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

December 27, 2016

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

RE: UM ______ Application for Transportation Electrification Programs

Enclosed is Portland General Electric's (PGE) December 2016 Application for Transportation Electrification Programs. 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. In addition to the filing, the following Appendices are attached to the Application:

- Appendix 1: Economic Modelling Estimates and Assumptions
- Appendix 2: Basic Transportation Electrification Terminology
- Appendix 3: Letter of Support from TriMet
- Appendix 4: Cost Effectiveness Analysis (via Navigant)

The purpose of this filing is to describe PGE's long-term strategy for increasing transportation electrification in our service area, and to describe how the proposed programs fit within a longer-term framework. The 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.

We propose to accomplish these goals through a series of pilot programs meant to accelerate the adoption of electricity as a transportation fuel, and to foster learning for PGE and other stakeholders. These pilots include outreach and technical assistance, Electric Mass Transit, community charging, and a series of "small demonstration pilots."

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

As directed by OPUC Staff, this filing is being served to participants in the AR 599 rulemaking.

Sincerely,

Karla Wenzel
Manager, Pricing and Tariffs

Enclosure

Transportation Electrification Plan

DECEMBER 2016

PGE

Contents

Contents 3
Acronyms 5
Executive Summary 8
Section 1. Background 12
1.1. Chapter 28, Oregon Laws 2016 12
1.2. Legislative Rulemaking (AR-599) 13
1.3. Stakeholder Engagement 13
1.4. Public Charging Infrastructure in Oregon 14
Section 2. Strategic Intent 16
2.1. Vision & Goals 16
2.2. Guiding Principles 17
2.3. Alignment with Smart Grid Strategy 18
Section 3. Market Insight 19
3.1. Market Sectors 19
3.2. Customer Research 22
3.3. Foreseeable Changes to the EV/Mobility Marketplace 30
Section 4. Electric Company Role 34
4.1. Outreach & Education 34
4.2. Financing a Reliable and Accessible Network 35
4.3. Learning, Planning, and Future Grid Services 37
4.4. Roles for Other Stakeholders 39
4.5. Conclusions 40
Section 5. Proposed Transportation Electrification Pilots 41
5.1. Outreach, Education, and & Technical Assistance 41
5.2. Electric Mass Transit 2.0 (TriMet pilot) 46
5.3. Electric Avenue Network (Community Charging Pilot) 52
5.4. Research, Development, and Small Pilot Projects 63
5.5. Cross-Pilot Evaluation 71

Section 6. Pricing and Recovery 73
6.1. Retail Prices for Third-Party Owned Public Charging 73
6.2. Current Industry Pricing Models 75
6.3. Proposed Recovery Structure 76
Section 7. Estimated Program Impacts 77
Section 8. Other Related Efforts 83
8.1. Low Carbon Fuel Standard (LCFS) 83
8.2. Zero-Emission Vehicle Mandate 85
8.3. Volkswagen Settlement 85
8.4. City of Portland EV Strategy 87
Section 9. Conclusion 88
Appendix 1. Economic Modelling Estimates and Assumptions 89
Appendix 2. Basic Transportation Electrification Terminology 91
Appendix 3. Letter of Support from TriMet 93
Appendix 4. Cost Effectiveness Analysis (Navigant Whitepaper) 95

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

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.

Our near-term focus is to encourage and facilitate more people choosing electricity as a transportation fuel. The longer-term benefits that electric transportation can bring to our system can only be realized if people first embrace electricity as a transportation fuel. At the same time, we need to begin building a foundation of programs and best practices so that when electric vehicles realize high penetration levels, we can effectively and efficiently integrate them into the grid. Excitingly, analysis suggests that each new electric vehicle added to a home in our service area provides a benefit to all of our customers today, because it uses existing grid infrastructure when it is otherwise underused, thereby creating negative pressure on prices. Accordingly, programs that can 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 that will enable PGE to most efficiently integrate electric vehicles in the future:

1. **Outreach & Technical Assistance**: To raise awareness of the benefits of driving electric (the largest barrier to electric vehicle adoption), we propose a 5-year pilot for strategic outreach, education, and technical assistance, which would include 1 FTE to manage these efforts. The pilot will promote transportation electrification for residential customers, including outreach to promote whole-house time-of-use rates to residential customers that drive electric vehicles, encourage drivers to charge at times that are beneficial to the grid, and expand technical assistance for non-residential customers (including non-profits that support low-income communities). 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 $600,000 per year for 5 years.

2. **Electric Mass Transit 2.0:** PGE is proposing 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, 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 is $625,000. TriMet will pay the applicable tariffed rate for electricity from the charging stations.

3. **Community Charging Infrastructure Pilot:** PGE endeavors to build on the success of Electric Avenue, a group of 5 electric vehicle stations located at World Trade Center in downtown Portland, by building 6 additional Electric Avenue sites. The sites will each include up to 4 dual-head fast chargers and 1 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. 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 will 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 $3.9M and expect it to generate $3.5M in revenues from subscriptions and usage charges (10-yr NPV).

4. **Small Demonstration Pilots:** PGE plans to further our learnings and plan for the future through several small demonstration projects:
   a. **Employee Research Pilot:** launched in 2016, this pilot evaluates PGE employees' charging habits and associated impacts of whole-home time-of-use rates, smart charging (demand response), and public charging.
   b. **Workplace Smart Charging Demonstration:** tests demand response at workplace charging stations on PGE property. PGE intends to expand this demonstration to at least one non-residential customer – to evaluate the impacts of demand response on our customer's customers/employees.
   c. **Vehicle to Grid (V2G):** PGE has begun a demonstration project in partnership with Nissan to understand the impacts of a PGE-owned vehicle interconnected regularly to a PGE facility using a 10 kW, 2-way charging station. The project will study V2G interconnection, power quality/reliability, and if identifiable, battery degradation.
   d. **Bring Your Own Charger Demand Response (DR):** This pilot would offer incentives to customers who have or purchase a qualifying DR-enabled home charging station. The pilot will test the effectiveness of home charging DR and customer satisfaction.
   e. **Low-income Pilot:** PGE will work with car manufacturers to negotiate discounted rates for non-profits to buy off-lease electric vehicles. For up to 3 organizations who buy an electric vehicle, PGE will install DR-enabled workplace charging infrastructure.

   The estimated cost of these small demonstration projects is $561,000 (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 $8.7M and generate $4.2M in customer payments (using a 10-year NPV):

Table 1: 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 & Technical Assistance	$ 2,427	-	$ 2,427
Electric Mass Transit 2.0	$ 1,239	$ 641	$ 598
Electric Avenue Network	$ 3,880	$ 3,547	$ 333
Small Demonstration Projects	$ 561	-	$ 561
Pilot Evaluation	$ 581	-	$ 581
Total	$ 8,688	$ 4,188	$ 4,500

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 1.35 and create a net benefit of $5.27M (using a customer perspective test) for all PGE customers through increased electricity sales, creating downward pressure on customer prices:

Table 2: 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	$ 15,152	$ 76,788	$ 78,819
Net Benefit	**$5,270**	**$ 4,878**	**$ 6,815**

Additionally, we anticipate the pilot programs to help the state of Oregon meet its greenhouse gas reduction goals by preventing 655,955 short 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 buses 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 & useful;
- Are expected to improve grid efficiency & operational flexibility (including renewable integration);
- Expected to stimulate innovation, competition, and customer choice.[4]

[1] https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2016orLaw0028.pdf
[2] Sec. 20.3
[3] Sec. 20.2
[4] Sec. 20.4

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]

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 3: 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.

[5] http://apps.puc.state.or.us/edockets/docket.asp?DocketID=20129
[6] http://apps.puc.state.or.us/orders/2016ords/16-447.pdf

1.4. Public Charging Infrastructure in Oregon

Today, there are 182 public quick charging stations in Oregon at 105 sites. Many of those chargers were installed or funded by federal grants or auto manufacturers:

Table 4: 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	**105**	**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. Just 16% of public quick chargers have dual-head connectors, providing accessibility to all EV drivers, and 48% of public quick chargers are only accessible by Tesla drivers.

- 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: site hosts lose interest in maintaining, 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.

In addition to the chargers indicated above, PGE installed 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.

Section 2. Strategic Intent

2.1. Vision & 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.*[7]

[7] 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.*[8]

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 1: PGE's Transportation Electrification Guiding Principles

Reliable & Safe	Accessibility & Inclusivity	Simple Customer Experience	Value-add Programs & 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[9] 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

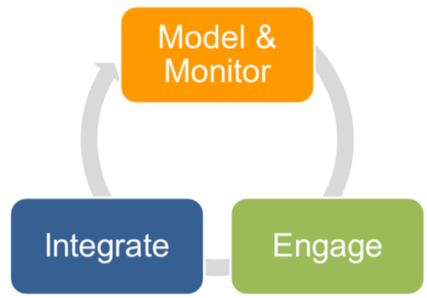
[8] Transportation Electrification: A Technology Overview EPRI, Palo Alto, CA: 2011. 1021334.
[9] Baumhefner, Hwang, Bull. NRDC. *Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles* (2016).

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[10]:

> 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 & 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 2: 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 & 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.

---

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

Section 3. Market Insight

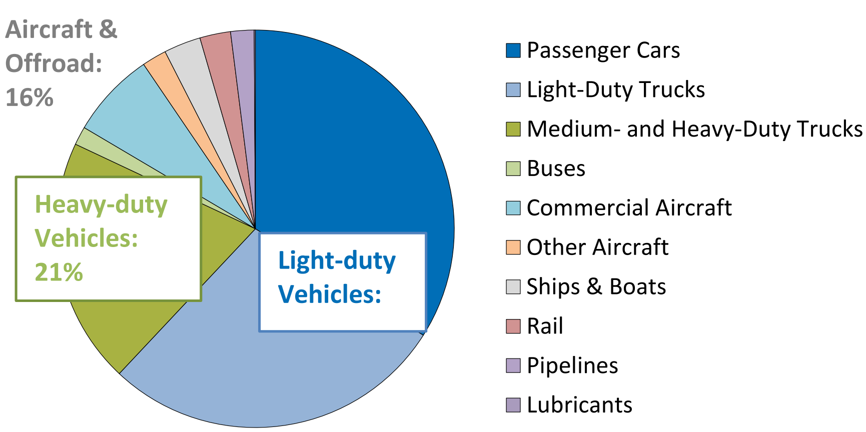
As we plan our pilot proposals, we are mindful of what's been done before, what is happening now, the makeup of the competitive market, the market barriers our customers are experiencing, and where we anticipate the market heading. Overlapping this understanding of the marketplace with the role outlined for electric companies in Chapter 28, Oregon Laws 2016, provides a framework for optimizing PGE's engagement to accelerate transportation electrification and efficiently integrate electric vehicles into our operations. This section discusses the market conditions that have helped inform and shape our pilot proposals.

3.1. Market Sectors

To prioritize pilot development efforts, we started with an assessment of the potential for transportation electrification within the service area. Given resource constraints, we intended to focus immediate efforts on the largest potential market opportunities. In other words, we wanted to find the market segments of the transportation sector that have the greatest potential for electrification.

We conducted a literature review that examined the share of emissions allocated to the various segments of the transportation sector. The EPA, in its Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014 study released in April, estimates that 26% of all U.S. emissions come from the transportation sector in 2014. The U.S. Department of Transportation dug even deeper into 2006 emissions data on the relative emissions shares from market segments within the transportation sector.[11]

Figure 3: U.S. Transportation Greenhouse Gas Emissions by Source, 2006[12]



[11] US EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014*. (April 15, 2016). https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-main-text.pdf
[12] US DOT. *Transportation and Greenhouse Gas Emissions.*(Accessed Dec. 1, 2016). https://climate.dot.gov/about/transportations-role/overview.html

The light-duty vehicle segment is responsible for 63% of transportation sector emissions. Medium and heavy-duty vehicles were responsible for 20% and buses were responsible for 1% of transportation sector emissions.

Given this data, we focused our efforts on estimating the electrification potential for light-duty vehicles. We have also included buses based on a unique opportunity with TriMet, potential impacts on local air quality issues, and to serve a wider base of PGE customers. In addition, we estimated electrification of forklifts and transportation refrigeration units given their prevalence in our service area. We used data from Navigant Research, Federal Highway Administration (FHA), and Oregon Department of Transportation (ODOT) to build estimates for these three market segments. (Due to the challenges in finding data, we were unable to get accurate estimates for the medium- and heavy-duty vehicle segments.)

Light Duty PEVs

There are about 2.3 million light duty vehicles (gross vehicle weight less than 8,500 lbs.) on the road in Oregon.[13,14] Of those vehicles, 1.34 million are in the Portland Metropolitan Statistical Area (MSA), which includes Vancouver, WA but does not include Salem. The number of light-duty vehicles in PGE's service area is likely a bit smaller.

According to the FHA, the average light-duty vehicle travels 13,500 miles per year[15] and the average efficiency among EVs sold is about 3 miles/kWh (average efficiency is weighted based on number of vehicles on the road).

Using these numbers, PGE estimated the technical potential of electricity consumption from light-duty vehicles to be roughly 514 MWa (approximately 23% of total system loads in 2015).[16] This technical potential is an estimate of the electricity consumption within PGE's service area if all vehicles were replaced with PEVs, assuming no growth in overall light duty vehicles.

Public Transportation

Public transportation within PGE's service area consists of light-rail, street car, and buses. Given that the light-rail and street cars are already electric, we focused these estimates on the market potential for bus electrification. We started by estimating the electrification potential of TriMet, which manages the public bus system in the Portland metro area.

---

[13] National Automotive Dealers Association annual reports, Federal Highway Administration (FHA) statistics

[14] US EPA. *Vehicle Weight Classifications for Emission Standards Reference Guide.* (Accessed Dec. 1, 2016). https://www.epa.gov/emission-standards-reference-guide/vehicle-weight-classifications-emission-standards-reference-guide

[15] 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

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

Using data provided by TriMet, we derived estimates for the electricity consumption of their bus fleet if all buses were converted to electric. There are 654 diesel buses within TriMet's fleet, each of which travels about 41,400 miles per year. Electric buses on the market today have an efficiency of 0.5 miles/kWh. From these inputs, PGE estimates that the technical potential of TriMet's bus fleet is approximately 5.7 MWa.[17]

To obtain an estimate of the electrification potential of other transit buses, including school buses, in our service area, we estimated the bus fleet by taking the number of schools in our service area and multiplying by the average number of buses used per school. Based on this analysis we estimate the technical potential of all bus electrification in PGE's service area to be approximately 11.8 MWa.

Forklifts

To estimate the market potential for forklifts in the PGE service area, we started with data on total North American forklift orders. We conservatively estimated that Oregon's market share is about 1% and Portland's share of the Oregon market to be 30%. We also assumed that each forklift charges about 260 times per year using about 40 kWh per charge. This resulted in an estimate of 15.4 MWa.

Conclusions

In summary, the highest technical potential for transportation electrification based on today's available technologies is in the mass-market light duty vehicle sector:

Table 5: Transportation Electrification Technical Potential, by Sector

Sector	Technical Potential (MWa)
Light Duty Vehicle	513.7
Buses	11.8
Forklifts	15.4

In order to maximize our impacts, our pilot proposals and market research are focused on light duty vehicles for their technical potential and public transportation for its customer reach and a near-term opportunity to partner with TriMet. In future plan updates we intend to include pilots in other sectors.

[17] PGE's service area covers other public transportation districts where TriMet does not provide service. At this moment, we do not have data to properly estimate the electrification potential of the bus fleet in these districts.

3.2. Customer Research

In approaching this Plan and our proposals, we have taken a customer-centric look at a typical customer's journey to acquiring a car. It's important to understand how customers' shopping for any car think about electric cars in their buying process to best understand what the marketplace needs to accelerate the adoption of electric transportation.

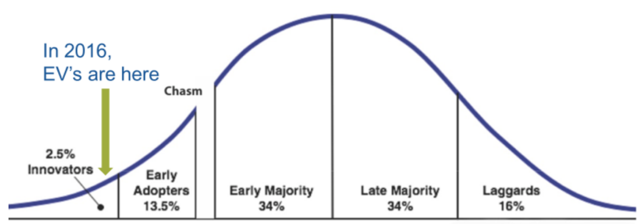
Our analysis of the marketplace demonstrates that most PGE customers lack the necessary awareness of electric vehicles to lead them to purchase a vehicle. Furthermore, the presence of visible public charging infrastructure can significantly increase customers' awareness of electric vehicles, while also improving the experience for existing EV drivers, who are key advocates for the proliferation of the technology.

3.2(a) Prospective Buyers

Electric vehicles are an emerging technology: today they account for less than 2% of the approximately 170,000 light duty vehicles sold in PGE service territory each year.[18]

Technology Adoption Life Cycle

Figure 4: Technology Adoption Curve



Everett Rogers' Diffusion of Innovation Curve is a theory that attempts to explain adoption trends of new ideas and technologies. The theory suggests that the first 2.5% of buyers of a new technology are Innovators—active information seekers who "are very eager to try new ideas". The next group is Early Adopters, 13.5% of the population who are restrained in what new technologies they adopt—often seen as influencers by many of their peers. Product adoption by Early Adopters decrease uncertainty by the majority of the population, paving the way for the remainder of the market to embrace new technology.[19]

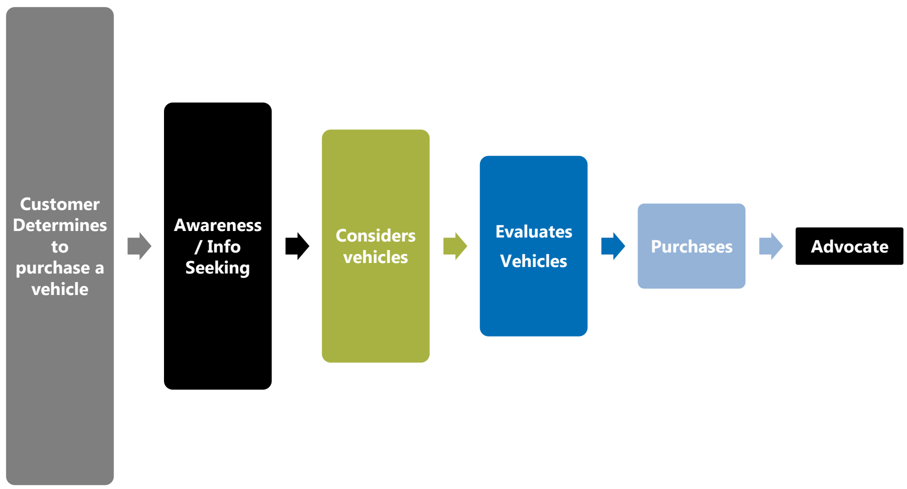
With plug-in electric vehicles accounting for less than 2% of all light duty vehicle sales, this technology is clearly still in the innovator phase. Through our program proposals, we aim to shift the market from innovator to early adopter.

We have utilized a modified version of McKinsey's Consumer Journey to inform our research and determine where, along the customer's purchase path, she experiences barriers to electric vehicle adoption. The funnel below highlights a purchase funnel, illustrating a large number of customers deciding to purchase a new vehicle each year (170,000) dwindling to a small number

[18] PGE estimates based on publically available data from Oregon Auto Dealers Association, US Commerce Department, Steel Association, Navigant Research, and Oregon Department of Transportation
[19] Rogers, EM (1995). Diffusion of Innovations. New York: Free Press

of electric vehicle purchases and advocates (1,000 – 2,000 new vehicles/yr.) and the various drop-off points along the way. The following sections will elaborate on each drop point to help inform approaches to reduce barriers to EV adoption.

