-third of PGE customers are not at all knowledgeable about plug-in electric vehicles.[32]

McKinsey acknowledges that among car brands, initially considered brands are three times more likely to be purchased than brands of which the customer was not originally aware.[33] Based on a 2014 study of PGE customers, we believe this to be the greatest barrier to EV adoption today. In a 2014 survey of 500 PGE customers, just 9% of customers reported that they are very knowledgeable about PEV technology and 36% of customers "are not at all knowledgeable about PEVs."[34]

A 2015 study by UC Davis highlights the lack of awareness among new car buyers:

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[31] http://tdworld.com/site-files/tdworld.com/files/archive/tdworld.com/go-grid-optimization/transportation-electrification.pdf

[32] 2014 PGE Customer Survey

[33] McKinsey Consulting. Modified from The Consumer Decision Journey. Jun 2009.

[34] 2014 PGE Customer Survey

> *"Overall, awareness of PHEVs, BEVs, and FCEVs is so low that the reasonable assumption is most new car buyers' prior evaluations of these vehicles are based largely on ignorance… **a lack of general consumer awareness of this basic availability is the first problem to be overcome to expand ZEV markets**."*[35]

Customers' perceptions of EVs are often biased to believe vehicles are small, slow, or funny looking—like a big golf cart. We have heard this rumor overcome at ride and drive events, when customers are able to get behind the wheel of actual car.

This is not without reason—today 99% of people drive internal combustion engine vehicles (ICEVs), and the auto industry has done little to educate consumers about the benefits of electricity as an alternative fuel source. In 2015, the auto industry spent $45 Billion on advertising, and less than $50 Million (0.11%) of that was directed to electric vehicles.[36,37,38] Some advertising has been actively discouraging drivers from considering electric (highlighting its relative complexities and nuances that are different from driving ICEV).

Existing outreach does not speak to buyers' motives

Many EV advocates focus messaging on facts around cost savings, maintenance, environmental benefits, etc. Purchasing a car, however, is a highly emotional process; car companies traditionally advertise by using humor, excitement, nostalgia, sex appeal, simplicity, relatability, and lifestyle. "Beyond practicality issues…the biggest trigger of automotive sales is purely emotional. Among existing car owners in the market to buy a car, 84 percent expressed a love of driving, which is significantly higher than the desire to fulfill a utilitarian purpose."[39] What little advertising that does promote electric vehicles today largely fails to capture the emotional and lifestyle motivations that often drive customers' buying decisions.

Lack of visible charging infrastructure

In addition to lacking credible information on EVs, numerous customer interviews and focus groups indicate that the lack of visible electric vehicle charging infrastructure impacts customers' limited awareness of EVs. If customers cannot see public charging infrastructure, they are less likely to know that it exists. When asked, where the nearest gas station to their home is, all customers are able to provide an answer; however, in contrast, most customers do

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[35] Kurani, Ken. "New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon". UC Davis. 2015.
[36] O'Reilly, Laura. "These are the 10 companies that spend the most on advertising." Business Insider. 6 Jul. 2015. http://www.businessinsider.com/10-biggest-advertising-spenders-in-the-us-2015-7
[37] Morris, Charles. "Auto Industry (except Tesla) Spends an Average $1,000 per Vehicle in Advertising." Charged EVs., 15 July 2016. https://chargedevs.com/newswire/auto-industry-except-tesla-spends-an-average-1000-per-vehicle-in-advertising/
[38] Maddox., Kate. "Global Ad Spending Will Be Up an Average 4.2% Next Year." Advertising Age., 11 June 2015. http://adage.com/article/btob/global-ad-spending-average-4-2-year/298980/
[39] Nielsen. "The Heart of the Issue: Emotional Motivators Rev Up Automotive Purchase Intentions Around the World." 15 Apr 201.4 http://www.nielsen.com/us/en/insights/news/2014/the-heart-of-the-issue-emotional-motivators-rev-up-automotive-purchase-intentions-around-the-world.html

not have any idea where the nearest public charging station. This lack of visibility creates a void and the impression of a lack of accessibility. Prominent charging infrastructure, like Electric Avenue at World Trade Center in Portland, not only motivates people to think about electric vehicles but also encourages people talking about electric vehicles. Customers and visitors frequently stop on the sidewalk to ask EV drivers about their car, charging, and the experience of driving electric.

A Cornell University research group studied the impact that a presence of an EV Charging network had on EV sales in 353 metro areas. They found that "the increased availability of public charging stations has a statistically and economically significant impact on EV adoption decisions."[40] "Lack of robust DC Fast Charging infrastructure is seriously inhibiting the value, utility and sales potential of medium range BEVs"[41]

Uninformed car sales staff

Auto dealers ultimately stand between the customer and their new car. A sales person who is unaware of the benefits of EVs or the process of charging can negatively impact EV sales and adoption. Sierra Club's 2016 Rev Up EVs Report studied the EV buying process at 308 different auto dealerships across 10 states – including Oregon – and discovered challenges with many dealers.

> *"Articulating to consumers the value of EV technology and incentives can be one of the most effective tools to increase widespread EV adoption. Automakers and auto dealers should engage in certification and training programs to ensure that salespeople have the proper knowledge and enthusiasm about EVs, including charging methods and state and federal rebates and tax credits."*

The report identifies that dealerships with successfully high EV conversion "have their salespeople participate in regular trainings to keep up to date on EV technology and public policies."[42] An additional barrier regarding educating sales staff is that the US auto industry has an exceptionally high turnover rate: the three-year retention rate at dealerships in 2015 was 45%.[43]

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[40] Li, S. et al., "The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts," Cornell University, June 2015.

[41] Hajjar, Norman, New Survey Data: BEV Drivers and the Desire for DC Fast Charging, Plug Insights, March 11, 2014.
http://www.pevcollaborative.org/sites/all/themes/pev/files/Hajjar_Recargo2_California%20PEVC%20Plug Insights%20Presentation.pdf

[42] Sierra Club 2016 Rev Up EVs Report

[43] http://www.autonews.com/article/20160928/RETAIL/160929804/u-s-dealerships-employee-retention-slides-study-finds?cciid=email-autonews-daily

Workplace charging readiness

Facility managers and sustainability managers are often involved in evaluating, planning for, installing, and maintaining workplace EV charging. USDOE states "employees at participating workplaces are up to 20 times more likely to drive electric vehicles."[44] As such, it is important to ensure that these stakeholders stay up to date on what the latest technologies are, what the benefits for their customers/staff are, and how to effectively maintain and install systems at the least cost.

Home charging readiness

Similarly, home builders, designers, and electricians all are key stakeholders in making homes "EV ready". Though "EV ready" homes do not alone increase EV adoption, they do increase visibility to our customers and help reduce costs and barriers to entry for somebody considering an EV. Furthermore, customers need to understand the scope and cost of potential upgrades to support an EV is their existing garage is not "EV ready". Anecdotally, we have learned that if customers tell contractors that they need to upgrade their service in their garage to accommodate an EV, the fee is often doubled compared to asking for upgrading service to accommodate a dryer in the garage.

Home charge challenged

Though most EV charging takes place at home, there are a number of segments of customers that do not have access to home charging. Many customers live in a home without off street parking or a garage (including many multi-family customers). Without adequate information about how and where a customer can charge, oftentimes these customers without home charging options will not consider an EV when shopping for a vehicle.

3.2(c) Description

PGE proposes an outreach, education, and technical assistance pilot aimed at increasing awareness, consideration, and ultimately adoption of electric vehicles. The pilot will include six primary elements:

- Technical assistance for non-residential customers
- Specialized training for key industry stakeholders
- Partner rewards and recognition
- Ride and drive and workplace pop-up events
- Time of Use outreach to EV Drivers
- Regional Market Transformation

Detail on each is outlined below:

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[44] http://energy.gov/eere/vehicles/ev-everywhere-workplace-charging-challenge

Technical assistance

Though we offer ad-hoc technical assistance to business customers today, we intend to expand our technical assistance offering by creating a formal EV technical assistance program for non-residential customers considering fleet electrification or installing workplace charging infrastructure. Additionally, the program will provide support to transit agencies, low-income service providers, and community-based organizations who are considering procuring electric vehicles for their existing operations.

- PGE will hire a new employee to oversee the development of the new technical assistance program. This employee will:
    - Develop targeted web content and outreach collateral for business customers.
    - Operationalize and develop standard processes for site visits.
- The new employee will be responsible for regular correspondence with business customers who inquire about electric vehicles.
- The new employee will conduct site visits with customers who are planning to move forward with charger installations.
    - Site visit will include cost-benefit analysis, siting criteria, vehicle selection considerations, and charger selection considerations.
    - All participating customers will receive a customized report based on their individual needs and circumstances.
- The technical assistance program manager will also provide support to transit agencies, low-income service providers, and community-based organizations who are considering procuring electric vehicles for their existing operations.

Specialized training for key industry stakeholders

PGE will conduct 5-10 specialized training sessions per year. Training curriculum will be tailored to key industry stakeholders:

- **Auto Dealerships:** dealers can make or break a sale, so it is critical to keep them engaged, educated, and motivated. PGE will provide educational sessions for dealership sales staff on charging infrastructure, PGE's whole-home TOU programs (and the economic benefits for their customers), EV benefits, etc.
- **Builders/Electricians/Architects/Engineers:** to make a home "EV Ready", a designer or builder simply needs to include a 240V outlet (or conduit for one), just like the one used by most commercially-available dryers. We will create training opportunities for builders and designers to better understand the simplicity of EV charging and the benefits for their customers.
- **Facility Managers:** we will provide training for technical staff who manage and operate buildings to ensure they understand key siting considerations, maintenance practices, and operating costs for installing, operating, and maintaining EV charging infrastructure.

- **Sustainability Managers:** often sustainability managers are the key drivers behind workplace charging initiatives. We will create curricula for these stakeholders on how to effectively launch workplace charging campaigns, including cost considerations, facilities considerations, and operations logistics.

Training materials will feature real-life case studies, site walks (e.g. at Electric Avenue at World Trade Center), tools/calculators, and outreach collateral.

Partner collateral and rewards

We will create PGE-specific outreach material which includes details on our TOU rates, our charging infrastructure, and relevant costs to 3rd parties.

In addition to providing educational materials, we believe there is additional opportunity to encourage our partners to promote EV adoption:

- **Ride and Car Share Companies:** PGE is actively working with transportation network and car share companies to create opportunities that encourage drivers to use electric vehicles and educate their riders when they are riding in an electric vehicle. Our intent is to provide these fleets and their drivers with a small incentive ($25-$50/month/vehicle) for including educational materials about EVs inside the car. Simply by making customers aware of the fact that they are in an electric vehicle can help customers understand the types of different electric vehicles and the experience of them. It also provides an opportunity to ask questions with an electric driver about the benefits in an organic setting. We also believe this channel can potentially provide data that could help inform charger siting, pricing, or other program designs. The initial pilot will be limited to 200 drivers.
- **Builders:** We believe by partnering with builders on new construction and substantial rehabilitation projects that we have an opportunity to make it easier for customers to install a home charging unit. We will pilot an "EV-ready" home concept with new home builders in the service area. We will provide an incentive (up to $25) for up to 1,000 new homes per year for installing an additional 240V outlet in the home's garage. We would also provide signage for the homebuilder to include in the home noting that the house is "Electric Vehicle Ready".
- **Auto Dealerships:** For participating in PGE training and closing EV sales, we will offer awards (funded by shareholders). Awards would be provided for top sales staff or organizations who actively participate in trainings and workshops. Awards would likely include sporting event tickets or something of comparable value.

Ride and drive and workplace pop-up events

PGE will contract with a 3rd party to conduct up to 10 ride and drive or employee pop-up events each year, with a goal of getting 5,000 customers to test drive a plug-in electric vehicle. Unlike dealerships, ride and drive events will feature more than one make and model of electric vehicle, educational materials on how charging an EV works, and experts on site to answer questions.

Where opportunity exists, we will coordinate Ride and Drive events with other utilities and with existing events—examples could include the State Fair, Sunday Parkways, Portland Auto Show, etc. Additionally, we will work with our large customers to create "pop-up" ride and drive events at workplaces to engage their employees. We have piloted similar ride and drives with PGE employees, which have proven to be quite effective at raising awareness and creating eventual EV buyers. We will work with municipalities and CBOs to create opportunities for disadvantaged communities. Additionally, we may host our own events to ensure that there are equitable opportunities across PGE's service area for all customers to participate.

For customers to find out more information after their test drives, PGE will enhance content on our website (i.e. information on next steps to buy a car, install a charger, etc.). The new web content will include EV basics, residential technical content, user stories, and other resources for interested customers.

Smart Charging and Time of Use (TOU) Rates

There is opportunity to engage our customers in the benefits of TOU rates as well as smart charging. Many EV drivers have the most to gain from a TOU rate, so we intend to make sure marketing collateral and technical assistance materials highlight these benefits.

> *"(Electric companies) need to offer well-formed TOU rates or other dynamic pricing to shift charging toward low-cost, off-peak hours; educate customers and vehicle dealers about the value proposition under these new rates; capture the potential value of EVs through controlled charging."*[45]

For charging service providers and site owners, we will continue to offer and educate customers about Schedule 38, a rate which does not include a demand charge component. We recognize demand charges can be a barrier to deployment of EV charging infrastructure and will continue to offer this pricing option and help our customers select the best rate for their circumstances.

Market Transformation

We anticipate collaborating with regional stakeholders on broader market transformation to promote effective standards for residential and workplace charging stations (i.e. efficiency, functionality, etc.), best practices for retail displays, and charging network interoperability between regional utilities. To the extent opportunities to collaborate with other utilities regionally or nationally present themselves, PGE anticipates using a portion of the outreach funds to promote regional market transformation.

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[45] http://www.rmi.org/Content/Files/RMI_Electric_Vehicles_as_DERs_Final_V2.pdf

3.2(d) Objectives and Evaluations

Through the pilot project, PGE hopes to learn:

- The impact of outreach efforts on awareness of electric vehicles in the service area.
- The impact of technical assistance programs on the installation of workplace EV chargers.
- The impact of outreach efforts on the consideration of electric vehicle for new car shoppers.
- The impact of outreach efforts on overall sales and leases of electric vehicles in the service area.
- The major challenges business customers face when planning for and siting electric vehicle charging infrastructure.
- The impact of outreach efforts on customer awareness and adoption of TOU rates

We will test the success of this effort by looking at the following:

- Measure the impacts that can be directly measured. Some of the components' impacts on customer adoption are large and concentrated enough to be directly measured – for example, surveys of customers served by technical assistance and the ride and drive events will provide useful metrics of those channels' impact on customer vehicle purchases.
- Survey customers on their awareness of electric vehicles and their exposure to our electric vehicle marketing campaigns. This approach will provide important data in case impacts are difficult to decipher from market-level sales data analysis. We will also ask customers whether marketing influenced their purchase as an indicator of effectiveness.
- Deploy survey instruments to a variety of populations, including:
    - Recent EV purchasers
    - Recent technical assistance customers
    - Recent non-EV purchasers
    - Trade allies (dealers, manufacturers)
    - Key stakeholders (Drive Oregon, transportation authorities, program staff)

Data collected from these populations will be critical in measuring impacts at each step of the vehicle purchasing process and on EV owners' charging behavior.

To provide an additional means of measuring the effectiveness of this pilot and rest of the proposed pilot portfolio, an indirect measurement approach of the market-wide impact of the pilots is covered in Section 3.4.

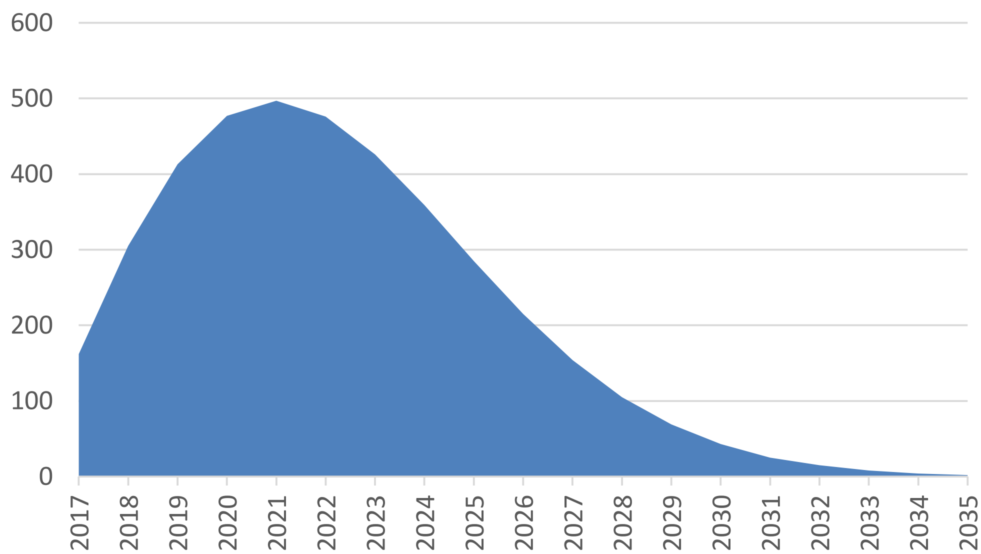
3.2(e) Cost-Effectiveness and Assumptions

Surveys of PGE customers show that awareness of plug-in electric vehicles is low and uncertainty regarding operation, reliability, costs, and charging is high relative to the conventional vehicle options. This is consistent with customer survey results throughout the United States.[46,47] Given that, we assume:

- An education program's direct impact on the electric vehicle market would have the largest impacts early in the forecast period when the average consumer is less educated on the technology.
- As the technology matures the average consumer will become more educated through other avenues and the impact of the "utility" electric vehicle program will diminish over time.
- The program's impacts will improve over the first years of the forecast period as administrators identify and replicate best practices.

Table 8 shows the distribution of the electric vehicle market lift on behalf of the education and awareness program.

Table 8: Estimated New Electric Vehicles attributable to Outreach and Education Pilot



Source: Navigant analysis, 2016

[46] 2014 PGE Customer Survey
[47] Navigant Research, Electric Vehicle Geographic Forecast Report, 2016

Table 9: Outreach and Education Cost Effectiveness (Net Benefits) by Test Type, (2017 $)

Customer Perspective Test (RIM)	Total Resource Cost Test (TRC)	Societal Cost Test (SCT)
$2,089,176	$3,465,122	$4,234,224

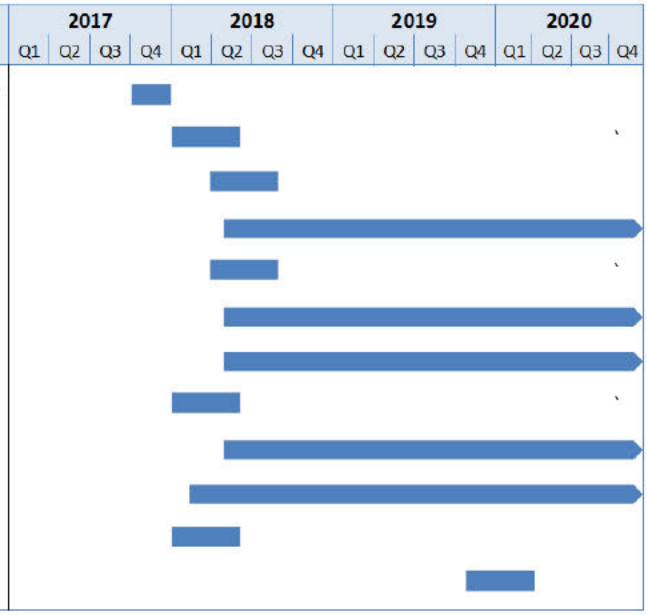
3.2(f) Schedule

Upon plan approval, PGE will hire the EV specialist to manage the development of transportation electrification collateral, manage partner relationships, and oversee the technical assistance program.

PGE will also conduct a 'baseline' survey of customer awareness and perceptions of electric vehicles before beginning customer-facing work. This will serve as a starting point for measuring the impacts of the pilot.

Figure 5: Outreach and Education Schedule

Outreach, Education, & Technical Assistance	Start	Finish
Hire Technical Assistance Staff	10/1/2017	12/31/2017
Contracting for Outreach, Training, Events	1/1/2018	5/15/2018
Develop outreach material & assessment tools	2/15/2017	6/15/2017
Technical Assistance Site Visits	5/1/2018	4/30/2022
Specialized Training Curricula Development	2/15/2017	6/15/2017
Specialized Trainings Conducted	5/1/2018	4/30/2022
Ride & Drive Events	5/1/2018	4/30/2022
Contracting for Partner Rewards	1/1/2018	5/15/2018
Manage & Operate Partnerships Rewards	5/1/2018	4/30/2022
On-going customer outreach (i.e. Social, web)	1/1/2018	4/30/2022
Baseline Surveys	1/1/2018	5/15/2018
Evaluation	11/15/2019	3/15/2020



3.2(g) Budget

We estimate the total cost of the pilot to be $2.1M (10-yr NPV). The budget includes the content creation, event management, partner rewards, specialized training, and 1 FTE to manage technical assistance activities as outlined this section. An estimated budget is included below:

Table 10: Outreach and Education Estimated Budget

Cost Element	Detail	2018	2019	2020	2021	2022
Technical Assistance	1 FTE	$ 183,000	$ 188,500	$194,200	$200,000	$206,000
Technical Assistance	Collateral and web	$ 25,000	-	$ 25,000	-	-
Specialized Training	Curricula development	$ 22,500	-	$ 22,500	-	-
Specialized Training	Collateral, tools, handouts	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Specialized Training	Administration/Training	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Partner Rewards	Content creation/admin	$ 60,000	$25,000	$25,000	$25,000	$25,000
Partner Rewards	Builder rewards	$6,250	$ 18,750	$ 25,000	$ 25,000	$ 25,000
Partner Rewards	TNC Rewards	$15,000	$ 22,500	$ 37,500	$ 60,000	$ 60,000
Partner Rewards	Print collateral	$7,500	$ 15,000	$ 22,500	$ 25,000	$ 25,000
Ride &drive/pop-ups	Planning & Development	$25,000	-	-	-	-
Ride &drive/pop-ups	Event management	$100,000	$ 100,000	$ 100,000	$ 100,000	$100,000
Regional Market Transformation Activities		$50,000	$ 50,000	$ 50,000	$50,000	$50,000
	Total	$ 524,250	$ 449,750	$ 531,700	$ 515,000	$ 521,000

3.2(h) Vendor Selection

Technical assistance will be conducted and managed by the formerly mentioned new FTE.

A competitive RFP process will be used to select one or more vendors to support:

- Outreach content material design and development (web, print, video)
- Develop specialized curricula and training materials for key industry stakeholders
- Conducting specialized trainings
- Content creation and administration of partner rewards pilots
- Planning and executing ride and drive events

PGE acknowledges that Pacific Power is seeking approval for outreach as well. If both programs are approved, PGE will work with Pacific Power to collaborate on procurement and planned activities to avoid duplication and maximize the efficiency and effectiveness of our efforts.

3.2(i) Risks

- **Vendor issues**: though we are confident that our procurement processes will lead to selection of an effective vendor to manage training, ride and drives, and content creation, we acknowledge that we could end up with implementation issues. To the extent our vendor has difficulties meeting our goals, we have mitigation strategies in place to remedy the situation and will replace vendors if necessary. EV promotion is a relatively new space and so the vendor landscape is somewhat limited, and vendor success is uncertain.
- **Content effectiveness**: we are aware that the barriers to EV adoption are high and acknowledge some risk that our content may not be effective at increasing adoption. We do think, however, that our planning and research will inform well-designed and effective content. We will regularly evaluate our efforts and consider modifications as necessary to increase overall effectiveness.
- **Market Readiness (long life and purchase cycle of vehicles)**: the car buying process takes a long time—in many cases it can be years after first considering a car before somebody actually purchases one. If our outreach efforts are effective, it does not guarantee that customers will adopt EVs immediately. There will be some lag between outreach and adoption. We do believe, however, this lag is well estimated in section 0.
- **External market forces**: there are a number of efforts underway in the mobility sector that could lead to significant adoption of EVs. For example, new vehicles could come to the market that significantly accelerate consumer demand for EVs. We will monitor market activities and consider programmatic updates if they become necessary. Similarly, elimination of certain state and federal programs and regulations that create incentives for electric vehicles could be amended or abolished, lowering the market push for increased adoption of EVs.

3.2(j) Equity and Inclusion

As noted above, the technical assistance program will include support to transit agencies, low-income service providers, and community-based organizations (CBOs) that are considering procuring electric vehicles for their existing operations.

We will also work with municipalities and CBOs to create ride and drive opportunities for low income and disadvantaged communities.

Additionally, the partner rewards pilot with TNCs and their drivers could support low-income families. Many TNC drivers live in disadvantaged communities, are low income, or are otherwise unemployed. By collaborating with TNCs, PGE will be helping to create opportunity to reduce barriers to entry for new drivers and to give those drivers opportunities to earn more.

3.3. Electric Avenue Network (Community Charging Pilot)

3.3(a) Summary

PGE intends to build a community charging network by constructing six additional Electric Avenue sites. The sites will each include up to four dual-head fast chargers and one level 2 charger for accessibility. Similar to a gas station, this model co-locates several chargers, thereby providing drivers in need greater confidence that they will be able to find a functional and available charger, effectively improving the availability and reliability of public charging infrastructure. Additionally, the network will include the 11 charging stations owned by PGE as a legacy of the EV Highway pilot. The sites will increase the visibility of electricity as a transportation fuel and empower the many customers who need to see convenient public charging infrastructure in order to consider an EV.

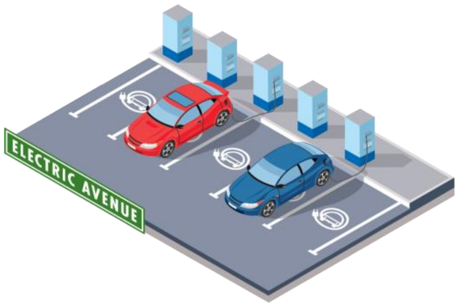


Figure 6: Illustration of Electric Avenue

3.3(b) Market Barriers

Lack of visible public charging infrastructure

For a new prospective buyer, an EV is confusing and complicated compared to a traditional vehicle. There are many new questions raised when one considers going electric (e.g. Where can I charge? How far can I go? How much does charging cost? Etc.).

Numerous sources point to the lack of public infrastructure as a major concern as individuals consider EVs. Customers today rely on an extensive fueling network for ICEVs. Despite most electric vehicle charging occurring at home, "addressing concerns about availability of away from home charging is much about perception of an extensive fueling network."[48] Public charging availability and reliability are critical for customers considering purchasing an EV.

> *"Beyond simply installing chargers, the build-out of a robust, connected PEV charging infrastructure in Oregon is important to help bridge the gap between Innovators and Early Adopters. With the deployment of a robust fast-charging network, the Northwest PEV driver will no longer be limited to the 100-mile range of the typical PEV, but will be able to traverse the state to destinations that were previously unattainable."*[49]

> *"Expansion of electric vehicle infrastructure, such as the I-5 West Coast Electric Highway, is seen as important for the region's future and a potential driver of tourism."*[50]

[48] New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon (2015 UC Davis)
[49] Energize Oregon. http://www.oregon4biz.com/assets/docs/EVrpt2013.pdf
[50] 2016 One Oregon: A vision for Oregon's Transportation System (Transportation Vision Panel report to Gov Kate Brown)

> *"If electric vehicles are to reach a broad market, rather than just serving as second cars for city dwellers with large garages, it will be essential to create a public electric charging infrastructure."*[51]

A Cornell University research group studied the impact that a presence of an EV Charging network had on EV sales in 353 metro areas. They found that "the increased availability of public charging stations has a statistically and economically significant impact on EV adoption decisions."[52] "Lack of robust DC Fast Charging infrastructure is seriously inhibiting the value, utility and sales potential of medium range BEVs"[53]

Accessible Chargers

In addition to evaluating features and elements of an electric car itself, customers spend time evaluating how they will use the vehicle and, in particular for EVs, how they will charge their car. Consumers raise the questions like "Where will I charge? Home, work, public?" In evaluating charging options, 90% of our customers surveyed stated that they want chargers on highways/interstates.[54] Customers consider the "once a year trip to the beach or desert" as the minimum requirement. Knowing highway access is available can relieve this range anxiety.