Figure 5: Customer Path to Purchasing a Vehicle[20]



Awareness

Awareness at the onset of the purchase process is critical. 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. [21] Based on a 2014 study of PGE customers, we believe this to be the single largest 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."[22]

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.[23,24,25]

[20]McKinsey Consulting. "Modified from The Consumer Decision Journey." Jun 2009. http://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/the-consumer-decision-journey
[21]McKinsey Consulting. Modified from The Consumer Decision Journey. Jun 2009.
[22] 2014 PGE Customer Survey
[23]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
[24]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/
[25]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/

Some advertising has been actively discouraging drivers from considering electric (highlighting its relative complexities and nuances that are different from driving ICEV).

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."[26] What little advertising that does promote electric vehicles today largely fails to capture the emotional and lifestyle motivations that often drive customers' buying decisions.

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

> *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***,.[27]

In addition to lacking credible information on EVs, we have found through numerous customer interviews and focus groups that customers' limited awareness of EVs is impacted by the lack of visibility of electric vehicle charging infrastructure. 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 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.

[26] 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
[27] Kurani, Ken. "New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon". UC Davis. 2015.

Consideration

For a customer aware of electric vehicles, the next major barrier is "consideration"—these are the questions that a customer might ask when thinking about whether an EV fits their lifestyle. Consideration is impacted by the perceptions and recent touchpoints of the technology.

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."[28] Public charging availability and reliability is key 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.* [29]
>
> *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.*[30]
>
> *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.*[31]

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."[32] "Lack of robust DC Fast Charging infrastructure is seriously inhibiting the value, utility and sales potential of medium range BEVs"[33]

---

[28] New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon (2015 UC Davis)
[29] Energize Oregon. http://www.oregon4biz.com/assets/docs/EVrpt2013.pdf
[30] 2016 One Oregon: A vision for Oregon's Transportation System (Transportation Vision Panel report to Gov Kate Brown)
[31] Consumer Acceptance of Electric Vehicles in the US. 2012. https://www.epa.gov/sites/production/files/2014-09/documents/kodjak121312.pdf
[32] Li, S. et al., "The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts," Cornell University, June 2015.
[33] Hajjar, Norman, New Survey Data: BEV Drivers and the Desire for DC Fast Charging, Plug Insights, March 11, 2014.

Evaluation

Once a consumer is really interested in pursuing a technology, they enter the evaluation phase: to gather more detailed information about how the vehicle will fit their lifestyle, often asking: "Does this meet my needs?"

Much of the evaluation stage for buying a car is within the realm of vehicle manufacturers—what type of cars are on the market, what features do those cars have, does it fit my lifestyle? Fortunately, the EV market is rapidly growing—today there are over 2 dozen plug-in vehicle models available for sale in PGE's service area, featuring a variety of styles, ranges, features, etc.

In addition to evaluating features and elements of the car itself, customers in this phase spend time evaluating how they will use the vehicle and, in particular for EVs, how they will charge their car. Consumers raise the question of "Where will I charge? Home, work, public?" In evaluating charging options, 90% of our customers surveyed stated that they want chargers on highways/interstates.[34] Customers consider the "once a year trip to the beach or dessert" as the minimum requirement. Knowing highway access is available relieves 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).[35] 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 days are less than 100 miles, customers express need for a security network so that they can charge if and when needed.[36]

> *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*

---

http://www.pevcollaborative.org/sites/all/themes/pev/files/Hajjar_Recargo2_California%20PEVC%20Plug Insights%20Presentation.pdf

[34] PGE customers survey (2014)

[35] See Section 1.4

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

the lack of "robust DC fast charging infrastructure is seriously inhibiting the value, utility, and sales potential" of typical pure-battery electric vehicles.[37]

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."[38] 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.

Purchase

Once a customer has decided they want an electric vehicle, they ultimately need to go into a dealership and walk away with the keys. Unfortunately, customers commonly experience challenges with dealerships and oftentimes are discouraged from choosing electric. Sierra Club's 2016 *Rev Up EVs* Report studied the EV buying process at 308 different auto dealerships across 10 states and discovered challenges with many dealers:

- Staff don't talk to their customers about incentives or public charging
- Inadequate inventory (or visibility of inventory)
- Sales staff with lack of EV expertise[39]

The New York Times summarized that many dealerships have a disincentive to actively promote electric vehicles, citing that sales processes take longer, they sell fewer service contracts, and most sales staff lack general education about the technology, charging, and incentives.[40]

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%.[41] Though the Portland dealer market is more mature than much of the country in terms of electric vehicle sales, we have heard these barriers echoed by our customers as well. One customer explained that the sales person was not at all knowledgeable about EVs, stating that "the sales person kept saying 'let me google that' to every question."[42]

It is important that dealerships are allies in supporting the acceleration of EV adoption and that they have the tools necessary to close the deal.

---

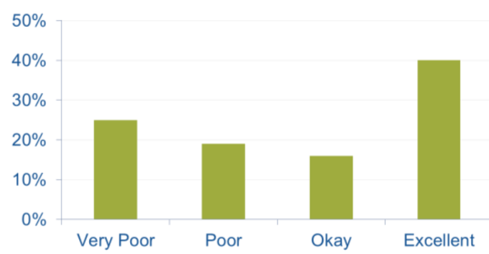
[37] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).
[38] Customer interview (July, 2016). (Conducted by Keller)
[39] Sierra Club 2016 Rev Up EVs Report
[40] http://www.nytimes.com/2015/12/01/science/electric-car-auto-dealers.html
[41] http://www.autonews.com/article/20160928/RETAIL/160929804/u-s-dealerships-employee-retention-slides-study-finds?cciid=email-autonews-daily
[42] Customer interview (July, 2016): Customer shopping for plug-in hybrid (Conducted by Keller)

3.2(b) Existing EV Drivers (EV Advocacy)

In addition to prospective EV drivers, it is also important to be mindful of existing EV drivers. These innovators (and soon to be early adopters) will not only influence their friends' and families' choice in a future vehicle, but they will also be vehicle shoppers again one day. It is imperative that customers who choose to drive electric are supported and have a positive experience. Driving an EV should be easier than owning an ICEV; unfortunately that is not the case today.

PlugShare is a mobile app for EV drivers to locate public infrastructure. Customers rate chargers and provide feedback to other drivers about broken equipment, blocked parking spots, or otherwise inaccessible infrastructure. Today, more than 20% of public chargers in PGE's service area have a 'very poor' rating and over 50% are rated less than 'excellent:

Figure 6: PlugShare Rating of Public Chargers in PGE Service Area[43]



Customer dissatisfaction at public charging sites can be caused by a variety of factors but the most frequent are: chargers are broken/not maintained; only 1 charger is available at a site; parking is not enforced (customers block parking spots long after their charge is done or non-EV customers occupy EV-only parking spots). Tesla's 12 Oregon charging sites, on the contrary, each of which has 4-8 fast chargers, receive "excellent" on 95% of ratings.[44,45]

The vast majority of EVs are second cars. The monetary and environmental benefits of these vehicles are dependent upon the amount they are driven compared to a customer's ICEV. Customer education and visibility of chargers increases the frequency and durations of these trips. They serve to reduce the range anxiety about the trip. Tesla drivers are in a unique circumstance as the company has made fast charging ubiquitous by installing a nationwide charging network.[46]

Over 70% of Tesla drivers in SMUD territory strongly agreed with this statement "The presence of DC fast-charging stations makes me more confident that my vehicle will not

[43] PlugShare. *PlugShare Quarterly: 2016-Q2 Census, US EV Infrastructure Exhibits*
[44] PlugShare. *PlugShare Quarterly: 2016-Q2 Census, US EV Infrastructure Exhibits*
[45] https://www.tesla.com/supercharger
[46] https://www.tesla.com/supercharger

> *run out of charge." 69% stated that they "looked for the location of DC fast-charging stations before buying or leasing an EV."*[47]

Energize Oregon sums up the current state of the public charging market as viewed by current EV drivers very effectively:

> *Satisfaction with the current infrastructure is split between respondents: 49 percent are very or somewhat dissatisfied and 36 percent are very or somewhat satisfied.*
>
> *Respondents expressed the most dissatisfaction with the current business models used to charge for charging. The two major issues highlighted in the responses were the operational aspects of certain chargers and the lack of seamless charging experience. Respondents on average had two or three charging membership cards and expressed frustration that payment methods and the use of charging networks were so varied and difficult.*
>
> *The respondents felt the most important aspects of a successful and usable infrastructure are convenience and affordability.*
>
> *Asked where future infrastructure development efforts should focus, respondents felt DC fast chargers should be placed along highways and at gas stations, and Level 2 should be placed at work, parking lots and major retail centers.*[48]

This study highlights the value of making public charging accessible, functional, and affordable. Public charging should provide all EV drivers with a sense of security. For most customers, "the whole idea of a charger network is for people never to actually use it but to be comforted that they're there so that they actually charge at home at night. And they only use the public chargers if they run out."[49]

3.2(c) Conclusions

As the previous section demonstrated, most PGE customers lack the awareness of electric vehicles needed to lead them to consider purchasing an electric vehicle. Furthermore, the presence of visible public charging infrastructure can significantly increase customers' awareness of electric vehicles and likeliness to purchase an EV. Reliable and accessible charging infrastructure can also improve the experience for new and existing EV drivers, key advocates for the proliferation of the technology. Moreover, anecdotal experience and demonstrated disincentive are making the purchasing experience at an auto dealership less than ideal for prospective EV drivers. Our program proposals (Section 5) focus in part on solving these

---

[47] Tesla DCQC Study (8,9 or 10 on 1-10 scale) (June 27, 2016)
[48] http://cubpolicycenter.org/pdfs/FNL_EVReport_v2.pdf
[49] Crane, David. (former NRG CEO) https://neo.ubs.com/shared/d1fdPUvVCxKZzcS/

problems, and leveraging the automakers' work in expanding vehicle range and decreasing vehicle cost.

3.3. Foreseeable Changes to the EV/Mobility Marketplace

3.3(a) Mobility Transformation

Amory Lovins argues that we are moving from "PIGS – Personal, Internal combustion, Gas-powered, Steel-dominated vehicles to SEALS – Shareable, Electrified, Autonomous, Lightweight, Service vehicles."[50] For the majority of the past century in the United States, mobility has been dominated by individuals driving internal combustion, gas-powered vehicles for their own personal use. In Oregon, 3.1 million licensed drivers operate 3.2 million registered passenger vehicles.[51,52] People drive and maintain their vehicle, which sits stagnant when not in use – the vast majority of the time. Service vehicles – public transit and commercial fleets – are the exception, rather than the rule. Nearly all of these vehicles depend upon gasoline or diesel to power their drivetrain. Historically, steel has been the material of choice; its strength has been prioritized above its heaviness.

However, this historic approach is being disrupted by the convergence of the electric, mobility, and information technology industries. Consumers are transitioning from personal ICEVs into shared, electric, autonomous, light-weight, service vehicles:

> *New materials will revolutionize the design and refurbishment of vehicles. Most importantly, this means the development of a carbon fiber material that makes cars lighter and more energy efficient, therefore making the broader adoption of electric vehicles a reality.*
>
> *Business models for urban transport will change rapidly. Presently, private, gasoline-powered, steel-made cars are the status quo. In the future, however, electric, autonomous driving will dominate with lightweight vehicles shared by many. Mobility will be provided as a service. E-cars will not just be "other" cars. Completely new business models will arise, quickening the pace of the transition. The pace of change will thus be dictated by newcomers, not by incumbents. Investors will invest their money in who they expect to be the winners of tomorrow, and divest from the losers.*[53]

Through choice or necessity, Portland residents are already making the transition. Companies like TriMet, Car 2 Go, Get Around, Reach Now, Uber, and Lyft are making it simpler and more

[50] Amory Lovins, "Disruptive Oil and Electricity Futures," Stanford Precourt Institute for Energy, October 13, 2015 https://www.youtube.com/watch?v=v02BNSUxxEA
[51] https://www.oregon.gov/ODOT/DMV/pages/news/factsstats.aspx
[52] https://www.oregon.gov/ODOT/DMV/docs/stats/vehicle/2015_Vehicle_County_Registration.pdf
[53] Amory Lovins, et al. Transforming the Transport Sector Towards a Fossil Fuel Free Future. March 18, 2016. http://ecologic.eu/13601

cost effective for residents not to own a car, but rather subscribe to transportation services from these emerging transportation service companies. As battery prices continue to decline and public charging infrastructure proliferates, these fleets will likely electrify; the long distances driven within urban environments makes electricity the most cost-effective fuel.[54] These existing service providers are likely just a small subset of what to expect in the future. Ford has launched a car-sharing service, GoDrive, and is investing heavily in autonomous mobility, ride-sharing, and car connectivity through its subsidiary, Ford Smart Mobility.[55,56] Tesla, Google, Apple, BMW, GM, and other industry players have all announced plans for supporting an autonomous vehicle share program of one form or another.[57,58,59,60]

> *RMI projects $2.8Bn of investment in autonomous mobility in the Portland Metro area by 2025. Economics will impel automated service providers to deploy electric autonomous vehicles (EAVs). Qualitatively, an ideal market would be a large, dense metro area with a tech-savvy populace, little or no snow (some autonomous vehicle technologies currently struggle in the snow), and a political and regulatory environment friendly to autonomous vehicles. This could lead to commodity mobility service dropping below operating cost of a personal vehicle, to around $0.30 per mile. This means that taking a commodity mobility service could cost less than gasoline and parking for a personal vehicle.*[61]

As these distributed fleets of shared electric vehicles proliferate, the role of the electric company is pertinent to ensure that the centralized "charging depots" are well-sited and integrated to ensure positive grid impacts.[62]

Almost 400,000 people have put $1,000 deposits down to reserve a $35,000, 200+ mile range Tesla Model 3.[63] Chevy just launched the all-electric Bolt EV with a range of 238 miles and a

[54] http://www.mckinsey.com/industries/high-tech/our-insights/disruptive-trends-that-will-transform-the-auto-industry
[55] https://www.theguardian.com/technology/2016/sep/12/ford-motors-selfdriving-car-uber-google
[56] GTM: How to accelerate EV market 2016 https://www.greentechmedia.com/articles/read/how-to-accelerate-the-electric-vehicle-market
[57] http://insideevs.com/google-reveals-electric-self-driving-car-video
[58] http://www.investors.com/news/technology/apple-car-moving-forward-direction-unknown/
[59] https://www.wired.com/2016/09/self-driving-autonomous-uberpittsburgh
[60] GTM: How to accelerate EV market 2016 https://www.greentechmedia.com/articles/read/how-to-accelerate-the-electric-vehicle-market
[61] Walker, Jonathan and Charlie Johnson. Peak Car Ownership: The Market Opportunity of Electric Automated Mobility Services. Rocky Mountain Institute, 2016. http://www.rmi.org/peak_car_ownership
[62] 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.
[63] http://www.theverge.com/2016/4/21/11477034/tesla-model-3-preorders-400000-elon-musk

price point of about $30,000. [64] Larger and more affordable batteries [65] and more affordable electric vehicles are the start of a major shift towards broader transportation electrification—a diverse array of vehicles has already started to hit the market and is expected to proliferate rapidly in the coming years:

> *The diversity of vehicle types is also expanding rapidly, from larger passenger vehicles to industrial equipment, electric transit buses, autonomous vehicles, and electric assist bicycles and scooters. The growing diversity of electrified vehicle types creates new opportunities, and Drive Oregon has been working aggressively to make Oregon an epicenter for all forms of electric mobility*[66]

In 2011, there were just 3 commercially available plug-in electric vehicles. Today there are more than 25.[67] With low-cost, 200+ mile range vehicles imminent, industry players are already planning how to charge those vehicles at a pace that customers will accept. USDOE, NREL, and industry partners are developing a technology roadmap to develop vehicle charging standards and equipment up to 350 kW. The effort will require active participation from utilities, regulators, vehicle & charger OEMs, battery supplies, and codes & standards bodies. [68]

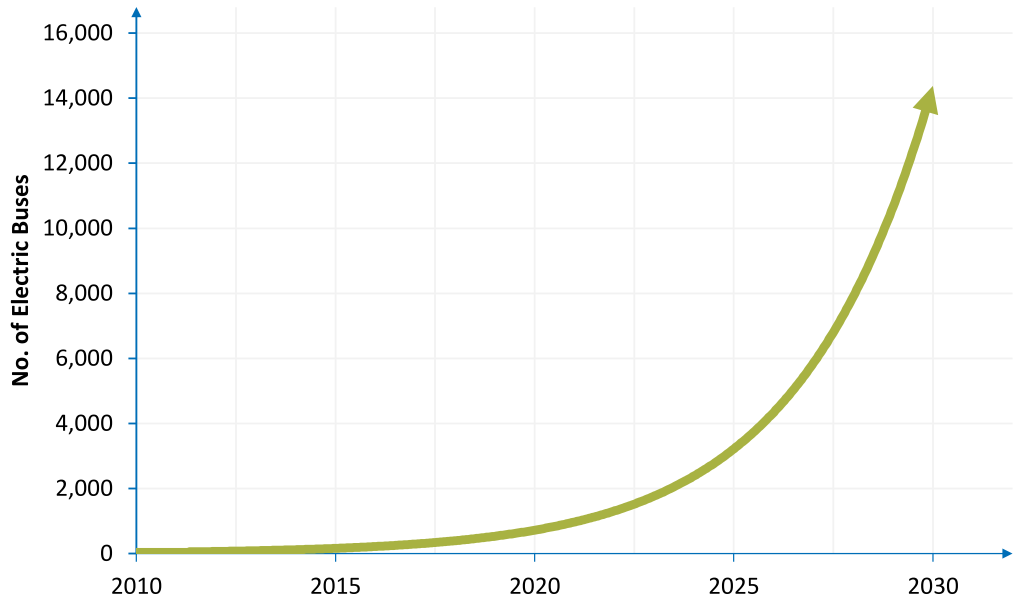
3.3(b) Bus Electrification

TriMet operates 654 buses in and around PGE's service area responsible for 23 million vehicle miles, 292 passenger miles, and 62 million boarding rides in 2015. Today TriMet spends over $170M annual on bus operating costs.[69,70] TriMet has expressed interest to electrify their fleet of buses in order to reduce operating costs, environmental impacts, and noise pollution of fleets. These benefits are not specific to TriMet; they could apply to any bus operator (transit, bus, etc.). A recent Forbes article explained that the nation's bus fleet may be one of the first to wholly electrify. CALSTART, an organization committed to supporting the clean transportation industry, projects 20x growth in the US electric bus fleet by 2030:

---

[64] http://www.greencarreports.com/news/1106042_2017-chevy-bolt-ev-electric-car-238-mile-epa-range-rating-119-mpge-combined
[65] https://www.greentechmedia.com/articles/read/How-Soon-Can-Tesla-Get-Battery-Cell-Cost-Below-100-per-Kilowatt-Hour
[66] Drive Oregon Charging Oregon's Future 2016
[67] GTM: How to Accelerate EV Market (2016)
[68] Michaelbacher, Christopher. *Enabling Xtreme Fast Charging: A Technology Gap Analysis of Charging up to 350kW*. Presentation 9/21/16.
[69] TriMet Bus Fleet Management Plan (November, 2016)
[70] https://trimet.org/about/pdf/trimetridership.pdf

Figure 7: US Zero Emission Bus Population Projections (USA)



"In total, commercial operators or municipalities can save more than $400,000 per vehicle over its lifetime in fuel and maintenance."[71] In addition noise and air quality agencies are also looking at opportunity to protect against fuel price volatility and to create opportunity to power its fleet with renewables.[72,73] The business case for fleets converting to electric buses is clear and will inevitably have an impact on the utility industry.