Accessibility does not just mean that charging stations are well distributed; it also means that charging sites can charge all electric vehicles and that there are adequate parking spaces to accommodate multiple vehicles at once. A common misconception of prospective buyers is that any vehicle can charge at any public facility—much like any car can fuel up at any gas station. Unfortunately, just 15% of fast charging sites in Oregon have SAE Combo quick charge plugs (required for VW, GM, and BMW vehicles).[55] This can create barriers as brand-loyal customers consider their potential charging options.

Additionally, PGE surveyed customers in line to pre-register for the Tesla Model 3—of those customers surveyed, 74% planned to do most charging at home, 14% planned to utilize public charging regularly, and 25% stated that PGE could help them by providing public charging infrastructure. Though 50% of driving days customers drive less than 30 miles and 95% of driving

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[51] Consumer Acceptance of Electric Vehicles in the US. 2012. https://www.epa.gov/sites/production/files/2014-09/documents/kodjak121312.pdf

[52] Li, S. et al., "The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts," Cornell University, June 2015.

[53] Hajjar, Norman, New Survey Data: BEV Drivers and the Desire for DC Fast Charging, Plug Insights, March 11, 2014. http://www.pevcollaborative.org/sites/all/themes/pev/files/Hajjar_Recargo2_California%20PEVC%20Plug Insights%20Presentation.pdf

[54] PGE customers survey (2014)

[55] See Section 1.4

days are less than 100 miles, customers express need for a security network so that they can charge if and when needed.[56]

> *"Drivers' purchase decisions are often disproportionately influenced by rare use cases; for example, the off-road capability of SUVs remains a driving force behind their market dominance, even though that capability is almost never used. Consumer research shows the lack of "robust DC fast charging infrastructure is seriously inhibiting the value, utility, and sales potential" of typical pure-battery electric vehicles."*[57]

One customer emphasized that it must not just be accessible but also fast: "As a single mom the logistics of it (public charging) do not work. It needs to take 15 minutes."[58] It's important that adequate quick charging solutions exist to ensure customers do not drop at the evaluation stage of the buying process. DC Quick Chargers can provide about 75 miles of charge in 15-20 minutes.

Home Charge Challenged

Though most EV charging takes place at home, there are a number of segments of customers that do not have access to home charging. Many customers live in a home without off street parking or a garage (including many multi-family customers).

Electrifying Shared Vehicles

Electric Vehicles yield the most potential operation savings for customers that drive a lot. Many transportation network drivers (i.e. Uber and Lyft) as well as car share company fleet operators do not see electric vehicles as a reasonable solution for their needs due to the lack of public charging infrastructure. Car share vehicles essentially have no "home" at which to charge, and TNC drivers often need a quick fill-up while on the go. We have heard directly from these stakeholders that the largest barrier to adding EVs to their fleets is the availability of public quick charging infrastructure.

3.3(c) Description

Accelerating EV adoption requires customers to be able to see, understand, and reliably use public charging infrastructure just like they do with gas stations today. Electric Avenue 2.0 at our World Trade Center offices in Portland has been a success; the site, activated on July 18, 2015, hosts four dual-head DCQCs and one dual-head L2 charger. To date Electric Avenue 2.0 has delivered more than 200,000 kWh and powered nearly 1,000,000 electric miles. We believe there is opportunity to build on our successes and learnings from this demonstration project.

PGE proposes to create a network of Electric Avenues in the Company service area to:

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[56] Alexander. Transportation Statistics Analysis for Electric Transportation EPRI Technical Report # 1021848 (2011)

[57] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).

[58] Customer interview (July, 2016). (Conducted by Keller)

- **Increase visibility** of electricity as a fuel source to customers who are not yet aware that it is an option. As we witness daily at Electric Avenue, installations such as this one can engage potential EV drivers in conversations with existing EV drivers to better understand the advantages of the technology. As supported by NRDC, Cornell University, UC Davis, and our own customer research, we believe that the presence of more public charging infrastructure will increase adoption of electric vehicles and create a net benefit for all customers;[59,60,61]

Figure 7: Electric Avenue (World Trade Center)

- **Increase the availability of reliable public quick charging** for customers who choose electricity to power their cars and reduces range anxiety and charging concerns of customers who are considering buying or leasing an electric vehicle. We believe this will increase adoption of EVs and total vehicle miles travelled by EV drivers;
- **Make charging accessible** for customers who live in multi-family dwellings (or otherwise do not have off-street parking), who do not have access to home charging infrastructure. This creates opportunity for new segments of customers to consider acquiring an electric vehicle;
- **Support car share companies in adopting electric vehicles** by creating accessible and reliable quick chargers throughout the service area. We have heard directly from car share companies (e.g., ReachNow) that the largest barrier to adding EVs to their fleets is the availability of public quick charging infrastructure;
- **Empower Transportation Network Drivers to drive electric**. TNC drivers tend to be on the road for extended periods of time and can log hundreds of miles in a single day. Without reliably accessible quick charging infrastructures, there is limited opportunity for a TNC driver to make a living in an electric vehicle. As we see TNC drivers regularly utilizing Electric Avenue 2.0 in Portland, we believe the emergence of an Electric Avenue network will encourage EV adoption by TNC drivers. A key benefit of engaging TNCs is that peak driving periods tend to be in the late hours of the evening, on weekends, and over holidays (all typical off peak periods for PGE). TNC drivers who choose electric will be able to drive during peak TNC hours and quickly charge during PGE's off peak-hours between their rides;

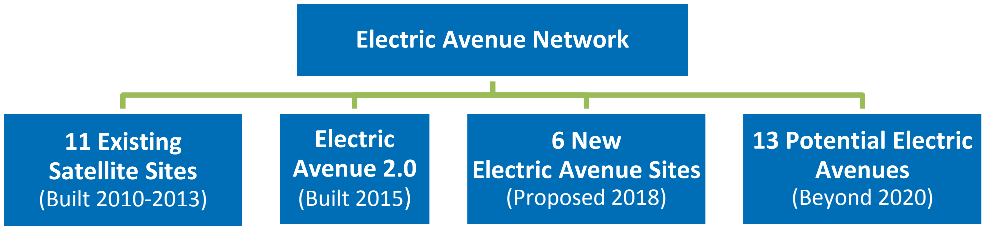
- **Learn about system and customer impacts associated with various pricing and demand reduction strategies.** Public charging will inevitably emerge in the service area as EV adoption continues to rise. It is important that PGE engage in public charging

[59] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).
[60] New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon (2015 UC Davis)
[61] Li, S. et al., "The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts," Cornell University, June 2015.

today to ensure we have developed best practices in encouraging smart charging behavior at public charging stations. We believe there is opportunity to send price signals to influence charging behavior today and even promote accepting excess renewables. Further, we envision a future state where public quick chargers are 2-way devices; given the cost of two-way charging infrastructure, it is likely to be cost-effective initially at high speed public infrastructure. We believe there is opportunity to provide pricing signals to customers to extract energy from their batteries to support the grid. As soon as this approach is technologically viable, we will explore opportunities to include it at one or more Electric Avenue sites.

Initial deployment will include the deployment of six new sites in the service area and incorporation of PGE's 11 existing public chargers as satellite sites, with the intent to scale to as many as 20 primary sites over time if the pilot proves to be successful and if the market need continues to exist.

Figure 8: Electric Avenue Network Composition and Timeline



Infrastructure

Upon plan approval, PGE will identify six new sites in the service area to host an Electric Avenue. Our vision is that each Electric Avenue site will include five electric vehicle charging stations: four 50 kW DCQCs and one 7 kW level 2 charging station infrastructure with at least two charging ports. We believe that having multiple chargers at each site is necessary to ensure availability and accessibility, which is crucial to a positive customer experience. As indicated in Section 1.4, charging sites with a single charger run the risk of being broken, in use, or otherwise occupied when another customer needs it. Similar to Electric Avenue 2.0, all DCQCs will be equipped with two interoperable charging ports (SAE Combo and CHAdeMO) in order to accommodate all mass market vehicles on the road. Our vision is that if a customer needs to charge her car to reach her destination, she ought to be able to dependably go to an Electric Avenue site to "fuel up".

All chargers procured though this pilot will be Open Charge Point Protocol 1.6 compliant to enable seamless communications between charging stations and vendor central systems. This will allow PGE to change vendors, collaborate with neighboring utilities, and enable smart-charging.[62]

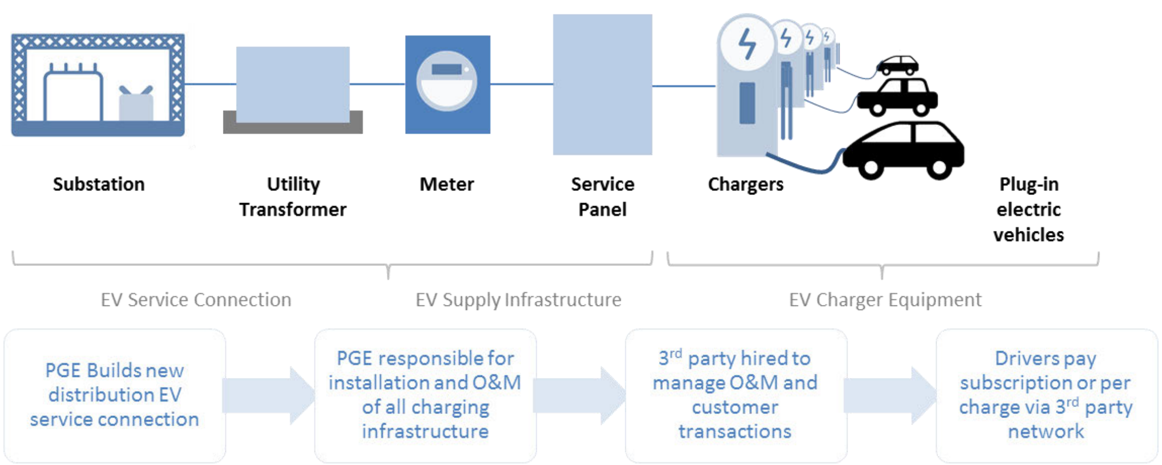
[62] http://www.openchargealliance.org/protocols/ocpp/ocpp-16/

All installations will be "future-proofed" to accommodate for advancements in fast charging infrastructure over time. Manufacturers are already developing high powered (> 150 kW) quick chargers. All Electric Avenue sites will be installed with adequately sized conduit such that chargers and conductors can easily be replaced with higher powered equipment as needed over time.

Though the Electric Avenues may be sited on PGE-owned or 3rd party locations, PGE anticipates contracting for services such as installation, operations (i.e. payment processing), and equipment maintenance. PGE has been involved with many of the charging infrastructure projects in Oregon that were a product of federal and private funding to 3rd parties to install public charging infrastructure. Unfortunately, some of the 3rd parties have gone out of business or have changed business focus which left many stations abandoned, with poorly maintained equipment.[63] As we evaluate accelerating the market, we believe that there is value for PGE to be a provider of reliable and accessible public charging infrastructure. We are committed to meeting our customers' needs today and years from now and, if the equipment fails for any reason, will make sure it is promptly repaired.

Though procurement for future Electric Avenue sites would not occur until this Plan is approved, PGE has recently issued a Request for Information to EVSE manufacturers and service providers to share equipment technical specifications, pricing, and company history. This information, along with our experience building Electric Avenue 2.0 and assisting in other charger site deployments, informs the cost estimates in this Plan and will be used to guide our procurement process.

Figure 9: Electric Avenue Design



[63] http://www.huffingtonpost.com/2013/10/13/electric-car-charger_n_4086326.html

Incorporation of Existing Infrastructure

As indicated in Section 1.4, PGE currently owns 11 DCQC sites that resulted from our Schedule 344 Pilot Rider.[64] PGE proposes to incorporate the 11 existing sites into the Electric Avenue Network. In order to incorporate these sites into the network, the following modifications to sites will be required:

Table 11: Modifications Required for Existing Chargers to be a part of the Electric Avenue Network

Site	Qty. of Chargers by Type	Modifications Required
Blink Network Sites	• 7 CHAdeMO DCQC • 11 Level 2 Chargers	• Sign new site agreements • Replace equipment with dual connector chargers • Update with consistent signage • Integrate into Electric Avenue payment Network as satellite site
Powin Sites	• 4 Dual-connector DCQC *Owned by Opconnect:* • 4 Level 2 Chargers	• Sign new site agreements • Purchase or replace level 2 chargers • Upgrade chargers with compatible payment mechanism • Update with consistent signage • Integrate into Electric Avenue Network as satellite site

Though the satellite sites currently have only a single quick charger per site, we believe there is value including these in the network for several reasons:

- Ensure existing infrastructure is maintained and operating properly;
- Create a larger network and more incentive for a prospective customer to enroll in a monthly subscription; and
- Send a consistent message to customers throughout the service area.

[64] PGE Report on EV Highway Pilot. Filed to OPUC on December 16, 2016.

Billing and Payments

The Electric Avenue Network is intended to provide benefit to PGE customers and to EV drivers from neighboring utilities. PGE proposes two pricing options for using the Electric Avenue Network to account for different use cases:

1. **Monthly Subscription:** customer pays a flat monthly fee and in exchange will not be required to pay an additional charge when using the charging station off-peak. Only PGE customers can sign up for this option.

2. **Pay-per-use:** non-subscribers (including non-PGE customers who use the Electric Avenue Network) pay a fixed charge (per charge) to cover administrative, system, and energy costs required to serve this driver.

   To send appropriate pricing signals and to discourage on-peak charging, all customers on either payment plan may be charged for on-peak energy consumption. We propose to utilize Schedule 6's Two Period TOU defined Summer Hours to define on-peak periods (on-peak is defined as 3pm – 8pm M-F excluding holidays).[65] *By using this schedule year-round, we believe this will simplify customer education, signage development, and program administration.*

Table 12 illustrates our preliminary pricing model:

Table 12: Proposed Electric Avenue Network Charging Pricing

	Monthly Fee ($/mo.)		Off-Peak Charge ($/charge)		On-Peak Energy Charge ($/kWh)
Option 1: Monthly Subscription	$25.00	+	-	+	$0.19
Option 2: Pay-per-Use (registered)	-		$5.00		$0.19

**It is our intent to partner with neighboring utilities to allow PGE customers to benefit from lower rates on stations outside of PGE's service area and vice-versa.*

Registered drivers will receive a radio-frequency identification (RFID) card, credit card style swipe card or be able to utilize an existing RFID card from a network provider or potentially just an app on their phone (this will ultimately be dictated by the vendor selection process). Our aim will be to make the driver user-experience as seamless as possible between our network, partner networks, and neighboring utilities. We anticipate that customers will pay for

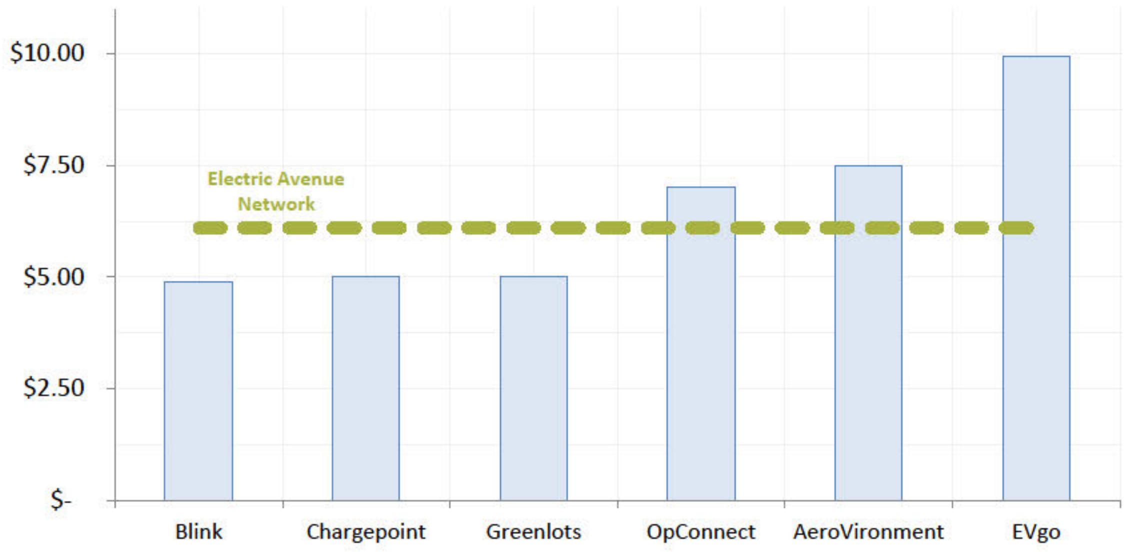
[65] https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_006.pdf

subscriptions and pay-per-use fees through a third party. Unregistered drivers will be able to pay for their charge with a credit card.

Though the prices above have been utilized for modelling costs and benefits, the final prices, units used for pricing (i.e. $/min, $/kWh, $/charge, etc.), and determination about whether to include on-peak charges may be modified based on on-going customer research. Our intent is to offer pricing that encourages customer adoption but that also aligns with the existing charging market. This will be reflected in our tariff filing after proposal approval.

In developing our pricing structures, we analyzed publically available charger pricing data to estimate average customer costs for utilizing public charging infrastructure:

Figure 10: Comparison of Market Rates for Public Quick Charging[66]



As illustrated in Figure 10 the proposed rates for Electric Avenue Network are designed to be comparable with existing market rates.

For the initial deployment, it is crucial to offer simple, easy to understand rates for both participants and prospective EV buyers. Specific pricing strategies deployed will be informed by direct customer feedback at the Electric Avenue sites, customer surveys, and focus groups. The intent is to first build a quality product that speaks to customers' needs to drive utilization; then, focus on encouraging use that drives overall system efficiency. It is important to keep in mind, however, that the Electric Avenue Network will only account for a maximum peak demand of less than 1.5 MW. Though small, we expect the learnings from dynamic pricing at public charging sites will create a foundation that we can apply to future public charging sites.

[66] http://www.plugshare.com/

3.3(d) Objectives and Evaluations

Through the expansion of the Electric Avenue project, PGE hopes to build on that successful pilot and continue to learn:

- The impact of the presence of visible, reliable, and accessible charging infrastructure on
    - Customers' willingness to purchase an EV
    - Customers' willingness to take longer trips in an EV
- Who the predominant users of the charging infrastructure are
    - Whether there are distinct use cases with predictable load profiles
    - Whether the chargers are regularly utilized by non-PGE customers
- Network load profiles and the impacts on PGE's distribution system and non-coincident peak loads of DC Quick Chargers, which will become increasingly important as we look at upgrading quick chargers to >100 kW units.
- The impacts of time-variant rates on customer use of charging infrastructure.
- The additional infrastructure, if any, needed to support and ensure high reliable public charging infrastructure (and applicable costs). What siting criteria can be utilized to limit or reduce distribution system upgrades necessary to install quick charging infrastructure.
- Charging infrastructure installation, operation, and maintenance costs.
- Challenges and best practices in permitting, designing, and siting DC quick charging infrastructure.

We believe a network of community charging stations with multiple DC quick chargers will:

- Enable customers with electric vehicles to use them more by creating a reliable and accessible network and reducing range anxiety
- Expand the base of potential buyers of electric vehicles by increasing visibility of charging infrastructure and empowering customers with the ability to charge publicly (including multi-family residents, car-sharing companies, and TNC drivers)

The impact of the Network on these goals is difficult to measure and depends heavily on customer awareness and perceptions of charging stations and electric vehicles generally. A direct measurement strategy is outlined in this section, while an indirect measurement of the market-wide effectiveness of this pilot and the Outreach, Education, and Technical Assistance pilot is covered in Section 3.4.

There are two main data sources for the evaluation of the Charging Station Network. One is the charging network itself, which will provide us with the following metrics:

- Revenue
- Coincidence Factor of Charging Stations
- Utilization
- Load Profile

- Load Factors
- Accessibility

The metrics will benchmarked against non-network chargers in the pre- and post-deployment windows to provide context for how these investments are performing relative to non-utility assets.

Another is surveys of electric vehicle owners, which will provide us with the following metrics:

- Type of vehicle
- Charging method decision process
- Typical commuting patterns
- Reported change in mileage due to charging station availability
- Reported impact of charging stations on purchase decision
- Reported discussions with non-EV owners at charging stations
- Percent of charging station users who live in rural/suburban/urban areas
- Percent of charging station users who are low-income
- Percent of charging station users who live in multi-family/single-family
- Percent of charging station users who have no/level-1/level-2 charging at home

Using any increased driving and or vehicle purchases reported by customers as being due to the new charging stations, the third-party evaluator will calculate estimated direct impacts on the mileage and the number of vehicles in the service territory.

3.3(e) Cost-Effectiveness and Assumptions

Though range anxiety and a lack of charging infrastructure are often cited as the primary drawbacks to purchasing a PEV,[67] there is uncertainty in the industry regarding which technical infrastructure solution is the most impactful in resolving the range/infrastructure nexus.[68] Regardless, all technical solutions are likely to mature and lead to greater consumer understanding of how an electric vehicle may replace their existing conventional vehicle. Additionally, the existence of visible charging infrastructure creates more awareness of Electric Vehicles as a potential transportation choice. Given that, we assume:

- The Electric Avenue network would be established early in the forecast period,
- The initial impact of the network would be small but would grow quickly as consumer awareness of the network grows. The vehicle purchase cycle is a long (5-10 years) so the impacts of the programs are delayed accordingly. Though these programs are expected to increase Electric Vehicle adoption, they will not change the car purchasing process overnight.

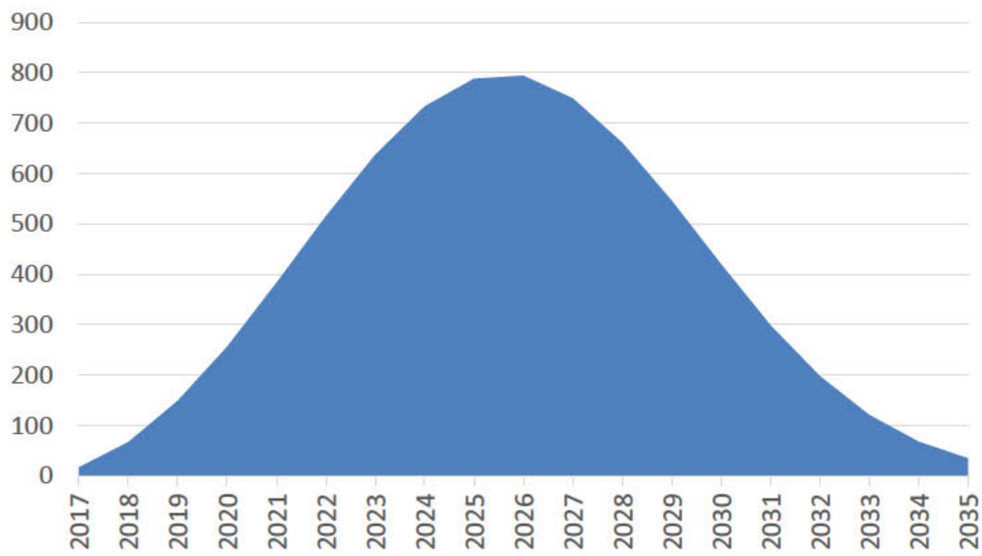
[67] Navigant Research, Electric Vehicle Geographic Forecast Report, 2016

[68] Potential solutions include: denser public charging, faster public charging, increased availability of MUD or 'end of commute' charging infrastructure

- Growing availability of 200 mile+ BEVs[69] would also increase the impact the DCQC network would have on the market in the near term, and
- New electric vehicle charging services (Multiple Unit Dwellings, Workplace) will develop over time and new technologies (wireless charging, faster DCQC)[70] will be introduced that will diminish the impact of the DCQC network on the electric vehicle market in the latter portion of the forecast.

Figure 11 shows the distribution of electric vehicle lift from the community charging infrastructure program.

Figure 11: Estimated New Electric Vehicle Sales Attributable to Electric Avenue Network



Source: Navigant analysis, 2016

Table 13: Electric Avenue Network Cost Effectiveness (Net Benefits) by Test Type, (2017 $)

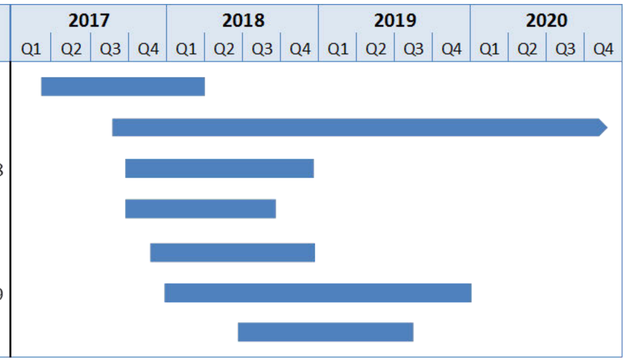
Customer Perspective Test (RIM)	Total Resource Cost Test (TRC)	Societal Cost Test (SCT)
$ 4,044,163	$ 2,297,870	$ 3,739,595

[69]Navigant Research, Electric Vehicle Market Forecast Report, 2015
[70]Navigant Research, Electric Vehicle Charging Services, 2016

3.3(f) Schedule

Figure 12: Electric Avenue Network Anticipated Schedule

Electric Avenue Network	Start	Finish
Site Selection (Stakeholder Meetings, Site Visits, etc)	2/28/2017	3/30/2018
Project Management, Reporting, Operations	3/1/2018	-
Procurement (RFP, equipment selection, order)	10/31/2017	12/30/2018
Equipment upgrades at satellite sites	10/31/2017	7/31/2018
Site Preparations (Easements, Permitting, Agreements	11/1/2018	5/31/2018
Franchise Agreement (If needed)	1/1/2018	12/31/2019
Equipment & Service Installation	5/1/2018	9/30/2018



Upon proposal approval, PGE will determine sites for Electric Avenue locations. PGE understands that right-of-way rules can cause delays and will look for collaborative partnerships with municipalities to site chargers when feasible. Additionally, to the extent necessary, we may issue a request for information (RFI) (or other form of solicitation) for interested parties to propose locations for hosting a site.

We anticipate site selection (site solicitation, site permitting and franchise agreements, etc.) to take 3-12 months (this may vary significantly by site host). During this process we will also ensure we have appropriate site agreements with our existing satellite stations as necessary.

Concurrently, PGE will issue RFPs for engineering/design, EVSE hardware, EVSE back-end payment network, and system maintenance as needed. We anticipate procurement to take three months. Upon site selection, site specific designs and equipment procurement will commence. We anticipate engineering, procurement, and construction to take 3-6 months (for comparison, the Electric Avenue took about 12 months from concept to first charge).