Due to the high power nature of bus chargers (often > 300 kW), unmanaged bus charging infrastructure could potentially have negative impacts to the local distribution system and have negative impacts on peak generation periods. However, there is opportunity if properly managed to utilize the large storage capacity of these buses to actually support grid operation: demand response, frequency regulation, renewables integration, V2G, etc.[74,75]

[71] http://www.forbes.com/sites/lianeyvkoff/2016/09/12/in-the-race-to-full-electrification-buses-may-take-first-place/#502abc385693
[72] http://www.vineyardtransit.com/Pages/VTA_BBoard/I056A90F2.0/VTA%20Final%20Report%20Alternative%20Fuel%20Study.pdf
[73] http://www.schoolbusfleet.com/article/713421/can-electric-school-buses-go-the-distance
[74] https://www.greentechmedia.com/articles/read/nations-first-all-electric-school-bus-hits-the-road
[75] http://www.calstart.org/Libraries/Publications/Electric_Truck_Bus_Grid_Integration_Opportunities_Challenges_Recommendations.sflb.ashx

Section 4. 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.*[76]
>
> *"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."*[77]

At its core, PGE provides its customers with safe, clean, affordable, reliable service; this is achieved through effective customer engagement, strategic asset management & 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.

4.1. Outreach & Education

As indicated in Section 3.2., we recognize that there are many barriers to EV adoption in our service area that we can serve break down:

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

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

[76] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).
[77] http://www.utilitydive.com/news/california-regulators-approve-sce-pilot-to-build-1500-ev-charging-stations/412240/

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.

4.2. 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.[78]

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.[79]

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.*[80]

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

---

[78] https://oregoneconomicanalysis.com/2012/02/13/self-service-gas-and-taxes/
[79] Hajjar, Norman, New Survey Data: BEV Drivers and the Desire for DC Fast Charging, Plug Insights, March 11, 2014
[80] Baumhefner, Hwang, Bull. NRDC. Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles (2016).
[81] 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.

- As discussed in Section 3.1, 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. [82]

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

---

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

4.3. 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.*[84]

> *Charging EVs during hours when the grid is underutilized increases utility revenues without commensurate increases in costs, putting downward pressure on electricity rates.* [85]

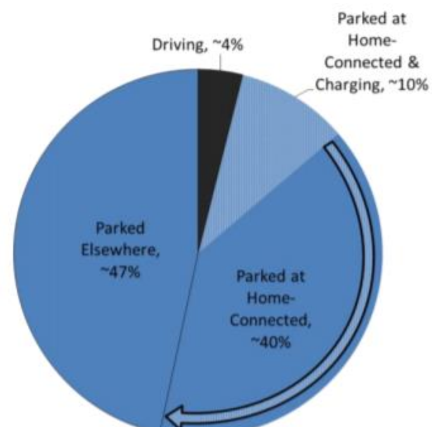


Figure 8: The time PEVs need to charge to meet mobility needs may be shifted throughout the time they are connected at home to accommodate grid operations (CPUC)

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.[86] 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:

[84] 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.

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

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

Table 6: Grid Services that Electric Vehicles Could Potentially Provide, By Grid Segment (modified from NRDC)[87]

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.

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

4.4. 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.

4.5. 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 5 fairly and effectively "accelerate transportation electrification" as outlined by law.[88]

[88] Chapter 28, Oregon Laws 2016.
https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2016orLaw0028.pdf

Section 5. 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.

5.1. Outreach, Education, and & Technical Assistance

5.1(a) Project Description and Objectives

As indicated in Section 3.2, 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.[89] Currently the automotive industry spends less than 1% of its $40 billion advertising budget to promoting electric vehicles.[90] We believe a strategic outreach plan can increase awareness of the benefits 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.*[91]

5.1(b) Proposed Plan/Key Elements

Partnership-driven approach

To make the most efficient use of funds, we plan on collaborating with our customers, industry partners, and other electric companies, to reach more customers with less. As a content-creator, PGE can disseminate EV educational materials through our existing channels as well as through partner channels to touch a wider range of customers at a lower cost.

---

[89] 2014 PGE Customer Survey
[90] http://adage.com/article/btob/global-ad-spending-average-4-2-year/298980/
[91]http://tdworld.com/site-files/tdworld.com/files/archive/tdworld.com/go-grid-optimization/transportation-electrification.pdf

Key partnerships include:

- **Builders:** to make a home “EV Ready”, a builder simply needs to install a 240V outlet (or conduit for one), just like the one used by most commercially-available dryers. 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.
- **Government agencies & sustainability bureaus:** We believe our goals are well-aligned with many government agencies (e.g., City of Portland, see Section 8.4). PGE will look for opportunities to collaborate on government-sponsored events and provide content for outreach materials.
- **Ride & Car Share Companies:** PGE is actively working with transportation network and car share companies to create channels 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 for including educational materials about EVs inside the car. We also believe this channel can potentially feedback data that could help inform charger siting, pricing, or other program designs.
- **Non-Governmental Organizations (NGOs):** PGE will provide content (i.e. mailer inserts or flyers) for NGO partners to distribute to their members to target customers who may have a high likelihood to consider an EV (i.e. members of environmental NGOs).
- **Auto Dealerships:** as indicated in Section 3.2(a), dealers can make or break a sale, so it is critical to keep them engaged, educated, and motivated. PGE will provide regular training/workshop sessions for dealership sales staff on charging infrastructure, PGE’s whole-home TOU programs (and the economic benefits for their customers), EV benefits, etc. For participating in our events and closing EV sales, we will offer quarterly or annual awards funded by shareholders. Awards would be provided for top sales staff or organizations who actively participate in trainings and workshops.
- **Other electric companies:** To the extent we and other electric companies see opportunity and value for our customers in outreach beyond service area boundaries (e.g. regarding travelling in an EV & access to public charging stations, etc.), we may commit some resources to collaborative regional outreach with neighboring electric companies. Additionally, we will explore opportunities to collaborate with utilities in the region on market transformation for vehicles and charging equipment.
- **Drive Oregon:** PGE is excited that Drive Oregon has recently won a $1 million grant to launch innovative regional marketing campaigns to engage consumers and promote the benefits of electric vehicles. We intend to create educational materials for their showroom in the World Trade Center and support events such as brand-neutral ride and drives to help expose customers to the excitement and experience of driving electric. By collaborating with Drive Oregon and other stakeholders we can effectively amplify the messaging around the benefits of EVs, encourage more drivers to sit behind the wheel, and ultimately drive adoption of the technology.

We believe that by working with these partner organizations, collectively we can extend the reach of our outreach funding and most effectively promote adoption of electric vehicles.

Leverage Existing Channels

In addition to creating content for partners to distribute, PGE will also utilize existing customer outreach channels. New content will be created for bill inserts, newsletters, web, videos, social media, and charger/vehicle wraps. By creating common messaging, we can drive home awareness of the benefits of electric vehicles and increase adoption of the technology.

Content Creation & Limited Paid Advertising

Much like PGE does with safety and energy efficiency and renewable campaigns, we believe that strategically targeted advertisements could be effective in lifting overall awareness of transportation electrification. We are proud of our role in leading our customers to create the nation's top green power program, which has been a product of our direct marketing efforts (i.e. print collateral, tabling events, direct customer outreach, etc.).[92] We believe we can build on these successes to increase awareness and adoption of electricity as a transportation fuel.

Technical Assistance

Today, PGE provides technical assistance on request to customers looking to install, site, or plan for electric vehicle infrastructure. Though no formal program, marketing collateral, or dedicated staff exists, we have served dozens of customers in the charging infrastructure or technical expertise they need. This work will continue and rise in importance as electric vehicle options grow and more workers expect charging infrastructure at their workplace. Some recent efforts include our work with EcoCab and the City of Portland on deploying EV charging infrastructure. We heard from stakeholders at our October 13th workshop that this service is valued, necessary, and should be expanded through our works on transportation electrification. We intend to take this opportunity to expand our technical assistance offering by:

- Dedicating and training a significant portion of the new staff resource to support EV technical assistance for commercial, industrial, and transit customers (in addition to utilizing existing staff resources);
- Developing targeted web content, outreach collateral for large customer service managers, and standard processes for scheduling a site visit;
- Continuing to provide siting assistance for customers, prospective customers, and EVSE service providers, small businesses, etc.

---

[92] http://apps3.eere.energy.gov/greenpower/resources/tables/topten.shtml

5.1(c) Smart Charging & Time of Use (TOU) Rates

We believe this effort creates a renewed opportunity to engage our customers in the benefits of TOU rates as well as smart charging. 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.*[93]

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.

5.1(d) Deployment Schedule

Upon plan acknowledgement, 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 take 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.

5.1(e) Budget

PGE proposes $600,000/year for five years be allocated for an outreach and technical assistance pilot. The budget includes the content creation, print & digital publishing, limited paid advertising, and technical assistance activities outlined this section and 1 FTE to manage the initiatives, partnerships, and engage in customer technical assistance. Less than 10% of the total pilot budget would be spent on paid advertising.

5.1(f) Evaluation, and Metrics

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 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.

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

- The major challenges commercial and industrial 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:

Some of the components' impact on customer adoption is large and concentrated enough to be directly measured – for example, surveys of customers served by technical assistance and the Drive Oregon showroom will provide useful metrics of those channels' effect on customer vehicle purchases.

We plan to survey customers on their awareness of electric vehicles and their exposure to our electric vehicle marketing campaigns. This will provide important data in case impacts are difficult to tease out from market-level sales data analysis. We will also ask customers whether marketing influenced their purchase as an indicator of marketing effectiveness.

We plan to deploy survey instruments to a variety of populations, including:

- Recent EV purchasers
- 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 5.5.

5.2. Electric Mass Transit 2.0 (TriMet pilot)

5.2(a) Background

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 100,000,000 trips annually, including 45% of downtown Portland commuters.[94] 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.[95,96] 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).

Electrifying a transit fleet is a complicated undertaking. 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.[97]

Additionally, electric buses require distribution system integration planning because electric buses typically utilize ultra-high-speed fast chargers (>300 kW). These chargers must be installed en-route in a location suitable not only for intermittently supplying high-power electricity but are also convenient for drivers to take breaks near their routes.

Due to the complexities presented by electrifying bus transit, TriMet applied for federal grant funding to cover the incremental cost of five new electric buses. This grant provides an opportunity to begin learning about how to plan for electric buses, operational considerations, driver impacts, and customer impacts. In August, 2016, Trimet received a $3.4 million grant from the Federal Transit Administration (FTA) to purchase 4 electric buses, 4 depot chargers, and 1 en-route charger.[98]

Though TriMet's grant includes funding for charging infrastructure, TriMet has expressed that they welcome PGE's partnership in owning, operating, and maintaining charging infrastructure. Bus charging infrastructure, particularly en-route chargers are 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.

---

[94] http://trimet.org/whytransit/index.htm
[95] http://www.oregonlive.com/commuting/index.ssf/2015/10/trimet_shows_off_new_generatio.html
[96] https://trimet.org/about/pdf/trimetridership.pdf
[97] TriMet Bus Fleet Management Plan (November, 2016)
[98] http://news.trimet.org/2016/07/trimet-awarded-3-4-million-federal-grant-to-buy-its-first-electric-buses/

5.2(b) Project Description and Objectives

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

- help accelerate bus electrification; and
- begin evaluating distribution 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 engaged FTA to receive permission 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 of new conduit across Merlo Road from PGE transformer to TriMet property;
- Installation of a transformer pad and a 500 kV transformer to serve new load;
- Installation of five (5) 100 kW bus chargers in TriMet's garage;
- Distribution upgrades to support en-route charger; and
- Installation of one (1) 300 kW en-route charger.

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.

Billing & Metering

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.

Maintenance

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.

Integrated Electric Transportation- Planning

As suggested above, electric mass transit creates a unique challenge to 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 intends to support working 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.

Our initial deployment with TriMet will include time of day rates with demand chargers (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.

Storage Integration

HB 2193 mandates PGE to install 5 MWh of energy storage in the service area by 2020.[99] We believe there may be an opportunity in making elements of both the storage mandate and the transportation electrification plan work together. By strategically locating a bus en-route 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.[100,101,102,103]

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.

---

[99] https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/HB2193

[100]https://www.greentechmedia.com/articles/read/HECO-Tests-Batteries-to-Enable-DC-Fast-Charging-And-Avoid-Grid-Upgrades

[101]https://chargedevs.com/newswire/stationary-storage-system-enables-a-quick-charge-without-straining-the-grid/

[102] Bayram et al. Strategies for Competing Energy Storage Technologies for DC Fast Charging Stations. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6485950

[103]http://www.calstart.org/Libraries/Publications/Peak_Demand_Charges_and_Electric_Transit_Buses_White_Paper.sflb.ashx

Intended Learnings

Through the pilot project, PGE hopes to learn:

- The impacts on PGE's distribution system and non-coincident peak loads of depot chargers. 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 peak demand impacts of high-powered bus charging.
- What (if any) additional infrastructure is 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.

5.2(c) Deployment & Evaluation 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. As such, we are seeking approval for this pilot in early 2017—a delay in approval on this pilot could jeopardize TriMet's grant funding.

Figure 9: TriMet's Grant Schedule

Task	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	1/3/2017	8/31/2019

5.2(d) Vendor Selection Process

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, however, 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.

5.2(e) Pricing and Economic Analysis

PGE would 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. TriMet will pay the applicable tariffed rate for electricity from the charging stations.

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

5.2(f) Equity, inclusion, and low income

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."[104] 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.

5.2(g) Barriers & 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 any 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.

[104] 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

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, we and TriMet believe that the vendor is committed to making sure their product is reliable for TriMet's needs.

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.

5.2(h) Research Question, Evaluation, and Metrics

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. 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.

5.3. Electric Avenue Network (Community Charging Pilot)

5.3(a) Project Description and Objectives

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.

Figure 10: Electric Avenue (World Trade Center)

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

- **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;[105,106,107]
- **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;
- **Empowering 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.

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

[106] New Car Buyers' Valuation of Zero-Emission Vehicles: Oregon (2015 UC Davis)

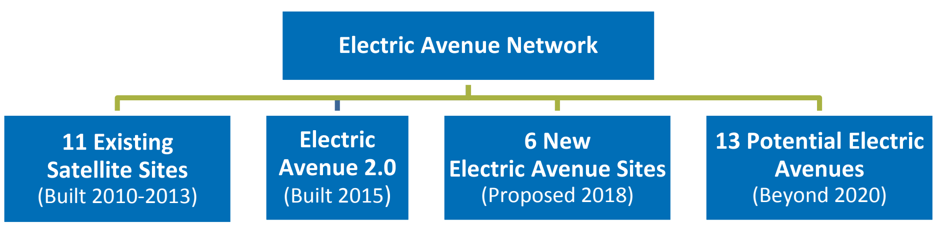
[107] Li, S. et al., "The Market for Electric Vehicles: Indirect Network Effects and Policy Impacts," Cornell University, June 2015.

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 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 11: Electric Avenue Network Deployment Overview



5.3(b) Proposed Plan/Key Elements

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 & 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.[108]

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.

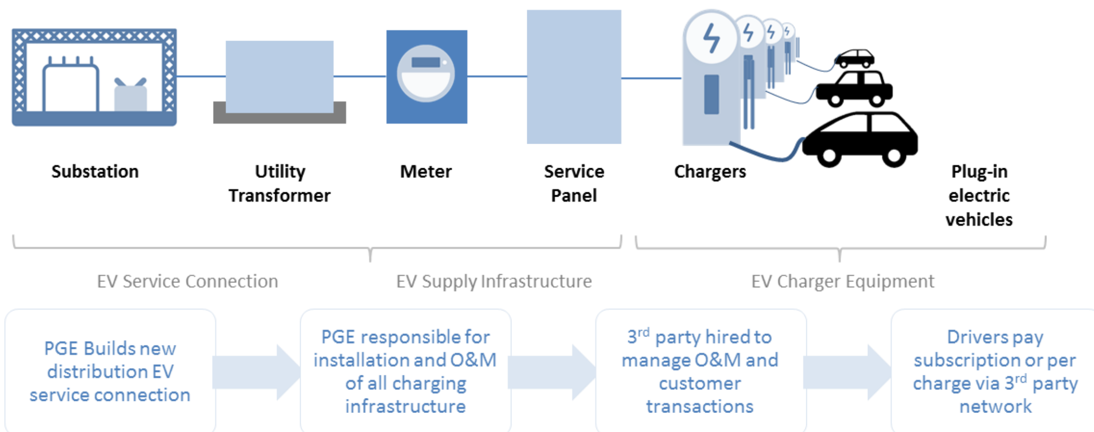
Though the Electric Avenues may be sited on PGE-owned or 3rd party locations, PGE anticipates contracting for services such as installation, operations (i.e. payment processing), and equipment maintenance. PGE has been involved with many of the charging infrastructure projects in Oregon that were a product of federal and private funding to 3rd parties to install public charging infrastructure. Unfortunately, some of the 3rd parties have gone out of business[109] or have changed business focus which left many stations abandoned, with poorly maintained equipment. 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 acknowledged, PGE has recently issued a Request for Information to EVSE manufacturers and

[108] http://www.openchargealliance.org/protocols/ocpp/ocpp-16/
[109] http://www.huffingtonpost.com/2013/10/13/electric-car-charger_n_4086326.html

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 12: Electric Avenue Design



Incorporation of Existing Infrastructure

As indicated in Section 1.4, PGE currently owns 11 charging sites that resulted from our Schedule 344 Pilot Rider.[110] 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 7: 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

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

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.

Billing & 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 a fixed charge when using the charging station. 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 to cover fixed administrative and system costs required to serve this driver.

   To send appropriate pricing signals and to discourage on-peak charging, all customers on either payment plan will 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).[111] *By using this schedule year-round, we believe this will simplify customer education, signage development, and program administration.*

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

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

Table 8 illustrates our preliminary pricing model:

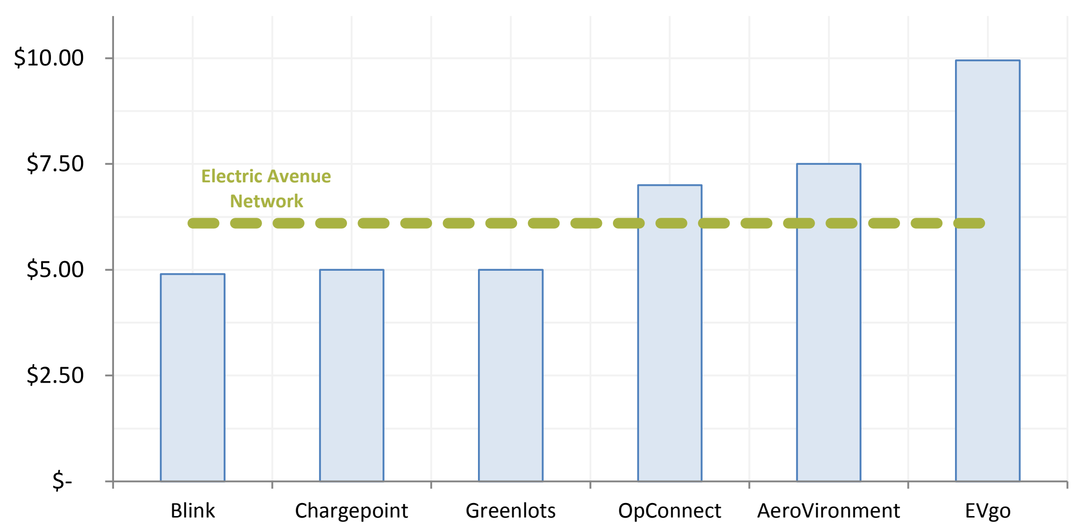
Table 8: Proposed Electric Avenue Network Charging Pricing

	Monthly Fee ($/mo.)		Fixed Charge ($/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.*

Additionally, the final units used for pricing (i.e. $/min, $/kWh, $/charge, etc.) may be modified or adapted based on on-going customer research. We are currently conducting research with customers to determine optimal pricing structures for accelerating transportation electrification. It is our intent to offer pricing that encourages customer adoption but that also aligns with the existing charging market. In developing our pricing structures, we analyzed publically available charger pricing data to estimate average customer costs for utilizing public charging infrastructure:

Figure 13: Comparison of Market Rates for Public Quick Charging[112]



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

As illustrated in Figure 13, the proposed Electric Avenue Network is not meant to undercut market rates but to be in the middle of it.

For the initial deployment, we believe it is advantageous and necessary to offer simple, easy to understand rates for participants (and for dealers to help explain to prospective buyers). Specific pricing strategies deployed will be informed by direct consumer feedback at the Electric Avenue sites and through customer surveys. The intent here 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 of dynamic pricing will create a foundation that we can apply to future public charging sites.

Intended Learnings

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.
- What (if any) additional infrastructure is 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.

5.3(c) Pilot Cost and Economic Analysis

We estimate the total cost of the pilot to be $3.9M 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.

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

5.3(d) Deployment & Evaluation Schedule

Construction of 6 Electric Avenues

Upon proposal acknowledgement, 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. 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*

We anticipate site selection (site solicitation, site permitting & franchise agreements, etc.) to take 3-6 months. 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 3 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 as the 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.

Site Selection Criteria

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.

5.3(e) Vendor Selection Process

A competitive process will be used for:

- Charging equipment & 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.

5.3(f) Barriers & 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 & 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.
- **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 O&M 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 do 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 & 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.[113]

5.3(g) Research Question, Evaluation, and Metrics

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)

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

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, & Technical Assistance pilot is covered in Section 5.5.

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.

5.4. Research, Development, and Small Pilot Projects

Research, development, and small pilot projects are important elements of PGE's smart grid strategy—they allow us to test new concepts, learn how new technologies work, and establish best practices. These initiatives contribute to the development of larger pilots and successful program deployments in the future.

5.4(a) Employee Research Pilot

Project Description and Objectives

To date, PGE has over 80 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/when people charge, how TOU rates impact home charging habits (and use of other appliances in the home), impacts of curtailing charging loads at home and work.

Proposed Plan/Key Elements

- **Time of Use:** 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 premise.[114] As such, half of the participating employees have been randomly selected to be put on Schedule 7's whole-home TOU rate which offers customers savings of greater than 40% for shifting energy consumption to off-peak hours.[115,116] 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. Additionally, we will directly engage with several employees to program 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

---

[114] 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
[115] https://www.portlandgeneral.com/residential/power-choices/time-of-use/time-of-use-pricing
[116] https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_007.pdf

better understand what drives people to charge outside of the premise, how often they publically charge, where they charge, and how long they charge for.

- **Survey Data:** Additionally, PGE intends to use the employee group to periodically survey for EV-related insights.

The pilot cost is approximately $250,000 utilizing existing R&D budget and existing staff. PGE shareholders are also contributing up to $200,000 to encourage adoption of EVs.

5.4(b) Workplace Smart Charging Pilot

Project Description and Objectives

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 visibility.[117] USDOE supports this claim stating that "employees at participating workplaces are up to 20 times more likely to drive electric vehicles."[118] One interviewed customer actually cited workplace charging as the tipping point for going electric: "Seeing it at work made me think it was possible." [119] It is clear that there is a role for workplace charging, however, it does present a potential grid challenge as it could encourage charging during on-peak hours. (Depending on the emergence of solar energy, however, today's peak hours, could be tomorrow's off-peak.)

As indicated in 5.4(a), PGE has already commenced an employee workplace smart charging pilot at its own locations. We believe there's opportunity to extend this pilot to 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.

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

- **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.

Proposed Plan/Key Elements

In 2017, PGE intends to collaborate with 1-2 commercial or industrial 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 for 4 years. If the pilot proves successful, PGE may expand the pilot to additional customers in the service area.

The pilot will evaluate: achievable coincident demand reductions, reliability of demand reductions, customer experience (both facilities and end-use vehicle owners). The demonstration will cost approximately $50,000 but will utilize existing R&D budget and existing staff.

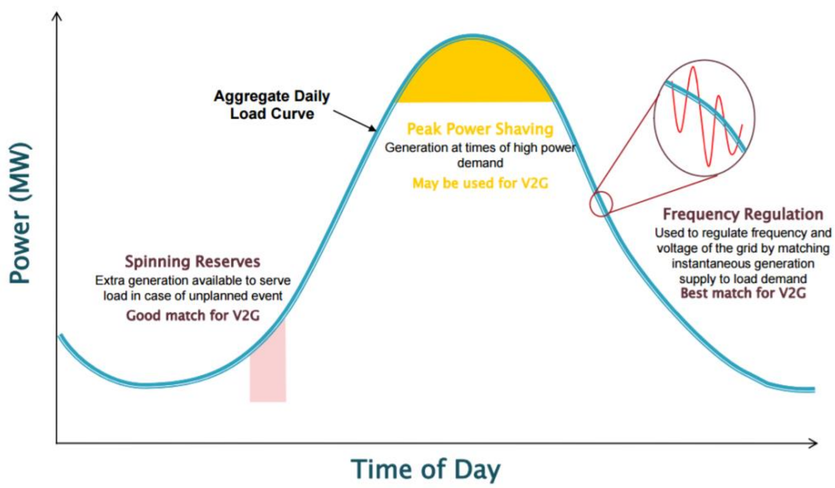
5.4(c) Vehicle-to-Grid Pilot

Project Description and Objectives

It is not unimaginable to think 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. To put that in perspective, PGE delivered 19,382,000 MWh of retail energy in 2015.[120] The large potential storage reservoir has the potential to provide a variety of vehicle-to-grid (V2G) applications (i.e. Vehicle-to-Home). V2G is used to describe that 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:

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

Figure 14: Visualization of Vehicle to Grid Use Cases[121]



Today, however, 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."[122] As such, no vehicles sold today are enabled for V2G use-cases (though often 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 A/S services if there is a risk of being stranded with a dead or worn out battery." [123]

Though V2G presents clear challenges, we feel that the opportunity it presents creates real potential value for low-cost grid benefit to all customers. As such, we are launching a V2G demonstration project with V2G-enabled Nissan Leaf and a 2-way charging station at a PGE site in late 2016/early 2017.

[121]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

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

[123](2015) Cooperative Research Network. *Managing the Financial and Grid Impacts of Plug-in Electric Vehicles*

Proposed Plan/Key Elements

The demonstration project is a partnership with Nissan and will utilize 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 utilized at the V2G pilot at Los Angeles Air Force Base). 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
- Long-term we hope the learnings will inform pilot design with long-term parking sites in our service area (i.e. 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.

The project cost is approximately $50,000 utilizing existing R&D budget and staff.

5.4(d) Bring Your Own Home Charger Pilot

Project Description and Objectives

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.[124] A pilot would offer incentives to customers who have or purchase a qualifying DR-enabled home charger.

Proposed Plan/Key Elements

The pilot will evaluate: (1) what tactics achieve program participation, (2) how much load can feasibly be shed during peak events, (3) technical & OEM viability, (4) attrition, and (5) cost-effectiveness.

- **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

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

technical viability and customer value, we will evaluate expanding to other OEMs and hardware.

- **Incentives**: major differences between home charging stations 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).
- **Participation:** pilot participation will be limited to 200 customers at initial deployment.

We estimate this pilot project costing approximately $200,000 utilizing existing staff.

5.4(e) Low-Income Pilot

Project Description and Objectives

Based on the feedback from stakeholders at the November 7 low-income workshop, in which human service agencies highlighted that they are often spending a lot on transportation (either in cash or opportunity cost) because they do not have dedicated vehicles in their fleets. We believe there's opportunity for PGE to provide technical assistance to non-profits, negotiate discounted off-lease vehicles, and offer limited free charging infrastructure for agencies that pursue electric vehicles.

Proposed Plan/Key Elements

- **General Education**: PGE will 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 individuals that they serve. These workshops will also encourage agencies to enroll in technical assistance and/or charging programs. We think there's value in partnering with the Community Energy Project in training them to do these types of workshops in the future. Additionally, PGE will educate about opportunities where funding may be available (i.e. Renewable Development Fund for EV/renewable integrated projects, etc.).
- **Technical assistance**: PGE will provide dedicated staff time to provide technical assistance to non-profit agency customers. Technical assistance will include a transportation audit, evaluation of costs, and a business case for electric vehicles (if applicable). The intent will be to demonstrate to an agency how (if at all possible) they

can save money by having one or more electric vehicles in their fleet. The audit will evaluate mileage, use cases, charging feasibility, and environmental impacts.

- **Negotiated rates/donations from OEMs**: PGE will utilize OEM relationships to organized discounted purchase rates or possible donations for non-profit agencies in the service territory to buy off-lease EVs. Agencies can then leverage the transportation audit and the low rate to buy (or fundraise for) an electric vehicle.
- **Pilot charging program:** PGE will install, maintain, and operate level-2 charging infrastructure for up to 3 non-profit organizations 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. Additionally, as indicated in section 5.3(d), PGE will consider proximity to low-income multifamily when siting future Electric Avenue locations.
- **Promote EV Volunteerism:** This fall, PGE's employee EV group sponsored its first EV food-drive event. The event transported 435 lbs. of food using a fleet of employee EVs. PGE believes there's opportunity to promote similar volunteer efforts within the community. We will start using our employee EV group but expand to a broader community to reduce the environmental impact associated with volunteer efforts and raise awareness of EVs.

5.4(f) Research Question, Evaluation, and Metrics

Employee Research Pilot

The primary aim of the employee research pilot (Section 5.4(a)) is to provide PGE and stakeholders with information about how customers charge their vehicles and how rates programs impact charging behavior. We believe that by enabling smart charging and promoting the benefits of TOU that we can shift charging behaviors to more favorable times for the system. We will analyze the charging & AMI data for participants and use the outputs to inform other pilots. Additionally we will interview and survey employees to understand their experiences with the different rates, smart chargers, etc.

Workplace Smart Charging Pilot

We believe that by creating a workplace smart charging demonstration we can effectively curtail or shift charging loads to off-peak periods with limited impact to the end-use customers. We intend to analyze load profiles during DR events and to survey charger-users to understand the impact of the curtailment.

Workplace Smart Charging, Vehicle to Grid, and Bring Your Own Charger

We believe that workplace smart charging, vehicle to grid, and bring your own charger pilots 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, for the workplace pilot we intend to survey charger-users to understand the customer experience of having your charge curtailed while away from home.

Low-Income Pilot

We believe that by offering technical assistance and electric vehicle chargers to non-profits that support the low-income community, more organizations will embrace electric vehicles as a tool to improve their business practices. Information provided by the non-profits served will enable PGE and its evaluator to determine to what extent the vehicles would not have been bought without PGE's involvement. Charger data will enable us to determine how much the chargers are being used. Survey data will enable us to determine who is using the chargers.

5.5. 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.

5.5(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.

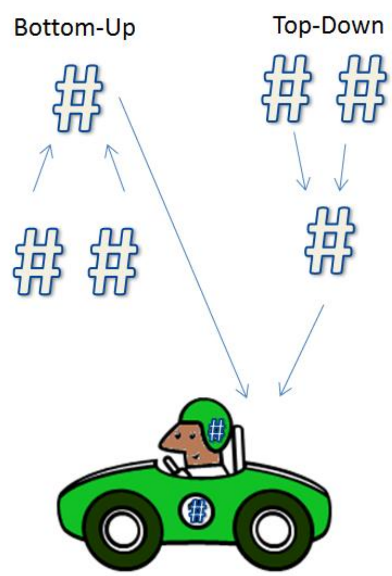


Figure 15: Bottom-up/Top-down Evaluation

For many of the pilots, estimating the impacts is fairly straightforward. In particular, the Electric Mass Transit 2.0 (Section 5.2) and Expanded Research, Development, and Small Pilot projects (Section5.4) have impacts that are mostly directly measurable. Those measurement techniques are described above in the pilot descriptions.

However, the Charging Station Network (Section 5.3) and Outreach, Education, and Technical Assistance (Section 5.1) 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 5. 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.

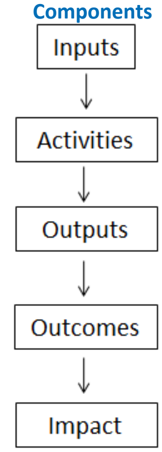
Realistically, it may be difficult to distinguish signal from noise in the early years of the pilots using the top-down approach, because the foreseen impacts are relatively small in the early years and the uncertainty in the forecast is relatively large. However, it is important to start the forecasting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

5.5(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:

Figure 16: Logic Model Components



- 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.

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.

5.5(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 biannual evaluation is $360,000.

Section 6. Pricing and Recovery

6.1. Retail Prices for Third-Party Owned Public Charging

Although it is widely recognized that a robust public charging network will help to spur the adoption of electric vehicles, significant questions remain regarding the role that standard-service utility prices can play in the viability of these public charging stations. In a 2015 white paper by the Idaho National Laboratory, the authors found that DCQC hosts whose host electric company assessed a demand charge on electricity sold to a public charging station (when a charger is coupled with the site host's original business service) could cause the host's utility bill to increase by as much as four times.[125] A utility may counter that nonresidential prices with a demand component incentivize efficient use of the grid and actually result in a price break for the site host as utilization of the charger increases (due to the lower energy charge that is associated with the presence of a demand charge). Further, the Idaho National Laboratory whitepaper analyzed several sample customers of different utilities and found that de-linking standard business service from DCQC service may be most advantageous in some cases. This high level of variability underscores the need for utilities and site hosts to work closely together to select the optimum rate for a DCQC customer.

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 PEV 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.

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

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

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.

EV Sub-metering

If the Customer chooses separately metered service for EV charging, the service may only be used for the sole purpose of EV charging. The Customer will install all necessary and required equipment to accommodate the second metered service. Further, Schedule 38 and Rule B (30) state that the separately metered EV service must have a network meter so that data collection and analysis can be conducted as follows: "Such service must be metered with a network meter as defined in Rule B (30) for the purpose of load research, and to collect and analyze data to characterize electric vehicle use in diverse geographic dynamics and evaluate the effectiveness of the charging station infrastructure."

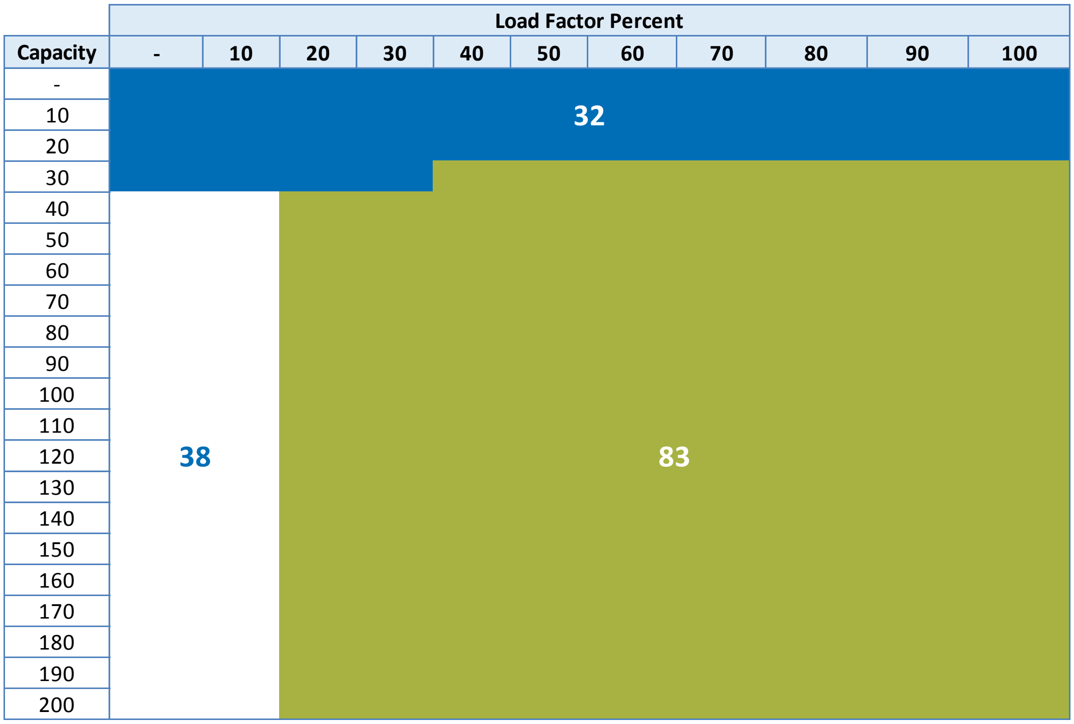
Structure of Demand Prices vs. Non-Demand Prices

Broadly speaking, both consumption (kWh energy) and demand (kW capacity) are part of many nonresidential electric customer bills. Due to the high variability of the capacity needs of commercial and industrial customers, demand charges serve to help the utility recover costs associated with keeping equipment such as substations, transformers, wires, and generation capacity on standby to meet the customer's peak needs.

From a customer perspective, demand charges send the price signal to use the system efficiently, and there is a linear correlation between higher load factor[126] and lower bills when a customer is on a demand-based rate. The challenge with this traditional utility pricing model is that DCQC infrastructure today typically operates at a load factor of ~7%, and newer DCQCs can have peak demands of >300 kW. As shown in Figure 17, PGE's non-demand price (Schedule 38) is the optimal pricing option for customers with load factors below 18%, and then once that threshold is crossed, a demand-based price becomes advantageous.

[126] Load factor is a measure of the efficiency of electrical energy usage, calculated by dividing the total energy [kWh] used in a billing period divided by the total possible energy used within a period [kW*total hours].

Figure 17: Tariff Pricing Optimization based on Capacity & Load Factor (Schedules 32, 28, and 83)



6.2. Current Industry Pricing Models

In states where electric companies currently own and operate charging infrastructure, there is significant variability in terms of the price at which electricity is sold to the EV driver, and the mechanism by which the utilities are able to set that price. In California (for San Diego Gas and Electric (SDG&E) and Pacific Gas and Electric (PG&E)), either the site host or the driver is able to utilize the utility's commercial (cost of serviced based) rate for service. However, in states such as Washington (Avista) and Hawaii (HECO), the utility, as a condition of owning the charging infrastructure, is asked to price DCFCs at the market price to promote competition. For the utilities in jurisdictions that utilize market pricing, they are instructed to check in periodically to show that their prices are not undercutting the other market participants who own DCFC infrastructure. PGE realizes that promoting and enhancing competition is an essential part of this program, and although we have priced our Electric Avenue pilot at a cost of service based rate as a learning opportunity as part of this pilot, the pricing for utilizing an Electric Avenue charger fall within the prices set in the competitive market as illustrated in Figure 13.

The ability of PGE to use a utility cost of service model to determine the Electric Avenue prices is an essential part of the learning anticipated from the pilot, as price elasticity and customer charging behavior in response to pricing signals will inform future decisions in the EV space. Any expansion of this pilot into a larger program would be subject to showing how competitiveness is not stifled.