Future Plans

As electric vehicle adoption climbs and utilization of the Electric Avenue network rises, PGE will carefully consider future strategic deployments of additional Electric Avenues (up to 13 additional sites in the service area). If the Electric Avenue network expands beyond this pilot phase, PGE will adjust pricing and recovery mechanisms to ensure that the program is revenue neutral or that non-participants are held harmless from a cost-test perspective. Any possible expansions to the Electric Avenue Network would be discussed with the Commission through a supplemental filing or an update to the transportation electrification plan.

3.3(g) Budget

We estimate the total cost of the pilot to be $4.1M and expect it to generate $3.5M in revenues from subscriptions and usage charges (10-yr NPV). This estimate does not include any credits associated with the low-carbon fuel standard or any other environmental compliance incentive. It also does not include additional revenue from additional EVs added to grid as a result of the pilot.

Table 14: Electric Avenue Network Estimated Budget, ($,000)

Cost Element	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Capital Carrying Costs	-	$ 512	$ 481	$ 439	$ 405	$ 375	$ 348	$ 321	$ 295	$ 272
O&M Expenses	-	$ 359	$ 285	$ 294	$ 304	$ 312	$ 321	$ 330	$ 340	$ 350
Tax Credits	-	($ 196)	($ 196)	($ 98)	($ 98)	($ 98)	-	-	-	-
Total Rev. Requirement	-	$ 675	$ 569	$ 636	$ 610	$ 589	$ 669	$ 652	$ 634	$ 622
Est. Customer Payments	-	$ 461	$ 482	$ 503	$ 526	$ 550	$ 574	$ 600	$ 627	$ 655
Net Costs	-	$ 214	$ 87	$ 133	$ 84	$39	$ 95	$ 52	$ 7	($ 34)

Detail about the revenue requirements model, forecasts, and model assumptions are included in Appendix 1.

3.3(h) Vendor Selection

A competitive process will be used for:

- Charging equipment and warranty service agreement: procurement for all charging station equipment for all six sites.
- Back-end service provider: network for payment servicing, credit card processing, and customer service for the Electric Avenue network.
- Electrical Contracting and General Construction
- On-going operations maintenance for upkeep of the system.

Interoperability

PGE is currently experimenting with multiple Demand Response Management Systems (DRMS) and has not yet piloted a Distribution Management System (DMS). The market for these products is evolving rapidly, and we are testing products to best understand what systems can ensure that we can realize maximum value from all DERs that we control. In the long-term, we do anticipate contracting for a DRMS and DMS, however, a schedule for that process has not yet been developed. We anticipate asking vendors to document interoperability standards that their systems comply with to ensure that we do get a system as flexible as possible.

Site Selection Criteria

PGE will predetermine several geographic locations to target based on the site selection criteria outlined in this section and geographic diversity across the Company service area. We anticipate deploying sites in the following cities:

- Portland (1-3)
- Gresham
- Hillsboro
- Salem
- Beaverton
- Wilsonville (0 – 1)
- *Note: Other areas may be considered during our site selection process*

Sites will be evaluated on a variety of criteria. The list below is meant to be demonstrative of our planning but not comprehensive.

- Geographic diversity
- Visibility by drivers and pedestrians
- Proximity to low-income
- Proximity to multi-family dwellings
- Proximity to major roads/corridors
- Proximity to existing chargers
- Proximity to "dead zones" between major destinations (i.e. Mt. Hood, Coast)
- Availability and cost of real estate
- Proximity to frequent transportation network hot spots
- PGE infrastructure/capacity barriers
- Site lease costs or revenues
- Limited barriers to installation

The company will engage our community partners and may issue an RFI to potential site hosts to quickly identify a broad number of locations where hosts wish to support or host charging infrastructure. This would allow us a means to evaluate a number of sites with a streamlined, consistent methodology.

Though we intend to standardize the customer experience across charging sites to the extent possible, each site may have site-specific requirements regarding time a customer can park, signage limitations, or other criteria. It will be our intent to work with site hosts to ensure that rules are visibly marked and enforced. Rules may dictate how long a car may be parked, charging, etc. and will be revisited periodically during the pilot period to ensure a positive customer experience.

3.3(i) Risks

- **Low utilization or insufficient subscriptions**: PGE anticipates revenues associated with drivers utilizing these chargers. Failure to realize targeted utilization would result in increased costs. We do believe that our targets will be realized, however, due to (1) the success of Electric Avenue, (2) thoughtful rate design, (3) outreach and education campaign, and (4) conservative use estimates. We are specifically reaching out to car share and transportation network companies to ensure significant utilization, which will also promote fewer total vehicles on the road.
  - It is likely that in the coming year's advancements in energy storage technology will reduce the cost and increase adoption of long-range (> 200 mile) electric vehicles. Some speculate that the emergence of these vehicles will eliminate the need for public charging infrastructure. Though it is possible that high range vehicles reduce the need for public charging, we do not believe it eliminates it. As indicated in Section 3.3(b), a number of key customer segments do not have access to home charging (e.g. multifamily housing residents and those without off-street parking) or otherwise need charging while on the go (e.g. TNC drivers, car share companies, travelers, etc.). We do not expect this demand to go away. Ultimately, however, if chargers are underutilized, the chargers could be sold and repurposed for fleet or workplace charging, and the site upgrades at the facility might be utilized to support bus charging, energy storage, or another DER technology.
- **Equipment reliability issues**: the EVSE industry has demonstrated difficulty ensuring charger availability. PGE will monitor and promptly attend to downed equipment, but purchased equipment could require more maintenance than budgeted. This would result in increased operations and maintenance costs.
- **Site negotiations**: it is our experience that some right-of-way or customer negotiations can take a significant amount of time to finalize. We believe the work we've done during our Schedule 344 Pilot Rider will pave the way for success on future sites. Nevertheless, there is a possibility that network deployment could be delayed due to lengthy negotiations.
- **Permitting and design review:** similarly, many municipal permitting departments are new to reviewing plans for sites with several DC Quick Chargers. As such this can create delays in the design and construction processes. One of the benefits of this pilot is to better understand these challenges and share best practices.
- **Competitive impact:** some may perceive that there is risk that inserting a new charging network into the service area will reduce customers' use of other charging networks. We believe, however, that the contrary is true. We believe that a visible, accessible, and reliable network for our customers will drive more people into electric vehicles and increase demand for public charging infrastructure. We are proposing a very limited

deployment of 6 new sites, modest compared to the more than 100 quick charge sites and 900 gas filling stations in Oregon.[71]

3.3(j) Equity and Inclusion

As indicated above, the public chargers will provide an opportunity for residents of multi-family housing to consider acquiring an electric vehicle. Furthermore, we include proximity to low-income as one of our criteria for siting, and anticipate one of our proposed sites likely being placed in or near a low-income neighborhood. We also believe that by collaborating with TNC companies like Uber and Lyft, we can create a compelling offer for drivers or potential drivers (who are oftentimes represented by a low-income segment of the population), to choose an electric vehicle in order to reduce costs and net more income on their drives. By encouraging TNC drivers to adopt EVs, we are increasing the accessibility of electric transport to a wide range of customers-- TNC's often serve low/moderate income customers who otherwise do not own their own vehicle.

[71] https://oregoneconomicanalysis.com/2012/02/13/self-service-gas-and-taxes/

3.4. Residential Smart Charging Pilot

3.4(a) Summary

PGE intends to create a R&D pilot for up to 200 customers focused on demand response opportunities associated with residential charging. The pilot will explore customer impacts and achievable curtailment from residential charging.

3.4(b) Market Barriers

Availability and cost of smart charging devices

Some charging stations on the market do not have embedded communications and controls and are not able to participate in smart charging programs. Typically, charging stations with embedded communications cost more than those without. Without a utility program offering incentives for smart charging customers may be inclined to purchase the cheaper alternative.

Customer awareness of smart charging

Customers do not typically consider the grid impacts of their charging behavior. It is unclear if they would be willing to accept an incentive in exchange for shifting when their vehicle is charged.

Uncertain coincidence of load

EV charging is only an available DR resource if customers are actively charging vehicles when PGE's system needs to shave peak. We anticipate that most EV home-charging in off-peak hours, and therefore limits the peak reduction that is achievable.

3.4(c) Description

In 2015, PGE launched a residential smart thermostat direct load control (DLC) pilot which leverages Nest thermostats as a demand response asset (Rush Hour Rewards). The Bring-Your-Own-Thermostat ("BYOT") pilot rewards customers $25 for enrolling in the program and provides a $25 reward for each season the customer participates in the program. The pilot has successfully reached over 2,500 customers and demonstrates value of Bring-Your-Own-Device programs.

We believe that residential electric vehicle charging stations present an opportunity to mimic the success of the Rush Hour Rewards pilot. Our 2016 IRP DR potential study recognizes 8 MW of achievable DR through home chargers.[72] A pilot would offer incentives to customers who have or purchase a qualifying DR-enabled home charger.

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[72] https://www.portlandgeneral.com/-/media/public/our-company/energy-strategy/documents/2016-02-01-demand-response-market-research.pdf?la=en

- **Qualifying Equipment**: we intend to select 1 or 2 equipment manufacturers to demonstrate smart charging feasibilities for the preliminary pilot deployment (much like we have done with Nest for the thermostat pilot). Once we have demonstrated technical viability and customer value, we will evaluate expanding to other OEMs and hardware. Control, interoperability, and functionality will depend on bidding vendor's capabilities. For a pilot of this scale, PGE intends to select a vendor that offers PGE control (either via their software or integrated into existing PGE systems; control means ability to curtail charging, set preferred and unfavorable charging times). We will evaluate technologies that can curtail loads at the charger, inside the vehicle, and from customer behavior.
- **Incentives**: major differences between home EV charging and home heating and cooling systems include (1) intermittent use (meaning that chargers are not always plugged into a vehicle and may not be available to call an event) and similarly (2) non-coincident use. Typical load profiles of home EV chargers do not appear to be highly coincident with system peak (though there may be longer term value of renewables integration). As illustrated in the DR potential study, the estimated average amount of peak coincident load available to curtail on a per-participant basis is less than 0.2 kW. As such, the potential benefits leave little room for sizeable incentives. We will evaluate incentives carefully before launching a pilot, however, we do not anticipate being able to offer larger incentives than the Rush Hour Rewards Pilot (despite higher customer equipment costs). Incentives for that pilot are $25 for enrolling and $25 for each participating season.
- **Participation:** pilot participation will be limited to 200 customers at initial deployment.

3.4(d) Objectives and Evaluations

The pilot will evaluate:

- what tactics achieve program participation,
- whether a small incentive influences a customer's decision to purchase a smart charger,
- how much load can feasibly be shed from a residential charging station,
- technical and OEM viability,
- attrition, and
- cost-effectiveness.

We believe that the pilot will improve electric vehicle grid integration and provide PGE flexibility in curtailing or shifting charging loads to off-peak periods or periods of excess renewable energy.

Data from the chargers will allow for estimation of the load characteristics of the chargers. A third-party evaluator will compare the chargers to other chargers and/or to the same chargers during periods when the device is not being controlled. This comparison will allow for an estimation of the changes in load attributable to the pilots.

Additionally, we intend to survey charger-users to understand the customer experience of having your charge curtailed.

3.4(e) Cost-Effectiveness and Assumptions

This study is for research purposes and was not designed for establishing a cost-effective program. No cost-effectiveness study has been completed.

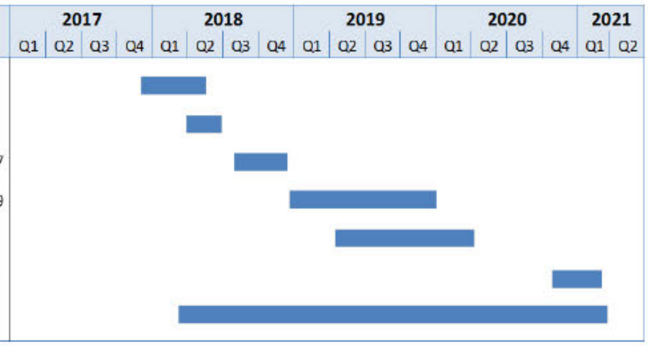
The pilot should yield results that inform (program costs, achievable curtailment, attribution, etc.) future program designs.

3.4(f) Schedule

The planning for the pilot will start in late 2017/early 2018, with intent to launch recruitment at the end of 2018. We will begin calling events in 2019.

Figure 13: Bring Your Own Charger Pilot Schedule

Residential Smart Charging	Start	Finish
Planning	12/1/2017	3/31/2018
Procurement	4/1/2018	6/30/2018
Design (systems, outreach plan, etc.)	7/1/2018	11/15/2017
Recruitment	11/15/2018	12/31/2019
Event calling, customer surveys, etc.	5/15/2018	5/15/2020
Pilot Evaluation	5/15/2020	8/15/2020
Project Management and Reporting	3/1/2018	3/1/2020



3.4(g) Budget

Table 15: Smart Charging Pilot Estimated Budget

Cost Element	Detail	2018	2019	2020
Incentive	Enrollment ($25)	-	$ 5,000	-
Incentive	Participation ($25/yr.)	-	$ 2,500	$ 2,500
Outreach	Content Creation	-	$ 25,000	-
Outreach	Recruitment	-	$ 25,000	-
Project Management		$ 40,000	$ 50,000	$ 50,000
	Total	$ 40,000	$ 107,500	$ 52,500

3.4(h)

3.4(i) Vendor Selection

A competitive process will be used for:

- Qualifying equipment and portal for calling DR events/setting timed charging schedules.
- Project administration services

The solicitation will encourage vendors to propose innovative solutions for offering residential smart charging. We will consider proposals that

3.4(j) Risks

- **Utility of vehicle:** Vehicles provide a service to customers that, in many cases, are essential to conduct their daily lives—they get people to school, work, doctors' appointments, etc. If a customer does not get a full charge while expecting it, it is conceivable that they may not have enough charge to reach their next destination. We need to be careful in curtailing or shifting charging loads to understand our customers' use cases such that we do not ever encumber our customers' abilities to use their vehicles.
- **On peak curtailment:** Because most home charging occurs off peak, it is possible that the realized value from curtailing home charging is low (in terms of reducing system peak). We do however see opportunity to potentially schedule charging for periods of anticipated high renewable production.
- **Vendor/technology risk:** The EV charging market is relatively young and we will need to be careful in selecting our vendor to ensure that the technology and systems selected will be viable to last the duration of the pilot period.

3.4(k) Equity and Inclusion

n/a

3.5. Cross-Pilot Evaluation

PGE recognizes how important it is to quantify the costs and benefits of electric vehicle pilots. We believe that our customers and stakeholders deserve a full, unbiased accounting of those costs and benefits. Evaluation performed by a third-party company, including both impact and process evaluation, is an important step towards achieving that accounting. Our proposed evaluation would cover both the impacts of the pilots, and the process of achieving those impacts. We believe it will both improve the pilot during their execution, and provide necessary data for stakeholders to inform future decisions concerning electric vehicles.

3.5(a) Impact Evaluation

Impact evaluation is the estimation of the direct, grid-relevant quantitative effects of a pilot. In this case, this includes:

- Load characteristics of electric vehicles and buses. These are important because they impact the costs and benefits the vehicles bring to the grid.
- The level of increased adoption and use of electric vehicles attributable to the pilots.

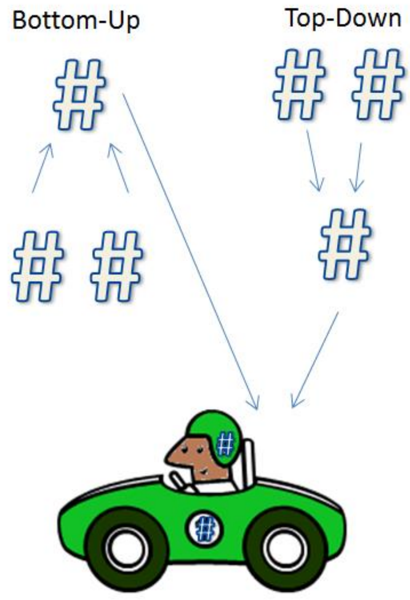


Figure 14: Bottom-up/Top-down Evaluation

For many of the pilots, estimating the impacts is fairly straightforward. In particular, the Electric Mass Transit 2.0 and Bring Your Own Charger Pilots have impacts that are mostly directly measurable. Those measurement techniques are described above in the pilot descriptions.

However, the Electric Avenue Network and Outreach, Education, and Technical Assistance pilots have as their primary benefit the acceleration of electric vehicle adoption and use. It is not possible to directly measure all the impacts of such initiatives. For this reason, we believe that measurement of the overall, market-wide increase in adoption due to the pilots is prudent. We also recognize the special difficulty of quantifying this increase because the electric vehicle market is so fast-changing and unpredictable. To best determine the impact of the pilots, we propose using both bottom-up and top-down approaches.

The bottom-up approach will estimate the direct impact on vehicle purchases and miles driven from the above pilots. The bottom-up approaches are discussed in Section 3. The sum of those estimated impacts will be the bottom-up impact estimate. The top-down approach will measure the impact of the programs as the difference between market-wide electric vehicle adoption and use forecasted in the absence of the pilots and the adoption and use observed in the presence of the pilot.

Realistically, it may be difficult to distinguish signal from noise in the early years of the pilots using the top-down approach, because the foreseen impacts are relatively small in the early years and the uncertainty in the forecast is relatively large. However, it is important to start the forecasting and measurement process promptly in order to prepare for later years.

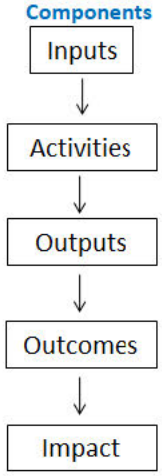
We believe that by triangulating between these two approaches, we can come to the best possible estimate of the impact of the Charging Station Network and Outreach, Education, and Technical Assistance pilots.

3.5(b) Process Evaluation

With estimates of the impacts of the pilots in hand, the next question would be, "What do we do now?" Qualitative "process" evaluation of the pilots makes the impact estimates actionable by identifying successful areas and problem areas of the pilots. They also provide earlier, interim feedback to help the pilots perform continuous improvement. Information sources in process evaluation include:

- Interviews with stakeholders and trade allies
- Surveys of participants and non-participants
- Demographic analysis to determine which types of customers are and are not participating in the pilots
- Creation of a "Logic Model" which helps identify any gaps in how the pilot's planned activities lead to the pilot's ultimate goals.

Figure 15: Logic Model Components



With direct impact evaluation, indirect impact evaluation, and process evaluation, we believe the pilots will provide a rich set of information. This information will allow customers, PGE, and stakeholders to assess the effectiveness of the pilots accurately and may well impact future transportation electrification policy.

3.5(c) Timeline and Cost Estimates

PGE anticipates conducting an evaluation of our pilots approximately once every two years. That schedule, however, will ultimately be dictated by final reporting/plan update requirements such that evaluation reports can be included in the transportation plan updates. The estimated cost for each biennial evaluation is $360,000.

Section 4. Proposed Recovery Structure

Upon approval of this application and Pursuant to ORS 757.259 and OAR 860-027-0030, PGE intends to request authorization to defer for later regulatory recovery the revenue requirement associated with the Transportation Electrification pilots outlined in this Plan. The deferral application would not represent a change in prices, but rather would minimize the frequency of price changes and match appropriately the costs borne by and benefits received by customers. If a deferral is filed, PGE would record the deferred amounts as a regulatory asset in FERC account 182.3, Other Regulatory Assets, with a credit to FERC account 407.4 Regulatory Credits.

A deferral, if filed, would include the revenue requirement of the Electric Avenue Pilot, the chargers associated with the Electric Mass Transit Pilot, administration of the smart charging pilot, and outreach and technical assistance costs associated with accelerating transportation electrification. The revenue associated with Electric Avenue subscriptions and usage, as well as the revenue associated with Electric Mass Transit, would be included as a credit. The estimated cost and revenue amounts are shown in Table 16.

Table 16: Estimated Transportation Electrification Pilots Financial Summary, by Program, 10-yr NPV (2017 $), ($,000)

	Total Revenue Requirements	Est. Customer Payments	Net Costs (Rev Req. less Cust. Payments)
Outreach and Technical Assistance	$ 2,054	-	$ 2,054
Electric Mass Transit 2.0	$ 1,239	$ 641	$ 598
Electric Avenue Network	$ 4,098	$ 3,547	$ 591
Bring Your Own Charger	$ 171	-	$ 171
Pilot Evaluation	$ 581	-	$ 581
Total	$ 8,142	$ 4,188	$ 3,954

Section 5. Estimated Program Impacts

In considering our legislative mandate to accelerate transportation electrification, it is important to estimate growth in electric vehicle adoption due to our intervention and the net benefit derived for our customers by that growth. Through the process of developing our proposals, we consulted with Navigant Consulting to develop a forecasting and cost-effectiveness methodology and analysis for our proposals. A full copy of their whitepaper is included in Appendix 4.

5.1(a) Forecasted Lift

In order to forecast incremental EV acquisition due to our portfolio of programs ("lift"), we must first have a baseline forecast of how EVs will grow in our service area without our intervention. Navigant's technology competition model evaluations high-level macroeconomic factors (i.e. GDP, population), purchasing costs, operating costs, range, availability of charging infrastructure, and local demographics.

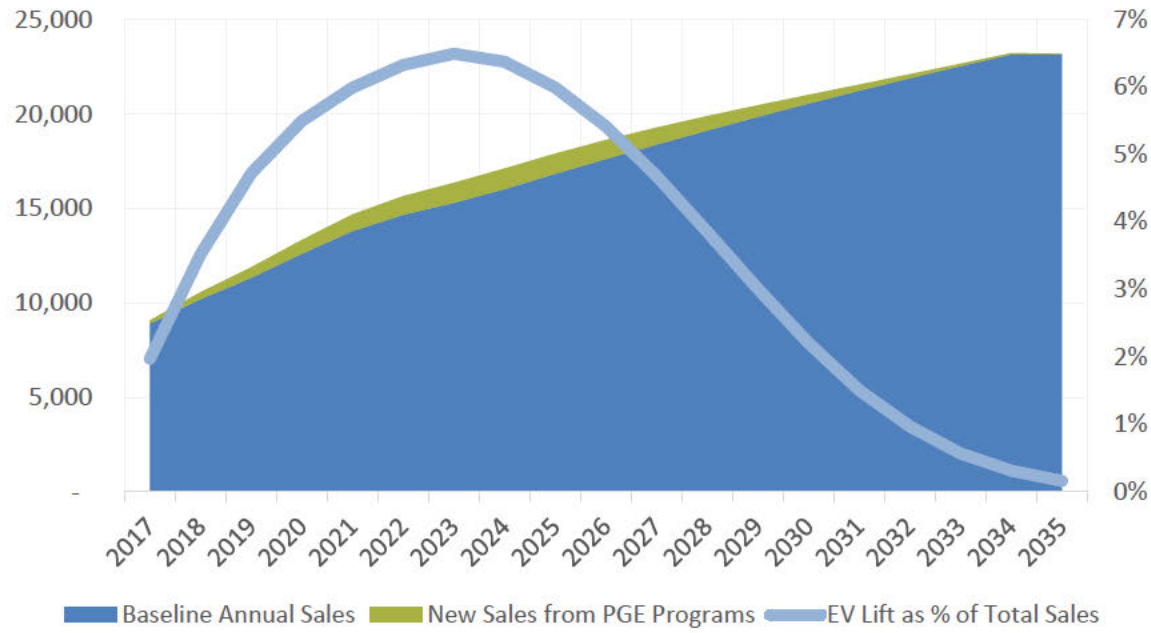
Navigant Research uses a technology competition model to forecast electric vehicle sales at the national level. The forecast model uses high-level macroeconomic factors like gross domestic product and population as well as vehicle density and historic sales data to project overall light duty vehicle market growth. Sales forecasts per technology segment analyzed are determined by estimating the market share of the technology against competing platforms as a function of a number of variables that feed into the consumer choice such as: purchase and operating costs, vehicle range, refueling/recharging infrastructure and other factors influencing electric vehicle capability and convenience. Navigant's forecast included in Table 17:

Table 17: Cumulative EV Forecast in PGE Service Area without PGE intervention

Year	No. Vehicles
2017	10,430
2020	40,858
2025	113,265
2030	205,092
2035	314,492

Navigant then estimated program impact of the outreach and education pilot as well as the Electric Avenue Network since they are broad and targeted at all customers, whereas the R&D pilots are very limited in scope and customer reach. Because there is not a long history of electric vehicle programs or EV adoptions, the model includes many conservative assumptions. Navigant forecasts approximately 11,500 new EVs will be acquired relative to the baseline as a result of these pilots:

Figure 16: EV Forecast (Baseline vs. Forecast)



As illustrated in Figure 16, Navigant found that the electric vehicle lift caused by PGE programs represents an average increase of roughly five percent of new vehicle sales in the total cumulative electric vehicle sales forecast.

5.1(b) Customer Benefits and Cost-Effectiveness

Cost-effectiveness tests are used to measure the benefit of programs and portfolios of programs relative to their costs from a given stakeholder perspective. In planning for PGE's transportation electrification pilots, we primarily used the RIM test (utility customer perspective), however we also modelled the TRC (total resource perspective) and SCT (societal perspective).

Customer Perspective (RIM)

Testing cost-effectiveness of our pilots from the customer perspective measures what happens to customer electric bills due to changes in utility revenues and operating costs caused by the program. Prices will go down if the revenues from the program are greater than the utility costs. For the purposes of this test, revenues include program revenues (retail payments to use charging infrastructure) as well as all new billing revenues attributable to EVs that are incremental and attributable to the program (this includes home, workplace, and out-of-network public charging in the service area). Conversely, prices will go up if revenues, collected after program implementation, are less than the total costs incurred by the utility in implementing the program. This test indicates the direction and magnitude of the expected change in customer bills. Benefits and costs in this test are classified as indicated below:

Benefits:
- Increased Electricity Sales
- Pilot revenues
- Utility tax credits (federal)
- Utility tax credits (state)

Costs:
- Incremental Capacity and T&D Costs
- Incremental Energy Supply Costs
- Utility Capital Costs
- Utility O&M
- Utility Admin

Total Resource Perspective (TRC)

Testing cost-effectiveness from the total resource perspective measures the net impacts of our pilots based on the total costs of the pilot, including costs borne by both our customers and PGE directly. Benefits and costs in this test are classified as indicated below:

Benefits:
- Avoided Gasoline Costs
- Customer Tax Credits (federal)
- Customer Tax Credits (state)
- Customer O&M Savings
- Utility tax credits (federal)
- Utility tax credits (state)

Costs:
- Incremental Capacity and T&D Costs
- Incremental Energy Supply Costs
- Utility Capital Costs
- Utility O&M
- Utility Admin
- Customer Incremental Vehicle Costs
- Customer Charger Costs

Societal Perspective (SCT)

From the societal perspective, cost-effectiveness measures the net impacts of our pilots on society as a whole. We are defining the boundaries of society for this purpose as the state of Oregon. The primary difference between the TRC and SCT is the treatment of emissions and tax credits. The cost of emissions in the SCT is the societal cost whereas in the TRC the cost of emissions is based on regulatory compliance. In addition, state tax credits in the SCT are considered a pass-through and as such are not modeled as a benefit. Since the boundaries of this measure are at the state level, federal tax credits are still modeled as a benefit. Benefits and costs in this test are classified as indicated below:

Benefits:
- Avoided Gasoline Costs
- Reduced Fuel Emissions
- Customer Tax Credits (federal)
- Customer O&M Savings
- Utility Tax Credits (federal)

Costs:
- Incremental Capacity and T&D Costs
- Incremental Energy Emissions
- Incremental Energy Supply Costs
- Utility Capital Costs
- Utility O&M
- Utility Admin
- Customer Incremental Vehicle Costs
- Customer Charger Costs

For each test, a discounted cash flow analysis is performed and cost-effectiveness is calculated as the net present value of benefits divided by the net present value of costs (>1.0 indicates there is a net benefit).