Table 9: US IOU Public Charging Network Projects' Scope and Recovery

Electric Company	San Diego Gas & Electric	Pacific Gas & Electric	Southern California Edison	Avista	Hawaii Electric Company	Kansas City Power & Light
Charger Ownership	SDG&E Owned	PG&E Owned	Site Host Owned	Avista Owned	HECO Owned	KCP&L Owned
Price/ Rate Design	Choice of commercial rate to driver or site host	Choice of commercial rate to driver or site host	Site host pays commercial rate, sets pricing	Market-based rate on Avista owned chargers	Market-based rate	Currently no price; KCP&L filing for rate recovery
Scope	3,500 L1 and L2 at 350 sites	7,500 L1; 100 DCQC	1,500 L1 and L2	265 L2; 7 DCQC	Up to 7 DCQC	1,000 L2

6.3. Proposed Recovery Structure

Upon acknowledgement 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 of 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, and outreach and education costs associated with accelerating transportation electrification. Many of the small demonstration projects have been and will continue to be paid through existing budgets. Incremental costs of new small demonstration projects would be included in the deferral. 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 10.

Table 10: 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 & Technical Assistance	$ 2,427	-	$ 2,427
Electric Mass Transit 2.0	$ 1,239	$ 641	$ 598
Electric Avenue Network	$ 3,880	$ 3,547	$ 333
Small Demonstration Projects	$ 561	-	$ 561
Pilot Evaluation	$ 581	-	$ 581
Total	$ 8,688	$ 4,188	$ 4,500

Section 7. 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.

7.1(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.

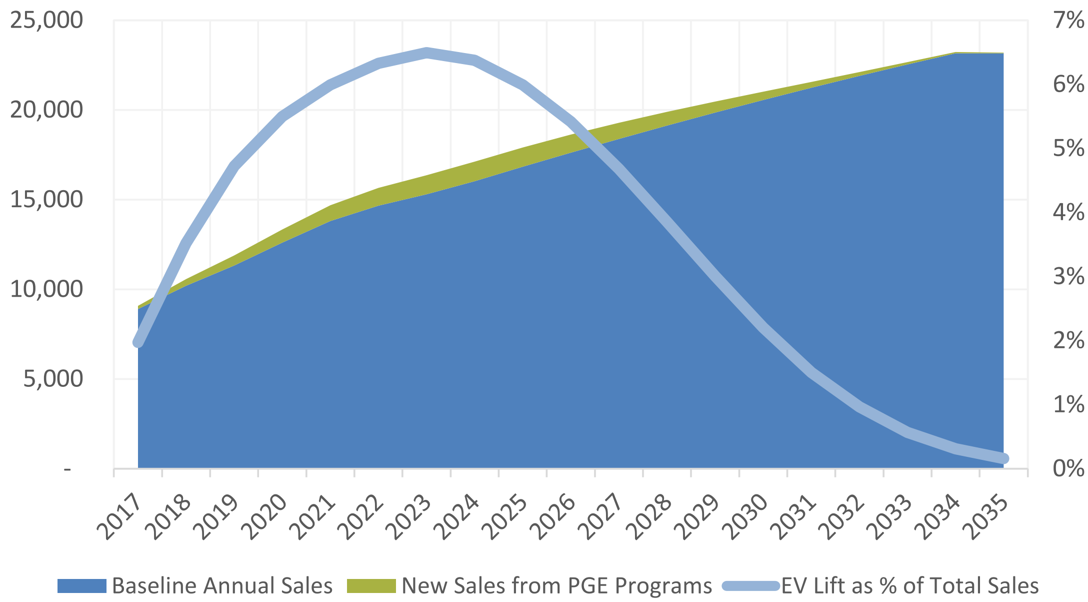
Navigant Research uses a technology competition model to forecast electric vehicle sales at the national level. The forecast model uses high-level macroeconomic factors like gross domestic product and population as well as vehicle density and historic sales data to project overall light duty vehicle 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 11:

Table 11: 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 18: EV Forecast (Baseline vs. Forecast)



As illustrated in Figure 18, 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.

7.1(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 & 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 & 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 & 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 12, 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 12: 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 & 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 & 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.

7.1(c) Environmental Benefits

As indicated in 7.1(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 13 illustrates a reduction of 655,000 short tons of CO_2 emissions through 2035 as a result of the incremental EVs attributable to these pilots:

Table 13: 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 (short tons CO_2)	Gas Alternative CO_2 Emissions (short tons CO_2)	Annual CO_2 Reductions due to PGE Pilots (short tons CO_2)
2017	179	0.82	291	1,109	818
2018	551	0.76	827	3,414	2,587
2019	1,113	0.76	1,641	6,896	5,255
2020	1,846	0.78	2,786	11,438	8,652
2021	2,726	0.71	3,680	16,890	13,210
2022	3,717	0.64	4,529	23,030	18,502
2023	4,780	0.67	5,945	29,616	23,671
2024	5,872	0.67	7,321	36,382	29,061
2025	6,945	0.70	8,851	43,030	34,179
2026	7,954	0.70	10,141	49,282	39,141
2027	8,857	0.70	11,209	54,877	43,668
2028	9,623	0.73	12,426	59,623	47,197
2029	10,238	0.73	13,240	63,433	50,193
2030	10,701	0.72	13,431	66,302	52,871
2031	11,025	0.72	13,752	68,309	54,557
2032	11,238	0.72	13,882	69,629	55,747
2033	11,367	0.72	13,880	70,428	56,549
2034	11,439	0.73	13,911	70,874	56,964
2035	11,476	0.42	7,971	71,104	63,132
**Assumes 13,500 VMT/vehicle/year.* [127]			**Total CO_2 Reductions (2017 – 2035)**		**655,955**

[127] 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 8. Other Related Efforts

8.1. Low Carbon Fuel Standard (LCFS)

8.1(a) Background

The 2009 Oregon Legislature passed HB 2186[128] 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[129] 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[130] – as filed with the Secretary of State.[131] 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.

8.1(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.

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

- 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.
    - 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 acknowledgement 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.
- PGE is able to register as a credit generator for our own Electric Avenue facilities, and we will consider this action when the facilities are built, if approved under this Plan.
- Finally, not registering to be a credit aggregator in 2016 does not prohibit us from registering in 2017. We hope that with another year of the program and with potential experiences of third-parties to learn from, PGE will be in a better position to judge the costs and benefits of registering as an aggregator for the 2018 calendar year.

8.1(c) 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.

8.2. 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.[132]

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.

8.3. 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.[133]

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.[134] The decree allows that 15% of the total funds

---

[132] http://www.deq.state.or.us/aq/orlev/
[133] http://www.deq.state.or.us/aq/vwsettlementfs.pdf
[134] 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.[135]

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). PGE views any funding from VW as supplemental, and any charging infrastructure that may be installed as augmenting those that are proposed by PGE in this filing. Future transportation electrification plans and updates will account for industry changes attributable to the distribution of VW settlement funds.

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

8.4. City of Portland EV Strategy[136]

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.[137]

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 & Technical Assistance, Electric Mass Transit, and Electric Avenue pilots.

[136] https://www.portlandoregon.gov/bps/article/619275
[137] https://www.portlandoregon.gov/bps/article/621016

Section 9. 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 $8.7M 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 $5.3M 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	

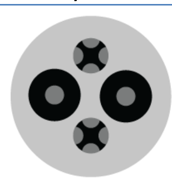
Electric Mass Transit Pilot

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	

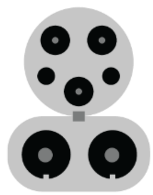
Appendix 2. Basic Transportation Electrification Terminology

Note: Terms and descriptions below complied from a variety of sources.[138,139,140]

Table 14: 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.

138 http://www.afdc.energy.gov/vehicles/electric.html
139 http://www.openchargealliance.org/about/appraisal/
140 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

Appendix 4. Cost Effectiveness Analysis (Navigant Whitepaper)

NAVIGANT

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

Presented by:

Navigant Consulting, Inc.

1375 Walnut Street, Suite 100

Boulder, CO 80302

303.728.2500

navigant.com

Table of Contents

Executive Summary 1
Section I Introduction and Background 4
Section II Methodology 4
2.1 Overview of Methodology 5
2.2 Baseline Electric Vehicle Forecast 7
2.3 Transportation Electrification Program Impact 8
2.3.1 Education and Awareness Program 8
2.3.2 Community Charging Infrastructure Program 10
2.3.4 Electric Mass Transit 2.0 Program 11
Section III Results 12
3.1 Electric Vehicle Market Impacts 13
3.2 Rate Impact Measure (RIM) Test 15
3.3 Total Resource Cost (TRC) Test 17
3.4 Societal Cost Test (SCT) 18
3.5 Electric Mass Transit 2.0 Program Results 20
Section IV Conclusions and Directions for Future Research 23
Appendix A. Cost Effectiveness Framework Definitions 24
Appendix B. Visual Overview of Electric Vehicle Forecast Methodology 25
Appendix C. Stakeholder Workshop #1 28
Appendix D. Stakeholder Workshop #2 29

NAVIGANT

Cost-Effectiveness Results of Transportation Electrification Program Options

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.

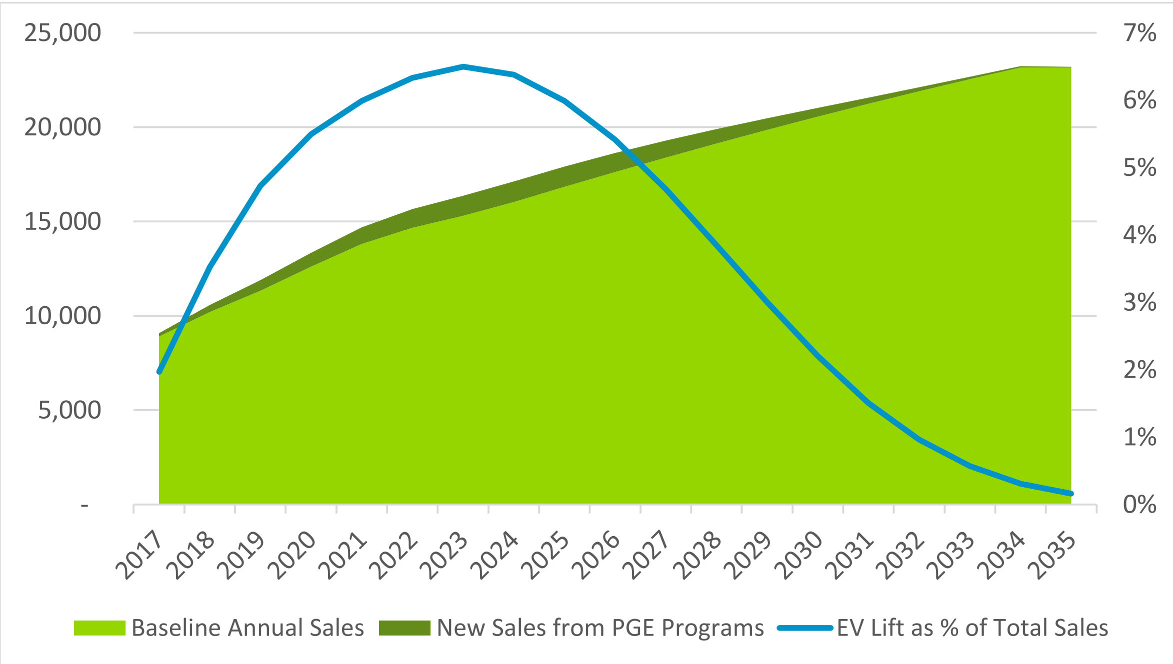
Through the course of this study, Navigant developed a cost effectiveness framework for transportation electrification support efforts that builds on the methodologies employed in other jurisdictions, including California and Seattle, and is consistent with the framework that PGE set forth for demand 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

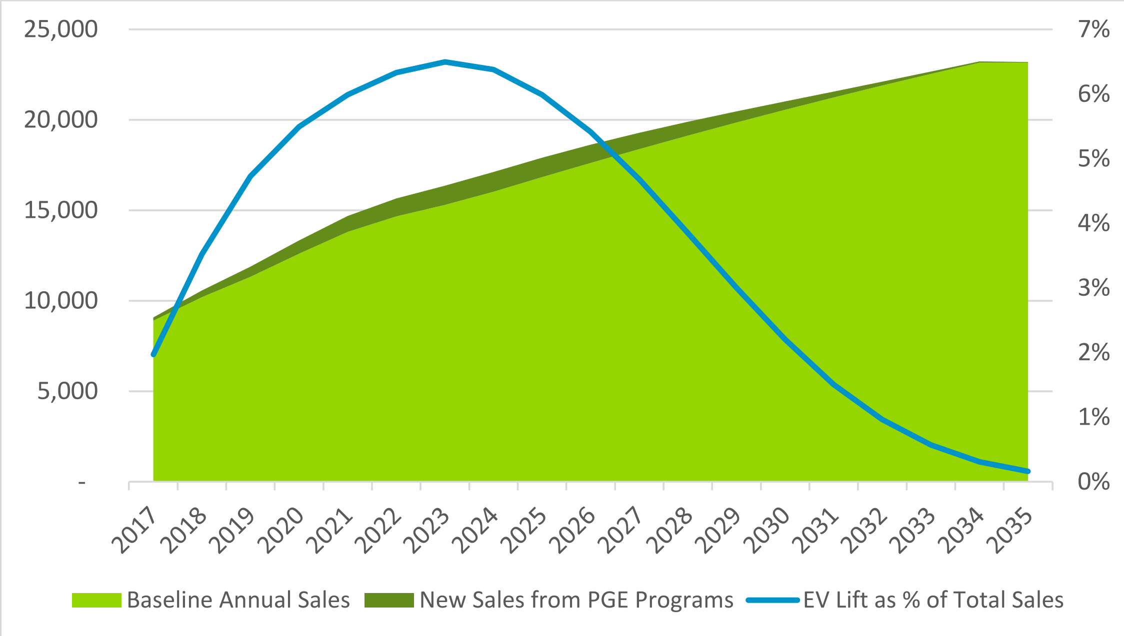
[1] UM 1708; http://edocs.puc.state.or.us/efdocs/HAD/um1708had113843.pdf.

NAVIGANT

Cost-Effectiveness Results of Transportation Electrification Program Options

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	$3,780,818	$2,034,525	$3,476,250
Education and Awareness	$2,526,860	$3,902,806	$4,671,908
Electric Mass Transit 2.0	$(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 $)			
DCQC Stations	$930	$527	$882
Education and Awareness	$889	$1,338	$1,607

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

Source: Navigant analysis, 2016

NAVIGANT

Cost-Effectiveness Results of Transportation Electrification Program Options

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.

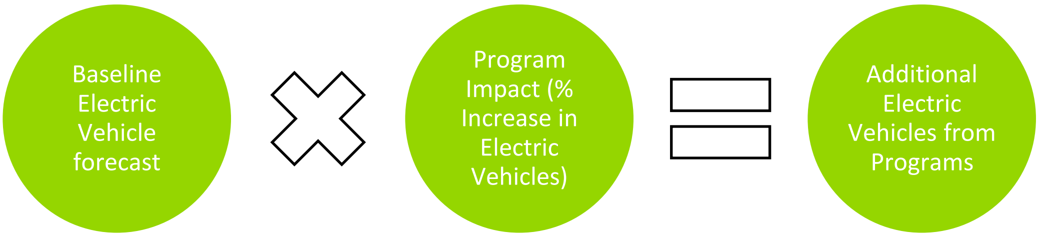
This section presents a high-level overview of the methodology, with more detailed information provided on the methodology for developing the baseline electric vehicle forecast and the transportation electrification program impacts.

Appendix B provides more detail on the overall methodology.

2.1 Overview of Methodology

The analysis was structured in two steps outlined below.

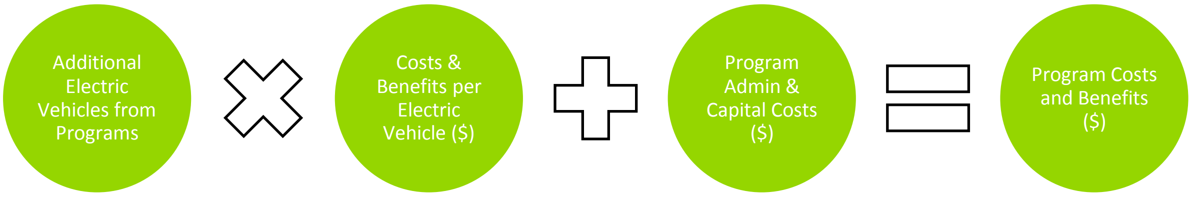
Step 1: What is the baseline electric vehicle market and PGE's influence on the market?



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		
Customer Tax Credits – State	Benefit		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

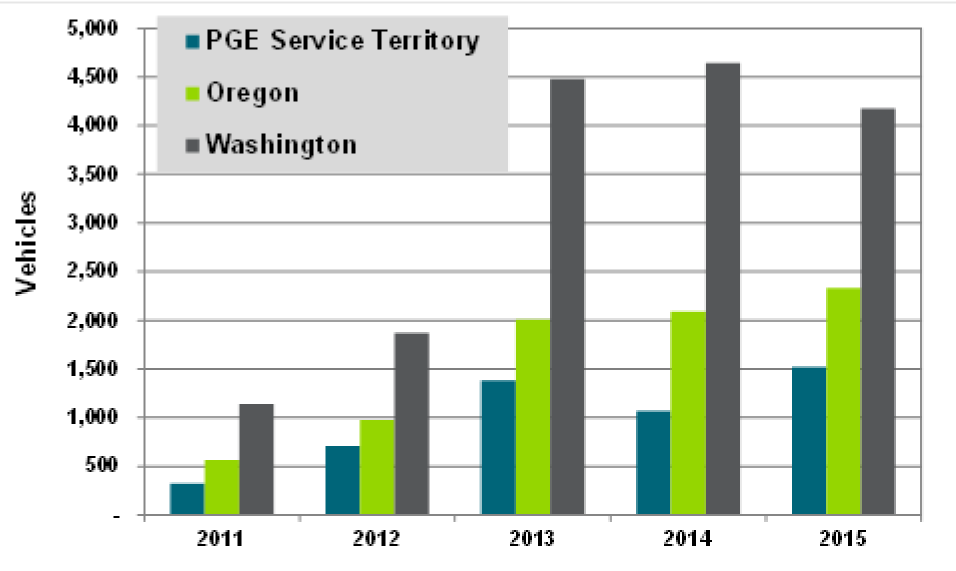


Figure 2: PEV Sales in Oregon, Washington, and PGE Service Territory 2011-2015

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.

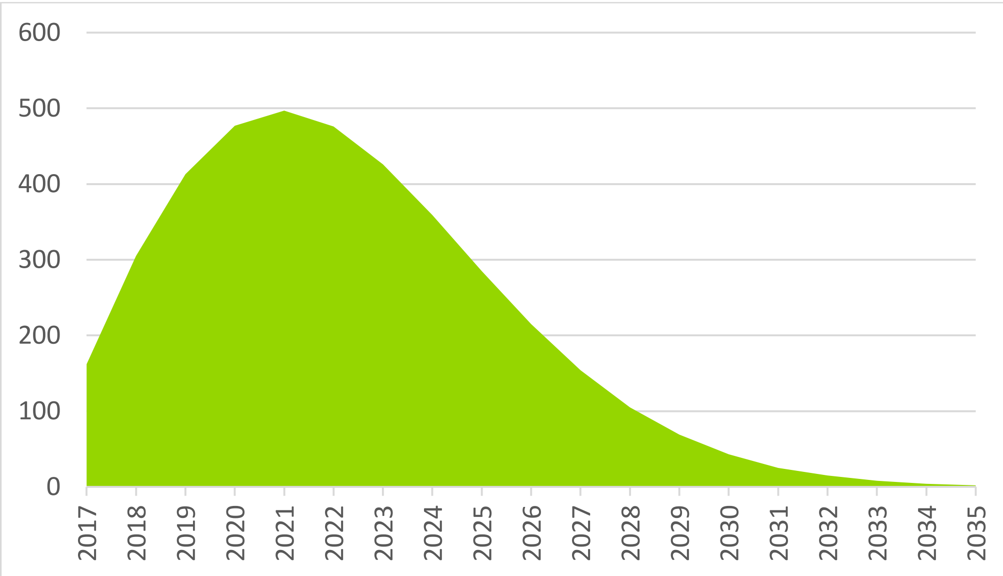
[7] 26 percent of respondents identified a lack of places to charge as the primary disadvantage to PEV ownership, 18 percent cited cost, 17 percent cited range; the remainder cited other concerns including battery reliability and technology unfamiliarity among others.