Results

As indicated in Table 18, PGE's Light Duty Vehicle programs are expected to be cost effective. When combined with the TriMet program, PGE's electric vehicle market support efforts are cost effective at the portfolio level.

Table 18: Transportation Electrification Pilots Cost-Effectiveness Summary

	Customer Perspective (RIM)	Total Resource Cost (TRC)	Societal Cost Test (SCT)
Net Benefits By Pilot (2017 $)			
Electric Avenue Network	$3,780,818	$2,034,525	$3,476,250
Outreach and Education	$2,526,860	$3,902,806	$4,671,908
Electric Mass Transit	($ 1,037,395)	($ 1,059,005)	($ 1,332,532)
Overall Portfolio	$5,270,283	$4,878,326	$6,815,625
Net Benefits Per Vehicle (2017 $)			
Electric Avenue Network	$930	$527	$882
Outreach and Education	$889	$1,338	$1,607
Electric Mass Transit	($ 1,037,395)	($ 1,059,005)	($ 1,332,532)

The TriMet program is a pilot designed to enable TriMet to purchase one additional bus. The pilot appears to have a net cost, predominately because the full cost of five chargers are incurred as utility capital costs, while the analysis only counts the benefits of the one additional bus attributed to the program. In reality, these five chargers could power significantly more than one or even five electric buses in the future. However, in order to stay consistent with the methodology employed in response to previous dockets (UM 1708) the analysis strictly accounts for only incremental costs and benefits as a direct result of the pilot.

5.1(c) Environmental Benefits

As indicated in 5.1(a), Navigant forecasts approximately 11,500 new EVs will be acquired relative to the baseline as a result of our proposed pilots. Those vehicles, as they are acquired by our customers will have immediate and lasting environmental benefits to our community.

Additionally, as generation fleet continues to be powered by more renewable energy sources, the environmental benefits grow. Table 19 illustrates a reduction of 595,071 metric tons of CO_2 emissions through 2035 as a result of the incremental EVs attributable to these pilots:

Table 19: Estimated Greenhouse Gas reductions due to PGE Transportation Electrification Pilots

Year	Cumulative New EVs due to PGE pilots	Est. Emissions Intensity (lbs. CO_2/kWh) *[PGE Preferred Portfolio, 2016 IRP]*	EV CO_2 Emissions (metric tons CO_2)	Gas Alternative CO_2 Emissions (metric tons CO_2)	Annual CO_2 Reductions due to PGE Pilots (metric tons CO_2)
2017	179	0.82	264	1,006	742
2018	551	0.76	750	3,097	2,347
2019	1,113	0.76	1,488	6,256	4,767
2020	1,846	0.78	2,527	10,376	7,849
2021	2,726	0.71	3,339	15,322	11,984
2022	3,717	0.64	4,108	20,892	16,784
2023	4,780	0.67	5,394	26,867	21,474
2024	5,872	0.67	6,641	33,005	26,364
2025	6,945	0.70	8,029	39,036	31,007
2026	7,954	0.70	9,199	44,708	35,508
2027	8,857	0.70	10,168	49,783	39,615
2028	9,623	0.73	11,272	54,089	42,817
2029	10,238	0.73	12,011	57,546	45,534
2030	10,701	0.72	12,184	60,148	47,964
2031	11,025	0.72	12,476	61,969	49,493
2032	11,238	0.72	12,594	63,166	50,573
2033	11,367	0.72	12,591	63,891	51,300
2034	11,439	0.73	12,620	64,296	51,677
2035	11,476	0.42	7,232	64,504	57,273
				Total CO_2 Reductions (2017 – 2035)	**595,071**

**Assumes 13,500 VMT/vehicle/year.*[73]

[73] US DOT Federal Highway Administration. *Average Annual Miles per Driver by Age Group.* (Accessed Dec. 1, 2016). http://www.fhwa.dot.gov/ohim/onh00/bar8.htm

Section 6. Other Related Efforts

6.1. Low Carbon Fuel Standard (LCFS)

6.1(a) Background

The 2009 Oregon Legislature passed HB 2186[74] authorizing the Oregon Environmental Quality Commission to adopt rules to reduce the average carbon intensity of Oregon's transportation fuels by 10% over a 10-year period. The 2015 Oregon Legislature passed SB 324[75] allowing DEQ to fully implement the Clean Fuels Program in 2016. The rules for the program are adopted in Oregon Administrative Rules Chapter 340 Division 253[76] – as filed with the Secretary of State.[77] The rule allows electric utilities to register as a credit aggregator for electricity used as a transportation fuel. Utilities must register by October 1, to generate credits for the subsequent year.

6.1(b) Current Status

As of October 1, 2016, PGE has not registered as a credit aggregator with the DEQ. After multiple discussions with DEQ and other parties, PGE made the decision not to enroll as a credit aggregator at this time but to reserve the option for later years. This decision was made for the following reasons:

- The benefits of the program for PGE customers at this time are speculative and temporal at best.
    - To our knowledge, as of this filing no trades of credits have been made in Oregon, thus providing no indication for the value of credits, if any.
- Administrative costs of this program are uncertain. PGE is currently participating in another DEQ rulemaking on implementing the LCFS. No party has yet had experience in administering a credit aggregation program and no party has benefitted from the credits themselves.
- It is unclear whether and when we will need to seek OPUC approval to sell credits and what resources would be required to demonstrate prudency. As stated above, no trades of credits have been made, in part because there is no functioning market for credits currently, though a rudimentary marketplace does exist. We are not certain when a liquid market will develop and we are also not able to predict when the value for credits will be maximized.

- Furthermore, today we do not have customer vehicle data; and we feel it improbable that we would be capable of fairly reporting and aggregating credits for our customers.

[74] https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2009orLaw0754.html
[75] http://www.deq.state.or.us/aq/cleanFuel/docs/SB324.pdf
[76] http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_253.html
[77] http://www.deq.state.or.us/aq/cleanFuel/

    - Without being able to identify our customers, we feel that it is important to leave the door open in the short term for brokers and customers to claim credits for their EVs where applicable.
    - Opportunity costs are real—any staff resources dedicated to standing up PGE as a credit aggregator in late 2016 and early 2017 would be resources pulled away from the development and execution of this Plan. We hope that by prioritizing efforts on accelerating greater adoption that we will realize a long-term increase in overall credits available to benefit our customers.
- Credits are generated based on vehicle miles travelled and thus will accrue at a compounding rate based on the growth of EVs in the service area. As such, our analysis of EV adoption numbers suggest that given the expected increase in EV adoption in coming years, PGE's decision not to participate as an aggregator in 2016-17 has at most sacrificed 3% of the total LCFS credits likely available in the next ten years.
    - Given the timing for approval and execution of this Plan, it is unlikely that any credits will be generated as a result of this Plan in 2017.
- Third parties (particularly Drive Oregon) have expressed interest in potentially serving as an aggregator for the state—serving PGE, Pacific Power, and other smaller utilities. Though we have not yet determined whether this is the best decision for our customers, we do think there could be opportunities for administrative savings and continuity across the state by pursuing a central generator. This will be evaluated looking forward.

6.1(c) Future Credit Generation

We understand that the OPUC intends to open an investigation into the aggregation and use of LCFS credits. We believe that is the best venue to discuss PGE's role in and the future of these credits. We look forward to participating in that process.

6.1(d) Stakeholder Engagement and Looking Forward

Since our decision to not enroll as a credit generator in 2016, the LCFS was discussed at our October 20 workshop and again at a stakeholder meeting focused on LCFS on November 10. At these engagements CUB, OPUC Staff, and DEQ were most active in discussions about PGE's potential role as an aggregator.

After discussions with stakeholders, we do believe that either applying as an aggregator or working with a broker (like Drive Oregon) in 2017 has potential value to complement the pilots outlined in this proposal. Unless unforeseeable change in the rule-making or legislative session, we anticipate pursuing one of these directions in October, 2017.

6.2. Zero-Emission Vehicle Mandate

In 2005, Oregon adopted California's Zero-Emission vehicle mandate which requires a certain percentage of vehicle sales each year be super low-emission vehicles, hybrids, plug-in hybrids and modest numbers of battery-electric and fuel cell vehicles. Oregon's program became effective with the 2009 model year. DEQ estimates the program to result in EVs and PEVs accounting for 5% of new vehicle sales in 2018 and 13% in 2025.[78]

Oregon anticipates participating in California's 2017 program evaluation process. The process will assess the program's progress and recommend any necessary adjustments. PGE will watch the evaluation closely to determine if recommended changes will have any impact on EV forecast, pilot plans, or any other part of this Proposal.

6.3. Volkswagen Settlement

Background:

On June 28, 2016, Volkswagen (VW) settled with the U.S. Department of Justice and the State of California for $14.7B as a result of the diesel emissions scandal discovered in 2015. The settlement funds are to be used for the following:

- Vehicle recall: VW will buy back (or bring into compliance) at least 85% of the 500,000 non-compliant 2.0L vehicles nationwide by June, 2018. ($10 billion nationally)
- Emissions mitigation activities: establishes a NOx mitigation trust fund, funded over three years, to be distributed to states according to their share of non-compliant vehicles. States have the flexibility to choose from a list of eligible mitigation actions. (National total is $2.7 billion; Oregon's share is $68 million.)
- ZEV infrastructure and promotion: VW will, over the next decade, promote the use of ZEVs and ZEV technology. Investments will include EV and other ZEV (e.g. hydrogen) charging infrastructure and brand-neutral education or public outreach related to ZEVs. There is $2.0 billion in this fund; $800 million is designated for California, and the remaining states share $1.2 billion.[79]

Emissions Mitigation Trust

The State of Oregon will receive $68 million, over three years for emissions mitigation activities. Eligible NOx mitigation actions are specified in Appendix D-2 of the approved Department of Justice Consent Decree and include class 4-8 school buses, class 4-7 local freight trucks, and various pieces of port and rail equipment.[80] The decree allows that 15% of the total funds

[78] http://www.deq.state.or.us/aq/orlev/
[79] http://www.deq.state.or.us/aq/vwsettlementfs.pdf
[80] https://www.vwcourtsettlement.com/en/docs/Appendix%20D-2.pdf

($10.M) can be spent on light duty zero emission vehicle supply equipment (including electric vehicle charging infrastructure).

The Oregon Governor will be asked to designate a lead state agency to work with this Trust Fund administrator, most likely Oregon Department of Environmental Quality (DEQ). The State legislature must approve a bill so that a state agency can accept these funds.

Currently we anticipate that the bulk of these funds will be used to assist Oregon school districts with an unfunded legislative mandate to replace older school buses that no longer meet emission requirements with clean diesel school buses.[81]

Zero-emission vehicle infrastructure and promotion recommendations:

As indicated above, VW will invest $2B over 10 years to promote the use of ZEVs and ZEV technology; $1.2B is to be spent in the 49 other states besides California. Under the settlement, the following vehicles are considered ZEV: EVs and PHEVs (with an all-electric range over 35mi for light-duty and 10mi for medium and heavy duty vehicles), hydrogen fuel cell vehicles, on-road heavy-duty vehicle auxiliary power systems.

These funds will be allocated in four (4) 30-month periods. VW is currently seeking input from various stakeholders on how best to deploy these funds in the first 30-month period. The final plan for this first phase is due in March/April 2017.

While Oregon and the West Coast metros have been leaders in the early adoption of ZEVs, there is no assurance that, outside of California, any of these funds will be made available to Oregon projects. PGE is working alongside a variety of Oregon and electric utility stakeholders to prepare a list of current needs for charging infrastructure, particularly along major highway corridors such as I-5, I-84, US 101 and US97. Many of these corridors travel through rural parts of Oregon, where there has been only a modest amount of charging infrastructure (particularly quick charging), and what has been installed have been single units with only the CHAdeMO connectors.

Though PGE will continue to monitor the progress of the settlement and collaborate with stakeholders to secure VW funding for Oregon, there are no assurances that any of these funds will be designated for Oregon projects (or projects in PGE's service area). Although PGE's ability to secure funding through this program is not guaranteed, we have submitted an investment case for the proposed Electric Avenue Network Pilot to VW. If VW selects PGE's investment case for funding, PGE would reduce the forecasted program cost to our customers. In the event the investment case is not selected by VW, we anticipate executed the plan as outlined in this document, subject to approval from the OPUC. Future transportation electrification plans and

[81] http://www.schoolbusfleet.com/news/714164/funds-from-vw-settlements-could-be-used-for-school-bus-replacement

updates will account for industry changes attributable to the distribution of VW settlement funds.

6.4. City of Portland EV Strategy[82]

On December 14, 2016, the Portland City Council unanimously adopted an updated Electric Vehicle Strategy in effort to meet their Climate Action Plan goals to reduce carbon emissions 40% by 2030 and 80% by 2050.[83]

Several key elements of the City of Portland's strategy align well with this proposed Plan:

- "The City is committed to creating mobility solutions that are equitable and empowering." The strategy supports the deployment of charging infrastructure near low-income multi-family residences and the education of communities on incentives and financing considerations for EVs.
- The strategy calls the City to "increase access to EV charging infrastructure" because "providing Portlanders with a robust and reliable charging network at home, work and in public places will reduce range anxiety, provide access to emergency charging and enable longer trips." Further the plan encourages "the installation of multi-modal EV charging pods similar to Electric Avenue around the metro area."
- The plan also calls for working with "utility and community partners to provide technical assistance to building managers and homeowners to install EV chargers."
- The strategy supports increasing public awareness working with community partners through improved signage, marketing and outreach."
- The City intends to "support TriMet's efforts to transition to electric buses".
- Encourage TNC's and other car share companies "to utilize EV's in their fleets".

PGE is supportive of the City's efforts and looks forward to collaborating with the City on the rollout of our Outreach and Technical Assistance, Electric Mass Transit, and Electric Avenue pilots.

[82] https://www.portlandoregon.gov/bps/article/619275
[83] https://www.portlandoregon.gov/bps/article/621016

Section 7. Conclusion

PGE is uniquely positioned to support EV acquisition in the service area while building a foundation that will enable all customers to realize value from transportation electrification for years to come. We believe that by promoting transportation electrification and creating a dependable and accessible network of charging infrastructure, we can create value for all PGE customers.

In summary, PGE is proposing a portfolio of transportation electrification pilots that will cost $8.1M and generate $4.2M in revenue (using a 10-year NPV). PGE anticipates that new EVs on the grid as a result of these programs will create $5.0M of net value for all PGE customers through increased electricity sales, creating downward pressure on rates.

We look forward to a positive discussion on proposal with the OPUC and stakeholders in 2017.

Appendix 1. Economic Modelling Estimates and Assumptions

Electric Avenue Network

Assumption	Value	Source
DCQCs per Station	4 (1 at satellite)	Same as Electric Avenue
Level 2 chargers per station	1	Planned proposal (1 charger/2 port)
Number of Sites	6 (plus 11 satellite)	Pilot program assumption
Fixed O&M expenses per station per annum	$2,000 - $15,000	5.5% of station capital cost determined from vendor interviews
Transaction Costs	8.1% of revenue	Comes from PGE's request for information from EV equipment vendors
Land Use/Site Rental Fees	$0 - $10,000	Average of Electric Avenue fee of $10,000 and sites with no fee
Federal Tax Credit	0%	Conservative assumption that the tax credit will not be renewed after expiration at 2016 end
State Tax Credit	35% of capital cost	Assuming renewal of AFVI from conversations with program staff
Growth rate of charging per annum	4.5%	Compound annual growth rate from Oregon study on Aerovironment chargers
% of subscriber DCQC charging off-peak	85%	Conservative assumption based on proposed zero variable cost charging off-peak
Monthly Subscriber Charges as % of Total Charges	65%	Estimate
Charges per station (DCQC)	700 (88 for satellite sites)	Estimate from historical data at Electric Avenue
Average electricity use per charge (DCQC)	10 kWh	Estimate from historical data at Electric Avenue
Charges per station (L2)	70 (7 for satellite sites)	Assumed 10% of DCQC
Customer chargers per month (L2)	1	Estimate
Average electricity use per charge (L2)	8.2 kWh	Estimate
Subscription price per month	$25	Based on competitive pricing analysis of current market participants and back solving for revenue requirement. We assume prices remain flat because we don't know which direction market pricing is going.
Retail price of electricity per kWh (on-peak)	$0.19	From PGE's tariff Schedule 6
% of non-subscriber charging off-peak	75%	Conservative assumption based on proposed zero variable cost charging off-peak

Assumption	Value	Source
Non-subscriber DCQC fixed price per charge	$5.00	Usage from average charge * variable rate + $5 fixed charge is about equal to average of charging costs for other market participants
Non-subscriber L2 fixed price per charge	$3.50	Usage from average charge * variable rate + $3.50 fixed charge is about equal to average of charging costs for other market participants
Price Escalation	0%	To be conservative, we assume all prices remain flat.
Capital Cost per Station	$266k - $271k/site ($40k for satellite chargers)	Pilot and Blink/Powin costs are PGE base case forecast; Electric Avenue is estimated net book value at 12/31/17.
Power Purchase Price per kwh (Year 1)	$0.024	Based on PGE net variable power cost forecast
Economic Life - Years	10	

Electric Mass Transit Pilot

Assumption	Value	Source
Depot/Shop Chargers	5	Pilot plan
En-Route Chargers	1	Pilot plan
Annual Fixed O&M expenses	$30k/year	5.0% of capital cost determined from vendor interviews
Transaction Costs	0	
Land Use/Site Rental Fees	$0	
Federal Tax Credit	0%	Conservative assumption that the tax credit will not be renewed after expiration at 2016 end
State Tax Credit	35% of capital cost	Assuming renewal of AFVI from conversations with program staff
Capital Cost - PGE	$625k	PGE is only responsible for costs of depot chargers (5@$60k) and en-route charger (1@$300k) and project management costs ($25k)
Power Purchase Costs	Schedule 83	
Revenue		TriMet will pay for O&M and electric power usage at tariff rate
Economic Life - Years	10	

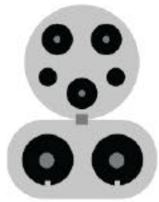
Appendix 2. Basic Transportation Electrification Terminology

Note: Terms and descriptions below complied from a variety of sources.[84,85,86]

Table 20: Electric Vehicle Terminology

Term	Description
Level 1 Charger	AC Level 1 EVSE (often referred to simply as Level 1) provides charging through a 120 volt (V) AC plug. Most, if not all, plug-in electric vehicles (PEVs) will come with an AC Level 1 EVSE cord set so no additional charging equipment is required. Level 1 charging yields 2 to 5 miles of range per 1 hour of charging. Plugging in at home using a standard outlet requires a dedicated circuit.
Level 2 Charger	AC Level 2 equipment (often referred to simply as Level 2) offers charging through 240V (typical in residential applications) or 208V (typical in commercial applications) electrical service. Most homes have 240V service available, and because AC Level 2 EVSE can charge a typical EV battery overnight, they will commonly be installed at EV owners' homes for home charging or are used for public charging equipment. This charging option can operate at up to 80 amperes and 19.2 kW. However, most residential AC Level 2 EVSE will operate at lower power. Many such units operate at up to 30 amperes, delivering 7.2 kW of power. These units require a dedicated 40 amp circuit. Level 2 charging typically yields 10 to 20 miles of range per 1 hour of charging. Some vehicles such as the Mercedes B Class electric and Tesla models and can charge at 40-80 miles per 1 hour of charging, respectively. All major auto manufacturers have adopted the SAE J-1772 Plug as a standard connector for both Level 1 and Level 2 Charging
DC Quick Charger (DCQC)	Direct-current (DC) quick charging equipment, sometimes called DC Level 2 (typically 208/480V AC three-phase input to the charger), enables rapid charging along heavy traffic corridors at installed stations. There are three types of DC fast charging systems, depending on the type of charge port on the vehicle: a J1772 combo, CHAdeMO, or Tesla. DCQC yields 50 to 70 miles of range per 1 hour of charging.
CHAdeMO Charger Port	 The CHAdeMO port was the first internationally used DCQC Standard connector and communications system, introduced by Nissan in Japan and then used by Nissan, Kia and Mitsubishi in U.S. deployment of their vehicles.

[84] http://www.afdc.energy.gov/vehicles/electric.html
[85] http://www.openchargealliance.org/about/appraisal/
[86] http://www1.udel.edu/V2G/

Term	Description
J1772 (SAE Combo) Charger Port	 European and U.S. auto manufacturers developed a new standard connector that they brought to the Society of Automotive Engineers to be adopted as the official SAE Standard. This connector uses the SAE-J1772 communications standard with added conductors for the DC high power charging. The SAE Combo connector is sometimes referred to as the Combined Charging System or CCS Combo.
Tesla Charger Port	 Tesla developed its own connector standard and offered to allow all manufacturers the ability to use this connector with no patent fees. This is used on the Model S, Model X and upcoming Model 3. Tesla has a different connector unique to the Tesla Roadster. Tesla also made an adapter to charge the Model S, 3 and X using a CHAdeMO charger. It is anticipated that they may make an adapter for the CCS Combo as well.
Range	The maximum amount of distance that a vehicle can travel on a single charge.
Electric Vehicle (EV)	EVs use a battery to store the electric energy that powers the motor. They receive electricity by plugging into the grid, and they store it in batteries. They consume no petroleum-based fuel while driving and produce no tailpipe emissions. EVs are sometimes referred to as battery electric vehicles (BEVs).
Plug-in Hybrid Electric Vehicle (PHEV)	PHEVs are powered by an internal combustion engine that can run on conventional or alternative fuel and an electric motor that uses energy stored in a battery. The vehicle can be plugged into an electric power source to charge the battery. Some can travel more than 70 miles on electricity alone, and all can operate solely on gasoline (similar to a conventional hybrid). Some types of PHEVs are also called extended range electric vehicles (EREVs).
Vehicle to Grid (V2G)	Electric-drive vehicles, whether powered by batteries, fuel cells, or gasoline hybrids, have within them the energy source and power electronics capable of producing the 60 Hz AC electricity that powers our homes and offices. When connections are added to allow this electricity to flow from cars to power lines, we call it "vehicle to grid" power, or V2G. Cars pack a lot of power. One properly designed electric-drive vehicle can put out over 10kW, the average draw of 10 houses. The key to realizing economic value from V2G are grid-integrated vehicle controls to dispatch according to power system needs.
Open Charge Point Protocol (OCCP)	OCCP is a freely available open standard that enables component vendors and network operators to “mix and match” interoperable hardware and software. It was first defined and deployed, as version 1.2 in 2010, and is a proven way to optimize the cost and risk of networked infrastructure investments. New versions of OCPP are collaboratively defined within an open industry alliance to ensure that the protocol continues to meet evolving market requirements. Today charging network operators and service providers in more than 50 countries rely on OCPP to manage more than 10,000 charging stations.

Appendix 3. Letter of Support from TriMet

TRIMET

December 19, 2016

Public Utility Commission of Oregon
201 High Street SE, Suite 100
Salem, Oregon 97301-1166

Dear Commissioners:

The purpose of this letter is to express the Tri-County Metropolitan Transportation District of Oregon's (TriMet's) interest in collaborating with Portland General Electric (PGE) on transportation electrification. TriMet is excited about the potential of our partnership with PGE and how it may illustrate a brighter future for both PGE and TriMet given the tremendous economic and environmental benefits associated with electrified transit buses.

In July 2016, the Federal Transit Administration (FTA) awarded to TriMet a $3.4 million grant sufficient to cover the costs of procuring four battery-run electric buses and the associated charging infrastructure for TriMet's Zero Emission Bus Project, also referred to as the Electric Mass Transit 2.0 Pilot (the "Pilot Project"). TriMet had applied to FTA for funding sufficient to procure five battery electric buses to expand the potential set of bus routes we could operate solely with electric buses, especially when including a spare vehicle for operational reliability.

If the Commission approves the proposed Pilot Project and PGE's procurement of charging equipment (five depot chargers and one en-route charger), we intend to purchase a fifth battery electric zero emissions bus, with a roughly 250 kWh battery. While PGE would own the chargers, TriMet would bear the cost of their installation and maintenance. TriMet would also pay for all power dispensed from the chargers (at the applicable standard rate).

TriMet has several goals for the Pilot Project, primarily evaluating the opportunity of making electric buses the default choice for bus procurement. If the pilot program determines that such a decision is warranted, the need for close PGE and TriMet collaboration will increase, given the long-term power needs associated with such a decision, and the opportunities for grid management afforded by each bus. Accordingly, we are excited about partnering closely with PGE in the initial deployment so that both organizations can obtain key learnings, and we can grow the share of electric buses most advantageously for our collective customers and stakeholders.

We encourage the Commission to approve the proposed pilot program, and look forward to our continued collaboration with PGE on transportation electrification.

Sincerely,

Neil McFarlane
General Manager

Tri-County Metropolitan Transportation District of Oregon
1800 SW 1st Avenue, Suite 300, Portland, Oregon 97201 • 503-238-RIDE (7433) • TTY 7-1-1 • trimet.org

Appendix 4. Letter of Support from City of Portland

Office of Mayor Ted Wheeler
City of Portland

March 14, 2017

Public Utility Commission of Oregon
201 High Street SE, Suite 100
Salem, OR 97301-1166

Ted Wheeler
Mayor
City of Portland
1221 SW 4th Ave, Ste 340
Portland, OR 97204

Dear Commissioners:

The City of Portland ("City") strongly supports Portland General Electric's ("PGE") proposed transportation electrification pilots.

Last December, the City Council unanimously adopted an Electric Vehicle Strategy in support of the City's Climate Action Plan to reduce carbon emissions by 80% by 2050. Improving access to affordable transportation options is critical to improving economic opportunity, wealth building and upward mobility. PGE's transportation electrification proposals align with our Electric Vehicle Strategy and commitment to create mobility solutions that are equitable, empowering, and clean.

- PGE's proposals to collaborate with TriMet and Transportation Network Companies (TNC) support Portland's transportation hierarchy for people movement: prioritizing shared transportation over private vehicles. By reducing TriMet's first cost to electrify their bus fleet, PGE will enable TriMet to purchase a 5th electric bus and electrify an entire bus route. By engaging TNC drivers, PGE will grow a network of EV ambassadors that will advocate for benefits of electric transit. By collaborating with TNC networks and transit agencies, both of whom play important roles in providing transportation services to underserved communities, PGE's proposal helps to bring electric transportation to a broader audience.

- PGE's Electric Avenue proposal will increase the availability and accessibility of public charging infrastructure. As we've seen in Portland with Electric Avenue, public charging increases awareness of and conversations about electric vehicles. Additional public charging stations will open doors for individuals who otherwise would have nowhere to charge to consider purchasing an EV (e.g. multi-family residents and TNC drivers). Additional, visible public charging infrastructure is greatly needed in Portland, and will help Portland residents adopt electric vehicles and facilitate the City's increasingly electrified fleet as well.

- Finally, changing the perception of electric vehicles from expensive to accessible to all income levels will help bring the benefits of cleaner, lower cost transportation to more households. By offering education and outreach, PGE will raise awareness that there are electric vehicles available on the market likely to meet any car buyer's needs.