[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.

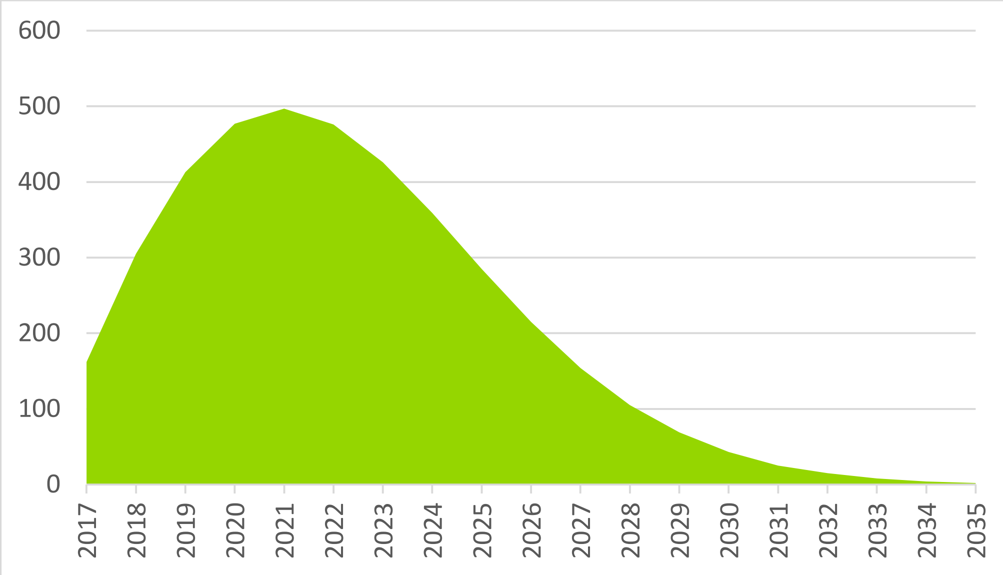
Table 3. New Electric Vehicles from Education and Awareness Program



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

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



Source: Navigant analysis, 2016

2.3.2 Community Charging Infrastructure Program

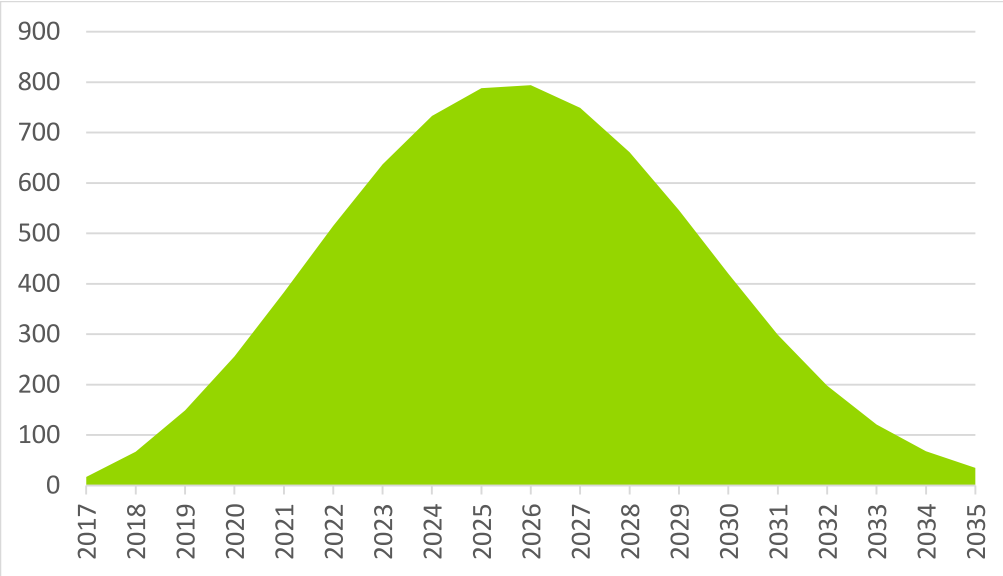
Though range anxiety and a lack of charging infrastructure are often cited as the primary drawbacks to purchasing a PEV,[10] there is uncertainty in the industry regarding which technical infrastructure solution[11] is the most impactful in resolving the range/infrastructure nexus. Regardless, all technical 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

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



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 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

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

Transit 2.0 Program

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.

[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

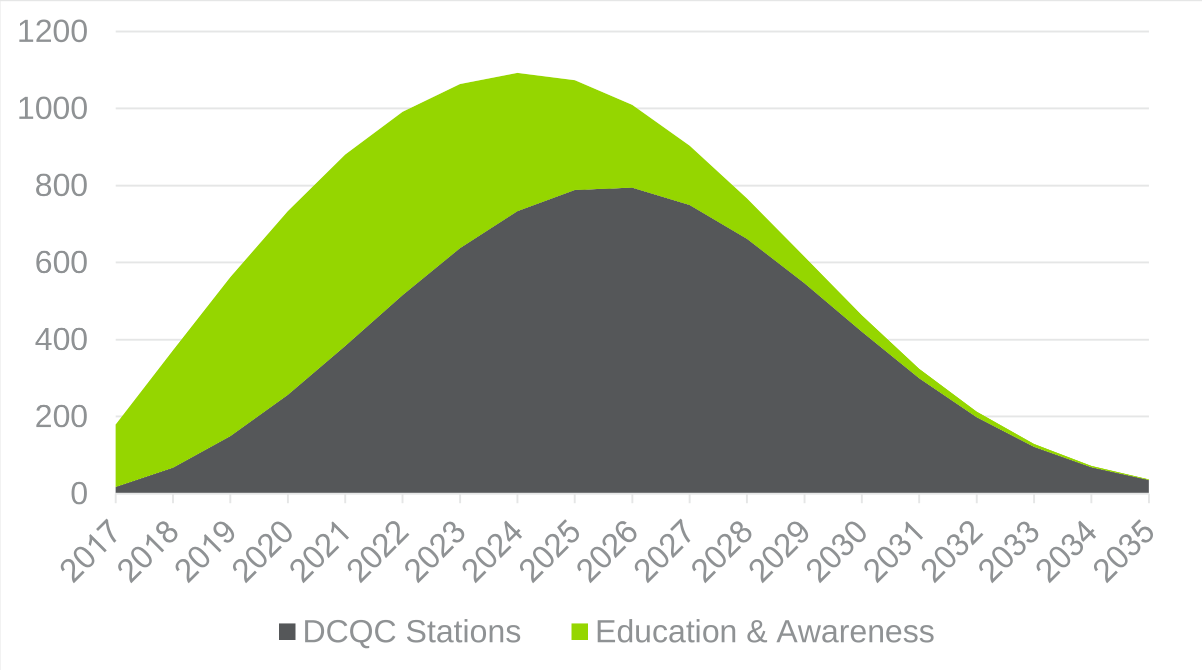
- The off-peak rate is approximately 70 percent of the flat rate, meaning that relative to the flat rate structure, revenue gains from charging during peak times are largely offset by the majority of charging occurring during off-peak times under the time-of-use rate.
- A portion of Electric Vehicle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

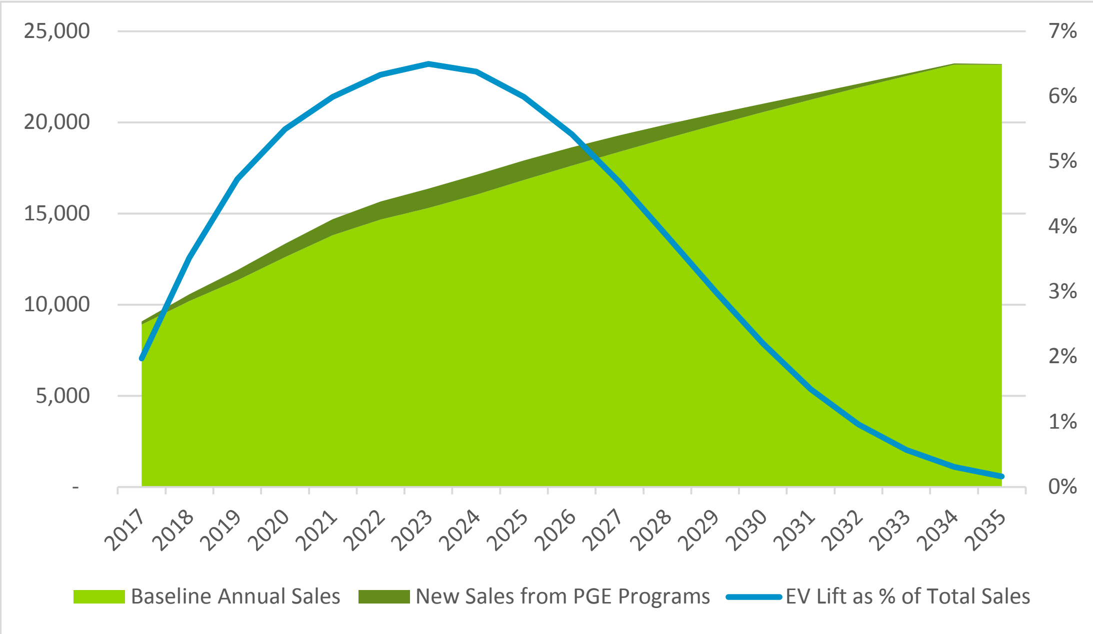
Table 6. New Electric Vehicles by Program



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.

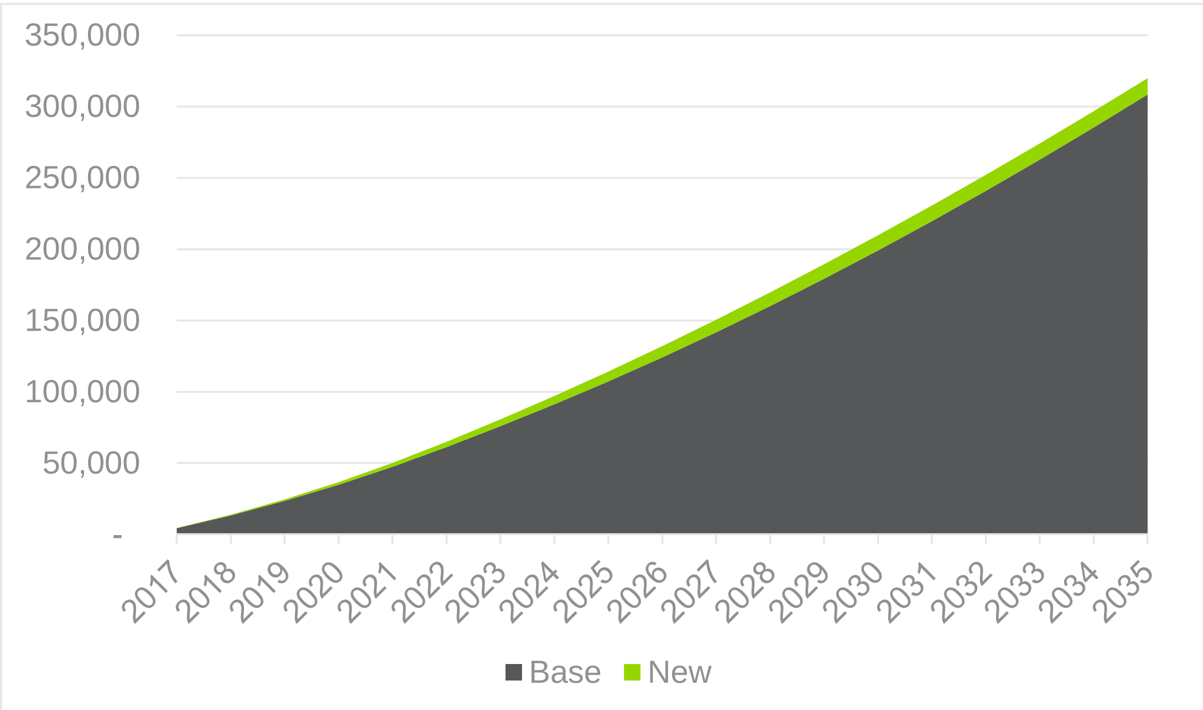
Table 7. Cumulative Electric Vehicles in PGE Territory



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

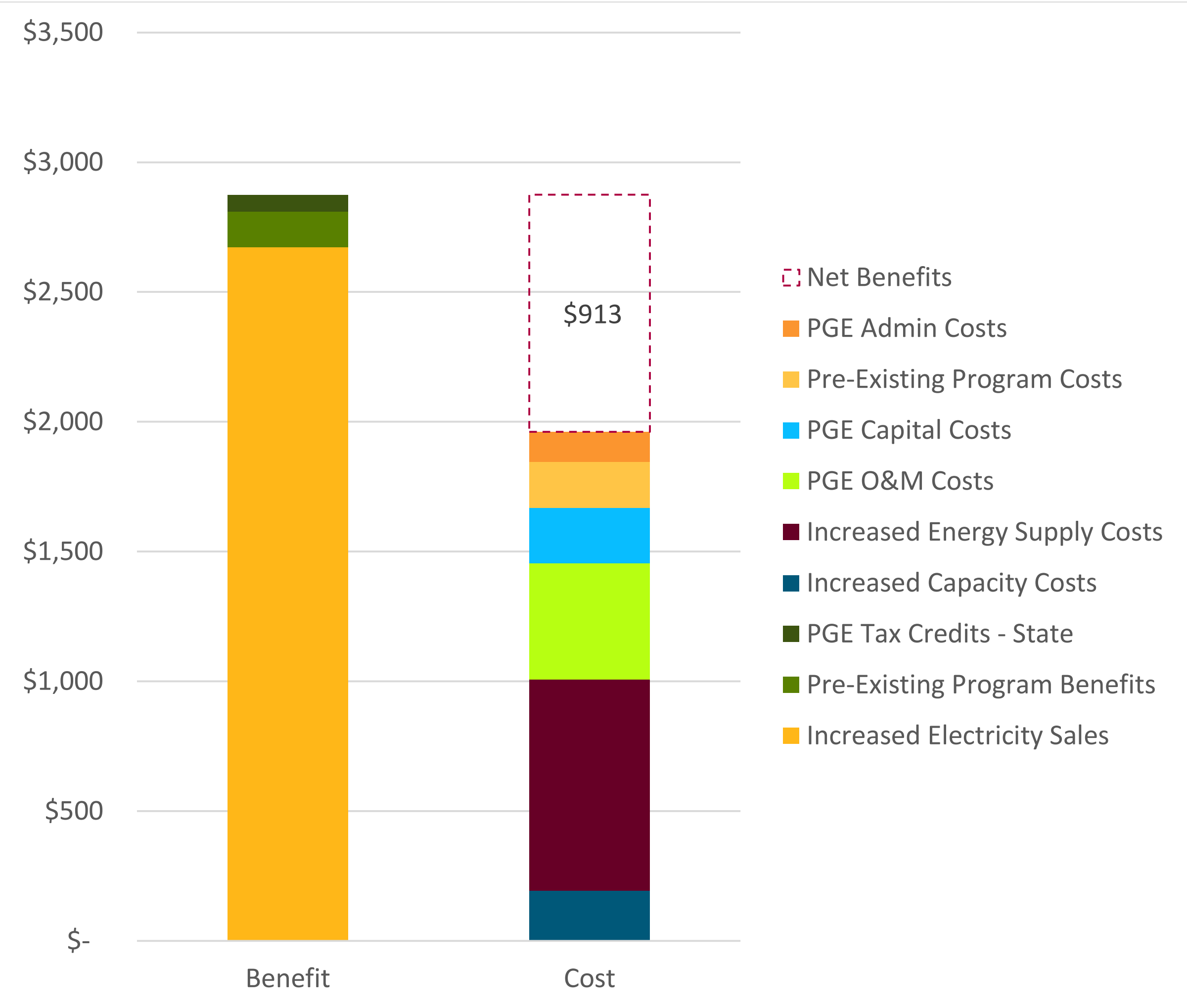
3.2 Rate Impact Measure (RIM) Test

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 $913 per light duty vehicle.

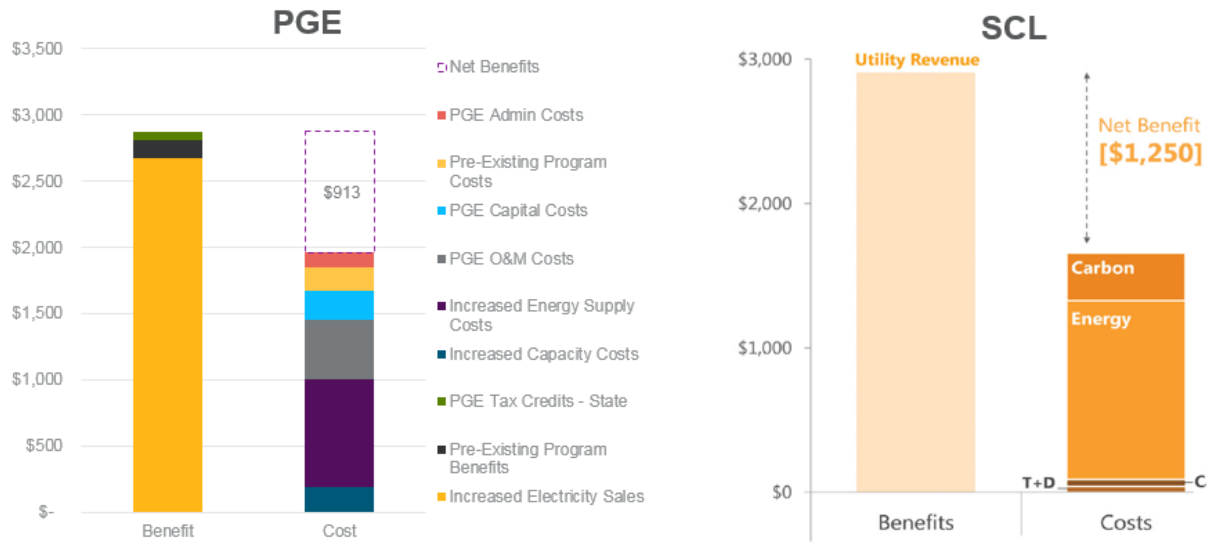
Table 9. Per Vehicle Benefits and Costs with RIM Test



Source: Navigant analysis, 2016

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

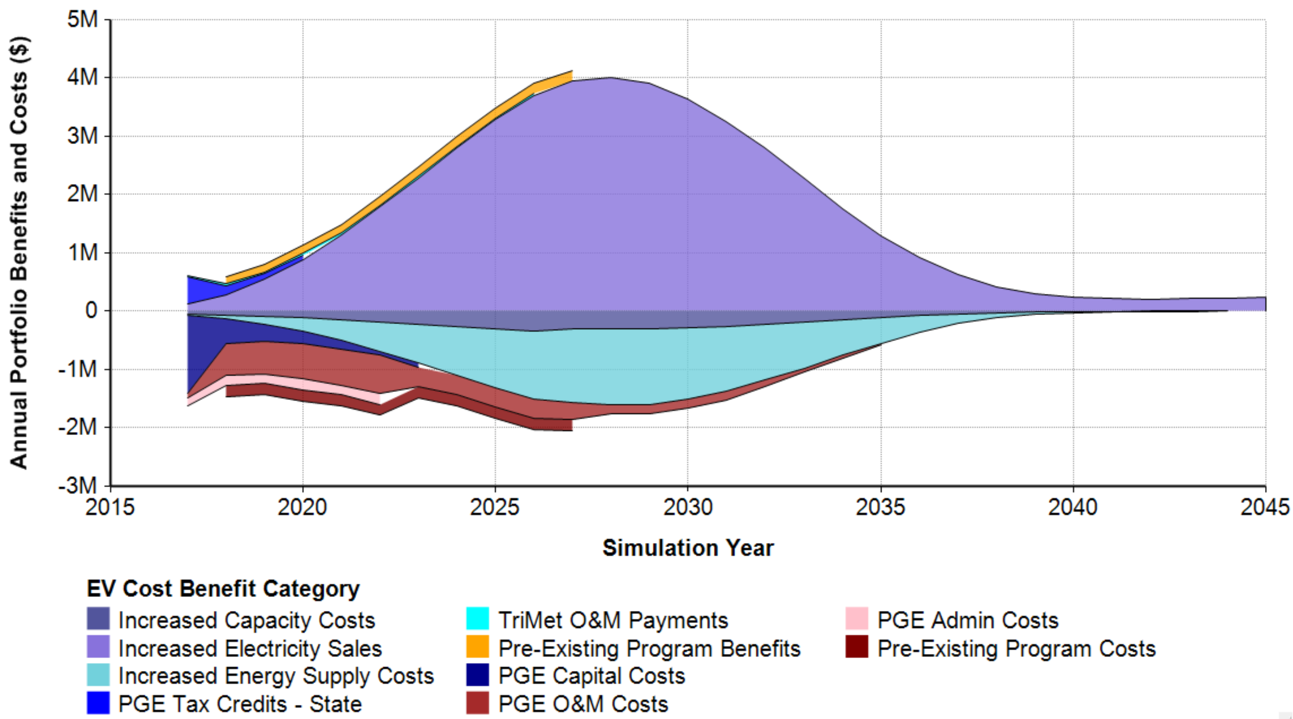
Table 10. Comparison of Results between PGE and Seattle City Light



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



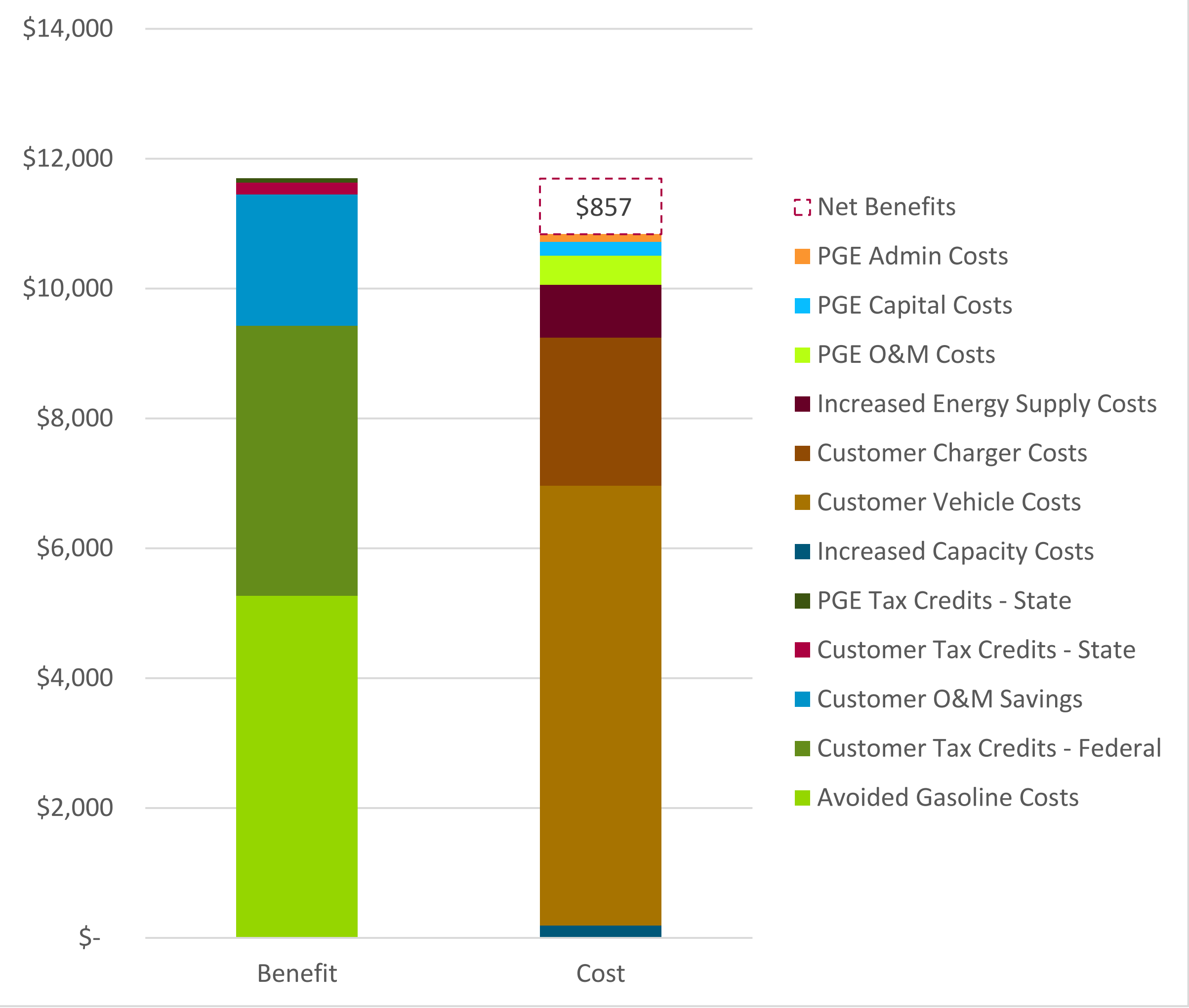
Source: Navigant analysis, 2016

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.

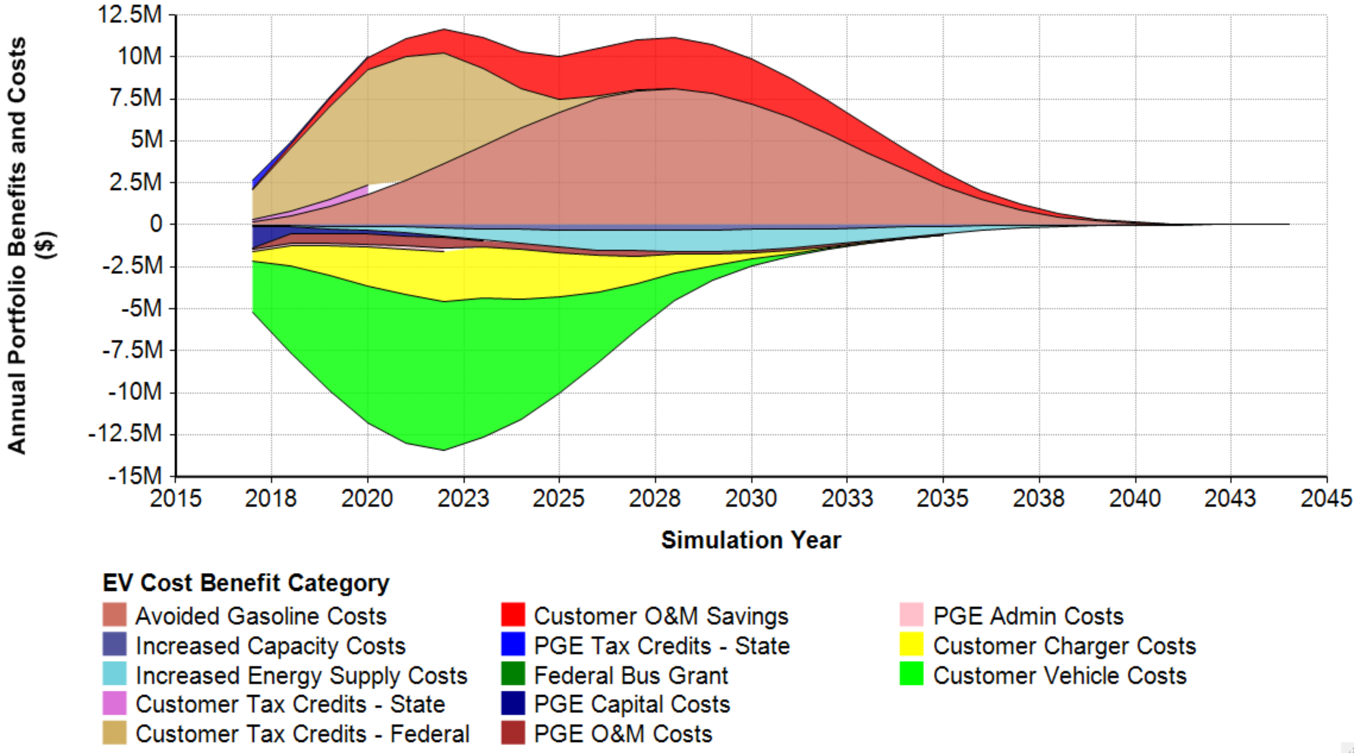
Table 12. Per Vehicle Benefits and Costs with TRC Test



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.

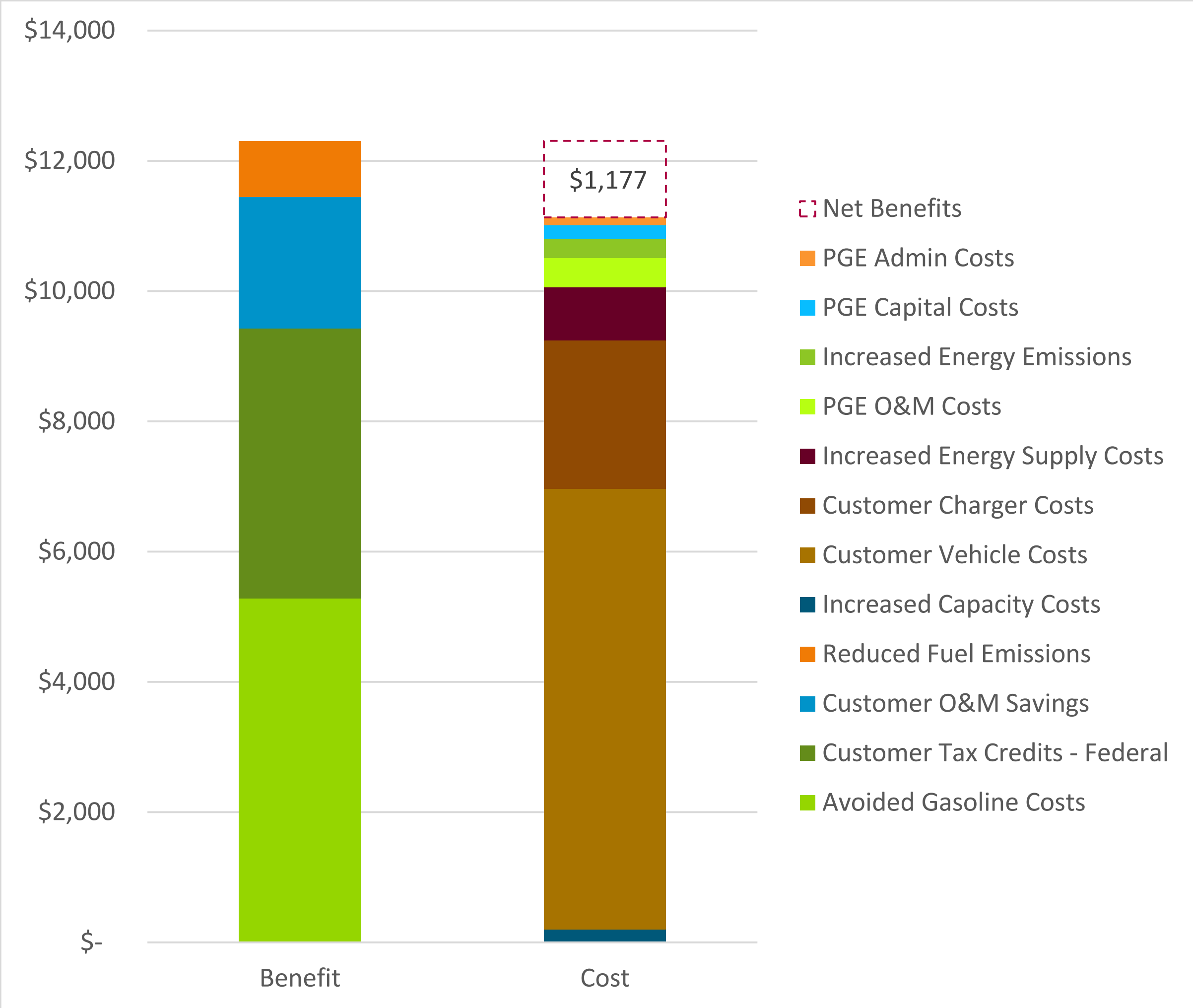
This analysis conservatively estimates the impact of only benefits to society that are easily monetized using Environmental Protection Agency values for the social cost of carbon[17], and does not consider other difficult-to-monetize benefits from transportation electrification[18].

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.

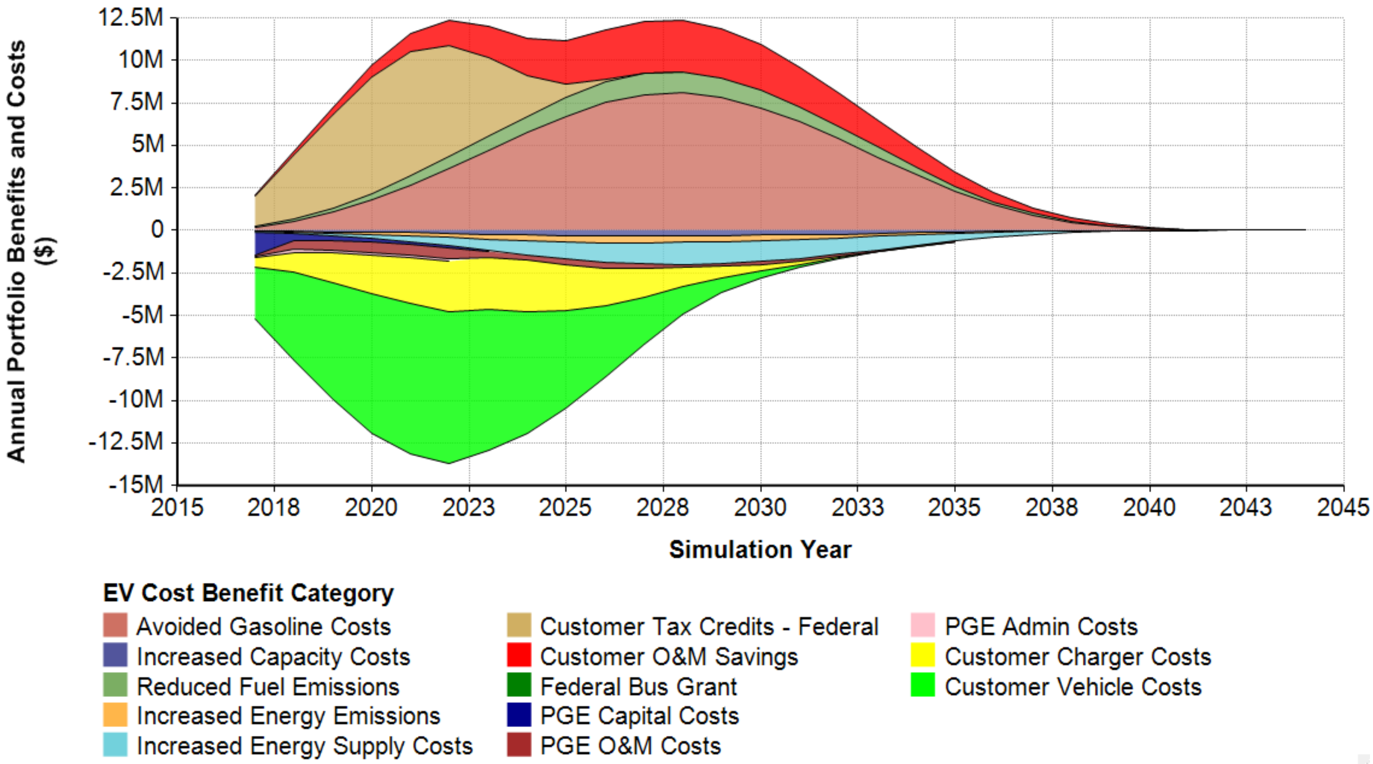
Table 14. Per Vehicle Benefits and Costs with SCT Test



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

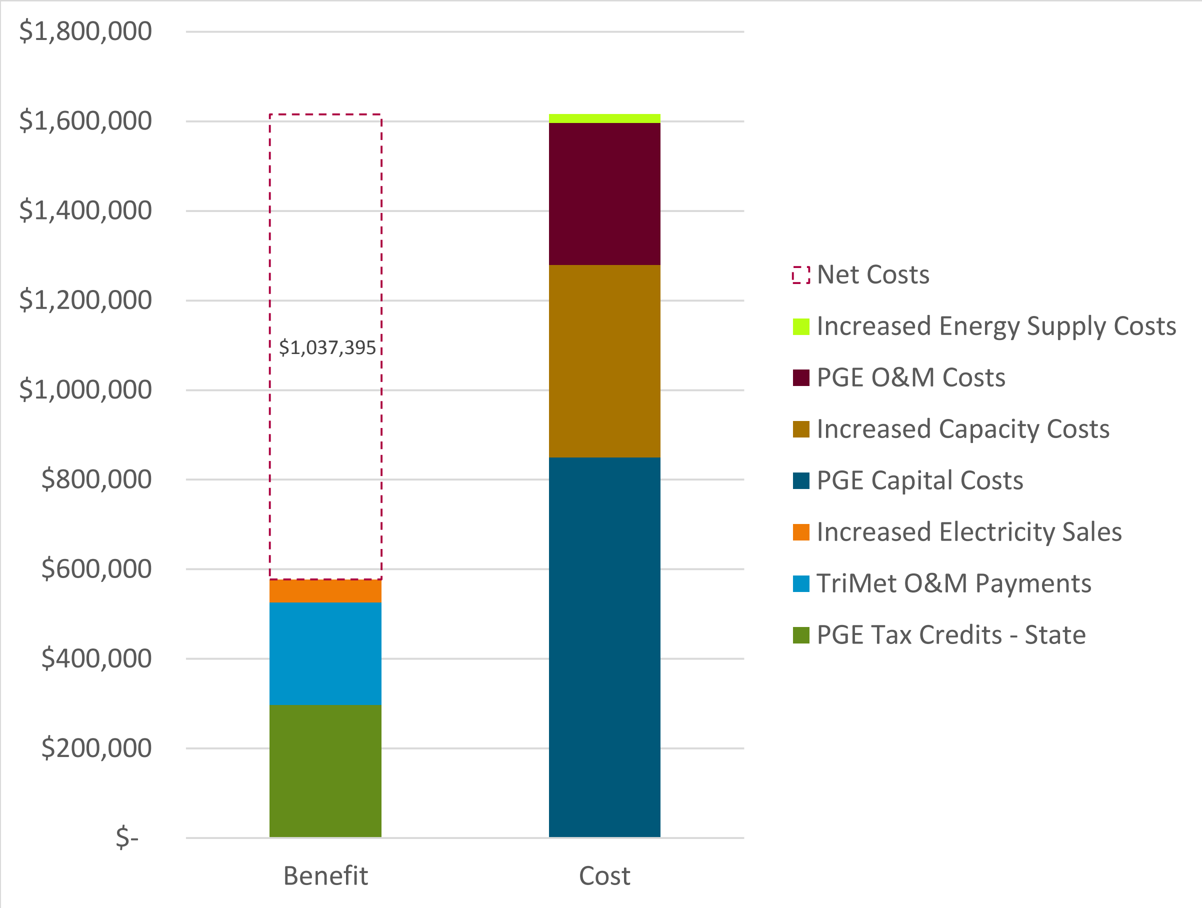
This section provides more detail on the results for the Electric Mass Transit 2.0 program individually, given the unique nature of this program within PGE's electrification transportation portfolio.