We are not just excited about the opportunities that PGE's proposals create but believe that PGE's proposals are necessary for us to reach our Carbon Action Plan goals. We are committed to working with PGE to make their pilots a success.

The City of Portland fully supports PGE's proposed efforts and recommends that the Commission approve them.

Sincerely,

Ted Wheeler

Appendix 5. Letter of Support from Uber

UBER

March 10, 2017

Public Utility Commission of Oregon
201 High Street SE, Suite 100
Salem, OR 97301-1166

Dear Commissioners:

The purpose of this letter is to express Uber Technologies' interest in partnering with Portland General Electric on transportation electrification. Uber is excited about the potential of our partnership with PGE, and how it could provide what we see as essential support for our efforts to have significantly more electric vehicles operating on the Uber network in Oregon.

Uber is a ridesharing app that connects passengers with drivers at the push of a button. This technology has enabled Uber to improve urban mobility and the quality of life for residents of the over 500 cities in which we now operate around the world. By providing people with access to attractive alternatives to driving, Uber is helping to drive a fundamental shift from the prevailing paradigm of private car ownership to one of shared car usage. This future of shared car usage is a future of fewer cars providing more mobility, less empty seats, more efficient and less-polluting vehicles, and more options for managing traffic congestion and safety.

Today, and in the future, it is also a system of mobility that gives millions of people around the world, including tens of thousands of Oregonians, the opportunity to earn extra money transporting riders using their personal vehicles.

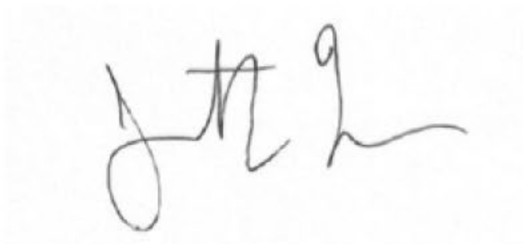
This growing network of over 324,000 active riders and over 6,000 active driver-partners in the Portland metro area also provides Oregon with one of the biggest opportunities to expand electric vehicle ownership and usage in the next few years.

In the Portland metro area we see a steadily growing number of Uber driver partners choosing to drive on the platform with an electric vehicle. Through research, interviews, and focus groups with Uber EV drivers, we have learned that the most significant barrier to increasing the number of Uber driver-partners who choose to go electric is the lack of public electric charging infrastructure, especially fast-charging stations, in the Portland metro area. Drivers report that they are willing to consider driving an electric vehicle, but fear that they will not be able to provide as many trips with only one public charging area in Portland. Current drivers report a persistent fear of losing their charge while transporting a passenger or losing fare-time while charging, and therefore choose to limit the amount of time they spend on the network.

This year Uber will be announcing an initiative to help drivers make the switch to electric vehicles, including making more electric vehicles available to drivers in 2017. We believe our pro-active efforts in support of drivers can enable a significant shift to electric mobility in the next few years. In addition to helping drivers earn more and the environmental benefits, more electric vehicles on the Uber app will give a personal EV experience to hundreds of thousands of riders - most for the very first time. As an illustration, based on our experience piloting EVs in other markets, with just 100 additional electric vehicles operating on the Uber system, tens of thousands of Oregonians could be exposed to electric vehicles within the first year.

The Commission's approval of PGE's planned expansion of public charging stations would be essential to increasing the scale of Uber Electric. Without access to an increased number of geographically dispersed public charging stations, we will be limited in the number of electric vehicles the Portland Uber network could sustain. If more public charging stations are installed in the next few years, Uber Electric can scale with this expansion.

Sincerely,



Jon Isaacs
Oregon Public Affairs Manager

Appendix 6. Electric Company Role

In the passing of Chapter 28, Oregon Laws 2016, the state legislature acknowledges that there is a role for the electric company to play in accelerating transportation electrification to reduce carbon impacts of the transportation industry and to aid in efficiently integrating renewables into PGE's grid.

The potential grid impacts (both positive and negative) of electrified transportation on the grid – and the importance of keeping prices affordable – require us to take a hard look at what is an appropriate role for the electric company in promoting and efficiently integrating electrified transit onto the grid. As NRDC states:

> *Electric utilities are uniquely positioned to facilitate the creation of this network because they can make use of spare grid capacity to charge EVs, generating significant new revenues. In turn, the growing customer investment in EVs with large, advanced batteries can be leveraged to bring more renewable energy into the system.*[87]
>
> *"Utilities have to be the ones because it will take a longer time and cost more than a private company will give it," said Greenlots CEO Brett Hauser. "Utilities can rate base the charging infrastructure upgrades and consider what is best for the community. Private sector financial concerns will focus the infrastructure on narrower, more affluent markets."*[88]

At its core, PGE provides its customers with safe, clean, affordable, reliable service; this is achieved through effective customer engagement, strategic asset management and maintenance, and modernization of our grid. We believe today there is a natural opportunity for us to pilot programs in the transportation electrification space, providing us with a foundation to leverage the learnings from these pilots to continue to provide our core service into the future.

Outreach and Education

As indicated in Section 3, we recognize that there are many barriers to EV adoption in our service area that we can serve break down:

- Lack of awareness and credible information
- Concerns about adequate charging infrastructure and range anxiety
- Reliable and accessible charging infrastructure

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[87] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).

[88] http://www.utilitydive.com/news/california-regulators-approve-sce-pilot-to-build-1500-ev-charging-stations/412240/

As the trusted energy partner of our customers, we provide outreach and education on many energy-related topics: energy efficiency, electrical safety, smart energy usage, demand response, clean energy, etc. Our customers look to us for answers, and we can aid them by providing reliable information to help inform their car buying and charging decisions.

Financing a Reliable and Accessible Network

Today there are 915 gasoline fueling stations in Oregon. Most of those stations include multiple pumps, have very high up-time, and are located on visible thoroughfares. Gasoline companies have large financial backing, and because up-front investment costs are relatively low – and internal combustion engine cars are many -- there are relatively small barriers to entry for a new service provider. Because gas stations are ubiquitous, a customer shopping for a car does not have to think about where they might fuel their new gas-powered car. Internal combustion car drivers can get behind the wheel of their car with little hesitation that they will be able to find a gas station in a few miles; nearly all know where the nearest gas station is.[89]

Conversely, today there are 105 fast electric fueling stations in Oregon. Most of those stations include a single port, are limited to select vehicles, and are hard to find. Many are occupied or are out of service. Because technology is relatively new, up-front installation costs are high, and because there are few electric vehicles on the road, the barriers and risks to installing charging infrastructure are high. Most customers don't consider electric vehicles when shopping for a car and those who do can frequently be discouraged by the lack or confusing nature of charging infrastructure.[90]

Though the electric vehicle industry today does not come near the size of the internal combustion vehicle industry, the role for an electric company in public charging infrastructure is clear: increase accessibility to and the reliability of public charging infrastructure.

> *Utility-scale investment is also needed to facilitate the expansion of the nascent competitive EV charging service industry.*[91]

Because a well-designed network can increase awareness, adoption, and utilization of electric vehicles, it can create a net benefit for all customers of an electric utility.[92] In one light, not installing such infrastructure could be considered a net opportunity cost for all PGE customers. A public charging network creates a net benefit for all PGE customers by promoting EV adoption and thereby increasing off-peak electricity sales, distributing PGE's fixed costs across more kWh,

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[89] https://oregoneconomicanalysis.com/2012/02/13/self-service-gas-and-taxes/
[90] Hajjar, Norman, New Survey Data: BEV Drivers and the Desire for DC Fast Charging, Plug Insights, March 11, 2014
[91] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).
[92] Chris Nelder, James Newcomb, and Garrett Fitzgerald, Electric Vehicles as Distributed Energy Resources (Rocky Mountain Institute, 2016), http://www.rmi.org/pdf_evs_as_DERs.

and putting overall downward pressure on rates. Public charging increases vehicle adoption and EV vehicle miles travelled through a variety of channels:

- As discussed in Section 3, increased visibility of electricity as a transportation fuel increases awareness, consideration, and adoption of electric vehicles.

- Accessible public quick charging gives multi-family dwellers (or customers who otherwise do not have off-street parking) a place where they could charge an EV. This opens up the EV market to many new potential buyers and can increase EV acquisition.

  This means serving the "garageless" who cannot buy a plug-in electric vehicle because they are not able to plug it in at home, and growing the market in low-income communities that are historically exposed to dangerous air pollution and also the most vulnerable to volatile gas prices.[93]

- Accessible public quick charging is the primary consideration for car share companies (i.e. Reach Now) considering how many electric vehicles to site in a City or region.[94] By creating more public places for these companies (who often do not own dedicated parking infrastructure) to charge electric vehicles, we will encourage higher EV acquisition.

- Accessible public quick charging empowers EV drivers to drive for transportation network companies (TNC) and empowers TNC drivers to choose electric vehicles. Without reliably accessible quick charging infrastructures, there is no opportunity for a TNC driver to make a living in an electric vehicle. As we see TNC drivers regularly utilizing Electric Avenue 2.0 in Portland, we believe the emergence of an Electric Avenue network will encourage adoption by TNC drivers. A key benefit of engaging TNCs is that peak driving periods tend to be in the late hours of the evening, on weekends, and over holidays (all typical off peak periods for PGE). TNC drivers who choose electric will be able to drive during peak TNC hours and quickly charge during PGE's off peak-hours between their rides.

Automakers, charging manufacturers and service providers as well as municipalities all could fill this space today, however, aside from Tesla, none have been willing to risk the high cost of deploying such a network with an uncertain reward. Indeed, as a straight-up business proposition, PGE's own analysis demonstrates that public charging infrastructure development costs outweigh charging revenues. Unlike all other investors, however, PGE is incentivized by the net benefit electric vehicles have on all of our customers, and has been mandated by the State

[93] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).
[94] Customer interview. July 6, 2016. Conducted by Milano.

to propose programs to accelerate transportation electrification and help unlock the "chicken and egg" challenge associated with electric vehicles and public charging infrastructure.

Learning, Planning, and Future Grid Services

EV charging and associated grid impacts will continue to grow over time. Today, we must begin to test and understand the load implications of charging, effectiveness of demand response and pricing approaches, synergies with energy storage, 2-way energy flows, and charger siting impacts. By getting involved now, PGE will better position its customers and grid to ensure high reliability and realize maximum customer value of electric vehicles when they are not in use:

The existing electricity infrastructure as a national resource has sufficient available capacity [off-peak energy] to fuel 84% of the nation's cars, pickup trucks, and SUVs (198 million) or 73% of the light duty fleet (about 217 million vehicles) for a daily drive of 33 miles on average.[95]

Charging EVs during hours when the grid is underutilized increases utility revenues without commensurate increases in costs, putting downward pressure on electricity rates.[96]

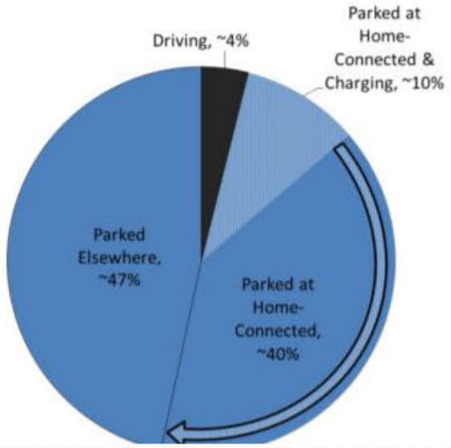

Figure 17: The time PEVs need to charge to meet mobility needs may be shifted throughout the time they are connected at home to accommodate grid operations (CPUC)

In 2013, the California Public Utilities Commission published a study on vehicle-grid integration. In that study, the CPUC determined that EVs are parked at home, connected, but not charging approximately 40% of the time; additionally they are parked elsewhere 47% of the time.[97] By developing pilots and demonstration projects, we feel there are opportunities to learn how to utilize these grid assets to provide future grid ancillary services and support for renewables integration. NRDC also highlights a variety of potential future value streams that we can begin to demonstrate and test today:

[95] Kintner-Meyer, M., K. Schneider, and R. Pratt, Impacts Assessment of Plug-in Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids, Pacific Northwest National Laboratory, November 2007, energyenvironment.pnnl.gov/ei/pdf/PHEV_Feasibility_Analysis_Part1.pdf.

[96] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).

[97] Adam Langton and Noel Crisotomo, Vehicle-Grid Integration, California Public Utilities Commission, October 2013., www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7744.

Table 21: Grid Services that Electric Vehicles Could Potentially Provide, By Grid Segment (modified from NRDC)[98]

Electric Vehicle Function	Potential Grid Service, by Grid Segment	
	Transmission	Distribution
Traditional Demand Response: Powering charging down or off	Day-ahead resource, spinning reserve	Grid upgrade deferral, demand charge mitigation
Advanced Demand Response: Powering charging down, off, on, or up	Day-ahead resource, spinning reserve, frequency regulation, one-way energy storage	Grid upgrade deferral, demand charge mitigation, energy arbitrage
Vehicle-to-Grid (V2G): Discharging energy stored in EVs back to the grid	Day-ahead resource, spinning reserve, frequency regulation, two-way energy storage	Grid upgrade deferral, power quality, demand charge mitigation, energy arbitrage
Battery Second Life: Deploying used EV batteries as stationary energy storage	Day-ahead resource, spinning reserve, frequency regulation, two-way energy storage	Grid upgrade deferral, power quality, demand charge mitigation, energy arbitrage

We believe there will be a future opportunity to provide pricing signals to customers to extract energy from vehicle batteries to support the grid. These functions do not exist at a scale (or exist at all) today to enable significant value-add to our grid. There are fewer than 10,000 vehicles in our service area today, which, given their irregular load shapes, do not make an adequate demand response resource. V2G applications are in the early demonstration phase, and any active demonstration of V2G capability immediately voids the warranty on a car's battery. However, as the electric vehicle market evolves, PGE needs to be involved at the early stages to best understand how and when these resources can be used. It is critical that we gain a strong understanding of how and when our customers choose to charge and begin developing tools that encourage charging habits that benefit all of our customers.

[98] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).

Roles for Other Stakeholders

As indicated above, we do not intend to dominate the EV or EV charging marketplaces. We believe there are many valuable players needed to create a vibrant and prosperous market, and we see our legislative mandate to help accelerate adoption and to ensure that our system is adequately prepared to realize value for all customers. The prospective grid impacts have consequences with the electric company first—it is paramount to the successful and effective growth of the EV market that we be involved in the early stages in understanding charging behaviors, distribution siting considerations, ancillary benefits, cost-effectiveness, and customer impacts of electric vehicle technologies.

In a new industry with a lot of uncertainty, it is important to create a guide for what roles various stakeholders play. We believe there are short-term needs for the electric company to be involved in outreach and education to raise awareness and guide customer charging behavior, public charging infrastructure to create a reliable and accessible public charging network, and research pilots to test the benefits of smart charging and V2G. There are important roles, however, that other stakeholders will also play.

- Charging manufacturers should continue to take a leadership role in proactively selling home and work place charging, installing public charging infrastructure, and developing standards and technologies for heavy duty charging, off road vehicles, and ancillary grid services.
- Vehicle manufacturers should continue to educate their customers and dealerships about the benefits of electric vehicles. Additionally, vehicle manufacturers should continue to develop technologies, standards, and specifications that allow for the batteries in their vehicles to be used as grid asset (i.e. V2G) without impact on customer warranties.
- Government bodies should take the lead on public education campaigns, creating incentives (cashback, tax rebates, free parking, etc.) to help accelerate adoption, and developing standards and codes that ensure deployments are safe, efficient, and effective.
- Non-Governmental Organizations will vary based on their charters, however, we see opportunity for organizations to provide outreach, education, and/or technical assistance to communities they serve. Additionally, where applicable, these groups should work to develop standards and best practices to accelerate industry adoption.
- Customers can and should continue to install chargers at their homes or business to meet their needs. We will work with them to ensure they have the necessary resources and service levels for successful installations.

Conclusions

In summary, there is a clear need for PGE's involvement in transportation electrification. Given the unique benefits transportation electrification creates for all of our customers, PGE has a singular opportunity to propel this market forward in our service area. Our relationship and experience with our customers make us a clear and cost effective leader in increasing awareness of electricity as a fuel source. Because public charging infrastructure is limited and often inadequate where it does exist, PGE can spur the market and create a visible public network that is accessible for all customers. It is also crucial that we start early in the market so that PGE can be actively involved in charging, pricing, and demand response pilots, and influence the behavior of electric vehicle charging before we are forced to react to its potential adverse impacts. We believe our proposed plans outlined in Section 3 fairly and effectively "accelerate transportation electrification" as outlined by law.[99]

[99] Chapter 28, Oregon Laws 2016. https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2016orLaw0028.pdf

Appendix 7. Cost Effectiveness Analysis (Navigant Whitepaper)

NAVIGANT

Cost Effectiveness Analysis of Transportation Electrification Program Options

Presented to:

Portland General Electric

Portland General Electric

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December 19, 2016

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Table of Contents

Executive Summary

PGE seeks to compare program options to determine which programs will cost-effectively support the transportation electrification market and to understand the cost effectiveness of a transportation electrification portfolio as a whole. The goal of this study was to develop a framework to continuously evaluate and improve PGE's transportation electrification support efforts, then apply that framework to PGE's proposed portfolio to provide initial indications about cost effectiveness.

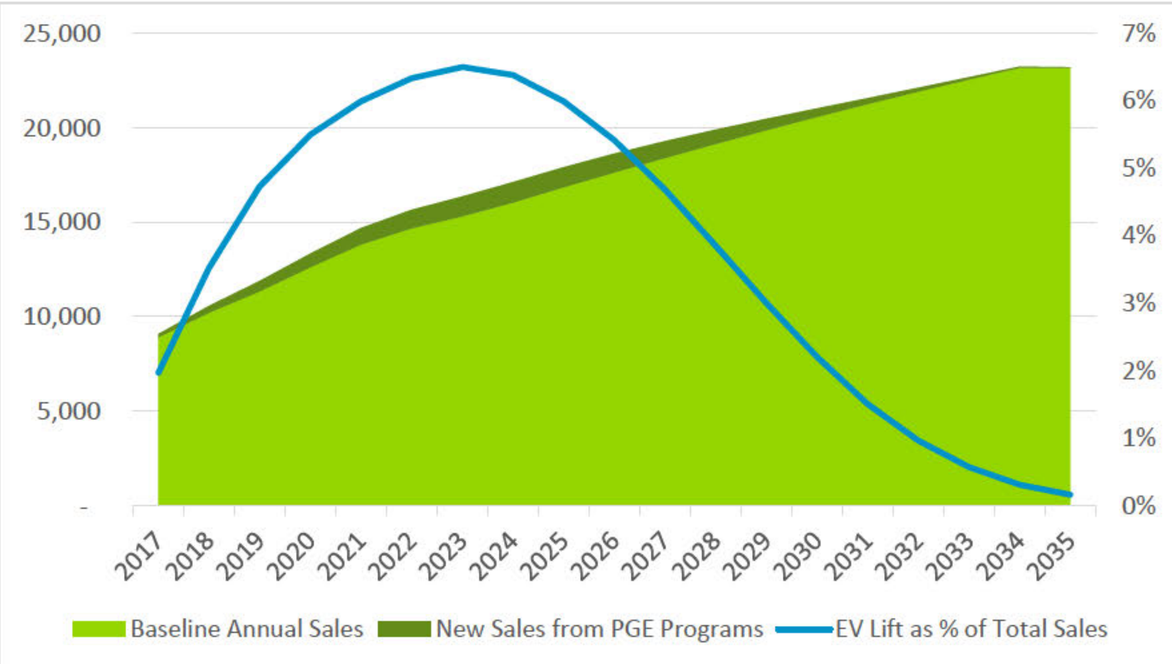
Through the course of this study, Navigant developed a cost effectiveness framework for transportation electrification support efforts that builds on the methodologies employed in other jurisdictions, including California and Seattle, and is consistent with the framework that PGE set forth for demand response cost effectiveness.[1] The framework sought to answer two questions:

- What is the baseline electric vehicle market and PGE's influence on the market (i.e., electric vehicle "lift")?
- What are the costs and benefits for each program and the portfolio of transportation electrification programs as a whole?

The analysis considered these questions for PGE's Electric Mass Transit 2.0, Outreach & Education, and Community Charging Infrastructure programs, as well as PGE's transportation electrification portfolio as a whole. To do this, Navigant developed a baseline forecast of electric vehicles within PGE's service area, then forecasted the estimates of each program's influence on the market, and finally monetized the value streams identified for each program.

Navigant found that the electric vehicle lift caused by PGE programs represents an average increase of roughly five percent new vehicle sales in the total cumulative electric vehicle sales forecast. Annual forecast electric vehicle sales and electric vehicle lift are shown in Figure 1.

As Figure 1: Annual Baseline and New Sales in PGE Territory

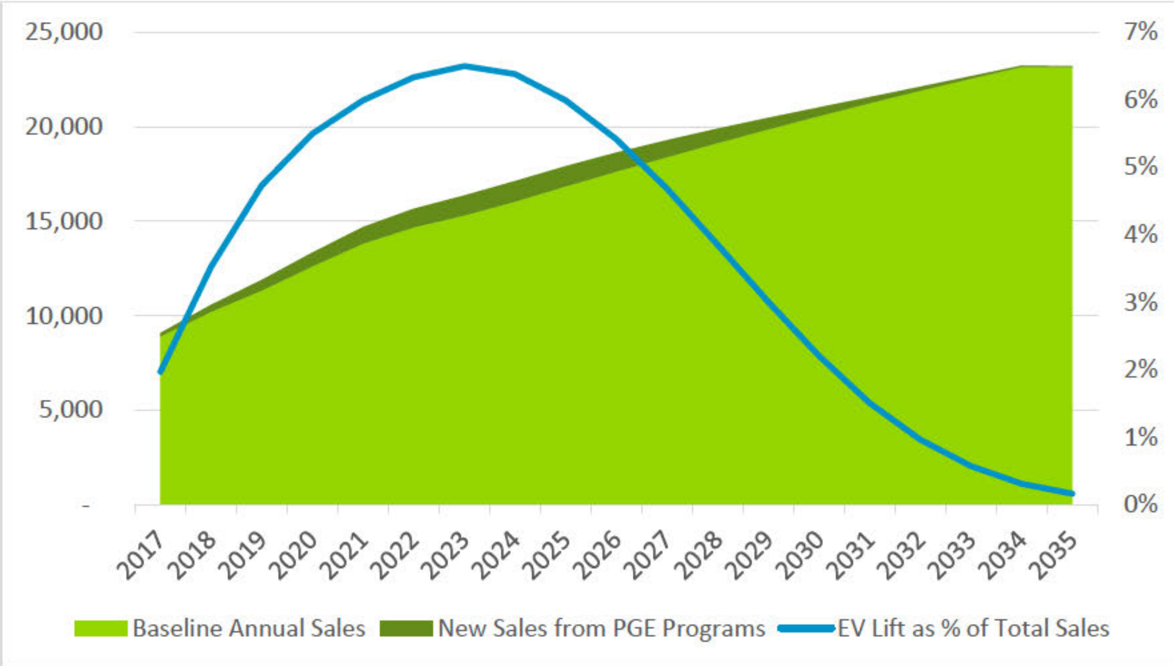


Source: Navigant analysis, 2016

[1] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf.

shows, PGE's Light Duty Vehicle programs are expected to be cost effective. When combined with the Electric Mass Transit 2.0 program, PGE's transportation electrification market support efforts are cost effective at the portfolio level.

Figure 1: Annual Baseline and New Sales in PGE Territory



Source: Navigant analysis, 2016

Table 1: Summary of Net Benefits by Program and Cost Effectiveness Test

	Rate Impact Measure Test	Total Resource Cost Test	Societal Cost Test
Net Benefits By Program (2017 $)			
DCQC Stations	$4,044,163	$2,297,870	$3,739,595
Education and Awareness	$2,089,176	$3,465,122	$4,234,224
Electric Mass Transit 2.0	$(1,037,395)	$(1,059,005)	$(1,332,532)
Overall Portfolio	**$5,095,945**	**$4,703,987**	**$6,641,287**
Net Benefits Per Vehicle (2017 $)			
DCQC Stations	$994	$592	$946
Education and Awareness	$734	$1,182	$1,452

Electric Mass Transit 2.0	$(1,037,395)	$(1,059,005)	$(1,332,532)

Source: Navigant analysis, 2016

Section I Introduction and Background

PGE seeks to compare program options to determine which programs will cost-effectively support the transportation electrification market and to understand the cost effectiveness of a transportation electrification portfolio as a whole. The goal of this study was to develop a framework to continuously evaluate and improve PGE's transportation electrification support efforts, then apply that framework to PGE's proposed portfolio to provide initial indications about cost effectiveness.

The framework is based on past studies and research:

- Studies in other jurisdictions (California and Seattle) quantify net benefits of electric vehicles on a per vehicle basis.
- Independent researchers develop electric vehicle sales forecasts based on market factors.
- State and local policymakers set electric vehicle sales goals.
- This framework is consistent with and builds upon the framework that PGE set forth for demand response cost effectiveness.[2]

The framework will allow PGE to:

- Determine net benefits on a per electric vehicle basis using different cost tests typically used for utility resource planning.
- Track transportation electrification market progress over time.
- Begin to attribute market progress to transportation electrification support efforts offered by PGE's portfolio of programs.

The scope of the analysis discussed in this report focused on the following program options:

- Outreach & Education
- Community Charging Infrastructure
- Electric Mass Transit 2.0

PGE is also currently conducting R&D pilots for transportation electrification; however, this analysis does not include R&D, given the focus is on longer-term learning, rather than direct market impacts, and does not lend itself to the same type of cost effectiveness analysis.

The remainder of this report includes the following sections:

- Section II outlines the cost effectiveness methodology employed for this analysis. This includes a description of the electric vehicle market forecast methodology, forecast estimates of PGE's influence on the market, and all monetized value streams in the analysis.
- Section III summarizes the results of the analysis by cost test and in terms of the additional electric vehicles sold as a result of PGE's programs.
- Section IV concludes findings from the analysis and provides a directive for further research required to more accurately assess the cost effectiveness of the PGE's transportation electrification programs going forward.

Section II Methodology

[2] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf. See also EPRI http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=3002007751.

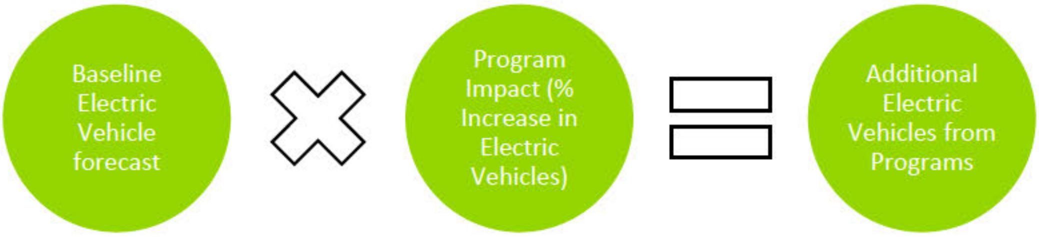
This section presents a high-level overview of the methodology, with more detailed information provided on the methodology for developing the baseline electric vehicle forecast and the transportation electrification program impacts.

Appendix B provides more detail on the overall methodology.

2.1 Overview of Methodology

The analysis was structured in two steps outlined below.