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

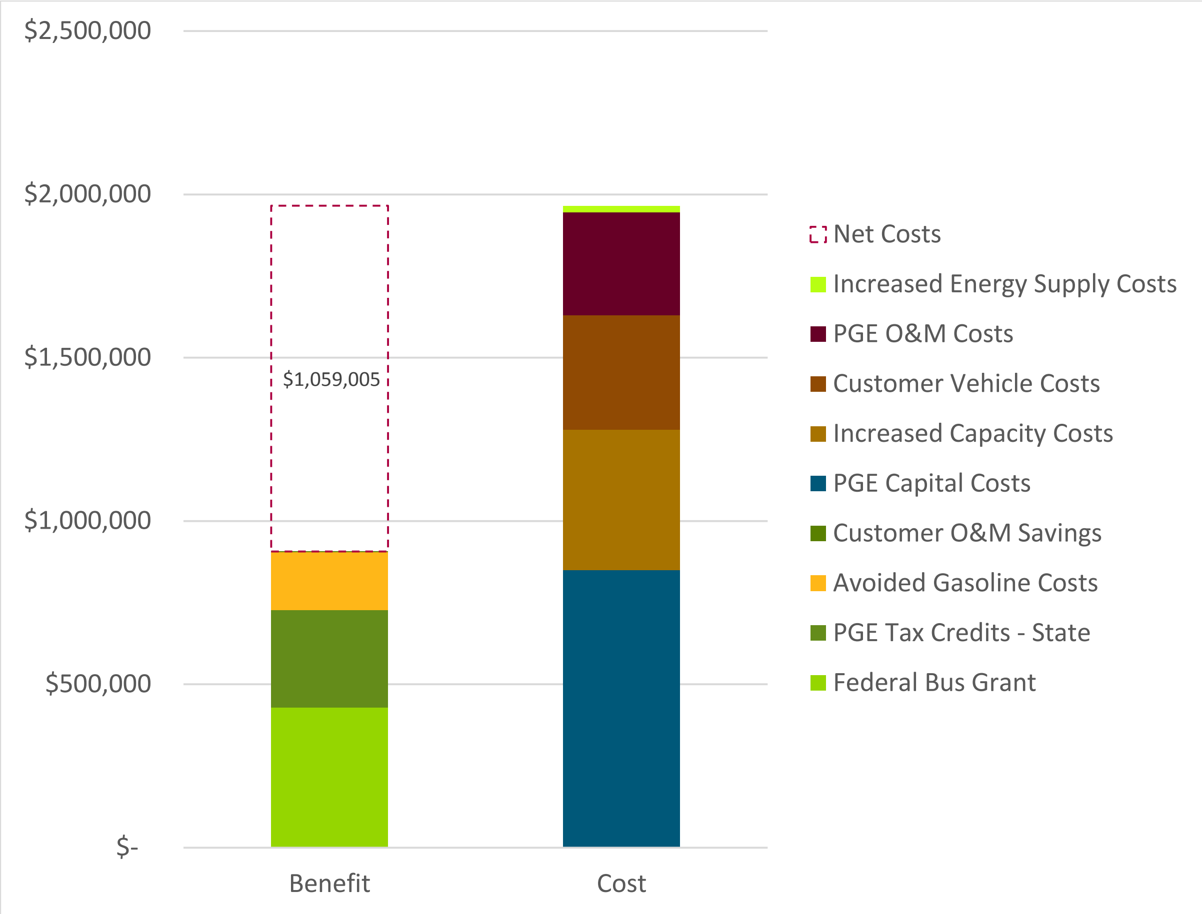
Table 16. Electric Mass Transit 2.0 Costs and Benefits with RIM Test



Source: Navigant analysis, 2016

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

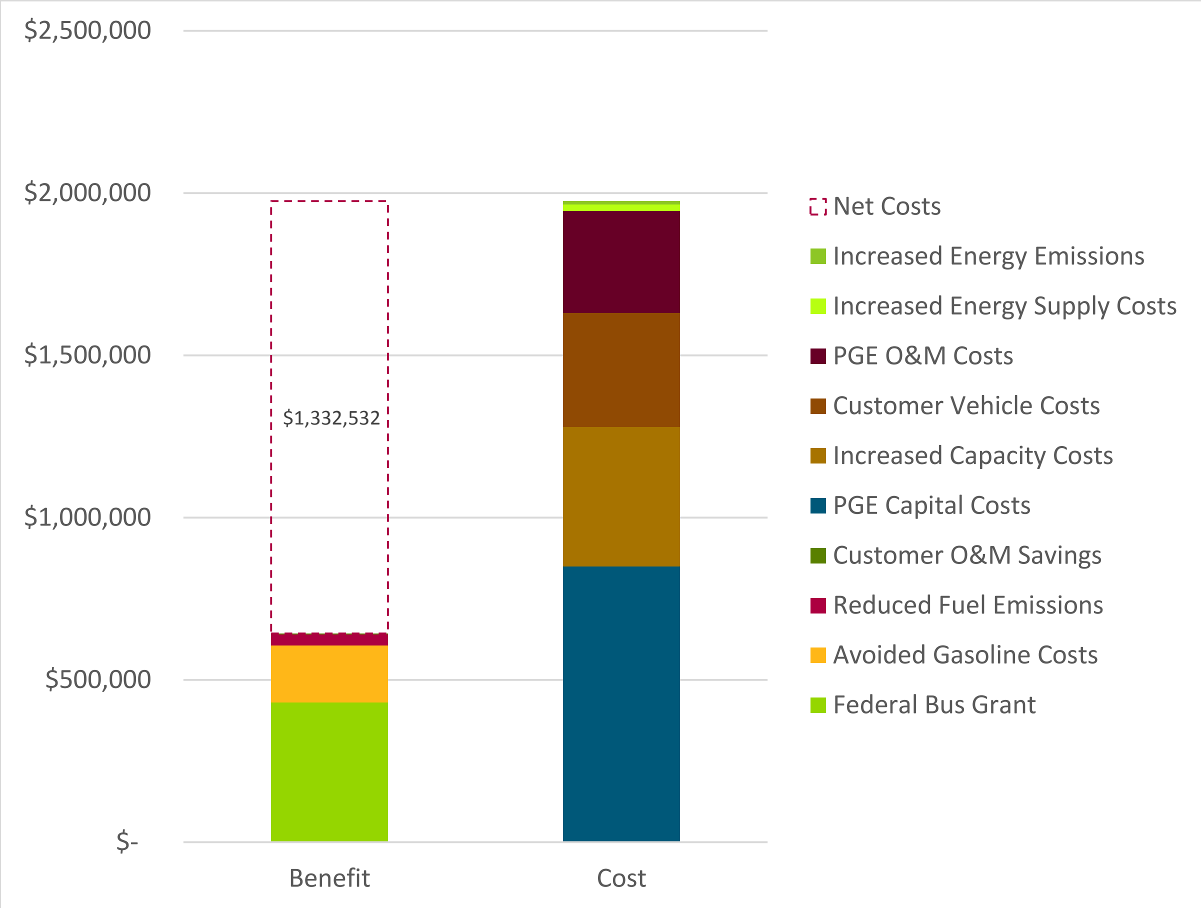
Table 17. Electric Mass Transit 2.0 Costs and Benefits with TRC Test



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

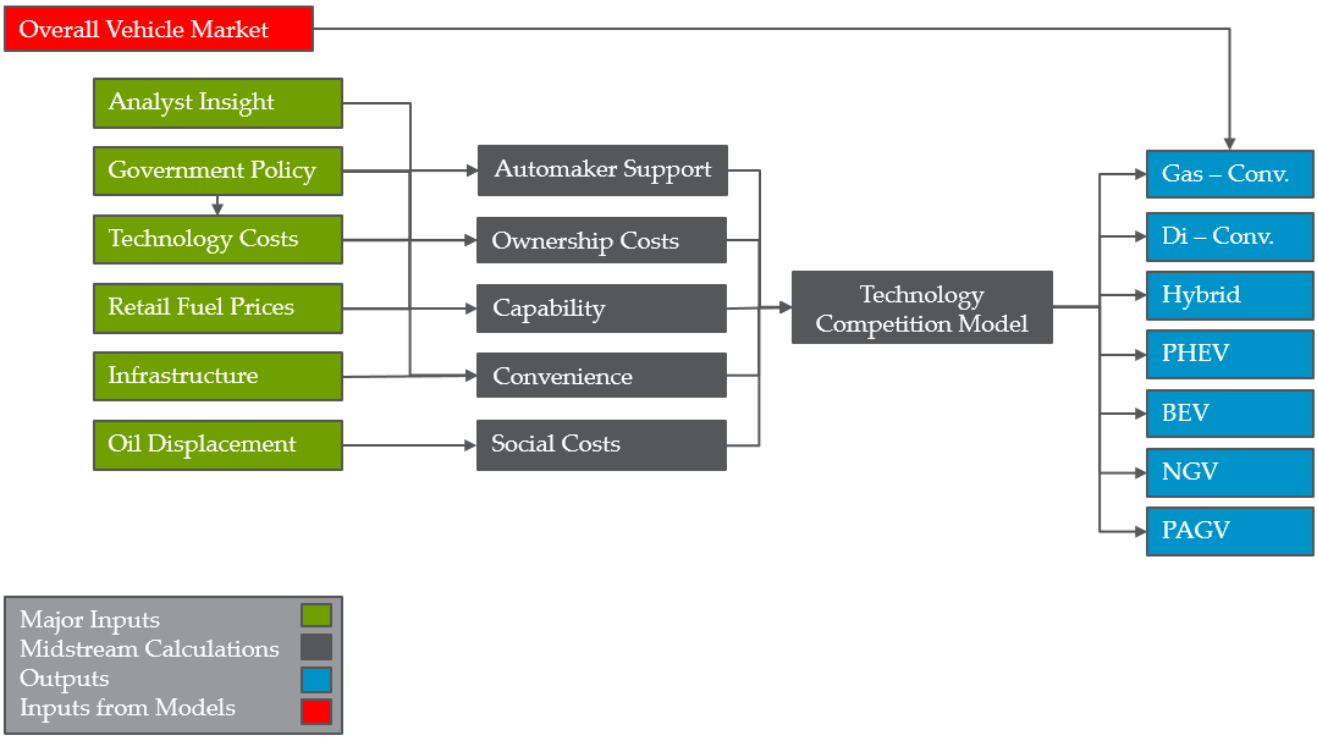
Cost/Benefit Category	Definition	Calculation Description	Monetization Unit
Avoided Gasoline Costs	A customer's value of avoided gasoline purchases	Based on VMT and fuel efficiency of the baseline gasoline powered vehicle	$/gallon of gasoline
Increased Capacity Costs	PGE's increased costs of capacity from providing electric vehicle charging service	Based on electric vehicle charging coincidence with system peak demand (MW)	the inverse of avoided capacity costs ($/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.

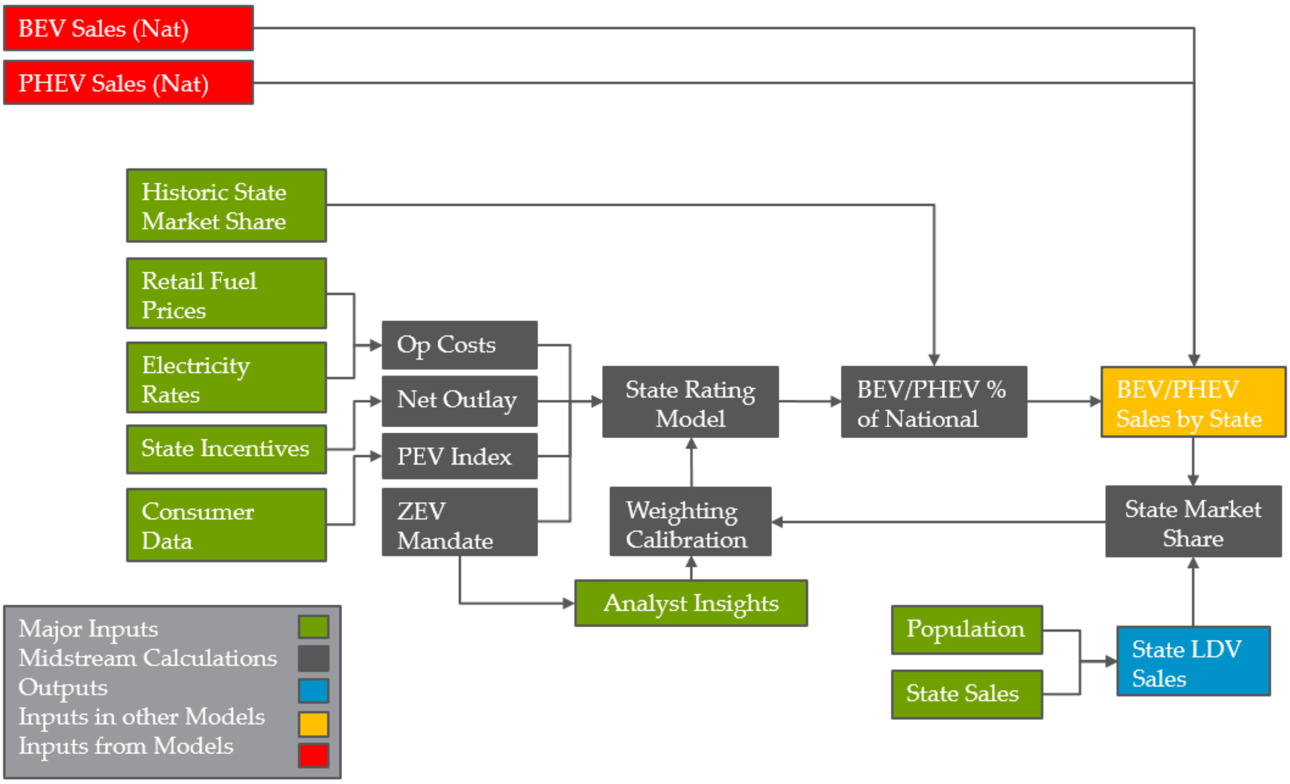
Figure 3: Electric Vehicle Forecast Method: Technology Adoption



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.

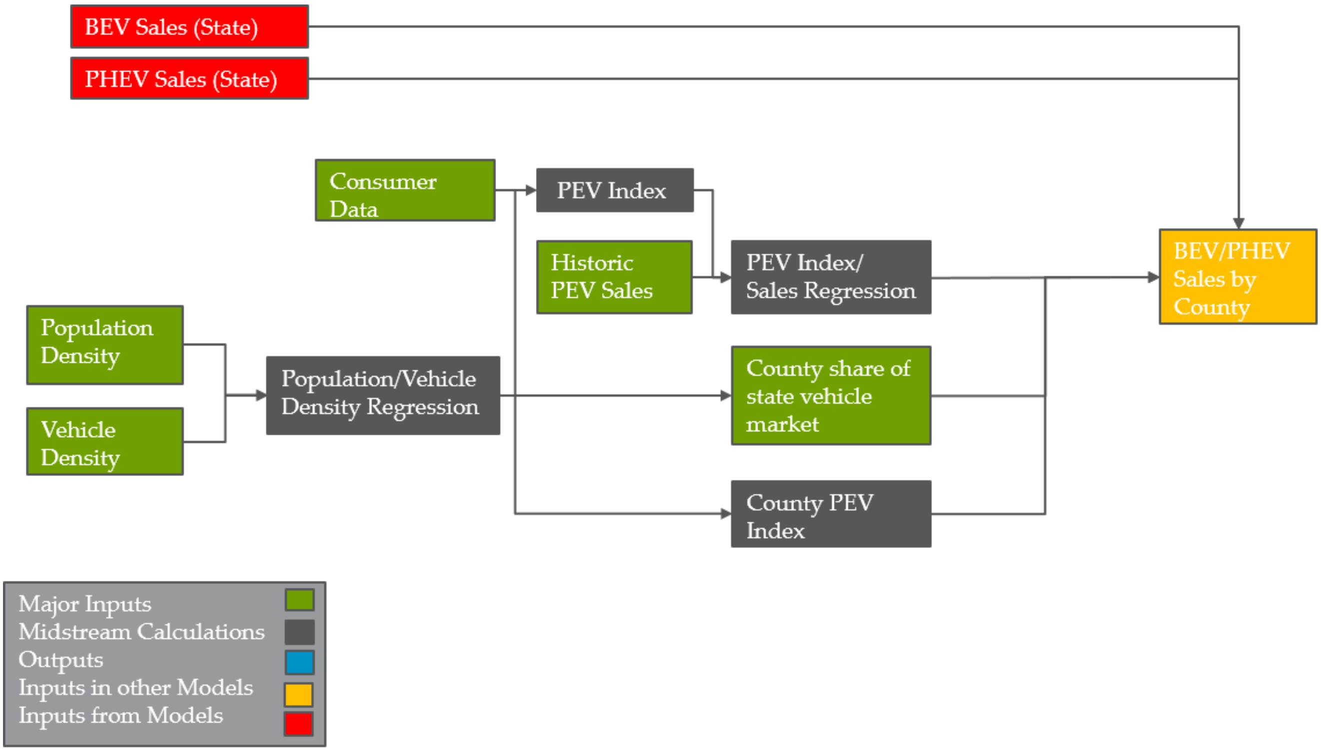
Figure 3: Electric Vehicle Forecast Method: State Disaggregation



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

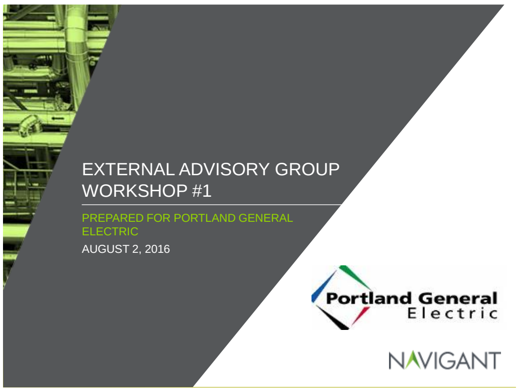


Source: Navigant analysis, 2016

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

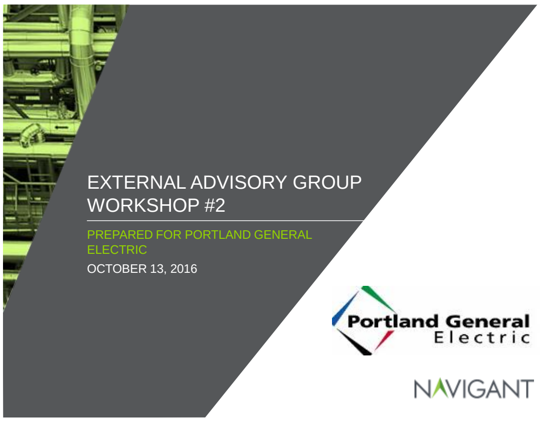
See attached presentation for the first external stakeholder workshop, conducted on August 2, 2016.



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

PGE Corporate Headquarters
121 S.W. Salmon Street | Portland, Oregon 97204
PortlandGeneral.com