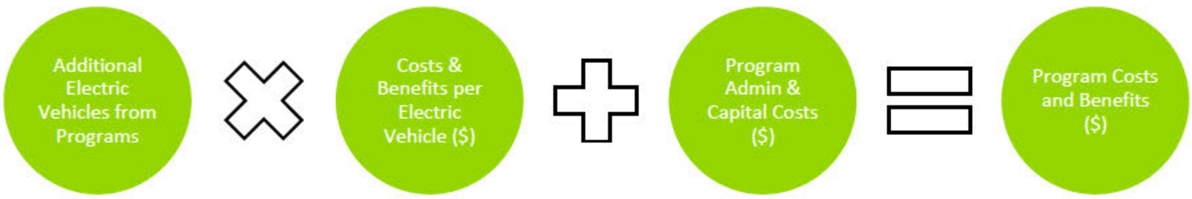
Step 1: What is the baseline electric vehicle market and PGE's influence on the market?



Source: Navigant analysis, 2016

Step 1 quantifies the additional electric vehicle sales attributed to PGE's programs, also known as "electric vehicle lift". The basis of this analysis is a baseline electric vehicle forecast by zip code in PGE's service area created by Navigant Research, as described in more detail in Section 2.2. The team defined the program impact using customized Weibull distributions to simulate market diffusion of electric vehicles based on the rationale for each program, as described in more detail in Section 2.3.

Step 2: What are the costs and benefits for each program?



Source: Navigant analysis, 2016

Step 2 quantifies the additional value streams (in terms of both costs and benefits) from each additional electric vehicle in the market. From there, addition of the overall program administrative and capital costs yields the total costs and benefits for each program.

As part of Step 2, Navigant assessed fourteen cost and benefit streams for transportation electrification cost effectiveness. Table 1 summarizes the cost and benefit streams quantified in this analysis by cost test.

This framework for transportation electrification cost effectiveness builds on the framework Navigant developed in coordination with PGE for demand response cost effectiveness,[3] with adjustments for costs and benefits specific to transportation electrification. The framework is consistent with the methods proposed in the California Public Utilities Commission's *2010 Demand Response Cost Effectiveness Protocols* and similar to the framework used in other jurisdictions, such as Seattle City Light and the Electric Power Research Institute.[4] Appendix A provides more information on each of the cost and benefit streams, including the definition, calculation description, and monetization unit.

[3] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf
[4] Seattle City Light Transportation Electrification: Technical Impacts, Market Research, Program Design. 2015. See also EPRI http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=3002007751

Given the nascent and uncertain future of the impact of utility programs on electric vehicle adoption, the inputs and assumptions used within this analysis should be regarded as early indicators of market trends, with a high degree of uncertainty. Over time, Navigant expects that the uncertainty bands will narrow as the industry collects more robust data through retrospective evaluation, bringing the impact of programs on electric vehicle adoption into focus.

Table 2 below summarizes the cost effectiveness tests and value streams used in the transportation electrification analysis. Note that the Pre-Existing Program benefits and costs refer to PGE revenues and costs from the existing Electric Avenue, Blink, and Powin charging stations respectively.

Table 2. Summary of Cost-Effectiveness Tests and Proposed Value Streams for Transportation Electrification Programs[5]

Cost/Benefit Category	Total Resource Cost Test	Rate Impact Measure Test	Societal Cost Test
Avoided Gasoline Costs	Benefit		Benefit
Increased Capacity Costs	Cost	Cost	Cost
Reduced Fuel Emissions			Benefit
Increased Energy Emissions			Cost
Increased Electricity Sales		Benefit	
Increased Energy Supply Costs	Cost	Cost	Cost
Customer Tax Credits – Federal	Benefit		Benefit
Customer Tax Credits – State	Benefit		
Customer O&M Savings	Benefit		Benefit
Utility Tax Credits – Federal	Benefit	Benefit	Benefit
Utility Tax Credits – State	Benefit	Benefit	
Pre-Existing Program Benefits	Benefit		
Pre-Existing Program Costs	Cost		
Utility Capital Costs	Cost	Cost	Cost
Utility O&M Costs	Cost	Cost	Cost
Utility Admin Costs	Cost	Cost	Cost
Customer Charger Costs	Cost		Cost
Customer Vehicle Costs	Cost		Cost
O&M Payments from TriMet		Benefit	
Federal Bus Electric Vehicle Grant	Benefit		Benefit

[5] Cost and benefit designations for each stream are based on Navigant analysis and California Public Utilities Commission, Attachment 1: *2010 Demand Response Cost Effectiveness Protocols*

Source: Navigant analysis, 2016

Several potential benefits and costs of transportation electrification were excluded from the analysis, due to the uncertainty associated with quantifying and monetizing the benefit. These include:

- The value of Low Carbon Fuel Standard[6] credits that PGE may earn as a result of the programs.
- The value of ancillary services and/or power quality services that transportation electrification may provide to PGE's distribution grid.
- Non-energy and non-emission-related benefits from transportation electrification, including enhanced public image for PGE and the City of Portland, customer satisfaction, noise pollution, etc.
- Additional potential costs of transmission and distribution

2.2 Baseline Electric Vehicle Forecast

Navigant Research uses a technology competition model to forecast electric vehicle sales at the national level. The forecast model uses high-level macroeconomic factors like gross domestic product and population as well as vehicle density and historic sales data to project overall light vehicle market growth. Sales forecasts per technology segment analyzed are determined by estimating the market share of the technology against competing platforms as a function of a number of variables that feed into the consumer choice such as: purchase and operating costs, vehicle range, refueling/recharging infrastructure and other factors influencing electric vehicle capability and convenience.

Results from the national sales model for PHEVs and BEVs are then fed into a model that disaggregates the forecasts by state. State PEV sales are disaggregated based on state and local purchase incentives, mandates, retail fuel prices, demographics, and historic sales data.

Results from the state-level disaggregation are fed into a model that further disaggregates the forecasts by county. This county-level disaggregation is based on consumer demographics, estimated county vehicle market size as a function of population density, sales history, and data derived from Navigant Research's *Electric Vehicle Consumer Survey*.

The Electric Vehicle Consumer Survey is used to determine the demographic distribution profile of the ideal PEV market. This PEV profile is used to compare demographic distributions among geographic jurisdictions in terms of potential interest in PEVs. The demographic characteristics analyzed include age, household income, and education. The PEV profile in 2016 is skewed toward younger, wealthier, and more educated population segments.

Navigant Research's underlying data on electric vehicle sales is updated depending on the level of its geographic granularity and availability. National level sales data is tracked monthly and is widely available publically; state level sales data is less available publically with the nearest tracking reports typically lagging the market by four to five months; lesser geographic segmentations are typically not available publically, however state DMV's do sometimes provide vehicle sales and registration data on request. Navigant Research does however collect county level vehicle registration data from a vendor on an annual basis. Figure 2 shows the plug-in electric vehicle sales in the region from 2011 through 2015.

[6] See SB 324 https://olis.leg.state.or.us/liz/2015R1/Measures/Overview/SB324

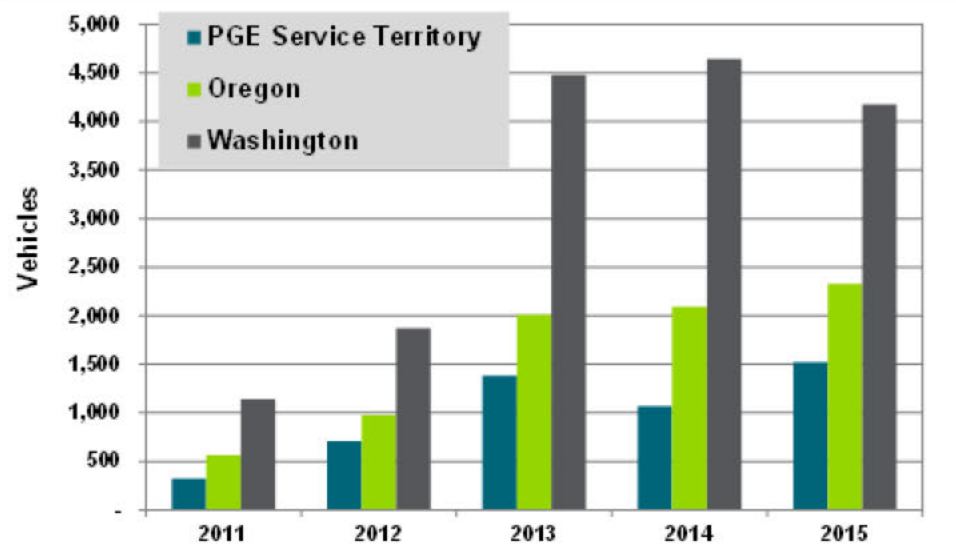


Figure 2: PEV Sales in Oregon, Washington, and PGE Service Territory 2011-2015

Source: Navigant Research analysis, 2016

2.3 Transportation Electrification Program Impact

As electric vehicles are a relatively new product, and utility electric vehicle programs have little history, estimates of PGE's impact on the local electric vehicle market are heavily assumption laden. The quickly evolving technologies and business models of the electric vehicle and infrastructure market continue to make empirical analysis of specific market development efforts difficult and few studies exist isolating the impact infrastructure or consumer education have on the electric vehicle market. Regardless of this aspect, it is clear, that investments in charging infrastructure and consumer education are highly likely to positively influence the market.

Navigant Research's *Electric Vehicle Consumer Survey* indicates a lack of charging infrastructure and familiarity with electric vehicles as primary disadvantages to electric vehicle ownership among respondents[7]. In order to capture the impact of PGE's program, the team first assessed what the impact of each program may be using what little data is available on traditional OEM consumer education spending estimates per vehicle sale and the historic growth of infrastructure relative to the electric vehicle market in the PGE service area. These impacts were then distributed over the forecast period under the assumption that impacts would vary over time based on the maturation of both the infrastructure and vehicle technologies and markets.

2.3.1 Education and Awareness Program

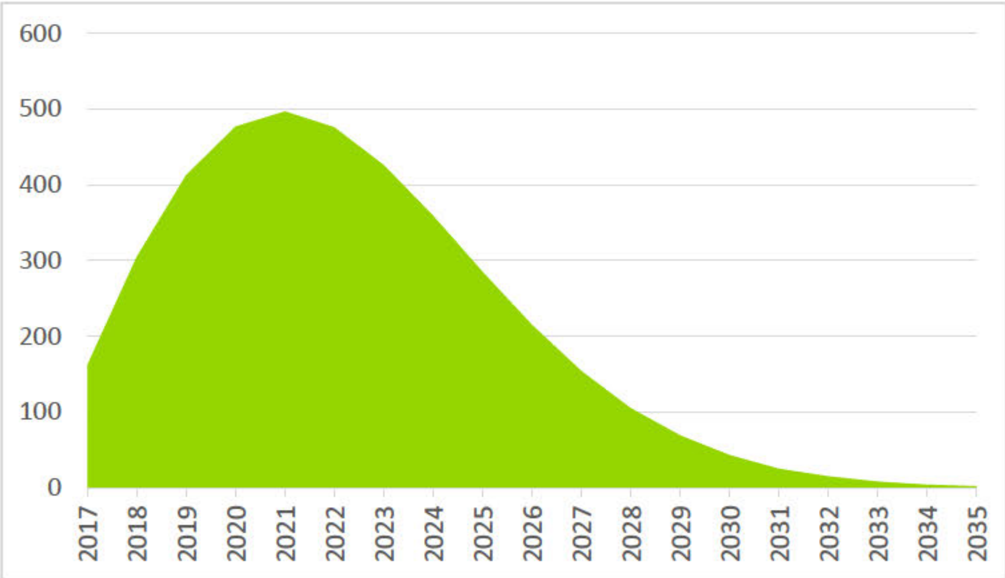
Surveys of PGE customers show that[8] awareness of plug-in electric vehicles is low and uncertainty regarding operation, reliability, costs, and charging is high relative to the conventional vehicle options.

[7] 26 percent of respondents identified a lack of places to charge as the primary disadvantage to PEV ownership, 18 percent cited cost, 17 percent cited range; the remainder cited other concerns including battery reliability and technology unfamiliarity among others.
[8] 2014 PGE Customer Survey

This is consistent with customer survey results throughout the United States[9] Given that, we assume:

- An education/marketing program's direct impact on the electric vehicle market would have the largest impacts early in the forecast period when the average consumer is less aware/educated on the technology.
- As the technology matures the average consumer will become more educated through other avenues and the impact of the "utility" electric vehicle program will diminish over time.
- The program's impacts will improve over the first years of the forecast period as administrators identify and replicate best practices.

Table 3. New



Electric Vehicles from Education and Awareness Program

shows the distribution of the electric vehicle market lift on behalf of the education and awareness program.

Table 3. New Electric Vehicles from Education and Awareness Program

Source: Navigant analysis, 2016

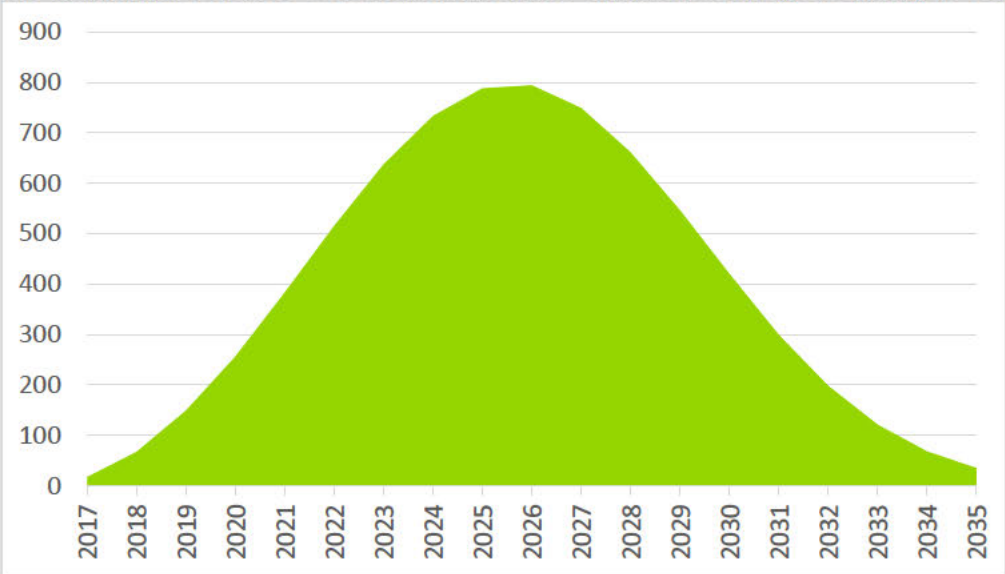
2.3.2 Community Charging Infrastructure Program

Though range anxiety and a lack of charging infrastructure are often cited as the primary drawbacks to purchasing a PEV,[10] there is uncertainty in the industry regarding which technical infrastructure

[9] Navigant Research, Electric Vehicle Geographic Forecast Report, 2016
[10] Navigant Research, Electric Vehicle Geographic Forecast Report, 2016

solution[11] is the most impactful in resolving the range/infrastructure nexus. Regardless, all technical solutions are likely to mature and lead to greater consumer understanding of how an electric vehicle may replace their existing conventional vehicle. Additionally, the existence of visible charging infrastructure creates more awareness of Electric Vehicles as a potential transportation choice. Given that, we assume:

- The PGE DCQC network would be established early in the forecast period,
- The initial impact of the DCQC network would be small but would grow quickly as consumers'



  awareness of the network grows. The vehicle purchase cycle is a long (5-10 years) so the impacts of the programs are delayed accordingly. Though these programs are expected to increase Electric Vehicle adoption, they will not change the car purchasing process overnight.
- Growing availability of 200 mile+ BEVs[12] would also increase the impact the DCQC network would have on the market in the near term, and
- New electric vehicle Charging Services (Multiple Unit Dwellings, Workplace) will develop over time and new technologies (wireless charging, faster DCQC)[13] will be introduced that will diminish the impact of the DCQC network on the electric vehicle market in the latter portion of the forecast.

Error! Reference source not found. shows the distribution of electric vehicle lift from the community charging infrastructure program.

Table 4. New Electric Vehicles from Community Charging (DCQC Stations) Program

Source: Navigant analysis, 2016

2.3.4 Electric Mass Transit 2.0 Program

Through this analysis, PGE also sought to explore the cost effectiveness of a unique charger lease

[11] Potential solutions include: denser public charging, faster public charging, increased availability of MUD or 'end of commute' charging infrastructure
[12]Navigant Research, Electric Vehicle Market Forecast Report, 2015
[13]Navigant Research, Electric Vehicle Charging Services, 2016

program established with TriMet, Portland's public transit entity.

TriMet received a federal grant to pursue electrification of a portion of the bus fleet in Portland. The grant was sufficient enough for TriMet alone to purchase four electric buses and the associated charging infrastructure. TriMet later discovered that, through a partnership with PGE under PGE's Electric Mass Transit 2.0 program, PGE could construct and own the charging infrastructure and TriMet would pay PGE for O&M to utilize the chargers to power their fleet. This would allow TriMet to use operating budget for the charging infrastructure, and utilize the federal grant to purchase an additional bus, for a total of five buses.

For the purposes of this cost benefit analysis, the team assumed the following:

- The known impact of the program is a single bus. Though this program could result in incremental electric vehicle lift at a later date, no additional lift beyond the known impact was forecast for this analysis.
- All chargers and associated installation costs are considered utility capital costs.
- Lease payments to PGE from TriMet are considered a benefit in the RIM, but a transfer in the TRC and SCT.
- The federal grant per bus ($430,000) to TriMet is included as a benefit in the Total Resource Cost test, but as a transfer in the Societal Cost Test.
- The utility tax credit value stream includes the Oregon Alternative Fuels Infrastructure Tax Credit[14], assumed to expire in 2020.

Table 5 summarizes the cost and benefit streams quantified in this analysis by cost test.

Table 5. Summary of Cost-Effectiveness Tests and Proposed Value Streams for Electric Mass Transit 2.0 Program

[14] http://www.afdc.energy.gov/fuels/laws/NG/OR

Cost/Benefit Category	Total Resource Cost Test	Rate Impact Measure Test	Societal Cost Test
Avoided Gasoline Costs	Benefit		Benefit
Increased Capacity Costs	Cost	Cost	Cost
Reduced Fuel Emissions			Benefit
Increased Energy Emissions			Cost
Increased Electricity Sales		Benefit	
Increased Energy Supply Costs	Cost	Cost	Cost
Customer O&M Savings	Benefit		Benefit
Utility Tax Credits - State	Benefit	Benefit	
Utility Capital Costs	Cost	Cost	Cost
Utility O&M Costs	Cost	Cost	Cost
Customer Vehicle Costs	Cost		Cost
O&M Payments from TriMet		Benefit	
Federal Bus Electric Vehicle Grant	Benefit		Benefit

Source: Navigant analysis, 2016

Section III Results

This section presents the market impacts from PGE's transportation electrification programs, as well as the costs and benefits of the transportation electrification portfolio from different cost test perspectives.

Navigant developed costs and benefits using both a flat rate structure and a residential time-of-use rate structure[15]. While the time-of-use structure provided greater net benefits, the difference between the two scenarios is slight due to the following factors:

- Electric vehicle charging times are somewhat flexible and shift away from peak times under the time-of-use rate.
- The off-peak rate is approximately 70 percent of the flat rate, meaning that relative to the flat rate structure, revenue gains from charging during peak times are largely offset by the majority of charging occurring during off-peak times under the time-of-use rate.
- A portion of Electric Vehicle charging occurs at the workplace, which is subject to commercial

[15] The flat structure is residential Schedule 7 Standard Service option, the time-of-use rate is the Schedule 7 TOU Portfolio option. https://www.portlandgeneral.com/our-company/regulatory-documents/tariff

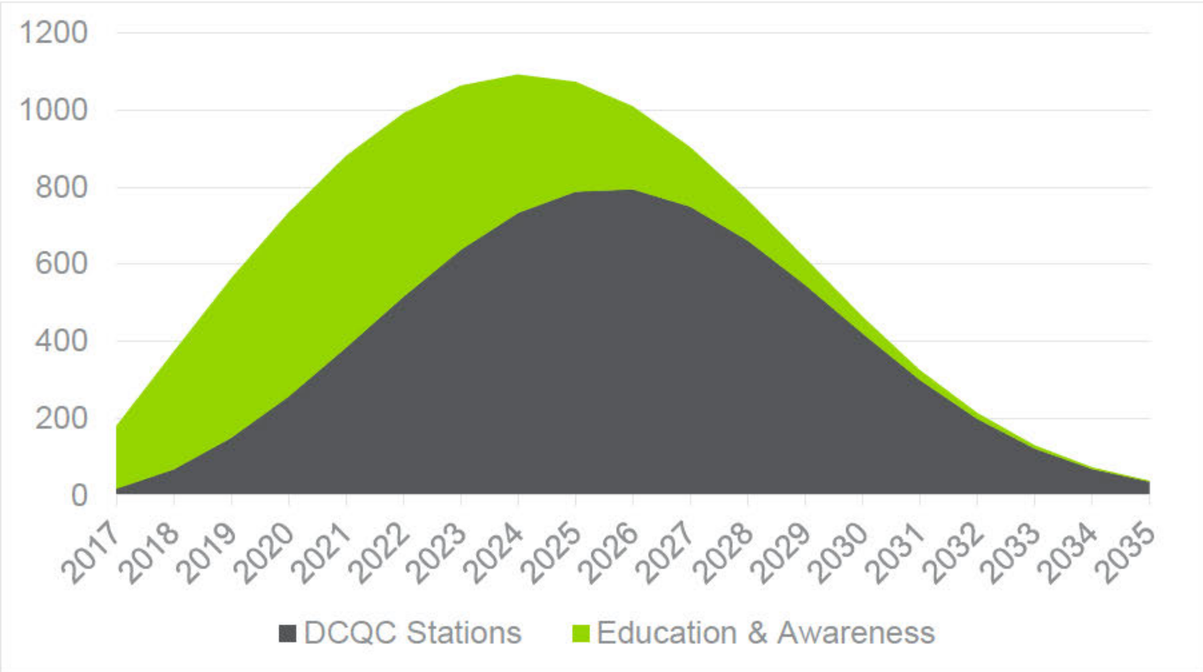
rates.

This report conservatively presents results using the flat rate scenario only.

3.1 Electric Vehicle Market Impacts

The cost effectiveness analysis looked at additional electric vehicles sold (i.e., "electric vehicle lift") as the unit basis for program-level costs and benefits.

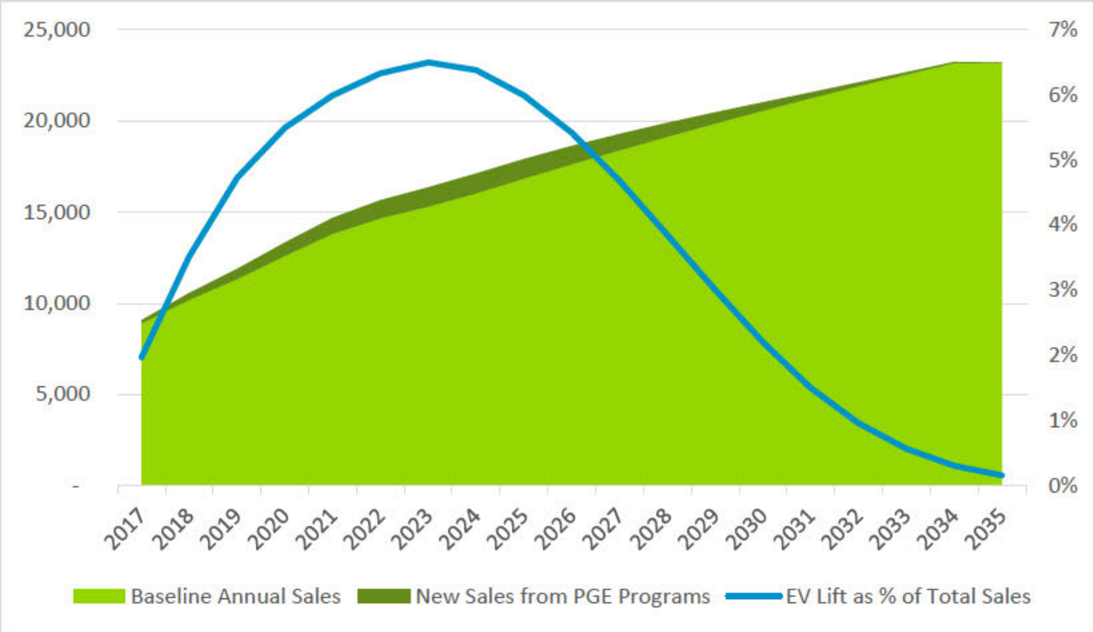
Table 6. New Electric Vehicles by Program



Source: Navigant analysis, 2016.

The electric vehicle lift caused by PGE programs represents an average increase of roughly five percent new vehicle sales in the total cumulative electric vehicle sales forecast.

Table 7. Cumulative Electric Vehicles in PGE Territory



Source: Navigant analysis, 2016

The electric vehicle lift caused by PGE programs represents 3.4 percent of total annual sales during the analysis period.

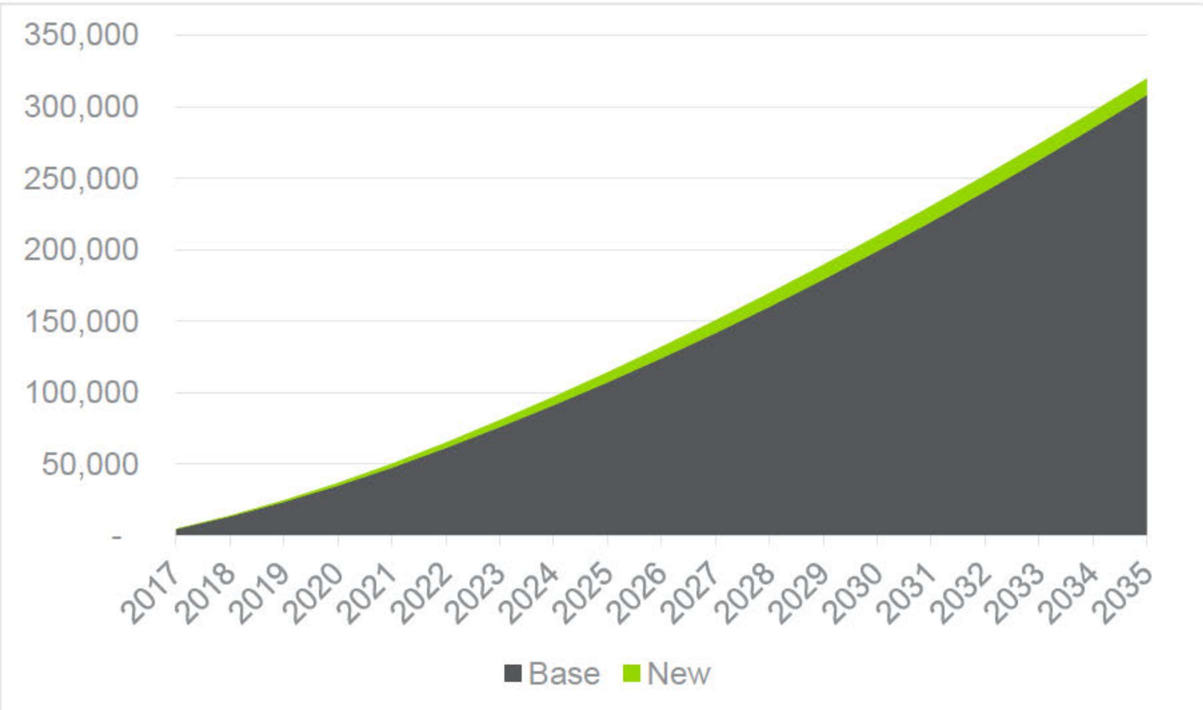


Table 8. Annual Baseline and New Sales in PGE Territory

Source: Navigant analysis, 2016

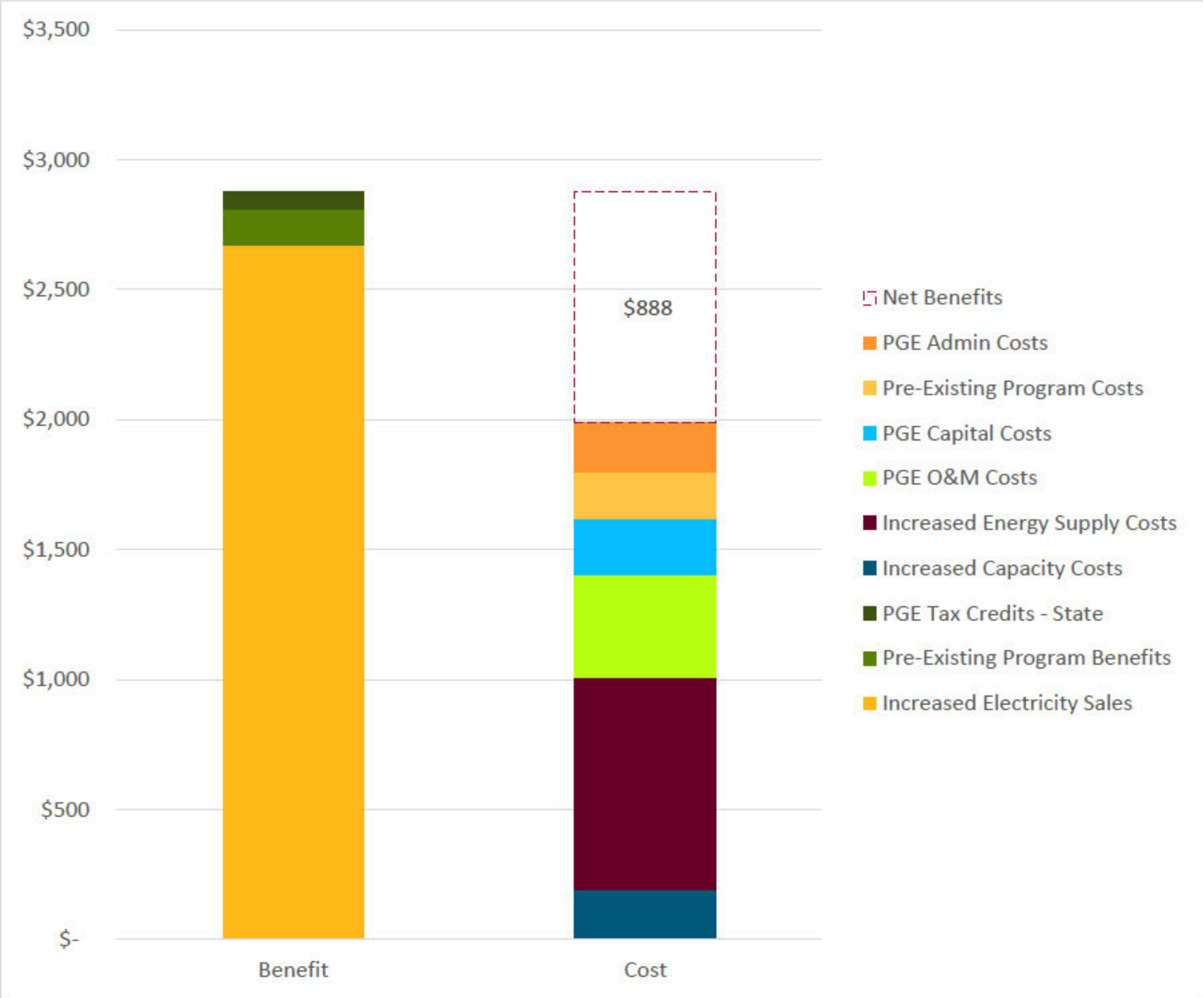
3.2 Rate Impact Measure (RIM) Test

This section presents the RIM test results for PGE's transportation electrification portfolio, as a whole.

The RIM test measures the net benefits of a program from the perspective of ratepayers. It is used to especially protect the interests of customers who are not program participants. Since programs are typically funded by customers, the cost streams included in the RIM test are overhead costs and capital costs. The benefit streams used in this test are increased revenue from electricity sales, and tax credits received by the utility.

The portfolio of programs result in a net revenue of approximately $888 per light duty vehicle.

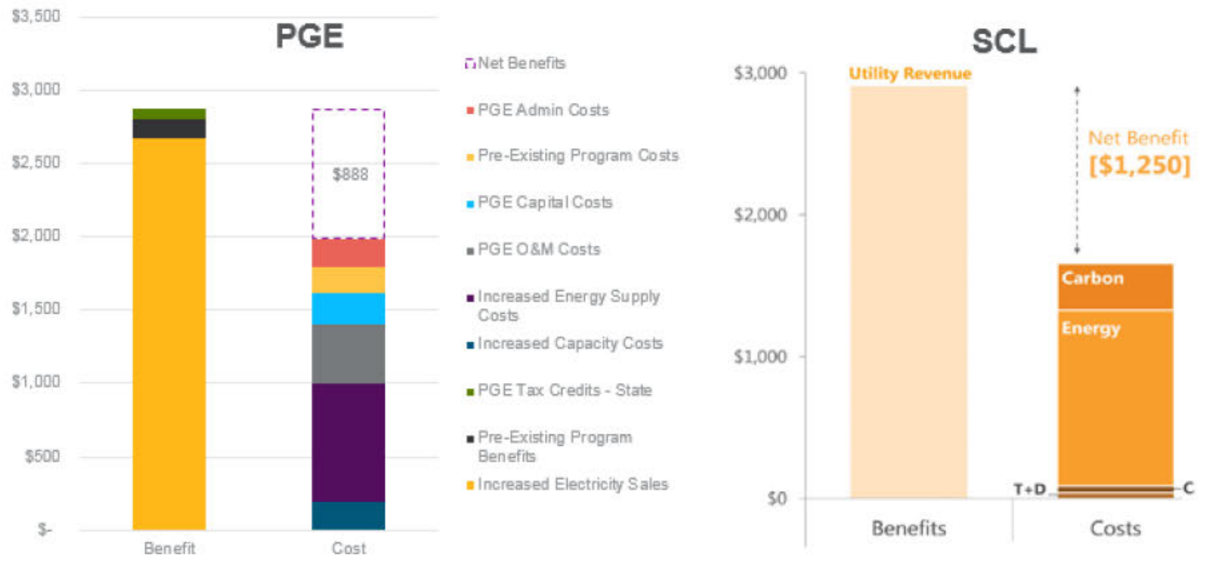
Table 9. Per Vehicle Benefits and Costs with RIM Test



Source: Navigant analysis, 2016

The results of PGE's analysis are roughly consistent with a recent analysis performed by Seattle City Light.

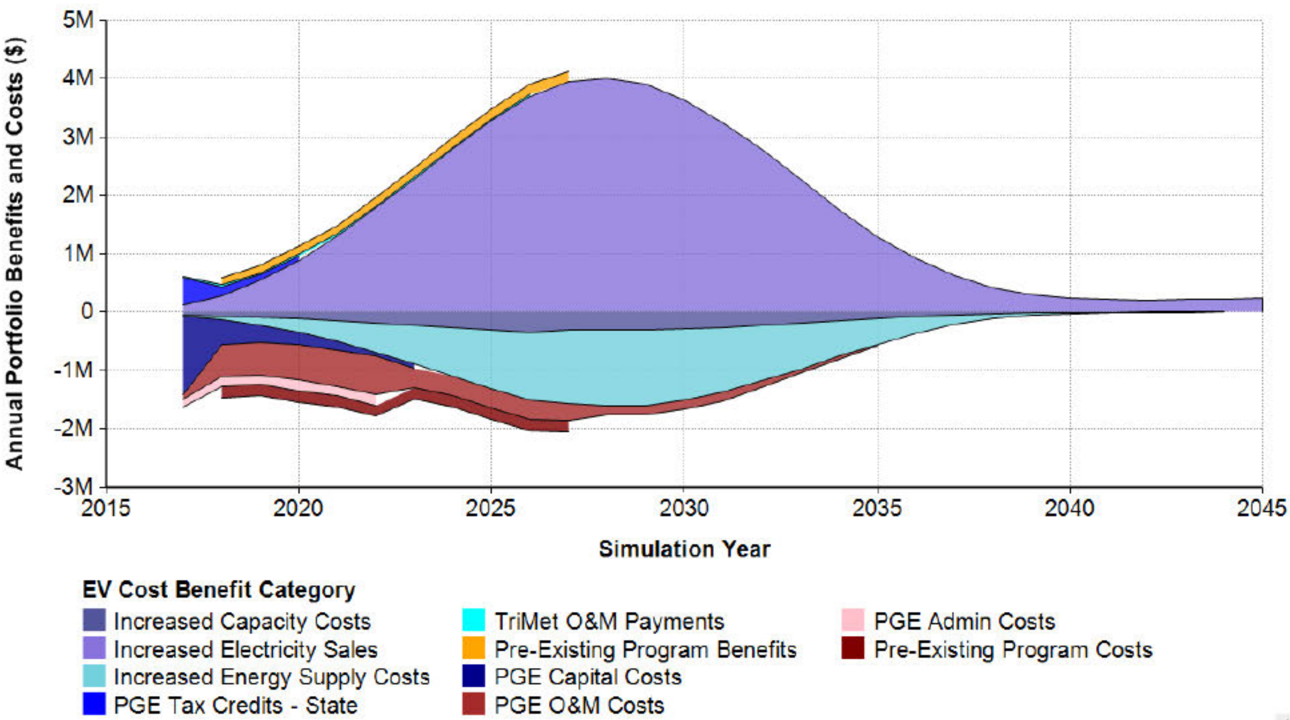
Table 10. Comparison of Results between PGE and Seattle City Light



Sources: Navigant analysis, 2016. Seattle City Light Transportation Electrification: Technical Impacts, Market Research, Program Design. 2015.

The time series graph below shows the quantified value streams for the RIM (costs and benefits) over time at the portfolio level. These results include the Electric Mass Transit 2.0 Program.

Table 11. Annual Portfolio Costs and Benefits with RIM Test



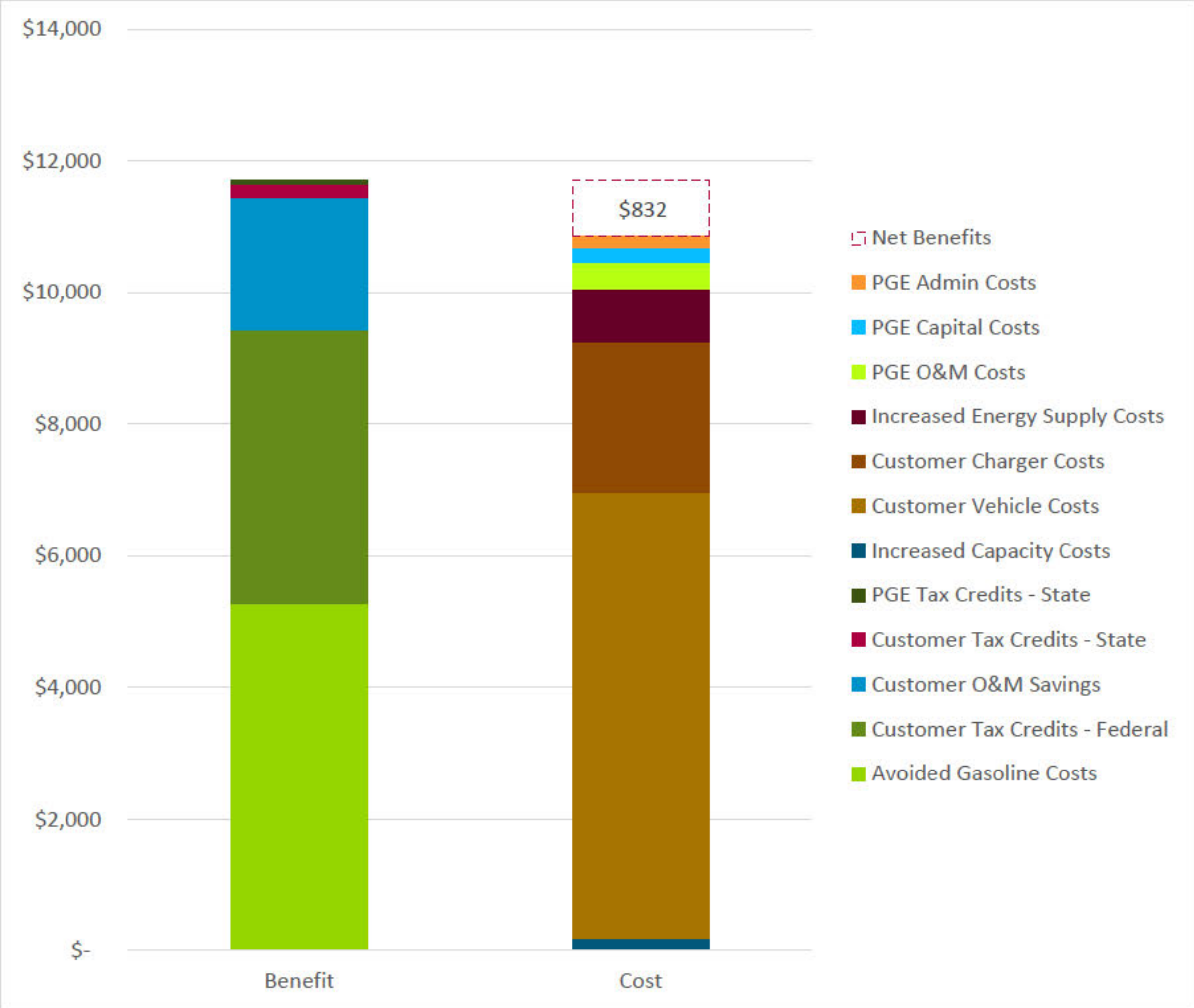
Source: Navigant analysis, 2016

3.3 Total Resource Cost (TRC) Test

The TRC measures net benefits of a program for all stakeholders involved. The cost streams included in the TRC test are overhead and capital costs incurred by the utility, as well as incremental costs of purchasing and installing equipment (e.g., vehicles and chargers) incurred by customers. The benefit streams used in this test are avoided costs of energy, capacity and gasoline; tax credits, and other non-energy benefits such as operations and maintenance savings. Increased electricity sales are not included in the TRC as they offset each other. Increased sales is a cost to customers on their electricity bills, while it is a benefit to the utility in the form of additional revenue.

The graph below shows the portfolio results per light duty vehicle using the TRC.

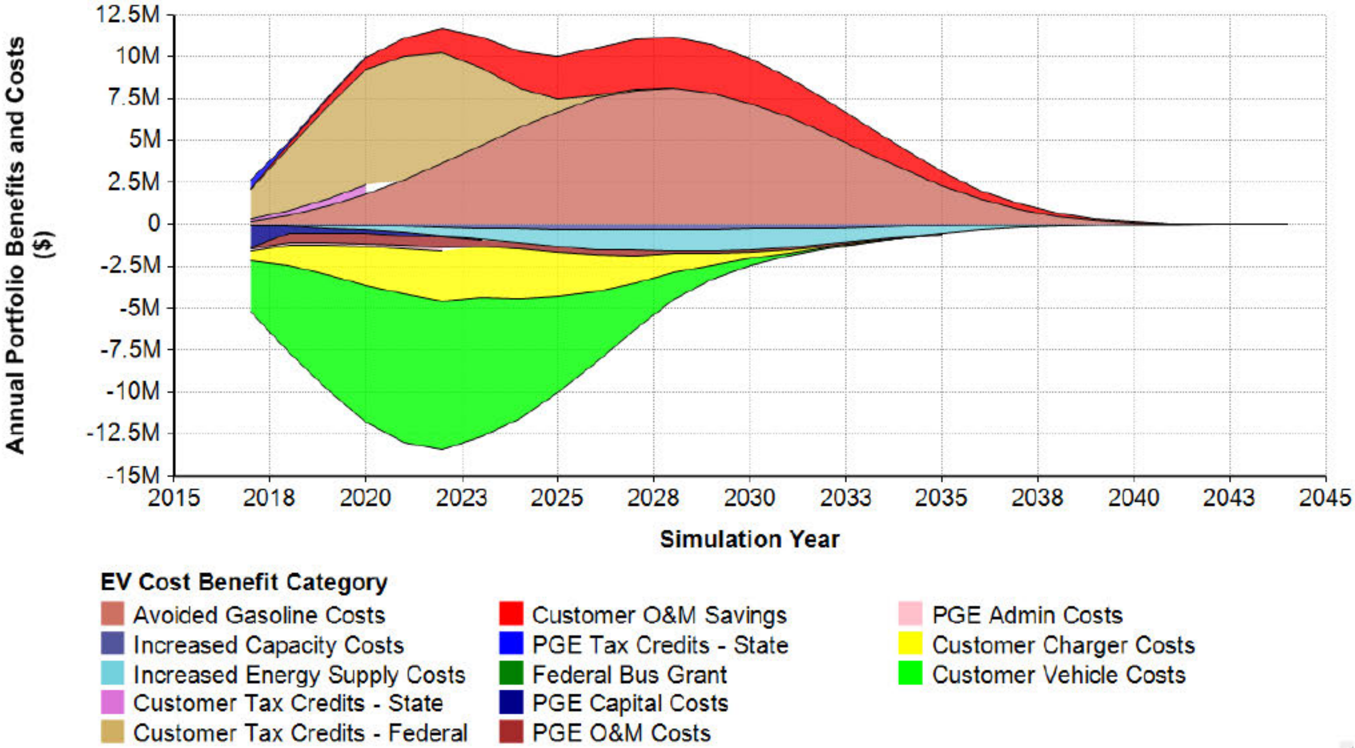
Table 12. Per Vehicle Benefits and Costs with TRC Test



Source: Navigant analysis, 2016

The time series graph below shows the quantified value streams for the TRC (costs and benefits) over time at the portfolio level, including the Electric Mass Transit 2.0 Program.

Table 13. Annual Benefits and Costs with TRC Test



Source: Navigant analysis, 2016

3.4 Societal Cost Test (SCT)

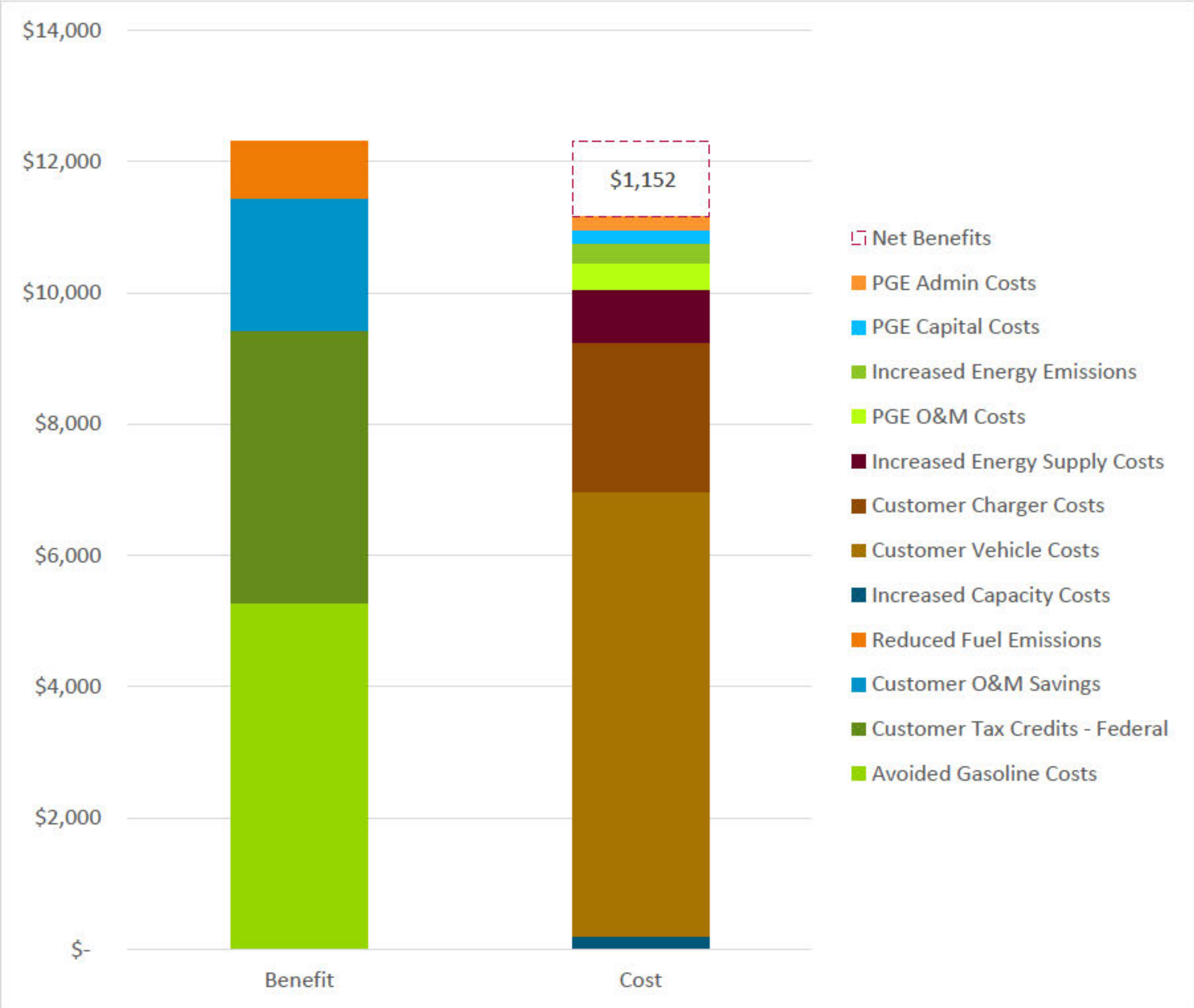
The SCT measures net benefits of a program for society at large. For this analysis, it is similar to the TRC, with the addition of benefits from reduced emissions, and the subtraction of state tax credits (tax credits are considered a transfer payment from the government to the recipient in the SCT, yielding no net benefit). As this analysis was conducted in response to Chapter 28, Oregon Laws 2016, the analysis team decided to define society as those within the state of Oregon[16]. Therefore, state tax credits are transfer payments in this analysis, while federal tax credits are still considered benefits. Notably, absent the tax credits, the programs are a net cost to society, due to the high incremental cost of an electric vehicle relative to internal combustion engine vehicles. As electric vehicles become more prevalent in the market, economies of scale will likely substantially reduce these incremental costs, yielding a significant net benefit to society per electric vehicle.

This analysis conservatively estimates the impact of only benefits to society that are easily monetized using Environmental Protection Agency values for the social cost of carbon[17], and does not consider other difficult-to-monetize benefits from transportation electrification[18].

The graph below shows the portfolio results per light duty vehicle using the SCT.

[16] During workshops conducted throughout Summer and Fall 2016, stakeholders did not object to this approach.
[17] https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2016orLaw0028.pdf
[18] Such benefits may include building demand response, ancillary service, or transactive energy market potential for PGE, national energy security from reduced reliance on foreign energy sources, PGE and City of Portland public relations.

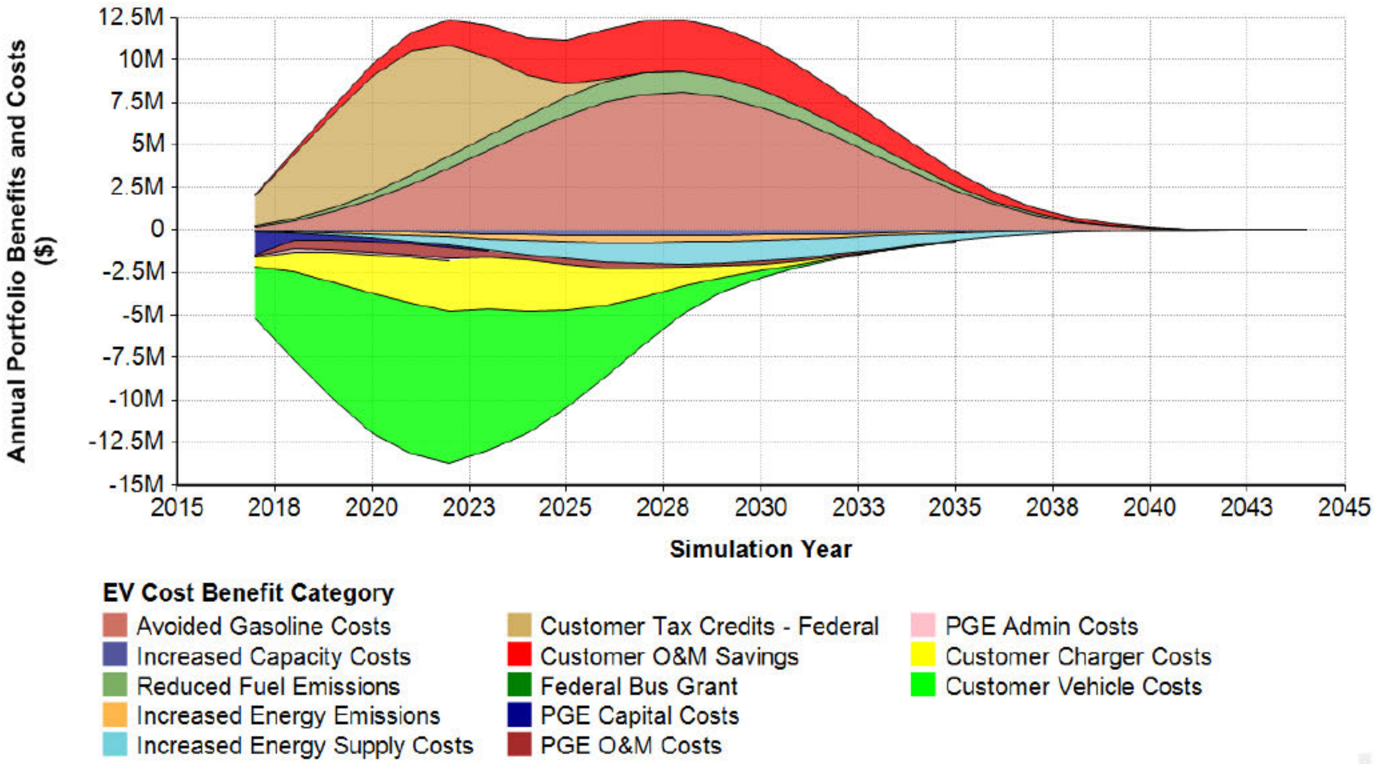
Table 14. Per Vehicle Benefits and Costs with SCT Test



Source: Navigant analysis, 2016

The time series graph below shows the quantified value streams for the SCT (costs and benefits) over time at the portfolio level, including the Electric Mass Transit 2.0 Program.

Table 15. Annual Benefits and Costs with SCT Test



Source: Navigant analysis, 2016

3.5 Electric Mass Transit 2.0 Program Results

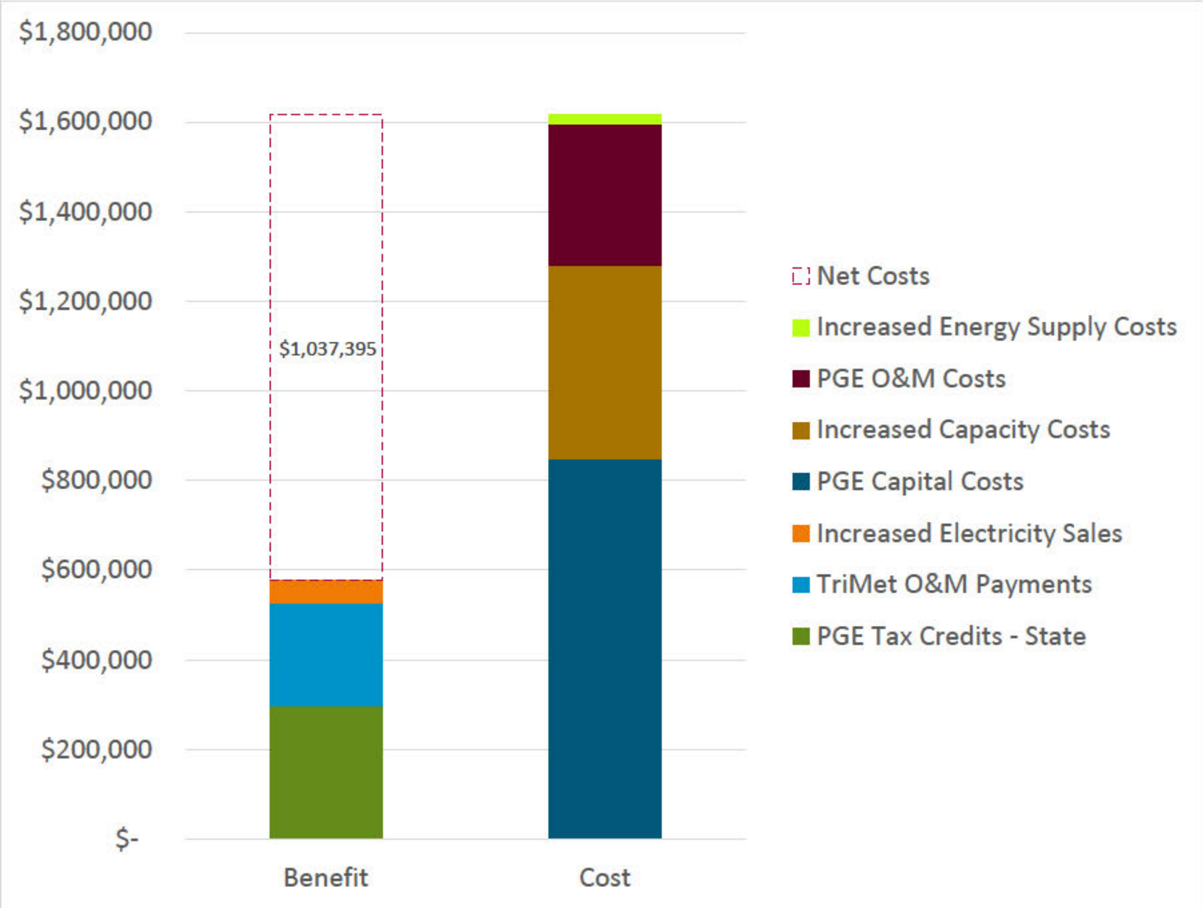
This section provides more detail on the results for the Electric Mass Transit 2.0 program individually, given the unique nature of this program within PGE's electrification transportation portfolio.

The Electric Mass Transit 2.0 program enables TriMet to purchase one additional bus. The program appears to have a net cost, predominately because the full cost of five chargers are incurred as utility capital costs, while the analysis only counts the benefits of the one additional bus attributed to the program. This is a conservative analysis, based strictly on the known impact of the chargers increasing the TriMet fleet by one bus. In reality, these five chargers could power significantly more than one or even five electric buses in the future. However, in order to stay consistent with the methodology employed in response to previous dockets[19] the analysis strictly accounts for only incremental costs and benefits as a direct result of the program.

The Electric Mass Transit 2.0 program results in a net cost of approximately $1 million according to the RIM test.

[19] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf

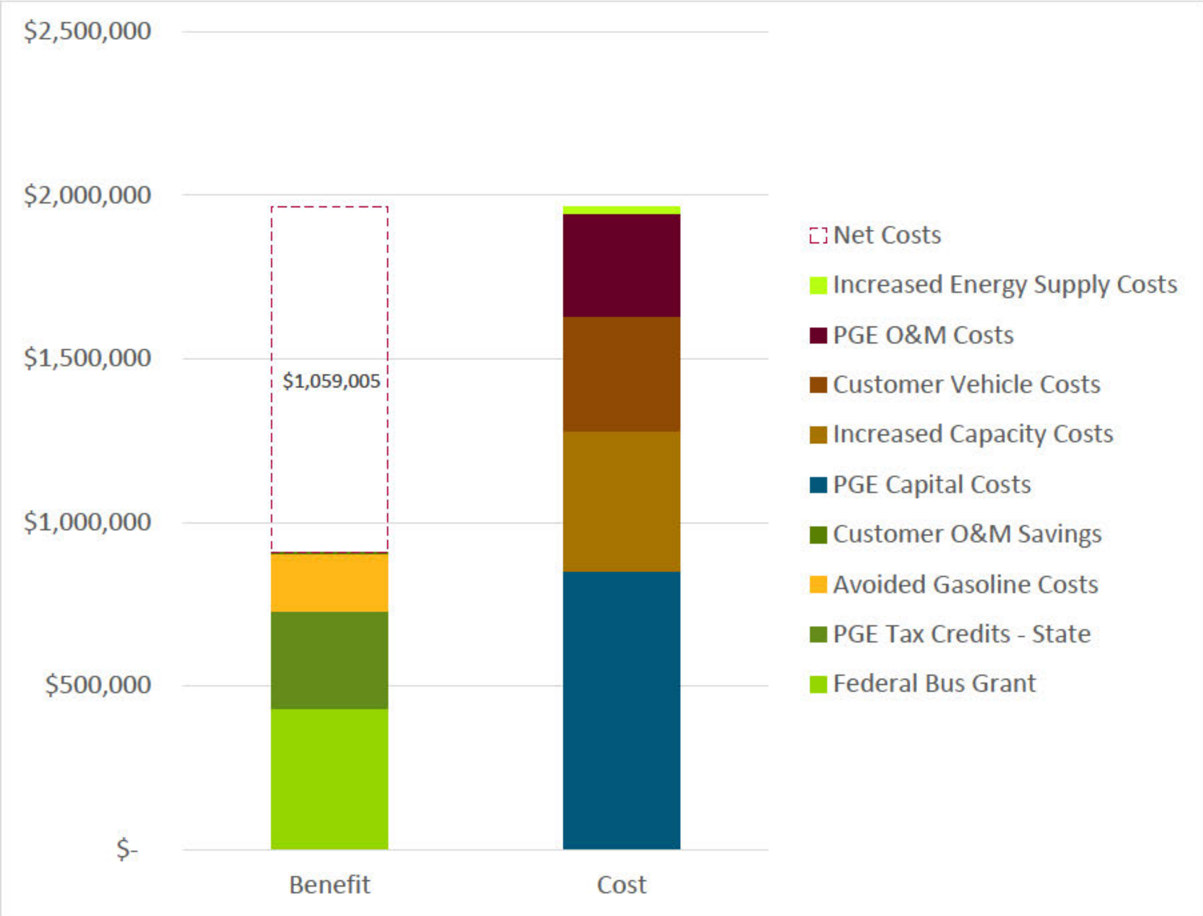
Table 16. Electric Mass Transit 2.0 Costs and Benefits with RIM Test



Source: Navigant analysis, 2016

The Electric Mass Transit 2.0 program results in a net total resource cost of approximately $1 million.

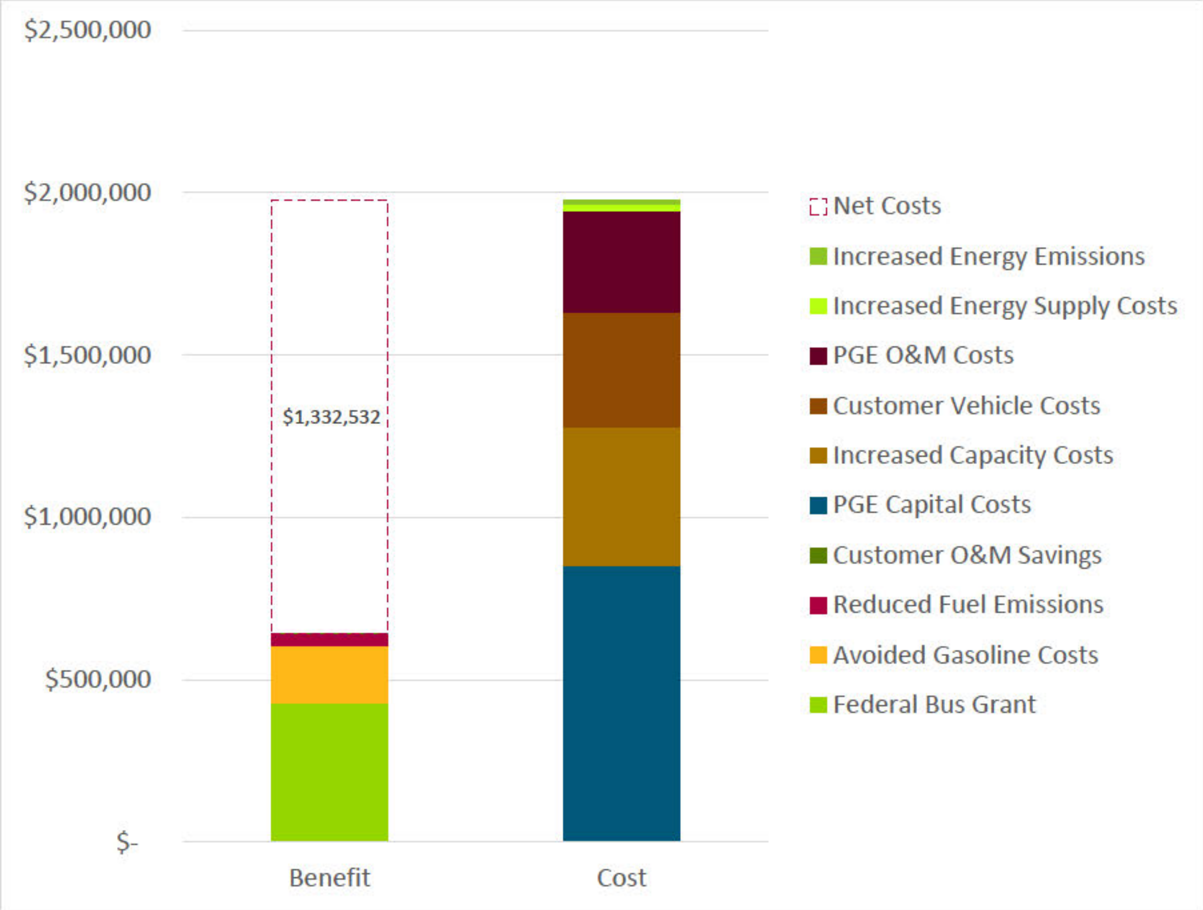
Table 17. Electric Mass Transit 2.0 Costs and Benefits with TRC Test



Source: Navigant analysis, 2016

The Electric Mass Transit 2.0 program results in a net societal cost of approximately $1.3 million. Consistent with the light duty vehicle analysis above, the societal cost test considers costs and benefits from the perspective of the state of Oregon. Therefore, the federal grant for the purchase of a single bus is considered a benefit in this analysis.

Table 18. Electric Mass Transit 2.0 Costs and Benefits with SCT Test



Source: Navigant analysis, 2016

Section IV Conclusions and Directions for Future Research

Based on the results presented above, PGE's transportation electrification program portfolio is expected to be a cost effective investment for PGE and their customers. In the future, additional research that may provide greater certainty in future cost effectiveness analyses for PGE's transportation electrification programs includes:

- Develop a framework to track key performance metrics and evaluate the impact of the transportation electrification program portfolio.
- Assess opportunities for transportation electrification to contribute to demand response and/or ancillary service benefits for PGE.
- Determine optimal criteria for siting of community charging infrastructure, and analyze traffic patterns, demographics, zoning restrictions, visibility etc. to optimize placement community charging infrastructure.

This framework is consistent with and builds upon the framework that PGE set forth for demand response cost effectiveness. PGE will continue to build on this robust framework as the Company continues to further develop customer-facing programs for encouraging adoption of distributed energy resources.

Appendix A. Cost Effectiveness Framework Definitions

Table 19. Cost Effectiveness Framework Definitions

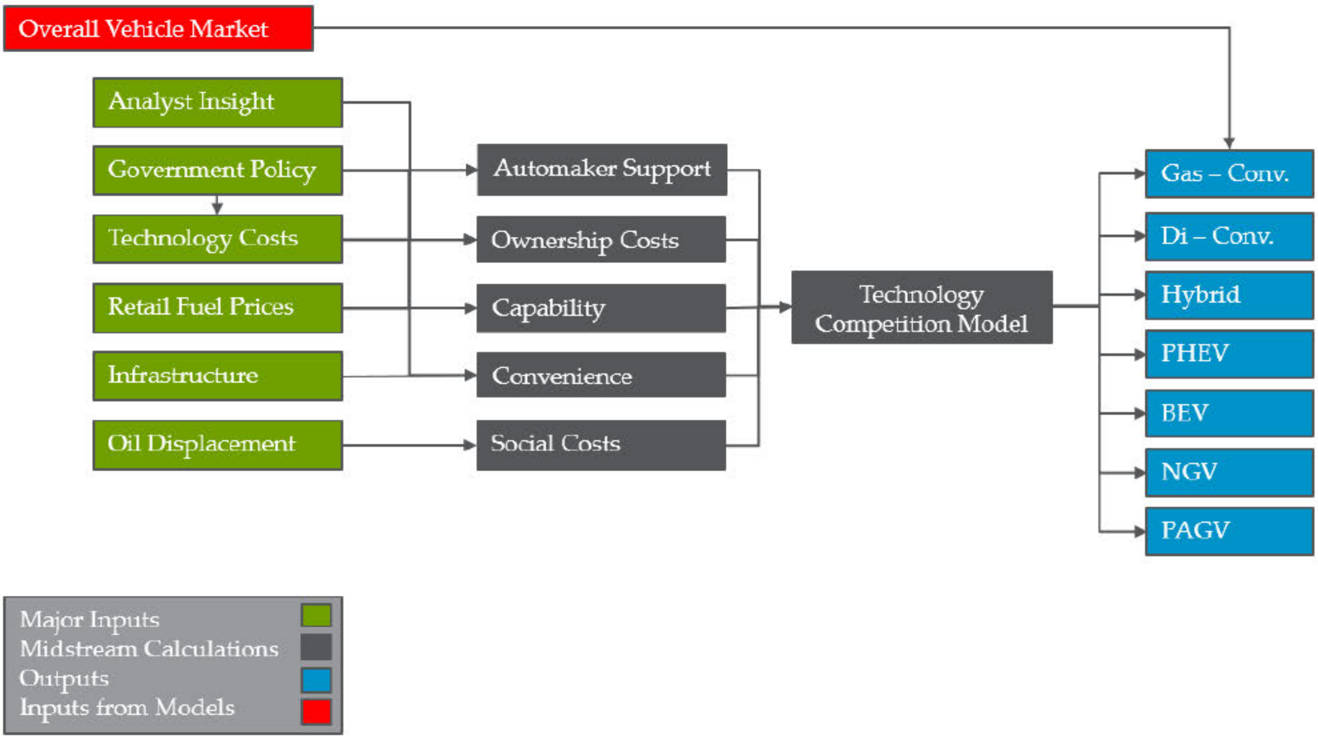
Cost/Benefit Category	Definition	Calculation Description	Monetization Unit
Avoided Gasoline Costs	A customer's value of avoided gasoline purchases	Based on VMT and fuel efficiency of the baseline gasoline powered vehicle	$/gallon of gasoline
Increased Capacity Costs	PGE's increased costs of capacity from providing electric vehicle charging service	Based on electric vehicle charging coincidence with system peak demand (MW)	the inverse of avoided capacity costs ($/MW)
Reduced Fuel Emissions	CO_2, NOx, and PM reductions from reduced gasoline consumption	Fuel emissions intensity (tons/gal) * gallons avoided	Cost of emissions ($/ton) by emissions type
Increased Energy Emissions	CO_2, NOx, and SOx emissions increases from more electricity consumption	Grid emissions intensity (tons/MWh) * increased energy consumption (MWh)	
Increased Electricity Sales	PGE revenue from increased electricity sales (MWh) due to electric vehicle charging	Electric vehicle charging consumption (kWh). Loadshape varies by sector and rate type	Retail rates by sector ($/kWh) varies by on/mid/off-peak and season
Increased Energy Supply Costs	PGE's increased costs of energy from providing electric vehicle charging service	electric vehicle charging consumption (annual kWh)	the inverse of avoided energy costs ($/MWh)
Customer Tax Credits	Customer tax credits for electric vehicle or EVSE purchases from federal and state sources	Vehicle purchase credit ($/electric vehicle) and Alt fuel infrastructure tax credit ($/project). With phase out assumptions.	
Customer O&M Savings	The decreased O&M associated with electric vehicles	Electric vehicle O&M costs relative to baseline vehicle O&M	Annual O&M savings ($/year)
Utility Tax Credits	PGE tax credits for EVSE purchases from federal and state sources	Alt fuel infrastructure tax credits (federal and state; percent of project costs). Phase out assumptions.	
Utility Capital Costs	PGE costs for installing DCQC and L2 chargers at public stations	Equipment, installation, interconnection, permitting costs for stations	$/station
Utility O&M Costs	PGE annual costs for O&M	DCQC station O&M, as well as marketing dollars for the Education & Awareness	$/year by program
Utility Admin Costs	PGE costs for administering the programs	Any additional FTEs for program admin	$/year by program
Customer Charger Costs	Customer costs for L2 chargers	Assume a percent of vehicle purchases also include L2 residential charger purchase	$/charger
Customer Vehicle Costs	Customer costs for electric vehicles	Incremental cost of electric vehicle over baseline gasoline vehicle	$/electric vehicle

Source: Navigant analysis, 2016

Appendix B. Visual Overview of Electric Vehicle Forecast Methodology

The following slides provide an overview of the electric vehicle baseline forecast methodology. Section 2.2 also contains detail on the methodology.

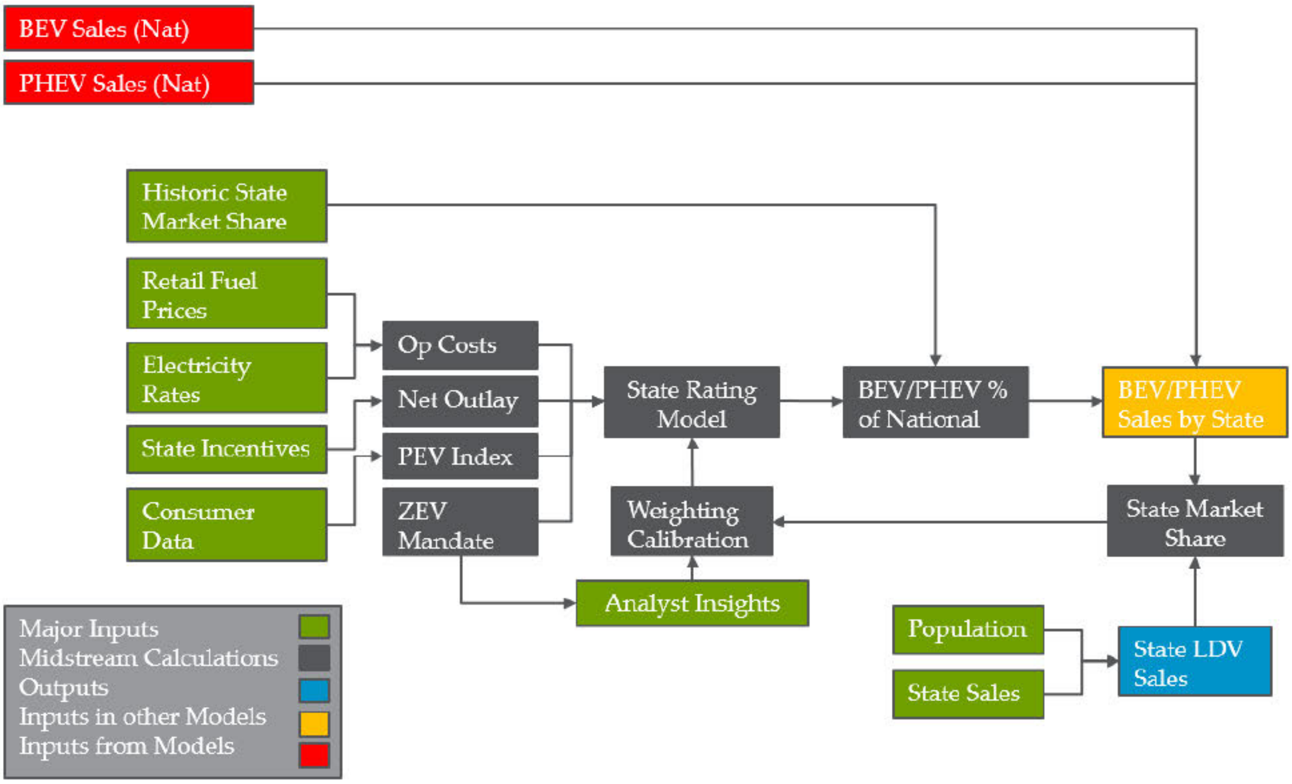
Figure 3: Electric Vehicle Forecast Method: Technology Adoption



Source: Navigant analysis, 2016

The above influence diagram visualizes the component of Navigant Research's national vehicle sales forecast model which determines market share of various vehicle fuel and powertrain combinations. The results of the model are disaggregated by lesser geographic jurisdictions.

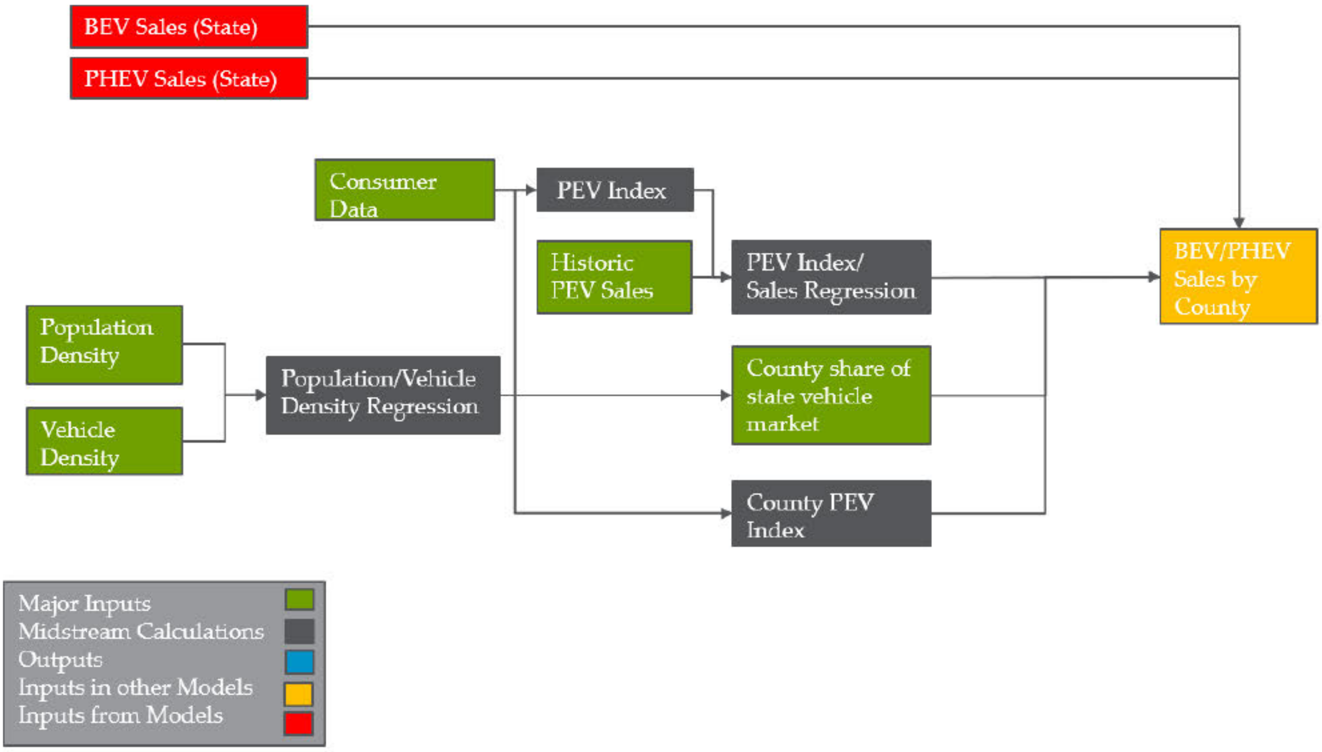
Figure 3: Electric Vehicle Forecast Method: State Disaggregation



Source: Navigant analysis, 2016

This influence diagram visualizes the first disaggregation of Navigant Research's national vehicle sales forecast model. This disaggregation is a function of a number of parameters including state regulations, incentives, retail fuel prices and electricity rates, demographics, and historic sales.

Figure 4: Electric Vehicle Forecast Method: County Disaggregation

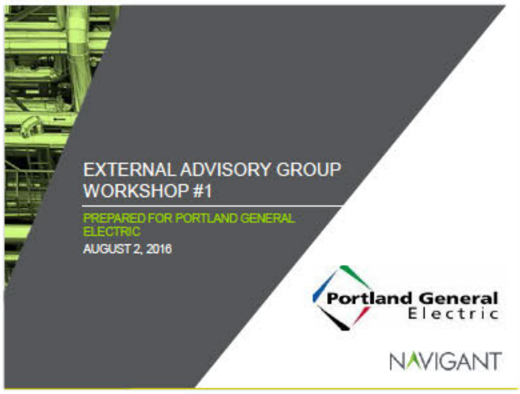


Source: Navigant analysis, 2016

This influence diagram visualizes the second disaggregation of Navigant Research's national vehicle sales forecast model. This disaggregation is primarily a function of historic sales, demographics, and population density.

Appendix C. Stakeholder Workshop #1

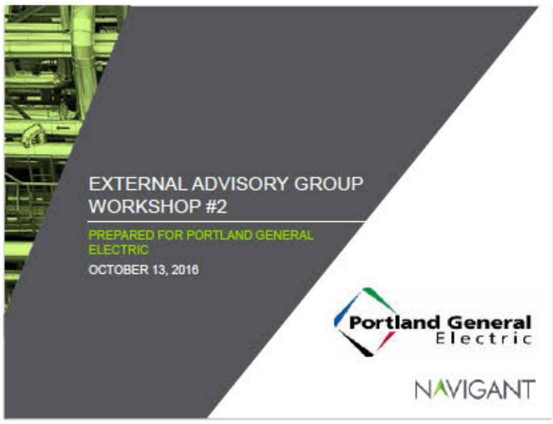
See attached presentation for the first external stakeholder workshop, conducted on August 2, 2016.



Source: Navigant analysis, 2016

Appendix D. Stakeholder Workshop #2

See attached presentation for the second external stakeholder workshop, conducted on October 13, 2016.



Source: Navigant analysis, 2016

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